

BRIEN HOLDEN VISION INSTITUTE

REFRACTIVE ERROR TRAINING PACKAGE

- STUDENT MANUAL -

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REFRACTIVE ERROR TRAINING PACKAGE

- STUDENT MANUAL -

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INTRODUCTION TO THE EYE

THINK

A mother brings her son to see you because his eyelid was injured while playing with a stick. You have to decide what to do.

How would you describe what was wrong with the child's eye in your examination records?

How would you describe the problem to another eye care worker?

If you decided to refer the boy to an eye specialist, what would you write in your referral letter if you did not know that part of the eye was called the "eyelid"?

AIM

This unit introduces you to some of the different parts of the eye – what these parts are called and what they do.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- identify and name parts of the eye
- describe what each of those parts do.

INTRODUCING THE EYE

The eyes let us see shapes, colours, and sizes of objects in the world. We use our eyes in almost every activity we perform, whether reading or writing, working in the kitchen, watching television, or riding a bicycle.

Sometimes people do not see well, or have pain or redness because there is a problem with some part of their eyes. It is important to know what the different parts of the eye do, so that you know what the effect will be and what complaints (also called “symptoms”) the person may have if a certain part does not work properly. This information can help you decide what is wrong with a person’s eyes and what you need to do about it.

LOOKING AT EYES

Some parts of the eye can be seen just by looking at a person’s face. Other parts of the eye are inside the eye and can only be seen when using special instruments.

We will begin by naming the parts that we can see without needing to use special instruments. When we examine eyes closely, it helps if we have a good light like a lamp, torch or flashlight. If you do not have these things you can also use sunlight.

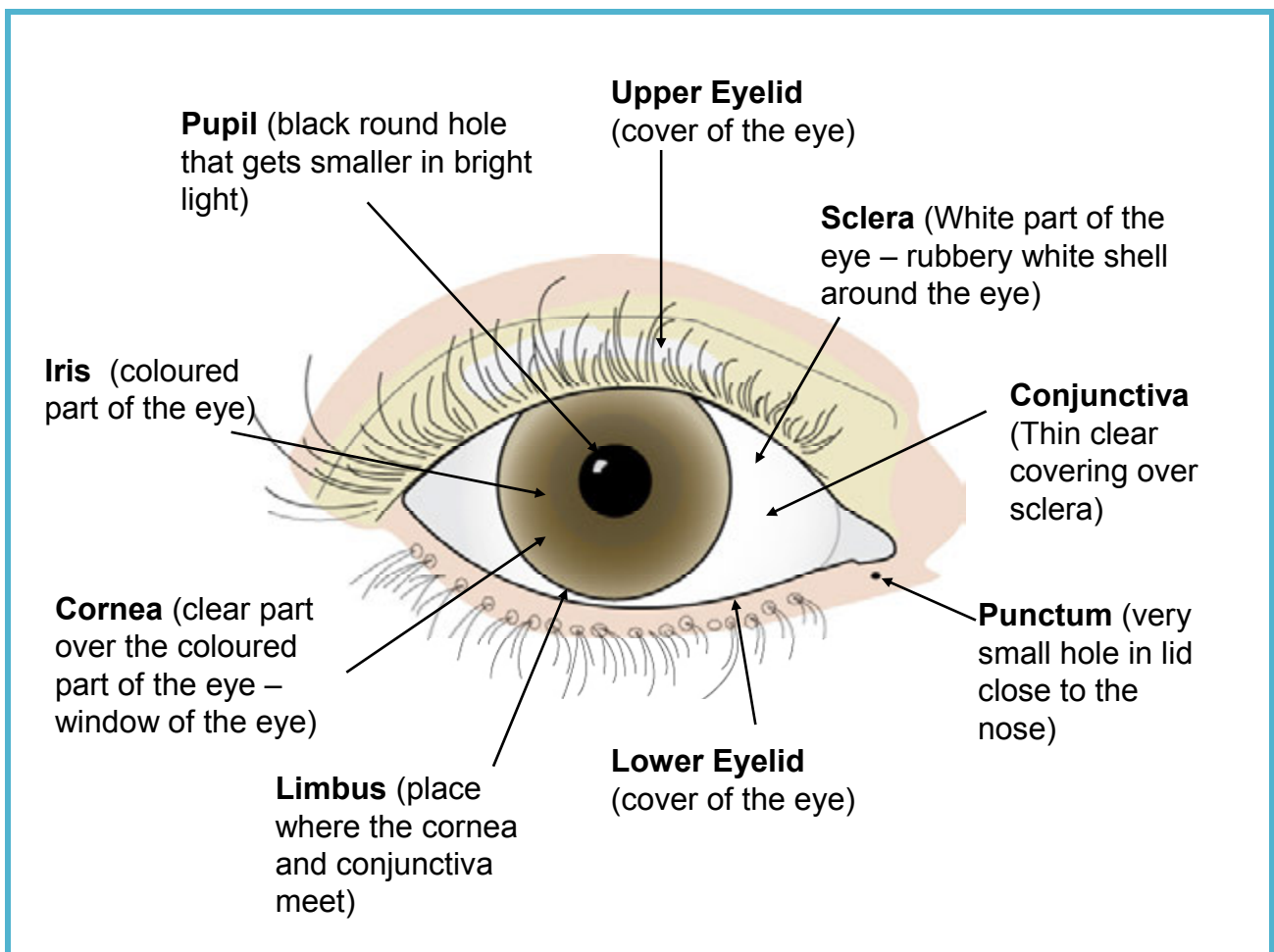


Figure 1.1: The external eye

If we take away the eyelids and cut the eyeball in half like we might do with an orange or a coconut, it would look like the diagram below.

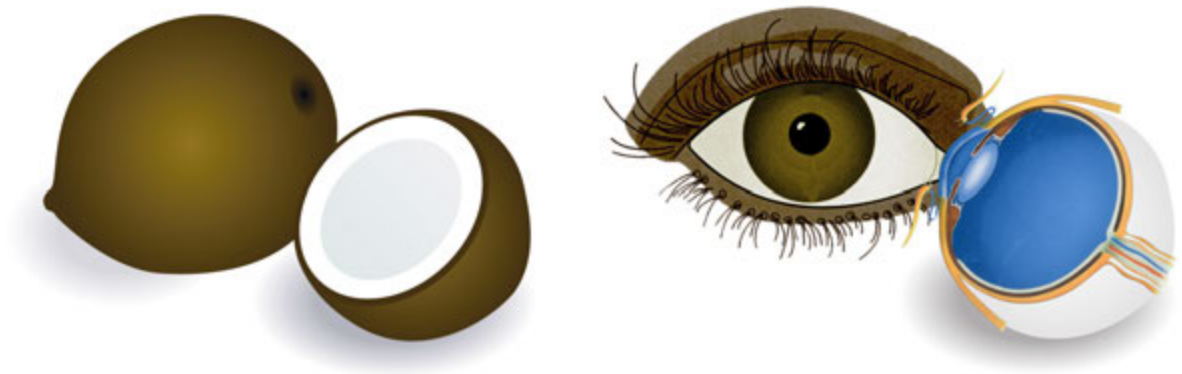
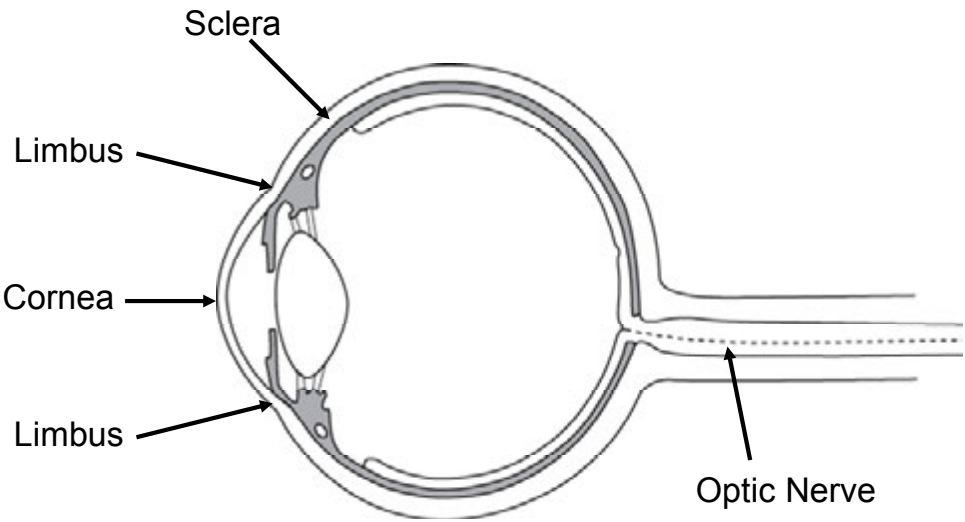


Figure 1.2: *Cutting the eye in half*

PARTS OF THE EYE

ORBIT	The eye is enclosed by a bony socket in the skull called the orbit.  The orbit helps to protect the eye.
TEAR FILM	The tear film is the watery layer at the front of the eye. The tear film keeps the outside of the eye wet, and provides nutrients to the cornea. It also creates a smooth surface for light to pass through to the cornea, and provides protection from infection.  The tear film helps to protect and nourish the eye, and helps light to enter the eye easily.  The diagram shows a cross-section of the eye. Labels with arrows point to the Sclera (the outer white layer), the Limbus (the junction between the sclera and cornea), the Cornea (the clear front part), and the Optic Nerve (the nerve exiting the back of the eye). <i>Figure 1.3: Looking at the eye from the side</i>
SCLERA	The diagram above shows the outside of the eyeball which is called the sclera. The sclera is white in colour and can be thought of as a rubbery <i>white shell</i> around the eye. Attached to the outside of the sclera are six extraocular muscles (that control eye movements), and the optic nerve (that connects the eye to the brain).  The sclera is very strong. It protects the inside of the eyeball and gives the eye its shape.

PARTS OF THE EYE (cont.)

CORNEA

The picture below shows the front of the outside of the eyeball, which is the cornea. The cornea is different to the sclera because the cornea is not white in colour, but transparent (clear), like glass. The cornea can be thought of as the *window of the eye*.

When we look at a person's eye we can see through the clear cornea to the coloured part of the inside of the eye. The cornea needs to be clear so that it can let light into the eyeball so we can see.

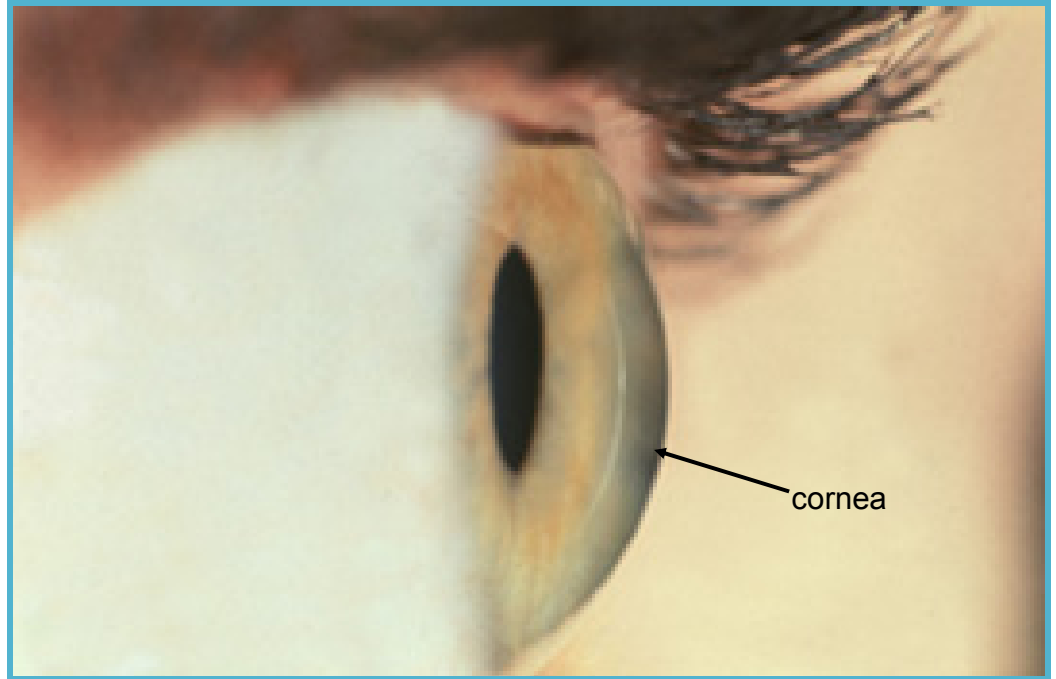


Figure 1.4: The cornea

The cornea is thin (only 0.5 mm thick), but it is also very strong. The cornea helps to protect the eye.

If something damages the cornea it will be very painful. This is because the cornea contains many nerve endings that send pain messages to the brain.

The cornea also helps to focus light that enters the eye. It provides $\frac{2}{3}$ rds of the eye's total focusing power.



The cornea:

- lets light into the eyeball
- protects the eye
- helps the eye to focus light.

PARTS OF THE EYE (cont.)

CONJUNCTIVA

The conjunctiva is the thin, clear layer that covers the front part of the sclera and the inside of the eyelids. When you look at a healthy eye you can see the white sclera through the clear conjunctiva. You will see a few small blood vessels in a healthy conjunctiva.

The conjunctiva has two parts:

- **Bulbar conjunctiva:** covers the sclera on the front part of the eye.
This part of the conjunctiva covers some of the sclera, but it does not cover the cornea.
- **Palpebral conjunctiva:** covers the inside of the top (upper) and bottom (lower) eyelids. Also called the conjunctiva of the eyelid.

You can see the conjunctiva of the bottom lid by pulling the eyelid down. To see the palpebral conjunctiva under the top lid you need to evert (or flip) the eyelid.

Because the palpebral conjunctiva is clear, you can see the pink eyelid underneath it.

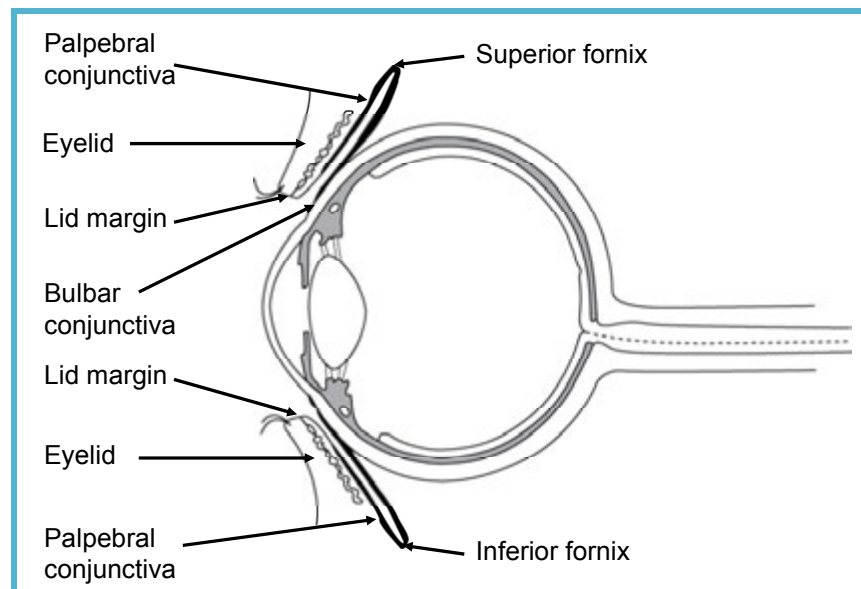


Figure 1.5: Conjunctiva and eyelids of the eye

There is no way for foreign bodies like grains of sand, pieces of stone or metal to slip behind the eyeball. This is because the bulbar conjunctiva joins the palpebral conjunctiva to form a fold (like a small pocket). Foreign bodies can go no further than the folds in the conjunctiva. These folds are called the superior (upper or top) fornix and the inferior (lower or bottom) fornix.

If there is a problem affecting the conjunctiva, the blood vessels in the conjunctiva may dilate (get bigger) and the conjunctiva will look red. The conjunctiva does not have as many nerves as the cornea. If there is an eye problem that affects the conjunctiva, it will usually not be as painful as an eye problem that affects the cornea.



The conjunctiva helps to protect the eye from infection and from damage by foreign bodies.

PARTS OF THE EYE (cont.)

LIMBUS

The limbus is where the cornea meets the bulbar conjunctiva. The previous diagrams also show the limbus.

Both the cornea and the conjunctiva are clear. The coloured part of the eye is behind the cornea and the white sclera is behind the conjunctiva. When we look at a person's eye, the limbus is the place where it looks like the coloured part of the eye meets the white part of the eye.



The limbus can be thought of as a landmark in the eye.

THE EYELIDS

The front of the eyeball can be covered or uncovered by two folds of skin called the eyelids. The edge of each eyelid is called the lid margin. Along the front of the lid margin are the eyelashes.

The eyelids and eyelashes protect the eyes from wind, dust, too much light, foreign bodies and infection.

The eyelids also spread out the tears each time we blink. This stops the eye from drying out and keeps the front surface of the eye smooth.



The eyelids and eyelashes protect our eyes from the environment and from too much light. They also spread out the tears each time we blink to keep the eye wet.

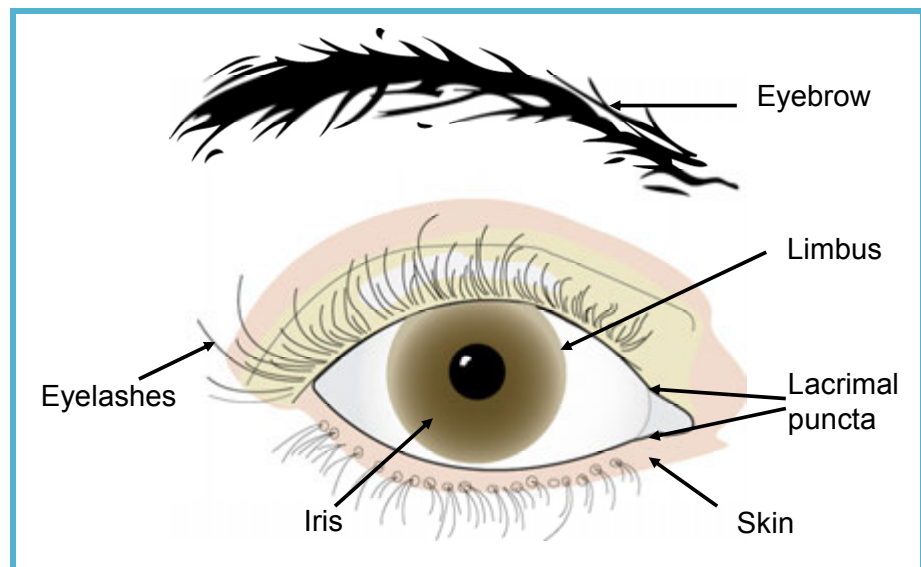


Figure 1.6: The outside of the eye

EYEBROWS

The eyebrows are the arches of hair located above each eye.



The eyebrows help to protect the eye from perspiration (sweat) and foreign bodies.

PARTS OF THE EYE (cont.)

LACRIMAL PUNCTA

Fresh tears are always being made, and tears need a way to drain out of the eyes. The openings to the tear drainage system are called the lacrimal puncta, or simply the puncta. These tiny drainage holes are located on the eyelid margins near the inside corners of the eyes.



The tears drain into the nose through the puncta. This is why your nose runs when you cry.

Sometimes people (especially older people and babies) have a blocked punctum. The tears then run over their cheeks and it may look like they are crying. When this happens the punctum might need to be opened or unblocked.

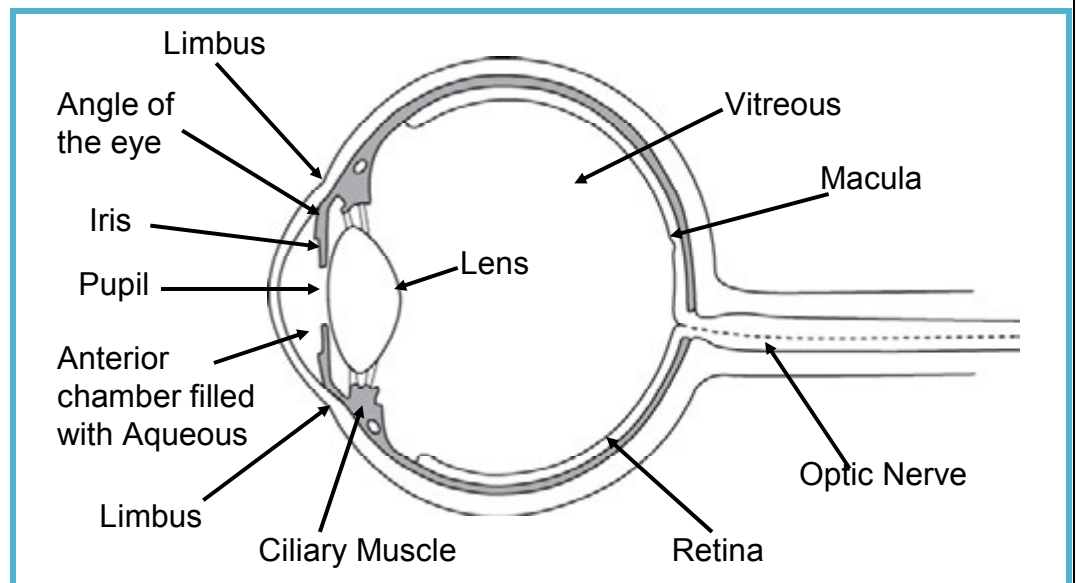


Figure 1.7: The internal eye

IRIS AND PUPIL

The coloured part of the eye is called the iris.

The iris is shaped like a compact disc – it is round and flat with a hole in the middle of it. It is located behind the cornea and the aqueous and in front of the vitreous.

The iris divides the eye into the anterior chamber (between the cornea and the iris), and the posterior chamber (between the iris and the retina).

Iris colour is different in different people. It can be brown, green, blue, or grey.

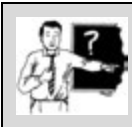
In the middle of the iris is a round hole called the pupil. The pupil usually looks black because the inside of the eyeball is dark.

Muscles in the iris change the pupil's size to let in the right amount of light.



In bright light the pupil is small and in dim light the pupil is large.

PARTS OF THE EYE (cont.)

AQUEOUS	The anterior chamber of the eye, between the cornea and the iris, is filled with a watery liquid called the aqueous humour, or simply the aqueous. The aqueous gives the front of the eye its shape.  The eyelids and eyelashes protect our eyes from the environment and from too much light. They also spread out the tears each time we blink to keep the eye wet. The area in the anterior chamber where the cornea and iris meet is known as the angle of the eye. This is the place where the aqueous humour drains from the eye. When aqueous humour is made it travels through the pupil into the anterior chamber and eventually exits the eye through the angle of the eye. The balance between production and drainage of aqueous fluid determines the eye's intraocular pressure (IOP). If the IOP is too high for long periods of time, it can cause blindness.
LENS	The diagram above shows the crystalline lens which is usually simply called the lens. The lens is located behind the iris and the pupil. The lens is normally transparent, like clear glass, and can usually only be seen with the help of special instruments. Sometimes the lens can become cloudy, especially in older people. This is called cataract. If the cataract is very dense, we can see the lens through the pupil because it looks white or yellow instead of black. The lens is suspended behind the pupil by zonular fibres. Zonular fibres are often simply called zonules. One end of the zonule is joined to the lens and the other end is joined to the ciliary muscle. When the ciliary muscle contracts or relaxes, the zonules change the shape of the lens, which changes the focusing power of the lens.  The purpose of the lens is to change the focus of the eye so that we can see things at different distances. When we are young the lens is soft and flexible and we can focus to see things that are very close to the eye. This is called accommodation.
CILIARY MUSCLE	The ciliary muscle is a ring of muscle located around the lens. The ciliary muscle is joined to the lens by the zonules. The ciliary muscle changes the shape of the crystalline lens so that the eye can accommodate.  When the ciliary muscle contracts (pulls together) the lens changes focus. When the ciliary muscle contracts, the zonules, which connect the ciliary body to the lens, loosen and the lens becomes thicker – this increases the focusing power of the lens. When this happens we say that the eye is accommodating. When the ciliary muscle relaxes, the zonules become taut (stretched tightly) and the lens becomes thinner – this decreases the focusing power of the lens.  A good way to think of the zonules is to imagine them as strands of a spider's web that join the ciliary muscle to the lens.

PARTS OF THE EYE (cont.)

CILIARY MUSCLE (cont.)

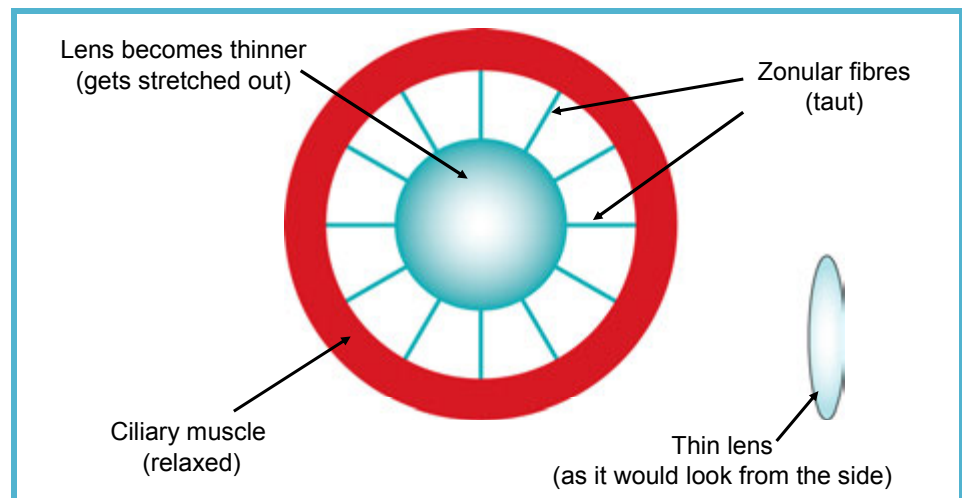


Figure 1.8: When the ciliary muscle relaxes it moves away from the lens. When this happens the zonules become taut and pull the lens outwards so that it is thinner

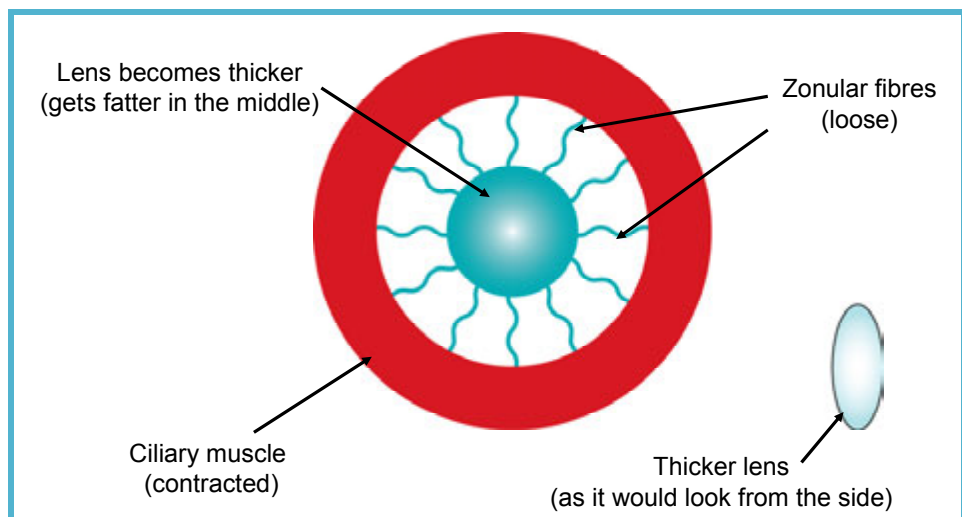


Figure 1.9: When the ciliary muscle contracts it gets closer to the lens. When this happens the zonules become looser and let the lens become thicker

As we get older, the lens slowly gets harder and less flexible and cannot change shape so easily. This means that we cannot change our focus so well. We can no longer hold things close to us and still see them well. This usually happens around the time we are 45 years old, and is called presbyopia.

Presbyopia can be corrected with reading spectacles. As the years go by the reading spectacles need to be made stronger because the lens gets harder and the presbyopia increases.

PARTS OF THE EYE (cont.)

VITREOUS BODY

The inside of the eye is filled with a transparent gel, or clear jelly. This is called the vitreous body, vitreous humour, or simply the vitreous. The vitreous is mainly water and accounts for about $\frac{2}{3}$ ^{rds} of the eye's volume.



The vitreous helps give the eyeball its shape.

FUNDUS

The fundus is a general term which refers to the inside of the eye that can be seen when looking through the pupil with a special instrument. The fundus includes the retina, the optic disc, and the blood vessels at the back of the eye. When we use a special instrument, such as an ophthalmoscope, to examine this part of the eye, we call it a fundus examination.

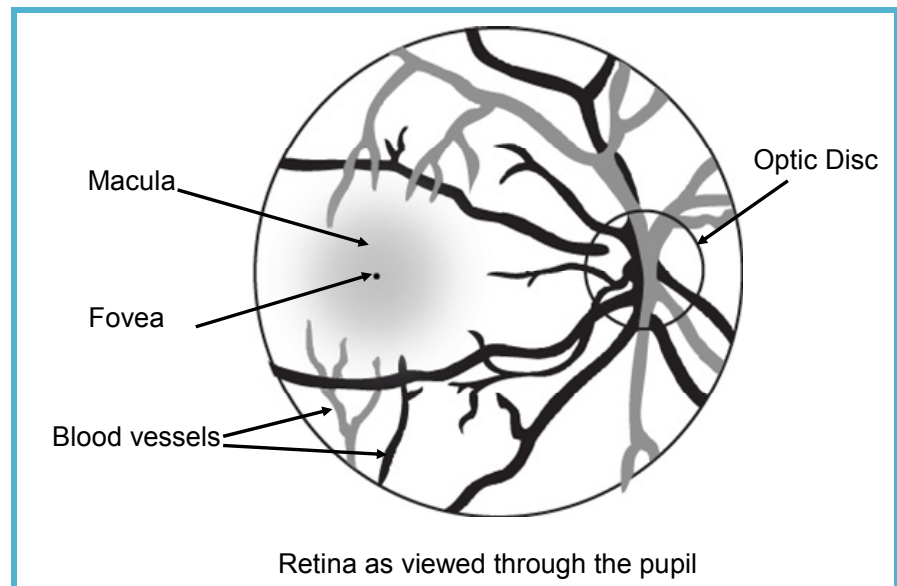


Figure 1.10: Diagram of the fundus when viewed with an ophthalmoscope

RETINA

The retina is the inside layer of the eyeball.

The retina is covered with millions of photoreceptor cells – almost like tiles on a bathroom floor. There are two different types of photoreceptor cells, namely rod cells and cone cells (or simply rods and cones). The rods are responsible for vision in dim light conditions. The cones are responsible for colour vision and good central vision.

When light rays enter the eye, they are received by the photoreceptor cells and changed into nerve messages. These nerve messages travel to the brain through the optic nerve.



The retina catches light that comes into the eye and changes it into nerve messages that are sent to the brain.

The centre of the retina is called the macula. It is a small and highly sensitive part of the retina that is responsible for clear central vision. The centre of the macula is called the fovea. The macula lets us see small details and do tasks that require good central vision like reading and sewing.

PARTS OF THE EYE (cont.)

OPTIC NERVE

The optic nerve can be thought of as a telephone wire that lets the eye talk to the brain – it tells the brain what it sees.



The optic nerve sends nerve messages from the retina to the brain.

When looking at the fundus through the pupil (using a special piece of equipment such as an ophthalmoscope), a part of the optic nerve can be seen. This part of the optic nerve is called the optic disc. The optic disc is sometimes also called the optic nerve head.

There is no retina over the optic disc, so this part of the back of the eye is not able to receive light, and is not able to send visual messages to the brain. This area is called the blind spot, and everyone has one in each eye.

The brain is very clever at disguising (hiding) the blind spot from us so most people never know that they have one.

EXTRAOCULAR MUSCLES

There are six muscles attached to the outside of each eye. These muscles are known as the extraocular muscles (EOMs) and are responsible for controlling eye movements.



The extraocular muscles move the eyeballs to point in different directions.

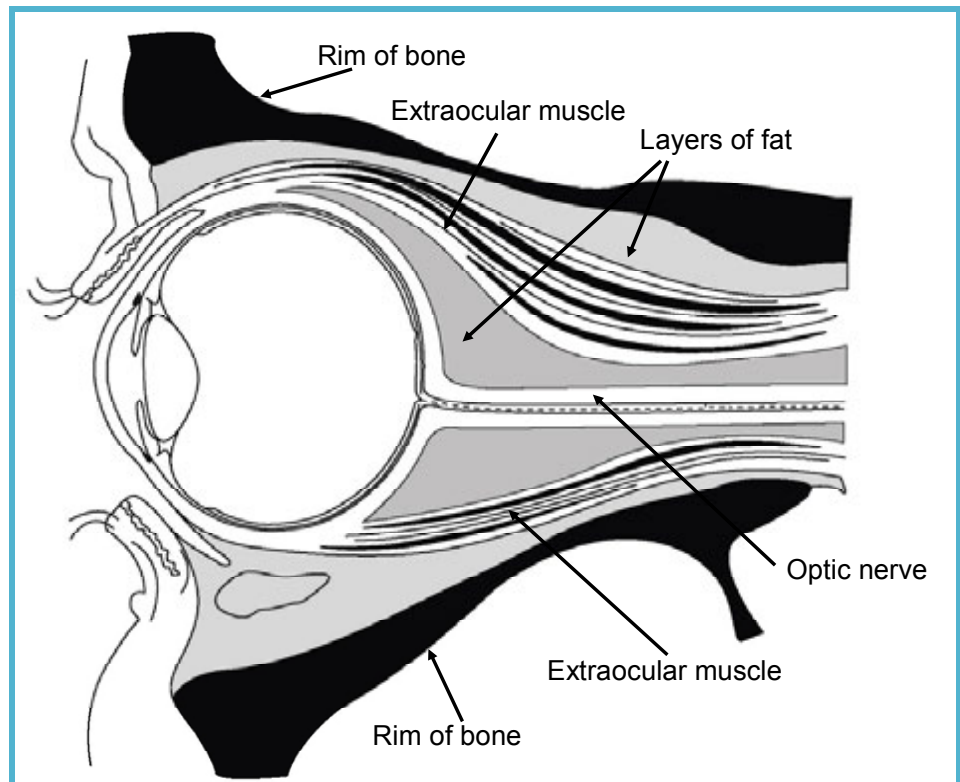


Figure 1.11: The orbit and the optic nerve

HOW DOES THE EYE SEE?

Being able to see depends on three things:

1. The tear film, cornea, aqueous humour, crystalline lens, and vitreous must be clear, so that light can reach the retina without being interrupted. These ocular structures all lie in a line along the visual axis of the eye.
2. The light from the image must be focused by the cornea and the crystalline lens so that it forms a clear image on the retina at the back of the eye.
3. The optic nerve must carry the information received by the retina to the brain, so that it can be translated into a meaningful visual image.

ANATOMICAL TERMS OF LOCATION

Directional Terms for the Eyes

A man comes to you complaining of a painful eye. When you examine him you discover that he has a piece of metal (a "foreign body") that has become stuck in his eye. You need to write a referral letter to a health professional so that he can have the metal foreign body removed. In order for you to describe the location of the foreign body when you write your letter, you need to know the appropriate "directional" terms to use:

Anterior:	In front of	<i>Example:</i> The cornea is anterior to the iris.
Posterior:	Behind	<i>Example:</i> The retina is posterior to the crystalline lens.
Superior:	Above	<i>Example:</i> The eyebrow is superior to the eye.
Inferior:	Below	<i>Example:</i> The mouth is inferior to the eye.
Nasal:	Closer to the nose; further away from the ear.	
Temporal:	Further away from the nose; closer to the ear.	

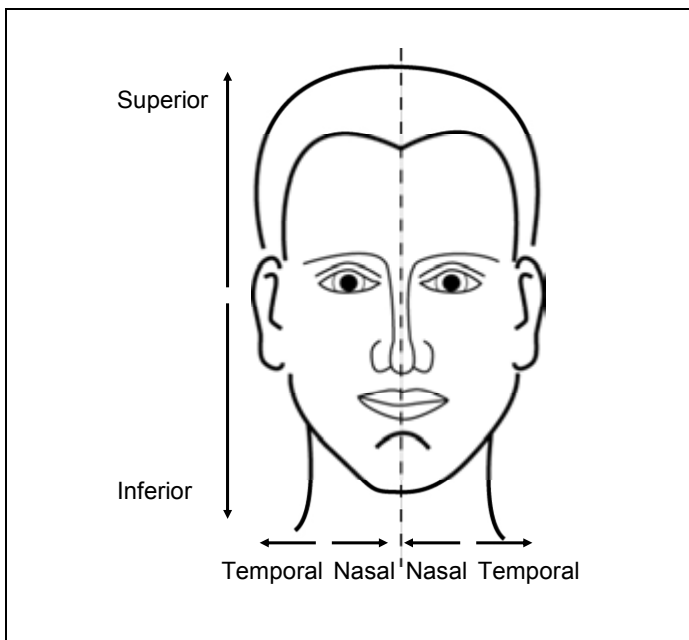


Figure 1.12: Front view of the head

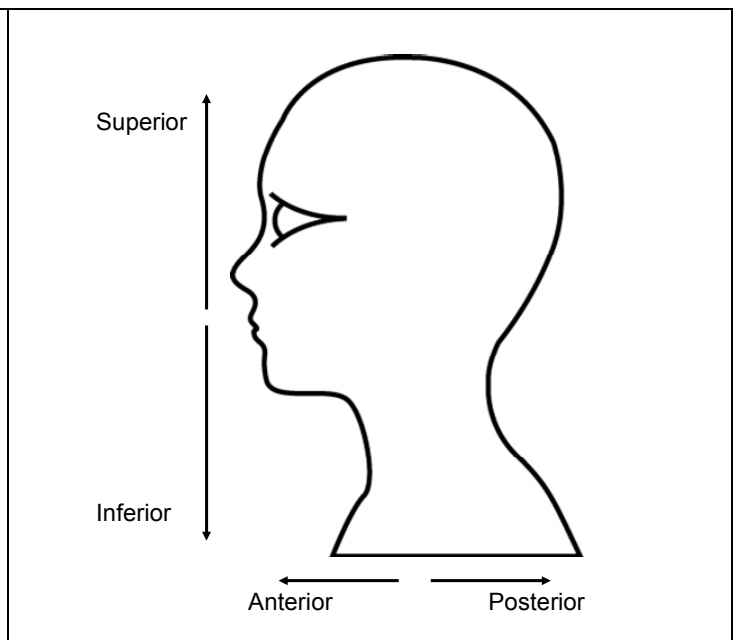


Figure 1.13: Side view of the head

SUMMARY: PARTS OF THE EYE

ORBIT

- The bony socket in the skull that holds and protects the eye.

TEAR FILM

- Provides nutrients to and protects the cornea, and keeps the eye wet.

SCLERA

- Strong white covering of the eyeball.
- Protects the eye and gives it its shape.

CORNEA

- Like the window of the eye.
- Transparent, so that it can let light into the eyeball to allow us to see.
- Helps to focus light that enters the eye.
- Contains many nerve endings, so is very sensitive to pain.

LIMBUS

- The limbus is where the cornea and the conjunctiva meet.

CONJUNCTIVA

- A very thin layer that is clear except for a few small blood vessels.
- The bulbar conjunctiva covers the anterior sclera, but not the cornea.
→ The white sclera can be seen underneath the bulbar conjunctiva.
- The palpebral conjunctiva covers the inside of the top and bottom eyelids.
→ The pink eyelid can be seen underneath the palpebral conjunctiva.
- The conjunctiva can look red if there is an eye problem.

EYELIDS

- Protect the eyes from the environment.
- Spread tears when blinking to keep the eye wet.

EYEBROWS

- Protect the eye from foreign bodies and perspiration.

LACRIMAL PUNCTA

- Drain tears from the eye.

SUMMARY – PARTS OF THE EYE (cont.)

IRIS AND PUNCTA

- The round coloured part of the eye is called the iris.
→ The iris is shaped like a compact disc – round and flat with a hole in the middle.
- The black, round hole in the middle of the iris is called the pupil.
→ The muscles in the iris change the pupil's size to let the right amount of light into the eye.

AQUEOUS

- Watery liquid in the anterior chamber.
- Provides nutrients to the cornea and the lens.

LENS

- Transparent in a normal eye.
- Suspended behind the pupil.
- Changes in the lens' shape change the eye's focus from distance to near.

CILIARY MUSCLE

- Changes the focusing ability of the eye by changing the shape of the lens.

VITREOUS BODY

- Transparent gel between the lens and the retina.
- Helps give shape to the eyeball.

FUNDUS

- The fundus is the inside of the eye that can be seen when looking through the pupil with a special instrument (such as an ophthalmoscope).
- It includes the retina, optic disc and blood vessels.

RETINA

- Catches the light that comes into the eye and changes it into nerve messages that are sent to the brain.
- The central portion of the retina is the macula.

OPTIC NERVE

- Sends messages to the brain.
- The visible part of the optic nerve (when looking through the pupil) is called the optic disc.

EXTRAOCULAR MUSCLES (EOMs)

- Six muscles are attached to each eye.
- EOMs move the eyeballs in various directions.

SUMMARY – PARTS OF THE EYE (cont.)

THREE KEY REQUIREMENTS FOR GOOD VISION

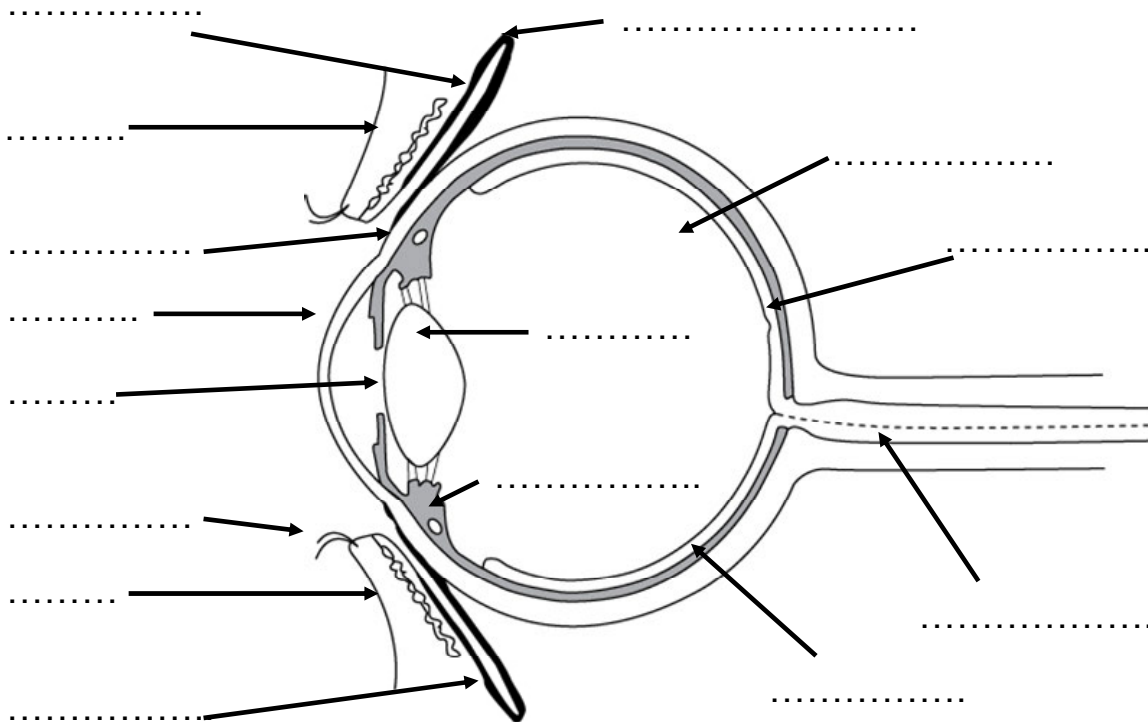
- The cornea, lens and vitreous must be transparent.
- Light is focused by the cornea and the crystalline lens to form a clear image on the retina.
- The optic nerve sends information received by the retina to the brain.

ANATOMICAL TERMS OF LOCATION

- **Anterior** = In front of
- **Posterior** = Behind
- **Superior** = Above
- **Inferior** = Below
- **Nasal** = Closer to the nose; further away from the ear
- **Temporal** = Further away from the nose; closer to the ear.

TEST YOURSELF QUESTIONS

1. Name parts of the eye in this diagram.



2. Complete this table.

PARTS OF THE EYE	WHAT THEY DO
Eyelids and lashes	
Conjunctiva	
Sclera	
Cornea	
Pupil	
Iris	
Lens	
Retina	
Optic nerve	
Punctum	
Vitreous	

NOTES



OPTICS

THINK

Have you ever looked through a magnifying glass? Have you ever seen a mirror that makes things look smaller than they really are? Have you ever seen a crystal make a rainbow of light on a wall?

All of these things use optics to change light and make you see images differently.

AIM

This unit will introduce you to the study of optics. You will learn how light travels and how some surfaces reflect light while others allow light to pass through.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- explain how light travels
- explain how light rays can be reflected, refracted or absorbed
- describe different optical media and how their refractive indices affect light
- discuss how a prism bends light
- describe how a lens focuses light
- explain what happens to light rays that travel through the optical centre of a lens
- define what a plano lens is.

LIGHT

We are able to see when the eyes receive light from an object, and the brain interprets the light messages that are received by the eyes. Light contains a lot of information about the object it comes from including its colour, its shape and its movement. The brain interprets this information, which helps us to identify the object.

To see clearly, the eyes must receive light and correctly focus it on the retina at the back of the eye. If an eye does not focus light correctly, spectacles may be required to give clear vision.

BEHAVIOUR OF LIGHT

Light travels from an object into our eyes by moving in straight lines. These lines are called light rays.

Light rays can be drawn on diagrams, so that we can predict the path that the light will take. These diagrams are called ray diagrams. Light rays on ray diagrams are drawn as straight lines with arrowheads which point in the direction that the light is travelling.

Light rays can travel in different directions or in the same direction. Types of light rays include:

- parallel light rays
- convergent light rays
- divergent light rays.

PARALLEL LIGHT RAYS

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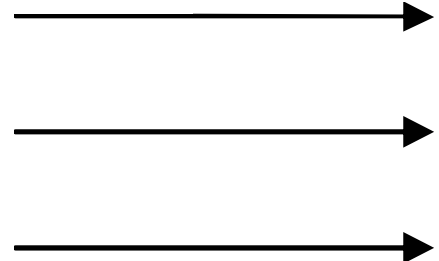


Figure 2.1: Parallel light rays



Parallel light rays come from all objects that are distant (far away). In optics, all objects that are 6 metres (m) or more away are considered distant. This means that parallel light rays come from all objects that are 6 m away or further.

BEHAVIOUR OF LIGHT (cont.)

CONVERGENT LIGHT RAYS

These light rays travel towards each other. Convergent light rays will meet at a focal point.

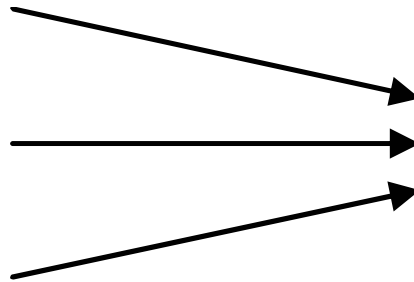


Figure 2.2: Convergent light rays and

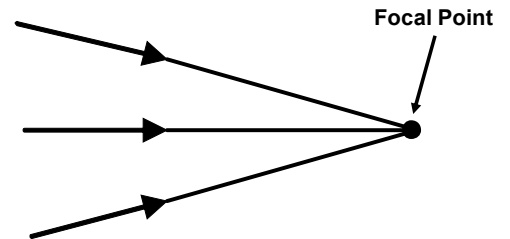


Figure 2.3: Convergent light rays converge to a focal point

DIVERGENT LIGHT RAYS

These light rays travel away from each other. Divergent light rays come from an object closer than 6 m from the eye.

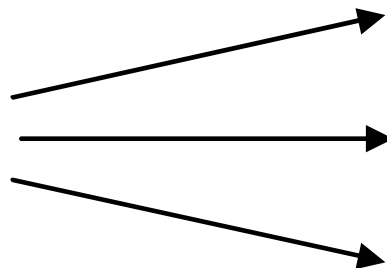


Figure 2.4: Divergent light rays and

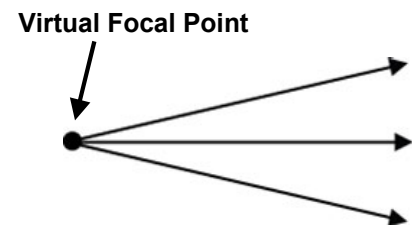


Figure 2.5: Divergent light rays diverge from an object closer than 6 m away

Light rays will travel in straight lines until they reach an object. When they reach an object they can be:

- reflected by the object - this is called **reflection** of light; or
- refracted by (travel through) the object – this is called **refraction** of light; or
- absorbed by the object.



Reflection and refraction can change the direction that light rays are travelling in.

Light rays will stop if an object absorbs them. If an object absorbs all light rays, it will appear black in colour.

BEHAVIOUR OF LIGHT (cont.)

OPTICAL MEDIUM	Light rays can travel through any transparent (clear) material. A transparent material that lets light travel through it is called an optical medium (or simply a medium). An optical medium can be a: • gas (like air) • liquid (like water) • solid (like glass or clear plastic).
REFRACTIVE INDEX	Every optical medium has a specific refractive index. The refractive index tells us how much faster light travels through air than it does through the medium. So, it is a comparison of the speed of light in air to the speed of light in the medium. Light travels faster in a medium that has a low refractive index (like air), and slower in a medium that has a high refractive index (like glass). <i>Example:</i> Air has a refractive index of 1 and glass has a refractive index of 1.5. This means that light travels 1.5 times faster in air than it does in glass.

REFLECTION

A light ray will bounce off a surface (like a ball that bounces off the ground) when it reaches a smooth reflecting surface, such as a mirror. This is called reflection of light.

When an incoming light ray (also called an incident light ray) hits a reflecting surface, it is reflected. This means it then travels away from that surface as a reflected light ray.

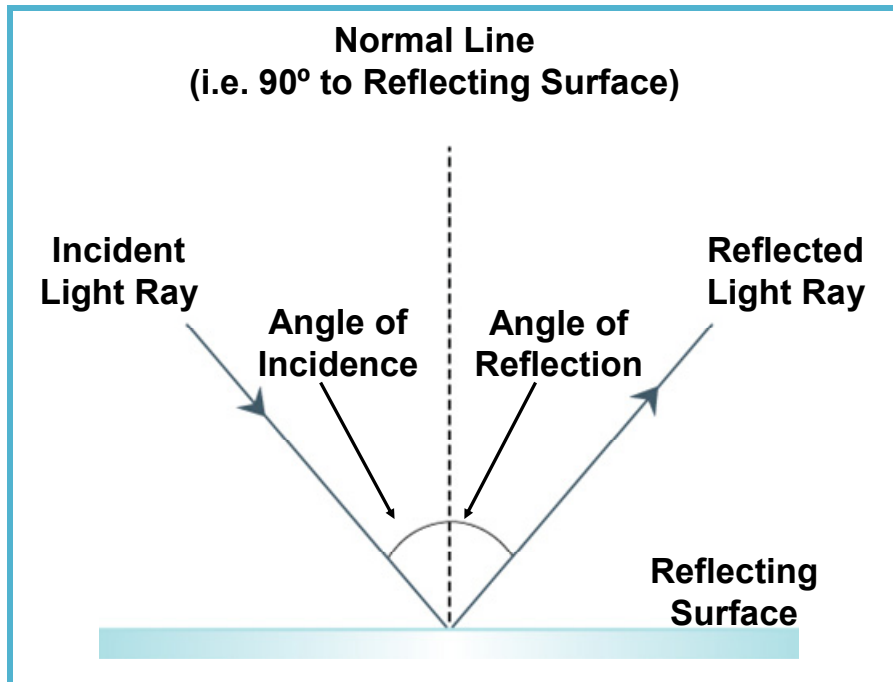


Figure 2.6: Reflection

At the point where the light ray hits the reflecting surface, we can draw a dotted line perpendicular (at an angle of 90°) to the reflecting surface. This dotted line is called the normal line (or simply, the normal).

The angle between the incident ray and the normal is called the *angle of incidence*.
The angle between the reflected ray and the normal is called the *angle of reflection*.



Law of reflection:
Angle of incidence = angle of reflection

REFRACTION

Sometimes, instead of light being absorbed or reflected from a surface, the light will continue to travel into the new medium. An incident light ray will hit a refracting surface and then travel through that surface as a refracted ray. The refracted ray changes direction when it travels through the new medium.

At the point where the light ray hits the refracting surface, we can draw a dotted line perpendicular (at an angle of 90°) to the refracting surface. This is the normal line (or normal). The angle between the normal line and the incident light ray is called the angle of incidence (i). The angle between the refracted ray and the normal is called the angle of refraction (i').

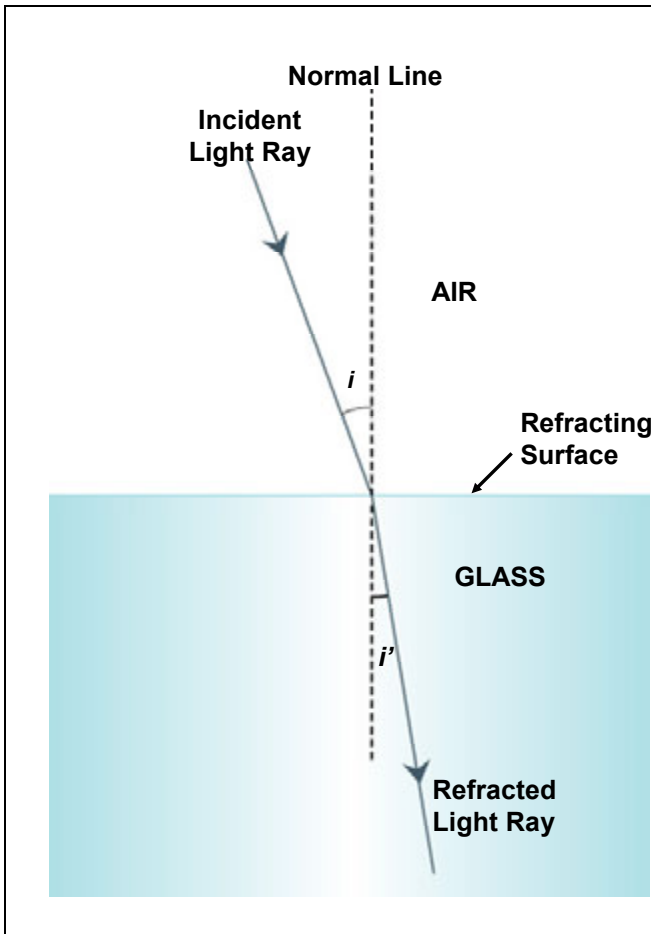


Figure 2.7: Refraction

When a light ray travels from one medium into another medium (such as from air into glass), the direction that the light ray is travelling in will change – the path of the light ray will be bent. This is called refraction of light.

Exception:
If the light ray enters a new medium perpendicularly (along the same line as the normal), the light ray will pass into the new medium without changing direction.

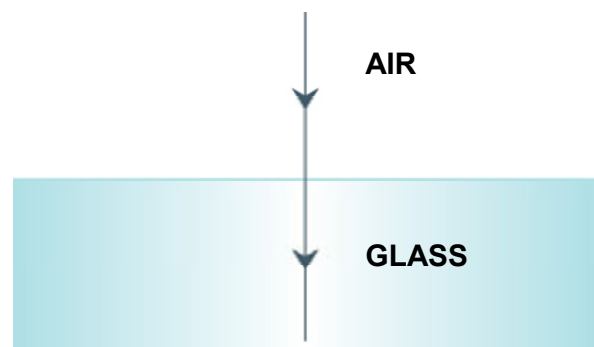


Figure 2.8: A light ray that travels along the same line as the normal will not change direction

The amount of light refraction (the amount that a light ray is bent) depends on the refractive index of the medium that the light ray is coming from and the refractive index of the medium that it is entering.



A light ray will be refracted *more* if there is a greater difference between the refractive index of the original medium and the refractive index of the new medium.

A light ray will be refracted *less* if there is a smaller difference between the refractive index of the original medium and the refractive index of the new medium.

REFRACTION (cont.)

When a light ray travels from a medium with a lower refractive index into a medium with a higher refractive index, the light ray is bent towards the normal.

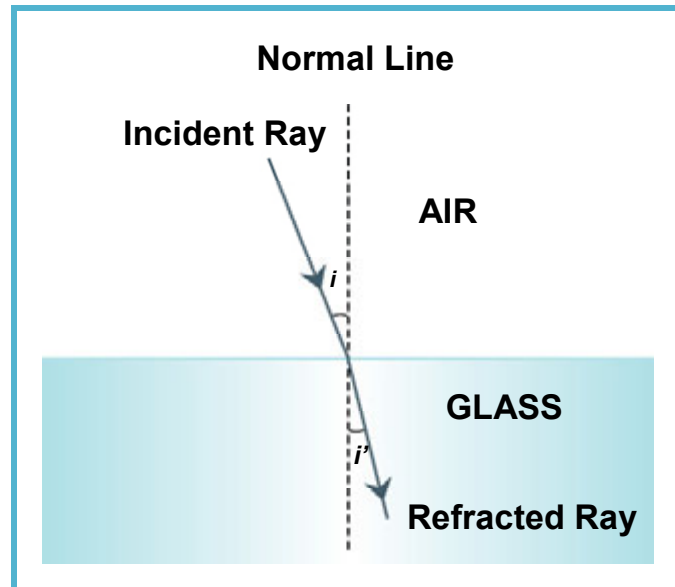


Figure 2.9: Light travelling from a medium with lower refractive index to a medium with higher refractive index

When a light ray travels from a medium with a higher refractive index into a medium with a lower refractive index, the light ray is bent away from the normal.

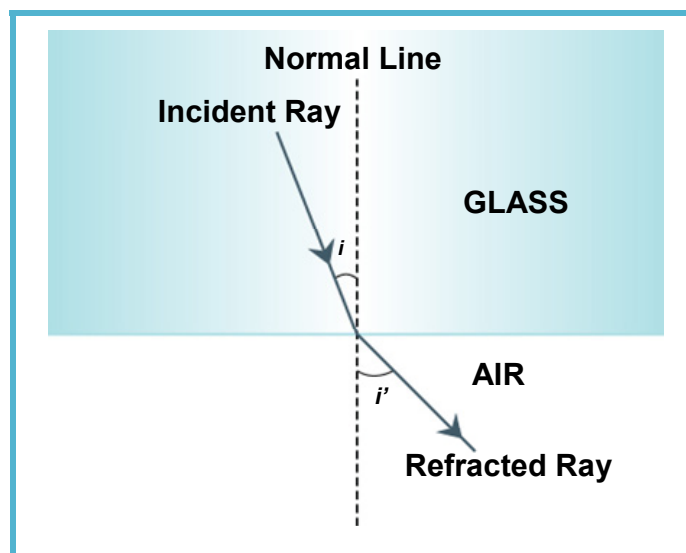


Figure 2.10: Light travelling from a medium with higher refractive index to a medium with lower refractive index



- If a light ray travels into a medium with a **higher refractive index**: the angle of refraction (i') **is smaller than the** angle of incidence (i).
- If a light ray travels into a medium with a **lower refractive index**: the angle of refraction (i') **is greater than the** angle of incidence (i).

PRISMS

Prisms bend light. An optical prism is made of transparent material (like glass or plastic) that has a higher refractive index than air.

A prism is shaped like a triangle. One side of this triangle is the base of the prism, and the corner opposite the base is called the apex. The angle of the apex is called the apical angle and its size will affect how much the prism will bend light.

At the point where the light ray hits the refracting surface, we can draw a dotted line perpendicular (at an angle of 90°) to the refracting surface. This is the normal line (or normal). When a light ray travels through the new medium, in this case a prism, it will change the angle between the normal line and the refracted ray.

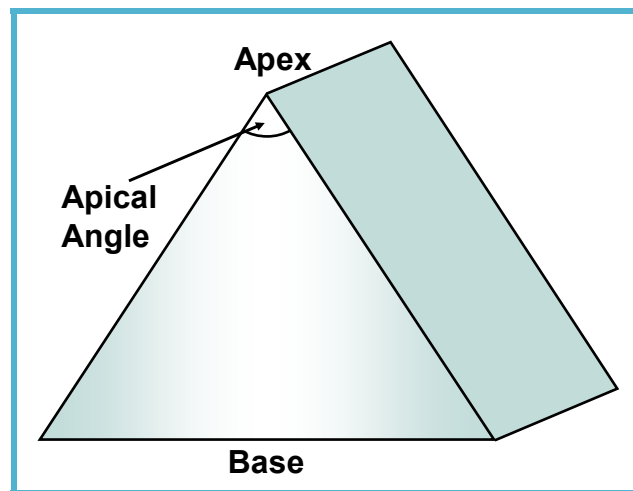


Figure 2.11: An optical prism



REMEMBER:

- If a light ray travels into a medium with a **higher refractive index**: the angle of refraction is **smaller** than the angle of incidence.
- If a light ray travels into a medium with a **lower refractive index**: the angle of refraction is **greater** than the angle of incidence.

PRISMS (cont.)

REFRACTIVE INDEX AND PRISMS

A glass or plastic prism has a higher refractive index than air (and air has a lower refractive index than glass or plastic). When an incident light ray enters a prism, the light ray will be bent towards the normal inside the prism and away from the normal when it leaves the prism.

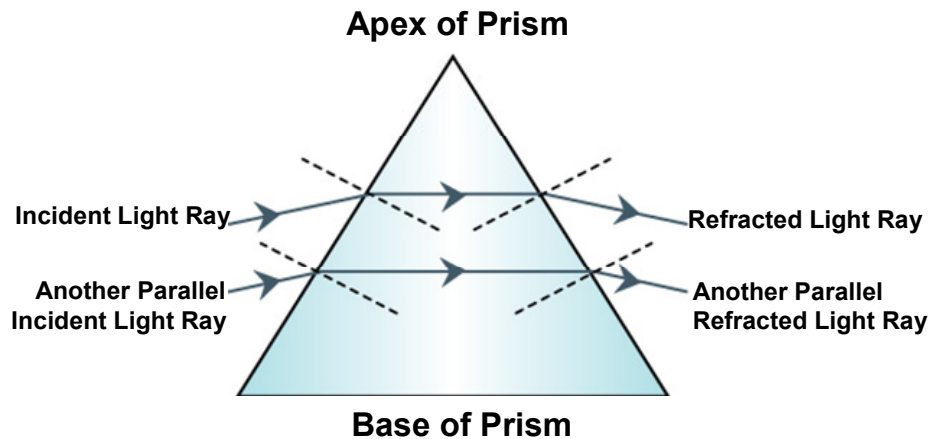


Figure 2.12: A prism will bend all light rays by the same amount, no matter where the light ray enters the prism. All parallel light rays that enter a prism will exit the prism travelling in the same new direction



Light entering a prism will always bend away from the apex of the prism.

APPARENT DEVIATION

A prism does **not** focus light. If parallel light goes in to the prism, then parallel light will come out the other side.

When we look at an object through a prism, the object will look like it is closer to the apex of the prism than it really is. This is called the apparent deviation of the object.

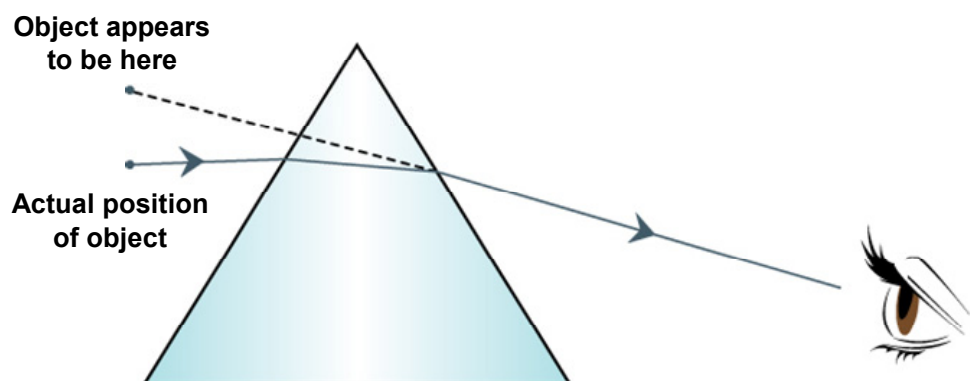


Figure 2.13: Apparent deviation: Light from an object bends towards the base of a prism, but the object appears to move towards the apex

LENSES

An optical lens (or simply a lens) is a piece of transparent material that is shaped so that it refracts light rays to focus at a certain point – called the focal point. While prisms just bend light, lenses focus light. Lenses are used for spectacles, magnifying glasses, microscopes and slide projectors.

A slide projector has lenses that can focus an image onto a screen. Spectacle lenses can change the focus of the eyes, so that sight becomes clearer.



If an eye has a refractive error (like hyperopia, myopia, astigmatism or presbyopia), a spectacle lens can be used to correctly focus the light coming into the eye so that the vision becomes clear.

All lenses have two surfaces: a front surface and a back surface. A lens must have at least one curved surface so that it can focus light.

Lenses are usually made of glass or plastic, and they come in many shapes. The most common lens shapes are:

- **Spherical:** plus and minus lenses
- **Astigmatic:** cylindrical and sphero-cylindrical lenses.

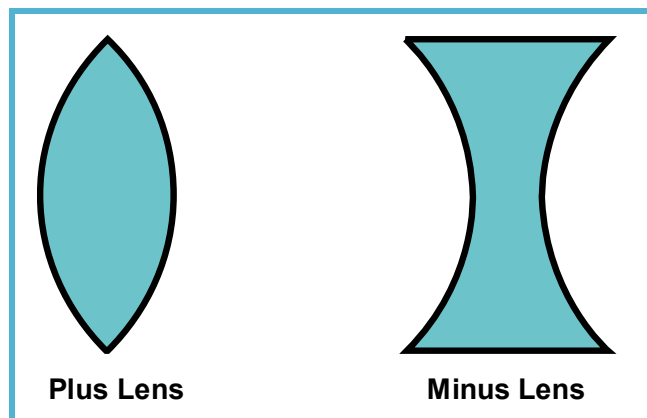


Figure 2.14: Plus and minus lenses

A plus lens has a focal point where all of the refracted light rays converge and meet. A minus lens makes light rays diverge as though the light rays are coming from one point.

A lens will bend light rays by different amounts depending on the refractive index of the lens material, and where on the lens surface the incident light ray enters.

Although prisms can only bend light and cannot focus light, a lens can be thought of as prisms that are joined together.



A plus lens can be thought of as two prisms that are joined base to base.
A minus lens can be thought of as two prisms that are joined apex to apex.

LENSES (cont.)

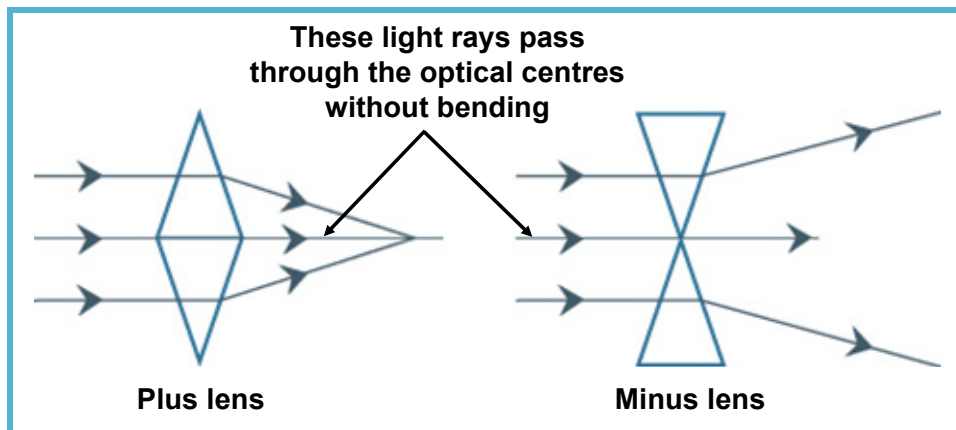


Figure 2.15: Lenses can be thought of as prisms that are joined together

This basic description of a lens helps us to understand how plus and minus lenses bend light – but it is not perfectly accurate. We can see the problem with this explanation if we add some more light rays to the diagram, as seen below. Here we can see that two prisms by themselves cannot focus light to a single point, they can only bend light.

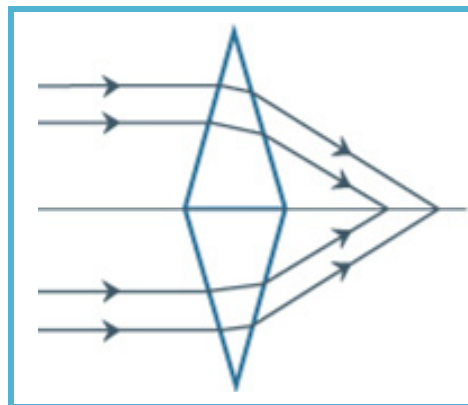


Figure 2.16: Light rays passing through two prisms

A lens is really like a large number of prisms that get stronger towards the edge. We can see from Diagram A below how this might work if we add just two extra prisms to the figure above. If we add more and more light rays you would need more and more prisms to bend the light to one focus (see Diagram B below).

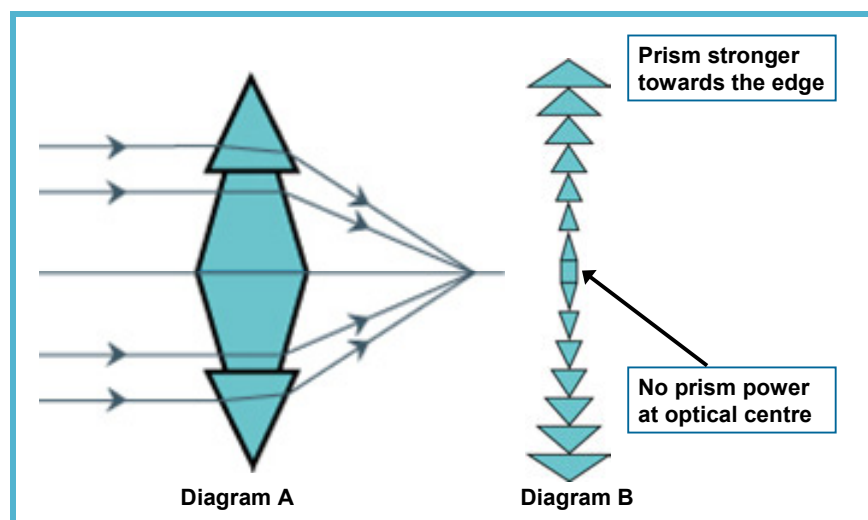


Figure 2.17: A lens is like a large number of prisms getting gradually stronger towards the edge of the lens

LENSES (cont.)

Another way of bending the light to focus at one point is to make at least one of the lens surfaces curved. This is just like a much larger number of prisms getting gradually stronger towards the edge of the lens. Most spectacle lenses have both surfaces curved.

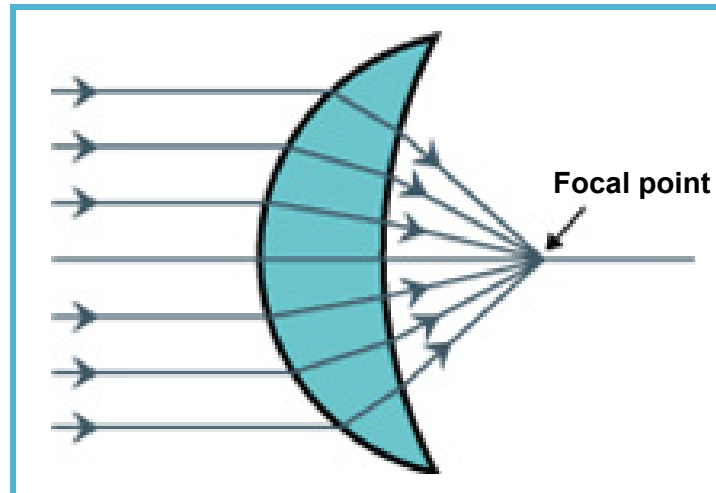


Figure 2.18: A spectacle lens has two surfaces curved. A curved surface lets the lens focus light

Notice that the light ray that travels through at the place where the two prisms join is not bent at all. This point is called the optical centre of the lens.

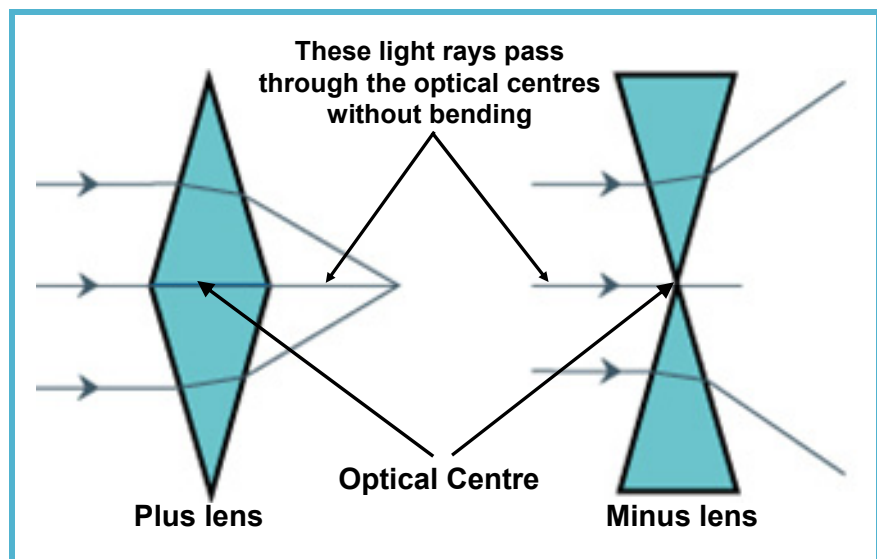


Figure 2.19: Optical centres of a plus and minus lens

The optical centre is the only part of a lens that a light ray can travel through without being refracted. It is the optical centre of a lens that we line up with a person's eyes when making spectacles.

The optical centre for a plus lens is the point where the lens is thickest. The optical centre for a minus lens is the point where the lens is thinnest.

OPTICAL CENTRE

LENSES (cont.)

PLANO LENSES

A lens that is neither plus nor minus is called a plano (or non-prescription) lens.

A plano lens has no focusing power – it cannot bend or refract light. Light will travel through a plano lens without being bent or focused, like light that travels through a glass window.

A plano lens can have two flat surfaces or two (equal and opposite) curved surfaces.

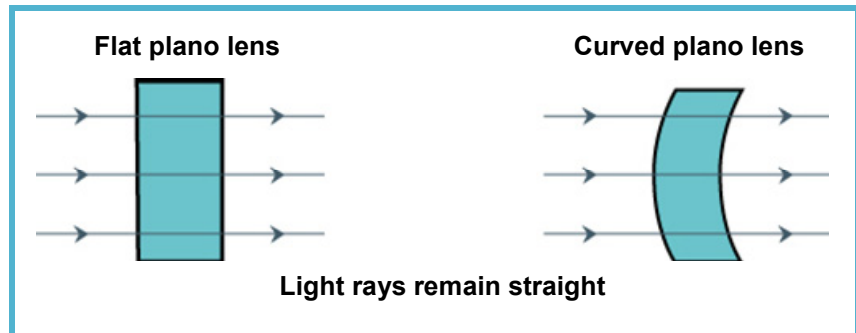


Figure 2.20: Plano lenses can be flat or curved.
Light rays that pass through a plano lens do not bend

SUMMARY: OPTICS

LIGHT AND SEEING

- Seeing is a result of the eyes receiving light from an object and the brain interpreting these light messages.
- To see clearly, the eyes must receive the light and correctly focus the light on the retina at the back of the eye.

BEHAVIOUR OF LIGHT

- Light travels in straight lines.
- Light rays can be parallel, convergent, divergent, or scattered.
- Parallel light rays come from distant objects (6 m or further away).
- Light can be reflected, refracted or absorbed when it reaches an object.

OPTICAL MEDIUM

- An optical medium will let light travel through it.
- An optical medium can be gas, liquid or solid.

REFRACTIVE INDEX

- Every optical medium has a specific refractive index.
- Light travels faster in media that have a low refractive index, and slower in media that have a high refractive index.

REFLECTION AND REFRACTION

- Reflection occurs when light bounces off an object.
- Refraction describes the change in direction of a light ray as it passes from one medium to another.
- The incident ray is the light ray that travels towards a surface. If it is not absorbed, it will become a reflected ray or a refracted ray once it touches the surface.

PRISMS

- A prism is a piece of glass or plastic in the shape of a triangle.
- A prism has a base and an apex
→ A prism bends light away from its apex.
- An object viewed through a prism looks like it is closer to the apex of the prism than it really is → this is called apparent deviation.

LENSES

- Light rays that enter lenses can be bent or refracted.
- Spherical lenses can be plus or minus lenses.
- Plus lenses converge light rays, while minus lenses diverge them.
- Astigmatic lenses can be cylindrical or sphero-cylindrical lenses.
- A lens can be thought of as a large number of prisms that get stronger towards the edge of the lens
→ A plus lens is like prisms joined base to base
→ A minus lens is like prisms joined apex to apex.

OPTICAL CENTRE

- A light ray will not be refracted or bent if it travels through the optical centre of a lens.

PLANO LENSES

- A plano lens has zero focusing power.
- Light rays will pass through a plano lens without bending or focusing.

SUMMARY: OPTICS (cont.)

AQUEOUS

- Watery liquid in the anterior chamber.
- Provides nutrients to the cornea and the lens.

LENS

- Transparent in a normal eye.
- Suspended behind the pupil.
- Changes in the lens' shape change the eye's focus from distance to near.

CILIARY MUSCLE

- Changes the focusing ability of the eye by changing the shape of the lens.

VITREOUS BODY

- Transparent gel between the lens and the retina.
- Helps give shape to the eyeball.

FUNDUS

- The fundus is the inside of the eye that can be seen when looking through the pupil with a special instrument (such as an ophthalmoscope).
- It includes the retina, optic disc and blood vessels.

RETINA

- Catches the light that comes into the eye and changes it into nerve messages that are sent to the brain.
- The central portion of the retina is the macula.

OPTIC NERVE

- Sends messages to the brain.
- The visible part of the optic nerve (when looking through the pupil) is called the optic disc.

EXTRAOCULAR MUSCLES (OEMs)

- Six muscles are attached to each eye.
- OEMs move the eyeballs in various directions.

THREE KEY REQUIREMENTS FOR GOOD VISION

- The cornea, lens and vitreous must be transparent.
- Light is focused by the cornea and the crystalline lens to form a clear image on the retina.
- The optic nerve sends information received by the retina to the brain.

ANATOMICAL TERMS OF LOCATION

- **Anterior** = In front of
- **Posterior** = Behind
- **Superior** = Above
- **Inferior** = Below
- **Nasal** = Closer to the nose; further away from the ear
- **Temporal** = Further away from the nose; closer to the ear.

TEST YOURSELF QUESTIONS

1. Name the three different types of light rays (in terms of their direction of travel).

2. Name the only two ways in which light rays can change direction.

3. What do we call a light ray travelling towards a surface?

4. What is refractive index a measure of?

5. What is a prism? In what direction is light bent as it passes through a prism?

6. When a light ray travels from a medium of a lower refractive index into a medium of a higher refractive index, is it bent *away from* or *towards* the normal?

7. When a light ray travels from a medium of a higher refractive index into a medium of a lower refractive index, is it bent *away from* or *towards* the normal?

8. Will a light ray be refracted more if there is a *greater* difference between the refractive index of the original medium and the refractive index of the new medium, or if there is a *smaller* difference?



EYE OPTICS AND ACCOMMODATION

THINK

A mother of four children comes to see you. She tells you that she has always made her children's clothes herself, but recently she has been getting headaches whenever she sews.

What do you think might be causing her headaches?

AIM

This unit introduces you to how light focuses in the eye, and what happens when the eye fails to focus light correctly.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- identify and name the parts of the eye's optical system
- describe how these parts work together to focus light and form a visual image
- define refractive error and list the different types of refractive errors
- explain how the eye can change its focus from distant objects to close objects
- explain why the ability to accommodate decreases as people get older
- recognise the symptoms of asthenopia.

REVIEW: EYE OPTICS AND ACCOMMODATION

HOW DOES THE EYE SEE?	Being able to see depends on three things: 1. The tear film, cornea, aqueous humour, crystalline lens, and vitreous must be clear so that the light can reach the retina without being interrupted. 2. The cornea and the crystalline lens must focus the light from the image, so that it forms a clear image on the retina at the back of the eye. 3. The optic nerve must carry the information received by the retina to the brain so that it can be translated into a meaningful visual image.
TEAR FILM	The tear film is the watery layer at the front of the eye.
CORNEA	The cornea is located at the front of the eyeball. The cornea is transparent (clear), like glass. The cornea can be thought of as the window of the eye. The cornea also helps to focus light that enters the eye.
THE LENS	The crystalline lens is located behind the iris and the pupil. The lens is normally transparent, like clear glass, and cannot usually be seen without special instruments. The lens is suspended behind the pupil by zonular fibres, or simply zonules. The zonules connect the ciliary muscle and the lens to each other. When the ciliary muscle contracts or relaxes, the zonules change the shape of the lens, which changes the focusing power of the lens. The purpose of the lens is to change the focus of the eye so that we can see things that are close to us. When we are young the lens is soft and flexible and we can focus on objects that are very close to the eye. This is called accommodation.
THE CILIARY MUSCLE	The ciliary muscle works to change the shape of the crystalline lens and change the focus of the eye. This is called accommodation. When the ciliary muscle contracts, the zonules (that connect the ciliary body to the lens) loosen and the lens becomes thicker – this increases the focusing power of the lens. When this happens we say that the eye is accommodating. When the ciliary muscle relaxes, the zonules become taut (stretched tightly) and the lens becomes thinner – this decreases the focusing power of the lens. As we get older, the lens slowly gets harder and less flexible and cannot change the focus so well. We can no longer hold things so close and still see them well. This is called presbyopia and can be corrected with reading spectacles. As the years go by the reading spectacles need to be made stronger because the lens gets harder.

LOOKING AT EYES

Light rays from an object enter the eye through the tear film and the cornea. They travel through the anterior chamber and the pupil. The light rays then pass through the crystalline lens and the vitreous before arriving at the retina.

Along the way, the light rays are converged (bent towards each other) – first by the cornea, and then by the crystalline lens. The bending or converging of the light allows the light to be focused. If the light is focused on the retina, a clear image will be formed.

At the retina, the light is changed into electrical signals which are sent to the brain via the optic nerve. These electrical signals are interpreted by the brain as a visual image.

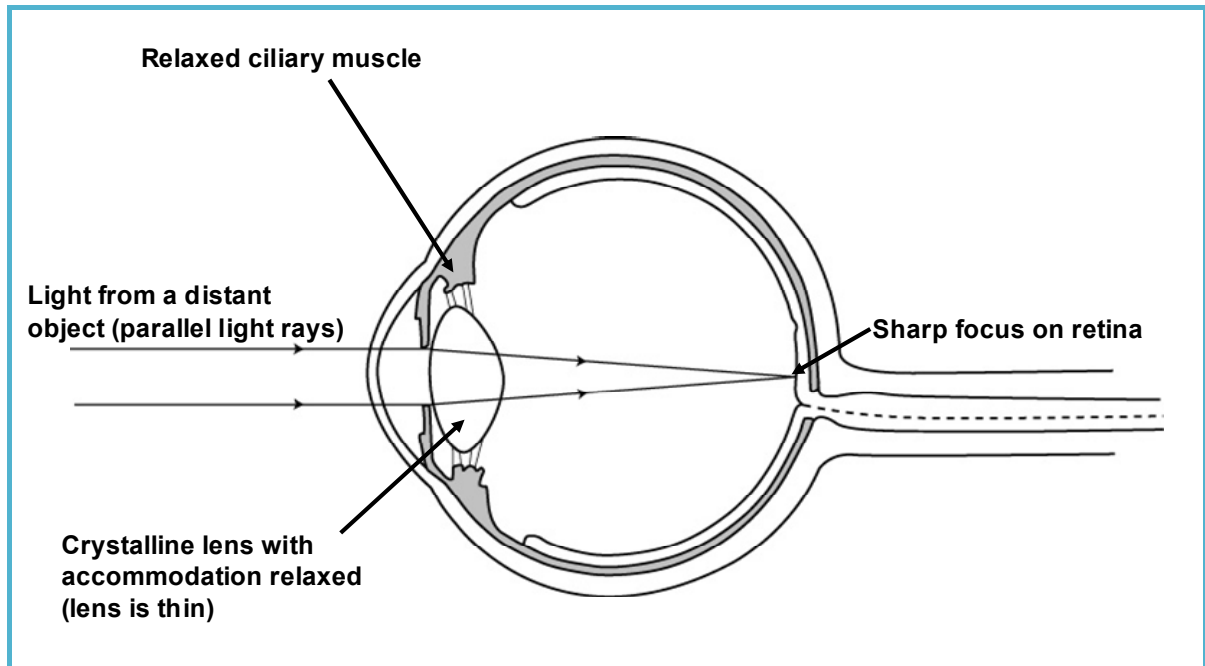


Figure 3.1: Light from a distant object focusing on the retina

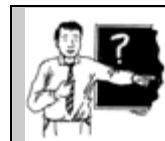
FOCUSING LIGHT IN THE EYE

It is important to know that light rays coming from a distant object are parallel (Figure 3.1). A distant object is usually considered to be any object that is further than 6 metres (m) away.

Light rays coming from a close object are divergent (they bend away from each other). The closer the object is to the eye, the more divergent the light rays become.

For light rays to focus exactly on the retina, the eye must have the following:

- The cornea and the lens must bend (or converge) the light by the correct amount.
- The eyeball must be of the correct length (the distance between the cornea and the retina).



The eye must be of the correct size and shape to have clear, comfortable vision.

LOOKING AT EYES (cont.)

FOCUSING STRUCTURES OF THE EYE

The cornea and the lens work together to refract incoming light rays so that the light rays converge and focus on the retina.

- The cornea provides $\frac{2}{3}$ ^{rds} of the eye's total focusing power.
 - It is the curved shape and thickness of the cornea that provides its focusing power.
 - The shape and thickness of the cornea cannot change, so the focusing power of the cornea does not change.
- The lens provides $\frac{1}{3}$ rd of the eye's total focusing power.
 - The curved shape and thickness of the lens provide its focusing power.
 - The lens can change its shape to become thicker (provide more focusing power) when the ciliary muscle contracts, so the focusing power of the lens can change.



The cornea provides $\frac{2}{3}$ ^{rds} of the eye's focusing power.

The lens provides $\frac{1}{3}$ rd of the eye's focusing power, but it can also fine-tune (make small adjustments to) the eye's total focusing power by changing its shape.

WHAT IS REFRACTIVE ERROR?

REFRACTIVE ERROR

A person who has a refractive error will need to wear spectacles (glasses) or contact lenses so that they can see clearly and comfortably. This is because their eye is not the correct size and shape and light does not focus correctly on their retina.



A person with a refractive error will have eyes that look normal, but they will not see well.

The amount of refractive error that an eye has depends on:

- the steepness/flatness of the cornea; and/or
- the thickness/thinness of the crystalline lens; and/or
- the length of the eyeball.

A person may have a combination of any of these three things which make the eye the wrong size or shape, and will stop light from focusing perfectly on the retina (Figure 3.2). If light from a distant or a near object does not focus properly on the retina, the person will have a problem seeing because they have a refractive error.

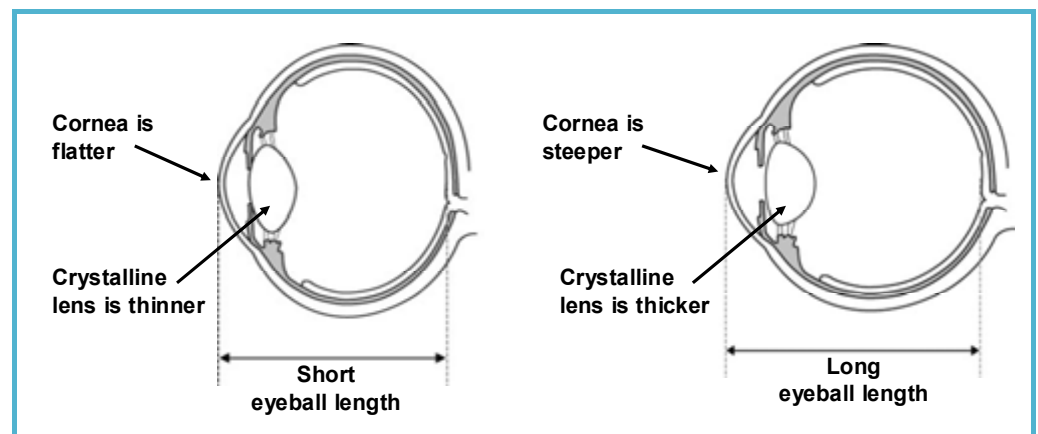
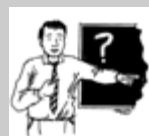


Figure 3.2: Possible differences in eyeball length, shape of the cornea, and shape of the lens.



When an eye does not have the correct size or shape, we say that the eye has a refractive error.

The amount of refractive error that an eye has depends on the size and shape of the cornea, the lens and/or the whole eyeball.

When an eye has the correct size and shape to focus light on the retina, we say that the eye is emmetropic.

WHAT IS REFRACTIVE ERROR? (cont.)

REFRACTIVE ERROR (cont.)

Depending on which part of the eye is the wrong size and/or shape, refractive error can be divided into four main types:

- **HYPEROPIA**

(also known as *longsightedness*, *farsightedness* or *hypermetropia*)

People with hyperopia (sometimes called “hyperopes”) can sometimes see far away, but might have difficulty with near vision. As hyperopes get older, even their distance vision could be affected.

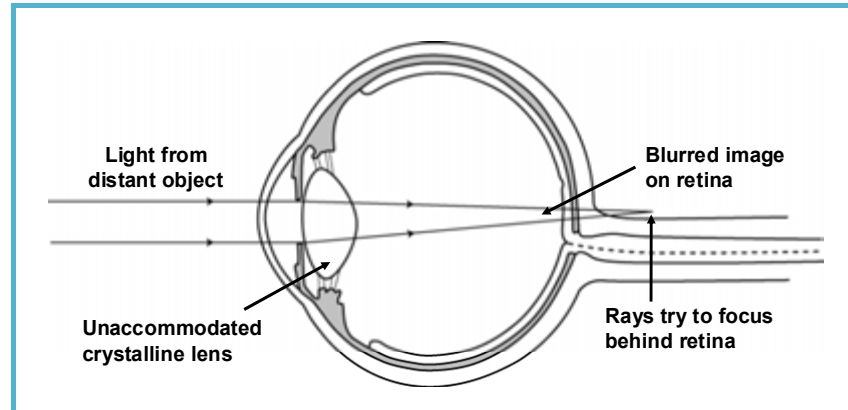


Figure 3.3: A hyperopic eye – light rays from a distant object focus behind the retina

- **MYOPIA**

(also known as *shortsightedness* or *nearsightedness*)

People with myopia (sometimes called “myopes”) can not see far away, but depending on the amount of myopia they have, their near vision might be good.

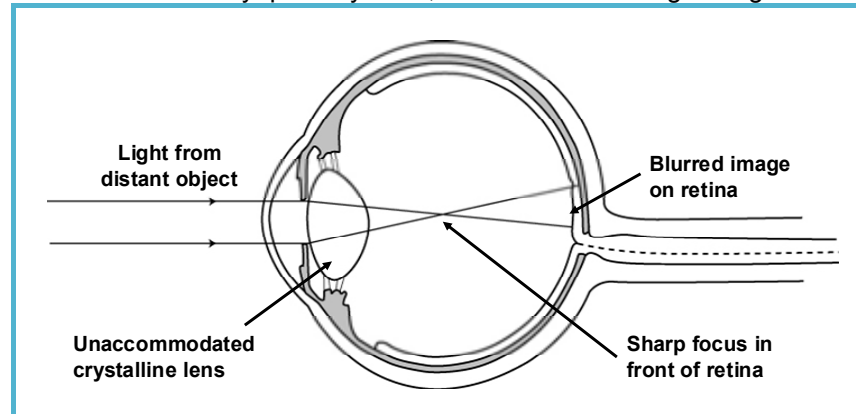


Figure 3.4: A myopic eye - light rays from a distant object focus in front of the retina

- **Astigmatism**

An eye with astigmatism has different powers in different meridians of the eye. This causes light entering the eye to focus in different places, rather than at one single point.

People with astigmatism (sometimes called “astigmats”) may have problems with both distance and near vision, because there is no distance at which a clear retinal image can form.

WHAT IS REFRACTIVE ERROR? (cont.)

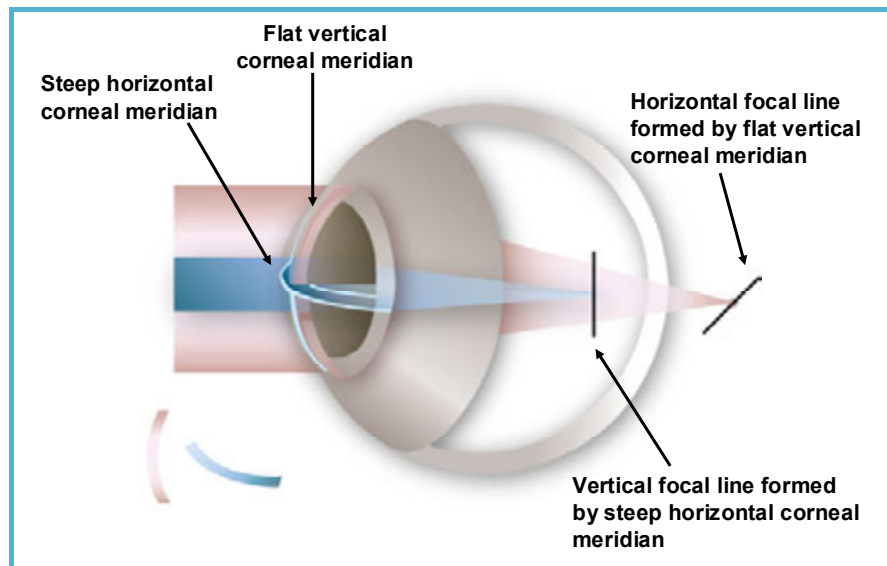


Figure 3.5: An astigmatic eye – light rays from a distant object focus in two different places

- **Presbyopia**

Presbyopia develops as we get older (usually after the age of 40 or 45), when the lens of the eye is no longer able to focus light from near objects. People with presbyopia (sometimes called “presbyopes”) have difficulty with near vision.

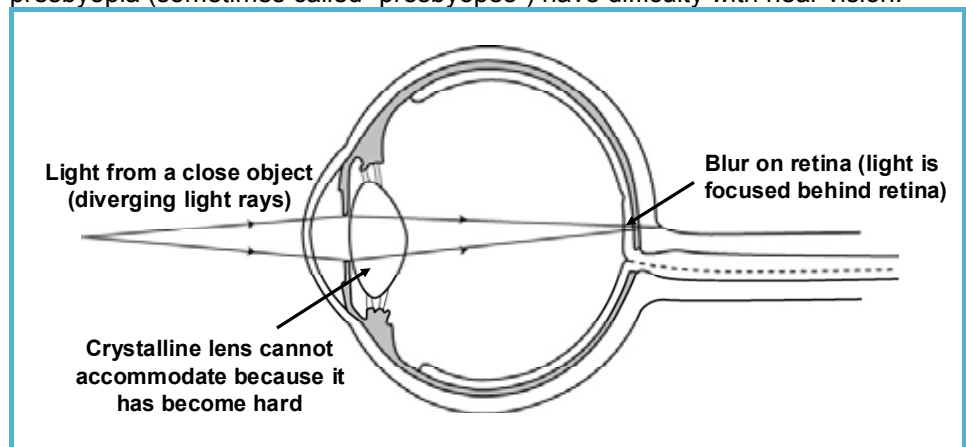


Figure 3.6: A presbyopic eye – light rays from a near object focus behind the retina

A person who has any of these refractive errors will need spectacles (glasses) in order to see clearly and comfortably.

A person's eye might just have one refractive error, or it might have a combination of different refractive errors. An eye may have any combination of refractive error, except myopia and hyperopia together. It is not possible for an eye to have both myopia and hyperopia at the same time.

To find out what sort of refractive error a person has, and how bad their refractive error is, the eyes must be examined in a special way.



An eye examination that tests for refractive error is called a refraction.

REFRACTIVE ERROR
(cont.)

WHAT IS ACCOMMODATION

Accommodation occurs when the ciliary muscle contracts and changes the shape of the crystalline lens (makes it thicker).

When an eye accommodates, the focusing power of the eye increases. This allows a person to see close objects clearly (Figure 3.7).

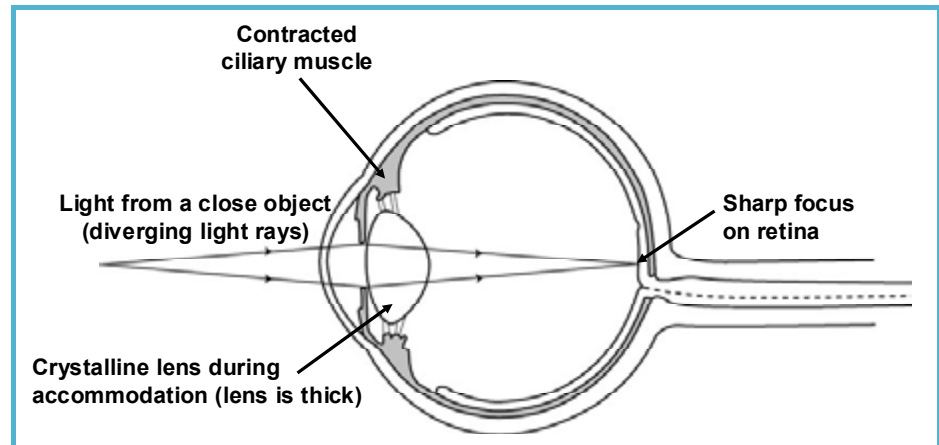


Figure 3.7: Light rays from a close object focusing on the retina in an accommodating eye

When the ciliary muscle is relaxed, a normal eye (an eye that is the right size and shape) will see objects in the distance (further away than 6 m) clearly. When this happens, we say that accommodation is relaxed, or that the eye is unaccommodated. Sometimes an eye with a relaxed ciliary muscle is also referred to as a relaxed eye.

When people accommodate they are usually unaware that they are doing so. A person who is accommodating will usually do so subconsciously (without thinking about it). They will not realise that they are using their ciliary muscle to accommodate.

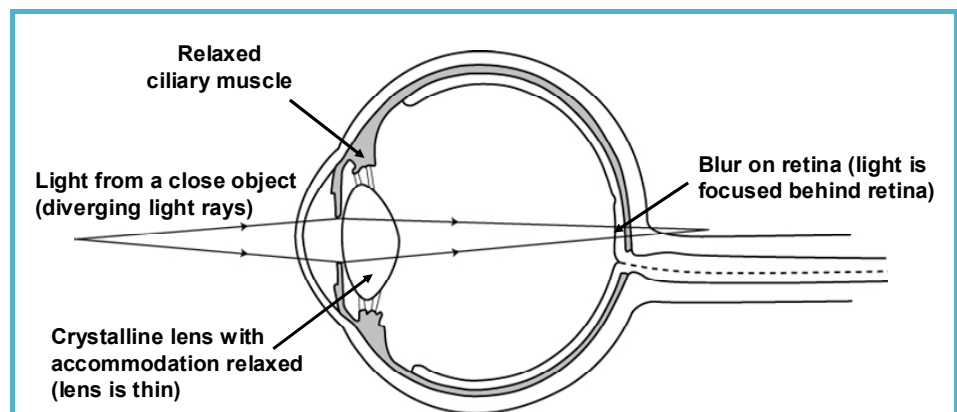


Figure 3.8: Light rays from a close object not focusing on the retina in an eye that is not accommodating

As we get older, the crystalline lens gradually gets harder and cannot change shape easily when the ciliary muscle contracts. This is a normal, natural aging process that is referred to as presbyopia. This means that an older person cannot accommodate (change the focus of their eye to see a close object) as easily as a younger person.

If the eye does not accommodate when looking at a close object, that object will appear blurry or out of focus (Figure 3.8). If a person cannot accommodate enough to see a close object, they will need glasses if they want to see things near to them clearly.

WHAT IS ACCOMMODATION

WHAT IS ACCOMMODATION (cont.)

AMPLITUDE OF ACCOMMODATION

A person's amplitude of accommodation is the total amount of accommodation that they have available. It is dependant on how much their lens can change its shape to increase its focusing power.

Children can accommodate about 15 D. This means that a child (who has no refractive error) is able to see things clearly even if what they are looking at is held only 7 cm from their eyes (Figure 3.9).

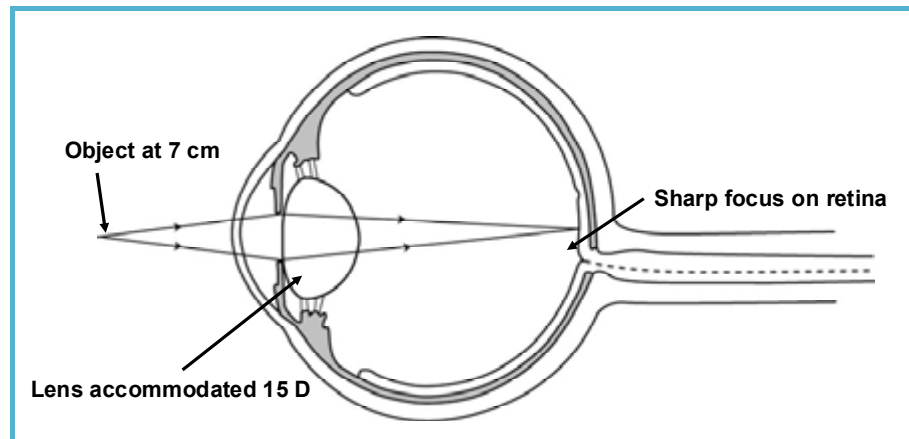


Figure 3.9: The focal length formula is: $f = 100/F$ (f in centimetres, F in dioptres)

In this case the amount of accommodation is 15 D ($=F$) so $f = 100/15 = 7$ cm approximately.

When we reach the age of 40, our eyes can only accommodate by about 5 D. A 40 year old person (who does not have myopia, hyperopia, or astigmatism) can only see objects clearly if they are 20 cm or further from the eyes (Figure 3.10).

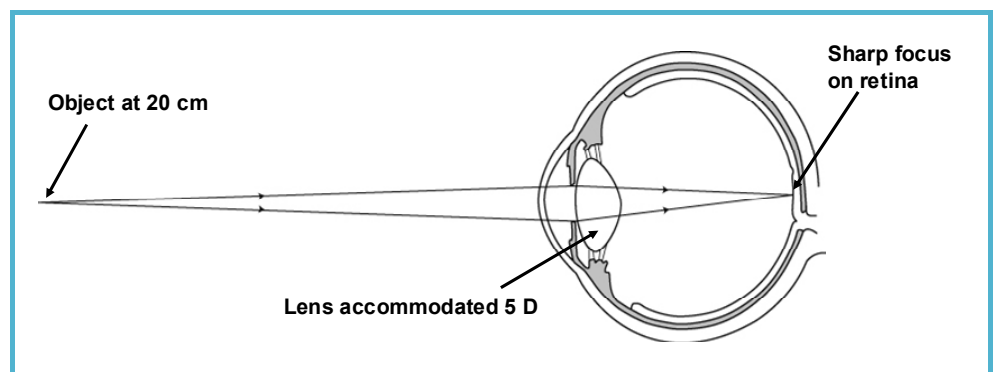


Figure 3.10: The focal length formula is: $f = 100/F$ (f in centimetres, F in dioptres)

In this case the amount of accommodation is 5 D ($=F$) so $f = 100/5 = 20$ cm.

WHAT IS ACCOMMODATION (cont.)

AMPLITUDE OF ACCOMMODATION (cont.)

By the time we are 60 years old there is almost no accommodation left.

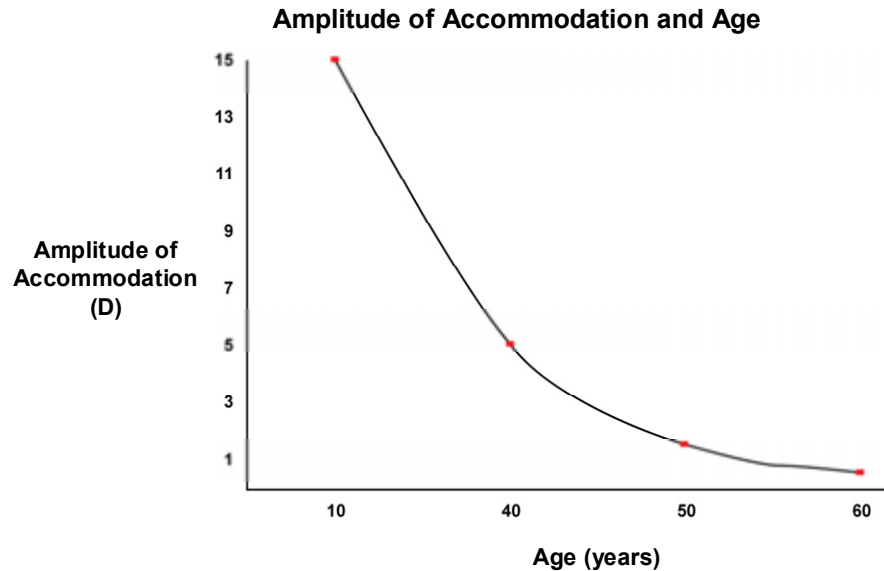


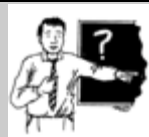
Figure 3.11: Amplitude of accommodation decreases as age increases

This graph is only an estimate, but it shows how our amplitude of accommodation decreases as we get older. Every person is different, and in reality some people who are the same age have slightly different amplitudes of accommodation.

ASTHENOPIA

It is not possible to use all of our accommodation all of the time – the ciliary muscle will get too tired. Our eyes were simply not designed to spend long periods of time reading, sewing, looking at a computer screen, doing craft work or other near tasks.

When the ciliary muscle gets tired it causes symptoms of asthenopia (visual fatigue).



Symptoms of asthenopia can include:

- sore, aching or burning eyes
- tired eyes
- headaches
- fatigue (general tiredness)
- falling asleep when doing near work
- loss of concentration
- blurry vision
- double vision
- itchy eyes.

A person who has asthenopic symptoms may have just one of these symptoms, or they may have several. Every person will be different.

WHAT IS ACCOMMODATION (cont.)

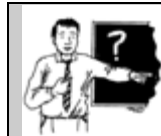
THE EYELIDS

A good way to think about accommodation is to think of the ciliary muscle as being like the muscles in your arms:

Imagine you go to the market and buy a very, very large bag of rice. You can pick the bag up, but if you try to carry the bag home, after a while it becomes too heavy and hurts your arms. Eventually you will not be able to carry the bag any further and you will have to put it down.

The same thing happens when you look at something that is very close to you. You might be able to accommodate to be able to see it clearly for a short period of time, but after some time, your ciliary muscle will get tired. Your eyes will hurt and your vision will go blurry.

Sometimes if you look at something that is close to you for too long you can get a cramp (spasm) in your ciliary muscle. This is like getting a cramp in your leg muscle when you are playing soccer. When you have a cramp your muscle cannot relax.



If a person wants to spend a long period of time doing near work, they can usually use half of their total amplitude of accommodation without getting asthenopia.

When a person has a cramp in their ciliary muscle they will not be able to relax their ciliary muscle – so their distance vision will be blurry. This problem is more common in young people.

Example:

A child might tell you that after they have been reading or writing for some time in the classroom, the blackboard looks blurry. After some time the blackboard will look clear again.

This is not myopia because it is not permanent. This is a near vision problem that has caused the ciliary muscle to cramp.

SUMMARY: PARTS OF THE EYE

THE NORMAL EYE

Light Entering the Eye

- Light rays entering the eye pass through the tear film, cornea, anterior chamber, pupil, crystalline lens and vitreous, before they reach the retina.
- Light rays are converged (focused) by the cornea and the crystalline lens.
- If the light rays focus correctly on the retina, a clear image will be formed.
- Light is changed at the retina into electrical signals (nerve messages).
- Information received by the retina is sent to the brain via the optic nerve.

Focusing Light in the Eye

- In a normal eye, light that enters the eye is focused on the retina because:
 - the cornea and the lens are the correct shape, and
 - the eyeball is the correct length.

THE EYE WITH REFRACTIVE ERROR

Refractive Error

- A person who has a refractive error will need to wear spectacles (glasses) or contact lenses so that they can see clearly and comfortably. This is because their eye is not the correct size and shape.
- There are four main types of refractive error: myopia, hyperopia, astigmatism and presbyopia.
- The amount of refractive error an eye has depends on:
 - the steepness of the cornea; and/or
 - the steepness of the crystalline lens; and/or
 - the length of the eyeball.
- A person with a refractive error will have eyes that look normal, but they will not see well.
- An eye examination to test for refractive error is called a refraction.

ACCOMMODATION

- Accommodation occurs when the ciliary muscle contracts and changes the shape of the crystalline lens (makes it thicker).
- This changes the optical focus of the eye so that close objects can be seen clearly.
- When accommodation in a normal eye (an eye without refractive error) is relaxed, objects in the distance are seen clearly.
- Presbyopia refers to the natural aging changes in the eye where the crystalline lens hardens with age. When this happens, the lens cannot change shape easily when the ciliary muscle contracts. This means that an older person cannot accommodate as much or as easily as a younger person.
- If a normal eye cannot accommodate (if a person has presbyopia), close objects will appear blurry.
- The amplitude of accommodation is the total amount of accommodation that is available to change the focus of the eye.
- Amplitude of accommodation decreases with age.
- Asthenopia (visual fatigue) happens when the ciliary muscle gets tired – when too much accommodation is being used.
- To avoid asthenopic symptoms during long periods of near work, usually only half the amplitude of accommodation should be used.
- Sometimes the ciliary muscle can cramp after too much near work. When this happens the distance vision will look blurry temporarily.

TEST YOURSELF QUESTIONS

1. Please list (from front to back) the five transparent (clear) parts of the eye which light rays must travel through before they reach the retina:

2. For light to focus correctly on the retina, the _____ must bend (or converge) the light by the correct amount, and the distance between the _____ and the _____ must be the correct length.
3. What is refractive error?

4. Name the four types of refractive error.

5. How does the eye accommodate?

6. Why is it more difficult for people to accommodate as they get older?

7. Why is it best for a person to use only half of their total amplitude of accommodation?

8. What are the symptoms of asthenopia?

NOTES

SPHERICAL LENSES

THINK

A man from another village comes to you for an eye examination. He tells you that he wears spectacles but that he does not know the name of his eye problem. Knowing whether the lenses in his spectacles are minus or plus powers will help you find out what his spectacles are for.

AIM

This unit will help you understand how plus and minus spherical lenses focus light.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- describe the types of refractive errors that spherical lenses can correct
- explain the differences between plus and minus lenses
- recognise the shapes of spherical lenses
- understand how spherical lenses focus light
- define a dioptre (D)
- write the power of a spherical lens
- understand how lens power (F) and focal length (f) are related.

REVIEW: SPHERICAL LENSES

BEHAVIOUR OF LIGHT	• Light always travels in straight lines. • Light rays can be parallel, convergent, or divergent. • Parallel light rays come from distant objects (6 metres or further away). • Light can be reflected, refracted or absorbed when it reaches an object.
LENSES	• Lenses refract light to form a focus. • Spherical lenses can be plus or minus lenses. • Astigmatic lenses can be cylindrical or sphero-cylindrical lenses.
PRISMS	• A prism bends light away from its apex. • Prism power is measured in prism dioptres (Δ).
OPTICAL CENTRE	• A light ray will not bend if it travels through the optical centre of a lens.
PLANO LENS	• A plano lens has zero focusing power.
REFRACTIVE ERROR	• A person who has a refractive error will need to wear spectacles (glasses) or contact lenses so that they can see clearly and comfortably. This is because their eye is not the correct size and shape. • There are four main types of refractive error: myopia, hyperopia, astigmatism and presbyopia.

SPHERICAL LENS SHAPES

The thickness of a spherical lens is different in the centre of the lens compared with the edge of the lens.



Plus lenses are always **thicker in the middle** and thinner at the edge.

Minus lenses are always **thinner in the middle** and thicker at the edge.

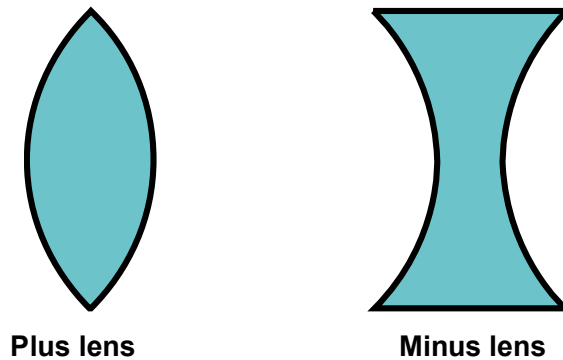
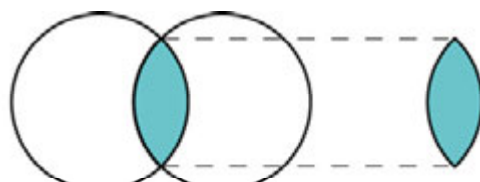


Figure 4.1: Plus and minus lenses

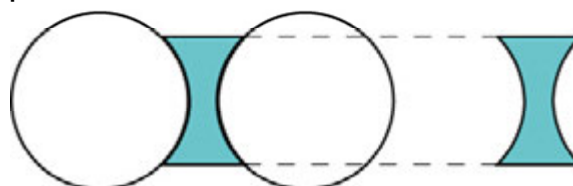
A good way to think about the shape of a spherical lens is to imagine the space between two spheres (balls) that are either overlapping (in the case of a plus lens) or are next to each other (in the case of a minus lens).

Overlapping spheres



Space inside is the same shape as a plus lens

Spheres next to each other



Space between is the same shape as a minus lens

Figure 4.2: The shape of a spherical lens is the same as the space between two spheres



Spectacle lenses can be different shapes.

They do not always look like the symmetrical shapes above.

SPECTACLE LENS SHAPES

Spherical spectacle lens surfaces can be:

- Plano (flat)
- Convex (curved like the outside of a ball)
- Concave (curved like the inside of a ball).

If you have a sphere (like a soccer ball) and you cut it in half, each of these halves has two surfaces: the outside surface and the inside surface.

- The outside surface of the sphere is convex.
- The inside surface of a sphere is concave.

A convex surface converges light and a concave surface diverges light.

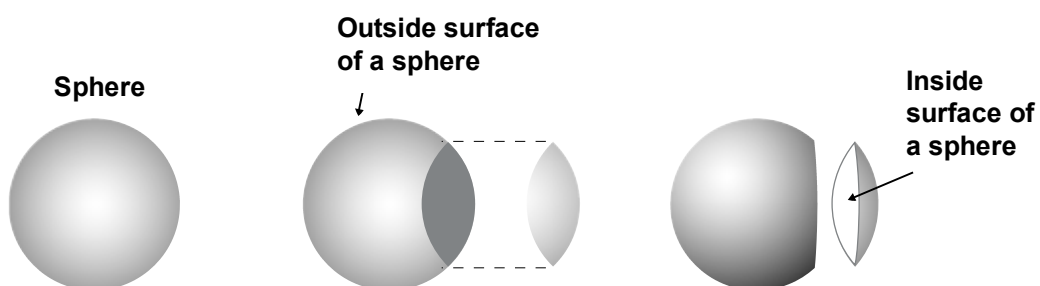


Figure 4.3: Looking at the outside and the inside surfaces of a sphere

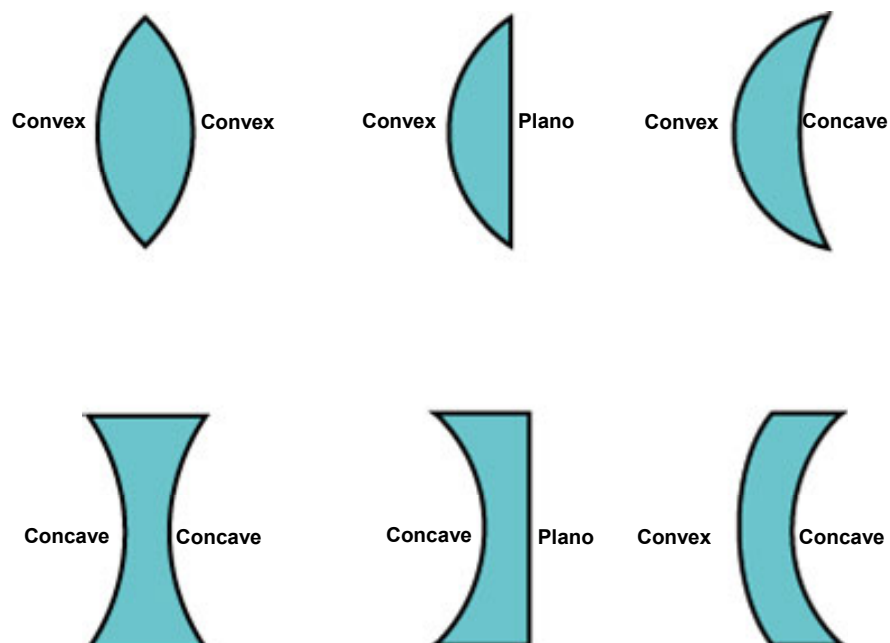


Figure 4.4: Some of the ways that plano, convex and concave surfaces can form lenses

SPECTACLE LENS SHAPES (cont.)

PLUS LENS	At least one surface of a plus lens is convex (like the outside of a ball). Plus lenses have other names too: • Positive lenses • Convex lenses • Converging lenses.
MINUS LENS	At least one surface of a minus lens is concave (like the inside of a ball). Minus lenses have other names too: • Negative lenses • Concave lenses • Diverging lenses. The image shows two diagrams of light rays passing through lenses. On the left, a convex (plus) lens is shown with parallel light rays entering from the left and converging to a single point on the right. On the right, a concave (minus) lens is shown with parallel light rays entering from the left and diverging outwards to the right. Below each diagram are the labels 'Plus lens' and 'Minus lens' respectively. Figure 4.5: Light rays travelling through plus and minus lenses. The plus lens is converging light and the minus lens is diverging light.

SPHERICAL LENSES AND REFRACTIVE ERROR

Spherical lenses are used to correct some types of refractive errors by correcting the focus of the eye.

Spherical lenses can be put into spectacles to help people with hyperopia, myopia and presbyopia see clearly.



Plus lenses are used to correct hyperopia and presbyopia.
Minus lenses are used to correct myopia.

SPHERICAL REFRACTIVE POWER

LENS POWER (DIOPTRES)

The refractive power (or strength) of a lens tells us how much focussing power the lens has.

A lens has two surfaces – a back surface and a front surface. Each surface has certain refractive power, but the total refractive power of the lens is the total of its two surfaces added together.



A convex surface converges light and has a plus (+) power.

A concave surface diverges light and has a minus (–) power.

A convex or concave surface which is more curved (a “steeper” curve) will be more powerful than a surface which is less curved (a “flatter” curve).

Spherical refractive power is measured in dioptres. This is usually written as “D”. A dioptre is a measure of how much a convex or a concave surface makes light converge or diverge.



Spectacle refractive powers are written with two decimal places (with two numbers after the decimal point).

For example:

A spectacle lens that has a power of plus two dioptres would be written as +2.00 D.



Spectacle refractive powers usually increase in quarter dioptre steps (0.25 D steps).

For example:

+0.25 D, +0.50 D, +0.75 D, +1.00 D, +1.25 D, +1.50 D...

–0.25 D, –0.50 D, –0.75 D, –1.00 D, –1.25 D, –1.50 D...

SPHERICAL REFRACTIVE POWER (cont.)

FOCAL LENGTH

Parallel light rays that travel through a plus lens will converge. These converging light rays will meet at a focal point behind the plus lens.

The distance between the lens and its focal point is called the focal length. The focal length is a positive number for a plus lens, because the focal point is behind the lens.

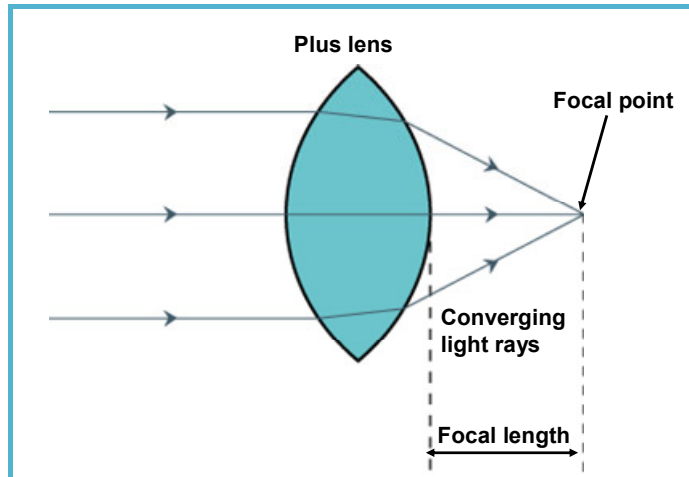


Figure 4.6: Parallel light rays travelling through a plus lens converge to a focal point

A parallel light ray that travels through a minus lens will diverge. These diverging light rays will not meet behind the minus lens – diverging light rays will travel away from each other.

A minus lens has a virtual focal point in front of the minus lens. A virtual focal point is an imaginary point where diverging light rays seem to be coming from.

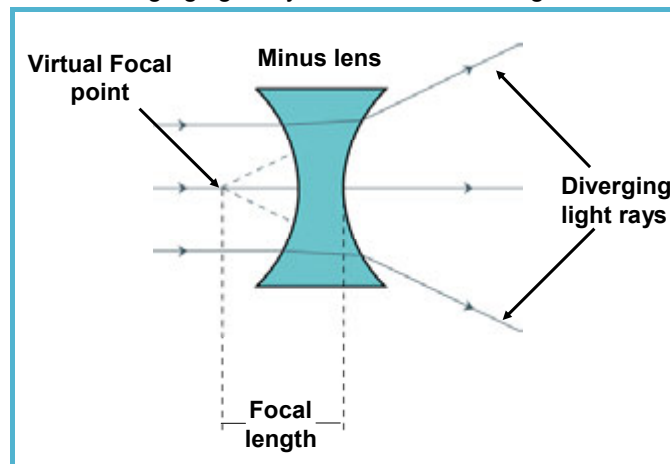


Figure 4.7: Parallel light rays travelling through a minus lens diverge. These diverging light rays look like they are coming from a virtual focal point.

For a minus lens, the distance between the lens and the virtual focal point is also called the focal length. The focal length is a negative number for a minus lens, because the virtual focal point is in front of the lens.

To find the focal length of any lens there is a formula:

$$f = 1/F \quad \text{or} \quad F = 1/f$$

Where: f = focal length in metres (m)
 F = lens power in dioptres (D)

We can therefore say that the refractive power of a lens, measured in dioptres, is equal to the reciprocal of the focal length of the lens measured in metres.

SPHERICAL REFRACTIVE POWER (cont.)

EXAMPLE 1

If parallel light rays enter a +1.00 D lens, how far away from the lens will the focal point be?

$$f = 1/F = 1/+1.00 = +1 \text{ m}$$

Therefore, the focal point of a +1.00 D lens will be 1 m behind the lens.

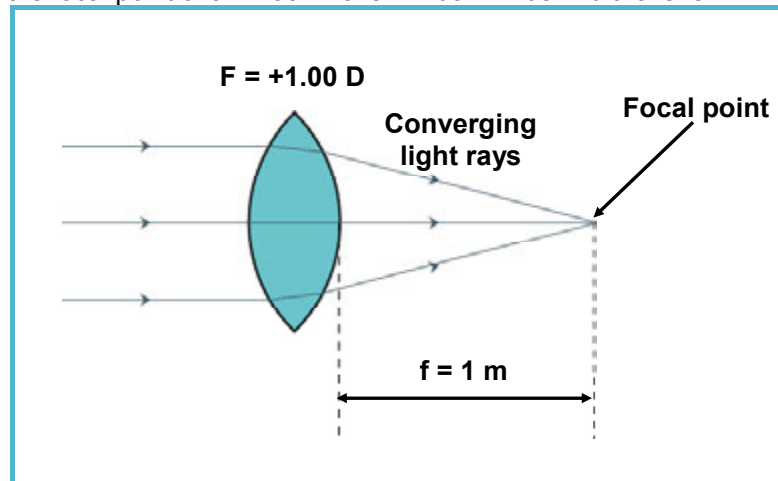


Figure 4.8: Parallel light rays will focus 1 m away from a +1.00 D lens

EXAMPLE 2

If parallel light rays enter a +2.00 D lens, how far away from the lens will the focal point be?

$$f = 1/F = 1/+2.00 = +0.5 \text{ m} = +50 \text{ centimetres (cm)}$$

Therefore, the focal point of a +2.00 D lens will be 50 cm behind the lens.

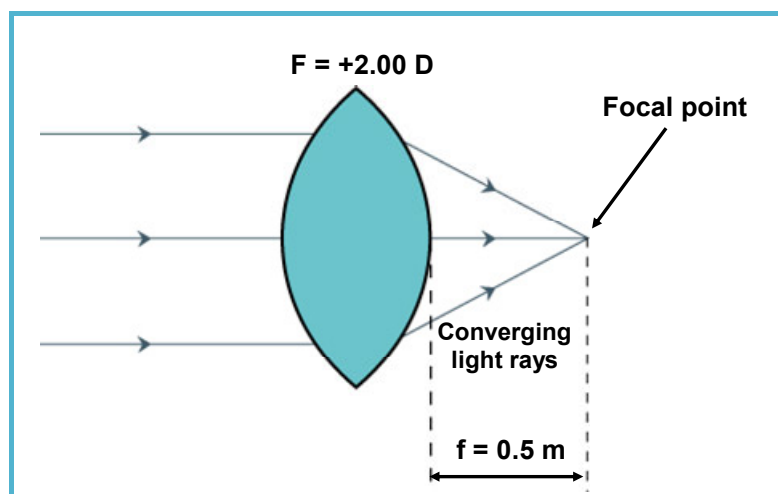


Figure 4.9: Parallel light rays will focus 50 cm away from a +2.00 D lens

SPHERICAL REFRACTIVE POWER (cont.)

EXAMPLE 3

If parallel light rays enter a -1.00 D lens, how far away from the lens will the virtual focal point be?

$$f = 1/F = 1/(-1.00) = -1 \text{ m}$$

Therefore, the virtual focal point of a -1.00 D lens will be 1 m in front of the lens.

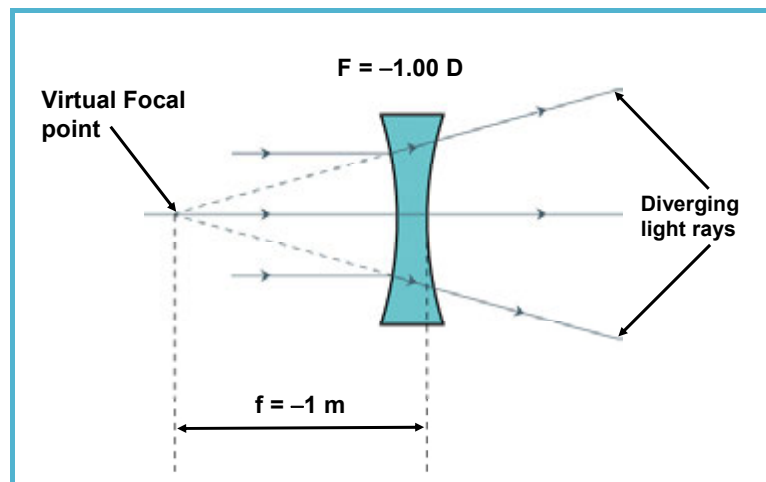


Figure 4.10: Parallel light rays travelling through a -1.00 D lens will form a virtual focal point 1 m in front of it

EXAMPLE 4

If parallel light rays enter a -2.50 D lens, how far away from the lens will the virtual focal point be?

$$f = 1/F = 1/(-2.50) = -0.4 \text{ m} = -40 \text{ cm}$$

Therefore, the virtual focal point of a -2.50 D lens will be 40 cm in front of the lens.

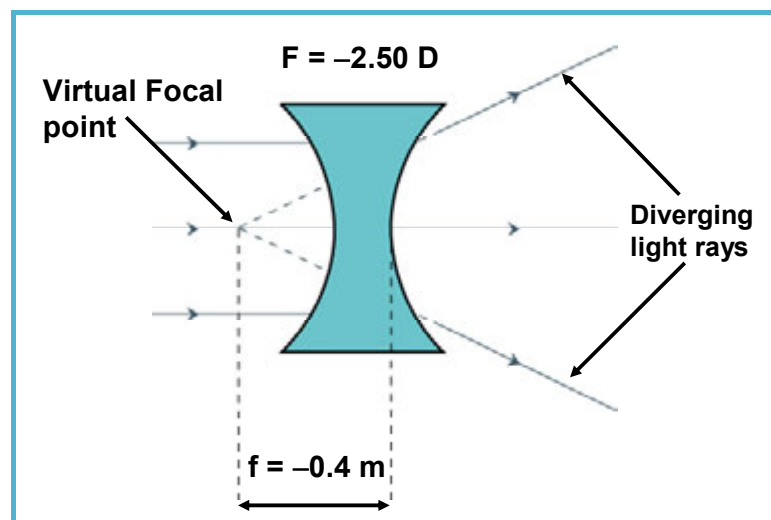


Figure 4.11: Parallel light rays travelling through a -2.50 D lens will form a virtual focal point 40 cm in front of it

SPHERICAL REFRACTIVE POWER (cont.)

LENS SHAPE AND LENS POWER

Lenses that have different shapes can still have the same power.

Example 1:

All the lenses below have the same power, even though they have different shapes. They are all +4.00 D lenses, so all of them will bend (converge) light by the same amount.

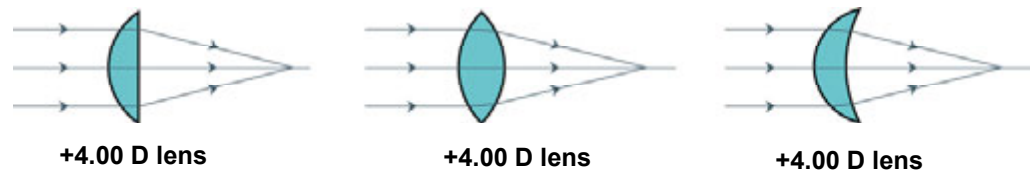


Figure 4.12: +4.00 D lenses can come in different shapes

Example 2:

All the lenses below have different shapes, but the same power. They are all -4.00 D lenses, so all of them will bend (diverge) light by the same amount.

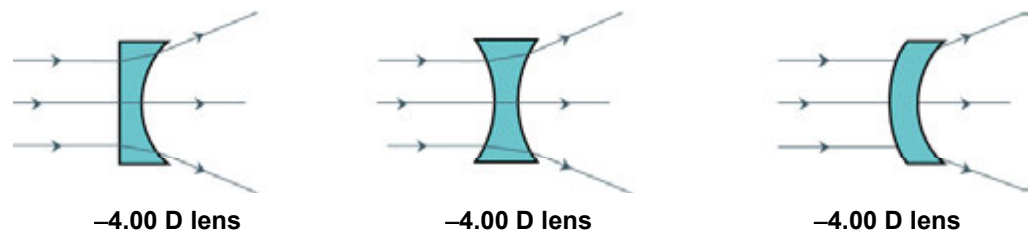


Figure 4.13: -4.00 D lenses can come in different shapes

SPHERICAL REFRACTIVE POWER (cont.)

PLUS LENSES

- **Lens Thickness**

It is usually easy to recognise a plus lens because it is thicker in the middle than it is at the edge. The optical centre is at the thickest part of a plus lens.

- **Lens Image Size**

Another way to know if a lens has plus power is to look at objects through the lens. When you look through a plus lens the objects viewed will appear bigger and closer. A magnifying glass is an example of a plus lens.

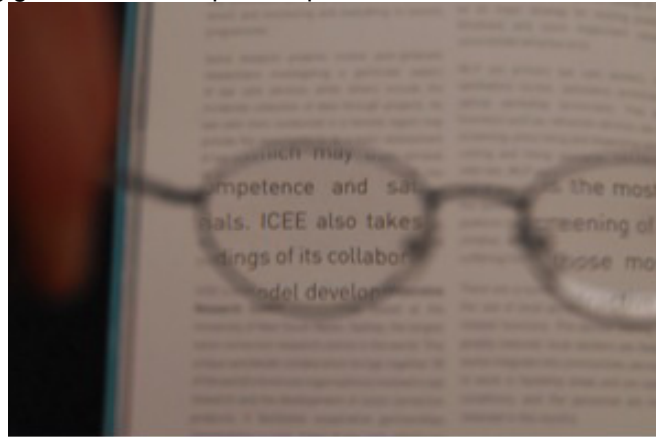


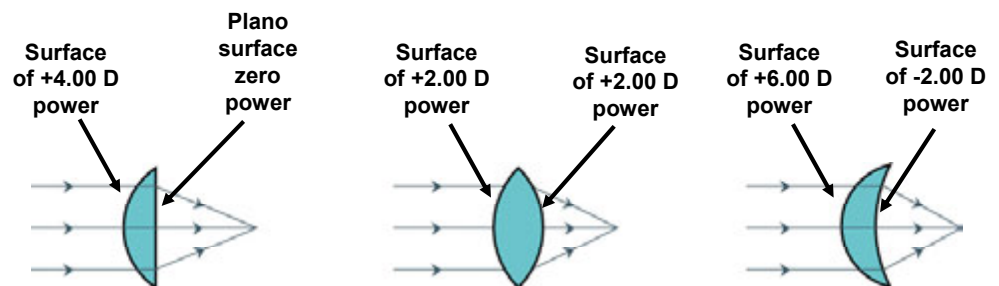
Figure 4.14: Objects seen through plus lenses look bigger and closer

- **Writing Plus Prescriptions**

People with hyperopia and presbyopia need positive lenses in their spectacles and you will often see something like this written in the spectacle prescription: +2.50 D.

- The “+” sign tells us it is a plus lens
- The “2.50 D” tells us the power is two and one-half dioptres.

- **Plus Lens Surface Powers**



All of these have a power of +4.00 D

Figure 4.15: Plus lenses converge light.

A plus lens may have:

- one flat and one convex surface; or
- both surfaces convex; or
- one convex and one concave surface, where the power of the convex surface is greater than the power of the concave surface.

The three lenses shown in Figure 4.15 all have a power of +4.00 D. This is because for each lens the total of the powers of the two surfaces equals +4.00.

SPHERICAL REFRACTIVE POWER (cont.)

MINUS LENSES

- **Lens Thickness**

It is usually easy to recognise a minus or negative lens, because it is thinner in the middle than it is at the edge. The optical centre is at the thinnest part of a minus lens.

- **Lens Image Size**

Another way to know if a lens has minus power is to look at objects through the lens. If you look through a minus lens, the objects viewed will appear smaller and farther away.



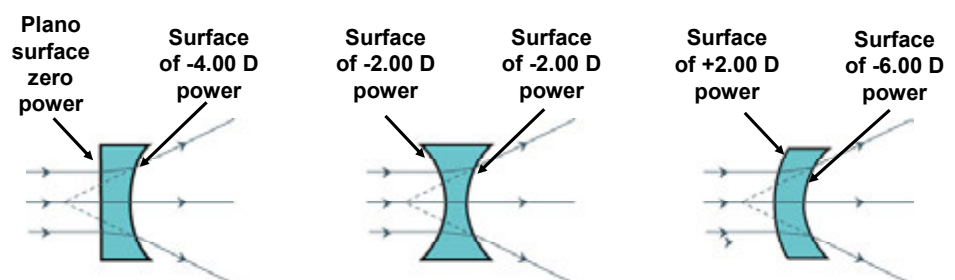
Figure 4.16: Objects seen through plus lenses look bigger and closer

- **Writing Minus Prescriptions**

People with myopia need minus lenses in their spectacles and you will often see something like this written in the spectacle prescription: -3.75 D.

- The “-” sign tells us it is a minus lens
- The “3.75 D” tells us the power is three and three-quarter dioptres.

- **Minus Lens Surface Powers**



All of these lenses have a power of -4.00 D

Figure 4.17: Minus lenses diverge light.

A minus lens may have:

- one flat and one concave surface; or
- two concave surfaces; or
- one convex and one concave surface, where the power of the concave surface is greater than the power of the convex surface.

The three lenses shown in Figure 4.17 all have a power of -4.00 D. This is because, for each lens, the total power of the two surfaces equals -4.00 .

SPHERICAL REFRACTIVE POWER (cont.)

LENS THICKNESS AND LENS POWER

Lenses that are of different thicknesses usually have different powers.

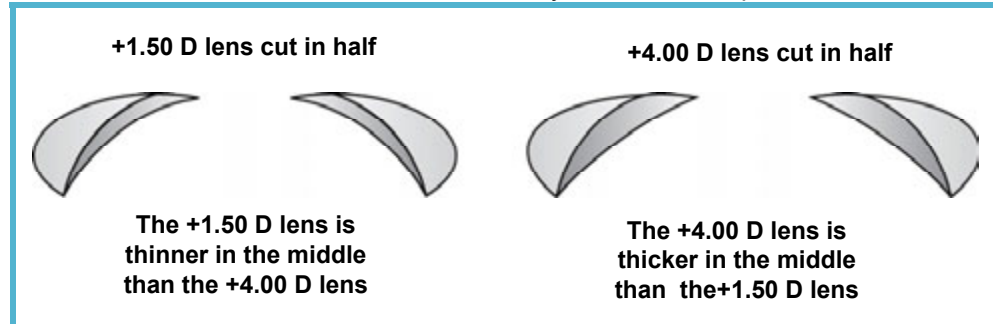


Figure 4.18: Plus lenses that have a stronger power are thicker in the middle

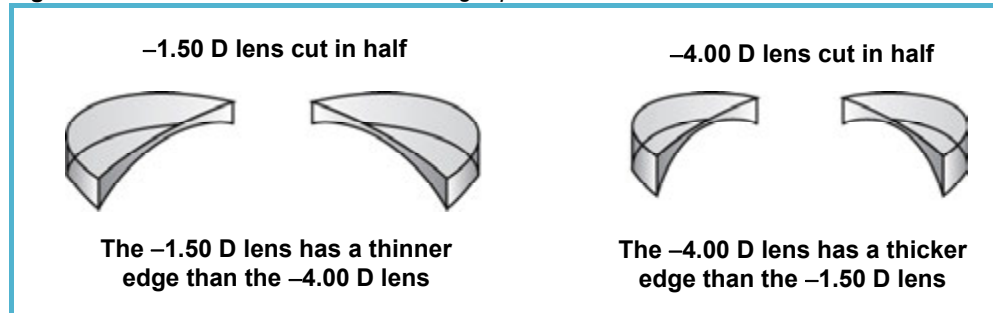


Figure 4.19: Minus lenses that have a stronger power are thicker on the edge



The more curved a surface is (the steeper the curve of a surface), the greater the power of that surface.

PLANO LENSES

Sometimes lenses with no power are needed. Lenses with no power are called plano lenses or “non-prescription” lenses.

A person with good vision who spends a lot of time outdoors may need sunglasses with plano lenses. A factory worker with good vision might need plano safety spectacles. Some people need a lens with power for one eye, but the other eye may be perfect. In that case, a plano spectacle lens would be used for the good eye.

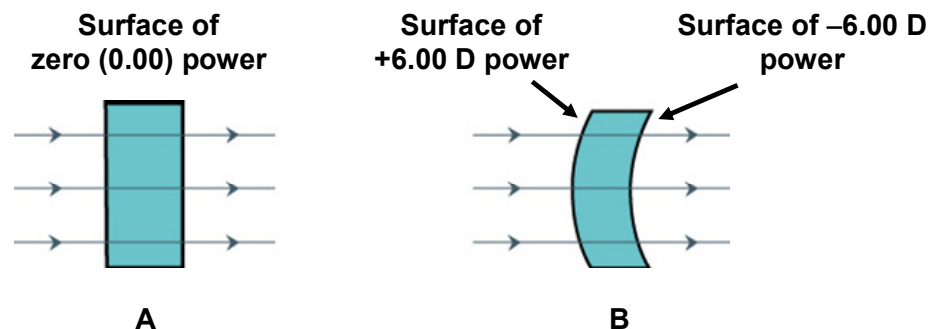


Figure 4.20: Plano lenses may be flat or curved.
Light rays that pass through a plano lens do not bend.

Like all lenses the power of a plano lens is the total of the powers of the two surfaces.

- The first lens in Figure 4.20 has a front surface that is flat (plano or zero power) and a back surface that is flat (plano or zero power). The lens power is $0.00 + 0.00 = 0.00$ D.
- The second lens in Figure 4.20 has a convex front surface of $+6.00$ D and a concave back surface of -6.00 D. The lens power is $+6.00 + (-6.00) = 0.00$ D.

You can see that for a curved lens to be of plano power, the curvature of both surfaces must be the same, but one must be convex and one concave. This means that the thickness of a plano lens is the same in the centre as it is at the edges.

When plano lenses are used as safety spectacles the lenses are usually made thicker, so that they are harder to break.

SUMMARY: SPHERICAL LENSES

SPHERICAL LENSES AND REFRACTIVE ERROR

- Spherical lenses correct hyperopia, myopia and presbyopia.
- Plus lenses correct hyperopia and presbyopia.
- Minus lenses correct myopia.

SPHERICAL LENS SHAPE

- Plus lenses are thicker in the middle than at the edge.
- Minus lenses are thinner in the middle than at the edge.
- Spherical lenses have at least one convex or concave surface.
- A convex surface converges light, it has plus (+) power.
- A concave surface diverges light, it has minus (–) power.

SPHERICAL LENS POWER

- Spherical refractive power is measured in dioptres (often written as “D”).
- Spherical refractive power is written with two decimal places (e.g. –2.75 D).
- Spectacle refractive powers usually increase in 0.25 D steps.
- Thicker lenses usually have stronger powers.
- The focal point of a plus lens is where the converging light rays meet (behind the lens).
- The virtual focal point of a minus lens is where the diverging light rays seem to be coming from (in front of the lens).
- Focal length is the distance between the lens and the focal point.
- Focal length (f) is related to the power (F) of the lens:

$$f = 1/F \quad \text{or} \quad F = 1/f.$$
- The refractive power of a lens, measured in dioptres, is equal to the reciprocal of the focal length of the lens measured in metres.

Lens Type	Lens Thickness	Lens Image Size	Writing a Lens Prescription	Total of Lens Surface Powers
Plus lens	Thickest in centre, thinnest at edges	Objects viewed through lens look larger and closer	“+”	Plus
Minus lens	Thickest at edges, thinnest in centre	Objects viewed through lens look smaller and further away	“–”	Minus
Plano lens	Equal thickness at edge and centre	Objects viewed through lens look the same	Plano	Zero

TEST YOURSELF QUESTIONS

1. Does light bend when it passes through the optical centre of a lens? (*tick one*)
☐ Yes ☐ No
2. Does a convex lens surface converge or diverge light?

3. How would you write the power of a plus lens of one and three-quarter dioptres?

4. Give two other names for a minus lens.
 - a. _____
 - b. _____
5. If a lens has one surface with a power of +3.00 D, and a second surface of power –6.00 D, what is its total power?

6. List two different uses for plano lenses.

7. List three differences between plus and minus lenses.

8. What is the focal length of a +2.50 D lens?

9. What type of refractive error can be corrected with minus lenses?

10. Name two types of refractive error that can be corrected with plus lenses:
 - a. _____
 - b. _____

NOTES



ASTIGMATIC LENSES

THINK

Spherical lenses can correct hyperopia, myopia and presbyopia – but there is one refractive error that spherical lenses cannot correct, namely astigmatism.

If a person has astigmatism they will need a special type of lens to allow them to see clearly.

AIM

This unit will explain how cylindrical and sphero-cylindrical lenses focus light to correct astigmatism.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- list the types of refractive error that astigmatic lenses can correct
- explain the difference between a cylindrical lens and a sphero-cylindrical lens
- describe the principal meridians of a cylindrical lens
- recognise the shapes of astigmatic lenses
- explain how astigmatic lenses focus light
- write and interpret the power of a sphero-cylindrical lens.

REVIEW: ASTIGMATIC LENSES

LENSES	• Light rays that enter lenses can be bent or refracted. • Spherical lenses can be plus or minus lenses. • Plus lenses converge light rays, while minus lenses diverge them. • Astigmatic lenses can be cylindrical or sphero-cylindrical lenses.
LENSES AND REFRACTIVE ERROR	• Lenses can be used to correct refractive error. • Spherical lenses correct hyperopia, myopia and presbyopia: - Plus lenses correct hyperopia and presbyopia; - Minus lenses correct myopia. • Astigmatic lenses correct astigmatism.
SPHERICAL LENS SHAPE	• Plus lenses are thicker in the middle than at the edge. • Minus lenses are thinner in the middle than at the edge.
FOCAL LENGTH	• Focal length is the distance between the lens and the focal point. • Focal length (f) is related to the power (F) of the lens: $f = 1/F \quad \text{or} \quad F = 1/f$
REFRACTIVE ERROR	• A person who has a refractive error will need to wear spectacles (glasses) or contact lenses so that they can see clearly and comfortably. This is because their eye is not the correct size and shape. • There are four main types of refractive error: myopia, hyperopia, astigmatism and presbyopia.

ASTIGMATIC LENSES

ASTIGMATIC LENSES AND THE EYE	Astigmatic lenses are used to correct the focus of the eye of people with astigmatism. Astigmatic lenses can be put into spectacle frames to help people with astigmatism see clearly. Astigmatic spectacles also correct the focus for people who have astigmatism combined with another refractive error such as: • astigmatism and hyperopia • astigmatism and myopia • astigmatism and presbyopia. There are two types of astigmatic lenses: cylindrical lenses and sphero-cylindrical lenses. A sphero-cylindrical lens is a cylindrical lens combined with a spherical lens. Cylindrical and sphero-cylindrical lenses have other names also: • Cylindrical lens = cylinder lens, cyl lens Sphero-cylindrical lens = sphero-cylinder lens, sphero-cyl lens.  The extraocular muscles move the eyeballs to point in different directions.

ASTIGMATIC LENSES (cont.)

MERIDIANS

A meridian is an imaginary line which crosses a lens at its optical centre. A lens has many meridians (depending on the direction the line travels through the optical centre), but there are only two main or “principal” meridians.

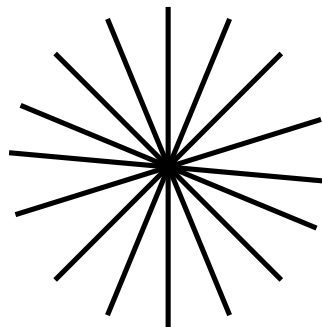
The “principal” meridians of every astigmatic lens are perpendicular (at 90°) to each other. The maximum power of the astigmatic lens lies along one of these principal meridians, while the minimum power lies in the other principal meridian (perpendicular to it).



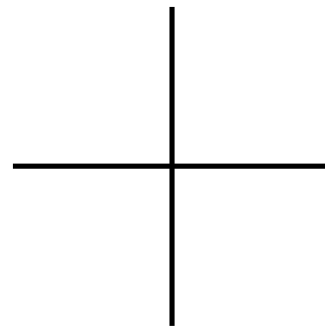
An astigmatic lens has two principal meridians:

- axis meridian (has the minimum power)
- power meridian (has the maximum power)

Usually we do not think about spherical lenses as having meridians because all the meridians of a spherical lens have the same power. Only astigmatic lenses have different powers in different meridians.



Sphere



Cylinder

Figure 5.1: Spherical lenses have the same power in all meridians, no matter what the direction of the meridian is. An astigmatic lens has two principal meridians and these are perpendicular to each other



Astigmatic lenses have different powers in different meridians. Spherical lenses have the same power in all meridians.

CYLINDRICAL LENSES

CYLINDRICAL LENSES

Cylindrical lenses (Figures 5-2A and 5-2B) may be minus or plus powered – just like spherical lenses may be minus or plus powered.

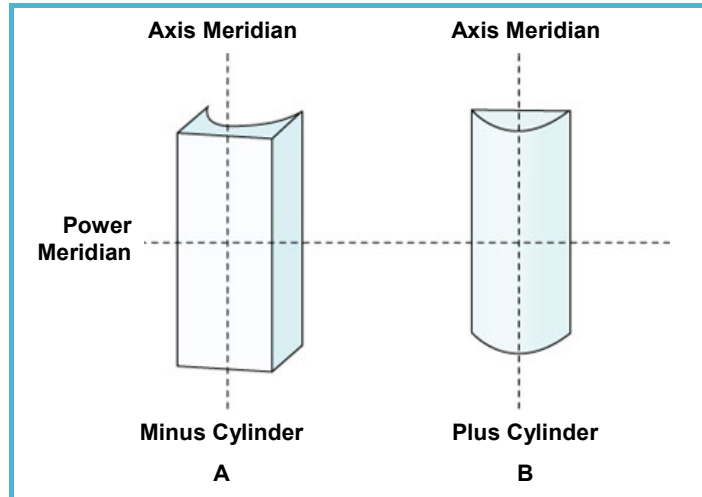


Figure 5.2: Minus and plus cylindrical lenses

A good way to understand the differences between cylindrical lenses and spherical lenses is to imagine cutting the lenses through their optical centres.

CUTTING SPHERICAL LENSES

Figure 5.3 shows what a plus spherical lens looks like when it is cut in half through its optical centre.

If you look at the inside of the lens (the cut surfaces) you can see that this plus spherical lens has one flat (plano) edge and one convex edge.

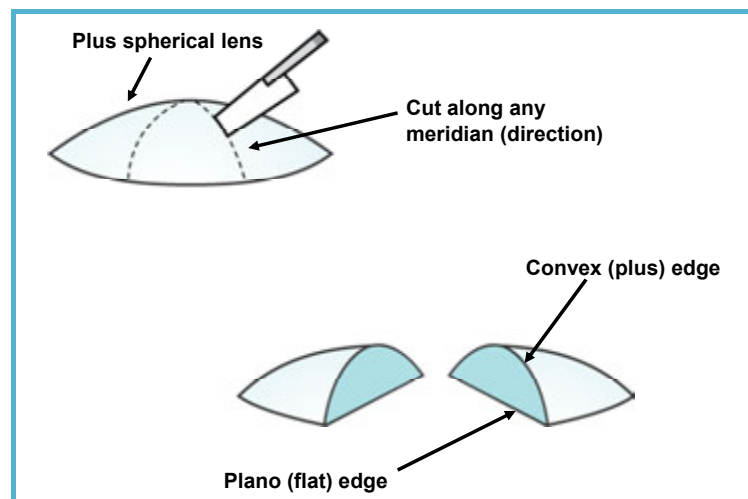


Figure 5.3: Cutting a plus spherical lens in half to show the inside of the lens (the cut surfaces)

We can cut the lens through the optical centre of a spherical lens in any direction (or meridian) and the shape of the two cut surfaces will always be the same. This is because a plus spherical lens has the same power in all meridians.

CYLINDRICAL LENSES (cont.)

CUTTING CYLINDRICAL LENSES (cont.)

If we cut a cylindrical lens *along the power meridian*, we get two halves as shown in Figure 5.4. You can see that the inside cut surfaces are the same shape as those for the plus spherical lens. There is a flat (plano) edge and a convex edge. This means that in this meridian there is plus focusing power.

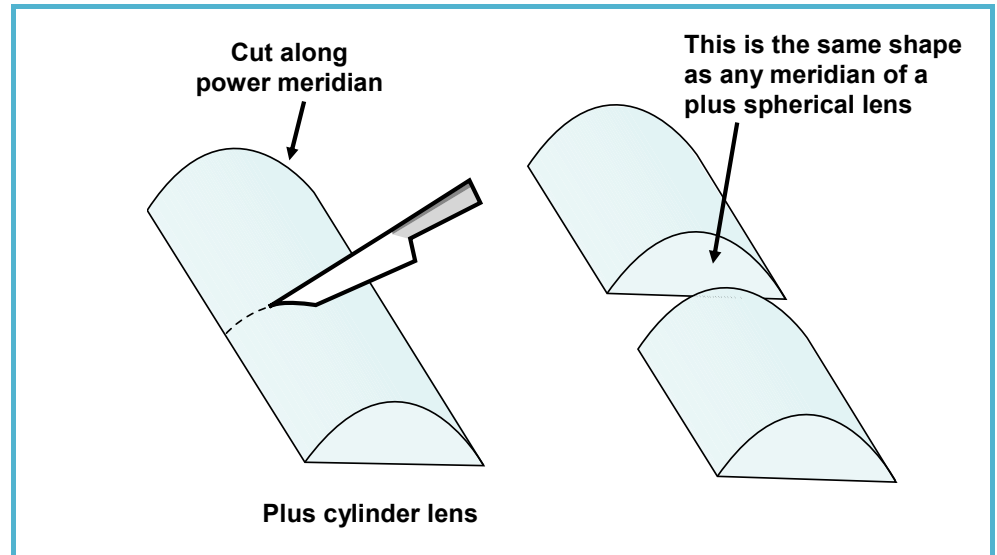


Figure 5.4: Cutting a plus cylindrical lens in half along its power meridian

If we now cut the cylindrical lens *along its axis meridian* (Figure 5.5) we get cut surfaces that have two flat (plano) edges. Both edges are straight and parallel, which means the axis meridian has no focusing power and no prism.

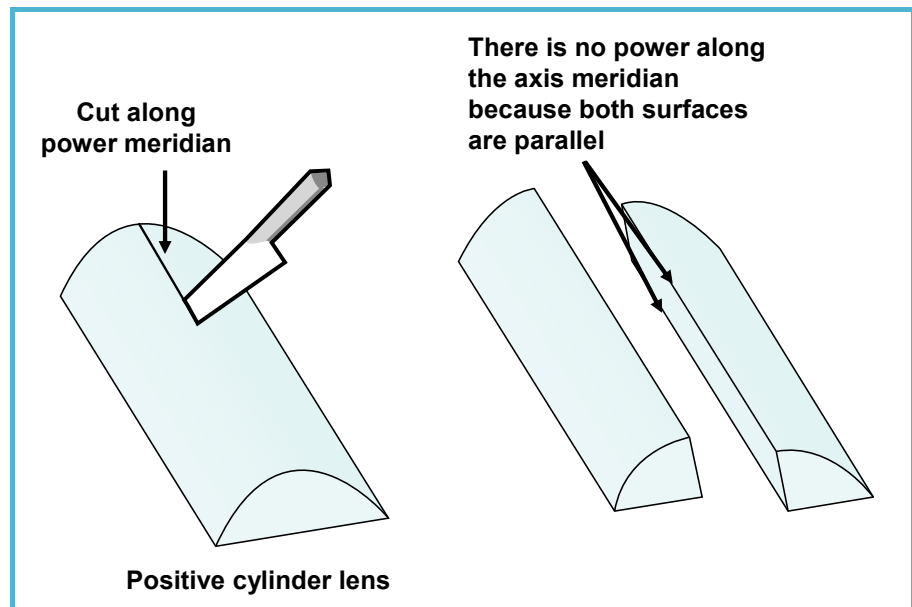


Figure 5.5: Cutting a plus cylindrical lens in half along its axis meridian

CYLINDRICAL LENSES (cont.)

CUTTING CYLINDRICAL LENSES (cont.)

Now, if we cut the cylindrical lens in any direction between the power meridian and the axis meridian (Figure 5.6), the upper surface becomes less curved the closer the cut is to the axis meridian. This means that the maximum power of a cylindrical lens is only along the power meridian, and the power at any meridian becomes less as it gets closer to the axis meridian where the power is zero.

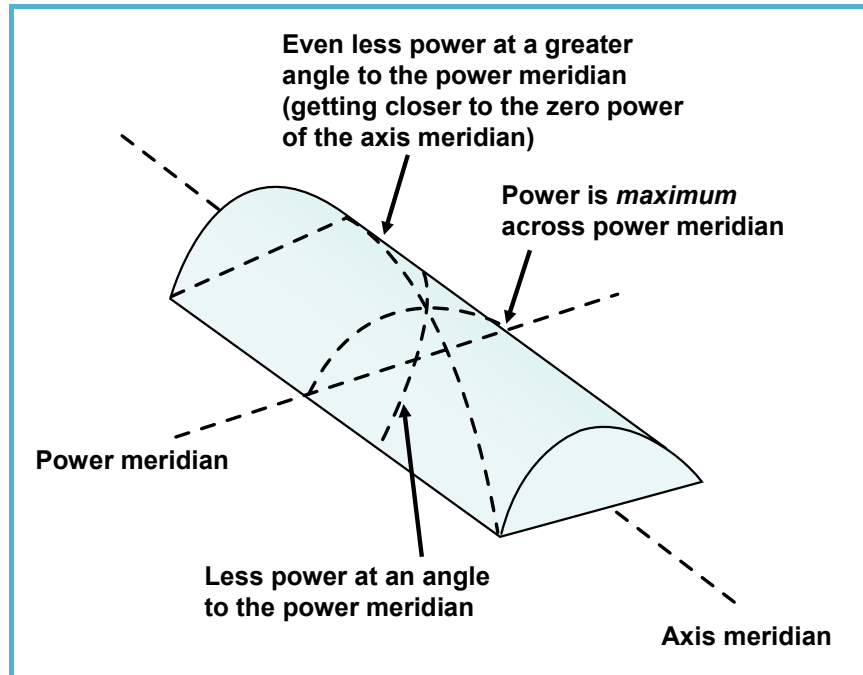


Figure 5.6: Power and axis meridian

REFRACTION OF LIGHT THROUGH A CYLINDRICAL LENS

Cylindrical lenses and spherical lenses refract light rays differently:

- Spherical lenses refract incident parallel light rays to a single focal point or virtual focal point.
- Cylindrical lenses refract incident parallel light rays to a focal line or virtual focal line.

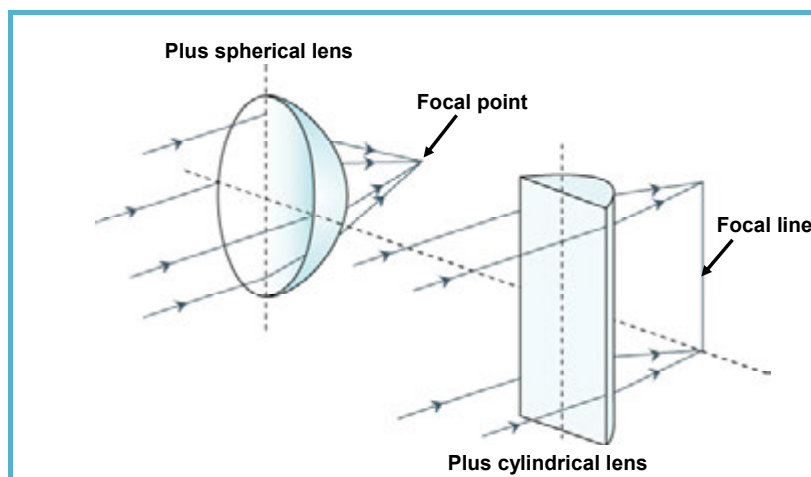


Figure 5.7: A plus spherical lens and a plus cylindrical lens refracting incident parallel light

Figure 5.7 shows the plus spherical lens refracting the incident parallel rays to a single focal point; while a plus cylinder lens refracts light to a focal line rather than a single focal point. You can see that the focal line is perpendicular (at 90°) to the power meridian.

CYLINDRICAL LENSES (cont.)

REFRACTION OF LIGHT THROUGH A CYLINDRICAL LENS (cont.)

Figure 5.8 shows parallel incident rays of light being refracted by a minus spherical lens and a minus cylindrical lens. The minus spherical lens forms a virtual focal point. The minus cylindrical lens forms a virtual focal line.

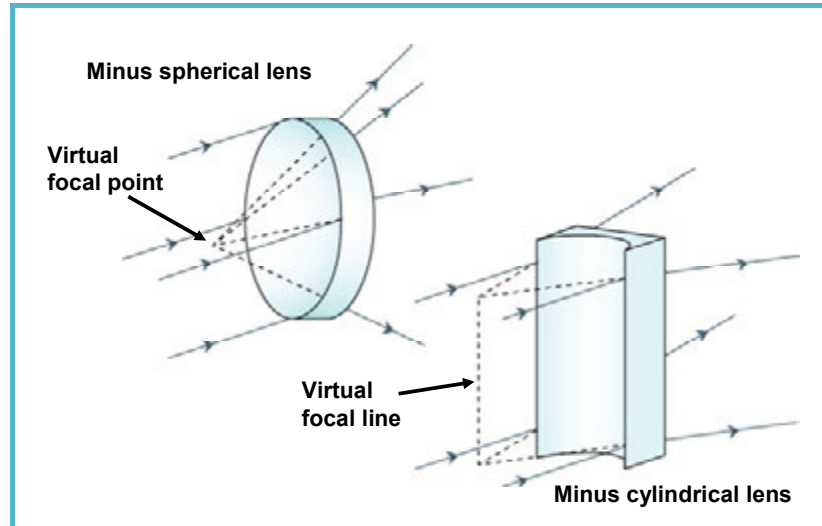


Figure 5.8: A minus spherical lens and a minus cylindrical lens refracting incident parallel light

SPHERO-CYLINDRICAL LENSES

Sphero-cylindrical lenses are also called sphero-cylinder lenses or just sphero-cyls.

Even though sphero-cylindrical lenses are just single lenses, they can be thought of as:

- two cylindrical lenses that have been stuck together perpendicularly (at 90°), or
- a spherical lens that is stuck to a cylindrical lens.

Sphero-cylindrical lenses have power in both principal meridians, but a different power in each:

- The power meridian has the maximum focusing power;
- The axis meridian has the minimum focusing power.

Unlike cylindrical lenses, the axis meridian of a sphero-cylindrical lens has a power that is greater than zero. This means that a plus sphero-cylindrical lens forms two focal lines, and a minus sphero-cylindrical lens forms two virtual focal lines (not just one like a cylindrical lens).

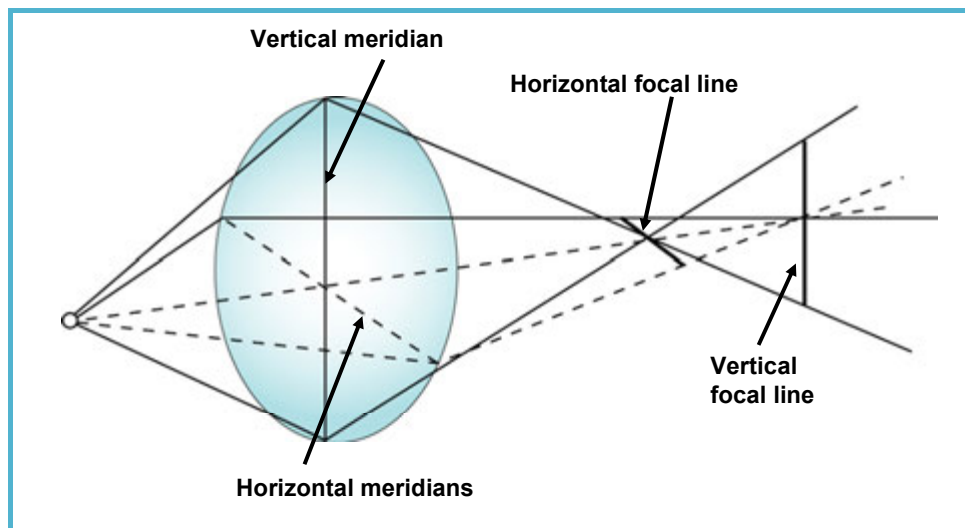


Figure 5.9: A plus sphero-cylindrical lens forms two focal lines

STANDARD AXIS NOTATION

Standard notation is used to show the direction of the power meridian of a cylindrical or a sphero-cylindrical lens.

For both right and left eyes we measure anti-clockwise from the horizontal meridian in degrees (°).

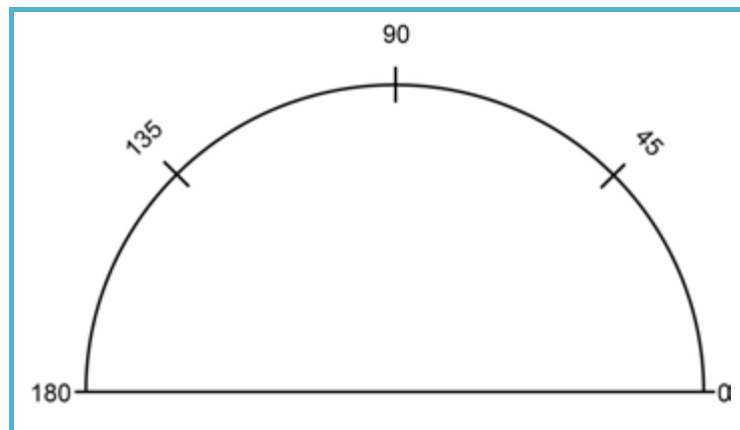


Figure 5.10: Axis scale used for measuring the orientation of cylindrical lenses

Although the horizontal line is both 0 and 180, we always call it 180. Therefore, the axis of a cylindrical or sphero-cylindrical lens can be anything between 1 and 180.

Usually, we also do not use the degree sign (°) because it can be confused with a zero (0).

POWER OF ASTIGMATIC LENSES

We measure the power of astigmatic lenses in dioptres cylinder. The short way of writing this is DC.

WRITING SPHERO-CYLINDRICAL LENS POWERS

When you write a sphero-cylindrical lens prescription, you need to write both the spherical part and the cylindrical part of the lens power. You also need to write what orientation (direction) the axis of the cylinder is in using standard axis notation.

Example:

Sphere power

−4.00 D

−1.00 DC x 90

Cylindrical power

Axis

or: −4.00 D / −1.00 DC x 90

or simply: −4.00 / −1.00 x 90

We say: “Minus four, minus one, axis ninety”.

ASTIGMATIC LENS SHAPE

The thickness of the edge of an astigmatic lens is different at different places around its edge.

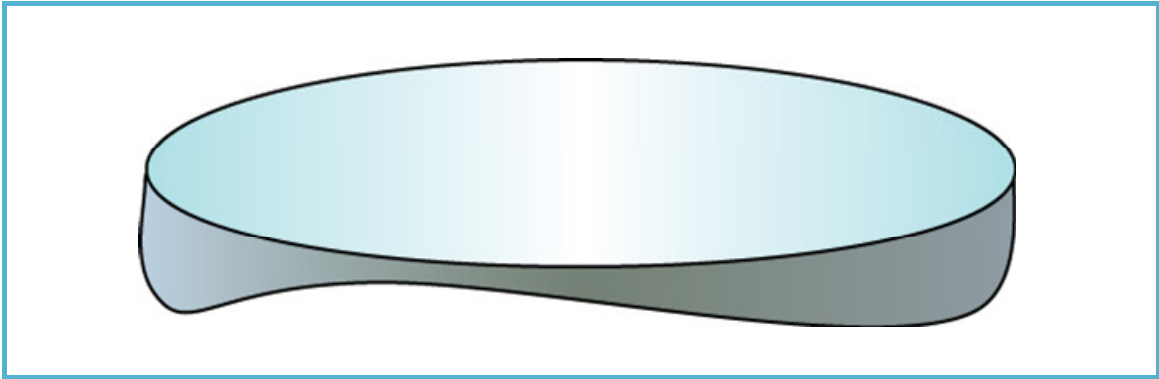


Figure 5.11: *The edge thickness of a cylindrical lens varies*

Just like spherical lenses, astigmatic lenses can come in different shapes.

Astigmatic lens surfaces can be:

- Plano (flat)
- Convex (curved like the outside of a ball)
- Concave (curved like the inside of a ball).

SUMMARY: ASTIGMATIC LENSES

ASTIGMATIC LENSES

Astigmatic Lenses and the Eyes:

- Cylindrical lenses correct astigmatism.
- Sphero-cylindrical lenses correct astigmatism combined with another refractive error (hyperopia, myopia or presbyopia).

Meridians:

- A meridian is an imaginary line which crosses a lens at its optical centre.
- An astigmatic lens has two principal meridians:
 - axis meridian (minimum power meridian)
 - power meridian (maximum power meridian).
- The meridians of a spherical lens are all equal in power.

CYLINDRICAL LENSES

- Cylindrical lenses correct astigmatism.
- Cylindrical lenses can be minus or plus powered.
- The two principal meridians of a cylindrical lens have different powers:
 - the power meridian has the maximum focusing power
 - the axis meridian has the zero focusing power (plano).

Refraction of Light Through a Cylindrical Lens:

- Spherical lenses refract incident parallel light to a single focal point or virtual focal point.
- Cylindrical lenses refract incident parallel light to a single focal line or virtual focal line.
- The focal line of a cylindrical lens is perpendicular to its power meridian.

SPHERO-CYLINDRICAL LENSES

- Sphero-cylindrical lenses correct astigmatism that is combined with myopia, hyperopia or presbyopia.
- Sphero-cylindrical lenses are single lenses, but they are like:
 - two cylindrical lenses that have been stuck together, or
 - a spherical lens that is stuck to a cylindrical lens.
- The two principal meridians of a sphero-cylindrical lens have different powers:
 - the power meridian has the maximum focusing power
 - the axis meridian has the minimum focusing power.

Refraction of Light Through a Sphero-Cylindrical Lens:

- Sphero-cylindrical lenses refract incident parallel light to two focal lines or virtual focal lines.

STANDARD AXIS NOTATION

- Used to show the direction of the power meridian of an astigmatic lens.
- Measured in degrees in an anti-clockwise direction from 1 to 180.

POWER OF ASTIGMATIC LENSES

- We measure astigmatic lens power in dioptres cylinder. The short way of writing this is DC.
- Writing a sphero-cylindrical lens prescription, you need to write:
 - spherical part of the lens power;
 - cylindrical part of the lens power;
 - axis of the cylinder using standard axis notation.

ASTIGMATIC LENS SHAPE

- The thickness of an astigmatic lens changes at different places around its edge.
- The thickness of a spherical lens is constant around its edge.

TEST YOURSELF QUESTIONS

1. How is an astigmatic lens different from a spherical lens?

2. What are the two principal meridians of an astigmatic lens? How are they different?

3. Is the focal line formed by a cylindrical lens in the same direction as the power meridian or the axis meridian?

4. What kind of refractive error(s) does a spherocylindrical lens correct?

5. What is the axis of this spherocylindrical lens: $-5.25 / -1.25 \times 67$?



OPTICAL CROSSES AND TRANSPOSITION

THINK

A woman comes to your clinic to buy a pair of spectacles. She had her eyes examined at another clinic last week and shows you the prescription for spectacles that she was given.

You notice that the prescription has been written using plus cylinder notation – but at your clinic you use minus cylinder notation.

How will you transpose the plus cylinder prescription into a minus cylinder prescription so that you can make the spectacles for the woman?

AIM

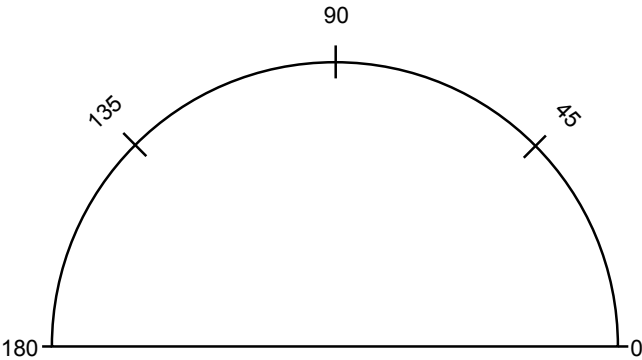
This unit will show you how to use optical crosses and how to transpose spectacle prescriptions.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- draw and use an optical cross to examine the powers of the principal meridians of a spherocylindrical lens
- transpose plus and minus cylinder prescription notations.

REVIEW: OPTICAL CROSSES AND TRANSPOSITION

SPHERICAL LENSES	- A spherical lens has the same refractive power along all of its meridians. - A spherical lens does not have an axis meridian.
CYLINDRICAL LENSES	- Cylindrical lenses correct astigmatism. - Cylindrical lenses have two meridians: an axis meridian and a power meridian. - There is no refractive power along the axis meridian. There is only refractive power along the power meridian.
SPHERO-CYLINDRICAL LENSES	- A sphero-cylindrical lens can be thought of as being the same as a spherical lens that is joined to a cylindrical lens. - Sphero-cylindrical lenses correct astigmatism that is combined with another refractive error (myopia, hyperopia or presbyopia). - The two principal meridians of a sphero-cylindrical lens have different powers: → Power meridian has the maximum focusing power → Axis meridian has the minimum focusing power - Astigmatic lenses can be cylindrical or sphero-cylindrical lenses.
POWER OF ASTIGMATIC LENSES	- We measure astigmatism lens power in dioptres cylinder. The short way of writing this is DC. - The power of a sphero-cylindrical lens is written like this: Sphere power $\begin{array}{r} +2.00 \text{ D} \\ \hline -1.25 \text{ DC} \times 70 \end{array}$ Cylinder power Axis or: $+2.00 \text{ D} / -1.25 \text{ DC} \times 70$ or simply: $+2.00 / -1.25 \times 70$ We read this lens power as: "Plus two, minus one point two five, axis 70". - The axis of a lens is always between 1° and 180° - We use standard axis notation for the axis direction.
STANDARD AXIS NOTATION	

OPTICAL CROSSES

SPHERO-CYLINDRICAL LENSES

We know that a sphero-cylindrical lens can be thought of as a cylindrical lens and a spherical lens joined together.

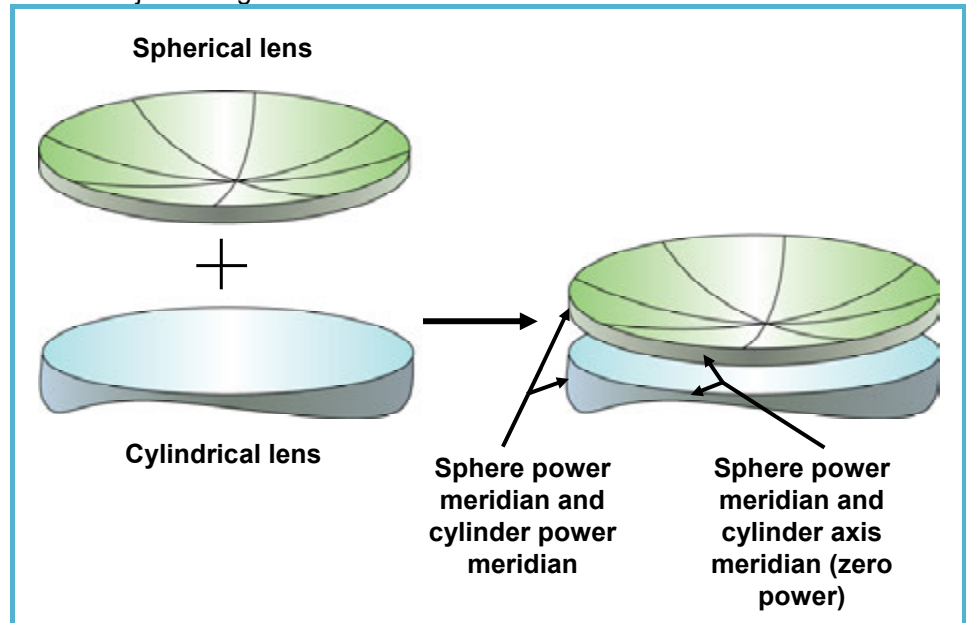


Figure 6.1: A sphero-cylindrical can be thought of as a cylindrical lens and a spherical lens joined together

A sphero-cylindrical lens has power in two different principal meridians. These meridians are always perpendicular (at 90°) to each other.

OPTICAL CROSS:

An optical cross is a diagram which shows the orientation (direction) of the principal meridians of an astigmatic lens and the focusing power of the lens in these meridians. It can help you to understand the actual powers that an astigmatic lens has.

Drawing an optical cross:

An optical cross is drawn with two perpendicular lines that represent the two principal meridians of an astigmatic lens.

Steps:

1. Draw a line in the direction of the axis of the cylindrical lens
→ this is your axis meridian line.
2. Draw a second line perpendicular (at 90°) to the first line
→ this is your power meridian line.
3. Write the sphere power next to the axis meridian line.

Add the cylindrical power to the sphere power and write this number next to the power meridian line.

REMEMBER:

The axis meridian of a cylindrical lens has no power.

In Step 3 you are actually adding the power of the cylindrical lens at its axis meridian (which is zero) to the sphere power (which is the same in all meridians).

To make it simple, for Step 3 we just say that we are using the sphere power only.



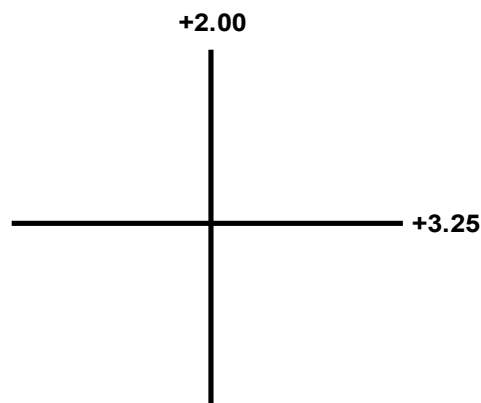
OPTICAL CROSSES (cont.)

EXAMPLE 1

Draw an optical cross for this sphero-cylindrical lens: $+3.25 / -1.25 \times 180$

Steps:

1. Draw a line in the direction of the axis of the cylindrical lens
→ The axis meridian line will be at 180°
2. Draw a second line perpendicular to the first line
→ The power meridian is at 90°
3. Write the sphere power next to the axis meridian line
→ $+3.25$
4. Add the cylindrical power to the sphere power and write this number next to the power meridian line
→ $+3.25 + (-1.25) = +2.00$



Now we can see that this sphero-cylindrical lens has power in both principal meridians:

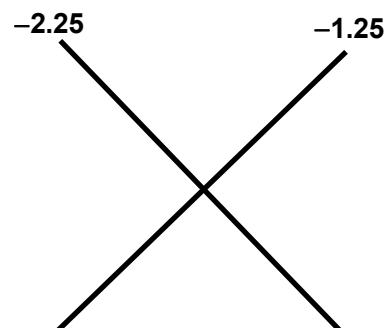
- $+2.00$ DC power at 90°
- $+3.25$ DC power at 180° .

EXAMPLE 2

Draw an optical cross for this sphero-cylindrical lens: $-1.25 / -1.00 \times 60$.

Steps:

1. Draw a line in the direction of the axis of the cylindrical lens
→ The axis meridian line will be at 60°
2. Draw a second line perpendicular to the first line
→ The power meridian is at 150°
3. Write the sphere power next to the axis meridian line
→ -1.25
4. Add the cylindrical power to the sphere power and write this number next to the power meridian line
→ $-1.25 + (-1.00) = -2.25$



Now we can see that this sphero-cylindrical lens has power in both principal meridians:

- -1.25 DC power at 60°
- -2.25 DC power at 150° .

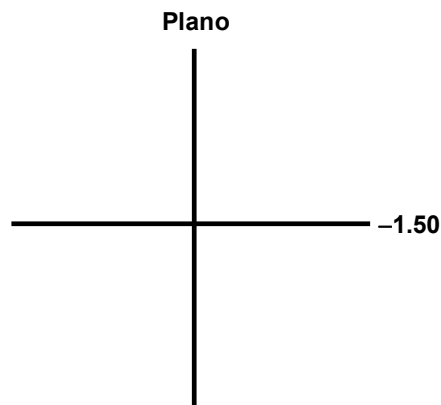
OPTICAL CROSSES (cont.)

EXAMPLE 3

Draw an optical cross for this cylindrical lens: plano / -1.50×90 .

Steps:

1. Draw a line in the direction of the axis of the cylindrical lens
→ The axis meridian line will be at 90° (vertical)
2. Draw a second line perpendicular to the first line
→ The power meridian is at 180° (horizontal)
3. Write the sphere power next to the axis meridian line
→ Plano
4. Add the cylindrical power to the sphere power and write this number next to the power meridian line
→ $0.00 + (-1.50) = -1.50$



Now we can see that this cylindrical lens has power in just one of its principal meridians:

- no (plano) power at 90° and
- -1.50 DC power at 180° .

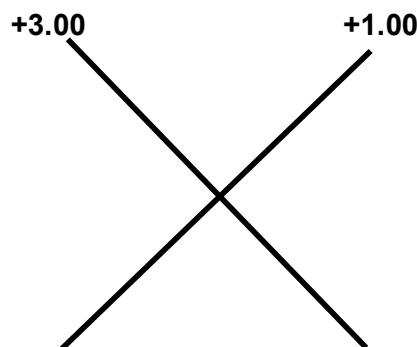
EXAMPLE 4

Draw an optical cross for this sphero-cylindrical lens: $+1.00 / +2.00 \times 45$.

(Note: this sphero-cylindrical lens has been written in plus cylindrical notation.)

Steps:

1. Draw a line in the direction of the axis of the cylindrical lens
→ The axis meridian line will be at 45°
2. Draw a second line perpendicular to the first line
→ The power meridian is at 135°
3. Write the sphere power next to the axis meridian line
→ $+1.00$
4. Add the cylindrical power to the sphere power and write this number next to the power meridian line
→ $+1.00 + (+2.00) = +3.00$.



Now we can see that this sphero-cylindrical lens has power in both principal meridians:

- $+1.00$ DC power at 45°
- $+3.00$ DC power at 135° .



The axis meridian always has less focusing power than the power meridian.

MINUS AND PLUS CYLINDER NOTATION

Optical prescriptions can be written in two ways:

- Minus cylinder notation
- Plus cylinder notation.

We usually use minus cylinder notation, but some practitioners choose to use plus cylinder notation. Both ways are correct, but in your clinic you should choose just one – we recommend that you choose minus cylinder notation.

The examples below show the two ways that an optical prescription can be written. These four notation examples are the same as the optical cross examples that were drawn on the previous pages.

	MINUS CYLINDER NOTATION		PLUS CYLINDER NOTATION
Example 1	+3.25 / –1.25 x 180	<i>is the same as</i>	+2.00 / +1.25 x 90
Example 2	–1.25 / –1.00 x 60	<i>is the same as</i>	–2.25 / +1.00 x 150
Example 3	Plano / –1.50 x 90	<i>is the same as</i>	–1.50 / +1.50 x 180
Example 4	+3.00 / –2.00 x 135	<i>is the same as</i>	+1.00 / +2.00 x 45

TRANSPPOSITION

Transposition is used to change a prescription from:

- minus cylinder notation to plus cylinder notation; or
- plus cylinder notation to minus cylinder notation.

METHOD FOR TRANSPPOSITION	Steps: 1. Add the sphere power to the cylinder power → This will be the new sphere power. 2. Change the sign of the cylinder power. 3. Change the axis by 90°.
EXAMPLE 1	+3.25 / -1.25 × 180 is written in minus cylindrical notation. Transpose it to plus cylindrical notation. Steps: 1. Add the sphere power to the cylinder power → This is the new sphere power $+3.25 + (-1.25) = +2.00$ 2. Change the sign of the cylinder → -1.25 changes to +1.25 3. Change the axis by 90° → 180° changes to 90°. So +3.25 / -1.25 × 180 becomes +2.00 / +1.25 × 90 .
EXAMPLE 2	-1.25 / -1.00 × 60 is written in minus cylindrical notation. Transpose it to plus cylindrical notation. Steps: 1. Add the sphere power to the cylinder power → This is the new sphere power $-1.25 + (-1.00) = -2.25$ 2. Change the sign of the cylinder → -1.00 changes to +1.00 3. Change the axis by 90° → 60° changes to 150° So -1.25 / -1.00 × 60 becomes -2.25 / +1.00 × 150 .
EXAMPLE 3	Plano / -1.50 × 90 is written in minus cylindrical notation. Transpose it to plus cylindrical notation. Steps: 1. Add the sphere power to the cylinder power → This is the new sphere power $0.00 + (-1.50) = -1.50$ 2. Change the sign of the cylinder → -1.50 changes to +1.50 3. Change the axis by 90° → 90° changes to 180° So pl / -1.50 × 90 becomes -1.50 / +1.50 × 180 .
EXAMPLE 4	+1.00 / +2.00 × 45 is written in plus cylindrical notation. Transpose it to minus cylindrical notation. Steps: 1. Add the sphere power to the cylinder power → This is the new sphere power $+1.00 + (+2.00) = +3.00$ 2. Change the sign of the cylinder → +2.00 changes to -2.00 3. Change the axis by 90° → 45° changes to 135° So +1.00 / +2.00 × 45 becomes +3.00 / -2.00 × 135 .



The optical cross for a lens will never change – only the notation that it is written in can change. This is because we are not changing the powers of the lenses, we are only changing the way they are written.

SUMMARY: OPTICAL CROSSES AND TRANSPOSITION

OPTICAL CROSS

Sphero-Cylindrical Lenses:

- A sphero-cylindrical lens has power in two principal meridians that are perpendicular to each other.
- A sphero-cylindrical lens can be thought of as a cylindrical lens and a spherical lens that are joined together.

Optical Cross:

An optical cross is a diagram which shows the orientation (direction) of the principal meridians of an astigmatic lens and the focusing power of the lens in these meridians.

Drawing an Optical Cross:

- An optical cross is drawn with two perpendicular lines that represent the two principal meridians of an astigmatic lens.
- Steps:
 1. Draw a line in the direction of the axis of the cylindrical lens: this is the axis meridian line
 2. Draw a second line perpendicular to the first line: this is the power meridian line
 3. Write the sphere power next to the axis meridian line.
 4. Add the cyl power to the sphere power and write this number next to the power meridian line.

Minus and Plus Cylinder Notation:

- Optical prescriptions can be written in two ways:
 - minus cylinder notation; or
 - plus cylinder notation.
- Both notations are correct, but in your clinic you should use just one – minus cylinder notation is recommended.

TRANSPOSITION

- Transposition is used to change a prescription from:
 - minus cylinder notation to plus cylinder notation; or
 - plus cylinder notation to minus cylinder notation.

Method for Transposition

Steps:

1. Add the sphere power to the cylinder power
→ This will be the new sphere power.
2. Change the sign of the cylinder power.
3. Change the axis by 90°.

TEST YOURSELF QUESTIONS

1. Why are the two lines of an optical cross always perpendicular (at 90°) to each other?

2. Draw optical crosses for the following prescriptions:

a) $+4.00 / -1.00 \times 90$	b) $-3.00 / -1.25 \times 60$	c) Plano / -1.75×135
d) $+2.00 / -2.00 \times 180$	e) $+1.00 / -1.50 \times 45$	f) $-1.00 / -1.50 \times 90$

3. Transpose the following prescriptions into minus cyl notation:

$+2.00 / +0.75 \times 90$

$-3.50 / +1.50 \times 150$

Plano / $+1.25 \times 60$

$+2.00 / +2.00 \times 45$

$+1.00 / +1.50 \times 80$

NOTES



INTERPUPILLARY DISTANCE

THINK

Have you ever noticed that some people have eyes that are close together, and other people have eyes that are far apart?

You need to know how to measure the distance between a person's eyes before you begin a refraction examination. You also need to know the distance between a person's eyes if you need to order a new pair of spectacles for them.

AIM

This unit will explain how to measure interpupillary distance (also called "PD").

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- define interpupillary distance (PD)
- measure distance PD using the limbus method and the corneal reflex method
- measure and calculate the near PD
- measure distance and near PD using a pupillometer
- explain why PD is important.

REVIEW: INTERPUPILLARY DISTANCE

ANATOMICAL TERMS OF LOCATION	• Anterior = In front of • Posterior = Behind • Superior = Above • Inferior = Below • Nasal = Closer to the nose; further away from the ear • Temporal = Further away from the nose; closer to the ear
PARTS OF THE ANTERIOR EYE	• Cornea → transparent window of the eye located anterior to the iris and the pupil • Sclera → white protective covering of the eyeball • Limbus → located where the cornea and the sclera meet • Iris → the round coloured part of the eye that is located posterior to the cornea • Pupil → the black round hole in the centre of the iris
SPHERICAL LENS SHAPE	• Plus lenses are thicker in the middle than at the edge. • Minus lenses are thinner in the middle than at the edge.
PRISM	• A prism bends light away from its apex. • A plus lens can be thought of as two prisms that are joined base to base. • A minus lens can be thought of as two prisms that are joined apex to apex.
OPTICAL CENTRE OF LENSES	• The optical centre is the only part of a lens that a light ray can travel through without being refracted (bent). • The optical centre of a plus lens is where the lens is thickest. • The optical centre of a minus lens is where the lens is thinnest. • The optical centre of a lens is not always in the centre of a lens.

INTERPUPILLARY DISTANCE (PD)

DEFINITION

The interpupillary distance (PD) is the distance between a person's pupils. This distance is measured in millimetres (mm), and will be different for different people. Most people have a PD between 50 mm and 75 mm.

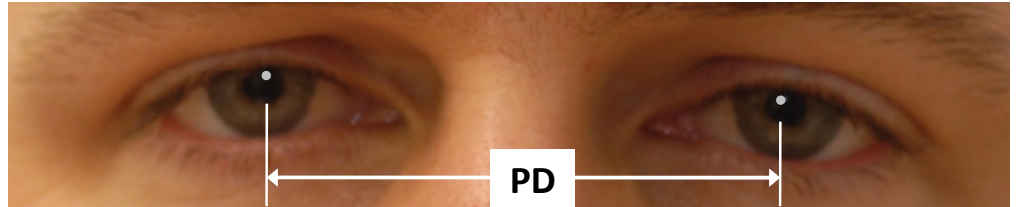


Figure 7.1: Interpupillary distance (PD)

There are two types of PD:

- **Distance PD**

This is the distance between the pupils when a person is looking at something far away.

This is often just called the "PD" instead of "distance PD".

- **Near PD**

This is the distance between the pupils when a person is looking at something that is close to them.

This will always be called "near PD".



When a person is looking far away, their eyes are further away from each other.

This is the resting position for the eyes.

When a person is looking at something close, their eyes turn in and are closer to each other. For this reason, near PD is less than distance PD.

When the eyes turn in we say that the eyes are converging.

PD MEASUREMENT

The PD is the distance between the centre of one pupil and the centre of the other pupil.

PD can be measured in two ways:

- with a PD rule (a small rule) and a pen torch
- with a pupillometer (a piece of equipment designed especially for measuring PDs).



The PD measurement needs to be accurate to within 0.5 mm.

If the PD measurement is not accurate, your refraction and the glasses that you make may be incorrect.

MEASURING DISTANCE PD WITH A PD RULE

If the PD is measured with a PD rule (a small ruler), it can be hard to see exactly where the centre of each pupil is. For this reason, special methods are used to measure PD.

These methods include:

- the limbus method
- the corneal reflex method.

To measure the PD you need to close each of your eyes, one at a time.

It is very important that you always:

- look at the person's right eye with your left eye (keeping your right eye closed)
- look at the person's left eye with your right eye (keeping your left eye closed).

If you do not do this your PD measurement will not be accurate.

It is also important that the person and the examiner are at the same eye level, and that both of you stay still while the measurement is taken.

LIMBUS METHOD



REMEMBER:

The limbus is the part of the eye where the clear cornea meets the white sclera.

Because the clear cornea covers the coloured part of the eye, when we look at a person's eye we see the limbus as the circle where the coloured part of the eye meets the white of the eye.

The limbus method measures PD by measuring the distance between the right eye's temporal (outer) limbus and the left eye's nasal (inner) limbus. It is easier to see the limbus than it is to know exactly where the centre of the pupil is – especially in people who have dark coloured eyes.

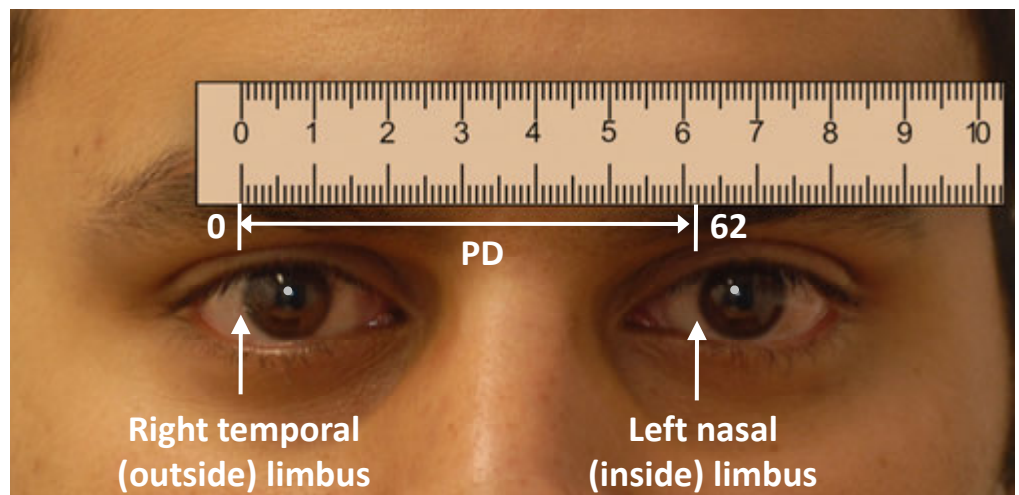


Figure 7.2: Measuring distance PD using the limbus method

The person shown in Figure 7.2 has a PD of 62 mm.

MEASURING DISTANCE PD WITH A PD RULE (cont.)

LIMBUS METHOD (cont.)

This measurement will be approximately the same as if you measured from pupil centre to pupil centre, because the distance from the centre of the pupil to the limbus is usually the same in both eyes.

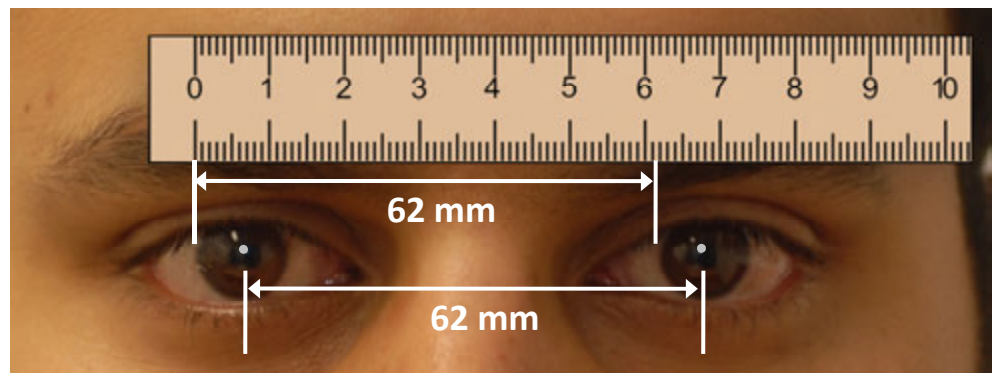
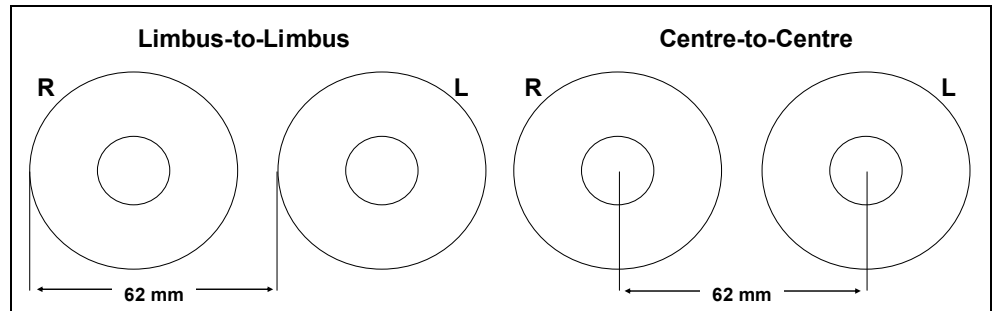


Figure 7.3: Limbus-to-limbus = centre-to-centre

For very young children or those with strabismus or nystagmus, the PD can be measured by measuring from the outer canthus of the right eye to the inner canthus of the left eye – but this method is not as accurate as the limbus method.

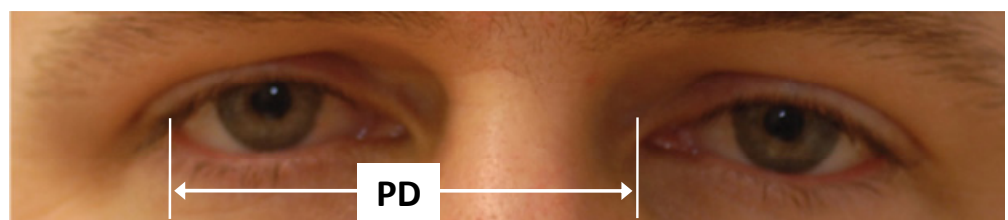


Figure 7.4: Outer canthus of right eye to inner canthus of left eye

MEASURING DISTANCE PD WITH A PD RULE (cont.)

METHOD

- **Step 1:**
Make sure that you are in good lighting, so that you can clearly see the person's eyes and the markings on the PD rule.
- **Step 2:**
Stand or sit facing the person – about 40 cm away from them.

Make sure your eyes are at the same height as their eyes (you may need to make yourself higher or lower). If the person is taller than you, you may both need to sit down. You also need to be directly opposite the person (not to the left or to the right of them).
- **Step 3:**
Tell the person: *"I am going to measure the distance between your eyes"*.
- **Step 4:**
Gently place the PD rule on the person's nose or forehead.



Figure 7.5: Measuring PD



You can rest one or two of your fingers on the person's cheek or forehead to help keep the PD rule still.

- **Step 5:**
Close your right eye and ask the person to look at your open (left) eye.
Say: *"Look at my open eye"*.
Sometimes, it helps if you use your finger or a pen to point to your open eye.
- **Step 6:**
Look at the temporal (outside) limbus of the person's right eye. Move the PD rule so that the zero mark on the PD rule is lined up with the right temporal limbus.



Once you have lined up the zero mark, make sure you do not move the PD rule or your head. Your head and the PD rule (and the zero mark) must stay in the same position while you are measuring.

MEASURING DISTANCE PD WITH A PD RULE (cont.)

METHOD (cont.)	Step 7: Now open your right eye and close your left eye. Ask the person to look at the eye that is open now (your right eye). Say: <i>"Look at my open eye"</i>. Step 8: Look at the nasal (inside) limbus of the person's left eye. Look at the number on the PD rule that is lined up with the left nasal limbus. This number is the person's distance PD measurement. Step 9: Repeat steps 4 to 8 to check the PD measurement. If your second measurement is not the same as your first measurement, repeat steps 4 to 8 again, until you get two readings that are the same.
CORNEAL REFLEX METHOD	If we shine a light in front of a person's eyes, the light will reflect from the centre of each of their pupils. These reflections are called corneal reflexes. The distance between each of these corneal reflexes is the person's PD. Method: Step 1: You need to take this measurement in normal or low lighting. Be careful that there are no extra light sources (e.g. windows, ceiling lights) in front of the person – otherwise you might see extra reflections in the person's eyes. If you cannot avoid extra light sources, it helps if the person sits with their back towards any extra light sources. Step 2: Stand or sit facing the person – about 40 cm away from them. Make sure your eyes are at the same height as their eyes (you may need to make yourself higher or lower). If the person is taller than you, you may both need to sit down. You also need to be directly opposite the person (not to the left or to the right of them). Step 3: Tell the person: <i>"I am going to measure the distance between your eyes"</i>. Step 4: Gently place the PD rule on the person's nose or forehead. Step 5: Close your right eye and ask the person to look at your open (left) eye. Say: <i>"Look at my open eye"</i>. Step 6: Hold a pen torch below your left eye. Shine the pen torch into the person's right eye. Step 7: Look at the corneal reflex in the person's right eye. Move the PD rule so that the zero mark on the PD rule is lined up with this corneal reflex.  Once you have lined up the zero mark, make sure you do not move the PD rule and do not move your head. Your head and the PD rule (and the zero mark) must stay in the same position while you are measuring.

MEASURING DISTANCE PD WITH A PD RULE (cont.)**CORNEAL REFLEX
METHOD (cont.)**

- **Step 8:**
Now hold the pen torch below your right eye.
Shine the pen torch into the person's left eye.
- **Step 9:**
Open your right eye and close your left eye.
Ask the person to look at the eye that is open now (your right eye).
Say: *"Look at my open eye"*.
- **Step 10:**
Look at the corneal reflex in the person's left eye.
Look at the number on the PD rule that is lined up with this corneal reflex.
This number is the person's distance PD measurement.
- **Step 11:**
Repeat steps 4 to 10 to check the PD measurement.
If your second measurement is not the same as your first measurement,
repeat steps 4 to 10 again, until you get two readings that are the same.

MEASURING NEAR PD WITH A PD RULE

The near PD is the distance between the pupils when a person is looking at something close to their eyes. When a person looks at something that is close to them, their eyes converge (move closer together). This means that the near PD will always be less than the distance PD.

There are two ways to find the near PD with a PD rule:

- corneal reflex method
- calculation method.

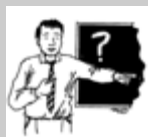
It is more accurate to measure near PD using the corneal reflex method (using a PD rule and a pen torch). The calculation method is less accurate.

CORNEAL REFLEX METHOD

Method:

- **Step 1:**
You need to take this measurement in normal or low lighting. Be careful that there are no extra light sources (e.g. windows, ceiling lights) in front of the person – otherwise you might see extra reflections in the person's eyes. If you cannot avoid extra light sources, it helps if the person sits with their back towards any extra light sources.
- **Step 2:**
Stand or sit facing the person – 40 cm away from them.

Make sure your eyes are at the same height as their eyes (you may need to make yourself higher or lower). If the person is taller than you, you may both need to sit down. You also need to be directly opposite the person (not to the left or to the right of them).
- **Step 3:**
Tell the person: *"I am going to measure the distance between your eyes"*.
- **Step 4:**
Gently place the PD rule on the person's nose or forehead.
- **Step 5:**
Hold a pen torch below your dominant eye.
Shine the pen torch on the bridge (top) of the person's nose.



Your dominant eye:

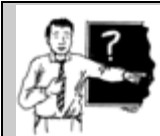
Everybody has an eye that they prefer to use – this is called their dominant eye.

There are several ways to find out which of your eyes is dominant. An easy way is to:

- Point to an object in the distance. Keep both of your eyes open.
- Close your right eye.
Are you still pointing to the object?
Yes → you are left eye dominant
No → you are probably right eye dominant.

Close your left eye.
Are you still pointing to the object?
Yes → you are right eye dominant
No → you are probably left eye dominant.

MEASURING NEAR PD WITH A PD RULE (cont.)

CORNEAL REFLEX METHOD (cont.)	• Step 6: Keep your dominant eye open, and close your other eye. Ask the person to look at your nose. Say: "Look at my nose". • Step 7: Look at the corneal reflex in the person's right eye. Move the PD rule so that the zero mark on the PD rule is lined up with this corneal reflex. • Step 8: Look at the corneal reflex in the person's left eye. Look at the number on the PD rule that is lined up with this corneal reflex. This number is the person's near PD measurement. • Step 9: Repeat steps 5 to 8 to check the PD measurement. If your second measurement is not the same as your first measurement, repeat steps 5 to 8 again until you get two readings that are the same.
CALCULATION METHOD	Sometimes it is not possible to measure the near PD using the corneal reflex method. If this is the case you can calculate the near PD instead of measuring it .– but remember, calculating near PD is not as accurate as measuring it using the corneal reflex method. Method: • Step 1: Measure the distance PD using the: - limbus method, or - corneal reflex method. • Step 2: Calculate the near PD: - If the distance PD is more than 64 mm, we subtract 4 mm from distance PD to find the near PD. - If the distance PD is less than (or equal to) 64 mm, we subtract 3 mm from the distance PD to find the near PD.  If the distance PD is > 64 mm: Near PD = Distance PD – 4 mm If the distance PD is ≤ 64 mm: Near PD = Distance PD – 3 mm
EXAMPLE 1	You measure the distance PD of a man and find that it is 67 mm. What is his near PD? • Distance PD = 67 mm • 67 mm > 64 mm So, Near PD = Distance PD – 4 mm = 67 mm – 4 mm = 63 mm
EXAMPLE 2	You measure the distance PD of a girl and find that it is 57 mm. What is her near PD? • Distance PD = 57 mm • 57 mm < 64 mm So, Near PD = Distance PD – 3 mm = 57 mm – 3 mm = 54 mm

MEASURING THE PD USING A PUPILLOMETER

PUPILLOMETER

A corneal reflex pupillometer (or simply, "pupillometer") is a piece of equipment that measures the distance between the visual axes of the eyes instead of the distance between the pupil centres.

A more accurate PD measurement can be achieved using a pupillometer compared to using a PD rule. A pupillometer can be used to measure both distance and near PD accurately.

- **Advantages** A pupillometer:

- provides a more accurate measurement than a PD rule
- provides a more consistent (repeatable) measurement than a PD rule
- allows you to occlude (cover) each of the person's eyes
This is useful for measuring the PDs of people with strabismus (eye turns)
- allows you to measure monocular PDs (*this can also be done using a special PD rule, but using a pupillometer is faster and more accurate*)
 - A monocular PD measurement is the distance from one eye to the mid-line of a person's face.
The right and the left eyes may have different monocular PDs.
 - Monocular PD measurements are necessary when prescribing special spectacle lenses (such as progressive addition lenses)
- allows you to measure the near PD for several different working distances
- can be used by people with minimal training
- is handheld and portable.

- **Disadvantages:** A pupillometer:

- is much more expensive than a PD rule and a pen torch
- is less portable than a PD rule and a pen torch
- can be more difficult to use on young children.

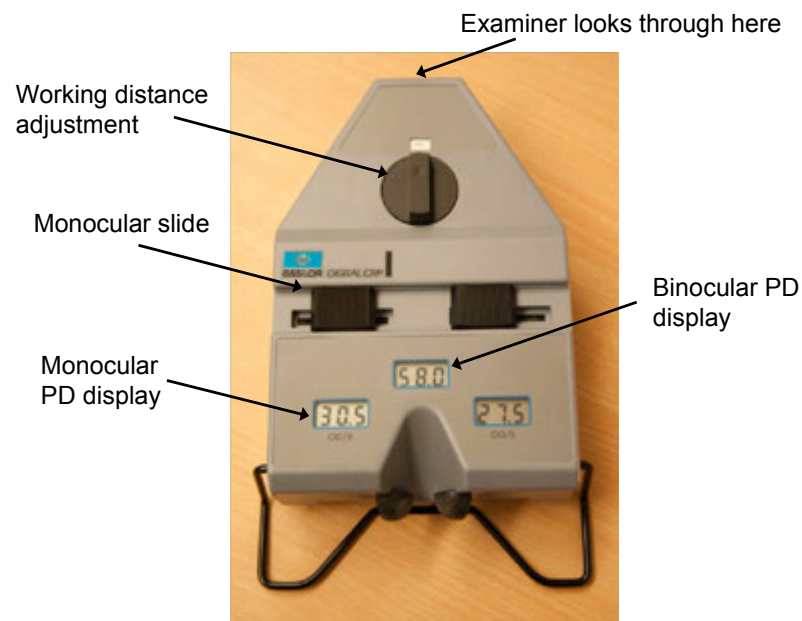


Figure 7.6: A corneal reflex pupillometer

MEASURING THE PD USING A PUPILLOMETER (cont.)

MEASURING DISTANCE PD WITH A PUPILLOMETER

Method:

- Step 1:**

Set the working distance adjustment button to infinity (∞).
This makes the circle target inside the pupillometer look like it is very far away.

Working distance dial
is set to infinity

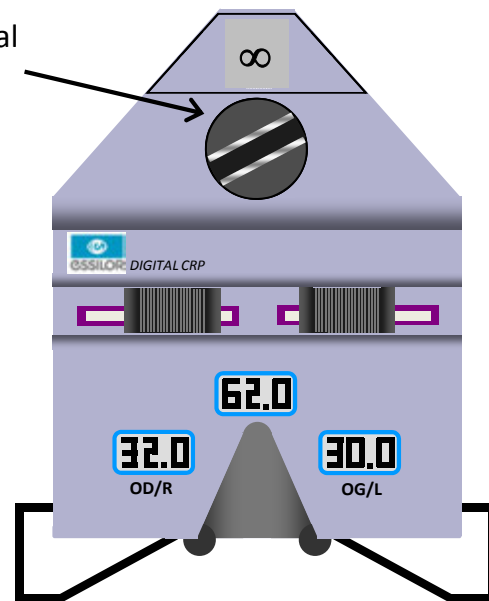


Figure 7.7: Setting the working distance dial to infinity

- Step 2:**

Tell the person: *"I am going to measure the distance between your eyes".*

- Step 3:**

Ask the person to hold the pupillometer as though it was a pair of binoculars.

- Step 4:**

Tell the person to look into the centre of the circle that they see inside the pupillometer.

Say: *"Look at the centre of the circle".*

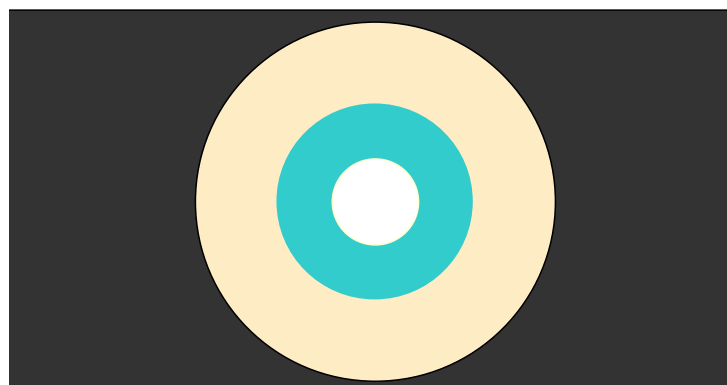


Figure 7.8: What the person sees when they look inside a pupillometer

MEASURING THE PD USING A PUPILLOMETER (cont.)

MEASURING DISTANCE PD WITH A PUPILLOMETER (cont.)

- **Step 5:**
Look into the pupillometer with both of your eyes open.

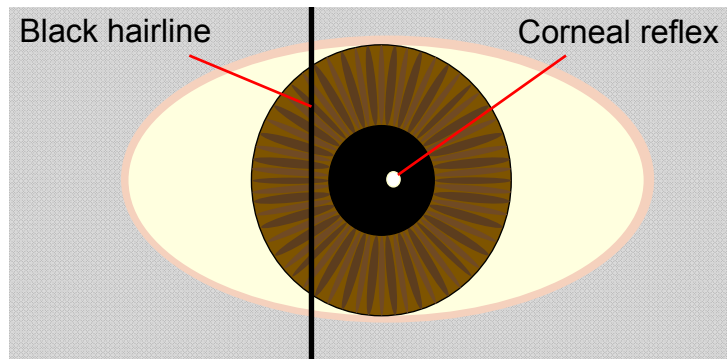


Figure 7.9: What the examiner sees when they look inside a pupillometer

- **Step 6:**
Use the occluder switch to cover the person's left eye, to measure the distance PD of the right eye.
- **Step 7:**
Move the monocular slide in front of the person's right eye until you see the black hairline lined up with the corneal reflex.

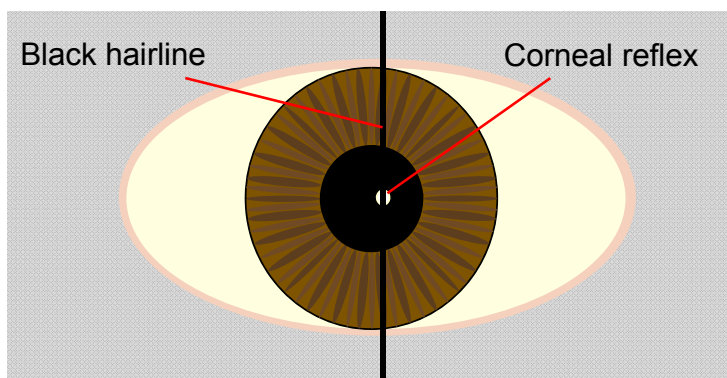


Figure 7.10: The black hairline and the corneal reflex are aligned

- **Step 8:**
Uncover the person's left eye and occlude the person's right eye.
- **Step 9:**
Move the monocular slide in front of the person's left eye until you see the black hairline lined up with the corneal reflex.
- **Step 10:**
Look at the pupillometer PD displays to read the binocular (or monocular) PD.

MEASURING THE PD USING A PUPILLOMETER (cont.)

MEASURING NEAR PD WITH A PUPILLOMETER

Method:

- **Step 1:**
Set the working distance adjustment dial to the person's preferred near working distance (normally 40 cm).
This makes the circle target inside the pupillometer look like it is at this distance.
- **Step 2:**
Tell the person: *"I am going to measure the distance between your eyes"*.
- **Step 3:**
Ask the patient to hold the pupillometer as though it were a pair of binoculars.
- **Step 4:**
Tell the person to look into the centre of the circle that they see inside the pupillometer.
Say: *"Look at the centre of the circle"*

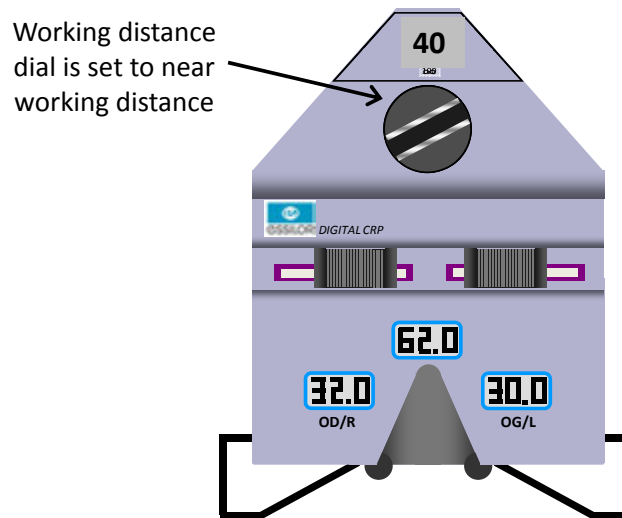


Figure 7.11: The pupillometer working distance is set at 40 cm

- **Step 5:**
Look into the pupillometer with both of your eyes open.
- **Step 6:**
Use the occluder switch to cover the person's left eye, to measure the near PD of the right eye.
- **Step 7:**
Move the monocular slide in front of the person's right eye until you see the black hairline lined up with the corneal reflex.
- **Step 8:**
Uncover the person's left eye and occlude the person's right eye.
- **Step 9:**
Move the monocular slide in front of the person's left eye until you see the black hairline lined up with the corneal reflex.
- **Step 10:**
Look at the pupillometer PD displays to read the binocular (or monocular) PD.

WHY IS PD IMPORTANT?

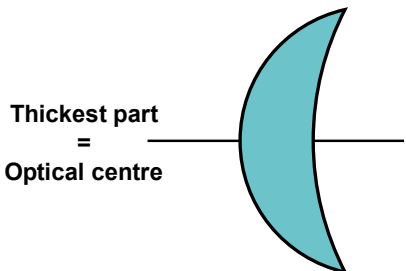
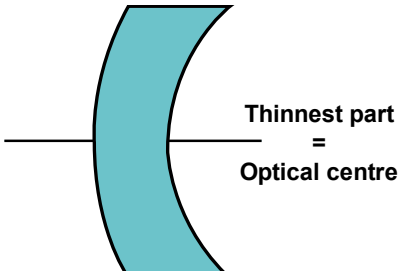
IMPORTANCE OF PD	The PD measurement must be accurate so that the: • refraction examination is accurate, and • spectacles are made correctly.
REFRACTION EXAMINATION AND PD	During a refraction examination, lenses of different powers are put in front of a person's eyes. The optical centres of these lenses must be aligned with the person's eyes otherwise the refraction will be incorrect. Knowing the person's PD measurement allows you to align the optical centres of the lenses with the person's eyes.
SPECTACLES AND PD	When lenses are put into a spectacle frame, the distance between the optical centres of the two lenses should be the same as the person's PD – this will align the optical centres of the lenses with the person's eyes. If a pair of spectacles is made incorrectly – if the optical centres are not aligned with the person's eyes – we say that there is unwanted "prism" in the spectacles. If a person has unwanted prism in their spectacles, they may have the following symptoms: → asthenopia (eye strain or headaches) → dizziness → nausea (stomach discomfort) → double vision → blurred vision. If these symptoms are very bad, the person may not be able to wear their spectacles.  If a person has prism in their spectacles, they may feel uncomfortable. Their symptoms may be so severe that the person will be unable to wear their spectacles. This can happen if: - the PD is measured incorrectly → examiner's error - the distance between the optical centres of the lenses is not the same as the PD → spectacle technician's error. A person is more likely to have problems with prism in their spectacles if they require high-powered lenses.
OPTICAL CENTRES OF LENSES	The optical centre of a lens is usually the: • thickest part of a plus lens, or • thinnest part of a minus lens. Plus lens  Minus lens 

Figure 7.12: Optical centres of lenses

WHY IS PD IMPORTANT? (cont.)

OPTICAL CENTRES OF LENSES (cont.)



Remember:

A lens can be thought of as being made of two prisms.

→ The point where these two prisms touch is the optical centre of the lens.

If the person does not look through the optical centre of a lens, they will be looking through one of these prisms.

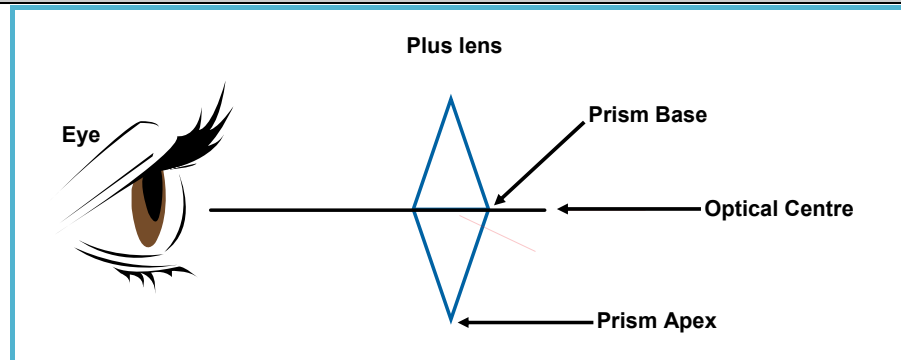


Figure 7.13: A spherical plus lens can be thought of as being like two prisms with their bases together. The part of the lens where the two prism bases meet is the optical centre of the lens. To avoid looking through prism, the person must look through the optical centre of the lens.

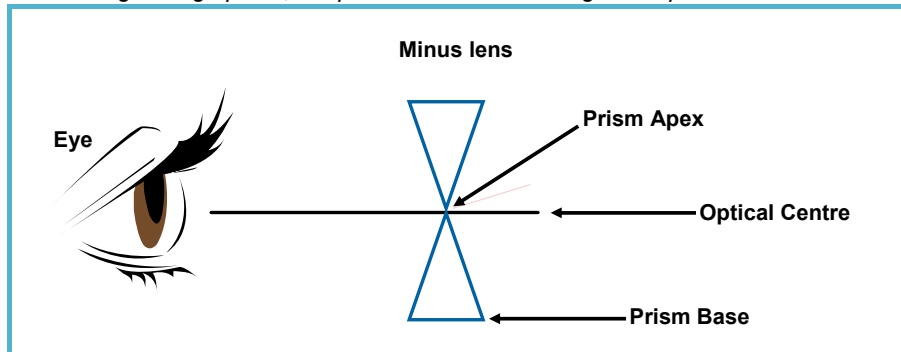


Figure 7.14: A spherical minus lens can be thought of as being like two prisms with their apexes together. The part of the lens where the two prism apexes meet is the optical centre of the lens. To avoid looking through prism, the person must look through the optical centre of the lens.

EXAMPLES

In the diagrams below, you need to imagine that you are looking at a person from above – you are looking down at their eyes and their spectacle lenses.

EXAMPLE 1

The distance between the optical centres (OCD) of two plus lenses is less than the person's PD.

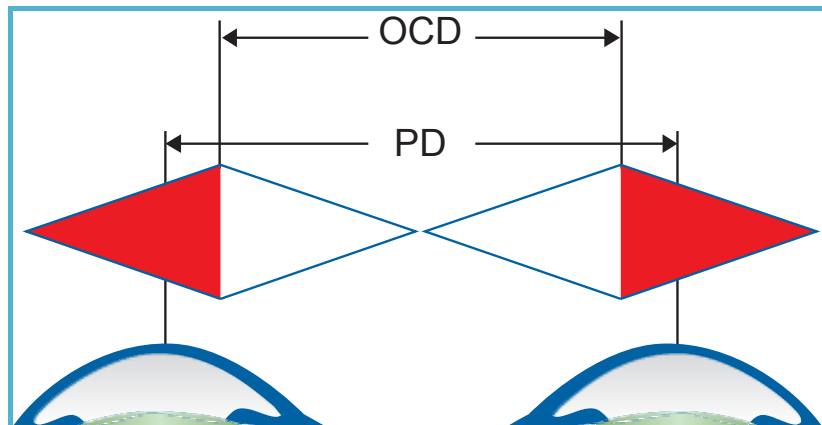


Figure 7.15: Plus spectacle lenses where $OCD < PD$

In this case, the person is looking through prisms with the bases facing each other. This is called "base-in prism".

WHY IS PD IMPORTANT? (cont.)

EXAMPLE 2

The OCD of two plus lenses is greater than the person's PD.

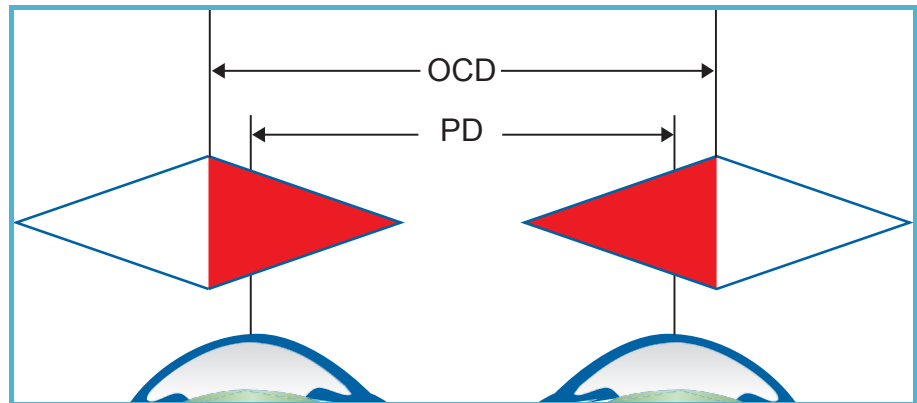


Figure 7.16: Plus spectacle lenses where $OCD > PD$

In this case, the person is looking through prism with the bases facing away from each other. This is called "base-out prism".

EXAMPLE 3

The OCD of two minus lenses is less than the person's PD.

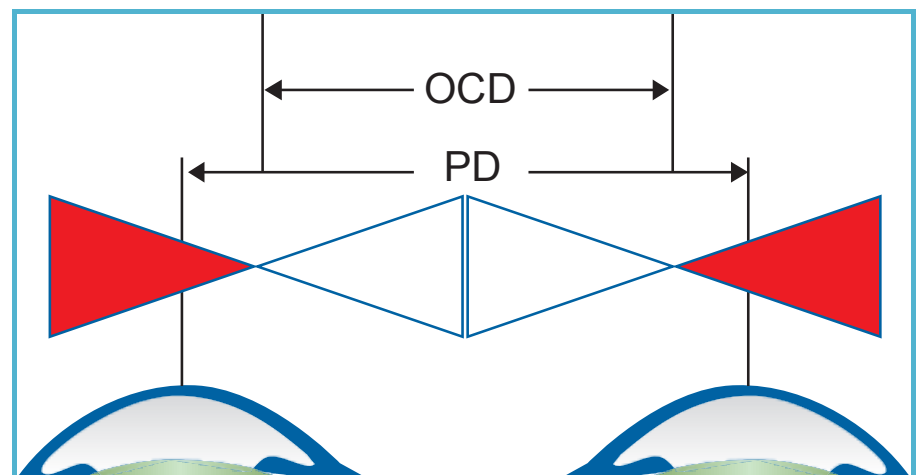


Figure 7.17: Minus spectacle lenses where $OCD < PD$

In this case, the person is looking through prism with the bases facing away from each other. This is called "base-out prism".

EXAMPLE 4

The OCD of two minus lenses is greater than the person's PD.

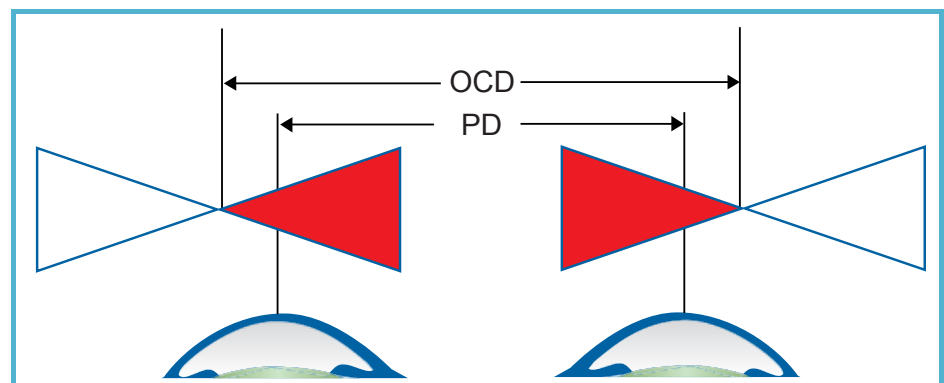


Figure 7.18: Minus spectacle lenses where $OCD > PD$

In this case, the person is looking through prism with the bases facing each other. This is called "base-in prism".

WHY IS PD IMPORTANT? (cont.)

EXAMPLE 5

The OCD of the lenses and the person's PD is the same.

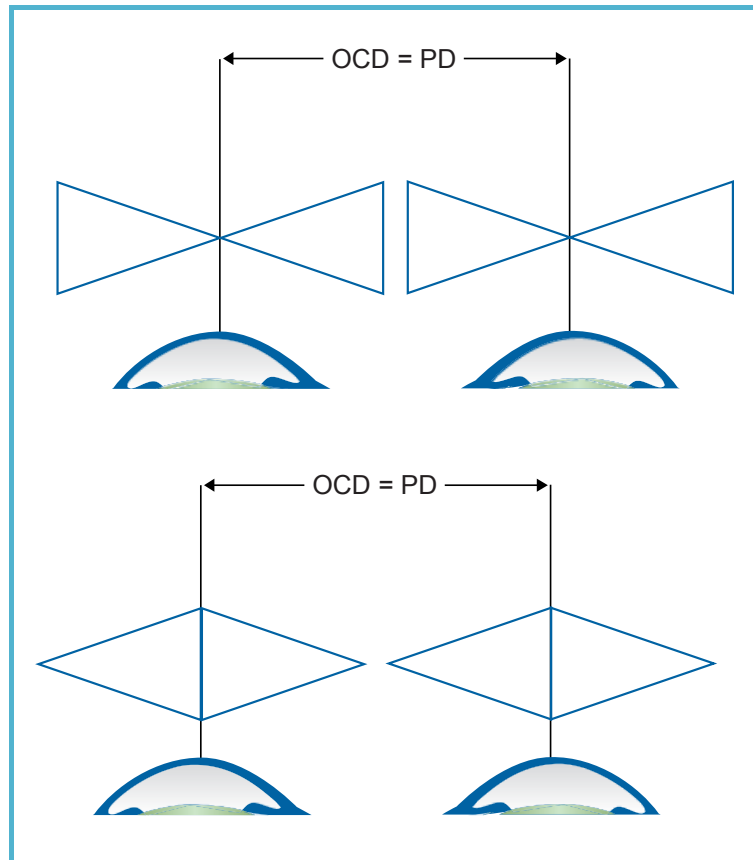


Figure 7.19: Minus spectacle lenses where $OCD = PD$ and plus spectacle lenses where $OCD = PD$. There is no unwanted prism in these spectacles

In these cases the person is looking through the optical centres of the lenses, and not looking through prism in their spectacles. This is the same for both plus and minus lenses.

INTENTIONAL PRISM

Very occasionally, an eye specialist will order spectacles with intentional prism.

In this case the distance between the optical centres will not be equal to the person's PD. This is because the eye specialist deliberately wants the person to look through prism as part of their treatment plan.

Unless you have received binocular vision training, you should never prescribe spectacles like these. If you do, you may cause problems for the person.



Usually:

Distance between optical centres of spectacle lenses = PD.

Rarely:

Distance between optical centres of spectacles lenses $\neq$ PD.

Spectacles that have been made this way should only be prescribed by someone who is specially trained to treat binocular vision problems like strabismus (eye turn or squint).

SUMMARY: INTERPUPILLARY DISTANCE

INTERPUPILLARY DISTANCE (PD)

Definition:

- PD is the distance (in mm) between a person's pupils.
- Distance PD is the distance between a person's pupils when the person is looking at something far away.
- Near PD is the distance between a person's pupils when the person is looking at something that is close to them.
- Distance PD is always greater than near PD, because the eyes converge when they look at things that are close to them.

PD measurement:

- There are two ways to measure PD:
 - with a PD rule (and pen torch)
 - with a pupillometer.

MEASURING DISTANCE PD WITH A PD RULE

- There are two ways to measure distance PD with a PD rule:
 - limbus method
 - corneal reflex method.
- The corneal reflex method is more accurate than the limbus method.

Limbus method:

- Measure the distance between the right temporal limbus and the left nasal limbus.

Corneal reflex method:

- Use a pen torch to reflect light from the centres of the person's pupils.
- Measure the distance between the corneal reflection of each eye.

FINDING NEAR PD WITH A PD RULE

- There are two ways to measure near PD with a PD rule:
 - corneal reflex method
 - calculation method.
- The corneal reflex method is more accurate than the calculation method.

Corneal reflex method:

- Use a pen torch to reflect light from the centres of the person's pupils while the person looks at your nose.
- Measure the distance between the corneal reflection of each eye.

Calculation method:

- Calculate near PD by using the distance PD measurement:
- If distance PD > 64 mm → subtract 4 mm
- If distance PD ≤ 64 mm → subtract 3 mm

SUMMARY: INTERPUPILLARY DISTANCE (cont.)

MEASURING THE PD USING A PUPILLOMETER

- A pupillometer measures the distance between visual axes of the eyes instead of the pupil centres.
- Measuring PD with a pupillometer provides a more accurate measurement than using a PD rule.

WHY IS PD IMPORTANT?

- The PD measurement must be accurate so that the:
 - refraction examination is accurate
 - spectacles are made correctly.

Refraction examination and PD:

- Optical centres of different lenses must be aligned with the person's eyes.

Spectacles and PD:

- The distance between the optical centres of the lenses in a spectacle frame should be the same as the person's PD.
- If this is not the case, prism will be created in the spectacles.
- Usually this is unwanted prism that will give symptoms including:
 - asthenopia
 - dizziness
 - nausea
 - double vision
 - blurred vision.
- Occasionally an eye specialist will put intentional prism into the spectacles.
 - **Unless you have received binocular vision training, you should never prescribe spectacles like these. If you do, you may cause problems for the person.**

TEST YOURSELF QUESTIONS

1. What is interpupillary distance (PD)?

2. What are two methods for measuring distance PD with a PD rule? Which method is more accurate?

3. What are two methods for finding near PD with a PD rule? Which method is more accurate?

4. Why is near PD always less than distance PD?

5. A person's distance PD is 68 mm. Calculate their near PD.

6. Complete the following table:

Advantages of Pupillometers	Disadvantages of Pupillometers

7. Why must the PD measurement be accurate?
- _____
- _____

NOTES

TRIAL SETS AND TRIAL FRAMES

THINK

A person's spectacles contain lenses of a certain power to correct their refractive error. It is rare for two people to have exactly the same refractive error.

During an eye examination we use a specially designed adjustable spectacle frame (called a "trial frame") into which we place various temporary lenses (called "trial lenses"). This lets us change the power of the lenses in front of the person's eyes quickly and accurately, in order to determine their refractive error and the most suitable spectacle prescription.

AIM

This unit introduces you to the features of trial lens sets and trial frames.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- identify and locate spheres, cylinders, prisms and accessories in a trial lens set
- tell the difference between plus and minus lenses
- adjust a trial frame correctly.

REVIEW: TRIAL SETS AND TRIAL FRAMES

REFRACTIVE ERROR	A person who has a refractive error will need to wear spectacles (glasses) or contact lenses so that they can see clearly and comfortably. This is because their eye is not the correct size and shape. There are four main types of refractive error: myopia, hyperopia, astigmatism and presbyopia. An eye examination that tests for refractive error is called a refraction.
LENSES	Lenses refract light to form a focus. Spherical lenses can be plus or minus lenses. Astigmatic lenses can be cylindrical or sphero-cylindrical lenses.
PRISMS	A prism makes light rays change direction by bending them. A prism has a base and an apex, and light is bent away from the apex.
OPTICAL CENTRE	A light ray will not bend if it travels through the optical centre of a lens.
INTERPUPILLARY DISTANCE (PD)	PD is the distance (in mm) between a person's pupils. Distance PD is the distance between a person's pupils when they are looking at something far away. Near PD is the distance between a person's pupils when they are looking at something close. The distance between the optical centres of the lenses in a person's spectacles should be the same as their PD.

TRIAL LENS SETS

A trial lens set (also called a trial lens case) is a collection of lenses that is used to measure a person's refractive error.

Trial lens sets usually contain:

- spherical trial lenses (plus and minus)
- cylindrical trial lenses (minus and sometimes plus)
- prism trial lenses
- accessory lenses.



Figure 8.1: A trial lens set

Trial lens sets come in different designs and colours, but they all contain the same basic lenses that are needed to do a refraction (examine the eyes for refractive error).

TRIAL LENS SETS (cont.)

TRIAL LENSES

The lenses contained in a trial lens set are called trial lenses.
Each lens is labelled so that its power can be identified easily.



The power of a spherical lens is measured in dioptres (D).
The power of a cylindrical lens is measured in dioptres cylinder (DC).
The power of a prism lens is measured in prism dioptres (Δ).

The rim (outside edge) of a trial lens can be made of plastic or metal. Sometimes the plastic rims of plus and minus lenses are coloured differently, to make it easier to tell them apart.
Each lens in a trial lens set has a particular place where it must be stored. The different types of lenses are kept in groups and in order of power. This makes it easier to find each lens, and also helps to avoid us accidentally using the wrong lens during a refractive examination.



If a trial lens is not kept in its correct place in the trial case, it will be confusing the next time the trial lens set is used, and can lead to mistakes in the refractive examination.

Every trial set is different, but usually:

- plus spherical trial lenses are on the right side of the trial lens set
- minus spherical trial lenses are on the left side of the trial lens set
- cylindrical trial lenses are in the centre (between the plus and minus spherical trial lenses)
- prism trial lenses are in the centre (near the cylindrical trial lenses)
- accessory trial lenses are in the centre (near the cylindrical trial lenses).

Spherical, cylindrical and prism trial lenses come in many different powers.

Usually, the powers of trial lenses between:

- ± 0.25 and ± 4.00 D increase in power in 0.25 D steps
- ± 4.00 and ± 6.00 D increase in power in 0.50 D steps
- ± 6.00 and ± 20.00 D increase in power in 1.00 D steps



Each trial lens set has two trial lenses for every spherical and cylindrical lens power.

This is because sometimes the same lens power is required for both the right eye and the left eye.

TRIAL LENS SETS (cont.)

SPHERICAL TRIAL LENSES

Spherical trial lenses are also called spherical lenses, or spheres.

Spherical lenses can be either plus or minus lenses.

There are two ways to tell the difference between a plus and a minus lens, namely the sign marking on the rim and the colour of the rim:

- Plus lenses
 - have a "+" sign on the rim
 - *usually* have a black or green coloured rim
- Minus lenses
 - have a "-" sign on the rim
 - *usually* have a red coloured rim.



Warning:

Some trial lens sets use colours that are the opposite from what is normal (*some* trial sets use black rims for minus lenses, and red rims for plus lenses).

Other trial sets might even use other colours altogether.

Always check which colour means plus and which means minus before you use a trial set for the first time.



Figure 8.2: A plastic rimmed spherical trial lens.
The black colour tells you that it is a plus lens, and the number tells you the power.
This is a +1.50 D trial lens.



Figure 8.3: A metal rimmed spherical trial lens.
The power of the lens is written on the lens.
This is a -1.50 D trial lens.

Sometimes a trial lens will not have a "+" or "-" sign on its rim. If this happens, you can tell the difference between the plus and minus lenses by looking at the shape of the high powered (stronger) trial lenses.

TRIAL LENS SETS (cont.)



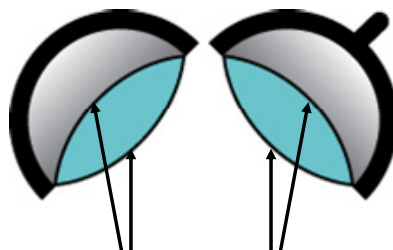
A plus trial lens will be thick in the middle of the lens, and thin near the rim of the lens.

The higher the power of the plus lens, the thicker it will be in the middle.

A minus trial lens will be thin in the middle of the lens, and thick near the rim of the lens.

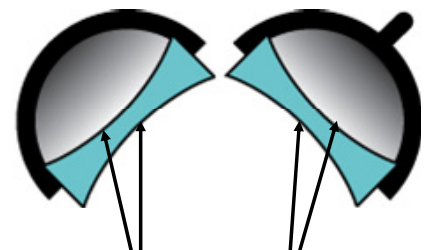
The higher the power of the minus lens, the thicker it will be near the rim.

Plus trial lens cut in two



Both surfaces are convex

Minus trial lens cut in two



Both surfaces are concave

Figure 8.4: Plus trial lenses are thicker in the middle and minus trial lenses are thinner in the middle

SPHERICAL TRIAL LENSES (cont.)

Unlike spectacle lenses, the optical centre of a trial lens is always in the exact centre of the trial lens.

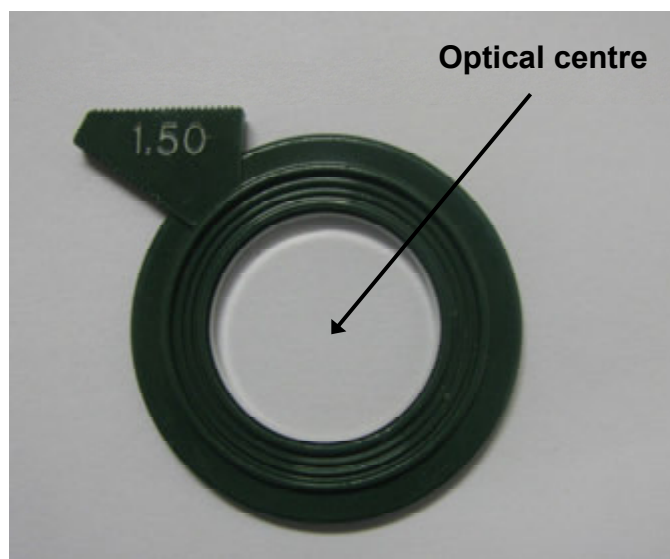


Figure 8.5: Optical centre of trial lens

TRIAL LENS SETS (cont.)

CYLINDRICAL TRIAL LENSES

Cylindrical trial lenses come in plus and minus powers, but usually it is only necessary to use the minus cylindrical lenses to do a refraction. In fact, some trial lens sets do not have plus cylinders, they only have minus cylinders.

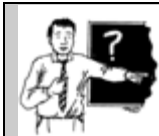


Cylindrical lenses are also called cylinder lenses, or cyls.

Like sphere lenses, cylindrical trial lenses are labelled so that they can be identified. They may have a “+” or “-” sign on the rim, or they may have a coloured rim.

Cylindrical lenses also have two small axis marks, which can either be located on the rim, or engraved (carved into) the edge of the lens. These small lines show the direction of the axis of the cylinder.

Sometimes these small axis marks on a cylindrical trial lens are the only things that make it look different from a spherical lens. You must look very carefully for the axis marks – this is the best way to tell the difference!



Cylindrical trial lenses can be confused with spherical trial lenses, so it is important to look for the axis marks.

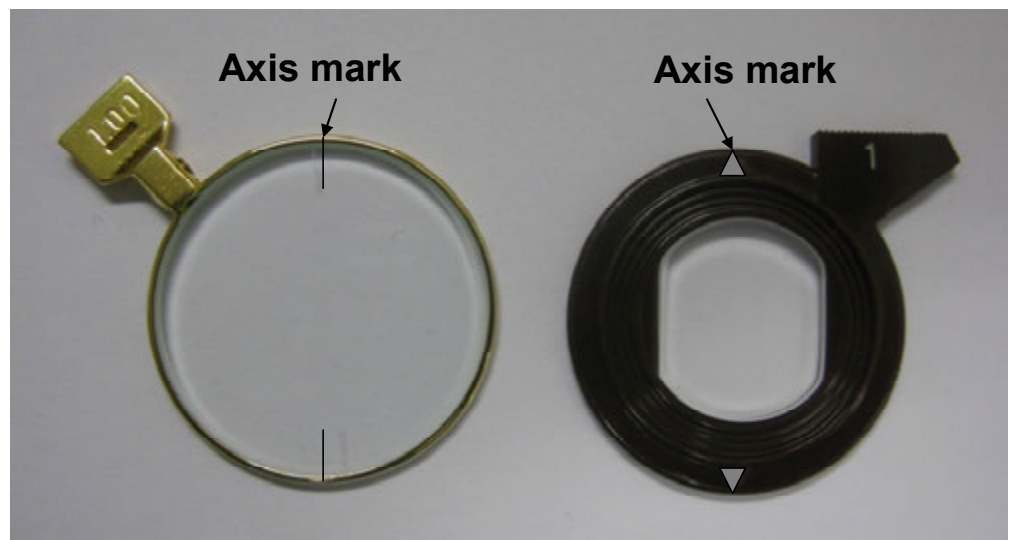


Figure 8.6: Metal rimmed cylindrical lens and plastic rimmed cylindrical trial lens

PRISM TRIAL LENSES

Prism trial lenses are also called prism lenses, or prisms.

Unlike spheres and cylinders, prisms do not have plus or minus powers.

This means that prism lenses are not coloured differently, and they do not have “+” or “-” signs on their rims.

Like cylinder lenses, prism trial lenses usually have a small line on the rim or on the edge of the lens. A prism usually only has one line, and a cylinder usually has two lines – but this is not always the case. If the prism has only one line, this line shows the location of the apex of the prism.

Prism lenses are thin at the apex (near the small line), and thick at the base (furthest away from the small line). The higher the power of the prism, the thicker the base will be.

TRIAL LENS SETS (cont.)



Figure 8.7: Plastic rimmed prism trial lens. This lens is a 3rd prism. It is thinner at the apex of the prism, and thicker at its base.



Figure 8.8: Metal rimmed prism trial lens. This lens is a 3rd prism. It has a small line at the apex of the prism, and a longer line at its base. You must be extremely careful not to confuse prism and cylindrical trial lenses.

ACCESSORY TRIAL LENSES

Accessory trial lenses are also called accessory lenses, or accessories. Accessory lenses can be thought of as tools that help with the refraction. Each accessory lens has a special purpose. Some trial lens sets have more accessories than others, but all trial lens sets should have:

- **Occluder** – This accessory is simply a piece of black plastic inside a lens rim. It is used to cover the eye that is not being examined.



Figure 8.9: An occluder

- **Pinhole** – This accessory looks similar to an occluder, but it has one or more small holes in it. It is used to conduct the pinhole test, to find out whether poor VA is caused by uncorrected refractive error or by an eye health problem.



Figure 8.10: A pinhole

TRIAL LENS SETS (cont.)

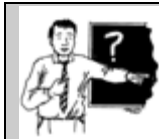
ACCESSORY TRIAL LENSES (cont.)

- **Cross cylinder** (also called a “cross cyl”, “Jackson cross cylinder”, or “JCC”). This is a special accessory lens with a longer handle than the other trial lenses.

It also has several lines and markings on the lens. Cross cyls are used to measure astigmatism.



Figure 8.11: A cross cylinder



When you have finished using a trial lens, you should make sure the lens is clean (with no fingerprints!), and put it back in its correct position in the trial lens set.

TRIAL FRAMES

A trial frame is an adjustable spectacle frame that is used to hold trial lenses in front of a person's eyes. It is especially useful when performing a refraction, because it makes it easy to change the lenses.



Figure 8.12: A woman wearing a trial frame with plastic rimmed trial lenses in it

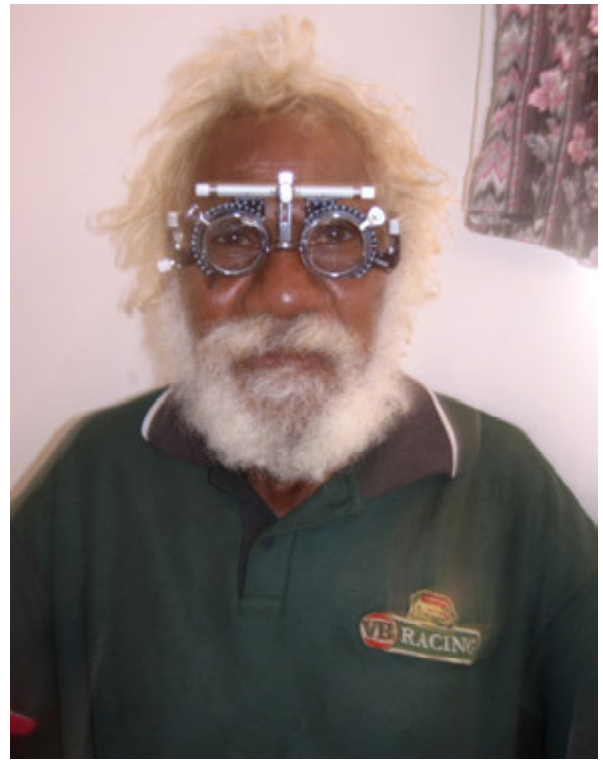


Figure 8.13: A man wearing a trial frame with metal rimmed trial lenses in it

LENS CELLS	The places where trial lenses are inserted into a trial frame are called lens cells. There are lens cells in front of the trial frame apertures (openings where the eyes will look through), and more lens cells at the back of the trial frame. It is better to place higher powered spherical lenses in the back lens cells of the trial frame. Lenses that are placed in the front cells can be rotated (turned). This is useful because cylindrical lenses need to be rotated during a refraction to determine the amount and axis of a person's astigmatism. It also allows the axis of the cylindrical trial lens to be accurately placed against the axis scale marked on the trial frame.
AXIS SCALE	The axis scale is painted on the trial frame. It has markings from 0° to 180° which increase in 5° steps. The axis scale is used for cylindrical lenses when testing for astigmatism. Cylindrical lenses can be rotated in the lens cells by using the front cell rotation knob.

TRIAL FRAMES (cont.)

AXIS SCALE (cont.)

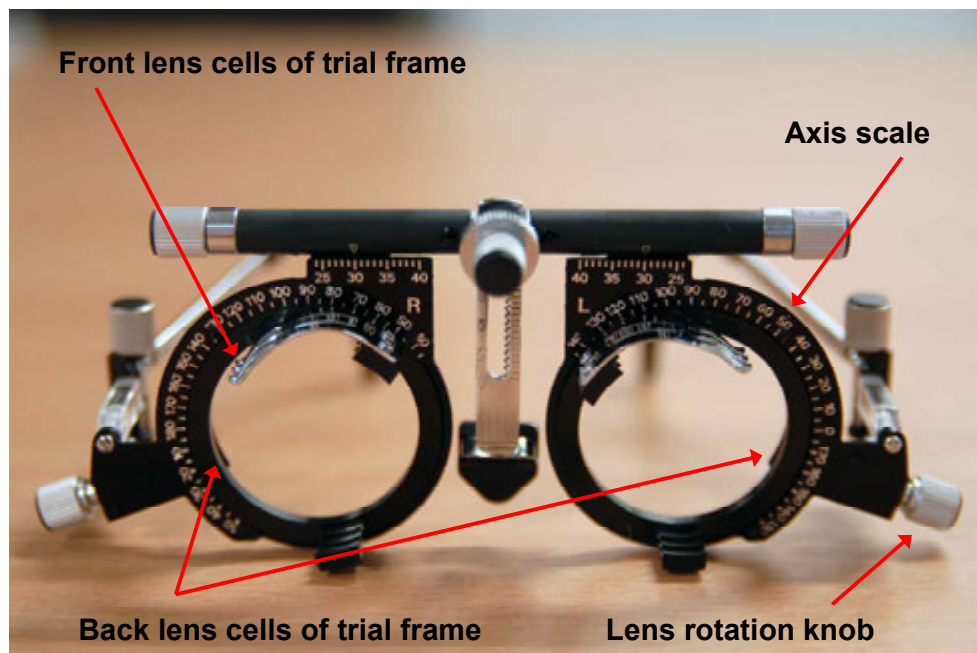


Figure 8.14: A trial frame is an adjustable spectacle frame for holding trial lenses

ADJUSTING THE TRIAL FRAME

Trial frames are adjustable so that they will fit every person's face properly. An accurate refraction depends on correct fitting of the trial frame.

Adjustable parts include:

- **temples (or ear pieces)** – These are the side arms of the trial frame. They can be made longer or shorter so that the trial frame fits firmly yet comfortably, and at the right distance from the person's eyes.
- **nose pad** – This is the part of the trial frame that sits on the bridge (top) of the person's nose. The nose pad can be made higher or lower so that the person's eyes are in the centre of the trial frame apertures (holes that the person looks through).
- **temple angle (or angle on the ear piece)** – These parts of the trial frame are located near the hinge of the temples. They can be adjusted so that the trial frame apertures sit vertically on the person's face.
- **interpupillary distance (PD)** – These knobs on each side of the trial frame move the trial frame apertures closer or further away from each other. They should be adjusted to the person's PD, so that their eyes are in the centre of the trial frame apertures.



Be gentle and careful when making adjustments to the trial frame – especially when it is on the person's face.

It can be uncomfortable for the person when trial lenses are put into and taken out of the trial frame.

It is best to hold the trial frame with one hand when inserting or removing lenses. This stops the trial frame from pressing on the person's face.

TRIAL FRAMES (cont.)

ADJUSTING THE TRIAL FRAME (cont.)

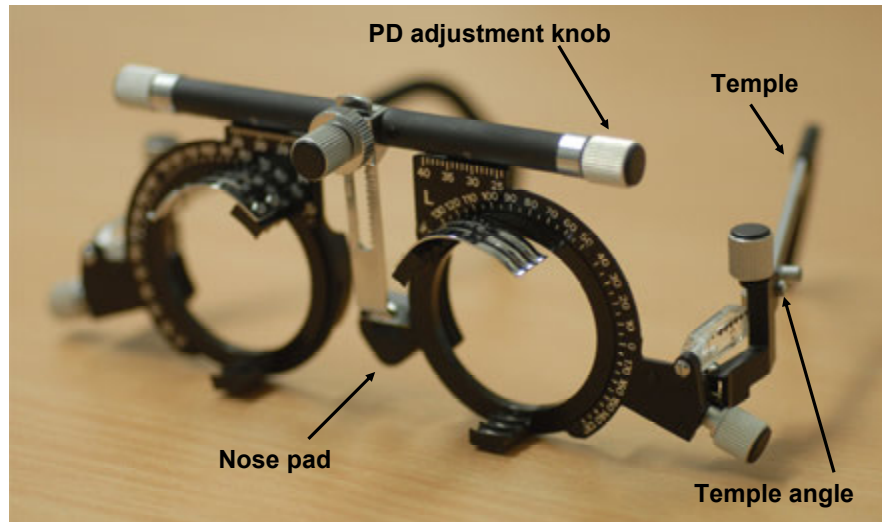


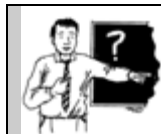
Figure 8.15: Adjustable parts of the trial frame

SETTING INTERPUPILLARY DISTANCE (PD)

Before you put a trial frame on a person, you must first measure the person's PD and then adjust the trial frame so that the PD setting on the trial frame is correct.



Figure 8.16: A PD rule is used to measure PD



Setting the correct PD on a trial frame is important – especially when using higher powered trial lenses.

Trial frames usually have two PD adjustment knobs (one for each trial frame aperture) and two half PD scales. Turning one of these knobs in one direction will make the trial frame aperture on that side move closer to the other trial frame aperture and closer to the nose pad; turning it in the other direction will make it move it further away.

After a person's PD has been measured with a PD rule, half of the total PD needs to be set on one half of the trial frame, and the other half needs to be set on the other half of the trial frame.

When an adjustment knob is turned, an arrow will move along the half PD scale. The number that it points to needs to be equal to half the person's PD.

TRIAL FRAMES (cont.)

SETTING INTERPUPILLARY DISTANCE (PD) (cont.)

If the trial frame has been adjusted properly, each eye should be exactly in the centre of each trial frame aperture. This means that when lenses are inserted into the trial frame, the eyes will look through the optical centres of the trial lenses.

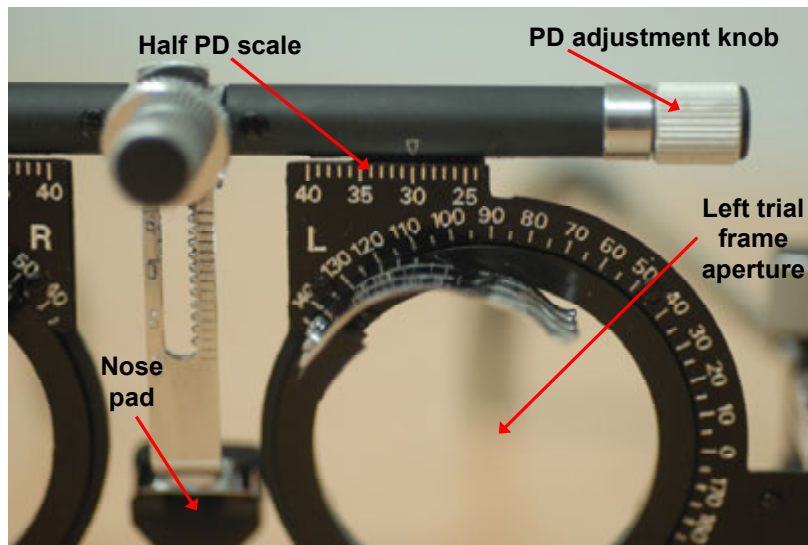


Figure 8.17: Half PD scale and adjustment knob for left trial frame aperture

EXAMPLE 1:

You measure a person's distance PD as 64 mm.

Step 1: Find half of the person's PD: $64 \text{ mm} \div 2 = 32 \text{ mm}$.

Step 2: Turn the PD adjustment knob on one side until the arrow points to the number 32.

Step 3: Turn the PD adjustment knob on the other side until the arrow points to the number 32.

EXAMPLE 2

You measure a person's distance PD as 67 mm.

Step 1: Find half of the person's PD: $67 \text{ mm} \div 2 = 33.5 \text{ mm}$.

Step 2: Trial frames do not have 0.5 settings on the scale, so you just set one side to 33 mm and the other side to 34 mm.

USING A TRIAL FRAME TO TEST NEAR VISION

When the trial frame is being used for near vision tests, the PD adjustment of the trial frame must be set for the near PD.

EXAMPLE 3

A person's near PD is 58 mm.

Step 1: Find half of the person's PD: $58 \text{ mm} \div 2 = 29 \text{ mm}$.

Step 2: Turn the PD adjustment knob on one side until the arrow points to the number 29.

Step 3: Turn the PD adjustment knob on the other side until the arrow points to the number 29.

SUMMARY: TRIAL SETS AND TRIAL FRAMES

TRIAL SET

- A trial set is a collection of spherical, cylindrical and prism lenses, as well as some accessory lenses, usually contained in a specially designed box.
- These lenses are used to measure a person's refractive error.

SPHERICAL TRIAL LENSES

- Plus and minus trial lenses are either:
 - labelled with a "+" or "-" sign; or
 - surrounded by a coloured rim.Usually plus lenses are black (or green) and minus lenses are red.
- Plus trial lenses are thickest in the centre of the lens.
- Minus trial lenses are thickest at the edge of the lens (near the rim).
- Unlike spectacle lenses, the optical centre of a trial lens is always in the centre of the trial lens.

CYLINDRICAL TRIAL LENSES

- Cylindrical trial lenses come in plus and minus powers, but usually we only use the minus cylinders to do a refraction.
- Cylindrical lenses have two small axis marks that show the direction of the axis of the cylinder.

PRISM TRIAL LENSES

- Prism lenses usually have one small line on the rim or edge of the lens. This line shows the apex of the prism.
- Prisms are thin at the apex and thicker at the base.

ACCESSORY TRIAL LENSES

- Occluder:** used to cover the eye that is not being examined.
- Pinhole:** used to check for refractive error.
- Cross cylinder:** used to measure astigmatism.

TRIAL FRAME

- A trial frame holds trial lenses in front of a person's eyes.
- It must be adjusted to fit each person individually.
- The adjustable parts include: temples, nose pad, temple angle, interpupillary distance (PD).
- The person's PD must be measured before a trial frame can be adjusted.

TEST YOURSELF QUESTIONS

1. What is interpupillary distance (PD)?

2. What types of lenses does a trial lens set usually contain?

3. How can you tell the difference between a plus and minus spherical trial lens?

4. How can you tell the difference between a cylindrical and a spherical trial lens?

5. How can you tell the difference between a prism and a cylindrical trial lens?

6. Complete the following table:

Accessory Lens:	Used for:
Occluder	
Pinhole	
Cross Cylinder	

7. Which parts of a trial frame can be adjusted?

8. In which cells of the trial frame should you place higher powered spherical lenses?

9. What is this person's PD?



NOTES

HAND NEUTRALISATION AND VERTOMETRY

THINK

A widow comes to see you for an eye examination. She brings a pair of spectacles that she bought elsewhere many years ago. She tells you that she thinks her vision has changed.

If you can measure the power of her spectacles:

- you can see if her refractive error has changed, and by how much
- it can give you a starting point for your refraction
- it will help you decide whether or not she needs to get new spectacles.

If you decide to order new spectacles for this widow, you will need to check the new spectacles when they come back from the optical workshop. To measure the power of the spectacles you will need to use hand neutralisation or vertometry.

AIM

This unit will show you two methods for measuring the power of spectacle lenses.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- use trial lenses to determine spectacle lens power
- use a vertometer to measure the power of spectacle lenses.

REVIEW: HAND NEUTRALISATION AND VERTOMETRY

SPHERICAL LENSES	- Spherical lenses correct hyperopia, myopia and presbyopia. - Plus lenses are thicker in the centre and minus lenses are thicker at the edge. - Spherical refractive power is measured in dioptres (D).
ASTIGMATIC LENSES	- Cylindrical lenses correct astigmatism. - A sphero-cylindrical lens can be thought of as being like a spherical lens that is joined to a cylindrical lens. - Sphero-cylindrical lenses correct astigmatism that is combined with hyperopia, myopia or presbyopia. - The thickness of an astigmatic lens is different at different places around its edge. - Cylindrical lenses have two meridians: an axis meridian and a power meridian. - Astigmatic lens power is measured in dioptres cylinder (DC). - The power of a sphero-cylindrical lens is written like this: Sphere power $\begin{array}{c} +2.00 \text{ D} \\ \hline -1.25 \text{ DC} \times 70 \end{array}$ Cylinder power Axis or: +2.00 D / -1.25 DC x 70 or simply: +2.00 / -1.25 x 70
TRIAL LENS SETS	- A trial set is a collection of spherical, cylindrical and prism lenses, as well as some accessory lenses. - Spherical plus and minus trial lenses are either: - Labelled with a "+" or "-" sign, or - Surrounded by a coloured rim (usually plus lenses are black and minus lenses are red).
INTERPUPILLARY DISTANCE (PD)	- PD is the distance (in mm) between a person's pupils. - PD is important, because we must make spectacles with the correct PD. If we make spectacles with the wrong PD, the person will not have comfortable vision, and they might not be able to wear them. - The distance between the optical centres of the lenses in a person's spectacles should be the same as their PD.

MEASURING SPECTACLE LENSES

There are two ways to measure the power of a lens. Both methods can be used to measure spherical and cylindrical lenses.

- Hand neutralisation:** a simple technique that can be performed using just a trial lens set.
- Vertometry:** a more accurate technique that uses a special instrument called a vertometer.



A vertometer is sometimes called a lensmeter or a focimeter.

HAND NEUTRALISATION

Hand neutralisation is a good way to measure spectacle lens power when you do not have a vertometer. Vertometers can be expensive and need electricity to work.

Hand neutralisation can be performed using only lenses from a trial lens set.

IMAGE MOVEMENT THROUGH LENSES	If you look at an object through a lens and move the lens from side to side (right and left), the image that you see through the lens will also move. A plus lens will make the image move in the opposite direction to the lens movement: → If you move the lens to the right, the image will move to the left. → If you move the lens to the left, the image will move to the right. A minus lens will make the image move in the same direction as the lens movement: → If you move the lens to the right, the image will move to the right. → If you move the lens to the left, the image will move to the left. The image of an object seen through a plano lens will not move.  The movement of a plus lens is called “against” movement. The movement of a minus lens is called “with” movement.
ADDING LENSES TOGETHER	When lenses are placed on top of each other, their powers can be added together.
EXAMPLE 1	If you have a +1.00 D lens and you put a +4.00 D lens on top of it, the total power is: +1.00 D + +4.00 D = +5.00 D. A +1.00 D and a +4.00 D lens together are the same as a +5.00 D lens. Image movement: • A +1.00 D lens gives against movement. • A +4.00 D lens gives against movement. • A +5.00 D lens gives against movement (the same as a +1.00 D lens and +4.00 D lens together).
EXAMPLE 2	If you have a +1.00 D lens, and you put a –5.00 D lens on top of it, the total power is: +1.00 D + –5.00 D = –4.00 D. A +1.00 D and a –5.00 D lens together are the same as a –4.00 D lens. Image movement: • A +1.00 D lens gives against movement. • A –5.00 D lens gives with movement. • A –4.00 D lens gives with movement (the same as a +1.00 D lens and –5.00 D lens together).

HAND NEUTRALISATION (cont.)

EXAMPLE 3

If you have a +3.00 D lens, and you put a -3.00 D lens on top of it, the total power is:
 $+3.00\text{ D} + -3.00\text{ D} = 0$.

A +3.00 D and a -3.00 D lens together are the same as a plano lens.

Image movement:

- A +3.00 D lens gives against movement.
- A -3.00 D lens gives with movement.
- A plano lens gives no movement
 (the same as a +3.00 D lens and -3.00 D lens together).

HAND NEUTRALISATION

If you have a lens of an unknown power, you can find out what power it is by "neutralising" it with another lens of a known power.

Neutralisation occurs when two lenses are held together and there is no movement of the image through the combined lenses. This will only happen when the two lenses are of equal but opposite power.

Examples:

A +3.00 D lens and a -3.00 D lens held together will give no movement. *We can thus "neutralise" the power of the +3.00 D lens by using a -3.00 D lens.*

A -7.00 D lens and a +7.00 D lens held together will give no movement.
We can thus "neutralise" the power of the -7.00 D lens by using a +7.00 D lens.

A -2.75 D lens and a +2.75 D lens held together will give no movement.
We can thus "neutralise" the power of the -2.75 D lens by using a +2.75 D lens.

If you know the power of one of the lenses you have neutralised, you will also know the power of the other lens.

HAND NEUTRALISATION METHOD

SET-UP

Draw a cross on the centre of a piece of paper. Make sure that the lines are perpendicular (at 90°) to each other, and that each line is at least 15 cm long.

- Place the cross approximately 1 m away from you (sometimes it is easiest to put it on the floor).
- Hold the lens close to your eye and look at the cross through the lens.
- Make sure that the cross is in the centre of the lens.



Hold the lens so that the lines of the cross that are seen through the lens line up with the lines outside the lens.

The lines of the cross should look aligned through the lens and outside the lens edge – then the centre of the cross is at the optical centre of the lens.

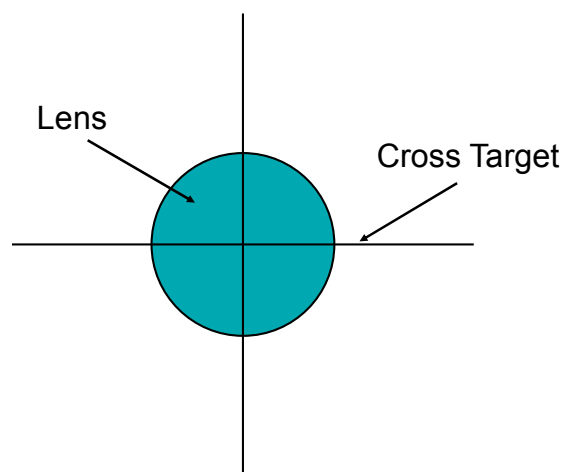


Figure 9.1: The lines of the cross inside and outside the lens are aligned, so the centre of the cross is at the optical centre of the lens

SPHERE OR CYLINDER?

To find out whether the lens you are holding is a spherical or an astigmatic lens, you need to rotate the lens in front of your eye. To rotate the lens you turn it clockwise or anti-clockwise, like the steering wheel of a car.

If the lines of the cross stay perpendicular when you rotate the lens, it is a spherical lens.

If the lines of the cross do not stay perpendicular when you look through the lens, the lens is a cylindrical or sphero-cylindrical lens. This movement is known as “scissors” movement.

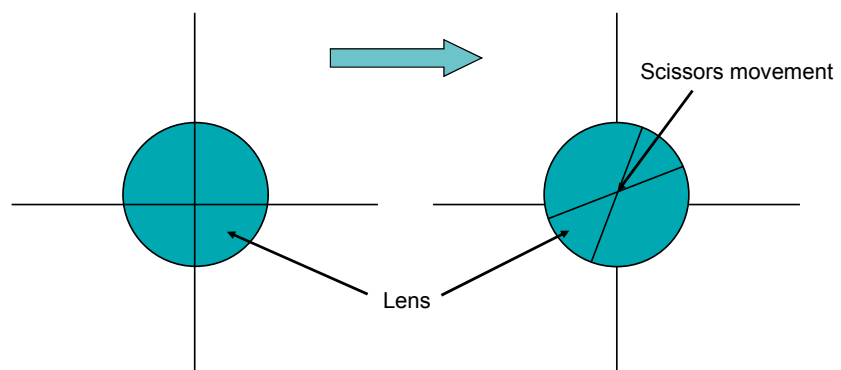


Figure 9.2: Rotating a sphero-cylindrical lens will give scissors movement



The movement of an astigmatic lens is called “scissors” movement.

HAND NEUTRALISATION METHOD (cont.)

PLUS OR MINUS SPHERE?

Once you know that you have a spherical lens (by rotating it), you need to find out if it is a plus or a minus lens.

Move the lens up and down and from side to side (right and left) in front of your eye.

If the lines of the cross move in the opposite direction to the movement of the lens ("against"), you have a plus lens. If they move in the same direction ("with"), you have a minus lens. If the lines do not move at all, you have a plano lens.

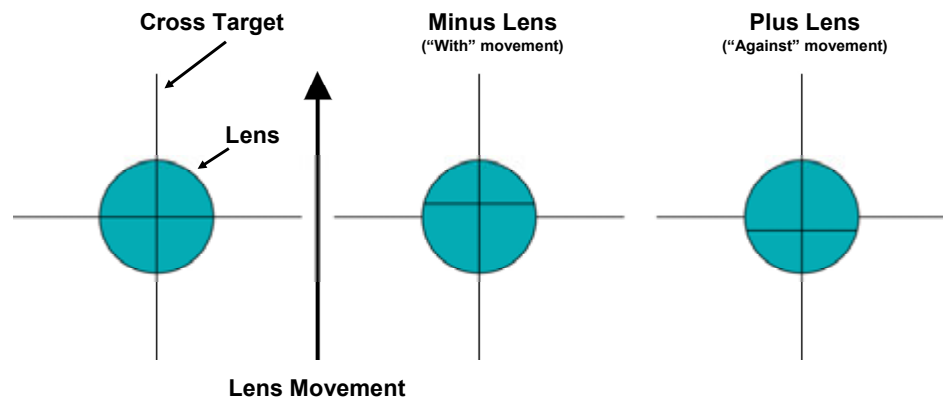


Figure 9.3: A cross is viewed through a lens, and the lens is moved upwards. A minus lens will give "with" movement and a plus lens will give "against" movement

FINDING THE POWER OF A SPHERICAL LENS

Now that you know whether you have a plus or minus lens, hold a trial lens of the opposite power against your unknown lens.

- If you have a plus lens, you will choose a minus trial lens.
- If you have a minus lens, you will choose a plus trial lens.

Remember that high power plus lenses are thicker in the centre, and high power minus lenses are thicker at the edge. Looking at the shape of the lens you want to neutralise might help you estimate the power of the lens needed to neutralise it.

Now hold the unknown lens and the trial lens that you have chosen to neutralise it together in front of your eye. Move the lenses up and down, and from side to side.

If there is still movement when you look through both lenses, you will need to choose a different trial lens.

- If there is **against movement** and your unknown lens is a:
 - plus lens → you need to choose a higher powered minus trial lens
 - minus lens → you need to choose a lower powered plus trial lens.
- If there is **with movement** and your unknown lens is a:
 - plus lens → you need to choose a lower powered minus trial lens
 - minus lens → you need to choose a higher powered plus trial lens.

Continue to try different trial lenses with your unknown lens until there is no movement of the cross lines when you look through both lenses together. When there is no movement, you have neutralised your lens. The power of your unknown lens will be equal and opposite to the power of the trial lens that neutralises it.

EXAMPLES

- The power of an unknown minus lens that is neutralised by a +4.00 D trial lens is: **-4.00 D**.
- The power of an unknown plus lens that is neutralised by a -2.75 D trial lens is: **+2.75 D**.

HAND NEUTRALISATION METHOD (cont.)

BRACKETING

You can save time when hand neutralising by using a technique known as bracketing. Bracketing is a logical method that helps you to choose your next trial lens.

Example:

You have an unknown lens that you rotate: you find that it is a spherical lens.

When you move the lens you see against movement: it is a plus lens.

Because it is a plus lens, you choose a -4.00 D trial lens from your trial lens case.

The two lenses together still give you against movement.

This means that your unknown lens is a plus lens that is stronger than $+4.00$ D.

You choose a -8.00 D trial lens next.

This time, the two lenses together give you with movement.

This means that your unknown lens is a plus lens that has a power between $+4.00$ D and $+8.00$ D.

Now, you **can** choose any trial lens between -4.00 D and -8.00 D to try and neutralise your unknown lens, but you will be more efficient if you “bracket”

→ which means using a logical way of choosing the next lens power to try.

To bracket, you choose a lens power that is half way between -4.00 D and -8.00 D

→ you chose a -6.00 D trial lens.

Together, your unknown lens and the -6.00 D lens give you against movement.

This means that your unknown lens has a power between $+4.00$ D and $+6.00$ D.

Bracketing again, you choose a lens that is half way between -4.00 D and -6.00 D

→ you choose a -5.00 D trial lens.

This time you get with movement.

This means that your unknown lens has a power between $+5.00$ D and $+6.00$ D.

You now choose a -5.50 D trial lens.

This time you get no movement when you look through both lenses.

This means that you have neutralised your unknown lens.

The power of your unknown lens is: $+5.50$ D.

HAND NEUTRALISATION METHOD (cont.)

FINDING THE PRINCIPAL MERIDIANS OF AN ASTIGMATIC LENS

An astigmatic lens will give scissors movement when it is rotated.



REMEMBER:

An astigmatic lens has two principal meridians that are perpendicular (at 90°) to each other.

To find the power of an astigmatic lens, the power of each principal meridian must be found separately.

The principal meridians can be found by rotating the lens until the lines of the cross (that show scissors movement) are lined up perpendicularly. When this happens, the lines of the cross are lined up over both principal meridians of the lens.

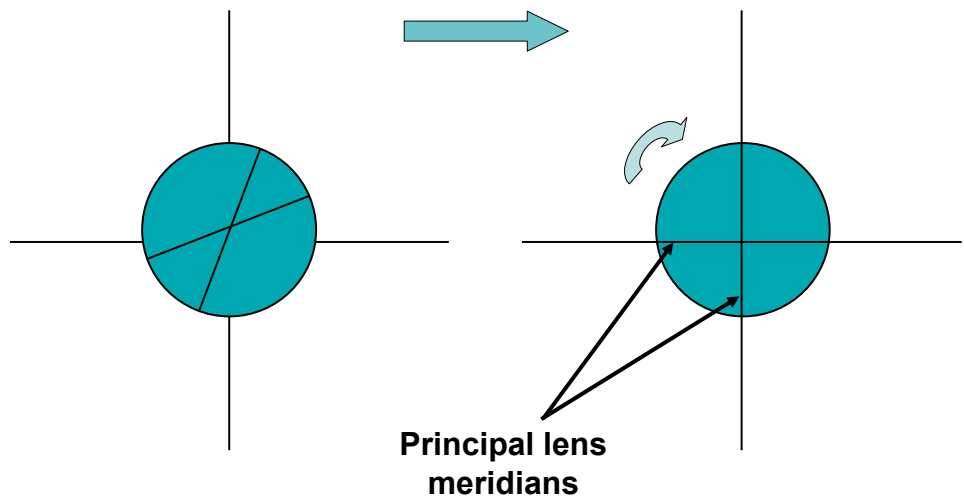


Figure 9.4: To find the principal meridians of a sphero-cylindrical lens, rotate the lens until the lines of the cross appear perpendicular through the lens

FINDING THE POWER OF AN ASTIGMATIC LENS

Hold the astigmatic lens with its principal meridians lined up with the cross:

- To find the power of the vertical meridian, move the lens up and down.
- To find the power of the horizontal meridian, move the lens from side to side.

You now need to neutralise each meridian separately.

It is useful to draw an optical cross for recording your findings.

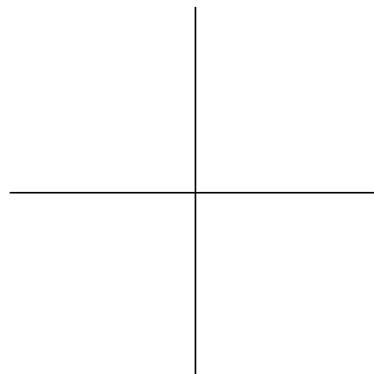


Figure 9.5: Optical cross

HAND NEUTRALISATION METHOD (cont.)

EXAMPLE

You have an unknown lens and you want to know where the optical centre is and what its power is.

You rotate the lens and see scissors movement → now you know the lens is a cylinder or spherocylinder.

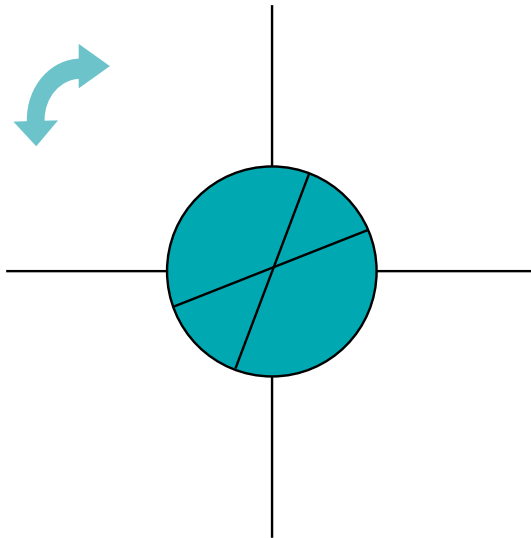


Figure 9.6: Scissor movement

FINDING THE OPTICAL CENTRE

You align the lens so that the lines of the cross seen inside the lens are aligned with the lines of the cross seen outside the lens.

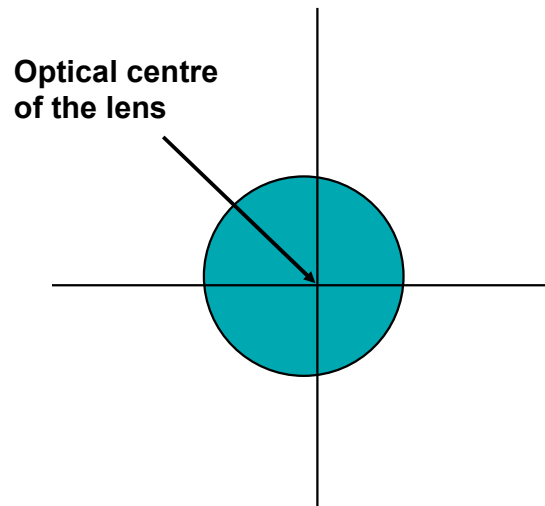


Figure 9.7: The lines of the cross inside and outside the lens are aligned, so the centre of the cross is at the optical centre of the lens



Notice:

The cross is not in the centre of the circle.

→ This means that in this case the optical centre of the lens is not in the middle of the lens.

HAND NEUTRALISATION METHOD (cont.)

FINDING THE OPTICAL CENTRE (cont.)

You can also find the optical centre of a lens by looking at the two reflections of a light source (like a light globe) on the front and back surfaces of the lens.

Tilt the lens until you get the smaller reflection in the middle of the larger one.

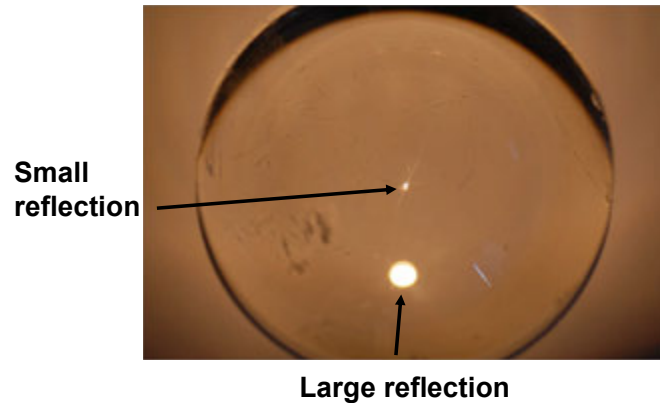


Figure 9.8: Finding the optical centre by reflection

You can mark the optical centre of the lens at the centre of the cross or where the two reflections meet by using a marker or a felt tipped pen.

THE POWER OF THE VERTICAL MERIDIAN

Move the lens up and down and see what type of movement it causes. If you see with movement, it means the vertical meridian has minus power.

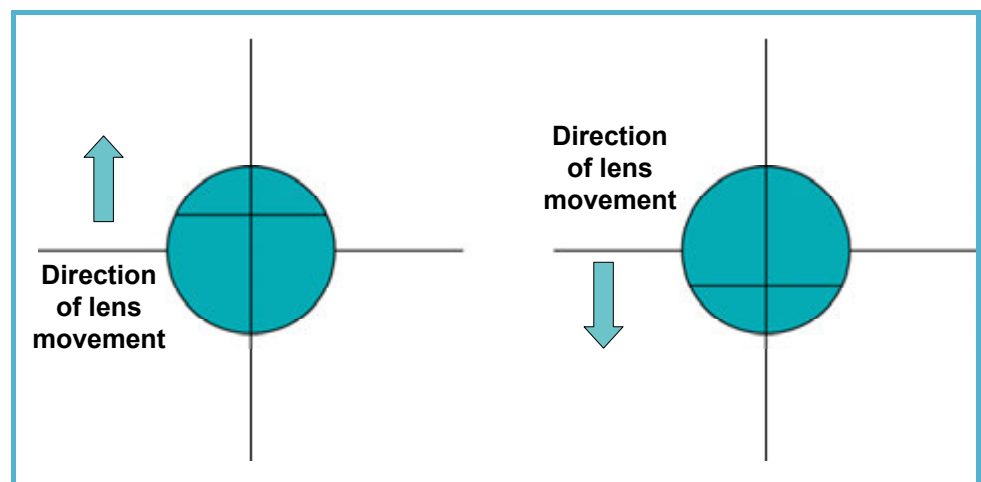


Figure 9.9: With movement in vertical meridian

Because the lens has minus power in the vertical meridian, you choose a plus power trial lens to neutralise the lens in this meridian.

You use the bracketing technique and find that a +4.50 D trial lens neutralises this vertical meridian.

→ This means that the power of the vertical meridian is -4.50 D.

You record this on your optical cross.

HAND NEUTRALISATION METHOD (cont.)

THE POWER OF THE VERTICAL MERIDIAN (cont.)

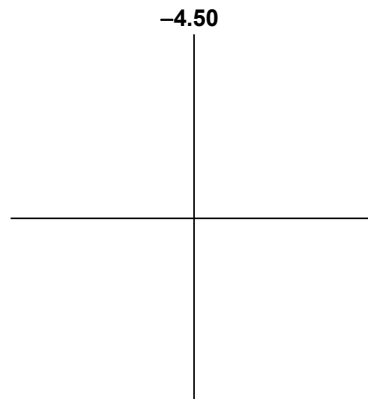


Figure 9.10: Optical cross with vertical meridian power recorded

Move the lens from side to side and see what type of movement it causes. If you see against movement, it means that the horizontal meridian has plus power.

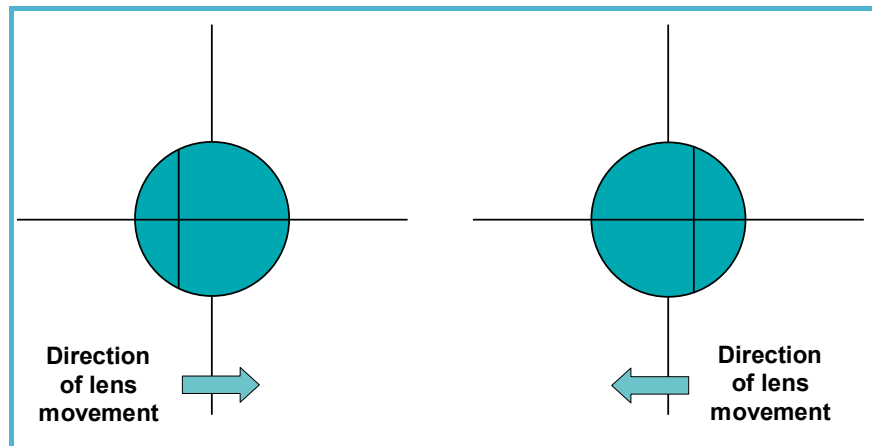


Figure 9.11: Against movement in horizontal meridian

THE POWER OF THE HORIZONTAL MERIDIAN

Because the lens has plus power in the horizontal meridian, you choose a minus power trial lens to neutralise the lens in this meridian.

You use the bracketing technique and find that a -2.25 D trial lens neutralises this horizontal meridian.

→ This means that the power of the horizontal meridian is $+2.25$ D.

You record this on your optical cross.

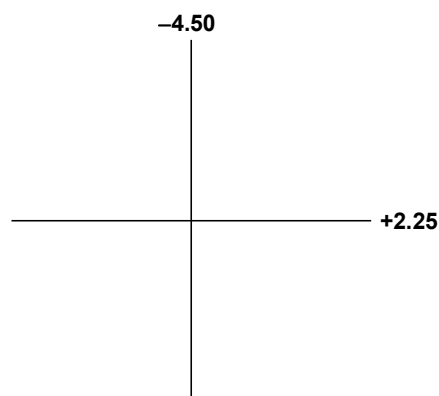


Figure 9.12: Optical cross with vertical and horizontal meridian powers recorded

HAND NEUTRALISATION METHOD (cont.)

WHERE IS THE AXIS?	The axis is in the direction of the most plus powered (or least minus powered) meridian. In this example, the most plus powered meridian is in the horizontal (180°) meridian.
HOW WOULD YOU WRITE THE PRESCRIPTION OF THIS LENS?	The amount of cylinder power in the lens is the difference between the powers of the two principal meridians. Looking at the optical cross (Figure 9.12), and knowing that the axis of the lens is at 180°, you would write the prescription of this lens as: +2.25 / -6.75 x 180.

VERTOMETRY (FOCIMETRY)

Vertometry is an accurate way to measure the power of spectacle lenses.

Vertometry is performed by using an instrument called a vertometer (also known as a focimeter or a lensmeter).

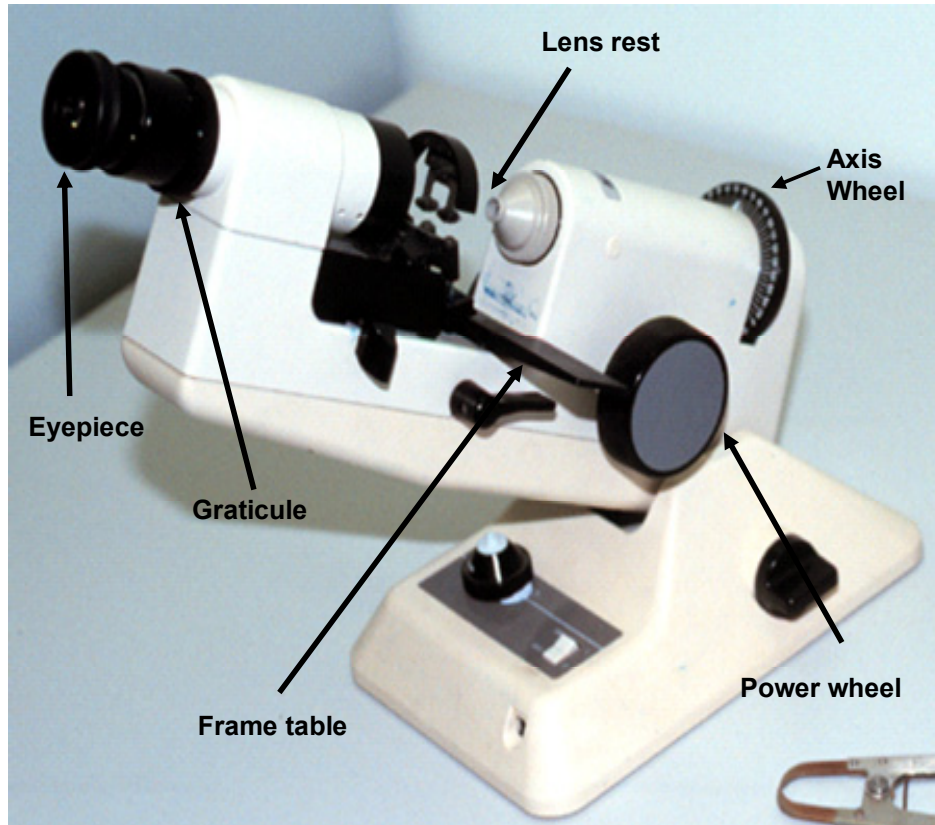


Figure 9.13: The parts of a vertometer

When you measure a lens on the vertometer, the edge of the lens rests on the frame table, so that the lens lies over the lens rest. The lens is then clamped in place so that it does not move, and the power wheel is turned to measure the power of the lens.

The eyepiece is the part of the vertometer that you look through to measure the lens power. When you look through the eyepiece you see the black lines and circles of the graticule, and the brightly lit coloured target. The graticule will be visible even when the vertometer is turned off, but you can only see the target when the vertometer is turned on. The target is usually green.

VERTOMETRY (FOCIMETRY) (cont.)

VERTOMETER TARGETS

There are two types of vertometer target:

Vertometers that use this sort of target need an axis wheel (as seen in Figure 9.13).

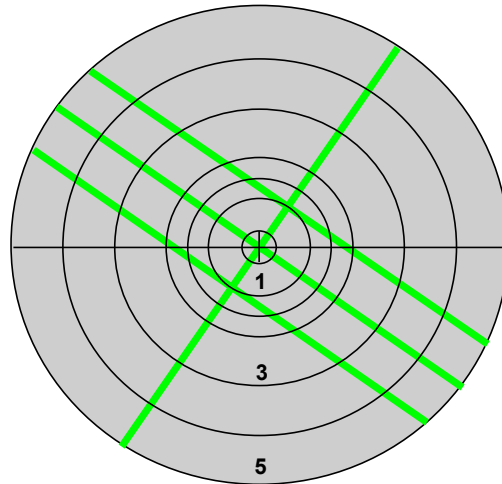


Figure 9.14: A crossed line target measuring a spherical lens

CROSSED LINE TARGET

If a sphere is being measured, all the lines of the target can be equally focused at the same time. If a sphero-cylinder is being measured, only the lines in one direction can be focused at any one time:

- If the single line is in focus, the three parallel lines will be blurred.
- If the three parallel lines are in focus, the single line will be blurred.

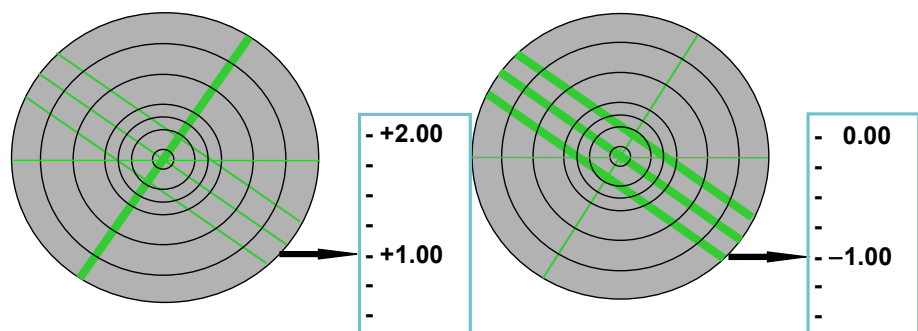


Figure 9.15: A line target measuring a spherocylindrical lens
– only one set of lines can be focused at any one time

VERTOMETRY (FOCIMETRY) (cont.)

DOT TARGET

Vertometers that use this sort of target do not need an axis wheel.

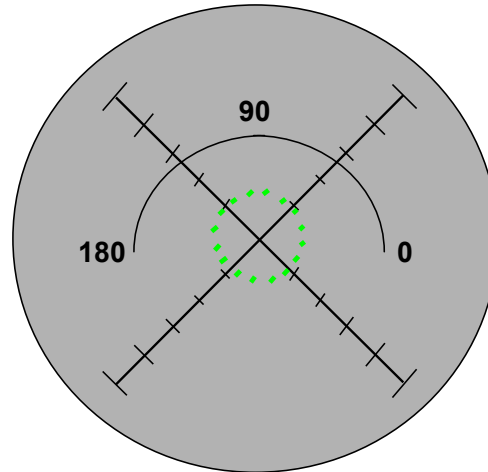


Figure 9.16: A dot target measuring a spherical lens

If a spherical lens is being measured, the target will look like a circle of small dots.

If an astigmatic lens is being measured, the target will look like a set of small parallel lines (stretched dots arranged in a circle).

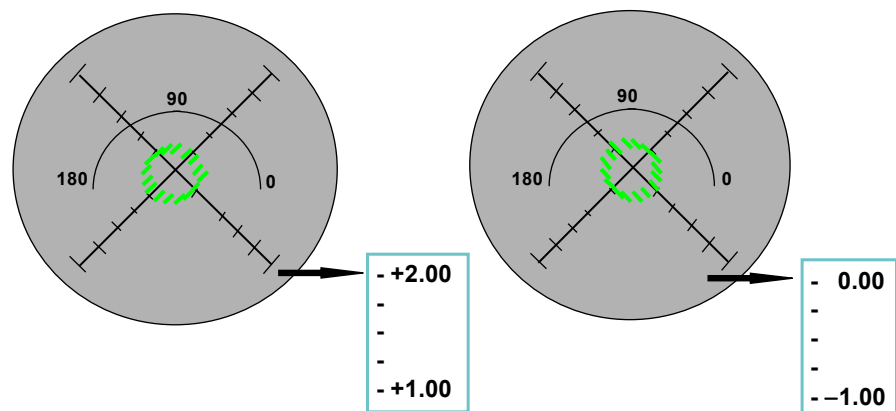


Figure 9.17: A dot target measuring a sphero-cylindrical lens

VERTOMETER METHOD

SET-UP

Focusing the Eyepiece

To get an accurate measurement, you must first focus the vertometer's eyepiece for your eye. The focus that your eye needs will probably be different to the focus that another person's eye would need, so it is important that you focus the eyepiece each time you start to use the vertometer.

- Step 1:** Before you turn the vertometer on, look through the eyepiece to see the black graticule lines and circles. If it is hard to see the graticule, you can hold a piece of white paper in front of the lens rest.
- Step 2:** Turn the eyepiece anti-clockwise until it stops. You will see that the graticule becomes blurry.
- Step 3:** Slowly turn the eyepiece clockwise until the graticule just comes into focus. It is important to stop as soon as the graticule becomes clear, otherwise you will need to repeat Steps 2 and 3.
- Step 4:** Turn on the vertometer to see the coloured target. Turn the power wheel until the lines or dots of the target become clear. If you have focused the eyepiece correctly, the power reading will be zero.

Inserting the Spectacle Frame

- Step 1:** Turn the spectacles so that the front of the spectacles is facing towards you. The temples (the arms of the spectacle frame) should be pointing away from you.
- Step 2:** Put the spectacles on the frame table. The bottom of the spectacles should rest on the frame table. Clamp the spectacle lens to keep it pressed against the lens rest.



It is good practice to always measure the right lens first and the left lens second.

When you look at the front of a pair of spectacles, the right lens is on your left hand side.

- Step 3:** Look through the eyepiece and move the spectacles until the target is in the centre of the black graticule.
- Step 4:** Change the height of the frame table to keep the frame horizontal in this position (to make sure one side does not drop down).
- Step 5:** Measure the power of the right lens (see the next set of steps).
- Step 6:** Unclamp the right lens. Do not change the height of the frame table. Move the spectacle frame and clamp the left lens. Measure the power of the left lens.

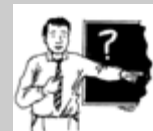


It is important to keep the height of the frame table the same for measuring both the right and left lenses. This is so that you can look for prism in the spectacles later.

MEASURING LENS POWER

Crossed Line Target Vertometer – Spherical Lenses

- Step 1:** Turn the power wheel to a high plus reading.
- Step 2:** Slowly decrease the power (reduce the plus by turning the power wheel) until all of the target lines just become clear. (If you turn the wheel further than this, your measurement will not be accurate.)



If all the lines of the target are clear, the lens you are measuring is a spherical lens.

If only some of the lines are clear, the lens you are measuring is an astigmatic lens.

VERTOMETER METHOD (cont.)

MEASURING LENS POWER (cont.)

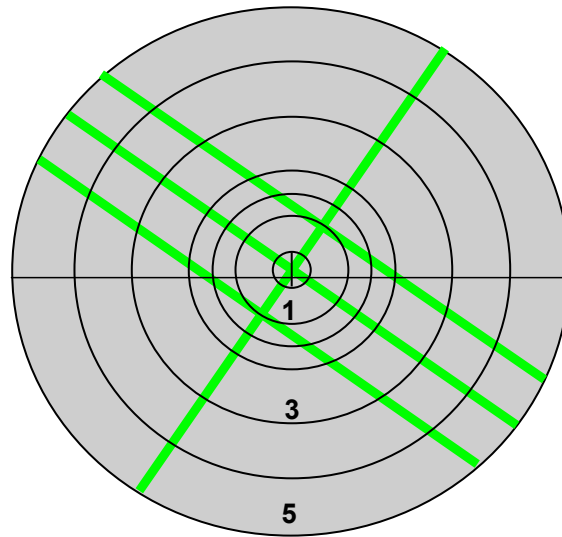


Figure 9.18: The three parallel lines are clear, straight and unbroken. The single line is also clear, straight and unbroken. This is a spherical lens

Crossed Line Target Vertometer – Astigmatic Lenses

- Step 1:** Turn the power wheel to a high plus reading.
- Step 2:** Slowly decrease the power (reduce the plus by turning the power wheel) until some of the target lines just become clear. (If you turn the wheel further than this, your measurement will not be accurate.)
- Step 3:** Turn the axis wheel until the three parallel target lines are straight and unbroken.

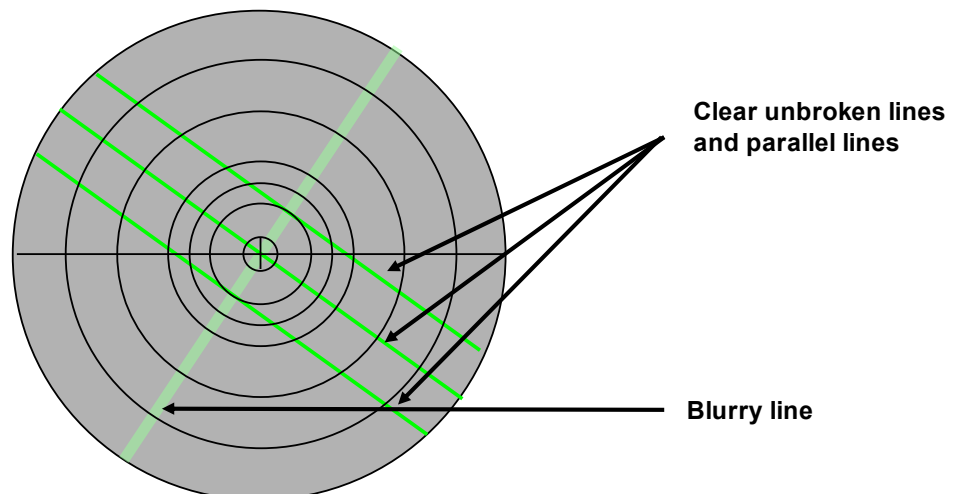


Figure 9.19: The three parallel lines are clear, straight and unbroken. The single line is blurry. This is an astigmatic lens

- Step 4:** If you are measuring an astigmatic lens, the number on the power wheel will tell you the power of the most positive meridian of the lens. This will be the spherical power when you write the astigmatic lens prescription.

VERTOMETER METHOD (cont.)

MEASURING LENS POWER (cont.)

Step 5: Slowly turn the power wheel to decrease the power until the other line is clear. The number on the power wheel will now tell you the power of the least positive meridian of the lens.

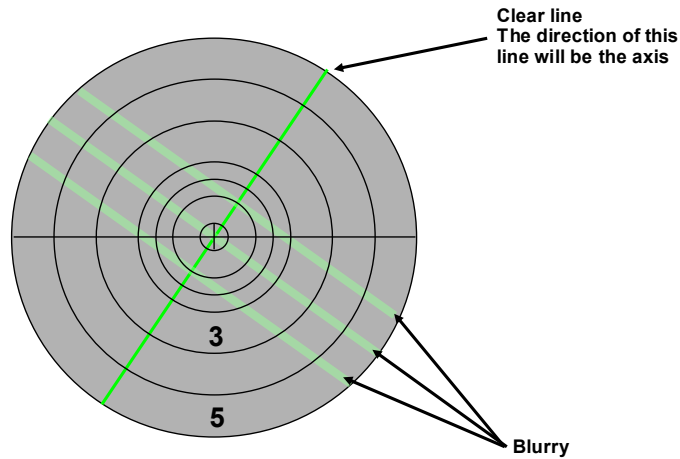


Figure 9.20: The single line is clear, straight and unbroken. The three parallel lines are blurry

Step 6: Find the cylindrical power of the lens.



Cylindrical power = second power reading (least positive power) – first power reading (most positive power).

Another way of looking at Step 6 is to look at how far you have turned the power wheel and in which direction.

Step 7: Find the axis of the lens.

The axis of the cylinder is the direction of the second power reading (the least positive power).

You measure the direction of this line by looking at the axis numbers on the graticule inside the eyepiece.

Finding the Sphere Power

Turn the power wheel to a high plus reading and slowly decrease the power until one set of lines becomes clear. Now, rotate the axis drum to ensure the lines are straight and unbroken. Write down the power which is displayed on the power wheel. In this case, the power reading is +1.00 D.

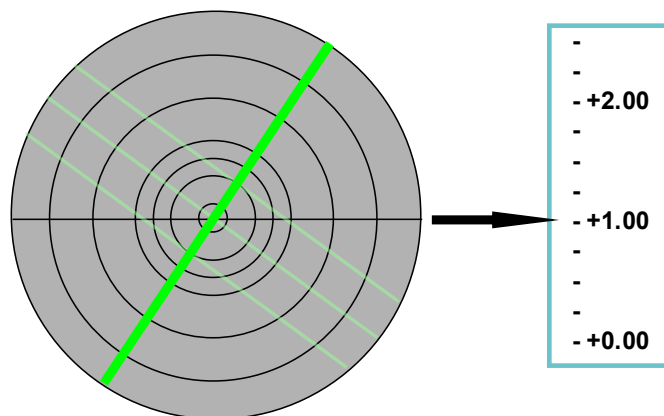


Figure 9.21: First reading (sphere power)

VERTOMETER METHOD (cont.)

Finding the Cylinder Power

Continue to turn the power wheel until the other lines become clear. The second power reading minus the first reading will give the power of the cylinder (and its correct sign).

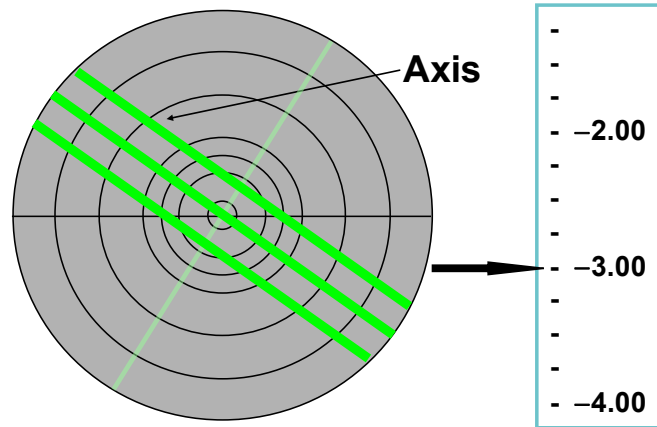


Figure 9.22: The second reading

In this case, the second power reading is -3.00 D. So, the cylinder power of the spectacle lens is the second power reading minus the first power reading:

$$-3.00 - (+1.00) = -4.00 \text{ DC.}$$

Or, we have turned the power wheel through 4.00 D in the negative direction (from $+1.00$ to -3.00).

Finding the Axis

Look at the direction of the lines of the second reading. This is the axis direction.

Look through the eyepiece and turn the long black line of the graticule, so that it is in the same direction as the lines of the target. This makes it easier to read the axis direction on the graticule. In this case, the least positive lines (the second reading) are lying at 120° .

So the power of this lens is $+1.00 / -4.00 \times 120$.



Be careful:

Some line target vertometers let you read the axis of the lens on the axis drum. In this case, the vertometer maker has chosen one set of lines to be for the sphere and the other to be for the cylinder.

But different brands of vertometer select different lines to represent the sphere and the cylinder. (For example, one brand of vertometer might be made so that the three parallel lines represent the sphere; another brand might be made so that these same lines represent the cylinder.)

Unless you know what each of the lines represents you cannot depend on the axis drum reading. You might get the wrong answer.

However, if you use the method described in this unit you will always get the correct result. This is because you are measuring the axis direction with the graticule, which is inside the eyepiece.

EXAMPLE 1:

MEASURING AN ASTIGMATIC LENS

VERTOMETER METHOD (cont.)

DOT TARGET VERTOMETER – SPHERICAL LENSES

Step 1: Turn the power wheel to a high plus reading.

Step 2: Slowly decrease the power (reduce the plus by turning the power wheel) until all the dots *just* become clear. (If you turn the wheel further than this, your measurement will not be accurate.)



If you have a ring of round dots, the lens you are measuring is a spherical lens.

If you have a ring of stretched dots (little lines), the lens you are measuring is an astigmatic lens.

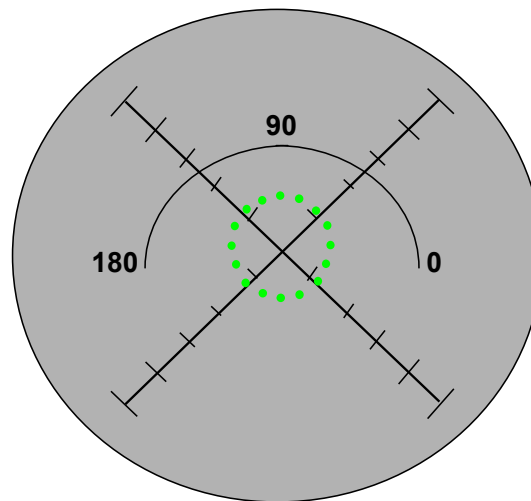


Figure 9.23: A ring of clear dots. This is a spherical lens

Step 3: If you are measuring a spherical lens, the number on the power wheel tells you the power of the lens. If it is a spherical lens, you have finished and can now measure the left lens.

DOT TARGET VERTOMETER – ASTIGMATIC LENSES

Step 1: Turn the power wheel to a high plus reading.

Step 2: Slowly decrease the power (reduce the plus by turning the power wheel) until all the dots *just* become clear little lines. (If you turn the wheel further than this, your measurement will not be accurate.) This will be the spherical power when you write the lens prescription.

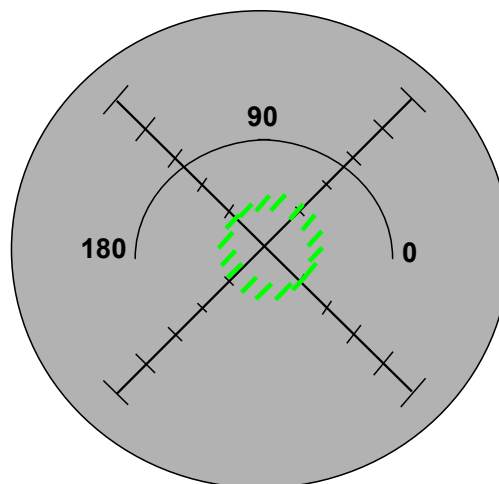


Figure 9.24: First reading (sphere power)

VERTOMETER METHOD (cont.)

DOT TARGET VERTOMETER – ASTIGMATIC LENSES (cont.)

Step 3: Slowly turn the power wheel to decrease the power until the second set of stretched dots (little lines) becomes clear. This time the dots will be stretched in a direction 90° to those in Step 2. The number on the power wheel will now tell you the power of the least positive meridian of the lens.

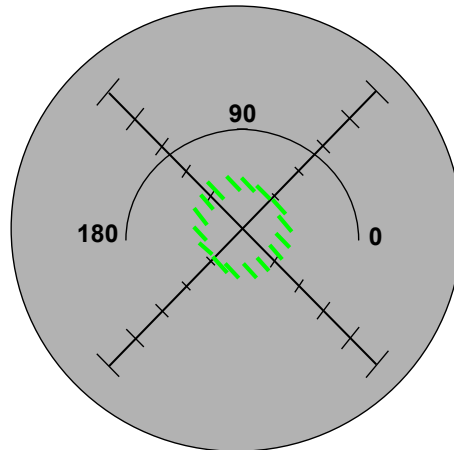


Figure 9.25: Second power reading (least positive meridian). This time the ring of stretched dots are stretched in a direction 90° to that of the first power reading.

Step 4: Find the cylindrical power of the lens.

Cylindrical power = second power reading (least positive power) – first power reading (most positive power).

Again, another way of looking at Step 4 is to look at how far you have turned the power wheel and in which direction.

Step 5: Find the axis of the lens. The axis of the lens is the direction of the little lines of the second power reading. You measure the direction of these lines by looking at the axis numbers on the graticule inside the eyepiece.

EXAMPLE 2: MEASURING AN ASTIGMATIC LENS

Finding the Sphere Power

Turn the power wheel to a high plus reading and slowly decrease the power until one set of stretched dots (or little lines) becomes clear.

Write down the power that is displayed on the power wheel. In this case, the power reading is: +2.50 D.

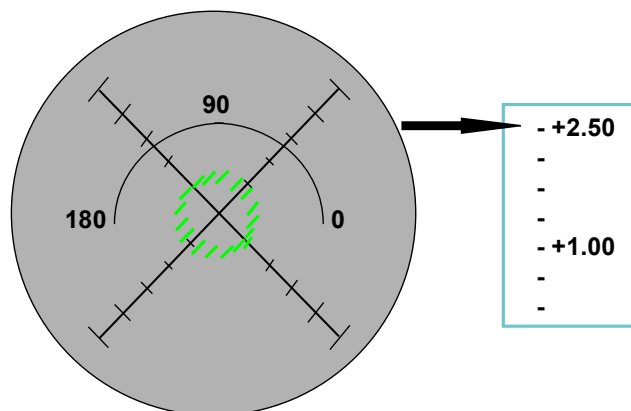


Figure 9.26: First reading

VERTOMETER METHOD (cont.)

EXAMPLE 2:

MEASURING AN ASTIGMATIC LENS (cont.)

Finding the Cylinder Power

Continue to turn the power wheel until the second set of stretched dots (little lines) becomes clear. The second power reading minus the first reading will give the power of the cylinder (and its correct sign). In this case, the second reading is +1.00 D.

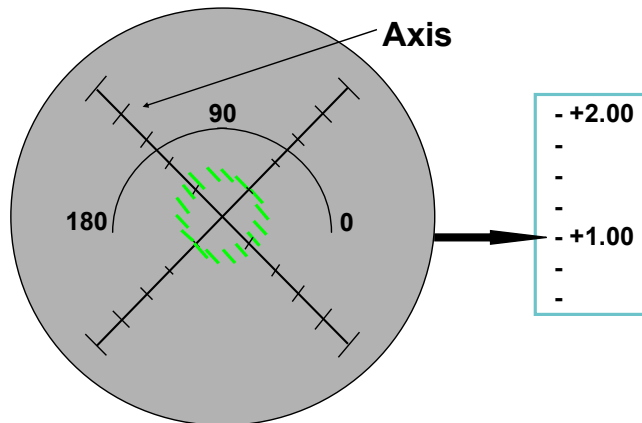


Figure 9.27: Second reading

The cylinder power of this lens is (second power reading – first power reading):
 $+1.00 - (+2.50) = -1.50$ DC.

Finding the Axis

Look at the direction of the lines of the second (*least positive*) reading. This is the axis direction. Look through the eyepiece and turn the lines of the graticule, so that they are in the same direction as the lines of the target – this makes it easier to read the axis direction on the graticule. In this case, the least positive lines (the second reading) are lying at 120°.

So the power of this lens is $+2.50 / -1.50 \times 120$.

FINDING THE OPTICAL CENTRE WITH A VERTOMETER

- **Centering a Lens on a Crossed Line Target Vertometer**

To find the optical centre of a lens using a crossed line target vertometer, you need to move the lens against the lens rest until the centre of the target is over the centre of the graticule. The centre of the target will be the point where the central target lines cross.

- **Centering a Lens on a Dot Target Vertometer**

To find the optical centre of a lens using a dot target vertometer, you need to move the lens against the lens rest until the centre of the target is over the centre of the graticule. The centre of the target will be the centre of the ring of dots.

If you have a sphero-cylindrical lens, it is best if you turn the power wheel until you are half way between the first reading and the second reading. At this point the target will look like a ring (although it will be a bit blurry).

- **Marking the Optical Centre**

Vertometers usually have an ink well and marking pins. When the lens is centred correctly, you can use the marking pins to put a mark (usually small dots) on the lens surface.

If the vertometer does not have an ink well or marking pins, you can use a marking pen (felt tipped pen) to mark the optical centre of the lens yourself. You will need to make the mark on the lens directly over the lens rest.



If you have a pair of spectacles and you measure the distance between the optical centres of the two lenses, this distance should be the same as the person's PD.

If it is not the same, the spectacles have prism in them.

FINDING PRISM WITH A VERTOMETER

Sometimes prism is added to a person's spectacle lenses to correct an eye muscle problem. Prism like this will only be prescribed by someone who is specially trained to do this. It is rare to have prism prescribed in spectacles.

More often, if there is prism in a pair of spectacles, it means that the lenses were not put into the frame properly. An error like this can cause the person to have asthenopia (eye strain) or even double vision when they wear their spectacles.

Spectacles with unwanted prism in them cannot be dispensed to a person, and need to be remade.

MEASURING VERTICAL PRISM

Step 1: Clamp the right spectacle lens against the vertometer lens rest. The lens should be clamped so that the optical centre of the lens is in the middle of the graticule.

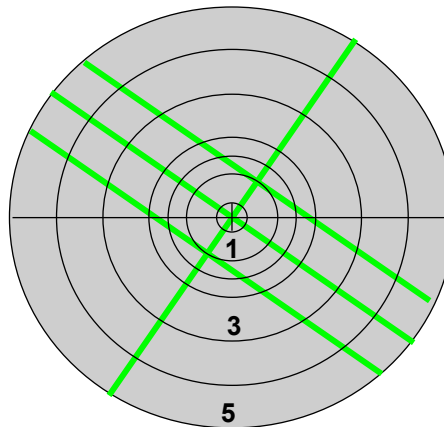


Figure 9.28: Centred target (optical centre)

Step 2: Adjust the height of the lens table - make sure that the bottom of the spectacle frame is resting on the lens table.

Step 3: Unclamp the right spectacle lens, and move the frame over to measure the left lens. *Important:* Do *not* change the height of the frame table.

Step 4: Look at the target through the eyepiece. If the target for the left lens looks higher or lower than the right lens, there is vertical prism in the spectacles.

Step 5: Find the direction of the prism.
If the target for the left lens is higher than for the right lens, there is base-up prism in the left lens (compared with the right lens).
If the target for the left lens is lower than for the right lens, there is base-down prism in the left lens (compared with the right lens) – as in the example below.

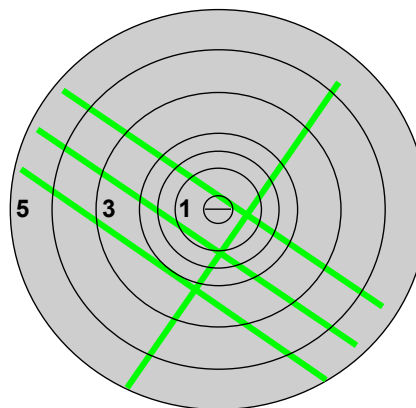


Figure 9.29: Crossed line target for left lens showing 1^A base-down prism for the left eye

FINDING PRISM WITH A VERTOMETER (cont.)

MEASURING VERTICAL PRISM (cont.)

Step 6: Measure the amount of prism.

The amount of prism is measured by looking at the circles of the graticule. Usually each circle represents a change of one prism dioptre (1^{Δ}), but sometimes there are also circles representing half-prism dioptre ($\frac{1}{2}^{\Delta}$). You will know if there are $\frac{1}{2}^{\Delta}$ steps, because the distance between the rings will be closer.

In the example above, the centre of the target for the left lens is lower than for the right lens, and is on the first circle of the graticule. That tells us there is 1^{Δ} of base-down prism in the left eye.

MEASURING HORIZONTAL PRISM

Step 1: Measure the person's PD. If the person is not with you, you should see the PD written on the spectacle prescription (the order form for the spectacles) or on the examination records.

Step 2: Mark the optical centres on each spectacle lens.

Step 3: Hold a ruler horizontally and put the zero point of the ruler on the optical centre mark of the right lens. Look at the number on the ruler that is the same as the person's PD and mark that point on the left lens with a marker pen (felt tipped pen).

Step 4: Clamp the left spectacle lens on the lens rest so that the PD mark that you made on the lens is over the centre of the lens rest.

Step 5: Measure the amount and the direction of the prism.

If the target is to the left (closer to the right lens), there is base-in prism.

If the target is to the right (further away from the right lens), there is base-out prism.

If the target is in the centre, there is no horizontal prism.

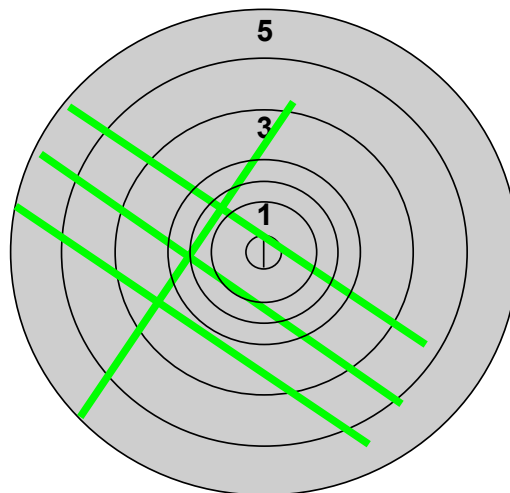


Figure 9.30: Target for left lens showing 1.5^{Δ} base-in prism

FINDING PRISM WITH A VERTOMETER (cont.)

PROCEDURE – CHECKING THE ADDITION IN BIFOCALS

The procedure described here is for checking front surface bifocals (which most bifocals are).

Step 1: Check the distance powers as normal.

Step 2: Now turn the spectacles around so that the temples of the spectacles are pointing towards you. Place the front surface of the right distance portion against the lens rest (Figure 9.31).

Step 3: Focus the lines or dots of the target that are closest to the vertical direction and determine the power.

Step 4: Move the spectacles up and place the front surface of the segment against the lens stop (Figure 9.32).

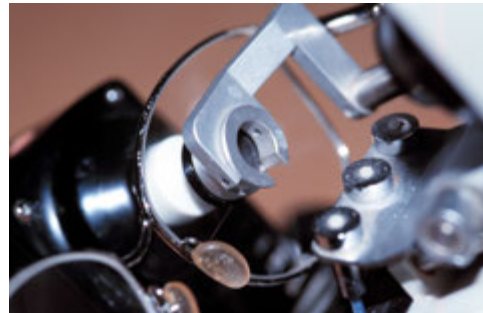


Figure 9.31



Figure 9.32

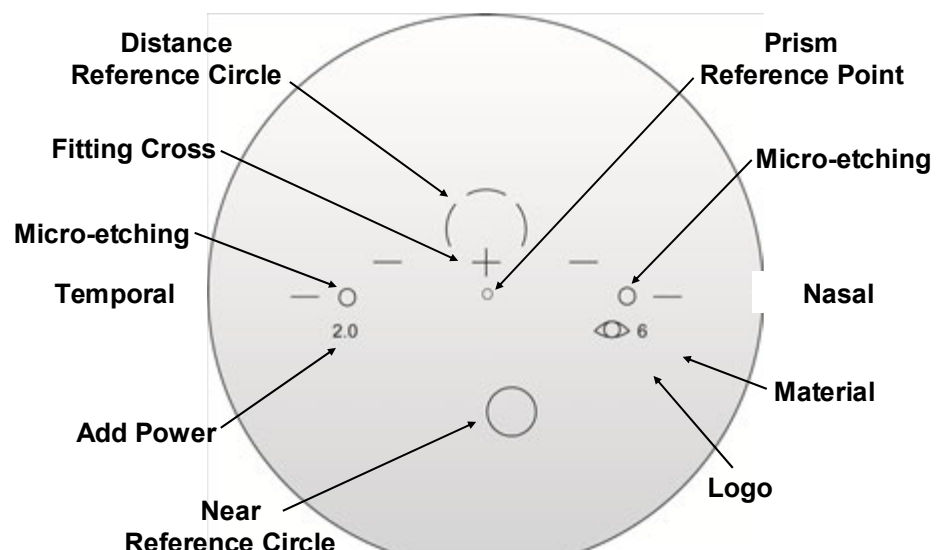
Step 5: Focus the lines or dots of the target that are closest to the vertical direction and determine the power.

Step 6: The difference between the two powers obtained in Steps 3 and 5 is the addition.

PROGRESSIVES LENSES

There are two ways to find the addition power in a progressive lens:

1. The add power is engraved on the lens. It is usually located on the temporal side of the lens (Figure 9.33).
2. Subtract the front vertex power of the distance reference circle from the front vertex power of the near reference circle.



RE LENS

Figure 9.33: Progressive lens markings

SUMMARY: HAND NEUTRALISATION AND VERTOMETRY

MEASURING SPECTACLE LENSES

There are two ways to measure the power of a lens:

- Hand neutralisation.
- Vertometry.

HAND NEUTRALISATION

- Plus lenses give against movement.
- Minus lenses give with movement.
- A lens can be neutralised by finding a lens of equal and opposite power.
- A lens that has been neutralised will give no movement.
- Use a cross to:
 - find out whether you have a spherical or spherocylindrical lens;
 - find the power of the principal meridians.
- The principal meridians of an astigmatic lens must be neutralised separately.

VERTOMETRY

- Focus the eyepiece.
- Clamp the right spectacle lens:
 - The front of the spectacles must face towards you.
 - Move the spectacles until the target is in the centre of the black graticule.
 - The spectacles must be horizontal on the frame table.
- Measure the lens power (turning the wheel slowly from plus towards minus).
- Find the optical centre of the lens.
- Clamp the left spectacle lens.
- Measure the lens power and find the optical centre of the left lens.
- Check for and measure vertical prism.
- Use the optical centre marks that you made and the person's interpupillary distance to check for horizontal prism.
- To check the addition of bifocals, turn the spectacles around and measure the distance and near powers again. The difference is the add.

TEST YOURSELF QUESTIONS

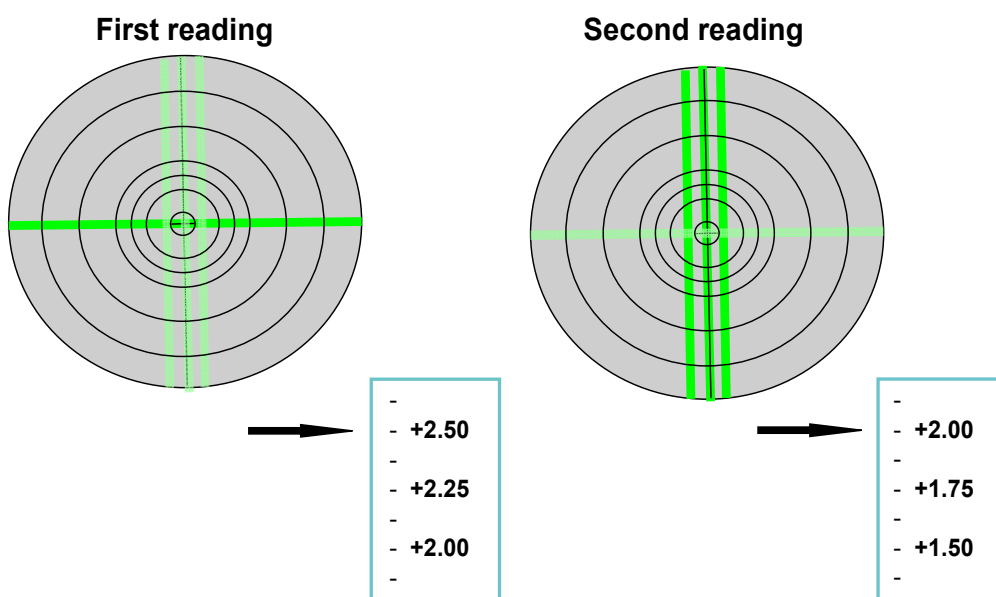
1. If you are holding a **+4.00** lens against an unknown minus lens and you see “with” movement, is the minus lens ... *(tick appropriate box)*
 - (a) stronger than -4.00 ☐
 - OR
 - (b) weaker than -4.00 ☐

2. You must always _____ the eyepiece before using the vertometer.

3. What are the three steps for finding the power of an astigmatic lens on a vertometer?
 - a. _____
 - b. _____
 - c. _____

4. If you are holding a -5.50 D lens against an unknown lens and you see no movement of the cross, what is the power of the lens? *(tick appropriate box)*
 - (a) -4.00 ☐
 - (b) $+6.00$ ☐
 - (c) $+5.50$ ☐
 - (d) -5.50 ☐

5. What is the power of this lens?





VISUAL ACUITY

THINK

Our vision lets us see shapes and colours and tells us where an object is. Some people can see things more clearly than other people.

It is important to be able to measure a person's vision to find out how well they see and if their vision is getting better or worse. Knowing how well someone sees helps us to find out if there is something wrong with their eyes.

When we measure a person's vision we call this measuring their visual acuity.

AIM

This unit teaches you how to measure a person's visual acuity.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- define visual acuity
- understand why measuring visual acuity is important
- describe the different types of visual acuity measurements
- recognise different types of visual acuity charts and know how to use them
- measure and record distance visual acuity
- measure and record near visual acuity.

VISUAL ACUITY

Visual acuity (VA) is a measure of how clearly a person sees when they are looking directly (straight) at an object. When a person looks directly at an object, they are using the part of the retina called the macula, which is used for central vision. Often VA is simply called vision – but vision actually includes everything that a person sees, not just their central vision.

Common causes of poor VA are:

- **Refractive error:**

In this case a person's eyes may be healthy, but they may not be the correct size and shape to focus light correctly onto the retina. A person who has a refractive error will need to wear spectacles if they want to see clearly.

- **Eye health problem:**

Some eye health problems (like cataracts) can cause poor vision. If a person has poor VA because of an eye health problem, spectacles will not improve their vision (unless they also have a refractive error).

VA TESTING DISTANCE	A person's VA can be different at different distances. Some people see things that are close to them well, but have trouble seeing things that are far away from them. Other people see things that are far away clearly, but they can't see things that are close to them. Some people have problems seeing things at all distances, no matter how far away an object is. This is why VA must be measured at different testing distances. Distance VA is usually measured at a distance of 6 metres (m). Most distance VA charts are designed to be placed 6 m away from a person, but there are some distance VA charts that are specially designed to be used at a distance of 3 m which can be more convenient in some cases. Near VA is usually measured at a distance of 40 centimetres (cm) from a person's eyes.
TYPES OF VA MEASUREMENT	One of the first things that you need to do when a person comes to you for an eye examination is to measure their VA. VA must be measured for the right and left eyes separately, and for both eyes together.  There are two reasons for this: 1. To get an accurate VA measurement: Other tests might affect the person's VA, or they might get better at reading the VA chart through practice. 2. To protect yourself legally: If a person says that their eyes have become worse because of the eye examination you gave them, you will have your initial VA measurement to use as a reference.
UNAIDED VA	A person's unaided VA is their VA without spectacles.

VISUAL ACUITY (cont.)

AIDED VA	A person's aided VA is their VA when they are wearing their spectacles. There are different types of spectacles. Spectacles can be for distance vision only, for near vision only, or for both distance and near vision.  Usually: If a person is given spectacles for distance only: → their vision for distance is clear when they wear their spectacles → their vision for near could be blurry when they wear their spectacles. If a person is given spectacles for near only : → their vision for near is clear when they wear their spectacles → their vision for distance is blurry when they wear their spectacles. If a person is given one pair of spectacles for distance and near: → their vision for distance is clear <i>and</i> → their vision for near is clear. When you measure aided VA, it is important to make sure that the person is wearing the appropriate spectacles for the distance that you are testing.  Ask the person whether they wear their spectacles: • all the time • only for looking at things that are far away (distance only) • only for looking at things that are close to them (near only). If they have distance only spectacles: → measure distance VA with the spectacles → measure near VA without the spectacles. If they have near only spectacles: → measure distance VA without the spectacles → measure near VA with the spectacles.
PRESENTING VA	A person's presenting VA is the VA that a person has when they arrive to have their eyes examined. • If they are wearing spectacles when they arrive, their presenting VA is the same as their aided VA. • If they are not wearing spectacles, their presenting VA is the same as their unaided VA. Presenting VA is sometimes called "Entering VA"
HABITUAL VA	A person's habitual VA is the VA that they usually have. This might be with or without spectacles. • If a person has spectacles, but does not usually wear them, their habitual VA is the same as their unaided VA. • If a person has spectacles and usually wears them, their habitual VA is the same as their aided VA. A person might own spectacles, but they might not wear them very often. They might tell you that: • their spectacles do not improve their vision • their spectacles make their eyes feel tired • they do not like the way they look when they are wearing their spectacles.  It is important to ask people whether they have worn spectacles in the past.

VISUAL ACUITY (cont.)

BEST-CORRECTED VA	The best possible VA that a person can have is their best corrected VA. This will be different for different people. After you have performed a refraction examination to see if a person has a refractive error, you must measure their VA again. → The VA that a person has with the spectacle lenses that improve their vision the most is their best corrected VA.
MONOCULAR AND BINOCULAR VA	Monocular VA is the VA that a person gets when just one eye is open (when the other eye is covered). Binocular VA is the VA that the person gets when both eyes are open and uncovered. Both monocular VA (for right and left eyes) and binocular VA must be measured for every person. The binocular VA is usually better than either of the monocular VAs.  Binocular VA is usually better than monocular VA. This is because two eyes that work together can usually see better than one eye alone. Best corrected monocular VA for the right eye and the left eye should always be approximately equal. If there is more than one line of difference between the two eyes you should suspect an eye health problem.  Best corrected VA for right eye should be about the same as best corrected VA for the left eye.
DISTANCE VA CHARTS	There are many types of VA charts available. Each type of chart has a special purpose, and a specific distance that it should be used at. Different types of VA charts have differently sized characters (letters, pictures, numbers or symbols). Some examples are shown in Figure 10.1. VA charts that use pictures or symbols (such as a “tumbling E” chart) are particularly useful for children or for people who cannot read or speak. VA charts include Snellen and LogMAR charts. Characters on a VA chart are usually largest at the top of the chart, and gradually get smaller towards the bottom of the chart.

		
Figure 10.1A: A LogMAR VA chart	Figure 10.1B: A picture VA chart	Figure 10.1C: A “tumbling E” VA chart

VISUAL ACUITY (cont.)

DISTANCE VA CHARTS (cont.)	Special rules must be followed when making a VA chart. The size of the letters or symbols on a VA chart (and the space between them) must be calculated and printed using special techniques. This is so VA measurements are accurate and repeatable (the same each time). Because VA charts are so difficult to make, we usually use readymade VA charts instead of making our own charts.
SNELLEN FRACTIONS	Each line of characters on a VA chart is labelled to tell you what vision a person needs to be able to see that line. Usually the label is a fraction number that is called a Snellen fraction. A Snellen fraction has a number on the top and a number on the bottom: - The number on the top tells you how far away the chart is from a person (usually a distance chart is 6 m away in which case the top number is 6). - The number on the bottom tells you how far away a person with normal vision could be and still see that line of characters.  TESTING DISTANCE (metres) VA = Distance at which someone with normal vision could read the same VA line (metres)
EXAMPLE 1	You measure a boy's VA and find that the smallest line of pictures that he can see is 6/6. → This means that when the boy is 6 m away from the VA chart he can see what a normal person sees if they were 6 m away from the chart. → This means that the boy's VA is normal.
EXAMPLE 2	You measure a woman's VA and find that the smallest row of letters that she can read is 6/48. → This means that when the woman is 6 m away from the VA chart she can only see the letter size that a person with normal vision could see if they were 48 m away from the chart. → This means the woman has poor vision.  VA of 6/6 is considered normal. If someone has 6/6 vision, their VA is considered to be 100%. The Snellen fraction can also be written in other ways. In some countries people use feet instead of metres to measure distances. For example: VA charts that are made in these countries usually write VA measurements as 20/20 or 20/200, instead of 6/6 or 6/60. This is because 20 feet is the same distance as 6 m.

VISUAL ACUITY (cont.)

Very good vision →
(If VA is equal to or better than all the letters on the 6/4.5 line)

Normal vision →
(If VA is equal to or better than all the letters on the 6/6 line)

Visually impaired →
(if VA is less than all the letters on the 6/18 line)

Blind →
(if VA is less than all the letters on the 6/120 line)

SNELLEN FRACTION	
METRES	FEET
6/3	20/10
6/4.5	20/15
6/6	20/20
6/7.5	20/25
6/9	20/30
6/12	20/40
6/15	20/50
6/18	20/60
6/24	20/80
6/30	20/100
6/48	20/160
6/60	20/200
6/120	20/400



A 3 m VA chart (a VA chart that is used to measure VA at a distance of 3 m instead of 6 m) should have Snellen fractions with the number 3 on the top of the fraction (in a 3/___ format).

However, the normal way to record VA is in 6/___ format.
This is because most VA charts have been designed to be used at 6 m.

Because 6/___ is most common (and most familiar) format, a 3 m chart will sometimes have its Snellen fractions converted to a 6/___ format for you.
This is to make it easier for you to record VA measurements in the 6/___ format that you are used to seeing, even when you are using a 3 m VA chart.

If you have a 3 m chart that has already done this conversion for you:

- you only need to look at the Snellen fraction next to the line that the person can read and record this fraction
- you do not need to do any calculations yourself.

If you have a 3 m chart that has *not* done this conversion for you, you may want to convert it to 6/___ format yourself. To do this you need to remember that Snellen fractions are just like normal fractions that can be changed into different formats.

Examples:

3/3 = 6/6

A person who can see the 3/3 line at 3 m will also see the 6/6 line at 6 m

3/4.5 = 6/9

A person who can see the 3/4.5 line at 3 m will also see the 6/9 line at 6 m

3/6 = 6/12

A person who can see the 3/6 line at 3 m will also see the 6/12 line at 6 m

3/9 = 6/18

A person who can see the 3/9 line at 3 m will also see the 6/18 line at 6 m

3/60 = 6/120

A person who can see the 3/60 line at 3 m will also see the 6/120 line at 6 m.

VISUAL ACUITY (cont.)

WORLD HEALTH ORGANIZATION (WHO)

Classes of Vision:

The WHO has grouped different levels of VA into special categories.

They have done this because they have decided that people who have vision worse than 6/18 should be given priority if resources are scarce (minimal).

WHO Category	Vision
Normal vision	A person who can see all of the 6/18 line or better. This person sees quite well.
Visually impaired	A person who cannot see all of the 6/18 line. This person does not see well.
Blind	A person who cannot see the 6/120 (or 3/60) line. This person can see very little, or nothing at all.

DISTANCE VA

RECORDING DISTANCE VA

Distance VA is usually recorded as a Snellen fraction.

If the person reads all of one line correctly, but cannot read any characters on the next line, VA is recorded as the Snellen Fraction of the line that was read correctly.

For example: If a person reads all of the 6/12 line correctly, but cannot read any characters on the next line, their VA is recorded as 6/12.

If the person reads a line correctly *and* some of the characters on the line below, VA is recorded as the Snellen Fraction of the whole line that was read correctly, *plus* the number of characters that were correct on the next line.

For example: If a person reads all of the 6/12 line correctly, as well as three characters from the next line, their VA is recorded as 6/12+3.



Remember to record whether the VA you measured was for:

- Right eye or left eye
- Aided or unaided
- Distance or near.

MEASURING DISTANCE VA

STEP 1

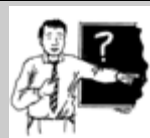
SET-UP

Make sure that the VA chart is clean and in good light. The chart should be flat and straight on the wall, and not positioned too high or too low.

Be careful that bright light is not reflecting off the VA chart. Glare on the chart makes it harder to see.

TESTING DISTANCE

The person should be the correct distance away from the VA chart (usually 6 m, but sometimes 3 m depending on the chart type). Each VA chart is designed to be used at a specific distance – if it is not used at this distance your VA measurement will be incorrect. Measure the correct distance with a tape measure. You can mark the place on the floor if this is practical.



USEFUL IDEA:

If you have a 6 m chart, but your room is only 3 m long, you can use a mirror to help you.

Put the mirror on the wall 3 m away from the person and put the VA chart on the wall above the person's head. The person can then look at the mirror and see the chart behind them.

Using a mirror like this you can make a 3 m room have a 6 m viewing distance.

STEP 2

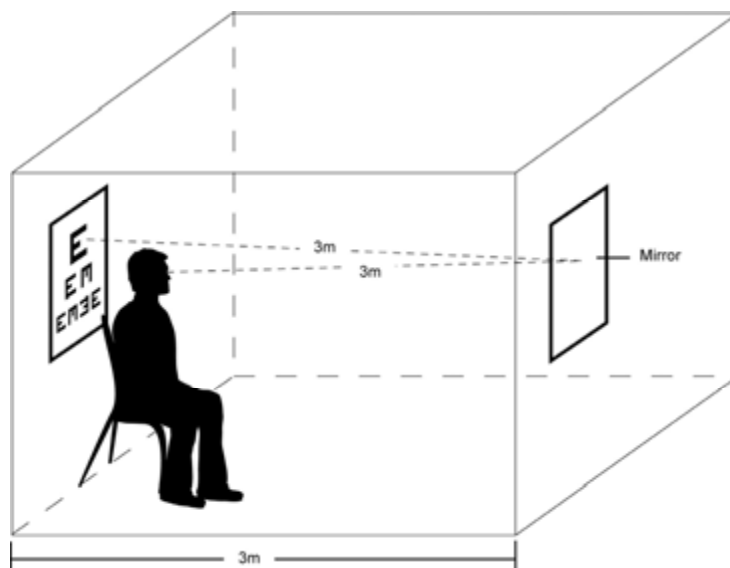


Figure 10.2: A mirror lets you use a 6 m VA chart in a room that is only 3 m long. The person looking in the mirror will see the chart as if it is 6 m away (3 m + 3 m = 6 m).

DISTANCE VA (cont.)

STEP 3

OCCLUDE THE EYE NOT BEING TESTED



Always test the right eye first (cover the left eye first).

Cover the person's left eye.

You can cover the eye with an occluder, or you can simply ask the person to use the palm of their hand.



Make sure that the person:

- does not press hard on the eye being covered
- keeps both eyes open (including the eye that is being covered)
- covers the eye with their palm, not their fingers
- does not lean forward or move closer to the chart.



Figure 10.3: Man using the palm of his hand to occlude one eye, while the VA of the other eye is being measured

DISTANCE VA (cont.)

STEP 4

Measure the VA

Start at the top of the chart where the larger letters or symbols are. Point to the characters that you want the person to read or name.

If the person finds the large characters very easy to see, you can just ask them to identify two on each line. When it becomes more difficult (further down the chart), you should ask the person to read the whole line.



Encourage the person to give you an answer (instead of just telling you they “don’t know”).

Sometimes people:

- are embarrassed that they might make a mistake
- give up easily.

Sometimes it can be helpful if you ask the person to guess – even if they are not sure.

Continue asking them to name smaller characters until the person gets at least half of the line wrong.



REMEMBER:

You need to find the smallest line that a person can see.



Figure 10.4: Measuring distance VA with a tumbling E chart

STEP 5

Record the VA measurement.

Write down the VA measurement on the record card. Remember to record whether the VA is aided or unaided, and which eye was tested

STEP 6

Repeat for the left eye.

Now cover the person’s right eye and repeat the above five steps for the person’s left eye.

DISTANCE VA (cont.)

EXAMPLES OF MEASURING DISTANCE VA EXAMPLE 1	A man has no distance spectacles. You measure his distance VA for each eye. • Right eye VA (left eye occluded): The man reads all the lines correctly down to and including all the characters on the 6/6 line. You ask him to try the line below (the 6/4.5 line), but he does not get these characters correct. → You write: VA RE 6/6 unaided. • Left eye VA (right eye occluded): With his left eye, this man can still read the 6/6 line. You ask him to try the characters on the line below (6/4.5 line), and he gets two of these characters correct. → You write: VA LE 6/6+2 unaided. This man has very good unaided distance VA. He probably does not need distance spectacles.
EXAMPLE 2	A woman has distance spectacles that she bought 1 year ago. You measure her distance VA for each eye. You ask the woman to put her distance spectacles on. • Right eye VA (left eye occluded): The woman reads all the 6/6 line correctly, and can also read five letters on the next line. → You write: VA RE 6/6+5 aided. • Left eye VA (right eye occluded): With her left eye, this woman can only read the 6/12 line and three characters on the line below it. → You write: VA LE 6/12+3 aided. Although this woman has distance spectacles, the vision in her right eye is different to the vision in her left eye. There is more than one line difference between her two eyes. Her problem might be a refractive error, or she may have an eye disease – further testing will be needed to find the reason.
EXAMPLE 3	A man comes to see you for an eye examination. He only has spectacles for reading. You measure his distance VA for each eye. The man should not wear his spectacles for distance vision testing, because they were prescribed for reading or near vision purposes. • Right eye VA (left eye occluded): The man reads the 6/60 letters correctly, and three more letters on the line below correctly. → You write: VA RE 6/60+3 unaided. • Left eye VA (right eye occluded): With his left eye, the man can still read the 6/60, and can also see four more letters on the line below. → You write: VA LE 6/60+4 unaided. This man's unaided VA is very poor. This man is visually impaired.

IF A PERSON CANNOT SEE THE TOP LINE

Sometimes, if a person has very poor vision, they cannot even see the largest characters at the top of the VA chart. If this happens you still need to measure their vision. There are several steps that you can take:

1. DECREASE TEST DISTANCE	Ask the person to move closer to the chart (or bring the chart closer to the person). Example 1: A man cannot see the 6/60 line at 6 m, so you decrease the test distance to 3 m. Now he can tell you what the characters on this line are so you record the VA as 3/60. Example 2: A woman cannot see the 6/60 line at 6 m or at 3 m, so you decrease the test distance again to 1.5 m. Now she can read the line below 6/60 which is the 6/48 line. So you record the VA as 1.5/48.
2. COUNTING FINGERS (CF)	If you cannot change the test distance between the person and the VA chart, you can use this method instead. Hold up one, two, three or five fingers at a distance of 3 m, 2 m, or 1 m from the person. Firstly, ask the person how many fingers you are showing them from 3 m away. If they can correctly tell you the number of fingers you are showing them, record the VA as CF @ 3 m (meaning that they could “Count Fingers” at 3 m).
3. HAND MOVEMENT (HM):	If the person cannot count fingers, wave your hand 20 cm in front of the person. Ask the person which way you are moving your hand. If the person can see movement, record the VA as HM.
4. LIGHT PERCEPTION (LP)	If the person cannot see HM, shine a light 20 cm from a person’s eyes and ask them to point to where they see the light. If the person can see the light, record the VA as LP.
5. NO LIGHT PERCEPTION (NLP)	If the person cannot see the light (thus they have no light perception), record the VA as NLP.  Hold the lens so that the lines of the cross that are seen through the lens line up with the lines outside the lens. The lines of the cross should look aligned through the lens and outside the lens edge – then the centre of the cross is at the optical centre of the lens.

MEASURING NEAR VA

To measure near VA we use a near VA chart or reading card.



Some people (especially older people) have spectacles that they use for near work or reading. The near VA is tested with these spectacles (or reading glasses), and the vision is recorded as “aided”.

Near VA charts have words or paragraphs of different sizes. Usually a near VA chart has the smallest words at the top and the largest words at the bottom. This is opposite to the distance VA chart which usually has the largest characters at the top of the chart.

ICEE Near Point Testing Card

N5

When you first wear your new glasses you may find that the ground looks like it is sloping or a door might look crooked. These distortions will disappear in time because the brain will adapt to the new visual conditions after a few weeks of wearing glasses. It is important to wear your glasses as much as possible so that you can get used to them more quickly.

3 8 2 6 1 9 7 4 5

N6

Diabetes is a condition that affects the whole body, including the eyes. Changes may occur at the back of the eye in the retina – especially after someone has had diabetes for a few years, or if they have poor control of their blood sugar levels. These changes are known as diabetic retinopathy. Diabetic retinopathy can make a person blind if it is not treated. In the early stages a diabetic person may not know that they have diabetic retinopathy until they are examined by their eye-care practitioner – that is why it is important to have your eyes examined every year if you have diabetes.

8 5 2 1 3 9 7 4 6

N8

Our eyes are very precious so it is important to look after them. There are simple steps we can take to look after our eyes. Every day the eyes should be gently washed in clean water – teaching children to do this is also important. Wearing safety glasses is a must when using tools or working with chemicals. We only have one pair of eyes – so we have to protect them!

5 9 4 2 1 3 7 8 6

N10

The strength of the sun can cause not only discomfort from the glare, but also permanent damage. Wearing sunglasses when out in the sun is always recommended. Your eye-care practitioner can talk to you about having prescription sunglasses so that you can see clearly and comfortably outside. Wearing a hat will also help to protect your eyes from the sun.

7 5 1 9 2 4 8 6 3

N14

If you have difficulty reading small print, remember that good lighting is important. Your eye-care practitioner can advise you on how to use lighting to improve your vision.

69 4 7 2 8 1 3 5

N24

**Cataracts are very common as we age.
Having cataracts removed is now very simple
and usually only takes a few hours!**

7 4 5 2 9 1 6 3 8

Figure 10.5: An example of a near VA chart used by the Brien Holden Vision Institute Foundation

MEASURING NEAR VA (cont.)

If a person cannot read, you can also use a near VA chart that has pictures, symbols or numbers on it instead of words.

Some near VA charts use Snellen fractions, but most use the N point scale or the Jaeger scale:

- **N point:**
Normal near vision is usually N6.
N5 is very small print, and N8 is approximately the size of normal print in a newspaper.
- **Jaeger “J” scale:**
J3 is the same as N5
J6 is the same as N8.



Near VA is usually measured with both eyes open.

You only need to measure near VA separately for each eye if there is more than one line of difference between the right and left eye for distance VA.

METHODS	SET-UP
STEP 1	Make sure that the person is seated in a space with good lighting. The person should hold the chart in their hands
STEP 2	TESTING DISTANCE The near VA chart is usually held at a distance of 40 cm away from the person’s eyes. Sometimes people will tell you that they prefer to hold their reading or near work closer to them or further away from them. The distance that a person likes to hold their reading or near work is called their preferred working distance. Example: A large man might like to read his newspaper at a distance of 50 cm. A small woman might prefer to hold her sewing 30 cm from her eyes. If the near VA is not measured at 40 cm, you must record the testing distance. N6 @ 50 cm N12 @ 30 cm.
STEP 3	Ask the person which size print is the smallest that they can see. Encourage the person to try the smaller prints. After the person has chosen their preferred working distance, make sure that they do not bring the near VA chart closer to them, or hold it further away from this original position.

MEASURING NEAR VA (cont.)

STEP 4

Record the VA measurement.
Write down the near VA measurement (and the testing distance if needed).
Remember to record whether the near VA is aided or unaided.

Examples of measuring near VA:
These examples use the same people who were used as examples for measuring distance VA previously.

Example 1:

This man has no distance spectacles and no near spectacles.
You measure his near VA at 40 cm while he keeps both his eyes open.
You ask the man to read the smallest print that he can see on the reading card. The smallest print that he can read is N12.
→ You write: **Near VA N12 unaided.**
This man has good distance VA, but he cannot read a newspaper or see small objects that are close to him.
He may need spectacles for close work or reading.

Example 2:

This woman has distance spectacles and near spectacles as well.
You measure her near VA while she is wearing her near spectacles.



REMEMBER:

This woman's aided distance VA was worse in her left eye than in her right eye, so she needs to have her near VA measured for each eye separately.

Right eye (left eye occluded)
You ask the woman to read the smallest print that she can see on the reading card, held at a distance of 40 cm.
The smallest print that she can read with her right eye is N6.
→ You write: RE Near VA N6 aided.

Left eye (right eye occluded)
With her left eye, the smallest print that she can read is N8.
→ You write: LE Near VA N8 aided.

Just like her distance VA, this woman's near VA is worse in her left eye than in her right eye.

Example 3:

This man has spectacles for near.
You measure his near VA while he is wearing his spectacles. He keeps both his eyes open.
You ask the man to read the smallest print that he can see on the reading card. The smallest print that he can read is N6.
→ You write: Near VA N6 aided.



REMEMBER:

This man's distance VA was RE 6/60+3 and LE 6/60+4 unaided – he is visually impaired when he looks in the distance.

With his reading glasses, this man has good near VA.
Because his near VA is so good, it is unlikely that he has an eye disease.
We would expect that his distance VA would also improve if he were given appropriate distance spectacles.

SUMMARY: MEASURING VISUAL ACUITY

VISUAL ACUITY

There are two ways to measure the power of a lens:

- Visual acuity (VA) is a measure of how clearly a person sees when they are looking directly (straight) at an object.
- Common causes of poor VA are:
 - Refractive error (when a person needs spectacles to see clearly)
 - Eye health problem (when a person has a problem with the health of their eyes).

VA TESTING DISTANCE

- A person's VA can be different for different distances.
- VA must be measured at both distance and near.
- Most distance VA charts are designed to be used at 6 m, but some distance VA charts are specially designed to be used at a distance of 3 m.
- Near VA is usually measured at a distance of 40 cm from a person's eyes.

TYPES OF VA MEASUREMENT

- VA measurement is usually one of the first tests that you do for a person when they come to you for an eye examination.
- Distance VA must be measured for the right and left eyes separately (we call these monocular VAs), and for both eyes together (we call this binocular VA).
- Near VA is usually just measured for both eyes together (binocularly).

UNAIDED VA

VA without the person's spectacles.

AIDED VA

- VA with the person's spectacles
 - distance spectacles for distance VA testing
 - near spectacles for near VA testing.

PRESENTING VA

- The person's VA when they arrive to have their eyes examined.
This will be the same as:
 - aided VA if they arrive wearing their spectacles
 - unaided VA if they arrive not wearing their spectacles.

HABITUAL VA

- VA that the person usually has.
This will be the same as:
 - aided VA if they usually wear their spectacles
 - unaided VA if they do not usually wear their spectacles.

SUMMARY: MEASURING VISUAL ACUITY (cont.)

BEST CORRECTED VA

- The best possible VA that a person has with their correct spectacle prescription in place
 - at the end of a refraction examination.

MONOCULAR AND BINOCULAR VA

- Monocular VA is the VA that a person gets when just one eye is used (when the other eye is covered).
- Binocular VA is the VA that a person gets when both eyes are open and uncovered.
- Binocular VA is usually better than monocular VA.

DISTANCE VA CHARTS

- Different VA charts have specific purposes, and a specific distance that it should be used at.
- VA charts use characters (letters, pictures, numbers or symbols) of different sizes.
- VA chart characters and the spaces between them are carefully calculated and printed. It is very difficult to make a correct VA chart, so we usually use readymade VA charts.

Snellen fractions:

- Each line of a VA chart is labelled. Usually the label is a fraction number called a Snellen fraction.
- A Snellen fraction has a number on the top and a number on the bottom:
 - The number on the top tells you how far away the chart is from a person (usually this number is 6 because the chart is 6 m away)
 - the number on the bottom tells you how far away a person with normal vision could be and still see that line of characters.

$$\text{VA} = \frac{\text{Testing distance (metres)}}{\text{Distance at which someone with normal vision could read the same VA line (metres)}}$$

World Health Organization (WHO) classes of vision:

- Normal vision → can see the 6/18 line or better.
- Visually impaired → can see the 6/60 line or better, but cannot see all of the 6/18 line.
- Severely visually impaired → can see the 6/120 line or better, but cannot see the 6/60 line.
- Blind → cannot see the 6/120 line.

RECORDING DISTANCE VA:

- Distance VA is usually recorded as a Snellen fraction.
- VA recording should always include the following information:
 - right eye or left eye
 - aided or unaided
 - the test distance.
- If the person reads a line correctly, but cannot read any characters on the next line, the recorded VA should be the Snellen fraction next to the line that was read correctly.
Example: 6/12
- If the person reads a line correctly and some of the characters on the next line, the VA is the Snellen fraction next to the line that was read correctly plus the number of characters that are correctly identified on the next line.
Example: 6/12+3

SUMMARY: MEASURING VISUAL ACUITY (cont.)

Method – Distance VA

- Make sure the chart is clean and in good light and that the person is the correct distance from the VA chart.
- Occlude the eye not being tested.
- Start at the top of the chart and ask the person to name the characters you point to. Gradually ask the person to identify smaller characters.
- Encourage the person to try hard to name the characters.
- Continue down the chart until the person gets at least half the line wrong.
- Record all important information about the VA measurement with as much detail as possible (including R or L eye, aided or unaided, and the test distance).
- Repeat for the other eye.

IF A PERSON CANNOT SEE THE TOP LINE

If the person cannot see even the largest characters on the VA chart (at its normal testing distance):

- **Decrease test distance**
→ Remember to change the top number of the Snellen fraction to the distance that the person is from the chart.
Example: If the person cannot see the 6/60 line at 6 m, but can only see that line when they come closer to see it at 3 m, you write VA 3/60.
- **Counting Fingers (CF)**
For people with severe visual impairment, hold up one, two, three or five fingers at a distance of 3 m, then 2 m, then 1 m.
Example:
If the person can only see how many fingers you are showing at 2 m, you record their VA as CF @ 2 m.
- **Hand Movement (HM)**
For people with severe visual impairment, wave your hand in front of the person's face. If the person can see which way your hand is moving you write VA HM.
- **Light Perception (LP) or No Light Perception (NLP)**
Another way to measure the VA of somebody with severe visual impairment is to shine a light 20 cm from the person's eyes. If the person can see the light, write VA LP. If the person cannot see the light, write VA NLP.

MEASURING NEAR VA:

- A near VA chart (or reading card) is used to measure near VA.
- Near VA charts have words or characters of different sizes. Usually the smallest words or characters are at the top and the largest words are at the bottom.
- Most near VA charts use N point measurements:
 - Normal near vision is usually N6.
- Near VA is usually measured with both eyes open.

Method – Near VA

- Make sure the chart is clean and in good light and ask the person to hold the chart at a distance where their arms feel comfortable.
- Near VA is usually measured binocularly.
- Most people like to hold their reading about 40 cm away from their eyes, but if they like to hold it further away or closer than this you must record their reading distance.
- Ask the person which size words or characters are the smallest that they can read or name. Encourage the person to try the smaller characters.
- Record the VA measurement (and the testing distance if it is not 40 cm). Remember to write down whether the near VA is aided or unaided.

TEST YOURSELF QUESTIONS

1. What is visual acuity (VA)?

2. What are common causes of poor VA?

3. What is the difference between:
 - monocular VA and binocular VA? _____

 - presenting VA and habitual VA? _____

 - unaided VA and best-corrected VA? _____

4. What type of VA charts could you use for someone who does not know how to read?

5. How do you record the VA of someone who:
 - sees all of the 6/9 line, but nothing on the 6/7.5 line? _____
 - sees all of the 6/24 line and two letters on the 6/18 line? _____
 - sees all of the 6/15 line and four letters on the 6/12 line? _____
 - sees the N8 print on a near reading card, but not the N6 print? _____
6. Why must you watch the person when you measure their VA?

7. If a person cannot see any of the characters on the VA chart, what other VA tests can you do?

8. Why should you encourage the person to read the next line on the VA chart even if they seem unsure?

NOTES



PINHOLE VISUAL ACUITY

THINK

A man comes to you and tells you that his vision has become worse over the past year.

When you measure his visual acuity, he can only read the 6/24 line with both his right and his left eyes.

You want to know if this man's vision is poor because of a refractive error, or if it is because he has an eye disease.

The pinhole test is an easy test that you can do to help you find the answer.

AIM

This unit shows you how to do the pinhole test and to understand what its results mean.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- recognise when you need to do a pinhole test
- describe what the results of the pinhole test mean
- use the pinhole test to measure and record pinhole visual acuity
- explain the possible causes, symptoms and treatment for amblyopia
- decide when to refer a person with poor VA for further care based on the results of the pinhole test.

REVIEW: PINHOLE VISUAL ACUITY

VISUAL ACUITY	- Visual acuity (VA) is a measure of how clearly a person sees when they are looking directly (straight) at an object. - Common causes of poor VA are: - Refractive error (when a person needs spectacles to see clearly) - Eye health problem (when a person has a problem with the health of their eyes). - VA measurement is usually the first test that you do for a person when they come to you for an eye examination. - VA must be measured for the right and left eyes separately.
DISTANCE VA CHARTS	- Different VA charts have specific purposes, and a specific distance that it should be used at. - VA charts use characters (letters, pictures, numbers or symbols) of different sizes. The largest characters are usually at the top of the chart and gradually get smaller towards the bottom of the chart. - VA chart characters and the spaces between them are carefully calculated and printed, to make sure VA measurements are accurate and repeatable. It is very difficult to make a correct VA chart so we usually use readymade VA charts.
SNELLEN FRACTIONS	- Each line of a VA chart is labelled. Usually the label is a fraction number called a Snellen fraction. - A Snellen fraction has a number on the top and a number on the bottom: - The number on the top tells you how far away the chart is from a person (usually this number is 6 because the chart is 6 m away) - The number on the bottom tells you how far away a person with normal vision could be and still see that line of characters. $\text{VA} = \frac{\text{Testing distance (m)}}{\text{Distance someone with normal vision could read the same VA line (m)}}$
PINHOLE AV	If the distance VA for either eye is worse than 6/18 you must do another test called the pinhole test.

PINHOLE TEST

The pinhole test is a simple test that lets you find out whether poor visual acuity (VA) is caused by refractive error or by an eye health problem.



A person with a refractive error needs to wear spectacles so that they can see clearly and comfortably.

To measure pinhole VA, the person must look through a special pinhole occluder (or simply, a pinhole) at a distance VA chart.

Pinhole VA is always measured monocularly (for each eye separately), and never binocularly (for both eyes together). The pinhole test is only used to measure distance VA, it is never used to measure near VA.

PINHOLE

A pinhole looks like an occluder, but it has a small hole (or sometimes many holes) in the middle of it. Usually a pinhole occluder is made of black plastic, but you can make your own from cardboard if you do not have plastic.



Figure 11.1: A pinhole occluder from a trial lens set

The size of the pinhole is important - if it is too big or too small, the pinhole test will not work properly. The size of the hole must be 1.0 millimetres (mm) to 1.5 mm in diameter.

A pinhole occluder may have only one hole, or it may have many holes. A pinhole occluder that has many holes is easier for a person to use because they may choose any of the holes to look through.



Figure 11.2: A pinhole occluder with multiple holes

PINHOLE TEST (cont.)

WHEN TO DO THE PINHOLE TEST

You must always do a pinhole test if a person's presenting distance VA is worse than 6/18 for either eye.



If VA is worse than 6/18 → you must do a pinhole test.

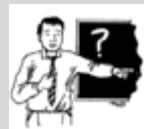
A pinhole test can also be used if

- a person has poor presenting VA (even if it is better than 6/18)
- a person still cannot read the 6/6 line when you have finished your refraction examination.

WHAT DO PINHOLE RESULTS MEAN?

VA improves when they look through a pinhole, the person has an uncorrected refractive error. You would expect that the person's best corrected VA (with spectacles) will be at least as good as their VA through the pinhole.

If the person's VA does not improve with the pinhole test, the person probably has an eye health problem. They might also have amblyopia (explained later in this unit). Spectacles will not improve this person's vision, unless they have both a refractive error and an eye health problem.



If VA improves with the pinhole test, it means that the eye has an uncorrected refractive error.

This does not mean that the eye is definitely healthy.

It is possible for an eye to have refractive error and an eye disease at the same time.

Therefore, we should always examine the health of the eye even if the pinhole VA is good.

If the VA improves to 6/12 or better when a pinhole is used (written as 6/12+ PH), the person must have a refraction examination. A refraction will tell you what power spectacles the person needs to make their vision better.



If the pinhole improves the VA, you can expect approximately the same improvement in VA with spectacles.

For example:

Presenting VA RE: 6/36 aided LE: 6/36+4 aided

Pinhole VA RE: 6/9 +2 PH LE: 6/7.5 PH

Best corrected VA RE: 6/7.5 aided LE: 6/7.5+2 aided

The pinhole VA and the best corrected VA are almost the same.

The best corrected VA is the best possible VA that a person gets after they have had their eyes refracted – this is the vision that they will get with spectacles.

PINHOLE TEST (cont.)

WHAT DO PINHOLE RESULTS MEAN?

If the VA is not better than 6/12 with a pinhole, they may have an eye health problem, with or without a refractive error.



An eye that has a VA worse than 6/12 (even when the pinhole is used) might have an eye disease and must be referred for further examination and care.

For example:

Presenting VA

RE: 6/24+2 unaided

LE: 6/48+4 unaided

Pinhole VA

RE: 6/12+2 PH

LE: 6/18 PH

This person must be referred because their LE pinhole vision is worse than 6/12.

BE CAREFUL

- **People with VA better than 6/18:**
Sometimes, doing the pinhole test for an eye that has good VA can make its VA worse. This is because less light can enter the pupil through a pinhole. For this reason, the pinhole test is less useful for people who already have good VA.
- **People with small pupils:**
The pinhole test might not work well for people who have small pupils. Older people have smaller pupils than younger people. You might find that your pinhole VA results for an older person are less accurate.



Pupils and Age:

As we get older our pupils get smaller. Small pupils can be thought of as natural pinholes in our eyes.

This is why some old people can see better than you would expect – they are using their pupils as natural pinholes!

Pupils and Light:

In bright light our pupils are smaller than in dim light.

There are two reasons why people see better in good bright light:

- more light can enter the eye
- small pupils are like natural pinholes.

If a person has a refractive error they will see better in bright light, when their pupil is small.

Squinting and Refractive Error:

You may have noticed that sometimes people squint their eyes (bring their eyelids closer together) when they want to see something better.

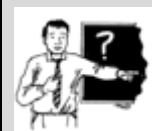
These people probably have refractive error. They have discovered that by making a small space between their eyelids, they can see better.

These people are making their own pinhole with their eyelids!

This is why it is important to make sure that people do not squint their eyes when you are measuring their distance VA, but keep their eyes open normally. Otherwise the VA measurement will be incorrect.

MEASURING PINHOLE VISUAL ACUITY

Measuring pinhole VA is similar to measuring normal distance VA.

STEP 1	Occlude (cover) the eye not being tested. Occlude the person's left eye. This can be done with an occluder, or simply with the palm of the person's hand.
STEP 2	Use the pinhole occluder on the other eye Put a pinhole occluder in front of the right eye. You can also ask the person to hold the pinhole occluder themselves.  If the pinhole is held closer to the person's eye, the VA chart will seem to be brighter. This will make it easier for the person to see.
STEP 3	Measure pinhole VA. Ask the person to look through the pinhole and name the characters on the smallest line that they can see on the distance VA chart.
STEP 4	Record pinhole VA. Write down the pinhole VA measurement on the record card. Remember to write down that it is a pinhole VA measurement: Example: RE 6/7.5 with pinhole or RE 6/7.5 PH
EXAMPLES OF MEASURING PINHOLE VA EXAMPLE 1	A woman who has no distance spectacles comes to you for an eye examination. You measure her distance VA for each eye. - Right eye VA (left eye occluded): The woman reads the 6/120 line correctly, but only gets two letters correct on the 6/60 line (below the 6/120 line). → You write: VA RE 6/120+2 unaided - Left eye VA (right eye occluded): With her left eye, this woman can read all of the 6/60 line. You ask her to try the characters on the line below (6/48 line), and she gets three of these characters correct. → You write: VA LE 6/60+3 unaided. This woman's VA is worse than 6/18 in both eyes so you must do a pinhole test. You measure her pinhole VA for each eye. - RE looks through the pinhole and LE is occluded. Now the woman can read all of the 6/7.5 line, but she cannot read any letters on the line below it. → You write: VA RE 6/7.5 PH - LE looks through the pinhole and RE is occluded. With this eye the woman can see all the letters on the 6/7.5 line and two letters on the next line. → You write: VA LE 6/7.5+2 PH From this we expect that the woman's poor VA is a result of refractive error and we expect that this woman will see very well with spectacles.

MEASURING PINHOLE VISUAL ACUITY (cont.)

EXAMPLE 2

A man comes to you for an eye examination. He was given distance spectacles 2 years ago and he wears them all the time.

You ask the man to put his distance spectacles on, and measure his distance VA for each eye (this is the man's habitual VA).

- Right eye VA (left eye occluded):
The man reads the 6/18 line correctly, and gets two letters correct on the 6/15 line (below the 6/18 line).
→ You write: **VA RE 6/18+2 aided**
You decide to try a pinhole test for this eye (even though this test is optional because the VA is better than 6/18).
With a pinhole he can read the 6/6 line, but nothing on the next line.
→ You write: **VA RE 6/6 PH**
- Left eye VA (right eye occluded):
With his left eye, this man cannot see any letters on the VA chart even when he is wearing his spectacles.
You ask the man to try very hard, but still he tells you that he cannot see any letters.
You hold up two fingers 3 m away from the man, and he correctly tells you that you are holding up two fingers.
→ You write: **VA LE CF @ 3 m aided**
This man's left eye VA is worse than 6/18 so you must do a pinhole test.

With a pinhole the man tells you that he still cannot see any letters on the chart.

You tell him to move the pinhole and see if that helps.

The man tells you that this does not make the VA chart easier to see.

→ You write: **VA LE CF @ 3 m aided PHNI**

PHNI = Pinhole No Improvement

This means that the VA does not improve with a pinhole.

This man has very poor vision that is not only due to uncorrected refractive error. This man probably has an eye health problem that is causing his poor vision and needs to be referred.

WHAT TO DO WITH PINHOLE VISUAL ACUITY RESULTS

You now know how to measure pinhole VA, but you also need to know what it means and what you should do next.

If the pinhole VA is 6/12 or better → Do a refraction.

If the pinhole VA is 6/12 or worse → Refer for an eye health check.
→ You can also do a refraction.

AMBLYOPIA

CAUSE OF AMBLYOPIA

An eye with amblyopia is sometimes called a lazy eye. An amblyopic eye will not see clearly – even if a pinhole is used.

Amblyopia develops during early childhood when the eyes are growing and the brain is developing.

During childhood, the brain makes pathways that let it interpret visual messages that are sent to it by the eye. If an eye does not see clearly during childhood, the brain will not be able to make these pathways.

During childhood, the brain makes pathways that let it interpret visual messages that are sent to it by the eye. If an eye does not see clearly during childhood, the brain will not be able to make these pathways.

Examples:

- A child will not see clearly if she has high refractive error.
- A child will not see clearly if he has a cataract.

Both of these children will probably get amblyopia if they do not get treatment in time.

Most brain development for vision occurs before a child is 7 years old. After 7 years the brain will still develop, but the growth will be much slower and the visual pathways to the brain will probably never work as well as they should – this is why amblyopia develops if eye problems are not treated when a child is still very small.

An adult who gets poor vision later in life will not develop amblyopia because the visual pathways already developed in the first years of life. Unlike a child, when the cause of the poor vision is removed, an adult will see clearly again.

Example

A 55 year old man gets a cataract, but he does not have the chance to have it operated on until he is 65 years old.

When the cataract is removed his eye will see clearly again – he did not develop amblyopia, because his visual pathways were already formed.

DETECTING AMBLYOPIA

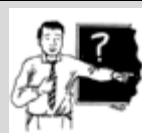
Sometimes a person who has poor vision in one eye never knows that they have a problem. This is because when both eyes are open the good eye can provide all the visual information that a person needs. It is only when both eyes are tested separately that the problem becomes obvious. This is why it is important to always measure VA for each eye separately during an eye exam.



If a child has poor vision in only one eye, it is extremely unlikely that she will notice it. This is because she will use her other eye to see.

Usually a child with poor vision in only one eye will only be identified if she has her eyes examined by a trained eye care worker.

Sometimes a person will tell you that their vision in one eye has always been poor. If a person tells you this they might have amblyopia, but you must check for all other eye problems first.



Amblyopia is a diagnosis of exclusion

This means that you can only say that a person has amblyopia if all other possible reasons for poor vision have been excluded (ruled out).

It can be very dangerous to just assume that a person has amblyopia when their vision is poor – they might have a more serious eye disease that you are missing!

AMBLYOPIA (cont.)

Usually the best corrected VA of an amblyopic eye will be 6/9 or worse.

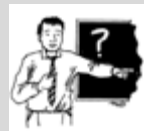
Sometimes an eye that has amblyopia will also have a strabismus (a turned eye).

- Strabismus can cause amblyopia (because the turned eye does not see very well and the visual pathways do not form normally; and
- Amblyopia can cause strabismus.

TREATMENT OF AMBLYOPIA

It is extremely important that a young child who has poor vision receives treatment for the eye problem as soon as possible.

If a child does not receive treatment for their poor vision early, the child might become amblyopic which means their vision will be permanently affected.



If you think that a child has amblyopia, you must refer the child to someone who is trained in the treatment of amblyopia (or someone who knows how to manage children's vision) as soon as possible.

The earlier a child is treated for the poor vision, the more likely it is that they will get their vision back and not develop amblyopia.

EXAMPLES

- You examine a 20 year old woman who has had high hyperopia in her right eye since she was a baby. You give her the first pair of spectacles she has ever had. Even though the image on her retina is now clear, her brain never learned how to interpret the visual message from this eye. Her vision with her right eye will never be perfectly clear – because the high hyperopia in that eye was treated at an early age while the visual pathways were still developing. She has amblyopia in her right eye.
- A 30 year old man comes to you for an examination. He tells you that he was born with a cataract in his eye. Last year he finally had the opportunity to have a cataract operation. Even though the cataract is now gone, his brain never learned to understand visual messages from this eye when he was a child. His vision with his left eye will never be perfectly clear – his left eye is amblyopic.



Can you see why it is important to treat the cause of poor vision at an early age?

- You examine the eyes of a 4 year old girl and discover that she has a large amount of refractive error in both eyes. You give her spectacles and tell her that she must wear them all the time – even though it might take a few weeks for her to feel comfortable wearing the glasses. Now her eyes have clear vision and her brain has a chance to make visual pathways. This girl will not develop amblyopia and will have good vision when she is older (although she will need to wear spectacles for her whole life to see clearly), because her refractive error was treated early and her visual pathways can now develop normally.



INTERESTING FACT:

Imagine this girl in the example is now 18 years old. She has worn her spectacles every day since she was 4 years old, but now she refuses to wear her glasses even though her vision is blurry without them.

Do you think that she will develop amblyopia now?

No! Even if she does not wear her spectacles again until she is 28 years old she will not develop amblyopia. This is because her brain made the visual pathways it needed when she was a small girl (when she was wearing her spectacles).

If this girl starts to wear her spectacles again when she is 28 she will see clearly again – she will not have amblyopia.



Amblyopia in an adult cannot be treated – it is too late. This is why it is so important to treat amblyopia and the causes of poor vision in children as early as possible.

SUMMARY: PINHOLE VISUAL ACUITY

THE PINHOLE TEST

- The pinhole test is a simple test that lets you find out whether poor visual acuity (VA) is caused by refractive error or an eye health problem.
- To measure pinhole VA, the person must look through a pinhole at a distance VA chart.
- A pinhole looks like an occluder, but it has a small hole (or sometimes many holes) in the middle of it.
- You can make your own pinhole, but you must be careful that the size of the hole or holes is between 1 mm and 1.5 mm in diameter.
- You must do a pinhole test if a person's presenting distance VA is worse than 6/18 for either eye.
- You can also do a pinhole test if:
 - the person has poor presenting VA (even if it is better than 6/18)
 - the person still can't read the 6/6 line after you have finished your refraction examination.

WHAT DO PINHOLE VA RESULTS MEAN

- If VA improves with a pinhole
 - the person has a refractive error.
 - This does not mean that the eyes are definitely healthy. It is possible for an eye to have a refractive error and an eye disease at the same time.
 - We should always examine the health of the eye even if the pinhole VA is good.
- If VA does not improve with a pinhole
 - the person has an eye health problem or amblyopia (a lazy eye).
- If VA improves to 6/12 or better with a pinhole, the person needs a refraction examination. A refraction will tell you what power spectacles the person needs to make their vision better.
- The best corrected VA (after a refraction) should be at least the same as the pinhole VA.

MEASURING PINHOLE VA

- Occlude the eye not being tested.
- Put a pinhole in front of the other eye.
- Measure the person's VA when they look through the pinhole.
- Record the pinhole VA.
Example: RE 6/7.5 PH

WHAT TO DO AS A RESULT OF PINHOLE VA

- If pinhole VA is better than 6/12 → do a refraction.
- If pinhole VA is worse than 6/12
 - Refer for an eye health check
 - You can also do a refraction.

AMBLYOPIA

- Sometimes called lazy eye. Usually the best corrected VA of an amblyopic eye will be 6/9 or worse.
- This is an eye problem that develops during early childhood (usually before a child is 7 years old) if the child does not see clearly. This is because the brain does not make pathways to interpret visual messages.
- An adult who gets poor vision later in life will not develop amblyopia because the visual pathways are already developed.
- An amblyopic eye will never see perfectly – even with a pinhole.
- Amblyopia is a diagnosis of exclusion
 - This means that you can only say that a person has amblyopia if all other possible reasons for poor vision have been excluded (ruled out).
- If you think that a child has amblyopia you must refer the child as soon as possible.
The earlier a child is treated, the more likely it is that they will get their vision back.
- Amblyopia cannot be treated in adults – it is too late.
This is why it is important to refer children as early as possible.

TEST YOURSELF QUESTIONS

1. What size (diameter) should a pinhole be to get the best results?

2. When *must* you do the pinhole test?

3. If a man's unaided distance visual acuity (VA) improves when he looks through a pinhole, what does this mean?

4. If a woman's unaided distance VA stays the same when she looks through a pinhole, what does this mean?

5. If a man has poor distance VA with his current distance spectacles, but good VA with a pinhole, what does this mean?

6. A woman's distance VA is 6/18 unaided and 6/6 with a pinhole. Does this mean that the woman does not have an eye health problem?

7. What things can make your pinhole VA measurement less accurate?

8. A pinhole test should always be done (*circle all correct answers*):
 - a. ☐ Monocularly ☐ Binocularly
 - b. ☐ For Distance ☐ For Near
9. If you think a child has amblyopia, what must you do?

10. If an adult has amblyopia, what must you do?

11. What must you do if the pinhole VA is worse than 6/12?

NOTES

HYPEROPIA, MYOPIA AND ASTIGMATISM

THINK

Have you noticed that some people have problems seeing far away – but can see clearly at a closer distance, while other people have problems seeing things that are close to them – but can see things in the distance very easily?

Different refractive errors affect vision at different distances. Depending on the type of refractive error, vision for distance, near, or both distance and near may be affected.

AIM

This unit shows you why some people with healthy eyes do not see clearly or comfortably, and explains how spectacle lenses can help these people see clearly.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- describe the causes of hyperopia, myopia and astigmatism
- know the visual symptoms of hyperopia, myopia or astigmatism
- identify which lenses correct hyperopia, myopia and astigmatism
- recognise complications that are associated with hyperopia and myopia
- understand how and why the symptoms of refractive errors change as people age.

REVIEW: HYPEROPIA, MYOPIA AND ASTIGMATISM

PARTS OF THE EYE	Cornea: • Like the window of the eye. • Transparent, so that it can let light into the eyeball to allow us to see. • Helps to focus light that enters the eye. Crystalline lens (or simply “lens”): • Transparent in a normal eye. • Changes shape to change the eye’s focus from distance to near. Retina: • The inside layer at the back of the eye. • Catches the light that comes into the eye and changes it into nerve messages that are sent to the brain.
HOW IS LIGHT RECEIVED BY THE NORMAL EYE?	• Light from an object enters the eye in the form of light rays. • Light passes through the tear film, cornea, anterior chamber, pupil, crystalline lens and vitreous, before arriving at the retina. • Light rays are converged (focused) by the cornea and the crystalline lens. • If the light focuses correctly on the retina, a clear image will be formed. • At the retina, light is changed into electrical signals (nerve messages). • Information received by the retina is sent to the brain via the optic nerve.
FOCUSING LIGHT IN THE EYE	• In an eye without refractive error, light that enters the eye is focused on the retina because: - the cornea and the lens are the correct shape; and - the eyeball is the correct length. • If an eye does not have the correct shape or length to focus light on the retina, it is said to have refractive error.
VISUAL ACUITY	• Visual acuity (VA) is a measure of how clearly a person sees when they are looking directly (straight) at an object. • Aided VA is a person’s VA when they are wearing their spectacles. Unaided VA is a person’s VA when they are not wearing spectacles. • Common causes of poor VA are: - Refractive error (this person needs spectacles to see clearly) - Eye health problem (this person has a problem with the health of their eyes).
WHAT IS REFRACTIVE ERROR?	• A person who has a refractive error will need to wear spectacles (glasses) or contact lenses so that they can see clearly and comfortably. This is because their eye is not the correct size and/or shape. • There are four main types of refractive error: myopia, hyperopia, astigmatism and presbyopia. • The amount of refractive error an eye has depends on: - the steepness of the cornea; and/or - the steepness of the crystalline lens; and/or - the length of the eyeball. • A person with a refractive error will have eyes that look normal, but they will not see well. • An eye examination that tests for refractive error is called a refraction.

REVIEW: HYPEROPIA, MYOPIA AND ASTIGMATISM (cont.)

WHAT IS ACCOMMODATION?

- Accommodation occurs when the ciliary muscle contracts and changes the shape of the crystalline lens (makes it thicker).
- This changes the optical focus of the eye so that close objects can be seen clearly.
- When accommodation in a normal eye (an eye without refractive error) is relaxed, objects in the distance are seen clearly.
- Presbyopia is the natural aging change in the eye where the crystalline lens hardens with age. When this happens, the lens cannot change shape easily when the ciliary muscle contracts. This means that an older person cannot accommodate as much or as easily as a younger person.
- If a normal eye cannot accommodate (if a person has presbyopia), close objects will appear blurry.
- The amplitude of accommodation is the total amount of accommodation that is available to change the focus of the eye.
- Amplitude of accommodation decreases with age.
- To avoid asthenopic (visual fatigue) symptoms during long periods of near work, usually only half the amplitude of accommodation should be used.

REFRACTIVE ERRORS

There are four types of refractive error:

- hyperopia
- myopia
- astigmatism; and
- presbyopia.

In this unit we will discuss three of these refractive errors (hyperopia, myopia and astigmatism).

Presbyopia is discussed in other units.

HYPEROPIA (“Longsightedness”)

WHAT IS HYPEROPIA?

When light rays from a distant object (6 m or further away) come into focus behind the retina in an unaccommodated eye, we say that the eye is hyperopic (or hypermetropic), or that the person is hyperopic. Hyperopia is sometimes also called “longsightedness” or “farsightedness”.

Figure 12.1 shows light from a distant object focussing at a focal point behind the retina of a relaxed, hyperopic eye.

The light does not truly focus behind the eyeball, but it would if the back of the eye did not block the light rays.

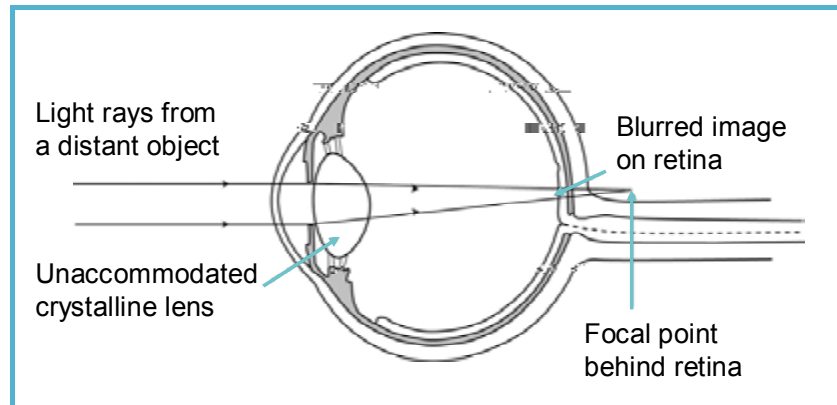


Figure 12.1: The focal point in a relaxed hyperopic eye is behind the retina

CAUSES OF HYPEROPIA

Hyperopia may be caused by:

- an eye that is shorter than average (called axial hyperopia)
- a cornea and/or crystalline lens that is too flat (not curved enough) and, therefore, too weak in power (called refractive hyperopia)

THE EFFECT OF ACCOMMODATION ON HYPEROPIA

Figure 12.1 shows how light from a distant object comes into focus behind the retina in a relaxed hyperopic eye.

Figure 12.2 shows the same eye when it accommodates just enough to bring the focal point onto the retina and makes the distance vision clear. In this way, a person with hyperopia may be able to accommodate enough to see clearly without spectacles.

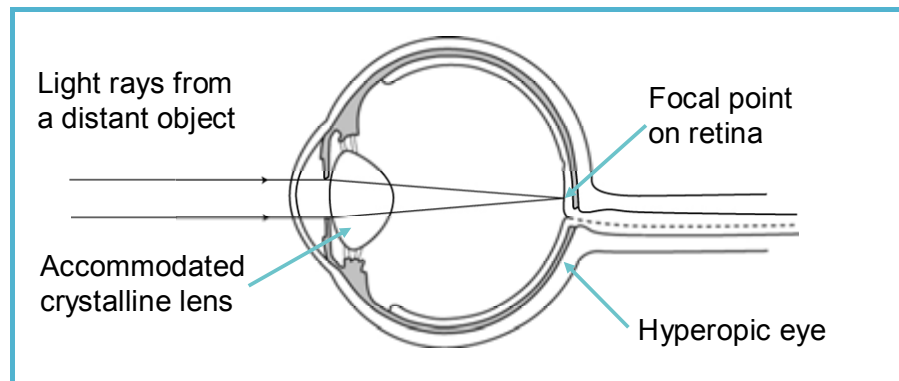


Figure 12.2: The focal point of the accommodated hyperopic eye is now on the retina



The symptoms of hyperopia vary depending on how much accommodation can be used (how old the person is), and the amount of hyperopia they have.

However, most people with hyperopia complain of difficulty seeing at near – usually they tell you that their near vision is worse than their distance vision.

Hyperopic people (sometimes called “hyperopes”) often find that their vision seems worse at night or in dim light.

HYPEROPIA (“Longsightedness”) (cont.)

SYMPTOMS OF UNCORRECTED HYPEROPIA	As a guide we can say: • If the amount of hyperopia is small (low hyperopia), the person may be able to accommodate enough to compensate for (make up for) their hyperopia – in this case they will have clear vision, both in the distance and at near, without spectacles. People with low hyperopia may (or may not) complain that their eyes feel tired or sore, or that they get headaches if they do a lot of close work such as reading or sewing. these pathways. These symptoms are sometimes called “asthenopia” (eye strain or visual fatigue) and are caused by fatigue (tiredness) of the ciliary muscle which works to make the lens accommodate. People with asthenopia may also have poor concentration when doing near work, or avoid near work if they can. • If the amount of hyperopia is of a medium amount (moderate hyperopia), the person may complain of blurry near vision, but might tell you that their distance vision is clear. • If the amount of hyperopia is large (high hyperopia), the person may tell you that both their distance and near vision is blurred. • A large amount of hyperopia may cause crossed or turned eyes (also called strabismus or squint). We will talk more about strabismus later in this unit.
WHAT HAPPENS WHEN HYPEROPES GET OLDER?	As seen in Figure 12.2, accommodation can move the focal point from behind the retina onto the retina so that a clear image is formed. With age, the symptoms of hyperopia usually get worse, even though the <i>amount</i> of hyperopia does not necessarily change). This is because, as we get older, the crystalline lens in the eye becomes harder and less flexible, which makes it more difficult for the ciliary muscle to change the shape of the lens – this makes accommodation more difficult. When this happens it is more difficult for the eye to compensate for the hyperopia by accommodating. The crystalline lens of a child is very soft and flexible, and a child can accommodate a lot. This means that even a child who has high hyperopia may tell you that they have no difficulty seeing (at distance or at near) – they may have clear vision at all distances. However, such a child may have other symptoms because they have to make their ciliary muscle work so much to see clearly. Symptoms that a child with high hyperopia might have include sore or tired eyes, eye rubbing, vision that is only sometimes blurry, or difficulty concentrating whilst doing near work. A child with high hyperopia might also have an eye that turns to the side instead of pointing straight ahead (this is called a strabismus – there will be more on that below). Eventually, as we get older, the crystalline lens becomes completely solid and is no longer flexible enough to accommodate – this is part of the natural ageing process, and happens to all of us around the age of 40 or 45. When this happens, no matter how much the ciliary muscle works, it cannot change the shape of the lens, and the eye can no longer accommodate. Most people who have hyperopia only require spectacles for close work in the beginning (because more accommodation is needed to see things up close than far away). However, as they get older, many hyperopes will need spectacles for their distance vision too. This is because as we get older we have less accommodation and even the small amount of accommodation needed to make a low or moderate hyperope’s distance vision clear, is too much.

HYPEROPIA (“Longsightedness”) (cont.)

HOW A PERSON WITH HYPEROPIA MAY SEE



Low hyperopia:
May have good distance vision and good near vision, but may have eyestrain and headaches.



Moderate hyperopia:
Near vision blurred, but good distance vision.



High hyperopia:
Both distance and near vision blurred (near vision is worse than distance vision).

Figure 12.3: How a person with low, moderate and high hyperopia might see

CORRECTION OF HYPEROPIA

Hyperopia is corrected with convex (or “plus”) spherical lenses. When we correct hyperopia, we are decreasing the need for the eye to accommodate by using positive spectacle lenses.

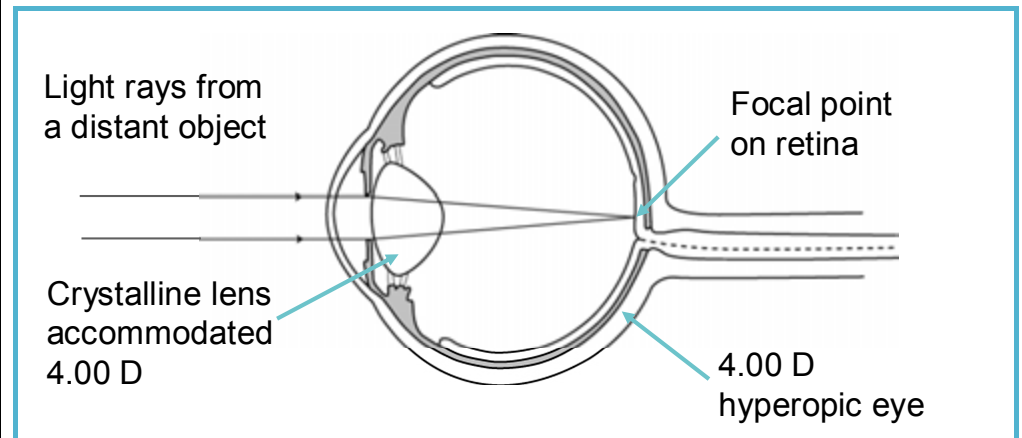


Figure 12.4: The eye of a young 4.00 D hyperope which is accommodating by 4.00 D; the focal point is on the retina and the distance vision is clear

In this case (Figure 12.4), if the person is younger than 20, you may prescribe only half of the refractive error amount (thus +2.00 D – as seen in Figure 12.5) because this person is young and still has a lot of accommodation.

HYPEROPIA (“Longsightedness”) (cont.)

CORRECTION OF HYPEROPIA (cont.)

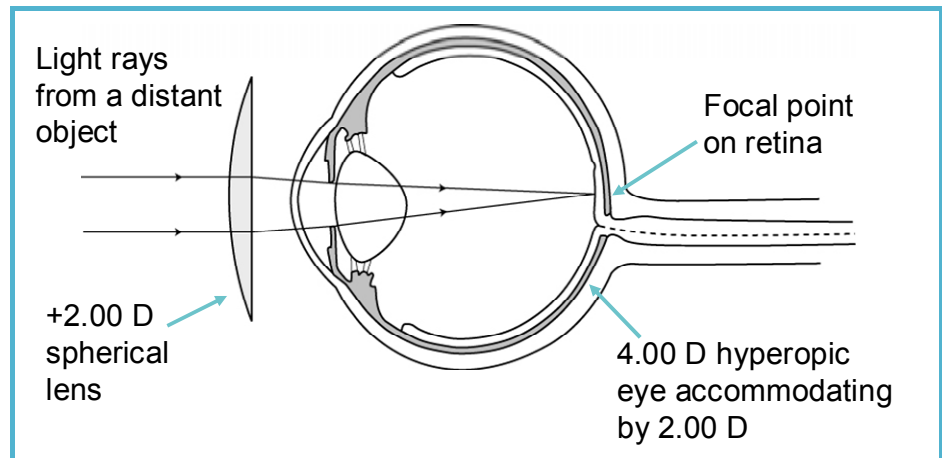


Figure 12.5: The same eye as above with a +2.00 D spectacle lens in front of it. Now the eye only has to accommodate 2.00 D to have clear distance vision. This will make the person's eyes feel more comfortable, especially when looking at near, because they do not have to accommodate as much.

If the person is 30 years old or older, you will probably prescribe the full +4.00 D (as seen in Figure 12.6) because their ability to accommodate is decreasing.

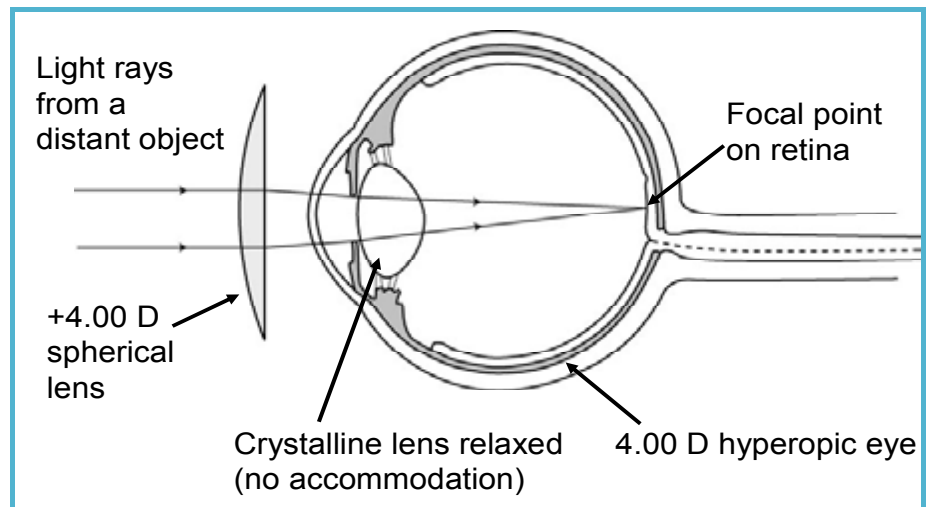


Figure 12.6: The same eye as above, but now we have placed a +4.00 D spectacle lens in front of it. Now the eye does not need to accommodate at all to keep the distance vision clear.

A full correction of the hyperopic refractive error is not needed in all cases. Younger people are usually more comfortable if only part of the hyperopia is corrected and some accommodation is used, because their eyes are used to accommodating. It is sometimes unwise to fully correct hyperopia because a younger person may complain of blurred vision at distance with the full correction – simply because they are unable to relax all of their accommodation. An example of a partial correction of hyperopia is seen in Figure 12.5.

As a hyperopic person gets older and has less accommodation, a positive spectacle lens of greater power is needed to make the vision clear.

By the time a person is about 60 years of age, there is little or no accommodation remaining and the hyperopia must be fully corrected (Figure 12.6).

HYPEROPIA (“Longsightedness”) (cont.)

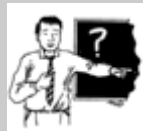
HYPEROPIA AND CONVERGENT STRABISMUS

Although we have said that a full correction of hyperopia may not be necessary for all young people, there are times when it is extremely important that all of the hyperopic error is corrected – even in young people.

Hyperopia in children may cause an eye to turn. This problem has several names:

- convergent strabismus
- eye turn
- crossed eyes
- convergent squint.

If we give these children their full correction for hyperopia, it will usually relax their accommodation and straighten their eyes – but often other treatment is also needed.



Children who have eyes that do not look straight (an eye may turn in, out, up or down), should always be referred to a person who is specially trained to treat this condition.

It is very important that these children are treated whilst they are still very young, so it is important to refer them promptly.

If treatment is not received whilst the child is young, the problem may become permanent.

Children have very active accommodation and usually cannot relax their accommodation even if they try. To test children’s eyes for hyperopia, accommodation must be fully relaxed, so a person who is trained to do so will use special eye drops called “cycloplegic drops”. These drops paralyse the ciliary muscles for several hours so that the child cannot accommodate and the full amount of hyperopia can be measured.

Note: Not all cases of strabismus are caused by uncorrected hyperopia, so spectacles will not help all types of strabismus.



Figure 12.7: A child with a strabismus (eye turn) should always be referred to a person who is trained to treat this condition

MYOPIA (“Shortsightedness”)

WHAT IS MYOPIA?

When light rays from a distant object (6 m or further away) come into focus in front of the retina of an unaccommodated eye, we say that the eye is myopic, or that the person has myopia.

In Figure 12.8 you can see that the parallel light rays from a distant object come to a sharp focus before they reach the retina. The light rays are diverging when they reach the retina. This means that the unaided distance vision will be blurred.

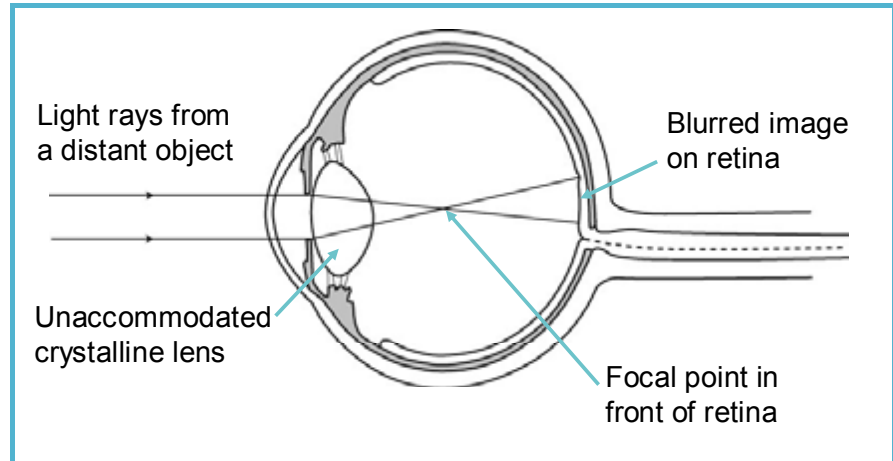


Figure 12.8: The focal point in a relaxed myopic eye is in front of the retina

CAUSES OF MYOPIA

Myopia may be caused by:

- an eye that is longer than average (this is called *axial myopia*)
- a cornea and/or a crystalline lens that is curved too much and, therefore, too strong in power (this is called *refractive myopia*).

THE EFFECT OF ACCOMMODATION ON MYOPIA

Accommodation has no effect on myopia.

A hyperopic person can use accommodation to make their distance vision clear. Why then does accommodation not help make distance vision clear in myopia?

If you look at Figures 12-2 and 12-4 you can see that when the hyperopic eye accommodates, the focal point moves closer to the crystalline lens. Accommodation only works in this direction.

Now look at Figures 12-9 and 12-10. You can see that when an uncorrected myopic eye accommodates while viewing a distant object, the focal point moves even further away from the retina. The blur on the retina will be even worse, so a person with myopia will not be able to see more clearly if they accommodate.

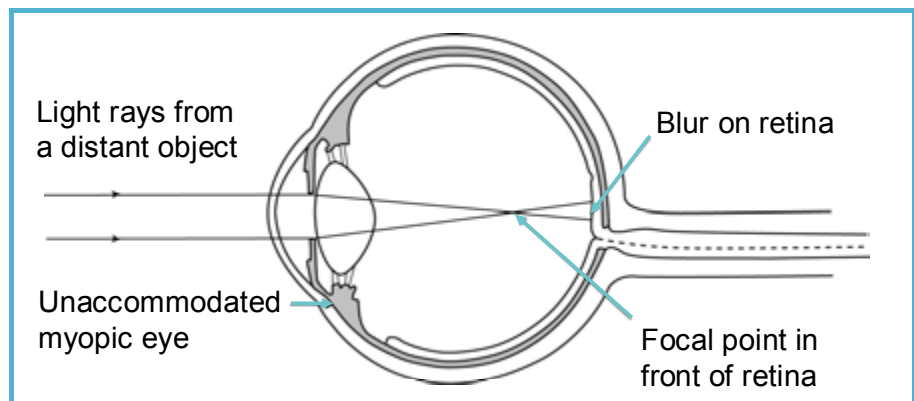


Figure 12.9: The focal point in a relaxed myopic eye is in front of the retina

MYOPIA (“Shortsightedness”) (cont.)

THE EFFECT OF ACCOMMODATION ON MYOPIA (cont.)

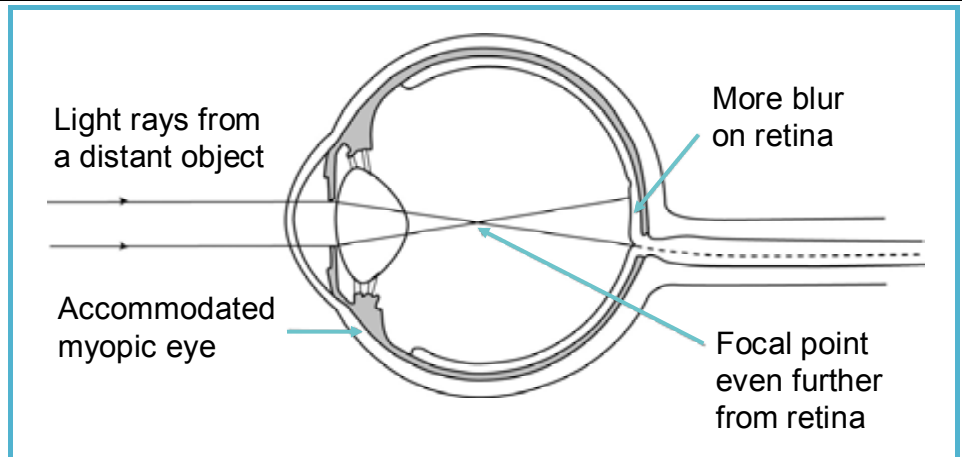


Figure 12.10: The focal point in an accommodated myopic eye is further away from the retina

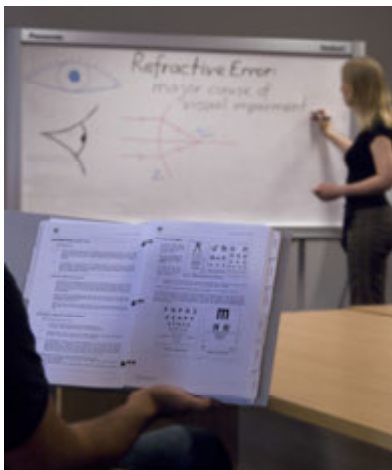
SYMPTOMS OF UNCORRECTED MYOPIA

Myopia is often called “shortsightedness”. The reason for this is that a person with myopia will have near vision that is better than their distance vision, no matter what age they are.

People with myopia (also called myopes) usually complain of blurry distance vision, or say that they cannot recognise people who are far away. They may tell you, or you may notice, that they see better when they almost close their eyes (“screw up” or “squint” their eyes).

Myopic people often find that their vision seems worse at night or in dim light.

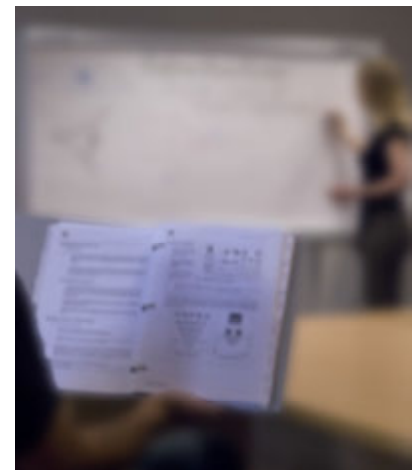
HOW A PERSON WITH MYOPIA WILL SEE



Low myopia:
Distance vision blurred,
but good near vision.



Moderate myopia:
Distance vision blurred,
but good near vision.



High myopia:
Both distance and near vision
blurred (distance vision is
worse than near vision).

Figure 12.11: How a person with low, moderate and high myopia might see

MYOPIA (“Shortsightedness”) (cont.)

CORRECTION OF MYOPIA

Concave (or “minus”) spherical lenses correct myopia. The next three figures will help explain how minus spheres do this.

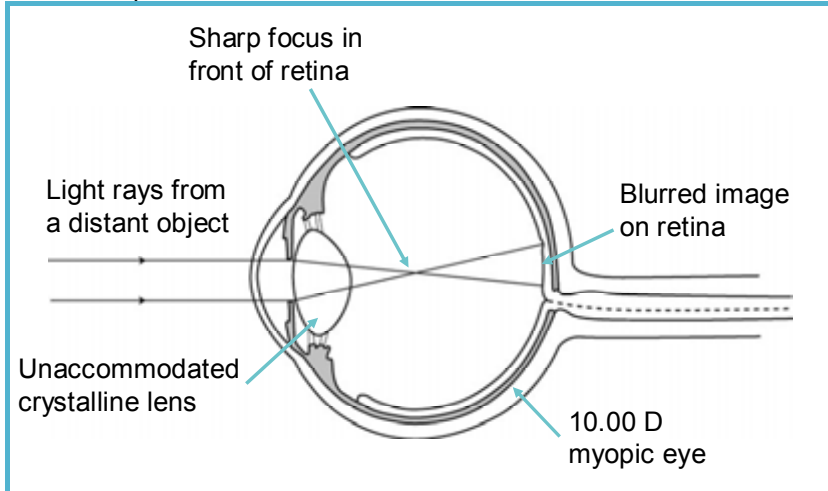


Figure 12.12: A relaxed, uncorrected eye with 10.00 D of myopia is looking at a distant object. The focal point is in front of the retina. The rays of light are diverging as they reach the retina and so the distance vision is blurred.

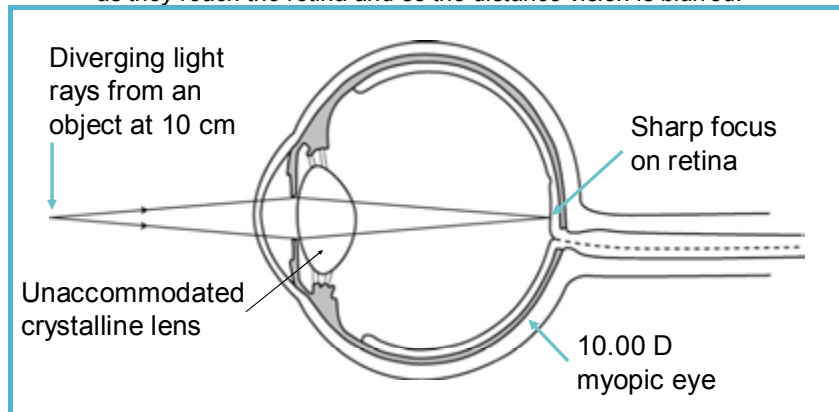


Figure 12.13: The same eye as above but this time looking at an object 10 cm in front of it. Now the focal point is on the retina so the near vision is clear. This eye will see objects clearly at 10 cm or closer.

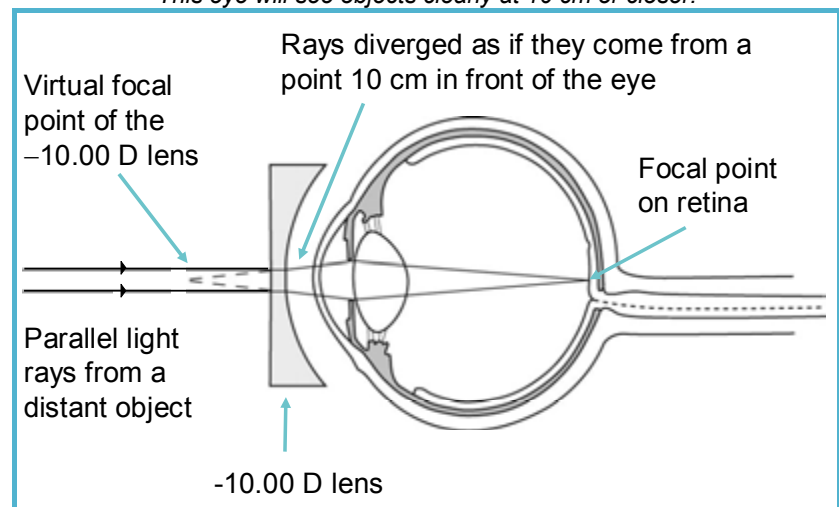


Figure 12.14: The same eye again, but this time looking at a distant object through a -10.00 D lens. You can see that the -10.00 D lens diverges the light rays before they reach the eye – as if they were coming from a point 10 cm in front of the eye. This is the same point at which the unaided myopic eye sees an object clearly. So with a -10.00 D lens in front of it, this myopic eye will see clearly at a distance.

MYOPIA (“Shortsightedness”) (cont.)

ESTIMATING THE POWER OF THE LENS NEEDED FOR A MYOPIC EYE

The unaided vision of a healthy, young myopic eye will be perfectly clear when an object is at a certain distance and also when the object is closer than that distance. But their vision will be blurred at any distance further away.

The table below can be used to estimate (guess) the power of the lens that a person may need to see clearly in the distance.

Table 12-1: *The distance at which a myopic eye can see clearly helps us to estimate the lens power they need.*

Can see clearly at this distance	Approximate power of lens needed to see clearly at 6 m
2 m	-0.50 D
1 m	-1.00 D
66 cm	-1.50 D
50 cm	-2.00 D
40 cm	-2.50 D
33 cm	-3.00 D
25 cm	-4.00 D
20 cm	-5.00 D
10 cm	-10.00 D

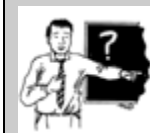


REMEMBER:

A “distant object” is something that is 6 m or more away from the eye.

From this table we can work out that if someone can see an object clearly at:

- **1 m** and closer they may need **-1.00 D** to see a distant object clearly.
- **50 cm** and closer they may need **-2.00 D** to see a distant object clearly.
- **25 cm** and closer they may need **-4.00 D** to see a distant object clearly.



If you bring an object closer and measure the distance at which a myopic person says they start to see it clearly, you can use the table above to estimate which power minus lenses they may need.

You will need to do a refraction examination for a person to get the exact power of the lens (or lenses) that will give them the best vision.

CALCULATIONS: THE DISTANCE AT WHICH A MYOPIC EYE CAN SEE CLEARLY

If you do not want to use the table, and want to know how to estimate the myopic refractive error yourself, you can use this formula:

$$F = 100/f$$

where **f** = distance (measured in cm)

and **F** = lens power (measured in D)

Example:

A boy can see clearly if things are 40 cm from his eyes or closer.
What refractive error would you estimate for this boy?

$$F = 100/f = 100/40 = 2.50 \text{ D}$$

From the boy’s symptoms you know that he is a myope, so he needs a minus lens to correct his refractive error. The power of the minus lens needed to give him clear distance vision will be approximately **-2.50 D**.

MYOPIA (“Shortsightedness”) (cont.)

PATHOLOGICAL MYOPIA	The eyeball of a myopic person is usually longer (and larger) than the eyeball of a person with a normal eye. Very myopic eyes sometimes grow so much longer than a normal eye that the sclera and the retina are stretched. For this reason, some very myopic eyes have a thin sclera and retina. This is called myopic degeneration. Eyes with myopic degeneration have pathological myopia and their vision may still be poor even if the myopia is corrected with spectacles. This is because the retina has been damaged. In some myopic eyes, the retina is stretched so tightly that it tears and detaches from the back of the eye. This is called a retinal detachment, and it can cause irreversible blindness if, it is not treated by an ophthalmologist within 24 hours. The symptoms of a retinal detachment are flashing lights (like lightning) and/or floating spots in the person's vision.  If a person tells you that they are seeing flashing lights or that they have suddenly noticed floating spots in their vision, it is an ocular emergency. These people must be referred urgently (immediately) to an ophthalmologist for treatment. Retinal detachments can happen to anyone, but they are more common in myopes.
WHAT IS ASTIGMATISM?	An eye with astigmatism has different powers in different meridians of the eye. This causes light entering the eye to focus in different places, rather than at one single point.
CAUSES OF ASTIGMATISM	The surfaces of the cornea and crystalline lens are the major refracting (focusing) surfaces of the eye. Normal eyes (those without refractive error) as well as hyperopic and myopic eyes all have spherical refracting surfaces. A spherical surface is like that of a round ball, and has the same curvature in all meridians (directions) on its surface.  In astigmatism, the refracting surfaces of the eye do not have the same curvature in all meridians (directions). The refracting surfaces of an astigmatic eye are more like the surfaces of a rugby ball or an egg. A surface that is like that of a rugby ball or egg – not equally round or curved in all directions – is called a toric surface. A toric surface has two meridians: one meridian is steeper (more curved), the other meridian is flatter (less curved).

MYOPIA ("Shortsightedness") (cont.)

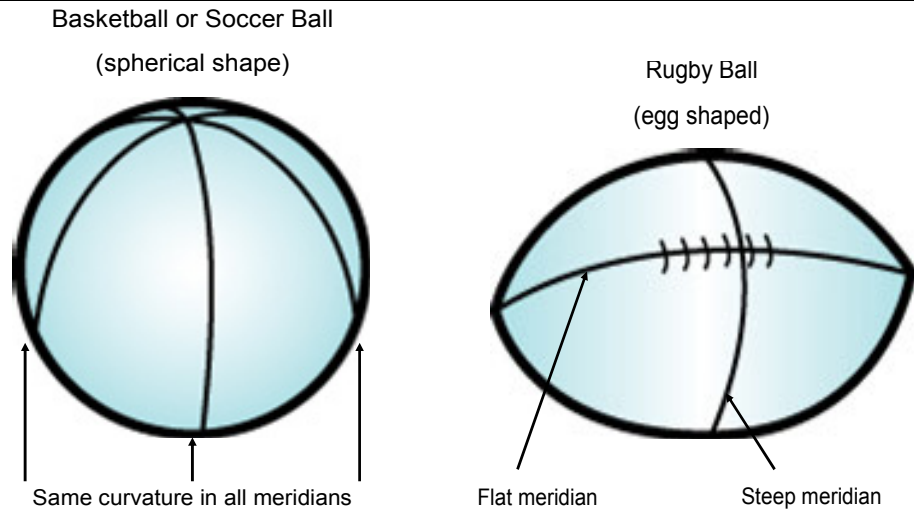


Figure 12.15: A soccer ball has a spherical surface.
A rugby ball (egg shaped) has a toric surface.

The two meridians of a toric surface are usually perpendicular to each other. Perpendicular lines are at an angle of 90° to each other.

Examples:

- One meridian can be horizontal (at 180°) and the other vertical (at 90°)
→ $180^\circ - 90^\circ = 90^\circ$
- One meridian can be at 45° and the other at 135°
→ $135^\circ - 45^\circ = 90^\circ$

The most common cause of astigmatism is a toric cornea. This is because the cornea is the eye's main refracting (light bending) surface.

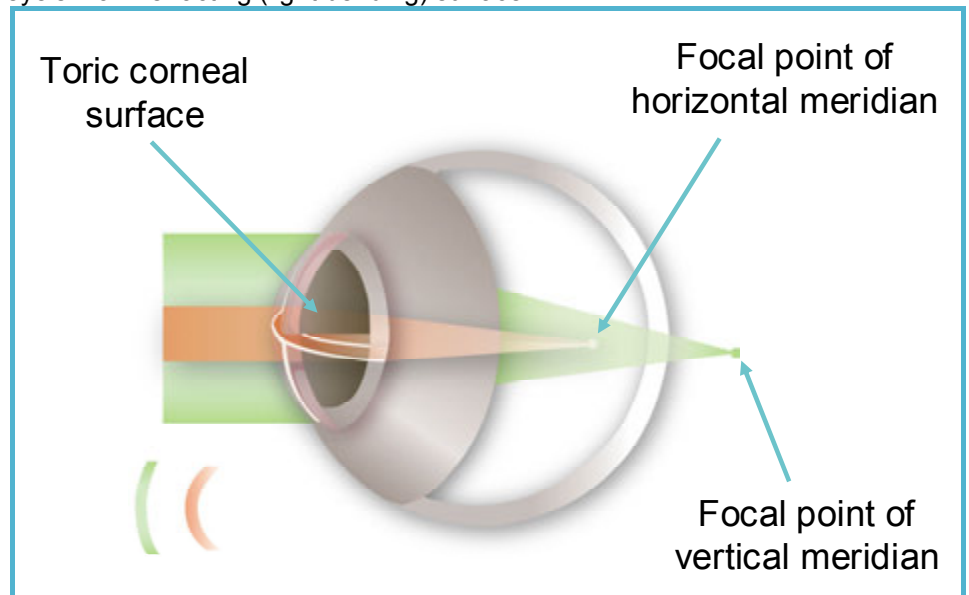


Figure 12.16: This cornea is not spherical so it does not focus light at one single point causing astigmatism in this eye. A surface which makes two focal points like this is called a toric surface.

CAUSES OF ASTIGMATISM (cont.)

MYOPIA (“Shortsightedness”) (cont.)

CAUSES OF ASTIGMATISM (cont.)

Because the two meridians of an astigmatic eye have different powers, the spectacle lens needed to correct astigmatism must also have different powers in different meridians. Each meridian can be corrected by a cylindrical lens. Usually two cylindrical lenses are needed (one for each meridian), and these cylindrical lenses are joined together to make a single sphero-cylindrical lens.



Sometimes it is easier to think of a toric eyeball as simply being like a soccer football that has been squashed a little bit.

A person with astigmatism usually has a corneal surface that is toric, but this will not be noticeable just by looking at them. Special instruments can measure a toric corneal surface, but if you just look at an astigmatic eye it will look perfectly round like a normal eye.

This is because the amount of corneal toricity only needs to be very small in order to create significant amounts of astigmatism.

SYMPTOMS OF UNCORRECTED ASTIGMATISM

A person with astigmatism (sometimes called an “astigmat”) may tell you they have problems with both distance and near vision, because there is no distance at which a clear retinal image can form. This is especially true for older people and for people with large amounts of astigmatism.

If the amount of astigmatism is small, and the person is young, unaided vision might be alright (but still not perfect) for both distance and near. However, in this case, the young person with astigmatism often has asthenopia (eye strain) or headaches. This is because young people have very active accommodation and often try to use their accommodation to compensate for (make up for) their poor vision (however using accommodation to compensate for astigmatism will not work and vision will remain poor).



REMEMBER:

When people accommodate they are almost always unaware that they are doing so.

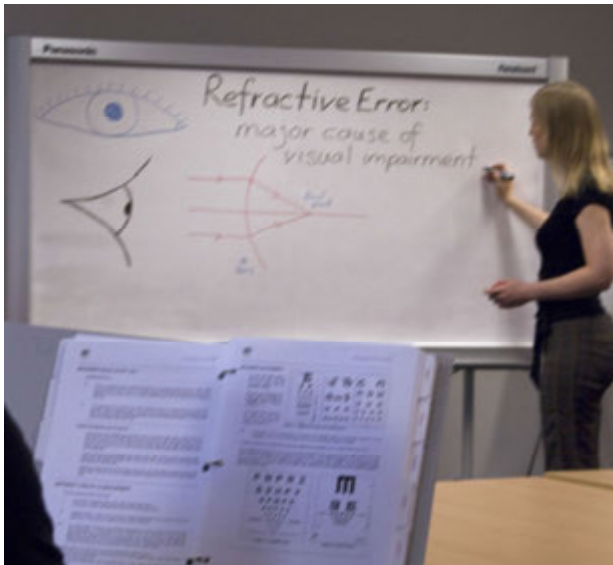
A young person with astigmatism who tries to make their vision clear by using their accommodation will do so subconsciously (without thinking about it). They will not realise that they are fatiguing (tiring) their ciliary muscle by accommodating too much.



A person with a large amount of astigmatism usually has difficulty seeing both in the distance and at a close working distance.

MYOPIA (“Shortsightedness”) (cont.)

HOW A PERSON WITH ASTIGMATISM MAY SEE



Moderate astigmatism:
Distance and near vision slightly blurred.



High astigmatism:
Distance and near vision more blurred.

Figure 12.17: How a person with moderate and high astigmatism might see

CORRECTION OF ASTIGMATISM

Astigmatism cannot be corrected with convex or concave spherical lenses only. This is because the refractive error of astigmatism is not the same in all directions.

To correct astigmatism, an astigmatic lens is needed. There are two types of astigmatic lenses – namely cylindrical and sphero-cylindrical lenses.

- **Cylindrical lenses:**

A cylindrical lens has power in just one meridian, while the other meridian has no power. This sort of lens is used for a person who only has astigmatism without another refractive error (such as hyperopia or myopia). A cylindrical lens is put in front of the eye at a specific angle so that the power of the lens (along its power meridian) matches the meridian of the astigmatism in the eye.

An example of a cylindrical correction is: $-2.00 \text{ DC} \times 90 \text{ DC}$

This means a minus two dioptre cylinder lens is located with its axis at ninety degrees. And we could say: “minus two cyl, axis ninety”.

- **Sphero-cylindrical lens:**

You can think of a sphero-cylindrical lens as a cylindrical lens that has been combined with a spherical lens. It has different powers in different meridians (unlike a spherical lens which has the same power in all meridians of the lens).

Some people have a refractive error with a spherical part (like hyperopia or myopia), *and* an astigmatic part. These people will need *both* a spherical lens and a cylindrical lens to correct their refractive error.

Fortunately, this does not mean that the person has to wear two spectacle lenses on top of each other. A sphero-cylindrical lens is a special lens which combines a spherical and a toric lens into one lens. Usually it is the front surface of the lens that is spherical, and the back surface that is cylindrical.

MYOPIA (“Shortsightedness”) (cont.)

CORRECTION OF ASTIGMATISM (cont.)

To correct astigmatism accurately we must make sure that the power of the astigmatic lens is correct. We must also make sure that the power or axis of the astigmatic lens is placed at the correct angle in front of the eye this angle is measured in degrees (°). This angle has to correspond with the meridians of the toric surfaces of the eye, to ensure that the power in each meridian of the eye is corrected accurately.

Instruments used to measure the refractive error of an eye will have an axis scale with markings similar to that shown in Figure 12.18. Notice that the axis of a cylinder will be somewhere between 0° and 180°. Even though 0° and 180° are the same axis direction, we always say “180°”, and not “0°”.

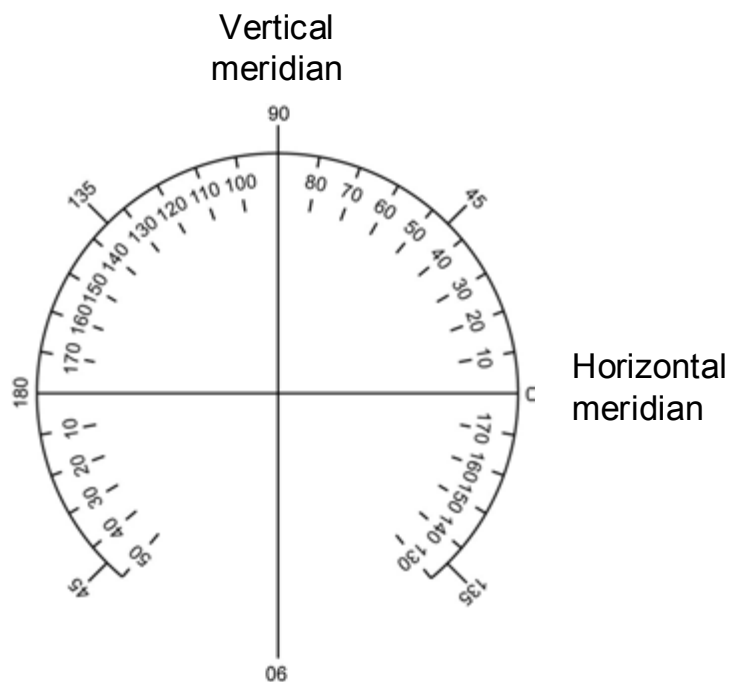
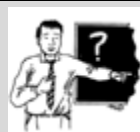


Figure 12.18: Axis scale for measuring astigmatism. Even though 0° and 180° are both in the horizontal direction, we always say 180°



A good way to remember the difference between “horizontal” and “vertical” is that horizontal is the same direction as the “horizon” (the line where the sky and the land meet).

EXAMPLE 1

An example of a sphero-cylindrical lens is: **+3.25 D / –1.50 DC x 180**

It can also be written as: **+3.25 / –1.50 x 180**

And we would read this as:

“plus three two five, minus one fifty, axis one hundred and eighty”.

EXAMPLE 2

Another example of a sphero-cylindrical lens is: **–0.50 D / –2.00 DC x 127**

It can also be written as: **–0.50 / –2.00 x 127**

This could be read as:

“minus oh fifty, minus two, axis one twenty-seven”.

MYOPIA (“Shortsightedness”) (cont.)

ADAPTING TO ASTIGMATIC CORRECTION	It is often difficult for people with astigmatism to get used to wearing their new spectacles. This is especially the case if it is the first pair of spectacles that they have worn to correct their astigmatism, or if their spectacle power has changed a lot. A person who has a new pair of astigmatic spectacles might tell you that the spectacles make them feel dizzy or sick, or that the world looks distorted. For example, the floor might look like it is sloping or the walls might not look straight – even though their vision is clearer with the spectacles on. Usually a person will adapt to their new spectacles within 2 weeks. This time period is called the adaptation period. It is important that the person wears their new glasses as much as possible during the adaptation period so that their adaptation symptoms improve faster. Sometimes it is better to give a newly-diagnosed astigmat only a partial astigmatic correction (part of their total correction) at first. Their vision might not be as clear as if they had their full astigmatic correction, but they will feel better wearing their new glasses. Their full astigmatic correction could then be given at a later stage (perhaps when they next want a new pair of spectacles).
IRREGULAR ASTIGMATISM	There are two types of astigmatism: - regular astigmatism - irregular astigmatism Usually when we refer to “astigmatism” we mean “regular astigmatism”. Irregular astigmatism is very rare and is usually the result of a corneal problem. Irregular astigmatism is usually caused by trauma affecting the cornea or an eye health problem called keratoconus (which means “conical cornea”). An eye with irregular astigmatism has principal meridians that are not perpendicular to each other. → Because the principal meridians are not perpendicular to each other, it cannot be completely corrected with astigmatic spectacle lenses. Sometimes poor VA from irregular astigmatism can be corrected with Rigid Gas Permeable (RGP) contact lenses (also called hard contact lenses) → This requires specialist-fitting by someone who is trained to fit hard contact lenses.

PRESBYOPIA

Unlike myopia, hyperopia, or astigmatism which affect only some people, presbyopia is a refractive error that affects all people as they get older. Presbyopia is due to the natural hardening of the crystalline lens which makes it more difficult, and eventually impossible, to accommodate. Presbyopia usually begins to be a problem after 40 or 45 years of age and slowly gets worse until about age 60.

Presbyopia is explained in more detail in other units.

REFRACTIVE ERROR – CHANGES OVER TIME

Every person is different (and in fact, every eye that you examine will be different!), but there are some refractive error changes that you can expect as a person gets older.

HYPEROPIA AND AGING	- It is normal for babies to be born with hyperopia. Hyperopia gradually decreases from birth until the age of 5 years. Usually, a child will need to wear spectacles if their hyperopia is more than +3.50 D. If the amount of hyperopia is less than +2.00 D, it is not necessary to give a child spectacles, unless they have convergent strabismus – in which case they should be referred to a person who specialises in children's eye care. Professional judgement must be used for cases between +2.00 D and +3.50 D of hyperopia. If you are not sure whether to prescribe spectacles for a child with this amount of hyperopia, you should refer the person to another eye care provider who can give another opinion. - People younger than 30 years may only need part of their hyperopia corrected (their glasses might not need to be full strength). Young hyperopes often only need to wear their spectacles for near tasks. - The symptoms of hyperopia get worse with age. This is because the eye's ability to accommodate decreases with age (as explained previously).
EXAMPLE	Imagine four people who all have +1.00 D of hyperopia – and think about which of them needs to be prescribed spectacles: Person 1 is 8 years old. Although she has +1.00 D hyperopia, she has no problems seeing the blackboard in the classroom, no problems seeing her reading and writing at her desk, and she has no asthenopic (eye strain) symptoms. Person 2 is 19 years old. He can see clearly in the distance and at near, but he complains of headaches and sore eyes after he has been reading for some time Person 3 is 32 years old. She tells you that she can no longer see clearly to sew, however she has no trouble seeing the television even when it is far away. Person 4 is 57 years old. He cannot see clearly to read, and he cannot recognise people in the street because his vision is too blurry at both near and far distances.

REFRACTIVE ERROR – CHANGES OVER TIME (cont.)

EXAMPLE (cont.)	- Some older people who have hyperopia become less hyperopic if they begin to get cataract. This is because a growing cataract can increase the focusing power of the crystalline lens. This is sometimes called “second sight”. Unfortunately, this improved vision is only temporary – as the cataract continues to grow, the vision will get worse again. When this happens the person will need surgery to see better again. - Today when people have cataract surgery, the eye surgeon will usually remove the cataract (take out the cloudy crystalline lens) and replace it with a plastic intraocular lens. Before intraocular lenses were available, surgeons used to just remove the crystalline lens without replacing it with anything. This left the patient with very high hyperopia (approximately +11.00 or +12.00 D). A person like this who has no crystalline lens and no intraocular lens is said to have aphakia. Aphakia can also be caused if a person has a traumatic accident and loses their crystalline lens as a result. A person with aphakia will need very strong plus spectacle lenses to correct their high hyperopia.
MYOPIA AND AGING	- It is extremely rare for babies or children under the age of 5 years of age to have myopia. - Myopia usually starts in the early teenage years (13 to 16 years) and gradually increases until the person is 25 to 30 years of age. Usually myopia does not increase to more than –3.00 or –4.00 D but occasionally the myopia will continue to increase up to –10.00 or –15.00 D or more. - Some older people become myopic when they begin to get cataract (when the crystalline lens becomes cloudy), and this myopia may increase as the cataract gets worse. This is because a growing cataract can increase the focusing power of the crystalline lens. This change is sometimes called a “myopic shift”. In this case, correcting the myopia will improve the distance vision in the beginning, but as the cataract gets worse the vision will become poor even with the best correcting spectacle lens. When this happens the person will need surgery to see better. - Myopia has a strong hereditary link (it runs in families). A child is much more likely to develop myopia if a parent, brother or sister is myopic.
ASTIGMATISM AND AGE	- Astigmatism does not change as much with age compared to hyperopia or myopia. - If the person only has a small amount of astigmatism, it may not be necessary for them to wear spectacles. This is especially true if the person is older than 40 years and has never worn glasses for astigmatism before. Sometimes a small amount of astigmatism can cause headaches and/or asthenopia (eyestrain) in young people – so in this case spectacles may be helpful. - In some countries it is difficult to get sphero-cylindrical spectacle lenses. In this case a person may use spectacles that give the best vision that can be obtained with spherical lenses, even though their vision would not be as good as if they were to have sphero-cylindrical lenses. - Astigmatism (especially high astigmatism) can be hereditary (it runs in families). A child is much more likely to develop astigmatism if a parent, brother or sister is astigmatic.
PRESBYOPIA AND AGE	Presbyopia only affects older people, and usually only starts after age 40. It is impossible for a healthy child or a young adult in their 20s to have presbyopia.

SUMMARY: HYPEROPIA, MYOPIA AND ASTIGMATISM

HYPEROPIA

Definition of hyperopia:

- In an unaccommodated hyperopic eye, light from a distant object focuses behind the retina.

Causes of hyperopia:

- Axial hyperopia – eye that is shorter than average.
- Refractive hyperopia – cornea and/or crystalline lens that is too flat (not curved enough) and therefore too weak in power.

Accommodation and hyperopia:

- If a hyperope has enough accommodation he can compensate for his hyperopia and make his vision clear.

Symptoms of hyperopia:

- The symptoms of hyperopia vary depending on:
 - how much accommodation can be used (how old the person is); and
 - the amount of hyperopic refractive error a person has.
- Symptoms can include:
 - blurred vision (near vision worse than distance vision)
 - headaches
 - asthenopia (eyestrain, sore eyes, tired eyes)
 - poor concentration
 - avoidance of near work.
- **Low hyperopia:**
 - might be able to accommodate enough to have clear distance and near vision.
 - might have asthenopic symptoms.
- **Moderate hyperopia:**
 - blurry near vision and clear distance vision.
- **High hyperopia:**
 - blurry near and distance vision
 - near vision worse than distance vision.

Ageing and hyperopia:

- Symptoms of hyperopia get worse with age.

Correction of hyperopia:

- Corrected with plus (convex) spherical lenses.
- Depending on their age and the amount of hyperopia, some hyperopes may not need to wear spectacles, or they might only need spectacles for near vision, or they may only need a partial correction.

Complications of hyperopia:

- High hyperopia can cause a convergent strabismus (inward turning eyes).
- A child with convergent strabismus must always be referred.

SUMMARY: HYPEROPIA, MYOPIA AND ASTIGMATISM (cont.)

MYOPIA

Definition of myopia:

- In myopia, light from a distant object focuses in front of the retina.

Causes of myopia:

- Axial myopia – eye that is longer than average.
- Refractive myopia – cornea and/or crystalline lens that is too steep (too curved) and therefore too strong in power.

Accommodation and myopia:

- Accommodation does not improve the vision of a myope.

Symptoms of myopia:

- A person with myopia has blurry distance vision.
- A person with high myopia might also have blurry near vision (but their distance vision will always be worse than their near vision).
- Myopic people (myopes) often find that their vision seems worse at night or in dim light.

Correction of myopia:

- Corrected with minus (concave) spherical lenses.

Complications of myopia:

- Pathological myopia: highly myopic people may have a thin sclera and changes to the retina. Their vision may be poor even if their myopia is corrected with spectacles.
- Retinal detachment: if a patient suddenly sees flashes of light and floaters, they could have a retinal detachment – refer urgently!

ASTIGMATISM

Definition of astigmatism:

- An eye with astigmatism has different powers in different meridians of the eye. This causes light entering the eye to focus in different places, rather than at one single point.
- Astigmatism may occur just by itself, or in an eye which also has another type of refractive error.

Causes of astigmatism:

- An astigmatic eye does not have the same curvature in all meridians (directions).
- It is helpful to imagine the corneal surface of an eye with astigmatism to be shaped like the surface of a rugby ball or an egg (this is called a toric surface) – even though if you look at the eye of a person with astigmatism it will seem round.
- There are two meridians in an astigmatic eye and these meridians are perpendicular (at 90°) to each other.

Accommodation and astigmatism:

- If the amount of accommodation is small and the person is young, the eye accommodates to try to make the vision clearer. This can cause asthenopia and/or headaches.

Symptoms of astigmatism:

- Distance and near vision may be blurred.
- Vision may be clear but the person could have asthenopia or headaches – especially young people with only a small amount of astigmatism.

SUMMARY: HYPEROPIA, MYOPIA AND ASTIGMATISM (cont.)

Correction of astigmatism:

- Corrected with astigmatic lenses.
- Astigmatic lenses can be cylindrical or sphero-cylindrical.
- Cylindrical lenses correct eyes with only astigmatism.
- Sphero-cylindrical lenses correct eyes with astigmatism and another refractive error.
- The axis of the astigmatic lens must be correct to give clear vision.
- It is often difficult for people with astigmatism to get used to wearing their new spectacles. Usually a person will adapt to their new glasses within 2 weeks.
- Sometimes it is better to give a newly-diagnosed astigmat only a partial astigmatic correction to help them adapt.

Irregular astigmatism:

- There are two types of astigmatism:
 - regular astigmatism
 - irregular astigmatism.
- Usually when we refer to “astigmatism” we mean regular astigmatism.
- Irregular astigmatism is very rare and is usually caused by:
 - corneal trauma, or
 - keratoconus (an eye health problem).
- The principal meridians of an eye with irregular astigmatism are not perpendicular to each other
 - This means that irregular astigmatism cannot be completely corrected with astigmatic lenses.
- Sometimes Rigid Gas Permeable (RGP) or “hard” contact lenses can be used to correct irregular astigmatism
 - These contact lenses must be fitted by a specialist.

PRESBYOPIA

Definition of PRESBYOPIA:

- Affects all people as they get older – it usually begins to affect near vision after 40 years of age.
- Caused by the natural hardening of the crystalline lens that makes it more difficult to accommodate.
- More details on presbyopia to follow in next unit.

REFRACTIVE ERROR: CHANGES OVER TIME

- Refractive errors are often hereditary.
- The symptoms of hyperopia get worse with age.
- Young hyperopes may only need a partial correction.
- Cataracts can cause a myopic shift – an increase in myopia or a decrease in hyperopia.
- Myopia usually starts early in life, and typically increases between the ages of 12 and 30.
- Astigmatism does not change much with age.

TEST YOURSELF QUESTIONS

1. What is hyperopia? What type of lens is used to correct hyperopia?

2. What are the symptoms of hyperopia for a person who cannot accommodate?

3. What are the symptoms of hyperopia for a person who can accommodate?

4. What should you do if a child who has a strabismus (eye turn) comes to you for an eye examination?

5. What is myopia? What type of lens is used to correct myopia?

6. What are the symptoms of myopia?

7. If a person tells you that they can only see things that are 50 cm away (or closer) from their eyes, how much myopia do you think they have?

8. What should you do if a person tells you that they are seeing bright lights or suddenly floating spots in their vision?

9. What is astigmatism? What type of lens is used to correct astigmatism?

10. What are the symptoms of astigmatism?



PRESBYOPIA

THINK

A 42 year old woman comes to see you and says, "I used to be able to see very well, but now when I sew I cannot see to thread my needle. I am afraid I am going blind."

Do you think she is going blind, or could there be another reason why she cannot see at near?

Have you noticed that older people sometimes have trouble seeing things close to them, but have less trouble seeing things that are far away?

AIM

This unit will explain why most people cannot see things close to them as they get older, and how spectacles can improve their near vision.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- explain the cause of presbyopia
- recognise the symptoms of presbyopia
- explain how presbyopia affects people with different refractive errors at different ages
- state how presbyopia may be corrected
- explain the difference between a near addition and a prescription for reading spectacles.

REVIEW: PRESBYOPIA

PARTS OF THE EYE	Cornea: • Like the window of the eye. • Transparent, so that it can let light into the eye. • Helps to focus light that enters the eye. Crystalline lens (or simply “lens”): • Transparent in a normal eye. • Changes in the lens’ shape change the eye’s focus from distance to near. Retina: • The inside layer at the back of the eye. • Catches the light that comes into the eye and changes it into nerve messages that are sent to the brain.
HOW DOES THE NORMAL EYE RECEIVE LIGHT?	• Light from an object enters the eye in the form of light rays. • Light rays entering the eye pass through the tear film, cornea, anterior chamber, pupil, crystalline lens and vitreous, before they reach the retina. • Light rays are converged (focused) by the cornea and the crystalline lens. • If the light focuses correctly on the retina, a clear image will be formed. • Light is changed at the retina into electrical signals (nerve messages). • Information received by the retina is sent to the brain via the optic nerve.
FOCUSING LIGHT IN THE EYE	• In a normal eye, light that enters the eye is focused on the retina because: - the cornea and the lens are the correct shape, and - the eyeball is the correct length. • An eye that does not do one or both of these things is said to have refractive error.
WHAT IS ACCOMMODATION?	• Accommodation occurs when the ciliary muscle contracts and changes the shape of the crystalline lens (makes it thicker). • This changes the optical focus of the eye so that close objects can be seen clearly. • When accommodation in a normal eye (an eye without refractive error) is relaxed, objects in the distance are seen clearly. • Presbyopia is the natural aging change in the eye where the crystalline lens hardens with age. When this happens, the lens cannot change shape easily when the ciliary muscle contracts. This means that an older person cannot accommodate as easily as a younger person. • All people will become presbyopic when they get older. It is impossible for a child or a young adult in their 20s to have presbyopia. • If a normal eye cannot accommodate (if a person has presbyopia), close objects will appear blurry. • The amplitude of accommodation is the total amount of accommodation that is available to change the focus of the eye. • Amplitude of accommodation decreases with age. • Asthenopia (visual fatigue) happens when the ciliary muscle gets tired – when too much accommodation is being used. • To avoid asthenopic symptoms during long periods of near work, usually only half the amplitude of accommodation should be used.

REVIEW: PRESBYOPIA (cont.)

WHAT IS REFRACTIVE ERROR?	- A person who has a refractive error will need to wear spectacles (glasses) or contact lenses so that they can see clearly and comfortably. This is because their eye is not the correct size and shape. - There are four main types of refractive error: myopia, hyperopia, astigmatism and presbyopia. - The amount of refractive error an eye has depends on: - the steepness of the cornea, and/or - the steepness of the crystalline lens, and/or - the length of the eyeball. - A person with a refractive error will have eyes that look normal, but they will not see well. - An eye examination that tests for refractive error is called a refraction.
HYPEROPIA	- In an unaccommodated hyperopic eye, light from a distant object focuses behind the retina. - If the person has enough accommodation they can compensate for their hyperopia and make their vision clear. - The symptoms of hyperopia vary depending on: - how much accommodation can be used (how old the person is), and - the amount of hyperopic refractive error a person has. - The symptoms of hyperopia can include: - blurred vision (near vision worse than distance vision) - headaches - asthenopia (eye-strain, sore eyes, tired eyes) - poor concentration - avoidance of near work. - Because loss of accommodation makes it more difficult to compensate for hyperopia, the symptoms of hyperopia will get worse with age. - Hyperopia is corrected with plus (convex) spherical lenses.
MYOPIA	- In a myopic eye, light from a distant object focuses in front of the retina. - Accommodation does not improve the vision of a myope. - A person with myopia has blurry distance vision. - A person with high myopia might also have blurry near vision (but their distance vision will always be worse than their near vision). - Myopia is corrected with minus (concave) spherical lenses.
ASTIGMATISM	- An eye with astigmatism has different powers in different meridians of the eye. This causes light entering the eye to focus in different places, rather than at one single point. - Astigmatism may occur just by itself, or in an eye which also has another type of refractive error. - An astigmatic eye does not have the same curvature in all meridians (directions). - A person with astigmatism usually has blurry distance and near vision. - Astigmatism is corrected with astigmatic lenses.
PRESBYOPIA	- Presbyopia affects all people as they get older. - Caused by the natural hardening of the crystalline lens that makes it more difficult to accommodate.

DEFINITION OF PRESBYOPIA

The gradual (slow) loss of accommodation as we get older is called presbyopia.

Everyone over the age of 40 to 45 years is affected by presbyopia. Some people, especially those living in the tropics, get presbyopia even earlier than this. This is because everybody loses the ability to accommodate as they age. The loss of accommodative ability and the subsequent onset of presbyopia happens to both eyes at the same rate.

People with presbyopia usually find it difficult to read or do any near task. Giving them spectacles for near vision helps them to again do the near tasks that they used to do previously.



Near tasks are sometimes referred to as close work, and include all work that requires good vision to see something that is within arm's reach of a person.

If a person can touch what they are looking at (if it is within arm's length of them), it is considered a near task or close work.

Sometimes an early presbyope (someone who is just starting to get presbyopia) will hold things further (and further!) away from their eyes so that they can see it more clearly.

This is because less accommodation is needed to see things that are further away from the eyes.

CAUSE OF PRESBYOPIA

Presbyopia is caused by the loss of accommodative ability that is associated with ageing.

As we get older, the crystalline lens gradually gets harder and cannot change shape easily when the ciliary muscle contracts. This is a normal, natural aging process. This means that an older person cannot accommodate as easily as a younger person.

If the eye does not accommodate when looking at a close object, the object will appear blurry or out of focus.

People often make the mistake of thinking that presbyopia is due to a weakness of the ciliary muscle, but this is not true. The ciliary muscle still works properly, but it has a more difficult job when it has to try to bend the inflexible crystalline lens.

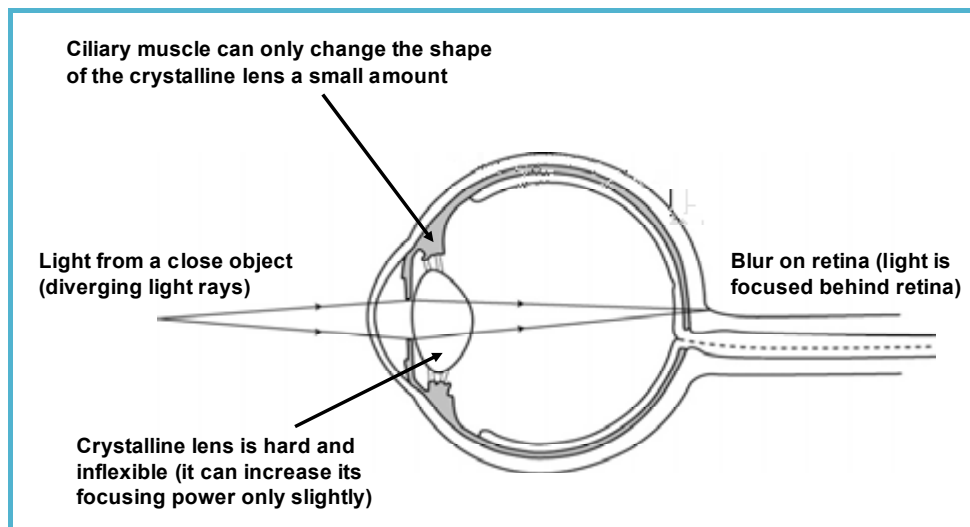


Figure 13.1: A presbyopic eye with some accommodation remaining.
Light from a close object does not focus on the retina.

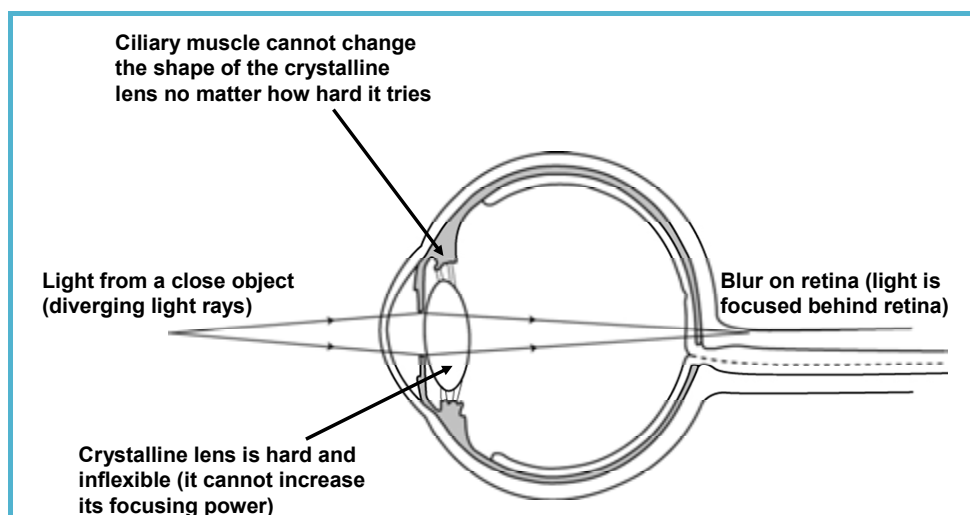


Figure 13.2: A presbyopic eye with no accommodation remaining.
Light from a close object does not focus on the retina.

SYMPTOMS OF UNCORRECTED PRESBYOPIA

People with presbyopia may have trouble with near tasks such as reading, sewing, and sorting rice. When presbyopia starts, they may say things like:

- “I can read in bright sunlight, but not in dim light”
- “My arms are not long enough!”
- “My eyes feel strained when I do a lot of sewing”
- “My eyes get tired when I read”
- “The writing in the newspaper is too small”
- “I find it difficult to thread a needle”
- “I find it hard to sort the stones from the rice when I’m cooking”
- “The distance looks blurred when I look up after I have been reading for a long time”.

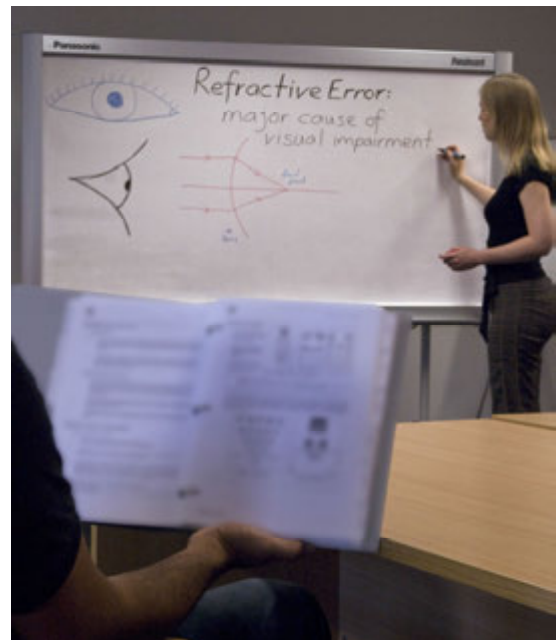
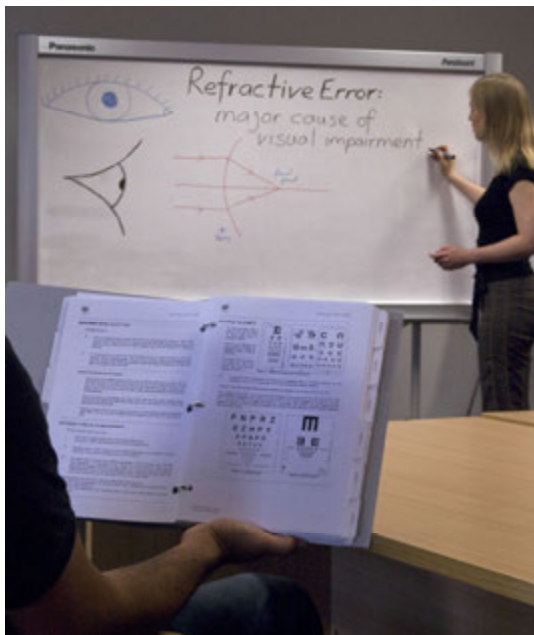


Figure 13.3:



CASE HISTORY

THINK

If you listen carefully to what a person tells you about their eye problem, and ask the right questions, you can obtain important information that can be useful in diagnosing their problem.

Using good communication skills can help to make the patient feel comfortable with you and your diagnosis and treatment plan.

AIM

This unit will teach you how to ask a person questions about their eyes to find out what sort of problems they are having.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- explain what a case history is and why it is important
- use good communication skills when talking to people who come to see you for an eye exam
- describe the things you need to ask about a person's eyes and their vision
- describe the things you need to ask about a person's general health and lifestyle.

UNDERSTAND THE PROBLEM

To find out whether a person has an eye or vision problem, there are three steps to follow:

- Ask the person about how their eyes feel and what their vision is like (symptoms)
- Look carefully at their eyes (signs)
- Measure how well the person can see and how healthy their eyes are (eye examination).

CASE HISTORY

Taking a case history is the first step that you take when you examine a person's eyes. It helps you to understand the person's problems and concerns.

The case history is a very important part of any eye examination, because it can help you to decide:

- the problem that the person is having with their eyes or vision
- whether the eye problem is getting better or worse (or staying the same)
- the tests that you will need to do
- if you are able to treat the person, or if the person needs a referral
- what type of eye health education a person (and their community) might need to prevent further eye problems.



Often a good case history is more helpful in diagnosing a person's eye problem than the results of the actual eye examination.

CASE HISTORY (cont.)

COMMUNICATING	Communication skills are important when taking a case history. You need to listen to the person and ask the right questions so that you can get the information that you need. Your manner and attitude when you take a case history will show the person that you care about them and that they can trust you. This is a good opportunity to build a good relationship with the person. When a person arrives to have their eyes examined: • Greet the person and introduce yourself; be friendly and polite. • Show the person where to sit. • Use good body language: turn your body to face the person, look at the person when you are speaking to each other, smile. • Listen carefully to the person. • Use words that the person understands; if the person does not understand you, repeat the question using different words. • Give the person time to think about their answer to your questions. • Be sensitive to the person's concerns – the person might be nervous or embarrassed about what they are telling you; try to give the person privacy if they need it. • Ask questions in a logical and organised way. • Ask follow-up (additional) questions, if you need more information about a person's answer. • Avoid questions that will only give you a "yes" or "no" answer. The type of questions that you ask will affect the type of answers that you get.
OPEN QUESTIONS	Open questions require a longer answer. The person will need to think about the question, and describe what they think or how they feel. Open questions usually begin with: "what...", "how...", "why...", or "describe..." Examples: "Why do you want your eyes checked today?" "How did you hurt your eye?" "Describe your headaches" "What work do you do?"
CLOSED QUESTIONS	Closed questions only need a short answer. These questions are quick and easy for the person to answer, but you might miss important information. Examples: "Do you get headaches?" "Did your problem start today?" "Do you have glasses?"
LEADING QUESTIONS	Leading questions can make a person feel like they need to tell you what they think you want to hear. You should avoid leading questions because they can give you false information. Example: "Did you come to see me because you can't see well?" The person might be nervous (or they might think that it is polite to agree with you), and say "yes" – even if their vision is not their main problem. This person's main problem might be that their eyes feel dry and uncomfortable, but you did not give them the chance to say this. If you thought that this person's main problem was their vision you might give them spectacles – but you would not be helping them with their real problem. The person might go home without having a solution to their dry eye problem

TAKING A CASE HISTORY

TAKING A CASE HISTORY

To obtain a full case history you must ask the person about their eyes, vision and general health.

A good case history includes descriptions of:

- Chief complaint and other symptoms
- Visual problems at distance and near
- Eye history
- Visual needs
- Family eye and health problems
- General health, medical history (including medications), and allergies.



Chemical Burns:

There is one situation where you do not take a full case history as the first step of the eye examination – and that is when a person comes to you and tells you that they have had a chemical in their eye. In this case it is very important to irrigate (wash) the eye immediately before you do anything else.

You should irrigate the eye for 20 to 30 minutes by pouring cold saline or sterile (clean) water into the eye continuously.

When you have finished irrigating the eye (after 20 to 30 minutes), you can then ask some more history questions, and refer the patient to the appropriate eye specialist.

CHIEF COMPLAINT AND OTHER SYMPTOMS

When a person comes to you for an eye examination they will usually tell you why they have come. The person's symptoms are the problems that they tell you about.

The chief complaint is the main reason that the person comes to you for an eye examination. It is the symptom that worries the person most.

Usually you can find the chief complaint by asking:

"Why have you come to see me?" or "Why would you like to have your eyes checked?"



The chief complaint is the main symptom you must concentrate on during the eye examination.

You must discuss the chief complaint with the person at the end of the examination, and tell them what you plan to do to help them (treatment or referral).

TAKING A CASE HISTORY (cont.)

ASKING FOR DETAILS	After a person tells you about their symptoms, you often need more information about them. You can ask the questions in this list for every eye problem that a person tells you about: • Sensation: How do the eyes feel? e.g. itchy, watery, light sensitive, gritty, painful → If there is pain, what is it like? e.g. dull, sharp, throbbing (with heartbeat). • Appearance: Do the eyes look different? e.g. redness, pus, swelling. • Location: Which eye has the problem? Where does it hurt? • Severity: How bad is the problem? • Onset: When did the problem start? Did it happen gradually (slowly) or suddenly? • Frequency: How often does the problem occur? • Duration: When you have these symptoms, how long do they last? – or are the symptoms constant (all the time)? • Associated Symptoms: What else do you notice when you have this problem? • Relief: Have you received treatment for this problem before? Did this treatment work? • Vision: Has your vision changed? At what distance is your vision blurry? Does anything help you to see better? • Other people: Do you know anyone else in the family who has the same problem? e.g. some eye problems are hereditary (run in families), and some eye problems are contagious (they can be given to other people).
VISION	• Is your vision blurry for distance or near? - Is it hard to see things that are far away? - Is it hard to see things that are close to you? • Do you ever get eye strain? Do your eyes ever feel tired? → Symptoms of eye strain (asthenopia) include: watery eyes, sore eyes, tired eyes, or eyelids that twitch (the person might tell you that they can feel their eyelids moving even though nobody else can see this twitching). • How is your vision at night? • Do you have problems with glare (bright light)? • Do you ever see floating spots or flashing lights in your vision?  FLASHES AND FLOATERS: If a person tells you that they are seeing irregular lights or moving spots in their vision, this might be an ocular emergency. Flashes and floaters can be caused by a retinal detachment (when the retina separates from the back of the eye). If someone has a retinal detachment they can go blind unless they see a retinal specialist within 24 hours. Visual flashes can also be caused by migraine headaches, but these flashes usually only last for 20 minutes. Floaters can also be caused by many other things. Some people have floaters for many years. If someone tells you that they have seen a floater in their vision for a long time (and it has not changed in size and they are not noticing it more often) it is probably not a problem. New floaters, or floaters that have changed, are more concerning. Flashes of light and/or changing floaters can be extremely serious. A person who has these symptoms must urgently be referred to an ophthalmologist.

TAKING A CASE HISTORY (cont.)

EYE HISTORY

- Have you had your eyes tested before? When?
- Have you ever had an eye disease or injured your eyes?
- **Spectacle History:**
It is helpful to know if someone has had spectacles in the past. If they do have spectacles, but are no longer wearing them, you need to know why.
 - Have you ever worn glasses?
 - If yes:
 - Were they for seeing far away or close up?
 - How long ago did you get these spectacles?
 - How is your vision with your current spectacles?
 - Are you happy with your current spectacles → why or why not?
- **Headache History:**
Headaches can sometimes be caused by eye problems.
 - Where do you feel the headache? Show me on your head where you feel the pain.
 - Usually (but not always) headaches that are due to eye problems are felt at the front of the head or behind the eyes.
 - How long does the headache last? How often does it happen?
 - When do you get the headache? Is it worse in the morning or the afternoon? What are you doing when it starts?
 - If a person wakes up with a headache, the headache is probably not caused by the eyes. You need to refer this person to a general doctor.
 - If the headache starts when the person is doing a visual task (like reading or sewing), the headache may be caused by a refractive error.



MIGRAINE HEADACHES:

Some people get migraine headaches. If someone has a migraine they will usually see strange colours or lights in their vision. These visual symptoms usually last for 20 minutes. People who get migraine headaches may be sick for many hours or even days.

It is unusual for migraines to be caused by a person's vision or their eyes. This is usually a medical problem and the person should be referred for a general health check.

It is important to understand the difference between the visual symptoms of a migraine and a retinal detachment:

- A migraine has visual symptoms that last for only 20 minutes.
- A retinal detachment has visual symptoms that will last for longer than this.

VISUAL NEEDS:

- What do you use your vision / eyes for?
 - Do you need good vision for work? (e.g. computers, sewing, driving, cooking)
 - Do you need good vision for school? (e.g. blackboard, reading, writing)
 - Do you need good vision for your hobbies? (e.g. drawing, sewing, reading)
 - Do you need good vision to play sport?
- Is there anything that you need to be able to see but cannot?

TAKING A CASE HISTORY (cont.)

GENERAL HEALTH, MEDICAL HISTORY AND ALLERGIES

Diseases in other parts of the body can be the cause of some eye problems.

It is important to ask the person about their general health.

- How is your health?
- Are you being treated for any health problems?
- Are you taking any medication? (Some medications have side effects that can affect vision.)
 - Name of medication?
 - What is it used for?
 - How much do you take and how often?
- Do you have diabetes? (sugar in the blood)
- Do you have high blood pressure?
- Do you have any allergies?

FAMILY EYE OR HEALTH PROBLEMS

Many eye problems are hereditary (genetic) and can be passed onto other family members. Some families are more likely to have these problems than other families.

- Does anyone in your family have any eye problems (now or in the past)?
 - Does any family member wear spectacles? When and what for?
 - Has anybody in the family had any eye operations?
 - Does anybody in your family suffer from blindness?
 - Does anybody in your family have glaucoma? (sometimes called pressure in the eye)
 - Has anybody in the family had cataract? (white pupils)
(This is especially important if it has happened to family members when they were young.)
- Does anyone in the family have general health problems?
 - Does any family member have diabetes or high blood pressure?



DIABETES, HIGH BLOOD PRESSURE AND OTHER HEREDITARY PROBLEMS:

If someone tells you that they have a family history of diabetes or high blood pressure you should refer them for a general health check.

People rarely have symptoms of these health problems in the early stages even though the problem might be damaging their body. It is important that a doctor detects these problems early, so that treatment can be started as soon as possible.

THINKING ABOUT THE CASE HISTORY

After you take a case history, you need to think about what the person has told you and what you think their problem might be.

Some questions to ask yourself:

- Does the person need a refraction, or should they be referred immediately for an eye health or general health check?

Example 1: A person who comes to you because they have a piece of metal in their eye needs an eye health check before you can do a refraction.

Example 2: A person who has sudden-onset vision loss (vision that has become worse very quickly) may have an eye health problem, not a refractive error.

- What sort of refractive error do you think the person might have? Listen carefully to their symptoms and think about the person's age.
- What visual needs does the person have? Are they happy with their vision as it is now, or do they want to be able to see better?
- What do you think the solution to the person's problem might be? Do you think that you can help this person?

SUMMARY: CASE HISTORY

UNDERSTANDING THE PROBLEM

- Ask for symptoms.
- Look for signs.
- Measure how well the person can see and how healthy their eyes are

CASE HISTORY

- Taking a case history is the first step that you take when you examine a person's eyes (unless the person has a chemical in their eye – which is an ocular emergency).
- A case history lets you know:
 - the problem that the person is having with their eyes or vision.
 - whether the problem is getting better or worse.
 - what tests you need to do.
 - whether the person needs a referral.
 - what type of education needs to be given to the person and their community about their eyes and vision.
- A good case history is often more helpful in diagnosing a person's eye problem than the results of the eye examination.
- Try to use open questions and encourage the person to tell you about their problem in their own words.

TAKING A CASE HISTORY

A good case history will include:

- Chief complaint:
 - The main reason that the person is coming to see you.
 - Must discuss this problem and what can be done about it at the end of the eye examination.
- Information about vision:
 - For distance and near
 - Eye strain or tired eyes
 - Flashing lights or floating spots.
- Eye history:
 - Previous eye examinations
 - Previous eye problems
 - Spectacle history.
- Visual needs:
 - Tasks or work that the person needs their vision for.
- Family eye or health problems:
 - Eye problems that anyone in the family has (or had).
 - Family health problems (such as diabetes or high blood pressure).
- General health, medical history (including medications) and allergies:
 - Any health problems that the person has (or had).
 - Any allergies the person has.

SUMMARY: CASE HISTORY (cont.)

Asking for details:

- Often you need to ask more information about a person's symptoms.
- Questions you should ask include:
 - Sensation → how do the eyes feel?
 - Appearance → how do the eyes look?
 - Location → where is the problem?
 - Severity → how bad is it?
 - Onset → when did it start?
 - Frequency → how often does it happen?
 - Duration → how long does it last?
 - Associated symptoms → what other symptoms happen at the same time?
 - Relief → previous treatments
 - Vision → how does the person see?
 - Other people → does anyone else in the family or community have the same problem?

THINKING ABOUT THE CASE HISTORY

When you have finished taking the case history you need to think about the information that the person has given you.

Ask yourself:

- Does the person need a refraction or should they be referred for an eye health check right away?
- What sort of refractive error do you think the person has?
- What visual needs does the person have?
- What do you think the person's problem might be?

TEST YOURSELF QUESTIONS

1. **When, during a normal eye examination, do you normally take a case history?**

2. **Why is it important to earn the trust and confidence of the person you are examining?**

3. **Why should we try to ask open questions when taking the case history, rather than closed and leading questions?**

4. **Why is it important to know what a person's chief complaint is?**

5. **List at least eight questions that should be included in the case history:**

6. **What should you do if someone tells you they have just splashed a chemical in their eye?**

7. **What should you do if someone tells you that they are seeing flashing lights or floating spots in their vision?**

8. **There are many diseases of the body that can also affect the eyes. Name two of these health problems.**



NOTES



INTRODUCTION TO REFRACTION

THINK

An artist comes to you for an eye examination. She tells you that she sometimes has trouble seeing clearly.

You take a complete case history from her, and measure her visual acuity and pinhole visual acuity.

You think that she has a refractive error – but what sort of refractive error does she have and how can you measure it?

AIM

This unit introduces you to the different ways of measuring refractive error and the goals of a refraction examination.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- explain the purpose of a refraction examination
- list objective and subjective refraction techniques
- explain the advantages and disadvantages of different refraction techniques
- identify the goals of a refraction examination
- predict the amount and type of refractive error based on case history and visual acuity
- describe the basic refraction examination procedure.

REVIEW: INTRODUCTION TO REFRACTION

WHAT IS REFRACTIVE ERROR?	• A person who has a refractive error will need to wear spectacles (glasses) or contact lenses so that they can see clearly and comfortably. This is because their eye is not the correct size and shape. • There are four main types of refractive error: myopia, hyperopia, astigmatism and presbyopia. • The amount of refractive error an eye has depends on: - the curvature of the cornea, and/or - the curvature of the crystalline lens, and/or - the length of the eyeball. • A person with a refractive error may have eyes that look normal, but they will not see well. • An eye examination that tests for refractive error is called a refraction.
WHAT IS ACCOMMODATION?	• Accommodation occurs when the ciliary muscle contracts and changes the shape of the crystalline lens (makes it thicker) and more curved. • This changes the optical focus of the eye so that close objects can be seen clearly. • When accommodation is relaxed in a normal eye (an eye without refractive error), objects in the distance are seen clearly. • Presbyopia is the natural aging change in the eye where the crystalline lens hardens with age. When this happens, the lens cannot change shape easily when the ciliary muscle contracts. This means that an older person cannot accommodate as easily as a younger person. • All people will get presbyopia when they get older. It is impossible for a child or a young adult in their 20s to have presbyopia.
WHAT IS VISUAL ACUITY?	• Visual acuity (VA) is a measure of how clearly a person sees when they are looking directly (straight) at an object. • Common causes of poor VA are: - refractive error (this person needs spectacles to see clearly) - eye health problem (this person has a health problem with their eyes).

CLINICAL REFRACTION

Refraction is the clinical technique for measuring refractive error. A refraction tells you:

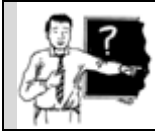
- the type of refractive error that a person has (hyperopia, myopia, astigmatism or presbyopia)
- how much refractive error a person has.

REFRACTION OF LIGHT	In optics, refraction refers to the way light is bent by a lens or a prism.
REFRACTION OF THE EYES	In eye care, refraction refers to the clinical technique used to measure a person's refractive error.

MEASURING REFRACTIVE ERROR

There are several ways to measure refractive error.

These different ways can be divided into objective and subjective tests.



Objective test results are not dependant on what a person says to the examiner.
Objective findings can be seen or measured without needing the person's opinion.

Subjective test results depend on what a person tells the examiner.

Objective refraction methods include:

- Retinoscopy
- Auto-refraction.

Subjective refraction methods include:

- Best vision sphere refraction
- Sphero-cylindrical refraction
- Near refraction.

Because both objective methods and subjective methods have advantages and disadvantages, a combination of these methods is usually used when performing a refraction.

OBJECTIVE REFRACTION METHODS

RETINOSCOPY

Retinoscopy is a good objective way to estimate the refractive error of an eye. A piece of equipment called a retinoscope is used to examine the optical properties of an eye when different trial lenses are held in front of the eye.

It is good to do retinoscopy before you do a subjective refraction because it gives you a starting point and will make your refraction faster.



Figure 15.1: Using retinoscopy to estimate the refractive error of a person's eye

ADVANTAGES OF RETINOSCOPY

- Fast estimation of a person's refractive error.
- Easier to control a person's accommodation than auto-refraction.
- Other eye problems (such as cataract or corneal scars) can be detected at the same time.
- Excellent method for estimating refractive error of children and people who cannot communicate with you (such as people who speak a different language).
- Small and portable (easy to transport).

DISADVANTAGES OF RETINOSCOPY

- Accurate measurements require training and practice.
- Difficult to do on people with small pupils.

OBJECTIVE REFRACTION METHODS (cont.)

AUTO-REFRACTION

An auto-refractor is a machine that is used to estimate the refractive error of an eye objectively.



Figure 15.2: An auto-refractor

- **Advantages of an auto-refractor:**
 - The measurement can be taken by someone who has minimal eye care training.
- **Disadvantages of an auto-refractor:**
 - Auto-refractors often over-estimate myopia and under-estimate hyperopia (especially for young people).
 - A trained eye care worker is needed to interpret the results correctly.
 - A trained eye care worker is needed to refine the results (make them more accurate).
 - Auto-refractors are expensive.
 - Auto-refractors are usually not portable (cannot be taken on outreach).



You should never prescribe spectacles just from an auto-refractor reading.

If you do, the person can have problems wearing their new spectacles.

Their eyes may not feel comfortable looking through the spectacle lenses.

An auto-refractor can be useful to give a starting point for a subjective refraction, but it is not necessary to have this type of equipment.

SUBJECTIVE REFRACTION METHODS

Subjective refraction is usually performed using trial lenses (from a trial lens set) which are put into a trial frame that is worn by the person being examined.

BEST VISION SPHERE (BVS) REFRACTION

A BVS refraction is a subjective technique that is used to accurately measure myopia and hyperopia.

The BVS is measured by asking a person what they can see on a VA chart when spherical trial lenses of different powers are put in front of their eyes.



Figure 15.3: In subjective refraction a person is asked what they can see on a VA chart when trial lenses are put in front of their eyes

Because BVS refraction only uses spherical trial lenses (plus and minus lenses), it can only measure spherical refractive errors. A BVS refraction cannot measure astigmatic refractive errors.

SPHERO-CYLINDRICAL REFRACTION

A sphero-cylindrical refraction accurately measures hyperopia, myopia and astigmatism subjectively.

A sphero-cylindrical refraction begins with a BVS refraction and then uses cylindrical lenses to measure any astigmatism that a person might have.

This is the best way to measure refractive error, but it takes training and practice to become good at this technique.



Figure 15.4: Both spherical and cylindrical trial lenses are used in a sphero-cylindrical refraction to measure a person's refractive error – including astigmatism

SUBJECTIVE REFRACTION METHODS (cont.)

SPHERO-CYLINDRICAL REFRACTION (cont.)

Sometimes, instead of using a trial frame and a trial lens set, a phoropter is used. A phoropter (also called a refractor head) is a special machine that is used for subjective refraction. Inside the phoropter are all the lens powers and accessory lenses that you can find in a trial lens set.

The person looks through the eyepieces of the phoropter and the examiner turns the dials to change the lens power in front of the person's eyes.



Figure 15.5: A phoropter can be used instead of a trial lens set and trial frame

A phoropter is heavy, fragile and expensive and it cannot be used for outreach clinics. Usually it is easier to use a trial frame and a trial lens set to do a refraction.

NEAR REFRACTION

Presbyopic people need to have a subjective near refraction examination as well as a subjective distance refraction examination. A near refraction measures how much presbyopia a person has.

A near refraction begins with a BVS (or sphero-cylindrical) refraction, and then the person looks at a near VA chart (or reading card) for a near refraction.

Only spherical lenses and a trial frame are used for a near refraction.

GOALS OF REFRACTION

GOALS OF REFRACTION

A refraction is performed to find the power of the spectacle lens that a person needs to correct their refractive error. A good refraction lets a person see clearly and comfortably with the spectacles that are made for them.

The goals of refraction are to find:

- the lens (or lenses) that gives the person the clearest vision; and
 - the lens (or lenses) that gives the person the most comfortable vision.
- Both of these goals are equally important.



If you give a person too much minus power you will make the person uncomfortable → this is because you are making the person accommodate to see clearly.

If you give a person too much plus power you will make the person's vision blurry.

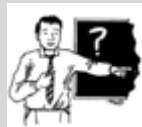
The examiner must find the one lens that gives the person clear vision and minimises their accommodation (makes the person comfortable).

CLEAR VISION

Often there are several lenses that will give a person good vision on the VA chart.
→ Not all these lenses will be comfortable for the person to wear as spectacles.

COMFORTABLE VISION

There will only be one lens that gives a person the most comfortable and clear vision.
→ This is the lens that will minimise the amount of accommodation the person needs to use.



The lens that gives the most comfortable vision is always the lens that has the least amount of minus power (or the most amount of plus power)

→ but still gives the best VA.

Accommodation will be minimised if the least minus (or most plus) lens is used.

PREDICTING REFRACTIVE ERROR – KNOWING WHAT TO EXPECT

Before you start a refraction, you should already have an expectation of the amount and type of refractive error that the person has. This expectation is based on:

- **Case history:** The person's visual symptoms → at what distance is the vision blurry?
The person's age → could the person have presbyopia?
- **Visual acuity:** Unaided VA → how bad is their distance and near vision?
Pinhole VA → is the poor VA caused by refractive error?

Usually a person's distance VA will get worse by one line on the VA chart for every 0.25 D of spherical refractive error.

→ This works best on a VA chart that has rows of characters that are these sizes:

6/6 6/7.5 6/9 6/12 6/15 6/18 6/24 6/36 6/48 6/60

Table 15.1: Predicting spherical refractive error from unaided VA

UNAIDED VA	EXPECTED REFRACTIVE ERROR (+ OR -)
6/6	0.25
6/7.5	0.50
6/9	0.75
6/12	1.00
6/15	1.25
6/18	1.50
6/24	1.75
6/36	2.00
6/48	2.25
6/60	2.50
< 6/60	> 2.50



Each 0.25 D of refractive error reduces VA by about one line.

- But!** This estimation will only work if:
- the person has no astigmatism (or only a little)
→ astigmatism affects a person's VA in a different way.
 - the person is not using any accommodation
→ young hyperopes can have good VA because they can accommodate.
 - the person has no eye health problem
→ some eye health problems can make the person's VA worse than expected.
 - the person has a refractive error less than 2.50 D
→ refractive errors that are higher than 2.50 D do not always follow this rule.

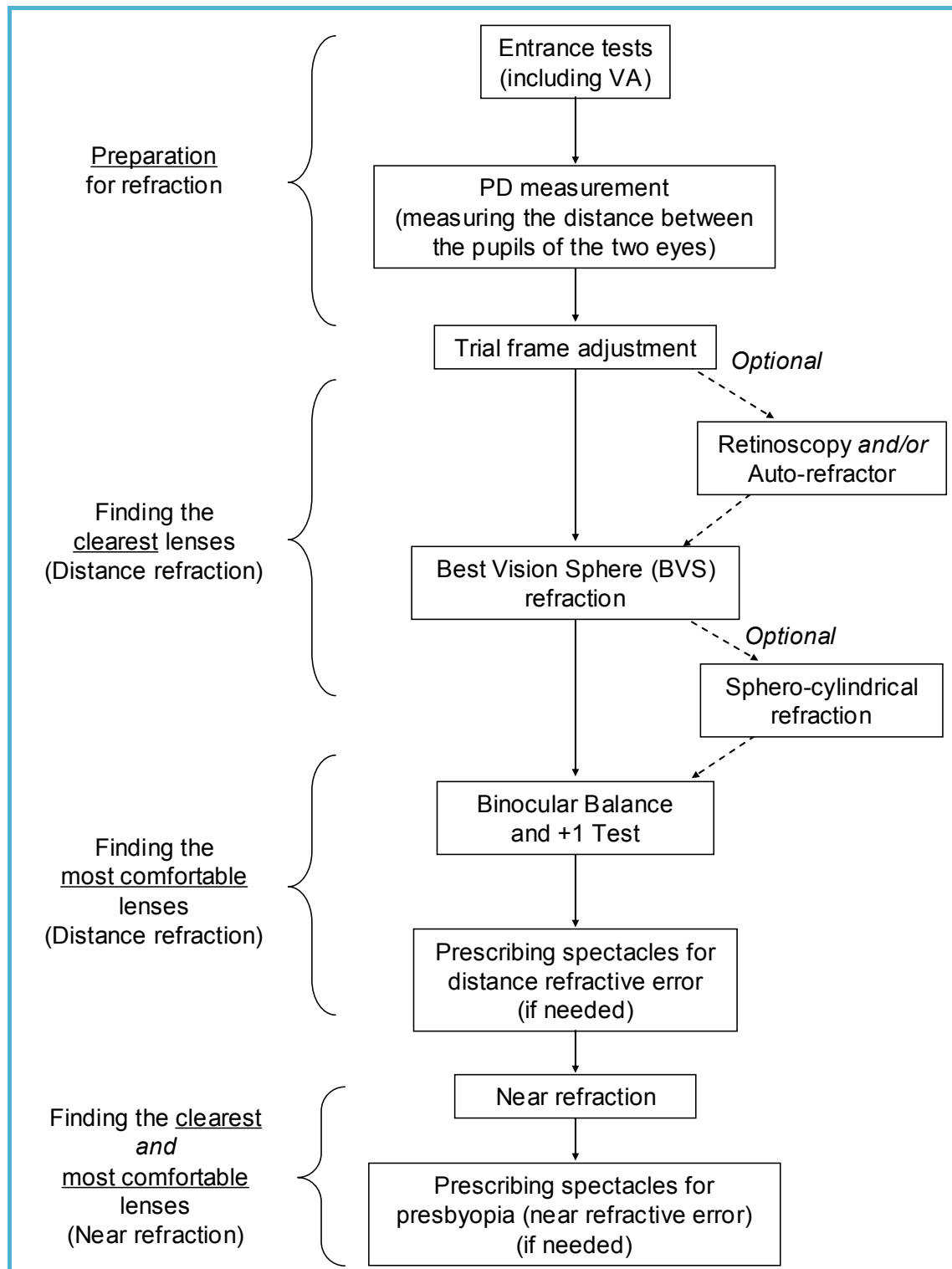
THE ART OF REFRACTION

The theory of refraction can be taught, but the practise of refraction requires an understanding that can only be learnt from experience. This is why refraction is sometimes called an art, not just a science.

WE ALL MAKE MISTAKES	Just like you will sometimes make mistakes, the person that you refract will sometimes make a mistake and tell you something that can confuse you. This may cause you to make a mistake in your refraction. This is particularly the case with people who are having their eyes examined for the first time, and with elderly people and young children.  Good communication will help the person to understand you, and for you to understand them. When you are learning to refract a person, refraction can take you a long time. If you take too long to do your refraction the person can get tired and bored. If this happens, the person's responses will become more unreliable.  You need to learn to do a reasonably fast refraction so that the person is alert and concentrating during the whole examination. This will make your refraction more accurate. Children need to be kept busy and entertained during an eye exam or they will lose interest and become unhelpful. Elderly people will get tired if the refraction takes too long. If this happens you must give them a rest or ask them to come back on another day.
CONTROLLING ACCOMMODATION	Vision is a complicated process. An especially complicated part of vision is accommodation. If a person has very active accommodation you can have difficulty controlling it, unless you are extremely careful. A person who has uncontrolled accommodation will tell you that sometimes the VA chart looks clear and sometimes it looks blurry - even if they are looking through the same lens and at the same letter!  A person who has poorly controlled accommodation will give you unexpected results. If you do not control accommodation, your refraction will probably be incorrect. Most people cannot control their own accommodation. In fact, most people do not even realise that they are accommodating. If accommodation is poorly controlled it is not the fault of the person being examined. Accommodation must be controlled by the examiner.
KNOWING WHAT TO EXPECT	A good examiner listens to a person's symptoms when taking their case history and starts to think about what the person's problem might be. The VA and pinhole VA will give more information about how much refractive error a person has. Before the examiner starts the refraction, they know what refractive error to expect and can estimate how much refractive error there will be. If the person being refracted gives answers that are surprising, a good examiner will know that the person's accommodation is not well controlled – or that the person is confused or tired – and they will know what to do about it.

THE REFRACTION PROCEDURE

There is the basic order that refraction tests are performed in. This order is summarised in the flow chart below.



SUMMARY: INTRODUCTION TO REFRACTION

CLINICAL REFRACTION

- Refraction is a clinical technique for measuring refractive error.
- A refraction tells you
 - the type of refractive error that a person has
 - how much refractive error a person has.

MEASURING REFRACTIVE ERROR

- Objective refraction methods include:
 - retinoscopy
 - auto-refraction.
- Subjective refraction methods include:
 - best vision sphere (BVS) refraction
 - sphero-cylindrical refraction
 - near refraction.

OBJECTIVE REFRACTION METHODS

- Retinoscopy:
 - A retinoscope and a trial lens set are used to determine the refractive error of the eye objectively
 - Good to do before a subjective refraction to use as a starting point.
- Auto-refraction:
 - An auto-refractor is used to estimate the refractive error of the eye
 - Must do a subjective refraction after auto-refraction as it is not accurate enough to prescribe spectacles from.

SUBJECT REFRACTION METHODS

- BVS refraction:
 - Measures the amount of hyperopia or myopia present.
- Sphero-cylindrical refraction:
 - Accurate measure of hyperopia, myopia and astigmatism
 - Begins with a BVS refraction
 - Best way to measure refractive error.
- Near refraction:
 - Measures how much presbyopia a person has
 - Begins with a BVS (or sphero-cylindrical) refraction
 - The person looks at a reading card or near visual acuity (VA) chart and a trial frame and spherical lenses are used to measure near refractive error.

SUMMARY: INTRODUCTION TO REFRACTION (cont.)

GOALS OF REFRACTION

- A refraction must find:
 - the lens that gives the person the clearest vision, **and**
 - the lens that gives the person the most comfortable vision.
- The clearest and most comfortable lens is always the lens that has the least amount of minus power (or most amount of plus power) but still gives the best VA.
- Amblyopia is a diagnosis of exclusion
 - This means that you can only say that a person has amblyopia if all other possible reasons for poor vision have been excluded (ruled out).

ESTIMATING REFRACTIVE ERROR – KNOWING WHAT TO EXPECT

- Case history and VA will give you clues as to what sort of refractive error a person probably has.
- Case history:
 - the person's visual symptoms
 - the person's age.
- VA:
 - unaided and pinhole VA
 - the amount of spherical refractive error can be predicted by looking at the unaided VA (every 0.25 D refractive error = approx. one line of VA)

But only if:

- the person has no astigmatism
- the person is not accommodating
- the person has no eye health problem.

THE ART OF REFRACTION

- People can sometimes tell you the wrong thing by accident
 - especially if they are tired, bored or have trouble understanding you.
- Uncontrolled accommodation can give you the wrong results
 - be especially careful when you are refracting young people with active accommodation.
- If you know what to expect (from the case history and VA) you will recognise when the refraction is giving unusual results.

TEST YOURSELF QUESTIONS

1. What is the difference between subjective and objective refraction tests?

2.
 - a) What are the advantages of objective refraction tests?

 - b) What are the advantages of subjective refraction tests?

3. What is the difference between a best vision sphere refraction and a sphero-cylindrical refraction?

4. What are the two main goals of refraction?

5. What information will help you estimate a person's refractive error before you start your refraction?

6. How can you use visual acuity to estimate a person's refractive error?

7. How can you help a person give you good answers during a subjective refraction?

NOTES



RETINOSCOPY

THINK

Retinoscopy is an objective refraction technique that can estimate a person's refractive error without them needing to say anything to you.

Retinoscopy should be done for every person that you examine as it gives you information that you cannot get any other way. It is also extremely useful for people who cannot communicate with you – such as young children or people with mental disabilities – because you can estimate their refractive error without needing to do a subjective refraction.

Doing retinoscopy for every person that you examine will make your refraction faster, more efficient and more accurate.

AIM

This unit will teach you how to perform retinoscopy to measure a person's refractive error objectively.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- explain why retinoscopy is a good refraction technique
- describe the parts of a retinoscope and know how it works
- describe the appropriate set-up for doing retinoscopy
- use a retinoscope to scope the principal meridians of an eye
- recognise “with”, “against” and neutral ret reflexes
- neutralise the ret reflex using trial lenses
- explain what to do if you have problems seeing the ret reflex.

REVIEW: RETINOSCOPY

LENSES	• Lenses refract light to form a focus. • Spherical lenses can be plus or minus lenses. • Plus lenses are also called: positive lenses, convex lenses, or converging lenses. • Minus lenses are also called: negative lenses, concave lenses, or diverging lenses. • Astigmatic lenses can be cylindrical or sphero-cylindrical.
POWER MERIDIANS OF LENSES	• A spherical lens has the same refractive power along all of its meridians. • A cylindrical lens has a refractive power along only one of its meridians. • A sphero-cylindrical lens has power in two different principal meridians.
FOCAL LENGTH	• The distance between a lens and its focal point is called the focal length. • To find the focal length of any lens there is a formula: $f = 1/F \quad \text{or} \quad F = 1/f$ Where: f = focal length (in metres [m]) F = lens power (in dioptres [D])
ASTIGMATIC EYE	• There are two types of astigmatism: – regular astigmatism – irregular astigmatism. • Usually when we refer to “astigmatism” we mean regular astigmatism. • Regular astigmatism is the most common type of astigmatism. When we refer to “astigmatism” we usually mean regular astigmatism. • There are two perpendicular principal meridians in an eye that has regular astigmatism. • For each of these principal meridians we refer to its: – “meridian” direction → this is where the focusing power is – “axis” direction → this has no focusing power. • Irregular astigmatism is very rare and is usually caused by: – corneal trauma, or – keratoconus (an eye health problem). • An eye with irregular astigmatism has principal meridians that are not perpendicular to each other. • Because the principal meridians are not perpendicular to each other, it cannot be completely corrected with an astigmatic spectacle lenses.
INTERPUPILLARY DISTANCE (PD)	• Interpupillary distance (PD) is the distance (in mm) between a person’s pupils. • The PD measurement must be accurate so that the: – refraction examination is accurate – spectacles are made correctly.
RETINOSCOPY	• A retinoscope and a trial lens set are used to determine the refractive error of the eye objectively. • Good to do before a subjective refraction to use as a starting point.

RETINOSCOPY

Taking a case history is the first step that you take when you examine a person's eyes.

It helps you to understand the person's problems and concerns.

DEFINITION	Retinoscopy refers to the use of an instrument (called a retinoscope) to measure a person's refractive error. Retinoscopy is an objective method of refraction – which means the person does not need to tell us about how they see. When we ask questions about how the person sees, it is called subjective refraction.
WHY DO RETINOSCOPY?	You should do retinoscopy on every person that you examine. Retinoscopy allows you to: • estimate a person's refractive error before you begin your subjective refraction → it provides a starting point for your refraction. • estimate the refractive errors of people who have problems communicating with you, such as: → babies or young children → people with a physical or mental disability → people who speak a language that you do not understand → deaf or mute people. • detect some eye diseases (like cataract or corneal opacities) that can affect a person's vision and your refraction examination.
HOW IT WORKS	When we shine the light of a retinoscope into a person's eye, we can look at the light reflected back from the retina. This reflected light is called the retinoscopic reflex (or simply, the "ret reflex"). The ret reflex looks like a red light inside the person's pupil. Depending on the person's refractive error, when we move the retinoscope the ret reflex will move in a particular way inside the pupil. Trial lenses can be used to measure the amount of movement that a ret reflex has so that the refractive error can be estimated accurately.
TYPES OF RETINOSCOPES	There are two types of retinoscopes: • Spot retinoscopes: → have an ordinary light globe that gives a "patch" or "spot" of light. • Streak retinoscopes: → have a special globe that gives a line, or "streak", of light.

RETINOSCOPY (cont.)

TYPES OF RETINOSCOPES (cont.)

In this unit, we will focus on the streak retinoscope and its use.



Figure 16.1: Streak retinoscope.

PARTS OF A RETINOSCOPE

- **Power switch**
 - turns the retinoscope on and off
 - controls the brightness of the light.
- **Small globe (light bulb)**
 - provides the light.
- **Electrical supply**
 - batteries (disposable or rechargeable) in the retinoscope handle, or
 - a power cord to connect the retinoscope to the main electricity.
- **Mirror**
 - reflects light from the globe into the person's eye.
- **Sight hole (viewing hole)**
 - allows the ret reflex to be seen.
- **Slide knob or sleeve**
 - rotates the axis of the retinoscope's light, and
 - changes the light beam from divergent to convergent light.

If a retinoscope is not working, it is usually because:

- it needs new batteries, or its rechargeable batteries need to be recharged.
- the light globe needs changing – each globe usually lasts for several years.



Retinoscope light globes are made especially for retinoscopes. You must buy your retinoscope light globe from the retinoscope manufacturer.

RETINOSCOPY (cont.)

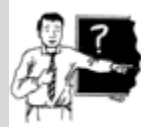
STREAK RETINOSCOPE

There are several different models of streak retinoscopes, but they are all similar to the one shown in Figure 16.1.

The streak of light can be changed by moving the slide knob or sleeve. It can be:

- rotated to any axis position (by rotating the sleeve)
- made thicker or thinner in width (by moving sleeve up or down)
- changed from convergent to divergent light (by moving the sleeve up or down).

Most retinoscopes produce convergent light when the sleeve is up and divergent light when the sleeve is down.



Retinoscopy is usually performed with the divergent light.

SPOT RETINOSCOPE

A spot retinoscope makes a “spot” of light instead of a “streak” of light.

The spot of light can be changed by moving its slide knob. It can be:

- made larger or smaller in diameter (by moving sleeve up or down)
- changed from convergent to divergent light (by moving the sleeve up or down).

Most retinoscopes produce convergent light when the sleeve is up and divergent light when the sleeve is down.



The spot light of a spot retinoscope does not need to be rotated (like the streak retinoscope) to examine different axis directions.

MOVEMENT OF THE RETINOSCOPE REFLEX

The refractive error of an eye can be estimated by moving the light from the retinoscope across the person's eye. This movement is called "sweeping". Sweeping is done to "scope" (search) for refractive error in a person's eye.

Sweeping should be a smooth, repetitive movement. It should be done several times back-and-forth, up-and-down and in oblique directions. Sweeping in different directions lets us look for astigmatism and measure the refractive error of the eye in different power meridians of the eye.

Sweeping the Horizontal Meridian:

- Use the slide knob to turn the streak to a vertical direction (90°).
- Move the streak of the retinoscope from side to side (along the horizontal meridian).

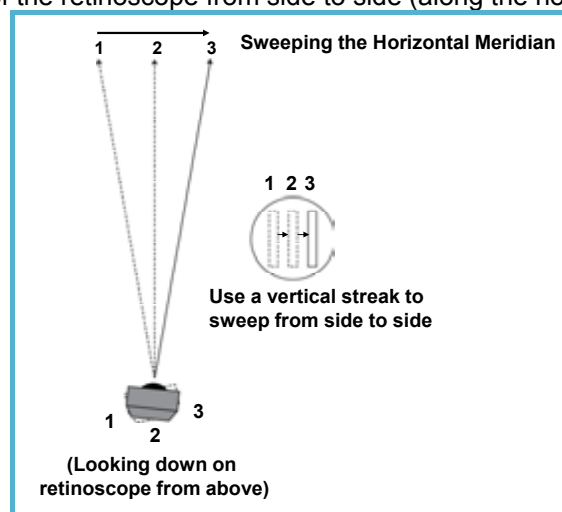


Figure 16.2: Sweeping the horizontal meridian

Sweeping the Vertical Meridian:

- Use the slide knob to turn the streak to a horizontal direction (180°).
- Tilt the retinoscope up and down (along the vertical meridian).

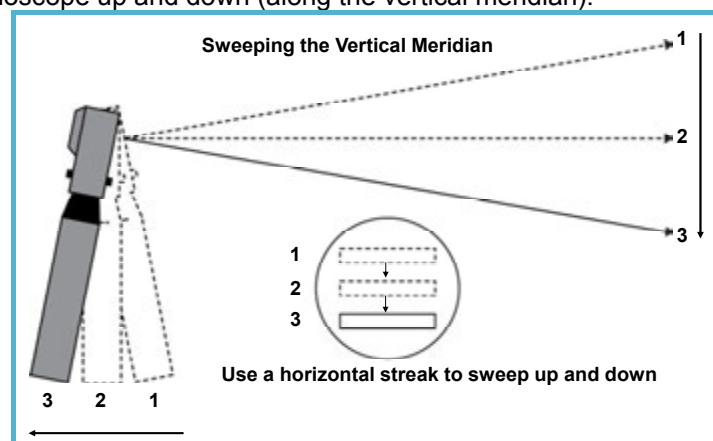


Figure 16.3: Sweeping the vertical meridian

Sweeping Oblique Meridians:

Oblique meridians are neither horizontal nor vertical, but they are at an angle.

- Use the slide knob to rotate the streak to an oblique angle (for example, 45°).
- Move the retinoscope in a direction that is at right angles to the streak direction (for example, 135°).



Practice sweeping by shining the streak on a wall and sweeping the horizontal, vertical and oblique meridians.

SWEEPING

LOOKING AT THE RETINOSCOPIC REFLEX MOVEMENTS

VIEW THROUGH THE SIGHT HOLE

When you look through a retinoscope at a person's eye you will see the red ret reflex when you shine the light into their pupil. The ret reflex usually looks like a narrow band of red light that covers part of the pupil.

If you have trial lenses in the trial frame, you will also see the light reflected on the rim of the trial lens.

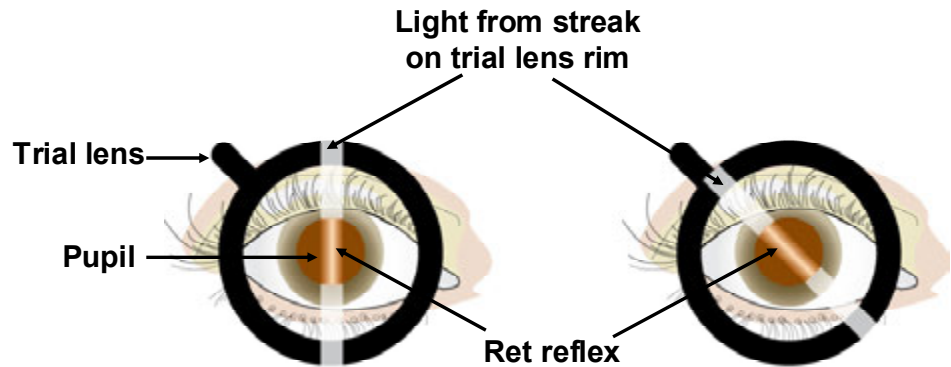


Figure 16.4: View through the sight hole of a streak retinoscope

When you move the retinoscope, the ret reflex also moves. The movements of the ret reflex may be “with”, “against” or “neutral”.

“WITH” MOVEMENT

When the ret reflex moves in the same direction as the sweeping motion of the retinoscope streak, it is called “with” movement.

“With” movement

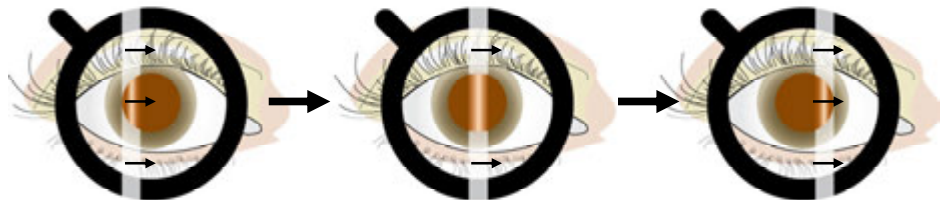


Figure 16.5: A ret reflex showing “with” movement

“AGAINST” MOVEMENT

When the ret reflex moves in the opposite direction to the sweeping motion of the retinoscope streak, it is called “against” movement.

“Against” movement

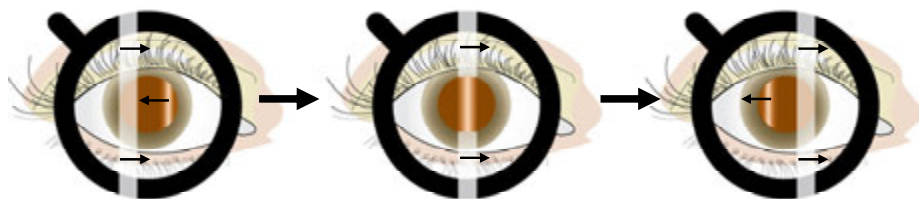


Figure 16.6: A ret reflex showing “against” movement

LOOKING AT THE RETINOSCOPIC REFLEX MOVEMENTS (cont.)

NO MOVEMENT (NEUTRAL)

When the whole pupil is filled with light and there is no movement of the ret reflex during sweeping, it is called the “neutral” point or “neutrality”.

Neutrality is what you aim to get when you are doing retinoscopy. When you have found the neutral point you can estimate the person’s refractive error.

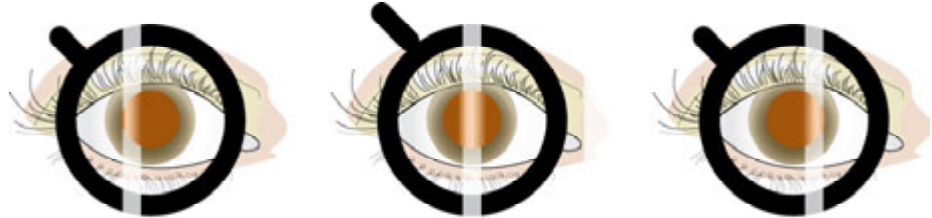


Figure 16.7: A ret reflex showing neutrality

“SCISSORS” MOVEMENT

Very rarely you will see an unusual ret reflex movement that is called “scissors” movement.

The appearance of scissors movement is:

- not neutral, and not “with” or “against”
- a “double” reflex that seems to rotate as the streak is swept over the pupil
- called “scissors” because it looks like a pair of scissors opening and closing.



Scissors movement is a sign that the person has irregular astigmatism.

A person with irregular astigmatism may:

- have poor visual acuity (VA) with spectacle lenses
- need a referral to a specialist to see if their vision can be improved.



Irregular astigmatism is usually first detected by an eye examination that includes retinoscopy.

CHARACTERISTICS OF THE RET REFLEX

- **Brightness:** Is it bright or dull?
→ The reflex gets brighter as you get closer to the neutral point.
- **Direction of movement:** Is it with or against motion?
→ “With” movement is neutralised with plus lenses
→ “Against” movement is neutralised with minus lenses.
- **Speed:** Is it fast or slow?
→ The speed of the reflex gets faster if it is close to the neutral point.
- **Thickness:** Is it wide or narrow?
→ The ret reflex becomes wider when it gets close to neutrality.



Figure 16.8: As you get closer to neutrality the ret reflex becomes wider

LOOKING AT THE RETINOSCOPIC REFLEX MOVEMENTS (cont.)

VIEW THROUGH THE SIGHT HOLE	<i>Figure 16.9: Characteristics of the ret reflex</i> • Meridians: Is the movement the same in all meridians? → If the movement is the same in all directions, it is a spherical refractive error. → If the movement is different in different directions, it is an astigmatic refractive error. • Break: Is the ret reflex parallel to (aligned with) the streak in all meridians? → If it is aligned in all meridians, the refractive error is spherical. → If it is not always aligned (if there is a “break”), the refractive error is astigmatic.
NEUTRALISING THE RET REFLEX	The ret reflex can be neutralised by adding plus or minus trial lenses to the trial frame. Irregular astigmatism is usually first detected by an eye examination that includes retinoscopy. If you add too much plus: • the movement will change from “with” to “against” → this means you have passed neutrality → you need to remove some of the plus to go back to the neutral point. If you add too much minus: • the movement will change from “against” to “with” → this means you have passed neutrality → you need to remove some of the minus to go back to the neutral point.
WORKING DISTANCE	When you do retinoscopy you are usually 67 cm away from the person (or sometimes 50 cm). This distance is called the working distance. The working distance is extremely important because you need to remember it when you calculate a person’s refractive error after doing retinoscopy.

LOOKING AT THE RETINOSCOPIC REFLEX MOVEMENTS (cont.)

WORKING DISTANCE (cont.)



Figure 16.10: Retinoscopy is usually performed at a working distance of 67 cm



When you are learning retinoscopy, you can use a piece of string to measure your working distance.

One end of the string is tied to the retinoscope and the other end is pulled tight to touch the person's trial frame. The string should be 67 cm (or 50 cm) long.

This will help you learn to "feel" the correct retinoscopy working distance. With practice you will know the correct distance without using the string.

NEUTRALITY AND WORKING DISTANCE

When the neutral point is reached it means that the person's retina is in sharp focus.

If you (and your retinoscope) were 6 m away from the person being examined, the lenses needed to neutralise the reflex would be the same as the person's refractive error. But being 6 m away from the person is impractical (it would be impossible for you to hold the trial lenses in front of the person's eye!) – so you must sit closer to the person.

Usually we choose to hold the retinoscope 67 cm away from the person's eye (or sometimes 50 cm away if you have short arms) – because this lets us hold trial lenses in front of the person's eye with an arm outstretched. If you are any closer than 50 cm to the person, your retinoscopy results will not be as accurate.

Because you are not 6 m or more away from the person, you must compensate for your working distance when you calculate the person's distance refractive error:



If you use a working distance of 67 cm (0.67 m):

→ **subtract 1.50 D from the lens powers that neutralise the ret reflex**

$$\begin{aligned} \text{Because: } F &= 1 / f \\ &= 1 / 0.67 \\ &= 1.50 \text{ D} \end{aligned}$$

If you use a working distance of 50 cm (0.5 m):

→ **subtract 2.00 D from the lens powers that neutralise the ret reflex**

$$\begin{aligned} \text{Because: } F &= 1 / f \\ &= 1 / 0.5 \\ &= 2.00 \text{ D} \end{aligned}$$

LOOKING AT THE RETINOSCOPIC REFLEX MOVEMENTS (cont.)

COMPENSATING FOR WORKING DISTANCE

There are two ways to compensate for the retinoscopy working distance when estimating a person's distance refractive error:

- **Calculation method:**
 - Find the trial lenses that give neutrality.
 - Subtract 1.50 D (or 2.00 D) from the power of these trial lenses (depending on your working distance).
 - This is the power of the lens that will correct the person's refractive error (as measured by retinoscopy).

Example 1:

- A +5.00 D trial lens gives a neutral ret reflex at a working distance of 67 cm
- $+5.00\text{ D} - 1.50\text{ D} = +3.50\text{ D}$
- The person's refractive error measured by retinoscopy is +3.50 D hyperopia.

Example 2:

- A -5.00 D trial lens gives a neutral ret reflex at a working distance of 67 cm
- $-5.00\text{ D} - 1.50\text{ D} = -6.50\text{ D}$
- The person's refractive error measured by retinoscopy is -6.50 D myopia.

- **Extra trial lens method:**
 - Put +1.50 D (or +2.00 D) trial lenses into the back cells of the trial frame (before you begin retinoscopy) and leave them there.
 - Find the trial lenses that give neutrality and put these lenses into the front cells of the trial frame.
 - Remove the +1.50 D (or +2.00 D) trial lenses from the back cells of the trial frame.
 - The trial lenses that are left in the front cells of the trial frame are equal to the power of the lenses that will correct the person's distance refractive error (as measured by retinoscopy).



The extra lenses that compensate for the working distance are sometimes called the "working lenses".

Example 1:

- You put a +1.50 D trial lens into the back cell of your trial frame (and leave it there).
- When you hold a +3.50 D trial lens in front of the trial frame you get a neutral ret reflex at a working distance of 67 cm.
- You put the +3.50 D trial lens into the front cell of the trial frame.
- You remove the +1.50 D trial lens from the back cell.
- The person's refractive error measured by retinoscopy is +3.50 D hyperopia.

Example 2:

- You put a +1.50 D trial lens into the back cell of your trial frame (and leave it there).
- When you hold a -6.50 D trial lens in front of the trial frame you get a neutral ret reflex at a working distance of 67 cm.
- You put the -6.50 D trial lens into the front cell of the trial frame.
- You remove the +1.50 D trial lens from the back cell.
- The person's refractive error measured by retinoscopy is -6.50 D myopia.



BEST VISION SPHERE REFRACTION

THINK

A metal worker comes to you for an eye examination. After taking a case history and measuring his visual acuity, you think that he has a refractive error – but you are not sure what sort of refractive error he might have.

A best vision sphere refraction is the first part of a refraction examination that you should do for all people who you suspect have a refractive error.

AIM

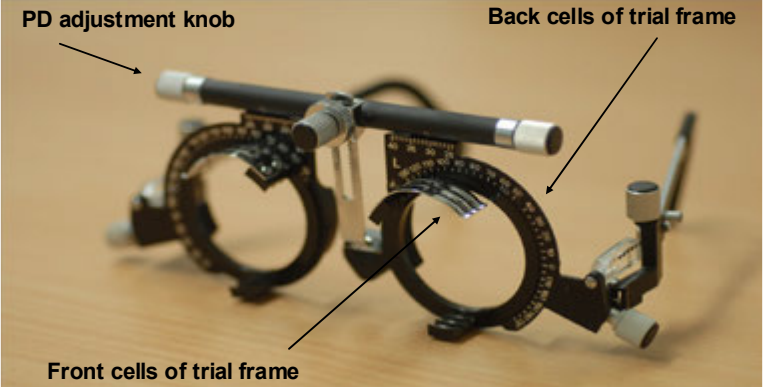
This unit teaches you how to do a subjective best vision sphere (BVS) refraction.

WHAT YOU WILL LEARN

When you have worked through this unit you should be able to:

- explain what is meant by the BVS
- explain the limitations of the BVS for people who have astigmatism
- demonstrate how to do a BVS refraction
- recognise when a BVS refraction is being affected by uncontrolled accommodation and know what to do about it.

REVIEW: BEST VISION SPHERE REFRACTION

REFRACTIVE ERROR	- A person who has a refractive error will need to wear spectacles (glasses) or contact lenses, so that they can see clearly and comfortably. This is because their eye is not the correct size and shape. - There are four main types of refractive error: myopia, hyperopia, astigmatism and presbyopia. - Myopia, hyperopia and presbyopia are corrected by spherical lenses. - Astigmatism is corrected by cylindrical lenses.
MEASURING INTERPUPILLARY DISTANCE (PD)	- PD is the distance (in mm) between a person's pupils. - Distance PD is the distance between the pupils when the person is looking at something far away. - Near PD is the distance between the pupils when the person is looking at something close. - Distance PD is always greater than near PD because the eyes converge when they look at things that are close to them.
TRIAL FRAME	 The image shows a trial frame, a device used to hold trial lenses. It has a central bridge with a PD adjustment knob. The front cells hold the trial lenses, and the back cells are for the patient's eyes. Labels with arrows point to the PD adjustment knob, the back cells, and the front cells.
TRIAL LENS SET	- A trial lens set is a collection of spherical, cylindrical and prism lenses, as well as some accessory lenses. - These lenses are used to measure a person's refractive error. - Plus and minus trial lenses (spherical lenses) are either labelled with a "+" or "-" sign, or surrounded by a coloured rim. - Cylindrical trial lenses come in plus and minus powers, but usually we only use the minus cylinders to do a refraction. - Cylindrical lenses have two small axis marks that show the direction of the axis of the cylinder.
GOALS OF REFRACTION	- A refraction must determine: - the lenses that give the person the clearest vision, and - the lenses that give the person the most comfortable vision. - The clearest and most comfortable lens is always the lens that has the least amount of minus power (or most amount of plus power), but still gives the best visual acuity (VA).

REVIEW: BEST VISION SPHERE REFRACTION (cont.)

MEASURING REFRACTIVE ERROR	• Objective refraction methods include: – retinoscopy – auto-refraction. • Subjective refraction methods include: – best vision sphere (BVS) refraction – sphero-cylindrical refraction – near refraction.
CONTROLLING ACCOMMODATION	• The most common mistake that examiners make when they do a refraction is giving the person more minus than they need (or not enough plus). • The person might tell you that their vision looks the same (or even better) if too much minus is added but their VA will not get better. • If spectacles with too much minus (or not enough plus) are prescribed, the person will need to accommodate to see clearly. This can cause asthenopia (eye strain and headaches). • People do not usually know that they are accommodating. They will only tell you that their eyes feel sore or tired. • Over-minused = too much minus in the person's spectacles • Under-plussed = not enough plus in the person's spectacles.
THE CLEAREST AND MOST COMFORTABLE LENS	• The clearest and most comfortable lens is the least minus (or most plus) lens that gives the best VA. • Because they have good accommodation, young people often see the VA chart clearly when more minus is placed in front of the BVS. The most comfortable of these lenses is the BVS. The BVS lens is the least minus (or most plus) lens that still gives good VA – and this is the lens that you should prescribe. • You must find the balance between the clearest lens and the most comfortable lens.
AVOIDING OVER-MINUSING	• When you are doing a refraction you must: – control the person's accommodation – check to make sure that the person has not been given too much minus.

CORRECTING REFRACTIVE ERROR

SUBJECTIVE REFRACTION	Refractive error can be measured objectively or subjectively. A subjective refraction measures the refractive error of a person by asking them what they see on a visual acuity (VA) chart when lenses of different powers are put in front of their eyes. • There are three main types of subjective refraction: • Best vision sphere (BVS) refraction → measures hyperopia and myopia • Sphero-cylindrical refraction → measures hyperopia, myopia and astigmatism • Near refraction → measures presbyopia. The first step of both a sphero-cylindrical refraction and a near refraction is to find the BVS.  When you have finished doing a BVS refraction, you will know whether you need to do a sphero-cylindrical refraction, or if you can go on to the next step.
BEST VISION SPHERE (BVS)	Refractive error can be measured objectively or subjectively. A subjective refraction measures the refractive error of a person by asking them what they see on a visual acuity (VA) chart when lenses of different powers are put in front of their eyes. • There are three main types of subjective refraction: • Best vision sphere (BVS) refraction → measures hyperopia and myopia • Sphero-cylindrical refraction → measures hyperopia, myopia and astigmatism • Near refraction → measures presbyopia. The first step of both a sphero-cylindrical refraction and a near refraction is to find the BVS.  If the BVS is plano (zero power), the person does not have a distance spherical refractive error.
ASTIGMATISM AND BVS	If a person has astigmatism, the BVS will give the person the best vision that is possible with a spherical lens, but it will not correct their astigmatism. This means that BVS VA for a person with astigmatism is poor. A person with astigmatism needs a cylindrical lens in addition to the BVS to correct their astigmatism and give them good vision.  Spherical lenses correct hyperopia, myopia and presbyopia. Spherical lenses do not correct astigmatism. Cylindrical lenses correct astigmatism. Sometimes cylindrical lenses are not available or are too expensive. If there is only a small amount of astigmatism, the BVS is sometimes good enough to improve a person's vision, and can therefore be given as their spectacle prescription.

METHOD

PERFORMING A BVS REFRACTION	The best way to learn how to do a BVS refraction is to do it yourself as often as possible. With practice you will become fast and accurate. This unit will show you how to do a BVS refraction using three learning methods: • Step-by-step instructions • Case studies • Flow charts (in the summary). Then you will be ready to do your first BVS refraction.

STEP-BY-STEP INSTRUCTIONS

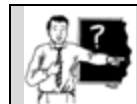
STEP 1	Measure and write down the unaided VA for each eye.
STEP 2	Measure the interpupillary distance (PD) and adjust the trial frame for that PD.
STEP 3	Put an occluder in the trial frame in front of the left eye.  It is good practice to always refract the right eye first.
STEP 4	Look at the unaided distance VA for the right eye to help you decide which lens to start with. If the unaided vision is: • 6/18 or better → start with +0.50 D then -0.50 D • worse than 6/18 (but better than 6/60) → start with +1.50 D then -1.50 D • worse than 6/60 or maybe even: → start with +3.00 D then -3.00 D → start with +5.00 D then -5.00 D You might choose to use a ± 5.00 D lens instead of a ± 3.00 D lens if the person's VA is extremely poor.  Always use plus lenses before minus lenses to control accommodation. Only use minus lenses if the VA gets worse with plus lenses.
STEP 5	Hold the trial lens that you have chosen in front of the right eye. Tell the person: <i>"Look at the letter chart."</i> <i>"Look at the smallest line that you can see."</i> Ask the person: <i>"Does this lens make the chart look BETTER, WORSE, or the SAME?"</i> You might need to show the person the chart with and without the lens a few times.  Always check the VA to make sure that the vision really is what the person says it is ("better", "worse" or "the same"). Sometimes people get confused and tell you that their vision is "better" when really it is "the same". You need to be extremely careful! This is especially important when you are adding minus lenses, and particularly when refracting young people. Another way you can ask the question is: <i>"Does this lens make it look CLEARER, or only SMALLER and DARKER?"</i> This question is especially useful if you are trying minus lenses.  If it only looks "<i>smaller and darker</i>" it is the same as the person telling you that it looks "<i>the same</i>" → and that is the BVS.

STEP-BY-STEP INSTRUCTIONS (cont.)

STEP 6

If the person sees:

- Better: → put the lens in the trial frame
- Worse: → do not put the lens in the trial frame
- Same: If it is a plus lens → put the lens in the trial frame
If it is a minus lens → do *not* put the lens in the trial frame.



If it only looks “*smaller and darker*” it is the same as the person telling you that it looks “*the same*”
→ and that is the BVS.

- If you did not put a new lens into the trial frame:
 - If the lens you tried was a plus lens → now try the minus lens and repeat Steps 5 and 6.
 - If the lens you tried was a minus lens → go to Step 9.

- If you did put a new lens into the trial frame:

Measure the VA with this new lens.

Use the VA you measure to decide which trial lens to try next.

If vision is:

- **6/6 or better** → use **+0.25 D** then **–0.25 D**
- **6/6 to 6/18** → use **+0.50 D** then **–0.50 D**
- **6/18 to 6/60** → use **+1.50 D** then **–1.50 D**
- **Worse than 6/60** → use **+3.00 D** then **–3.00 D**

Combine trial lenses if you need to. If you have two or three lenses in front of one eye, the trial frame can be heavy on the person’s nose. It is also harder for the person to see through several layers of glass than it is just one. You can add up the total power of all the spherical lenses and replace them with just one lens which has the total power.

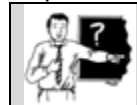
STEP 7

Example

There are two spherical lenses in the right cell of the trial frame:

+1.00 D and –0.25 D. You can add these two lenses together:

→ put a +0.75 D lens into the trial frame and remove the +1.00 D and –0.25 D lenses.



To help control accommodation:

When you are replacing several lenses with just one...

- plus lens → put the new plus lens into the trial frame before removing the other lenses
- minus lens → remove the other lenses before putting the new minus lens into the trial frame.

Repeat Steps 5 and 6 until you find a lens that:

- after adding +0.25 D makes the VA worse
- after adding –0.25 D makes the VA worse, or does not change the VA.



WARNING:

Young people especially will often tell you that the minus lens that you are trying makes their vision look “*better*”...

...but when you check their vision they can only see the same line on the VA chart

– so their vision is not really improving.

When this happens you know that the person is accommodating → they do not need the minus lens, so you do not add the minus lens to the trial frame.



SPHERO-CYLINDRICAL REFRACTION

THINK

A best vision sphere refraction only measures spherical refractive error (myopia, hyperopia or presbyopia) – it does not measure astigmatism.

Spherical lenses only correct spherical refractive errors – they will not correct astigmatism. If a person has significant astigmatism, they will not see clearly or comfortably with spherical lenses only.

A person with significant astigmatism needs a sphero-cylindrical refraction.

AIM

This unit teaches you how to do a subjective sphero-cylindrical refraction.

LEARNING OUTCOMES

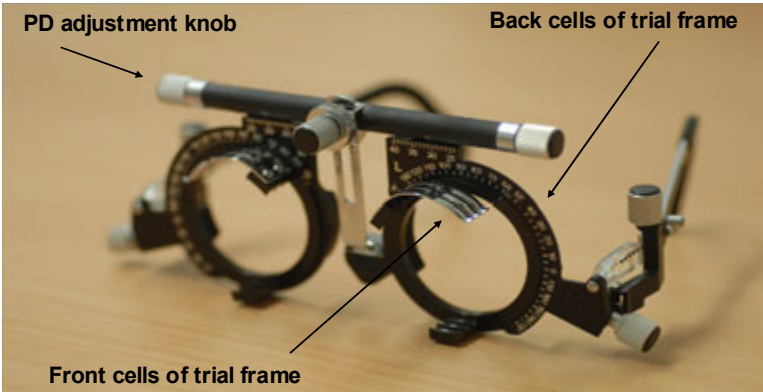
When you have worked through this unit you should be able to:

- explain when a sphero-cylindrical refraction is necessary
- demonstrate the correct use of a cross cylinder
- demonstrate how to do a sphero-cylindrical refraction.

REVIEW: SPHERO-CYLINDRICAL REFRACTION

REFRACTIVE ERROR	- A person who has a refractive error will need to wear spectacles (glasses) or contact lenses so that they can see clearly and comfortably. This is because their eye is not the correct size and shape. - There are four main types of refractive error: myopia, hyperopia, astigmatism and presbyopia. - Spherical lenses correct myopia, hyperopia and presbyopia. - Cylindrical lenses correct astigmatism.
ASTIGMATISM	- In an eye with astigmatism, light from an object does not focus evenly at one point, but instead it focuses at two different points. - Astigmatism may occur in an eye which also has myopia or hyperopia, or just by itself. - Astigmatism is corrected with cylindrical lenses. Astigmatism that is mixed with other refractive errors is corrected with sphero-cylindrical lenses. Both of these sorts of lenses are called astigmatic lenses. - Both the power and the axis of the astigmatic lens must be correct to give clear vision.
VISUAL ACUITY	- Visual acuity (VA) is a measure of how clearly a person sees when they are looking directly (straight) at an object. - Common causes of poor VA are: - refractive error (this person needs spectacles to see clearly) - eye health problem (this person has a health problem with their eyes).
PINHOLE VISUAL ACUITY	- The pinhole test is a simple test that lets you find out whether poor VA is caused by refractive error or an eye health problem. - To measure pinhole VA, the person must look through a pinhole at a distance VA chart. - If VA improves with a pinhole → the person has a refractive error. This does not mean that the eyes are definitely healthy. It is possible for an eye to have a refractive error and an eye disease at the same time. We should always examine the health of the eye even if the pinhole VA is good. - If VA does not improve with a pinhole → the person has an eye health problem or amblyopia (a lazy eye). - The best corrected VA (after a refraction) should be at least the same as the pinhole VA.
MEASURING INTERPUPILLARY DISTANCE (PD)	- PD is the distance (in mm) between a person's pupils. - Distance PD is the distance between the pupils when the person is looking at something far away. - Near PD is the distance between the pupils when the person is looking at something close. - Distance PD is always greater than near PD because the eyes converge when they look at things that are close to them.

REVIEW: SPHERO-CYLINDRICAL REFRACTION (cont.)

TRIAL FRAME	 PD adjustment knob Back cells of trial frame Front cells of trial frame
TRIAL LENS SET	• A trial set is a collection of spherical, cylindrical and prism lenses, as well as some accessory lenses. • These lenses are used to measure a person's refractive error. • Plus and minus trial lenses (spherical lenses) are either labelled with a "+" or "-" sign, or surrounded by a coloured rim. • Cylindrical trial lenses come in plus and minus powers, but usually we only use the minus cylinders to do a refraction. • Cylindrical lenses have two small axis marks that show the direction of the axis of the cylinder.
GOALS OF REFRACTION	• A refraction must find. – the lenses that give the person the clearest vision, and – the lenses that give the person the most comfortable vision. • The clearest and most comfortable lens is always the lens that has the least amount of minus power (or most amount of plus power) but still gives the best VA.
MEASURING REFRACTIVE ERROR	• Objective refraction methods include: – retinoscopy – auto-refraction. • Subjective refraction methods include: – best vision sphere refraction – sphero-cylindrical refraction – near refraction.

MEASURING ASTIGMATISM

SPHERO-CYLINDRICAL REFRACTION

A sphero-cylindrical refraction (or simply a sphero-cyl refraction) measures the amount of astigmatism that a person has so that astigmatic lenses can be prescribed.

All refractions start with a best vision sphere (BVS) refraction.



After the BVS refraction you have to do a sphero-cyl refraction if:

- pinhole visual acuity (VA) is better than BVS VA (VA with BVS spherical lenses),
- OR**
- BVS VA is worse than 6/9.

A person who has astigmatism needs a cylindrical (or sphero-cylindrical) lens that:

- is the correct cylindrical power, and
- is placed at the correct orientation in front of the eye (the axis of the cyl must be at the correct angle).

A sphero-cyl refraction finds the correct power and axis orientation of the cylindrical lens so that the person with astigmatism can see clearly and comfortably.

CROSS CYLINDER

A cross cylinder (or simply a cross cyl) is a piece of equipment that is used to do a sphero-cyl refraction. A cross cyl is sometimes called a Jackson Cross Cyl (JCC).

Every cross cyl has two axes: a minus axis and a plus axis. Cross cyls come in several powers, but the most common cross cyl used is a ± 0.50 D cross cyl.

A cross cyl looks like a trial lens that has a long handle, which is at 45° to the axes. There are small marks engraved or painted on the edge of the lens. These marks tell you what the power of the cross cyl is, and where the axes of the cross cyl are.

The axes of the cross cyl are usually shown by two coloured dots or lines (usually red / orange for the minus axis and white / black for the plus axis).

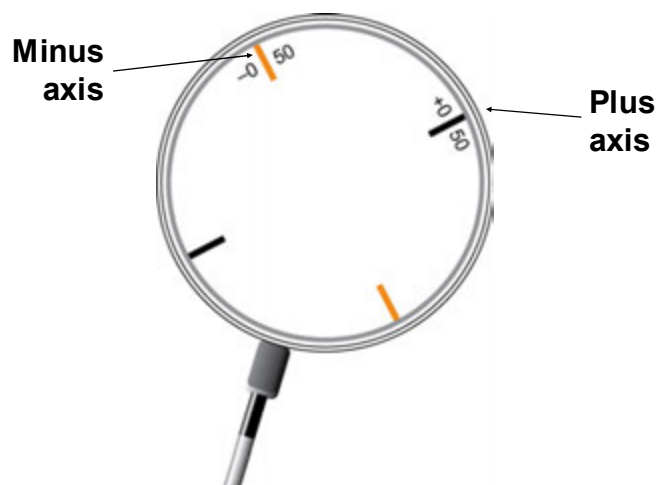


Figure 18.1: A ± 0.50 D cross cylinder

MEASURING ASTIGMATISM (cont.)

MAINTAINING EQUIVALENT SPHERE

Maintaining equivalent sphere during a sphero-cyl refraction is important because it helps you to keep the person's accommodation controlled.

Whenever you change the power of a minus cylindrical trial lens in a trial frame by 0.50 DC you must also change the power of the spherical lens by 0.25 D:

- If you add -0.50 DC to a trial frame, you must balance it by adding $+0.25$ D of sphere power.
- If you remove -0.50 DC from a trial frame, you must balance it by removing $+0.25$ D of sphere power.

You can think of spherical lens power as being twice as strong as cylindrical lens power.



$$\text{Cylindrical power} = \frac{1}{2} \times \text{Spherical power}$$

When you maintain equivalent sphere you are making sure that the overall BVS doesn't change and that accommodation is kept relaxed.

METHOD

METHOD	 People often find the sphero-cyl refraction the most difficult and confusing part of their eye examination. The accuracy of a sphero-cyl refraction depends on: • a good sphero-cyl refraction technique • the instructions that you give the person. There are three parts to a sphero-cyl refraction: • Astigmatism search • Finding the cylinder axis • Finding the cylinder power. Like a BVS refraction, the best way to learn how to do a sphero-cyl refraction is to do it yourself as often as possible. With practice you will become fast and accurate. This unit will show you how to do a sphero-cyl refraction using two learning methods: • Step-by-step instructions with examples • Flow charts (in the summary). After working through these, you will be ready to do your first sphero-cyl refraction.
BEFORE YOU BEGIN	• Put the BVS sphere lens or lenses in the back cells of the trial frame. • Occlude the left eye (remember we always refract the right eye first). • Tell the person to look at a distant target: - A circle target or an O shape (about the size of the 6/12 letters) is best → You can make your own O target. (Make sure the circle is absolutely round and the thickness of the line is even.) - If you do not have an O target, you can ask the person to look at a letter on the VA chart instead. Choose a letter that is two or three lines larger than the smallest line that the person can see. • Hold the cross cyl and tell the person: <i>"This test will make the circle (or letter) look blurry, but I want you to tell me which makes it look better: one or two."</i> <i>"You should also tell me if one and two look the same."</i>

STEP-BY-STEP INSTRUCTIONS

ASTIGMATISM SEARCH	This part of a sphero-cyl refraction is to find out: • if the person has any astigmatism at all, and if so... • the approximate axis of the person's astigmatism.
STEP 1	Hold the cross cyl in front of the right eye. Rotate the cross cyl so that the minus axis of the cross cyl is at 180° (horizontal). This is position 1 for the cross cyl.
STEP 2	Ask the person: <i>“Does the circle (or letter) look better with number one? Or ...”</i> Now twist the handle of the cross cyl so that the person is looking through the other side of the lens. Now the minus axis of the cross cyl should be at 90° (vertical). This is position 2 for the cross cyl. Finish your question: <i>“...with number two? Or do they look the same?”</i> Figure 18.2: Astigmatism search at 90° and 180° If the circle (or letter) looked better in position 1 or 2: → Put a –0.50 DC trial lens in the trial frame with its axis in the same direction as the minus axis of the cross cyl in the better position: <i>If position 1 was better, place the axis of the –0.50 DC trial lens at 180°</i> <i>or</i> <i>If position 2 was better, place the axis of the –0.50 DC trial lens at 90°.</i> → Then go to <i>Finding the Cylinder Axis.</i> If the circle (or letter) looked the same in positions 1 and 2: → Go to Step 3.

STEP-BY-STEP INSTRUCTIONS (cont.)

STEP 3

Rotate the cross cyl so that now the minus axis of the cross cyl is at 45° . This is position 1 for the cross cyl.

Ask the person: **“Can you see better with number one? Or ...”**

Now twist the handle of the cross cyl so that the person is looking through the other side of the lens. Now the minus axis of the cross cyl should be at 135° . This is position 2 for the cross cyl.

Finish your question: **“...with number two? Or do they look the same?”**

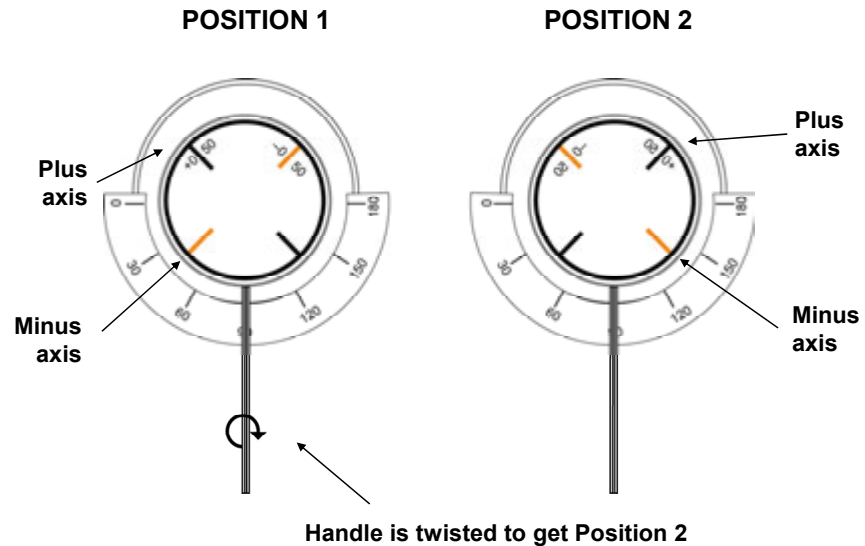


Figure 18.3: Astigmatism search at 45° and 135°

STEP 4

If the circle (or letter) looked better in position 1 or 2:

→ Put a -0.50 DC trial lens in the trial frame with the axis in the same direction as the minus axis of the cross cyl when it was in the better position.

If position 1 was better, place the axis of the -0.50 DC trial lens at 45° or

If position 2 was better, place the axis of the -0.50 DC trial lens at 135° .

→ Then go to **Finding the Cylinder Axis**.

If the circle (or letter) again looked the same in position 1 and 2, and the BVS VA is good:

→ The person probably has no astigmatism

→ You can prescribe the BVS lenses.

If the circle (or letter) again looked the same in position 1 and 2, and the BVS VA is poor:

→ Choose a -0.50 DC lens and place its axis at 180°

→ Go to **Finding the Cylinder Axis**.



EXAMPLE:

Step 1: You hold a cross cyl in front of a person's right eye.

Step 2: You show the person position 1 (minus axis at 180°) and position 2 (minus axis at 90°).

The person tells you that number one and two look the same.

Step 3: You rotate the cross cyl and show the person the next position 1 (minus axis at 45°) and position 2 (minus axis at 135°).

The person tells you that number one was clearer.

Step 4: You look at the position of the minus axis in position 1.

You see that the red dots (the minus axis) are at 45° , so you know that the axis of the person's astigmatism is closer to 45° .

You put a -0.50 DC trial lens into the trial frame with its axis at 45° .

STEP-BY-STEP INSTRUCTIONS (cont.)

FINDING THE CYLINDER AXIS	After you have found the approximate axis of the person's astigmatism, you need to find the exact axis location.
STEP 1	Look at the axis of the -0.50 DC trial lens that you have put into the trial frame. Hold the handle of the cross cyl parallel to (along the same line as) the axis of the -0.50 DC trial lens.
STEP 2	Ask the person: <i>"Does the circle (or letter) look better with number one? Or ..."</i> Now twist the handle of the cross cyl so that the person is looking through the other side of the lens. Finish your question: <i>"....with number two? Or do they look the same?"</i> Figure 18.4: Finding the axis direction of the person's astigmatism
STEP 3	If the circle (or letter) looked better in position 1 or 2: → Rotate the cylindrical trial lens in the trial frame so that its axis mark moves towards the minus axis of the cross cyl when it is in the better position. - Rotate the handle of the cross cyl as well (so that the handle of the cross cyl is parallel to the new axis of the cylindrical trial lens). → Then go to Step 4. When you are finding the cylindrical axis you must always hold the handle of the cross cyl parallel to (lined up with) the axis of the cylindrical lens. If the circle (or letter) looked the same in position 1 and 2: → the axis of the cylindrical trial lens in the trial frame is correct → you have found the axis of the person's astigmatism → go to <i>Finding the Cylinder Power.</i>

STEP-BY-STEP INSTRUCTIONS (cont.)

STEP 4	Repeat Steps 2 and 3 until the person tells you that the circle (or letter) looks the same with number one and number two.  EXAMPLE: Step 1: The person tells you that the circle (or letter) looks better with number one. Step 2: Rotate the axis of the cylindrical trial lens in the direction of the minus axis of the cross cyl (when the cross cyl is in position 1). Rotate the handle of the cross cyl so that the handle is parallel to the new axis position of the trial lens. Step 3: Show the person the new position 1 and position 2. - The person tells you that position 2 is better. You rotate the axis of the cylindrical trial lens in the direction of the minus axis of the cross cyl (when it is in position 2). You rotate the handle of the cross cyl to keep it parallel with the axis of the cylindrical trial lens. Step 4: Show the person the new position 1 and position 2. - The person tells you that both positions seem the same. - This means that the axis of the cylindrical trial lens in the trial frame is correct. → You now know the exact axis of the person's astigmatism.
BRACKETING OF SPHERO-CYLINDRICAL REFRACTION	You can save time (and effort) by using the logical technique of "bracketing".  You can think of bracketing as playing a game of "guess the number" with your friend. This is a game where your friend thinks of a number and you have to guess it. Example: You guess the number is 90 → your friend tells you that it is lower You guess the number is 45 → your friend tells you that it is higher You guess the number is 65 → your friend tells you that it is lower You guess the number is 55 → your friend tells you that you are correct! Do you notice that each time you guess a new number you choose one that is halfway between the two numbers you already know? This is the most efficient (fastest) way to guess the number. When you use bracketing to find the exact cylinder axis, you use a similar method.  EXAMPLE: You do an astigmatism search, and find an approximate axis of 90° → you put a -0.50 DC trial lens at axis 90° into the trial frame. You hold the handle of the cross cyl at 90° (parallel to the axis of the -0.50 DC trial lens) → the two axes of the cross cyl are now at 45° and 135° → you show the person two options again. The person tells you that the circle (or letter) looks better with "number one" (when the cross cyl is positioned with its minus axis at 45°) → you turn the trial lens axis to 65° (this is about halfway between 90° and 45°). You now hold the handle of the cross cyl parallel to the axis of the cylindrical trial lens (at 65°) → the two axes of the cross cyl are now at 20° and 110° → you show the person two options again. The person tells you that the circle (or letter) looks better with "number one" (when the cross cyl is positioned with its minus axis at 20°) → you turn the trial lens axis towards 20°, but choose a number that is between 45° and 65° (you know from before that the number is higher than 45° so you do not turn it all the way to 20° – you just turn it in that direction) → you turn the trial lens axis to 55° (this is halfway between 45° and 65°) You now hold the handle of the cross cyl at 55° (parallel to the new axis direction of the -0.50 DC trial lens) → the two axes of the cross cyl are now at 10° and 100° → you show the person two options again. The person tells you that position 1 and position 2 look the same → the axis of the trial lens in the trial frame is correct → the axis of the person's astigmatism is 55°.

STEP-BY-STEP INSTRUCTIONS (cont.)

FINDING THE CYLINDER POWER	Once you have found the exact axis of a person's astigmatism, you need to find the cylinder power that will correct it.
STEP 1	Look at the axis of the cylindrical trial lens in the trial frame. Hold the cross cyl so that the minus axis of the cross cyl is parallel to the cylindrical trial lens axis (along the same line).
STEP 2	Ask the person: <i>"Does the circle (or letter) look better with number one? Or ..."</i> Now twist the handle of the cross cyl so that the person is looking through the other side of the lens. Finish your question: <i>"....with number two? Or do they look the same?"</i> Figure 18.5: Finding the power of the person's astigmatism
STEP 3	If the circle (or letter) looks better in position 1 (with the cross cyl minus axis parallel to the cylindrical trial lens axis): → Rotate the cylindrical trial lens in the trial frame so that its axis mark moves towards the minus axis of the cross cyl when it is in the better position. → remove the cylindrical trial lens from the trial frame and replace it with a cylindrical trial lens that is 0.25 DC "stronger" (more minus cyl). → make sure that you keep the axis of the cylindrical trial lens the same! → repeat Steps 1 and 2 until the person tells you that the circle (or letter) looks the same with number one and number two – then you have found the power of the person's astigmatism.  Whenever you add -0.50 DC to a trial frame, you must maintain the equivalent sphere by adding $+0.25$ D of sphere power. This is extremely important! If you do not do it you can lose control of the accommodation!

STEP-BY-STEP INSTRUCTIONS (cont.)

STEP 3 (cont.)	If the circle (or letter) looks better in position 2 (with the cross cyl plus axis parallel to cylindrical trial lens axis): → remove the cylindrical trial lens from the trial frame, and replace it with a cylindrical trial lens that is 0.25 DC “weaker” (less minus cyl). → make sure that you keep the axis of the cylindrical trial lens the same! → repeat Steps 1 and 2 until the person tells you that the circle (or letter) looks the same with number one and number two – then you have found the power of the person’s astigmatism. If the circle (or letter) looked the same in position 1 and 2: → the power of the cylindrical lens is correct → you now know the power of the person’s astigmatism (cylinder power) → go to Step 4. If the power of the preferred cylindrical trial lens is changing back and forth between two powers that are close together (say just 0.25 DC different): → the exact cylinder power required probably lies somewhere between those two trial lens powers. → choose the “weaker” (least minus) of the two cylindrical trial lenses as the final cylinder power.  Check the VA often. You should only add cylinder power if the VA improves.
STEP 4	Move the occluder from the left eye to the right eye and repeat the sphero-cyl refraction for the left eye.
STEP 5	Proceed to +1 Test and Binocular Balance.  REMEMBER! Whenever you add -0.50 DC to a trial frame, you must maintain the equivalent sphere by adding $+0.25$ D of sphere power. This is extremely important! If you do not do it you can lose control of the accommodation!
EXAMPLE 1	The trial frame has two lenses in front of one eye: $+1.00$ D and -0.50 DC. The other eye is occluded. You increase the power of the cylindrical trial lens by 0.25 DC twice: → first you change the cylindrical trial lens from -0.50 DC to -0.75 DC → then you change the cylindrical trial lens from -0.75 DC to -1.00 DC. You have added a total of -0.50 DC to the trial frame, so you must also add $+0.25$ D of sphere power (to maintain the equivalent sphere). You: → first put a $+1.25$ D trial lens in the back of the trial frame and → then remove the $+1.00$ D trial lens.

STEP-BY-STEP INSTRUCTIONS (cont.)

EXAMPLE 2	The trial frame has two lenses in front of one eye: -1.00 D and -0.50 DC. The other eye is occluded. You increase the power of the cylindrical trial lens by 0.25 DC twice: → first you change the cylindrical trial lens to -0.75 DC → then you change the cylindrical trial lens to -1.00 D.C You have added a total of -0.50 DC to the trial frame, so you must also add $+0.25$ D of sphere power. You: → first remove the -1.00 D trial lens, and → then put a -0.75 D trial lens in the back of the trial frame.  REMEMBER! Adding $+0.25$ D of sphere power is the same as: • Increasing plus power by 0.25 D <i>(Example 1: $+1.00$ D becomes $+1.25$ D)</i> • Decreasing minus power by 0.25 D <i>(Example 2: -1.00 D becomes -0.75 D)</i>
EXAMPLE 1	The trial frame has two lenses in front of one eye: $+1.00$ D and -1.00 DC. The other eye is occluded. You decrease the power of the cylindrical trial lens by 0.25 DC twice: → first you change the cylindrical trial lens from -1.00 DC to -0.75 DC → then you change the cylindrical trial lens from -0.75 DC to -0.50 DC. You have removed a total of -0.50 DC from the trial frame, so you must also remove $+0.25$ D of sphere power (to maintain the equivalent sphere). You: → first put a $+0.75$ D trial lens in the back of the trial frame, and → then remove the $+1.00$ D trial lens.
EXAMPLE 2	The trial frame has two lenses in front of one eye: -1.00 D and -1.00 DC. The other eye is occluded. You decrease the power of the cylindrical trial lens by 0.25 DC twice: → first you change the cylindrical trial lens to -0.75 DC → then you change the cylindrical trial lens to -0.50 DC. You have removed a total of -0.50 DC from the trial frame, so you must also remove $+0.25$ D of sphere power. You: → first remove the -1.00 D trial lens and → then put a -1.25 D trial lens in the back of the trial frame.  REMEMBER! Removing $+0.25$ D of sphere power is the same as: • Decreasing plus power by 0.25 D <i>(Example 1: $+1.00$ D becomes $+0.75$ D)</i> • Increasing minus power by 0.25 D <i>(Example 2: -1.00 D becomes -1.25 D)</i>

SUMMARY: SPHERO-CYLINDRICAL REFRACTION

MEASURING ASTIGMATISM

Sphero-cylindrical refraction:

- Measures the amount of astigmatism that a person has, so that astigmatic lenses can be prescribed.
- You must do a sphero-cyl refraction if:
 - pinhole visual acuity (VA) is better than best vision sphere (BVS) VA
 - BVS VA is worse than 6/9.
- A person who has astigmatism needs an astigmatic lens that has:
 - the correct cylindrical power
 - been placed at the correct orientation (correct cyl axis).

Cross cylinder:

- A cross cylinder (or cross cyl) is sometimes called a Jackson Cross Cyl (JCC).
- All cross cyls have two axes: a minus axis and a plus axis. These two axes are perpendicular (at 90°) to each other.
- The minus axis is usually marked with red or orange dots. The plus axis is usually marked with white or black dots.

METHOD – SPHERO-CYL REFRACTION

- There are three parts to a sphero-cyl refraction:
 - Astigmatism search
 - Finding the cylinder axis
 - Finding the cylinder power.

Before you begin:

- Put the BVS sphere lens (or lenses) in the back cells of the trial frame.
- Occlude the left eye.
Remember: always test the right eye first.
- Tell the person to look at a distant target
 - an O shape is best (the size of the 6/12 letters)
 - a letter on the distance VA chart that is two or three lines bigger than the smallest letters that the person can see can also be used.
- Hold the cross cyl in front of the person's eye and tell them:
*"This test will make the circle (or letter) look blurry, but I want you to tell me which is better: **one** or **two**. You should also tell me if **one** and **two** look the same."*

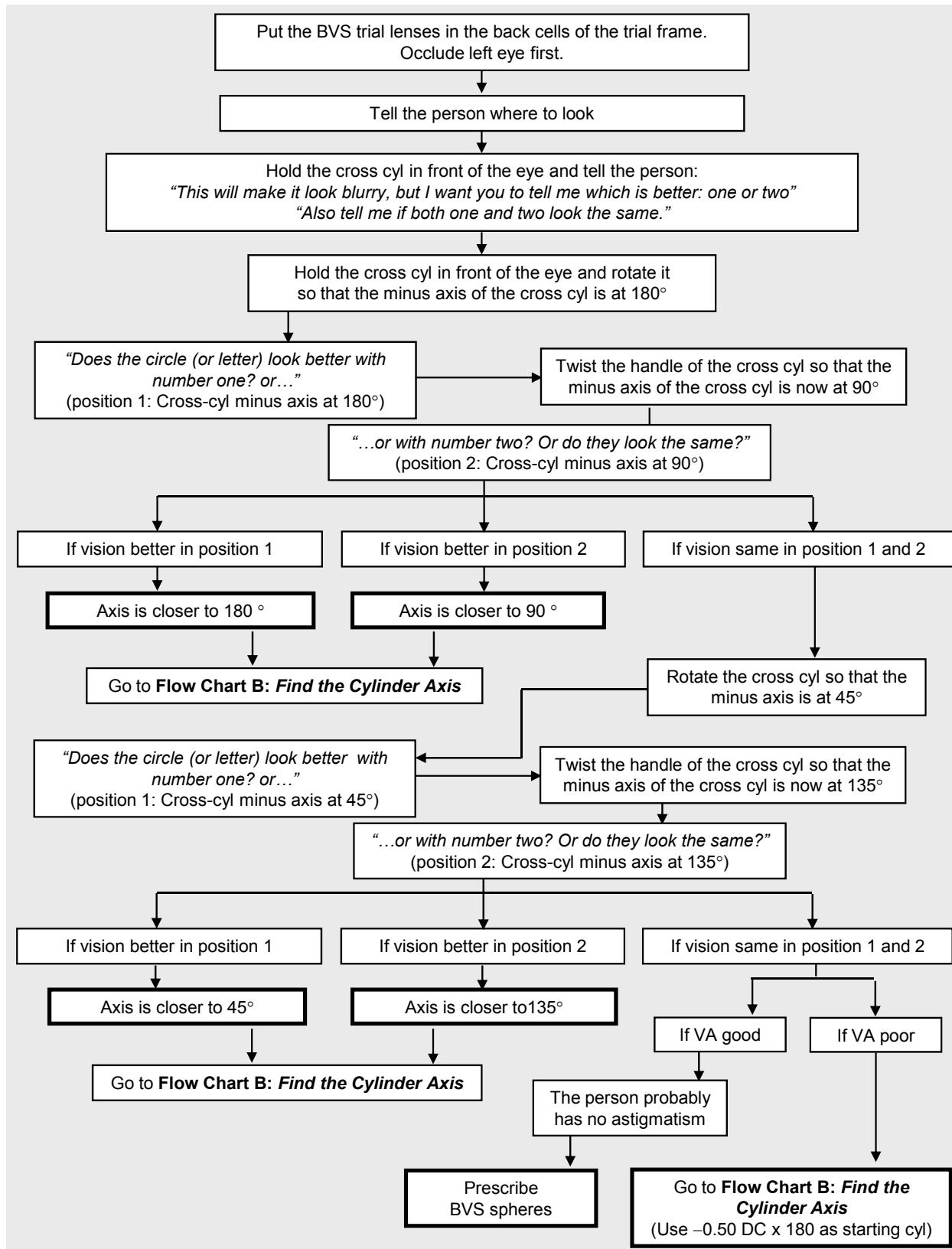
FLOW CHARTS

On the following pages are flow charts that summarise the three parts of a sphero-cyl refraction:

- Astigmatism search
- Finding the cylinder axis
- Finding the cylinder power.

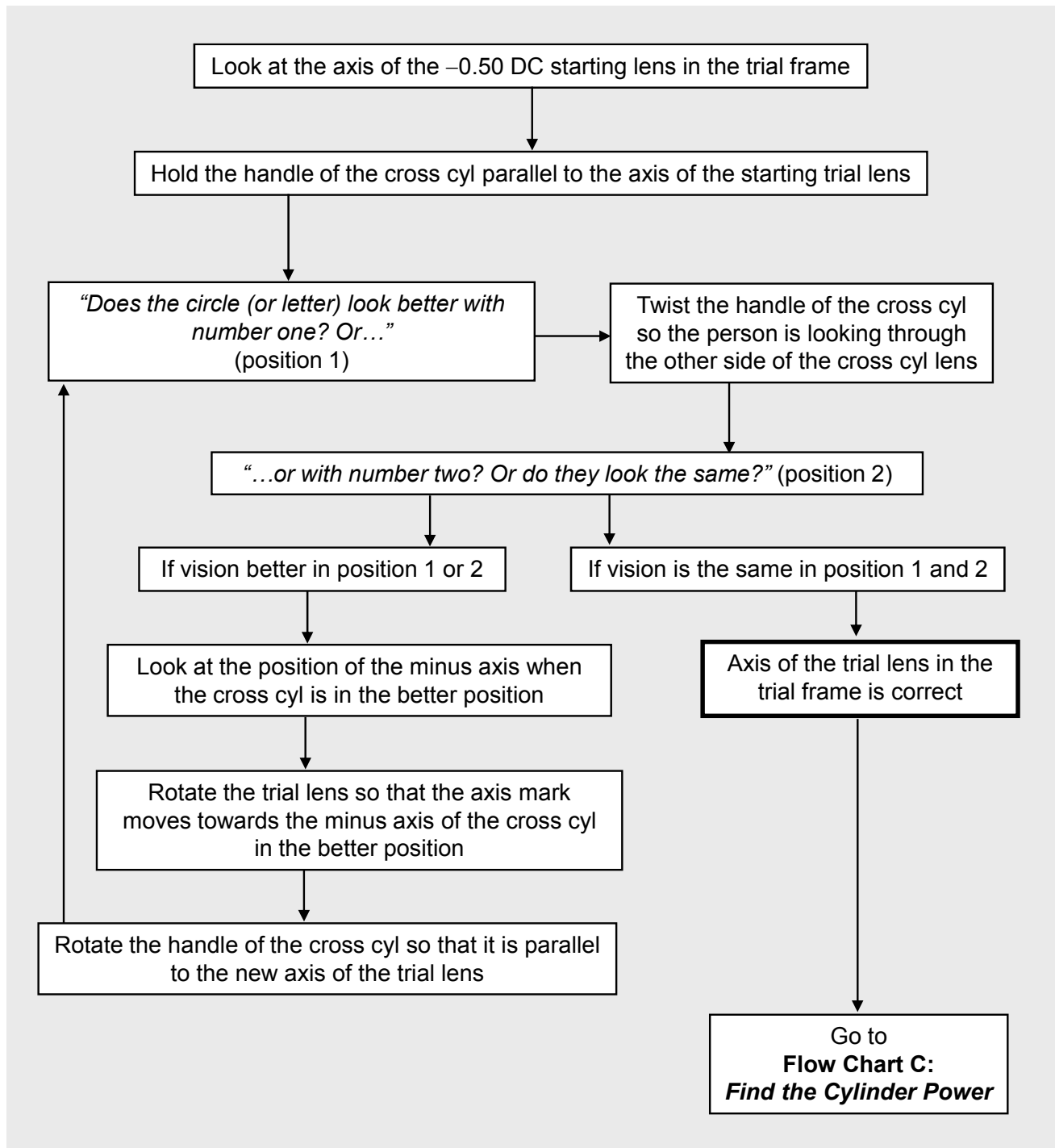
SUMMARY: METHOD - SPHERO-CYLINDRICAL REFRACTION

Flow Chart A: Astigmatism Search



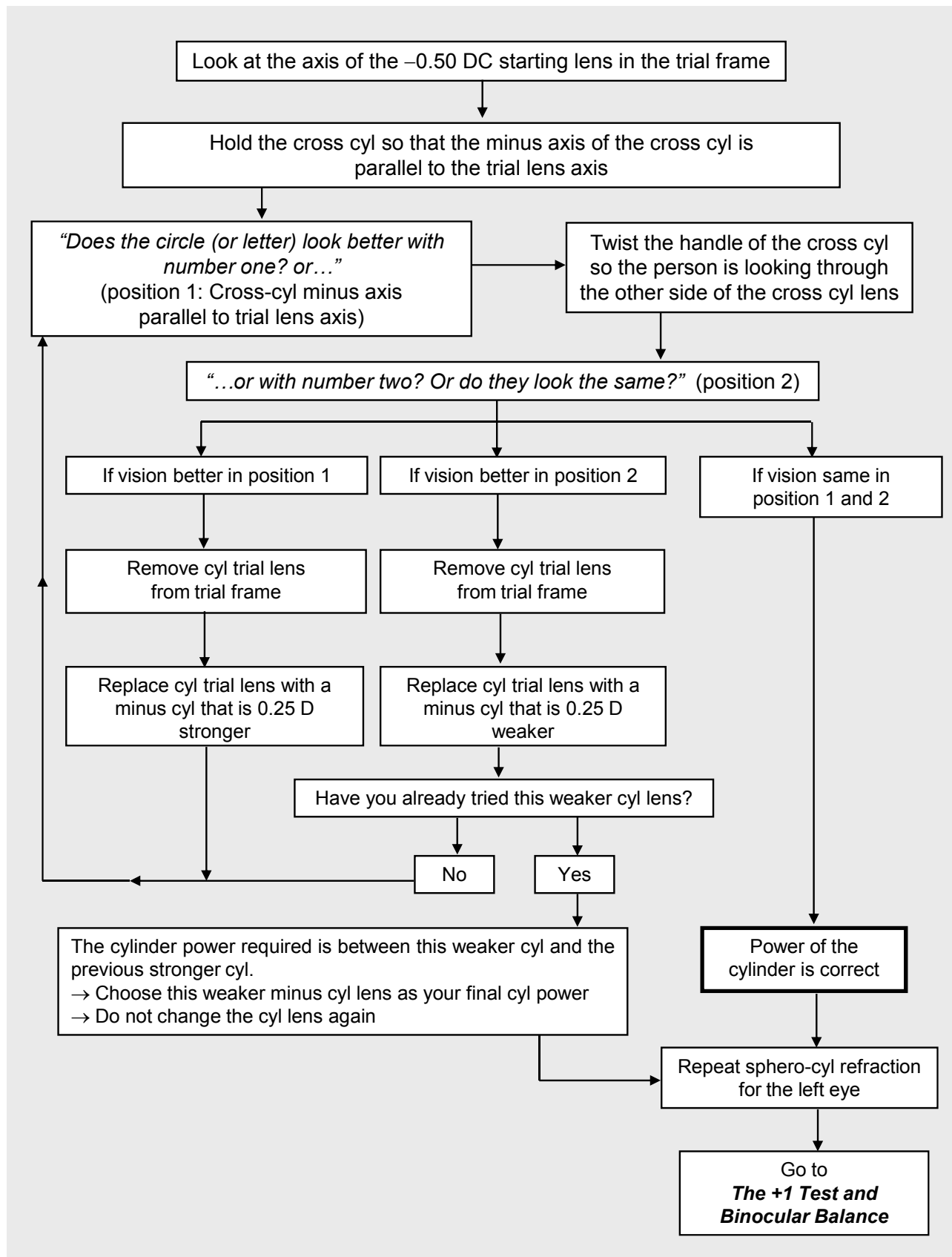
SUMMARY: METHOD - SPHERO-CYLINDRICAL REFRACTION (cont.)

Flow Chart B: Finding the Cylinder Axis



SUMMARY: METHOD - SPHERO-CYLINDRICAL REFRACTION (cont.)

Flow Chart C: Finding the Cylinder Power



TEST YOURSELF QUESTIONS

1. How do you decide whether or not to do a sphero-cylindrical refraction after your best vision sphere refraction?

2. What does a sphero-cylindrical refraction measure?

3. Why is it best to ask the person to look at an ○ shaped target when we do the cross cyl test?
(*Hint: Think about the way astigmatism distorts a person's vision.*)

4. Why is bracketing helpful?

5. If you put a -0.50 DC trial lens in the trial frame, by how much must you change the sphere?

6. If you remove a -1.00 DC trial lens from the trial frame, by how much must you change the sphere?

7. Why do you change the sphere power by 0.25 D when you change the cylinder power by 0.50 DC?
(i.e. why is it important to maintain the equivalent sphere?)



CONTROLLING ACCOMMODATION

THINK

A mother brings her two children to see you. She says her 14 year old son cannot see what the teacher is writing on the blackboard, and her 12 year old daughter complains of headaches when she reads. These children may have uncorrected refractive errors, so you need to do a refraction examination for them.

Young children have active accommodation, so you need to be very careful to control their accommodation when you refract them.

AIM

This unit will introduce you to the problems that active and uncontrolled accommodation can create during a refraction.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- explain how uncontrolled accommodation can cause errors in refraction
- recognise the signs that indicate that a person's accommodation is uncontrolled
- avoid over-minusing (or under-plussing) a person during a refraction
- check to make sure that you have not given too much minus.

REVIEW: CONTROLLING ACCOMODATION

REFRACTIVE ERROR	• A person who has a refractive error will need to wear spectacles (glasses) or contact lenses so that they can see clearly and comfortably. This is because their eye is not the correct size and shape. • There are four main types of refractive error: myopia, hyperopia, astigmatism, and presbyopia. • Myopia is corrected with minus lenses. Hyperopia is corrected with plus lenses. Astigmatism is corrected with cylindrical lenses. Presbyopia is corrected with a near add (plus lenses). • The amount of refractive error an eye has depends on: – the shape of the cornea, and/or – the shape of the crystalline lens, and/or – the length of the eyeball. • A person with a refractive error will have eyes that look normal, but they will not see well. • An eye examination that tests for refractive error is called a refraction. • A refraction tells you: – the type of refractive error that a person has – how much refractive error a person has.
ACCOMMODATION	• Accommodation occurs when the ciliary muscle contracts and changes the shape of the crystalline lens (makes it thicker). • This changes the optical focus of the eye so that close objects can be seen clearly. • When accommodation in a normal eye (an eye without refractive error) is relaxed, objects in the distance are seen clearly. • Presbyopia is the natural ageing change in the eye where the crystalline lens hardens with age. When this happens, the lens cannot change shape easily when the ciliary muscle contracts. This means that an older person cannot accommodate as easily as a younger person. • All people will get presbyopia when they get older. It is impossible for a child or a young adult in their 20s to have presbyopia.
VISUAL ACUITY	• Visual acuity (VA) is a measure of how clearly a person sees when they are looking directly (straight) at an object. • Common causes of poor VA are: – Refractive error (this person needs spectacles to see clearly) – Eye health problem (this person has a health problem with their eyes).
GOALS OF REFRACTION	• A refraction must find: – the lens that gives the person the clearest vision, and – the lens that gives the person the most comfortable vision. • The clearest and most comfortable lens is always the lens that has the least amount minus power (or most amount of plus power) but still gives the best VA.
ESTIMATING REFRACTIVE ERROR	• Case history and VA will give you clues as to what sort of refractive error a person probably has. You should look at: – the person's visual symptoms – the person's age. • VA – unaided and pinhole VA – the amount of spherical refractive error can be predicted by looking at the unaided VA (each 0.25 D refractive error = approx. one line of VA) • But only if: → the person has no astigmatism → the person is not accommodating → the person has no eye health problem.

THE MOST COMMON REFRACTING MISTAKE

The most common mistake that examiners make when they do a refraction is giving the person more minus than they need (or not giving them enough plus).

It is easy to give a person too much minus power. This is because adding a small amount of extra minus power might not make the vision worse if the person can accommodate. If the person is accommodating they may say that their vision looks the same, or they may even say that it seems better.

When a person accommodates during their refraction, the spectacle prescription that they will be given will be incorrect. Often the spectacles that are made from an incorrect prescription will only give the person clear vision if they accommodate while they are wearing them.

If a person wears spectacles that make them accommodate they can get asthenopia (eye strain and headaches) after wearing them for long periods of time (hours). Sometimes these symptoms will be so bad that the person will not be able to wear the spectacles (even if the spectacles make their vision clearer).

EXAMPLES	These people have been given too much minus power (or not enough plus power): • A person with myopia who has a refractive error of -3.50 D, but is given -4.00 D. • A person with hyperopia who has a refractive error of $+3.25$ D, but is given $+2.50$ D.  If a person has too much minus in their spectacles we say that they are over-minused. If a person does not have enough plus in their spectacles we say that they are under-plussed. You can think of over-minusing as being like making a person become hyperopic – a person with hyperopia can get asthenopic symptoms because they have to accommodate to make their vision clear. You can think of under-plussing as leaving a person with uncorrected hyperopia.
THE CLEAREST AND MOST COMFORTABLE LENS	The clearest and most comfortable lens for a person is the least minus (or most plus) lens that gives them the best VA. Young people will often see the VA chart clearly with more than one lens. This is because young people have a lot of accommodation that they can use to compensate for small errors in refraction.  If you are refracting a young person they might tell you that their vision seems better with more minus (less plus), but really they will see equally clearly and more comfortably with less minus (more plus). If you accidentally give someone too much minus (not enough plus) in their spectacles, they will say that their vision is clear... ...but, they may come back to see you later to complain that their eyes do not feel comfortable when they wear the spectacles that you gave them.

THE MOST COMMON REFRACTING MISTAKE (cont.)

THE CLEAREST AND MOST COMFORTABLE LENS (cont.)

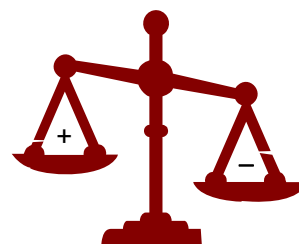
People are usually unaware that they are accommodating. However, when a person accommodates for long periods of time (hours), their ciliary muscles become tired. This can lead to symptoms of asthenopia (eye strain).

**Too much plus
(or not enough minus)**



The person's vision will be blurry.

**Too much minus
(or not enough plus)**



The person may accommodate to make it clear. This can result in uncomfortable eyes (asthenopia).

**The correct lens for the person
(not too much plus, not too much minus)**



The person's vision will be clear and comfortable.

Figure 19.1: When doing a refraction, we need to find a balance between the clearest lens and the most comfortable lens

HOW TO AVOID OVER-MINUSING

To make sure that you do not give too much minus (or not enough plus) when you are doing a refraction you must:

- Control the person's accommodation – you must keep their accommodation relaxed.
- Check that you have not given too much minus.

Over-minusing (or under-plussing) occurs when the person's accommodation is not controlled during the refraction.

When performing a subjective refraction you must control the person's accommodation. This is especially important with young people who have a lot of accommodation.

CONTROLLING ACCOMMODATION

How to Control Accommodation

1. Always try plus lenses before minus lenses.

If you put a minus lens in front of an eye that does not need a minus lens the eye will accommodate.

Once an eye has started to accommodate it is hard to make it relax again. It is better to stop the eye accommodating from the beginning.



Always show plus lenses before minus lenses.

2. Is the person really seeing better?

When you hold a minus lens in front of a person's eye, ask:

"Does this lens let you see more letters or does it just make everything look smaller and blacker?"

If the person says that the lens makes things look smaller and blacker, they are probably accommodating. You are adding too much minus.

3. When refracting hyperopic eyes: put the second (plus) trial lens in the trial frame before removing the first trial lens.

When refracting myopic eyes: remove the first (minus) trial lens before putting the second trial lens in.

4. Check the VA before adding minus lenses (or removing plus lenses). If the VA does not improve, do not add more minus.

5. If you think a person is accommodating, add more plus and decrease the power slowly.

Encourage the person to read the next line on the VA chart – ask them to try hard and "guess" even if they are not sure.

Check that you have not given too much minus:

During a refraction an examiner must pay attention to what is happening. The examiner must be alert to things that do not make sense.

HOW TO AVOID OVER-MINUSING (cont.)

ASK YOURSELF

1. What do the person's symptoms tell you about their refractive error?
Example:
If a person has hyperopic symptoms, you should not be giving them minus lenses.
2. How much refractive error do you expect?
When you measure the unaided VA you can estimate the amount of refractive error they will have. Remember that each 0.25 D refractive error = approximately one line of VA:

Refractive Error (+ or -)	Expected Unaided VA
0.25	6/6
0.50	6/7.5
0.75	6/9
1.00	6/12
1.25	6/15
1.50	6/18
1.75	6/24
2.00	6/36
2.25	6/48
2.50	6/60
> 2.50	< 6/60

Example:

A person tells you they can see clearly at near, but they cannot see far away. You measure their unaided VA: 6/12.

Their symptoms (poor distance vision) tell you that they probably have myopia. Their unaided VA (6/12) tells you that they have approximately -1.00 D of refractive error.

If your refraction finds -2.00 D the person is probably accommodating and you have given them too much minus.

3. Is the person's VA improving as expected?
Each time you add 0.25 D the VA should improve by approximately one line. If it does not improve by one line the person might be accommodating.
4. Is the person's VA variable (does it change)?
If you measure a person's VA with the same lens power it should not change.

Example:

You put a +2.00 D lens in front of a person's eye and they can see 6/7.5.

A short time later, they can only see 6/9 through the +2.00 D lens.

This means that the person has uncontrolled accommodation. You need to relax their accommodation.

5. Is the final VA as good as the pinhole VA?
At the end of your refraction the VA should be as good as the pinhole VA.

Example:

A person has unaided VA of 6/60. Pinhole VA is 6/9.

You would expect that at the end of your refraction the VA will be at least 6/9 or better (maybe even 6/7.5 or 6/6).

6. Does an extra +1.00 D make the vision worse?
There is a test you can do called the +1 Test. In this test you put a +1.00 D lens into the trial frame after you think that you have finished your refraction. The +1.00 D lens should make the person's VA at least two lines worse. If it does not make the person's VA two or more lines worse the person is accommodating, which means the refraction is over-minused or under-plussed.

HOW TO AVOID OVER-MINUSING (cont.)

EXAMPLES

- Example 1:**

A teenage boy comes to you for an eye examination.

You do a refraction on him and find that he can see the 6/6 line with many different lens powers.

Each time you add more minus he tells you that he is seeing more clearly, but when you measure his VA he can still see only 6/6 (and no extra letters on the next 6/5).

-0.75 D (Clearer)	→	6/9
-1.00 D (Clearer)	→	6/7.5
-1.25 D (Clearer)	→	6/6
-1.50 D (Clearer)	→	6/6
-1.75 D (Clearer)	→	6/6
-2.00 D (Clearer)	→	6/6

This boy can see the 6/6 line of the VA chart with -1.25 D, -1.50 D, -1.75 D and -2.00 D lenses. The least minus of these lenses is the -1.25 D lens.

The clearest and most comfortable lens for this boy is the -1.25 D lens.

- Example 2:**

An 8 year old girl comes to you for an eye examination.

You do a refraction for her and find that she can see the 6/7.5 line with many different lens powers.

Each time you decrease the plus she tells you that she is seeing more clearly – but no matter how much you decrease her plus, she still cannot see the 6/6 line below.

+3.75 D	→	6/12
+3.50 D (Clearer)	→	6/9
+3.25 D (Clearer)	→	6/7.5
+3.00 D (Clearer)	→	6/7.5
+2.75 D (Clearer)	→	6/7.5
+2.50 D (Clearer)	→	6/7.5

This girl can see the 6/7.5 line of the VA chart with +3.25 D, +3.00 D, +2.75 D and +2.50 D lenses. The most plus of these lenses is the +3.25 D lens.

The clearest and most comfortable lens for this girl is the +3.25 D lens.

CYCLOPLEGIC EYE DROPS

Sometimes a person's accommodation can be extremely active or unstable. In these situations it may be necessary to use cycloplegic eye drops to do a cycloplegic refraction.

Cycloplegic eye drops are used to temporarily paralyse the ciliary muscle so that the eye cannot accommodate. This can make it easier to do a refraction on people with active or unstable accommodation – especially children.

After a cycloplegic refraction the person will have blurry vision for a few hours and will be photophobic (light sensitive) for the rest of the day.

Cycloplegic eye drops should only be used by eye care workers who are trained to use them.

SUMMARY: CONTROLLING ACCOMMODATION

CONTROLLING ACCOMMODATION

- The most common mistake that examiners make when they do a refraction is giving the person too much minus (or not enough plus).
- The person might tell you that their vision looks the same (or even better) if too much minus is added but their VA will not get better.
- If too much minus (or not enough plus) is prescribed, the person will need to accommodate to see clearly with their new spectacles. This can cause asthenopia (eye strain and headaches).
- People do not usually know that they are accommodating. They will only tell you that their eyes feel sore or tired.
- Over-minused = too much minus in the person's spectacles. Under-plussed = not enough plus in the person's spectacles.

The clearest and most comfortable lens

- The clearest and most comfortable lens is the least minus (or most plus) lens that gives the best visual acuity (VA).
- Young people often see the VA chart clearly with more than one lens
– the most comfortable of these lenses is the least minus (or most plus) lens.
- You must find the balance between the clearest lens and the most comfortable lens.

HOW TO AVOID OVER - MINUSING

- When you are doing a refraction you must:
 - control the person's accommodation
 - check to make sure that the person has not been given too much minus.

Controlling accommodation:

- Always show the person a plus lens before a minus lens.
- Check to see that the person is really seeing better
 - When you hold a minus lens in front of a person's eye ask: "Does this lens let you see more letters or does it just make it look smaller and blacker?"
 - "smaller and blacker" means that the person is probably accommodating and you are adding too much minus.
- When refracting hyperopic eyes
 - put the second plus trial lens in the trial frame before removing the first plus trial lens.
- When refracting myopic eyes
 - remove the first minus trial lens before you put the second minus trial lens in the trial frame.
- Check the VA before adding minus lenses (or removing plus lenses)
 - if the VA does not improve, do not add the minus lens (or remove the plus lens).
- If you think the person is accommodating, add more plus and decrease the plus power slowly.
 - encourage the person to try hard or "guess" the next VA line even if they are not sure.

SUMMARY: CONTROLLING ACCOMMODATION (cont.)

HOW TO AVOID OVER – MINUSING (cont.)

Check that you have not given too much minus:

- Pay attention to what is happening and what the person is telling you
 - does it make sense, based on their symptoms and unaided VA?
- Think about the person's symptoms
 - what sort of refractive error do you expect?
- Look at the person's unaided VA
 - how much refractive error do you expect?
- Watch the person's changing VA
 - you should expect one line of VA improvement for every 0.25 D change in lens power
 - is the VA changing unexpectedly?
- Look at the person's pinhole VA
 - the final aided VA should be as least as good as the pinhole VA, or even better.
- The +1 Test
 - does an extra +1.00 D make the person's VA at least two lines worse?

Cycloplegic eye drops:

- Cycloplegic eye drops temporarily paralyse a person's ciliary muscle so that they cannot accommodate.
- Cycloplegic refraction may be necessary if a person has extremely active or unstable accommodation.
- Cycloplegic eye drops should only be used by eye care workers who are trained to use them.

TEST YOURSELF QUESTIONS

1. What is the most common mistake people make when they are doing a refraction?

2. You accidentally give a young woman too much minus power, but you notice that she can still see clearly?
 - a) Why can she still see clearly?

 - b) If she can still see clearly, why is it a problem?

3. What are some things that you can do to help control a person's accommodation when you are refracting them?
 - a) _____
 - b) _____
 - c) _____
 - d) _____
 - e) _____

4. A man tells you that he can see well at near, but has trouble seeing things that are far away. You measure his VA for his right (R) and left (L) eyes and find: R: 6/12 L: 6/18
 - a) What *type* of refractive error does this man have? _____
 - b) What do you estimate the *amount* of the man's refractive error to be? R: _____ D
L: _____ D

5. A woman sees 6/9 with her right eye when a +1.50 D lens is in the right cell of a trial frame. If you change the lens to a +1.25 D lens she says that her vision is better. What would you expect her VA to be?

6. A woman sees 6/9 with her left eye when a +1.50 D lens is in the left cell of a trial frame. If you change the lens to a +1.25 D lens she says that her vision is worse. What would you expect her VA to be?



+1 TEST AND BINOCULAR BALANCE

THINK

You have examined a young man, but you are concerned that he may have been accommodating during your refraction examination. If he was accommodating, the results of your refraction will be incorrect. You must check to make sure that his accommodation was relaxed during the refraction examination.

AIM

This unit shows you how to do a +1 test and a binocular balance, and explains why these tests are important.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- control accommodation during your refraction
- adjust the refraction if the accommodation of one or both eyes is not relaxed
- make sure that both eyes have equally relaxed accommodation.

REVIEW: +1 TEST AND BINOCULAR BALANCE

GOALS OF REFRACTION	- A refraction must find: - the lens that gives the person the clearest vision, and - the lens that gives the person the most comfortable vision. - The clearest and most comfortable lens is always the lens that has the least amount of minus power (or most amount of plus power) but still gives the best visual acuity (VA). - Young people often see the VA chart clearly with more than one lens – the most comfortable of these lenses is the least minus (or most plus) lens. - You must find the balance between the clearest lens and the most comfortable lens.
CONTROLLING ACCOMMODATION	- The most common mistake that examiners make when they do a refraction is giving the person more minus than they need (or not enough plus). - The person might tell you that their vision looks the same (or even better) if too much minus is added but their VA will not get better (as measured on the VA chart). - If too much minus (or not enough plus) is prescribed as spectacles the person will need to accommodate to see clearly. This can cause asthenopia (eye strain and headaches). - People do not usually know that they are accommodating. They will only tell you that their eyes feel sore or tired. - Over-minused = too much minus in the person's spectacles Under-plussed = not enough plus in the person's spectacles.
HOW TO AVOID OVER-MINUSING	- When you are doing a refraction you must: - control the person's accommodation - check to make sure that the person has not been given too much minus.
HOW TO CONTROL ACCOMMODATION	- Always show the person a plus lens before a minus lens. - When refracting hyperopic eyes → put the second plus trial lens in the trial frame before removing the first plus trial lens. - When refracting myopic eyes → put the second minus trial lens in the trial frame before removing the first minus trial lens. - Check the VA before adding minus lenses (or removing plus lenses) → if the VA does not improve, do not add the minus lens (or remove the plus lens). - Check to see that the person is really seeing better - When you hold a minus lens in front of a person's eye ask: "Does this lens let you see more letters or does it just make it look smaller and blacker?" → "smaller and blacker" means that the person is probably accommodating and you are adding too much minus. - If you think the person is accommodating, add more plus and decrease the plus power slowly → encourage the person to try hard or "guess" the next VA line even if they are not sure.
CHECK THAT YOU HAVE NOT GIVEN TOO MUCH MINUS	- Pay attention to what is happening and what the person is telling you → does it make sense? - Think about the person's symptoms → what sort of refractive error do you expect? - Look at the person's unaided VA → how much refractive error do you expect? - Watch the person's changing VA → you should expect one line of improvement for every 0.25 D change in lens power → is the VA changing unexpectedly? - Look at the person's pinhole VA → the final aided VA should be at least as good as the pinhole VA. - The +1 test → does an extra +1.00 D make the person's VA at least two lines worse?

AFTER THE BEST VISION SPHERE (AND SPHERO-CYL) REFRACTION

OVER-MINUSING AND THE +1 TEST

Even experienced examiners over-minus (or under-plus) by accident sometimes when they do a best vision sphere (BVS) refraction.

This is because it can be difficult to control a person's accommodation.

Over-minusing (or under-plussing) can give a person asthenopia and headaches – but their vision might still be clear. Sometimes the symptoms of asthenopia or headaches will be so bad that the person will not be comfortable wearing their spectacles.

Young people can accommodate a lot, which might make it difficult for you to find their true refractive error. This can happen in both hyperopia and myopia.

- **Myopia**

A myope can be over-minused.

Your refraction can show more minus than is really there.

This can mean that the person will get spectacles that are too strong.

- **Hyperopia**

A hyperope can be under-plussed.

Your refraction can show less plus than is really there.

This can mean that the person will get spectacles that are not strong enough.

The +1 test is a good way to make sure that the person's accommodation was relaxed during the refraction – and that you have not given the person too much minus (or not enough plus).

If you discover that a person has been over-minused you can fix your refraction so that the person will be comfortable wearing their spectacles.

BALANCING ACCOMMODATION

The two eyes cannot accommodate by different amounts.

If one eye accommodates the other eye must accommodate by the same amount.

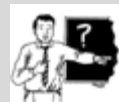


Figure 20.1: Two bulls that are yoked together must move forwards together by the same amount. If one bull tries to go forward, the other bull must too

You can think of the accommodation of the two eyes as being like two bulls that are yoked together. If one eye uses its ciliary muscle to accommodate, the other eye must do the same.

If one eye needs to accommodate more than the other to see clearly, there will be rivalry between the two eyes – they will fight each other. This can cause asthenopic symptoms and headaches. If both eyes have equally relaxed accommodation the eyes will feel most comfortable.

To relax the same amount of accommodation in both eyes we do a binocular balance.



A binocular balance makes both the need for accommodation and the VA of the two eyes equal.

AFTER THE BEST VISION SPHERE (AND SPHERO-CYL) REFRACTION (cont.)

BALANCING ACCOMMODATION (cont.)

You cannot balance the VAs of the two eyes if the best corrected VA of one eye is worse than the other (such as from a cataract). If you try to balance the VA of both eyes you will make the VA in the good eye worse.

If one eye has poor best corrected VA you cannot do a binocular balance. Instead you must be extra careful when you are doing your refraction.



NOTE:

Only the spherical lenses of the refraction can be changed during the +1 test and the Binocular Balance. If there are cylindrical lenses in the trial frame, the power and the axis of these lenses will stay the same.

+1 METHOD

The time to do the +1 test is after you have done your BVS refraction (and sphero-cyl refraction) for both eyes. Make sure that you remember to measure the best corrected VA for the right and left eyes.

STEP 1	Remove the occluder so that both eyes can see the distance VA chart. Leave the BVS or sphero-cylindrical refraction lenses in the trial frame.
STEP 2	Measure distance binocular VA (the person looks at the chart with both eyes open).
STEP 3	Tell the person that you are going to make everything look blurry.
STEP 4	Take two +1.00 D lenses from the trial set and put one in front of each eye (do not remove all the other lenses that are there from your BVS and/or sphero-cyl refraction).  When we blur a person's vision by adding plus, we say that we are "fogging" their vision. If we add a fog during a refraction, the accommodation should relax.  Figure 20.2: A real fog (or "mist") is caused by water drops that hang in the air – like a cloud. It is hard to see things when the weather is foggy. It looks a bit like air pollution (or smoke) in cities – sometimes this is called smog.
STEP 5	Measure binocular VA again (with these extra +1.00 D lenses). The VA should be between two and four lines worse.
STEP 6	If the VA is more than two lines worse: go to Step 9. If the VA is the same or only one line worse → go to Step 7.
STEP 7	If the VA is the same or only one line worse → add +0.25 D to both eyes.  If the VA is the same or only one line worse, you know that you have given the person too much minus (or not enough plus) during your refraction. The person was accommodating during your refraction.

+1 METHOD (cont.)

STEP 8	Measure the VA again. The VA should be two lines worse. Repeat Steps 6 and 7 until the binocular VA is more than two lines worse (compared with the binocular VA that you measured in Step 2).
STEP 9	Look at the best corrected VA for the right and left eyes (that you measured and wrote down at the end of your BVS and/or sphero-cyl refraction). If the best corrected VA for the right and left eyes are almost the same you now need to do a binocular balance → go to binocular balance method. If the best corrected VA for the right and left eyes are different you cannot do a binocular balance → go to Step 10.  After Step 9 of the +1 test, you need to do a binocular balance – but only if the best corrected VA for the right and left eyes is the same. If the best corrected VA for the right and left eyes is different, you need to continue with Step 10 of the +1 test.
STEP 10	Decrease the power of the lenses in front of both eyes by 0.25 D.
STEP 11	Measure the binocular VA with these lenses. You should expect the VA to improve by approximately one line. Encourage the person to try the line below (you can tell them that they can guess even if they are not sure).
STEP 12	Repeat Steps 10 and 11 until the VA stops getting better.
STEP 13	Measure the VA of the good eye with the trial lenses (occlude the poor eye). The VA should be the same as the best corrected VA you measured for this eye after your BVS or sphero-cyl refraction. If the VA of the good eye is worse than what you found during the refraction, add -0.25 D and measure the VA again.  Make sure that the person's good eye sees as clearly as possible. They will depend on this eye!
STEP 14	Measure the VA of the other eye (occlude the good eye). The VA should be the same as the best corrected VA you measured for this eye after your BVS or sphero-cyl refraction.
STEP 15	Write down the spectacle prescription (the total of all the lenses in the trial frame) for each eye. Write down the aided VA for each eye (it will be different for each eye).

BINOCULAR BALANCE METHOD

STEP 1	Measure the right eye VA (occlude the left eye).  Do not put the occluder in the trial frame. Just hold it in front of the eye. The VA of the right eye should be slightly worse than the binocular VA.
STEP 2	Measure the left eye VA (occlude the right eye). If the VA of the left eye is almost the same as the right eye: go to Step 5. If the VA of the right eye and the left eye are not the same: go to Step 3.
STEP 3	Add +0.25 D to the better eye. Measure the VA of this eye.
STEP 4	Repeat step 3 until the VA of both eyes is almost the same.
STEP 5	Ask the person to keep both their eyes open. Ask the person to look at a small letter that they can see.
STEP 6	Quickly occlude first the left eye, then the right eye. (You should move the occluder to the other eye every ½ second.) You can say: <i>“Is it easier to see with your right eye... or your left eye...?”</i> <i>Your right eye... or your left eye...?”</i> Or... <i>“Is it easier to see with this first eye... or this second eye...?”</i> <i>The first eye... or the second eye...?”</i> Or... <i>“Is it easier to see with number 1... or number 2...?”</i> <i>1... or 2...?”</i>
STEP 7	If the person tells you that both eyes are equally clear → go to Step 9. If the person tells you that one eye is clearer than the other eye → go to Step 8.  You must be extremely careful when you do binocular balance. It is very easy for the person to get confused: • The person might tell you that they prefer their right eye when really they mean their left eye. • The person might always prefer the first eye (or the second eye) because that is what they are expecting.

BINOCULAR BALANCE METHOD (cont.)

STEP 8	Add +0.25 D to the eye that sees better.  If you add more than +0.25 D to one eye, you should check to make sure that the person is not confused. It would be surprising if you added more than +0.50 D to one eye. Repeat Steps 6, 7 and 8 until: - the person tells you that both eyes are equally clear, or - the person has alternate preferences (prefers one eye, then the other eye... so that you find yourself adding +0.25 D to first one eye then the other eye) → in this case choose the lenses that make the eyes most similar in power.  Steps 6, 7 and 8 are sometimes called the alternating balance test.
STEP 9	Measure the binocular VA.
STEP 10	Change the power of the lenses in front of both eyes by −0.25 D.
STEP 11	Measure the binocular VA with these lenses. You should expect the VA to improve by approximately one line. Encourage the person to try the line below (you can tell them that they can guess even if they are not sure).
STEP 12	Repeat Steps 10 and 11 until the VA stops getting better. This is the person's best corrected binocular VA.
STEP 13	Measure the VA of the right eye (occlude the left eye).
STEP 14	Measure the VA of the left eye (occlude the right eye).
STEP 15	If the VA for the right eye and the left eye is the same as the best corrected VAs that you measured after your BVS or sphero-cyl refraction → go to Step 17. If the VA for the right eye or the left eye is worse than for the best corrected VA → go to Step 16.
STEP 16	Add −0.25 D to <i>both</i> eyes and measure the right and left VA again.  You can only do this step once. If the VA for one of the eyes is still worse than the best corrected VA, you have made a mistake. You need to recheck your refraction. The VA for the right and left eyes should now be the same. The VA for each eye should be the same as the best corrected VA of the right and left eyes before you started the +1 test.

SUMMARY: THE +1 TEST AND BINOCULAR BALANCE

AFTER THE DISTANCE REFRACTION

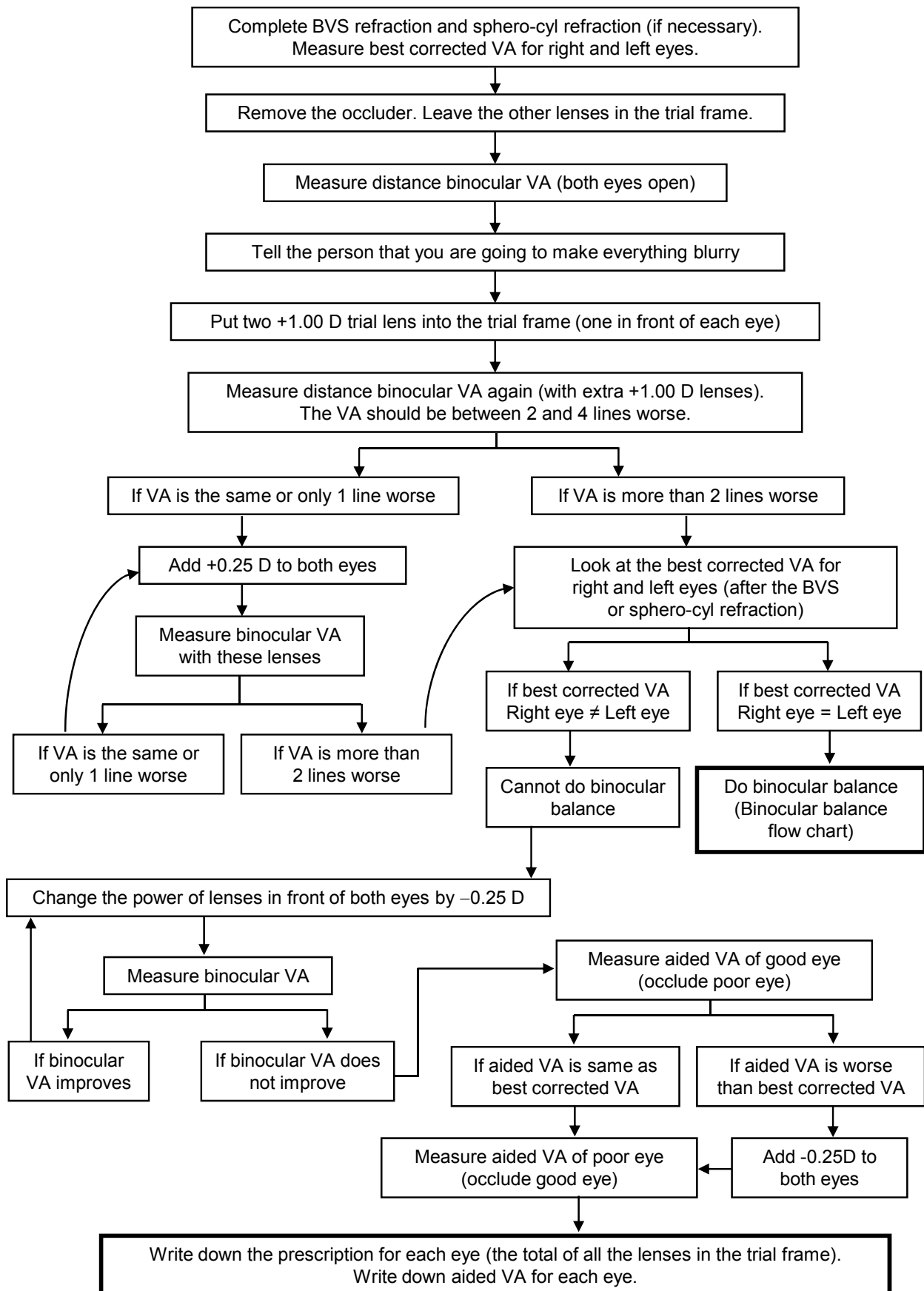
Over-minusing / under-plussing and the +1 test:

- It is easy to over-minus (or under-plus) by accident because it can be hard to control a person's accommodation.
- Over-minusing (or under-plussing) can give the person asthenopia and headaches
 - but their vision might still be clear.
- If you over-minus a myope:
 - your refraction shows more minus than is really there
 - the person will get spectacles that are too strong.
- If you under-plus a hyperope:
 - your refraction will show less plus than is really there
 - the person will get spectacles that are not strong enough.
- The +1 test is a good way to make sure that the person's accommodation was relaxed during the refraction
 - and that the person was not over-minused or under-plussed.

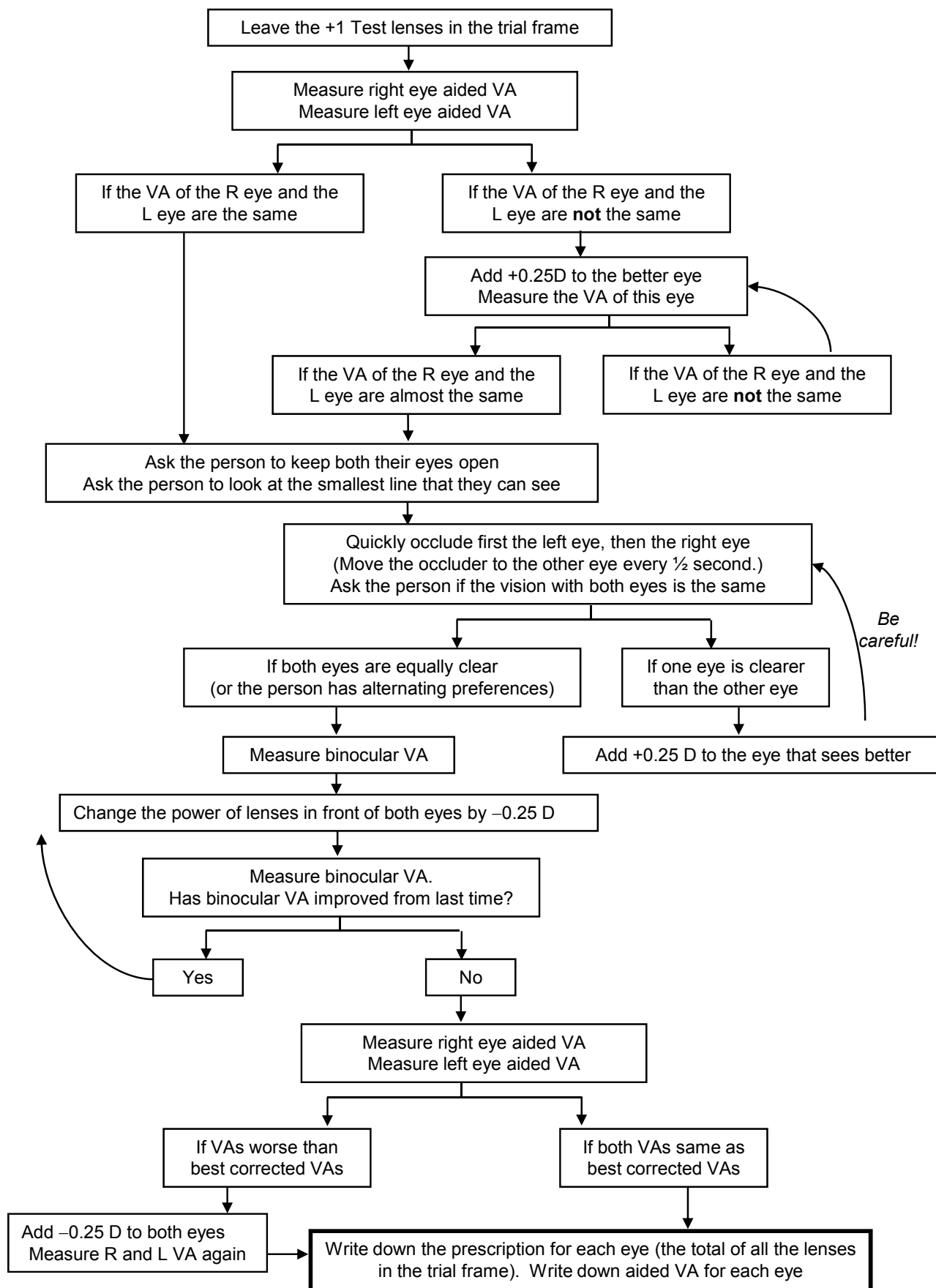
Balancing accommodation:

- The two eyes always accommodate by the same amount.
- If one eye needs to accommodate more than the other to get clear vision there will be rivalry (fighting) between the two eyes and vision will be uncomfortable. This is why it is important to make sure that both eyes have equally relaxed accommodation.
- To relax the same amount of accommodation in both eyes we do a binocular balance.
- A binocular balance makes equal
 - the amount of accommodation in the two eyes
 - the visual acuities of the two eyes.
- If one eye has poor best corrected VA you cannot do a binocular balance → instead you must be extra careful when you are doing your refraction

+1 TEST METHOD



BINOCULAR BALANCE METHOD



TEST YOURSELF QUESTIONS

1. Why should we do a +1 test?

2. If accommodation was relaxed during the refraction, how much worse should VA be when the +1 test is performed?

3. What are we trying to do when we balance or equalise a refraction?

4. When a refraction is balanced, will both eyes have the same VA?



NEAR REFRACTION FOR PRESBYOPIA

THINK

A 43 year old woman comes to you for an eye examination. She tells you that she can see very well when she looks far away, but for the last few years she has had trouble seeing up close, especially for sewing.

You measure her distance visual acuity and it is very good. You measure her near visual acuity and it is poor.

You know that this means that the woman has presbyopia and will need to wear near spectacles so that she can see her sewing clearly. How will you know what power near spectacles to give her?

AIM

This unit shows you how to do a near refraction for a person with presbyopia so that you can give them the correct reading addition.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- explain what is meant by the near lens addition (and how this is different from the near spectacle prescription)
- define preferred working distance
- define range of clear vision
- demonstrate how to do a near refraction.

REVIEW: NEAR REFRACTION FOR PRESBYOPIA

PRESBYOPIA	- The gradual (slow) loss of accommodation as we get older is called presbyopia. - Presbyopia affects everyone and usually starts around the age of 40. - People with presbyopia usually find it difficult to read or do other near tasks. - If a presbyope also has hyperopia or myopia, it will affect them when they need to get spectacles for close work. Some people who have myopia may never need to wear reading spectacles.
COURSE OF PRESBYOPIA	- As we get older, the crystalline lens gradually gets harder and cannot change shape easily when the ciliary muscle contracts – this is a normal, natural ageing process. - This means that an older person cannot accommodate as much or as easily as a younger person.
PRESBYOPIA SYMPTOMS	People with presbyopia may have trouble doing near tasks such as reading, sewing, and sorting rice. This is because they have blurry vision when they look at things that are close to them.
CORRECTION OF PRESBYOPIA	- Presbyopia is corrected with a near addition (or “add”). - The “add” is a positive spherical lens power that is added to the distance correction that a person needs (if they also have hyperopia, myopia or astigmatism) so that they can see their near work clearly. - Distance Spectacle Prescription + Near Addition = Reading / Near Spectacle Prescription
TYPES OF PRESBYOPIA SPECTACLES	Reading spectacles: - are only worn for close work; - make close vision clear, but distance vision blurry; - must be taken off for clear distance vision. Bifocal spectacles: - have two parts divided by a line: the top part has power for distance vision, while the bottom part (the “seg”) has power for near vision; - allow a presbyopic person to see clearly both at near and in the distance. Progressive addition spectacles: - do not have a line like bifocals: the distance prescription at the top of the lens gradually blends with the near prescription at the bottom of the lens; - allow a presbyopic person to see clearly at near, far away, and at an intermediate distance.
MEASURING REFRACTIVE ERROR	- Objective refraction methods include: - Retinoscopy - Auto-refraction. - Subjective refraction methods include: - Best vision sphere refraction - Sphero-cylindrical refraction - Near refraction.

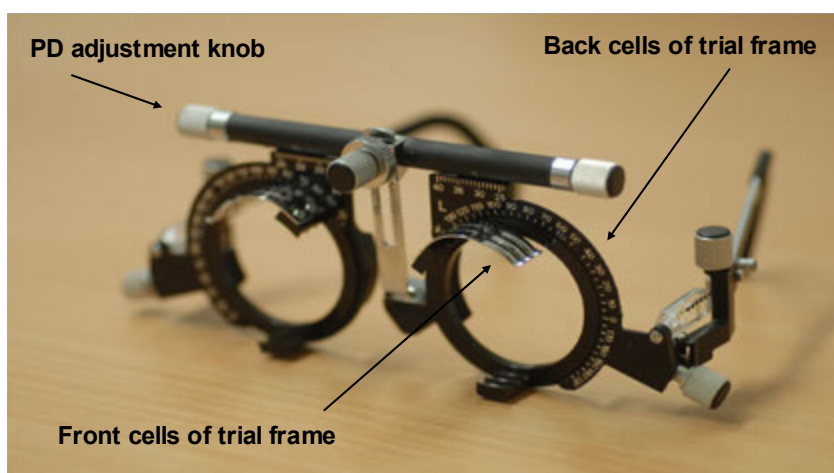
REVIEW: NEAR REFRACTION FOR PRESBYOPIA (cont.)

MEASURING INTERPUPILLARY DISTANCE (PD)

- PD is the distance (in mm) between a person's pupils.
- Distance PD is the distance between the pupils when the person is looking at something far away.
- Near PD is the distance between the pupils when the person is looking at something close.
- Distance PD is always greater than near PD because the eyes converge when they look at things that are close to them.
- Calculating near PD:

If distance PD > 64 mm	→ subtract 4 mm
If distance PD ≤ 64 mm	→ subtract 3 mm

TRIAL FRAMES



CORRECTING PRESBYOPIA

NEAR ADDITION

Many people confuse the near addition with the near spectacle prescription – but they are not the same.

The near addition (or simply, the “add”) is the extra amount of plus power that must be added to the person’s distance prescription (for hyperopia, myopia or astigmatism) so that they can see things that are close to them clearly.

The near spectacle prescription is the combined total of the near add and the distance prescription.



$$\text{Distance prescription} + \text{Near add} = \text{Near spectacle prescription}$$

The only time the near add and the near spectacle prescription are the same is when the person’s distance prescription is zero – that is, when the person is emmetropic at distance.



Figure 21.1: A man wearing look-over reading spectacles. He looks through the near spectacle prescription lenses to read his book and looks over them to see things that are in the distance.

STRENGTH OF THE NEAR ADDITION

The near add strength that a person needs depends on the person’s:

- age
- preferred working distance
- best corrected distance visual acuity (VA).

AGE

The strength of the near add increases as people get older. This is because the crystalline lens continues to gradually get harder until it becomes completely solid. Therefore the amount of accommodation that a person has also decreases as they get older.

Example:

A 40 year old person might need a +1.00 D add. When they are 42 they might need a +1.50 D add. When they are 55 they might need a +2.25 D.

For this reason, a person’s near spectacle prescription will also increase as they get older. Older people need stronger near vision spectacles.

CORRECTING PRESBYOPIA (cont.)

STRENGTH OF THE NEAR ADDITION (cont.)	Table 21.1: Approximate near add expected for people living in hot equatorial countries	
	Person's Age	Expected Near Add
	35 to 40	+0.75 D to +1.25 D
	40 to 45	+1.25 D to +1.75 D
	45 to 50	+1.75 D to +2.25 D
	Over 50	+2.25 D to +2.75 D
	 Presbyopia affects people in some countries earlier than other countries. People who live in hot countries near the equator seem to get presbyopia earlier than people who live in countries like Australia or the United Kingdom.	
PREFERRED WORKING DISTANCE	- A person's preferred working distance is the distance that they like to keep between their eyes and their near work. - Usually, a small person with shorter arms will have a closer preferred working distance than a larger person who has longer arms. - The strength of the near add must be higher for closer working distances. A person who wants a close working distance will need a higher powered near add, and stronger near vision spectacles. - When you take a case history, you must remember to ask the person the distance at which they would like to do most of their near work. This distance is usually about 40 cm, but it might be further away or closer than this.	
	 Be careful when you ask someone what distance they like to hold their close work. A person who is starting to become presbyopic will start to hold things further away from them so that they can see more clearly. They might not be comfortable doing this, but they have become used to doing it. A good way to find out a person's preferred working distance is to ask them to show you where their arms feel most comfortable when they are holding their sewing, reading, or other close work.	
	 Figure 21.2: This man is holding his newspaper more than 40 cm away from his eyes. You need to find out whether he is holding it at this distance because he wants to (because it is more comfortable for his arms) or if he is holding it this far away to see it better.	

CORRECTING PRESBYOPIA (cont.)

PREFERRED WORKING DISTANCE (cont.)



Figure 21.3: This woman is holding her book closer than 40 cm away from her eyes. Some people are more comfortable holding things closer.

Best Corrected Distance VA

- If a person has very poor distance vision – even if they are looking through the best lenses that correct their distance refractive error – they are said to have “low vision”. Low vision is usually caused by an eye health problem which permanently affects the person’s vision.
- Normal presbyopes struggle to see small objects up close, but people with low vision have trouble seeing anything that is close to them. They will also have trouble seeing things that are far away from them.
- Sometimes a person with low vision is prescribed a “high add”. A high add lets the person hold their near work much closer to them, to make it look bigger and easier to see.



A near add is always a plus power.

A near add is usually between +1.00 D and +3.00 D.

A high add is much stronger than a normal near add.

A high add can be as strong as +10.00 D.

CORRECTING PRESBYOPIA (cont.)

When a presbyope wears near vision spectacles, there will be a limit to how close and how far away they can hold their near work and still have clear vision. This is known as the range of clear vision. Objects that are held within the range of clear vision are clear to see.



Objects that are held closer than the range of clear vision are blurry
Objects that are held further away than the range of clear vision are blurry

Figure 21.4: A presbyope wearing near vision spectacles has a range of clear vision. Only objects within the range of clear vision will be clear with the near vision spectacles.



A good pair of near vision spectacles has the person's preferred working distance in the centre of the range of clear vision.

RANGE OF CLEAR VISION

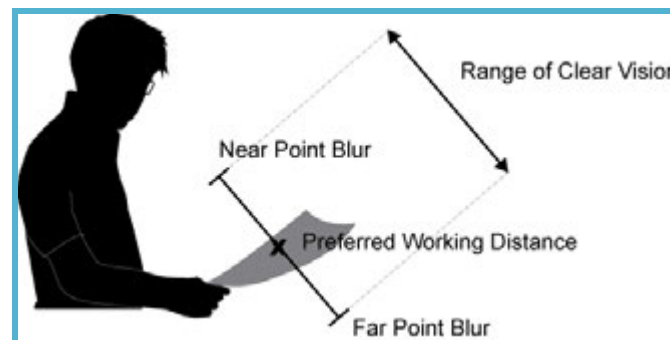


Figure 21.5: This man is wearing spectacles that put his preferred working distance in the centre of his range of clear vision. This makes it more comfortable for him to see.

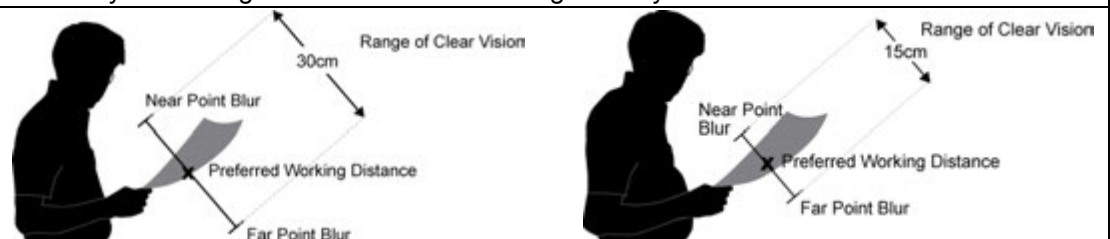
A person's range of clear vision decreases as they get older. A younger presbyope will be able to use their near spectacles for a range of close distances, but an older presbyope will not be able to hold their near work too close or too far away.

Example:

A 45 year old has a larger range of clear vision than a 55 year old.

→ A 45 year old might have a clear vision range of 30 cm.

→ A 55 year old might have a clear vision range of only 15 cm.



A 45 year old with a 30 cm range of clear vision

A 55 year old with a 15 cm range of clear vision

Figure 21.6: A younger presbyope has a larger range of clear vision than an older presbyope.

CORRECTING PRESBYOPIA (cont.)

GOALS OF NEAR REFRACTION

The goals of a near refraction are to find the plus lenses that give the person the best range of clear vision (with the preferred working distance in the centre of this range) and the lowest powered plus lenses that the person needs to see close work clearly. This is because too much plus at near can make a person feel uncomfortable.

In some ways this can be thought of as the opposite of a distance refraction – where we are looking for the most plus (or least minus) that gives clear vision.



Goal of distance refraction:

To find the highest powered plus lens (or lowest powered minus lens) that gives the clearest distance vision.

Goal of near refraction:

To find the lowest powered plus lens that gives the clearest near vision.

METHOD – NEAR REFRACTION

Before you do a near refraction you must first do a complete distance refraction, including:

- best vision sphere (BVS) refraction
- sphero-cylindrical refraction (if necessary)
- +1 Test
- Binocular balance.

There are three parts to a near refraction:

- Preparation and estimation of the add
- Adjusting the add power
- Checking the range of clear vision.

The best way to learn how to do a near refraction is to do it yourself as often as possible. With practice you will become fast and accurate. This unit will show you how to do a near refraction using two learning methods:

- Step-by-step instructions
- Flow charts (in the summary).

This information will help prepare you to do your first near refraction.

STEP-BY-STEP INSTRUCTIONS – NEAR REFRACTION

PREPARATION AND ESTIMATION OF THE ADD

Step 1: Leave the lenses from the person's final distance refraction in the trial frame. Remove all occluders.



A near refraction is done with both the person's eyes open. The near add lenses will always be the same for the right eye and the left eye.

Step 2: Adjust the trial frame for the person's near PD.

Step 3: Give the person a near VA chart (or reading card). Ask the person to hold it at the distance where they would like to hold things they want to see.



Make sure that this is really the distance they want to use for near work. You can tell the person that this is the distance that you will set for their near spectacles.

Once the person has chosen their preferred working distance, you must make sure that they keep the near VA chart at this distance during the near refraction (they should not move the near chart closer to them or further away from them).

Make sure that there is good light so that the person can see the near VA chart more easily.

Step 4: To decide which trial lenses to start with when doing a near refraction, we use the person's age as a guide. If the person is:

• 35 to 40 years old	→	start with +0.75 D for both eyes
• 40 to 45 years old	→	start with +1.25 D for both eyes
• 45 to 50 years old	→	start with +1.75 D for both eyes
• Over 50 years old	→	start with +2.25 D for both eyes

Put these trial lenses into the back cells of the trial frame (one in front of each eye).

STEP-BY-STEP INSTRUCTIONS – NEAR REFRACTION (cont.)

ADJUSTING THE ADD POWER

Step 1: Take two +0.25 D trial lenses and hold them in front of the person's eyes.

Tell the person:

“Look at the reading card.

Look at the smallest words that you can see.”

Ask the person:

“Do these lenses make the chart look BETTER, WORSE or the SAME?”

You might need to show the person the near VA chart with and without the lenses a few times.

Step 2: If the person sees:

- “Better” with the plus lenses
 - Add +0.25 D to each eye
 - Repeat Steps 1 and 2.
- “Worse” with the plus lenses
 - Do not change the lenses in the trial frame
 - Go to Step 3.
- “Same” with the plus lenses

Because they are plus lenses...

 - Do not change the lenses in the trial frame
 - Go to Step 3.



Remember:

Near refraction can be thought of as being like the opposite of distance refraction



Always give the person the least amount of plus that is necessary for them to have clear vision at near.

Repeat Steps 1 and 2 until the person says that the plus lenses make their vision worse or the same.



Adding +0.25 D to each eye:

When you add +0.25 D to the trial frame you do not need to add the +0.25 D trial lenses themselves. Instead just replace the add lenses that are in the trial frame with new add lenses that are 0.25 D more plus.

Example:

If you already have +1.25 D trial lenses in the back of the trial frame and you need to add +0.25 D → remove the +1.25 D lenses and replace them with +1.50 D lenses.

STEP-BY-STEP INSTRUCTIONS – NEAR REFRACTION (cont.)

ADJUSTING THE ADD POWER (cont.)

Step 3: Take two -0.25 D trial lenses and hold them in front of the person's eyes.

Tell the person:

“Look at the reading card.

Look at the smallest words that you can see.”

Ask the person:

“Do these lenses make the chart look BETTER, WORSE or the SAME?”

You might need to show the person the near VA chart with and without the -0.25 D lenses a few times.

Step 4: If the person sees:

- “Better” with the minus lenses
 - Add -0.25 D to each eye
 - Repeat Steps 3 and 4.
- “Worse” with the minus lenses
 - Do not change the lenses in the trial frame
 - Go to “Checking the range of vision”.
- “Same” with the minus lenses
 - Because they are a minus lenses...
 - Add -0.25 D to each eye
 - Repeat Steps 3 and 4.

Repeat Steps 3 and 4 until the person says that the minus lenses make their vision worse.

Adding -0.25 D to each eye:



When you add -0.25 D to the trial frame you do not need to add the -0.25 D trial lenses themselves. Instead just replace the add lenses that are in the trial frame with new add lenses that are 0.25 D more minus, or 0.25 D less plus.

Example:

If you already have $+2.25$ D trial lenses in the back of the trial frame and you need to add -0.25 D → remove the $+2.25$ D lenses and replace them with $+2.00$ D lenses

STEP-BY-STEP INSTRUCTIONS – NEAR REFRACTION (cont.)

CHECKING THE RANGE OF CLEAR VISION

Step 1: Ask the person:
**“Look at the reading card.
 Look at the smallest words that you can see.”**

Step 2: Tell the person:
**“Slowly bring the reading card closer to you.
 Stop when the words start to get blurry.”**

**“Slowly move the reading card away from you.
 Stop when the words start to get blurry.”**

Look at the where the near VA chart is from the person’s eyes when it starts to get blurry – both when they bring it closer and when they move it further away. The distance between these two points is the person’s range of clear vision. The person’s preferred working distance should be in the middle of these two points.

If the person’s preferred working distance is in the middle of the range of clear vision → go to Step 5.

If the person’s preferred working distance is not in the middle of the range of clear vision → go to Step 3.

Step 3: If the person’s preferred working distance is not in the middle of the range of clear vision, you need to move the range of clear vision.

The range of clear vision can be moved:

- closer to the person → by adding +0.25 D to both eyes.
- further away from the person → by adding –0.25 D to both eyes.

Example 1:

You have +2.00 D near add trial lenses in the trial frame.

You measure the range of clear vision

→ you find that the person’s preferred working distance is further away from them than the middle of their range of clear vision.

You must add +0.25 D to both eyes.

You remove the +2.00 D lenses and replace them with +2.25 D lenses.

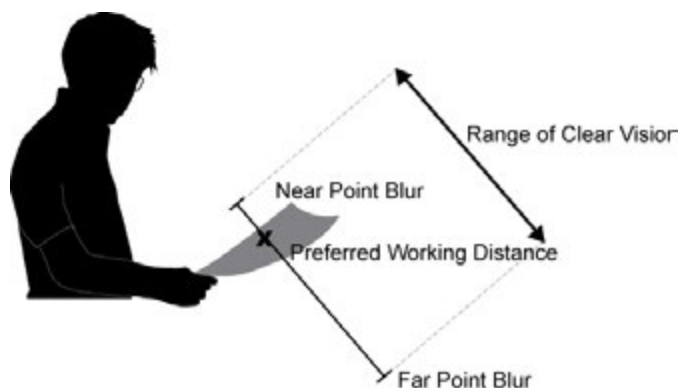


Figure 21.7: The range of clear vision is too far away from the person. More plus must be added to the near add so that the preferred working distance is in the centre of the range of clear vision.

STEP-BY-STEP INSTRUCTIONS – NEAR REFRACTION (cont.)

CHECKING THE RANGE OF CLEAR VISION (cont.)

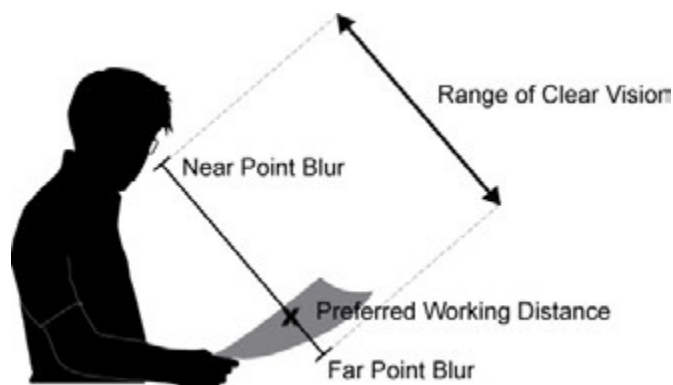


Figure 21.8: The range of clear vision is too close to the person. Plus in the near add must be reduced so that the preferred working distance is in the centre of the range of clear vision.

Step 4: Repeat Steps 1 to 3 until the person's preferred working distance is in the middle of their range of clear vision.

Step 5: Show the person their range of clear vision. Let the person move the card back and forth to see where it gets blurry.

Ask the person:

“Is there any close work (including hobbies and special work tasks) that you need to do that is closer than this... or further away than this.”

Adjust the range of clear vision for the person if you need to as explained in Step 3.

If the person needs to see things clearly at more than one distance (and if both distances are not within the range of clear vision) the person may need to have more than one pair of spectacles, or bifocal spectacles.

Step 6: Measure the binocular near VA (aided) and write it on the record card. Write the near add on the record card (because it is the same for both eyes, you only need to write it once).

Example:

Near VA (aided) N6

Add +2.00 D

SUMMARY: NEAR REFRACTION FOR PRESBYOPIA

CORRECTING PRESBYOPIA

Lens addition

- Near addition (add) is not the same as near spectacle prescription.
- The add is the extra amount of plus power that must be added to the person's distance prescription so that they can see clearly at near.
- Distance prescription + Near add = Near spectacle prescription.

Strength of the near add:

- The near add strength depends on:
 - age
 - preferred working distance
 - best corrected distance VA.
- **Age**
 - The strength of the near add must increase as the person gets older and their presbyopia gets worse.
 - This table shows the approximate near add expected for people living in hot equatorial countries:

Person's Age	Expected Near Add
35 to 40	+0.75 D to +1.25 D
40 to 45	+1.25 D to +1.75 D
45 to 50	+1.75 D to +2.25 D
Over 50	+2.25 D to +2.75 D

- **Preferred working distance**
 - This is the distance that a person likes to keep between their eyes and their close work. It is usually about 40 cm, but may be closer or further away.
 - Smaller people usually have closer working distances than larger people.
 - A stronger add is needed for people who have closer working distances than for people who have working distances further away.
 - The preferred working distance needs to be determined during the case history.
- **Best corrected distance VA**
 - A person with very poor best corrected distance VA has "low vision".
 - Sometimes people with low vision are given "high add" reading spectacles.
 - These spectacles are very high powered and let the person hold things very close to their eyes to see.

Range of clear vision:

- A presbyope who wears near spectacles has a limit to how close and how far away they can see when they are wearing their spectacles.
- The range of clear vision describes the distances where the person's near vision is clear.
- A good pair of near spectacles is prescribed so that the person's preferred working distance is in the centre of the range of clear vision.
- A person's range of clear vision decreases as they get older.

Goals of near refraction:

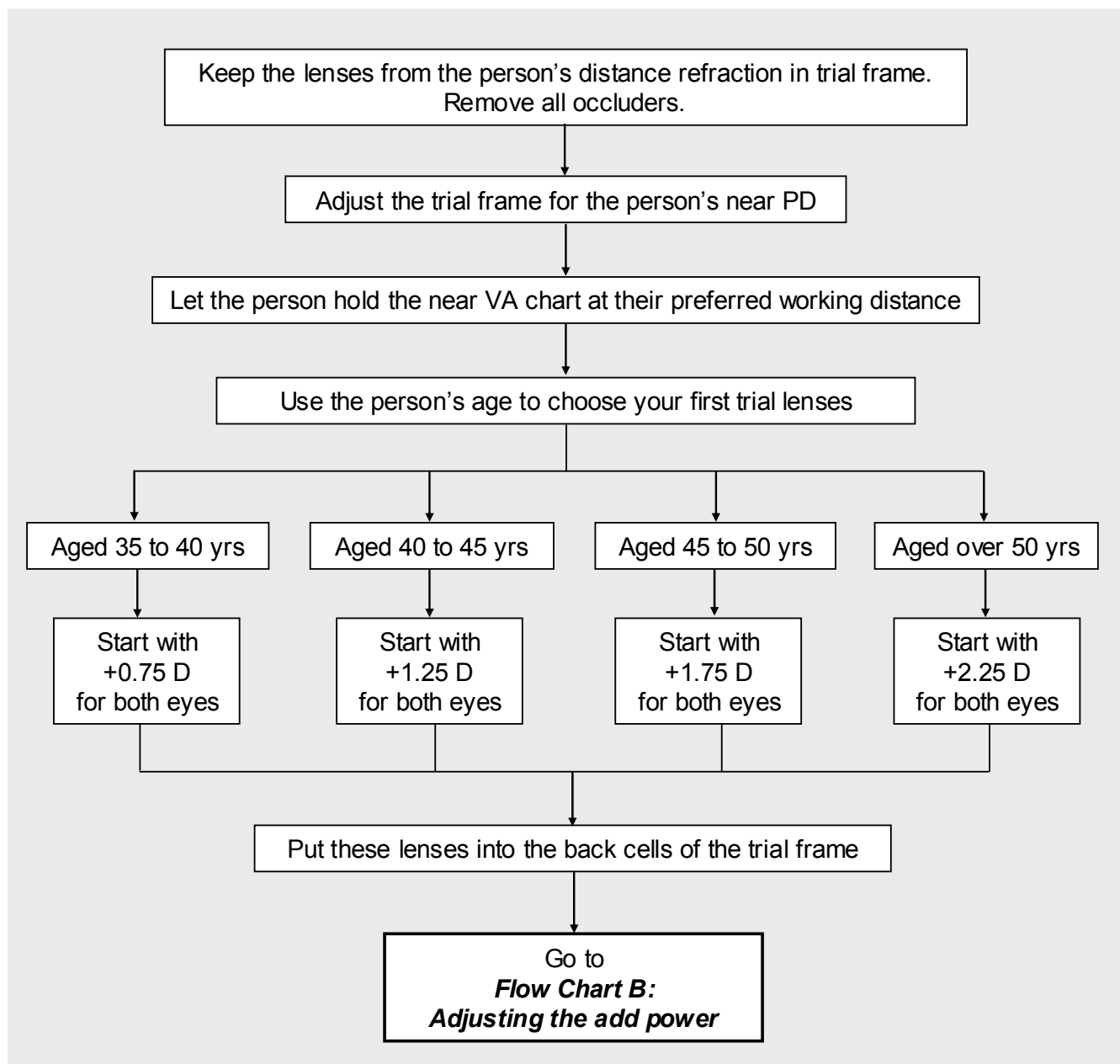
To find:

- the plus lenses that give the person the best range of clear vision (with the person's preferred working distance in the centre) of that range.
- the lowest powered plus lenses that the person needs to see close work clearly.

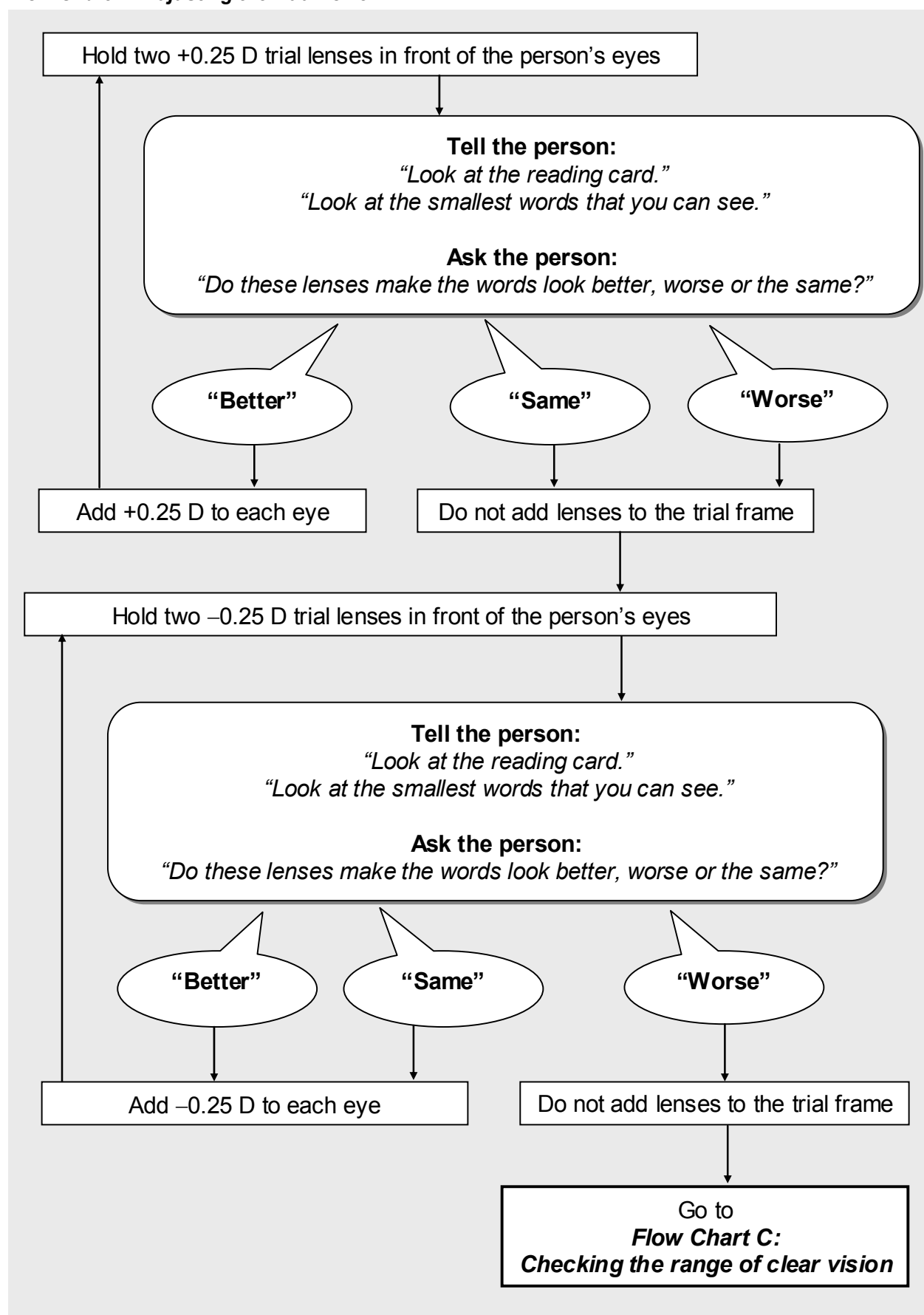
SUMMARY – METHOD – NEAR REFRACTION

- Before you can do a near refraction, you need to know the person's final distance refraction.
- There are three parts to a near refraction:
 - Preparation and estimation of the add
 - Adjusting the add power
 - Checking the range of clear vision.

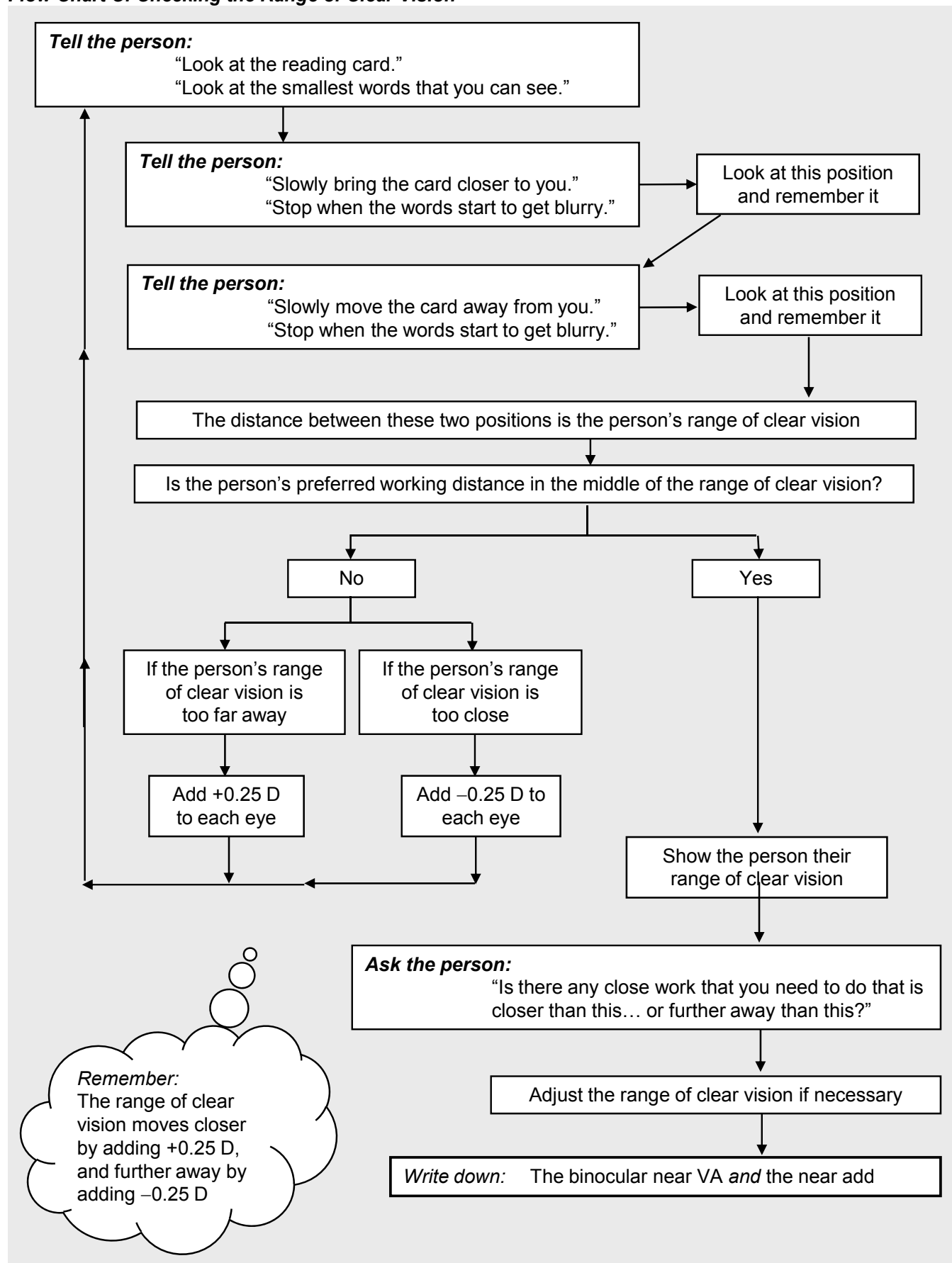
Flow Chart A: Preparation and Estimation of the Add



Flow Chart B: Adjusting the Add Power



Flow Chart C: Checking the Range of Clear Vision



TEST YOURSELF QUESTIONS

1. What is the difference between the near lens addition (add) and the near spectacle prescription?

2. Why do people need a stronger near add as they get older?

3. Why is it important for us to know a person's preferred working distance when prescribing near spectacles?

4. What is a person's range of clear vision?
How do you move the range of clear vision closer to a person? How do you move it further away?

5. What are the goals of a near refraction?

6. We know that, for a distance refraction, we want to give the person the most amount of plus that gives them the best VA. How is a near refraction different? Why is this so?



RECORD KEEPING AND REFERRAL LETTERS

THINK

It is impossible to remember all the details of every person that you examine. Even if you could, you need to make sure that, when somebody else examines that person in future, they will know exactly what tests you performed and what results you obtained.

AIM

This unit will teach you how to keep a record of the person's eye examination and how to write a referral letter for a person.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- keep patient records which are meaningful to you and other eye care providers
- write a referral letter.

EXAMINATION RECORD

An examination record (or simply a record) is a permanent copy of what was found during a person's eye examination.

Each time a person is examined their record is added to and updated.

Anyone who looks at a person's record should be able to know what the person's problems were and what was done about them. When the person has their eyes examined again in the future, the examiner will know if the person's eyes are getting better or worse.

It is important that the information that is written on the record is written neatly and can be easily understood. Most people use special record cards or record log-books that include information about all the people who have had their eyes examined.



A person's record card contains private information. Most people do not want other people to know about their health or eye problems.

You must make sure that the information that you write on the record card is kept confidential (secret).

DETAILS TO RECORD

PERSONAL DETAILS	• Date of examination • Full name of person • Date of birth (DOB) or age of person • Gender (male or female) • Contact details (address, telephone number, email) • Location of examination (name of clinic/hospital, place of outreach camp)
CASE HISTORY	• Chief complaint and other symptoms • Vision and eye health history (including previous spectacles and visual needs) • General health, medication, allergies • Family history (eye and general health)
VISUAL ACUITY (VA)	• Presenting distance and near VA • Pinhole VA (if necessary) • Unaided, aided, and best corrected VA (for both distance and near)
EXAMINATION RESULTS	• Details and results of all tests performed during the eye examination • Refraction results and spectacle prescription provided • Eye health assessment • Anything else that you notice during the eye examination that you think might be important
DIAGNOSIS AND PLAN	• Identification (name) of the problem(s) • Treatment: spectacles (or medication) prescribed • Referral (if necessary) • Details of what to review or test at the next eye examination
ADVICE	• What you told the person • Explanation of the chief complaint and symptoms • Treatment: what (spectacles or medication) and how to use • Referral: why and what to expect (if necessary) • When to return for their next eye examination • What the person agreed to

DETAILS TO RECORD (cont.)



You must write everything in the person's examination record.

Even if you do a test and the result is normal, or you look at the eye and it is healthy, you must document your findings:

Examples:

"Distance VA (unaided) RE 6/6 LE 6/6"

"No family history of diabetes"

"Cornea clear and healthy"

If you do not write your results down, it will be assumed that you did not ask the question or that you did not do the test.

If a result is not written on the record it is the same as if you have not done the test!

EXAMINATION RECORD

RECORD CARD

A record card is a piece of paper or cardboard that can be kept in a folder with the person's other record cards (from previous eye examinations). Record cards can be filed by the person's name or by a number so that they can be found easily in the future.

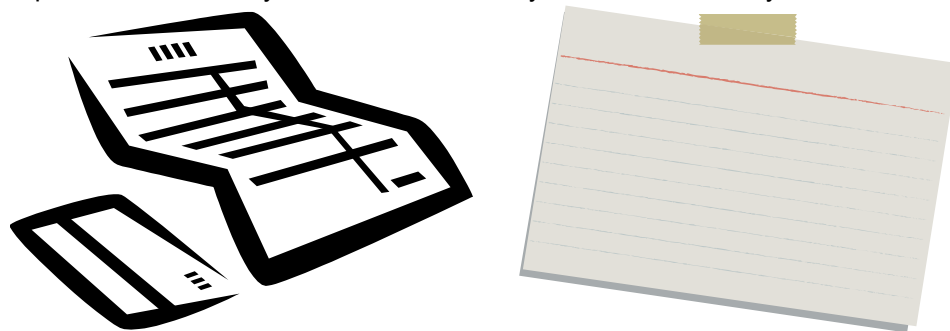


Figure 22.1: Record cards can be specially printed (or photocopied) so that the layout of all the cards is identical, or they can be blank so that you can write whatever you like

EXAMPLE: RECORD CARD LAYOUT

Name:		Address:		☐ Male / ☐ Female		Date:					
DOB / Age		Occupation / tasks:									
Chief complaint:											
Case history:											
General health:					Family history:						
Presenting Distance VA aided/unaided					Presenting Near VA aided/unaided						
Distance VA (Unaided)		Distance VA (Aided)		Distance VA (pinhole)		Near VA (Unaided)		Near VA (Aided)			
Eye Health											
PD		Preferred Reading Distance		Other tests							
		Right Eye				Left Eye				Both eyes	
		sph	cyl	axis	VA	sph	cyl	axis	VA	add	VA
Refraction											
Distance prescription given											
Near prescription given											
Diagnosis / treatment / spectacles											
Instructions / Advice given to patient											
Referral to						Examiner					

EXAMINATION RECORD (cont.)

RECORD LOG BOOK

A record log-book is sometimes called a line-listing record. It is usually a large book that has the details of every person examined written into it. Sometimes a record log-book will have columns drawn down two pages – each column will be for a specific detail.



Figure 22.2: A large book can have columns drawn down both pages to make a record log-book for eye examination records

Record log-books can also be useful for students who are making an examination portfolio for assessment or registration purposes.

The headings for each column of a log-book can include:

- Date
- Name
- Date of birth (DOB)
- Male/female
- Chief complaint
- Case history
- General health
- Family history
- Occupation / Tasks
- VA (R & L): Distance and near
→ presenting, pinhole, unaided, aided
- Eye health
- Interpupillary distance (PD)
- Refraction
- Diagnosis
- Treatment recommendations (including spectacles)
- Advice given to the person
- Referral (if necessary)
- Name of examiner



If the record of a person's eye examination is lost it can cause serious problems.

Because record cards are single pieces of paper, they can easily be lost. If you use a record card system you must make sure that you have a good filing system that is used correctly.

It is more difficult to lose a log-book record. If the person knows the date that their eyes were last examined the record can always be found somewhere in the log-book.

Some eye clinics choose to use both a record card and a record log-book to be safe.

EXAMINATION RECORD (cont.)

COMPUTERISED RECORD	Some clinics now use computer databases to record the details of people who are examined. It can be easier to find a person's record on a computer database, and examination reports and referral letters can be generated directly from a computerised record. If a computerised record is used, care must be taken to make sure that information is not deleted or changed by accident. Back-ups of the computer databases need to be made regularly in case the computer is broken or stolen. Information can also be lost if the electricity stops unexpectedly. Computerised records are extremely inconvenient if outreach clinics are performed as the information (written on paper) must be transferred (typed) into the computer when you return to your clinic. This can waste a lot of time.

REFERRAL LETTERS

Sometimes when you examine a person's eyes you will find a problem that you cannot treat yourself. This person needs to be referred to someone who specialises in that problem.

When a person is referred you must send a referral letter with them. The referral letter is addressed to the eye care provider who will examine them, and should include the following information:

- the reason that you are referring the person
- the parts of the case history and test results that are relevant to the problem
- any treatment (including spectacle prescriptions) that the person has received.

DETAILS TO INCLUDE	• Date that the letter is written • Name (if possible) and address of the eye care provider that you are referring the person to • Name and DOB / age of the person • Address of the person (and name / address of nearest relative) • Main problem (and other problems if relevant) • Relevant case history • Visual acuity • Relevant test results → remember to specify which eye has the problem • Complete details of any treatment given to the person (by yourself or someone else) → spectacle prescription → drug names and dosages (if relevant) • A polite request for advice and treatment • Your name, address, signature, and official title Referrals can be written on blank or letterhead paper, or can be written on a specially made referral form.
REFERRAL LETTERS	If you choose to write a referral letter, it needs to look professional. It must be written neatly (or typed) and be easy to understand.

REFERRAL LETTERS (cont.)

EXAMPLE

Letterhead
(Your eye clinic address)

Mountain Vision Centre
Top Health Clinic
Mountain Town

3 August 2008

Dr Lookgood
Super Eye Hospital
Capital City

Details of the specialist or hospital that you are referring to

Dear Doctor

Details of the person that you are referring

RE: Mrs Flower Garden
2 Rocky Road, One Tree Village, Mountain Town
Telephone number: 455 6767
Nearest relative: Mr Herb Garden (son) at same address

DOB: 29/2/1960

Summary of reason for referral

Reason for referral: **Scratched Left Eye**

Thank you for seeing Mrs Garden whom I first saw yesterday (2/8/08).
On 2 August 2008 her right eye was injured with a stick while she was gardening.

Mrs Garden complained of a painful, watery right eye.
Unaided VA: RE 6/6 LE 6/6
My examination showed a red right eye with a small scratch on the inferior cornea near the limbus. The left eye looked normal.

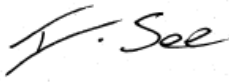
I instilled Tetracycline ointment 10% and asked Mrs Garden to return the next morning.

Today (3/8/08) the eye is more red than yesterday and visual acuity for the right eye has decreased to 6/12+2.
Mrs Garden tells me that the pain is worse than before.

I am concerned that Mrs Garden's eye has developed an infection. I am referring her to you for urgent advice and further treatment.

Polite request for advice and treatment

Best regards



Your official title

Ms Isabelle See
Vision Technician

REFERRAL FORM LETTERS	Some people prefer to use a referral form when they refer a person. A referral form can be useful because it helps you to remember all the information that you need to include, but sometimes there is not enough space for all the details. (If more space is needed, you can write on the back of the form also.)

EXAMPLE

Name:	Mrs Flower Garden	DOB: 29 / 2 / 1960	Gender: ☒ F / ☐ M	Date: 3 / 8 / 08
Address:	2 Rocky Road, One Tree Village, Mountain Town. Telephone: 455 6767			
Case History:	Painful red right eye. Stick in right eye while gardening. Painful, watery R eye			
VA distance with spectacles	R: L:	VA distance without spectacles	R: 6/6 L: 6/6	
VA pinhole	R: L:	VA near with spectacles		VA near without spectacles
EXAMINATION	Conjunctiva bulbar: Red Cornea: R: small scratch on cornea near nasal limbus. L: normal Pupil: pupils same size Lids: normal Lashes: normal Other:		IDENTIFICATION DIAGNOSIS Reasons: Corneal abrasion, (history: scratch on cornea from plant)	
TREATMENT	RE: Tetracycline ointment 10%	REFERRAL NECESSARY	☒ Urgent ☐ As soon as possible ☐ Next opportunity	
OTHER	Patient instructed to return the next morning (3/8/08). Follow-up examination (3/8/08): VA (unaided) R 6/12+2 L 6/6. Patient reports more pain. Eye more red than previous day. Plan: Urgent referral			
REFERRAL	☐ For an eye health and general check: History or symptoms of Diabetes and / or Hypertension	☐ For an eye health check: Distance vision 6/18 or worse in either the left or right eye AND does NOT improve to at least 6/9 with pinhole	☐ Refer for an eye test for their distance vision: Distance vision is 6/18 or worse in either the right or left eye and DOES improve to at least 6/9 with pinhole	
REFERRAL DETAILS	Referred for: Because of possibility of an eye infection Referred to: Dr Lookgood, Eye Hospital, Capital City Arrangements made for referral: ☐ Date of appointment: 4/5/04 ☐ Transport: Son will take her ☐ Other _____			
Instructions / When to return (Date)				
Please examine and advise. Yours sincerely  Ms Isabelle See Vision Technician				

SUMMARY: RECORD KEEPING AND REFERRAL LETTERS

EXAMINATION RECORD

- Permanent copy of what was found during the eye examination.
- Any eye care provider who looks at the examination record should know what the person's eye problems were and what was done about them.
- The person's examination record is added to each time they come to you for an eye examination.
- Examination cards contain private information about the people you examine. You must make sure that the information is kept secret.

DETAILS TO RECORD

- Personal details:
 - date, name, DOB, gender, contact details, location of examination.
- Case history:
 - Chief complaint and other symptoms, vision and health history, family history.
- Visual acuity (VA):
 - presenting VA, pinhole VA, unaided VA, aided VA, best corrected VA (for distance and near).
- Examination results:
 - tests performed and their results, refraction and spectacles, eye health.
- Diagnosis and plan:
 - identification of problem, treatment (including spectacles), referral, when to return for a check-up, what the person agreed to.

TYPES OF EXAMINATION RECORD

- Record card:
 - piece of paper or cardboard with the person's eye examination information written on it
 - filed with other people's record cards by name or number.
- Record log-book:
 - also called a line-listing record
 - large book that usually has columns drawn down its pages
 - each column is for a specific detail
 - all the people that you examine will have their examination information written in this book.
- Computerised record:
 - examination information is typed into a computer database
 - must be extremely careful that examination information is not deleted or changed by accident
 - inconvenient if outreach clinics are performed.

TYPES OF EXAMINATION RECORD

- You need to refer people who have a problem that you cannot fix yourself.
- You must write a referral letter for every person whom you refer.
- Referral letters must contain:
 - date
 - name of the person / hospital that you are referring to
 - name, DOB, address of the person
 - details of the problem that you are referring the person for
 - relevant case history
 - VA
 - relevant test results
 - details of any eye treatment that the person has already received (including spectacles)
 - polite request for advice and treatment
 - your name, address, signature, and official title.
- A referral must be typed or carefully handwritten, or you can use a referral form letter.
- A referral form letter is a printed letter with spaces in which you can write the referral information.

TEST YOURSELF QUESTIONS

1. Why is it important to keep good eye examination records?

2. Why should you be careful to keep examination records safe and private?

3. A woman had her eyes examined by you 2 years ago. She comes to you again today to have another eye examination. Do you ...

a. add to her previous record?	☐ Yes / ☐ No
b. compare her results from 2 years ago with the results you found today?	☐ Yes / ☐ No
c. throw her old record in the bin?	☐ Yes / ☐ No
d. file the old and the new records together?	☐ Yes / ☐ No

4. Complete the following table.

Type of Record	Advantages	Disadvantages
Record Card		
Record Log-Book		
Computerised Record		

5. List the details that need to be included in a referral letter.



PRESCRIBING SPECTACLES

THINK

You examine a woman's eyes and find that she has a refractive error. You now need to decide what power spectacles to prescribe, how many pairs of spectacles to prescribe and what type of lens design to prescribe. You also need to think about what the woman's visual needs are and what she wants.

AIM

This unit will guide you on when and how to prescribe spectacles for a person.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- check your refraction to make sure that it is clear and comfortable for the person
- explain the limitations of the spectacles that you are prescribing
- explain why people with diabetes, women who are pregnant, and people taking some medications may have problems adapting to their new spectacles
- advise people about adapting to their new spectacles
- explain your examination findings to the person in simple language that they can understand
- write a spectacle prescription.

REVIEW: PRESCRIBING SPECTACLES

CASE HISTORY	A good case history will include: • chief complaint (main problem the person has noticed) • vision (distance and near; asthenopia) • eye history (previous eye exams, previous spectacles, previous eye problems) • visual needs • family eye or health problems • general health, medical history (including medications) and allergies.
REFRACTIVE ERROR	• A person who has a refractive error needs to wear spectacles (glasses) or contact lenses, so that they can see clearly and comfortably. This is because their eyes are not the correct size and shape. • There are four main types of refractive error: myopia, hyperopia, astigmatism and presbyopia. • An eye examination that tests for refractive error is called a refraction.
ASTHENOPIA	• Asthenopia is also known as eye strain. • Symptoms of asthenopia include: sore eyes, tired eyes and headaches. • Asthenopia can be caused by many things including uncorrected refractive error and incorrectly prescribed spectacles.

REFRACTION CHECK

After you have finished your refraction, you need to double check your results.

ASK THE PERSON	• Does your distance (or near) vision look clear with these lenses? • Do your eyes feel comfortable with these lenses? • Do you notice a difference between these lenses and your old spectacles? → Let the person compare their vision with their old spectacles to their vision with the new prescription lenses in the trial frame. → If the person tells you that their vision is the same (with their old spectacles and with the lenses in the trial frame) you should not prescribe new spectacles for the person – unless they want a new frame or if their lenses are scratched.  To check a distance refraction you can ask the person to stand up and look outside the window or the door. To check a near refraction you can ask the person to look at the near visual acuity (VA) chart or something else that they want to see clearly at near. Encourage the person to explore their range of clear vision by moving the near VA chart back and forth.

REFRACTION CHECK (cont.)

DISTANCE	If the person tells you that their distance vision is not clear or comfortable you must check your refraction: → First check the sphere • Add +0.25 D to both eyes • Add -0.25 D to both eyes (only if this improves the VA!) → Then check the cylinder • Turn the axis of the cylinder a small amount → towards the axis of their previous spectacles - or → towards 90° or 180° (whichever is closer) • Decrease the power of the cylinder by 0.25 D or 0.50 D (remember to add -0.25 D sphere for every -0.50 D cyl you take away!)
NEAR	If the person tells you that their near vision is not clear or comfortable, you must check your near refraction: → Check the near add • Add +0.25 D to both eyes • Add -0.25 D to both eyes.
SHOW THE PERSON	Demonstrate how the spectacles improve the person's vision at certain distances but can make it worse for other distances.
EXAMPLE 1	Near spectacles can make objects in the distance look blurry. In this case the person must take their near spectacles off (or change them for their distance spectacles) if they want to see far away. The person might also like to look over the top of their near spectacles if they want their distance vision to be clearer.  Figure 23.1: A man wearing look-over reading spectacles. He looks through the near spectacle prescription lenses to read his book and looks over them to see things that are in the distance.
EXAMPLE 2	Distance spectacles can make near vision blurry. In this case the person must take their distance spectacles off (or change them for their near spectacles) if they want to see things close to them.

BEFORE YOU PRESCRIBE

When you take a case history you must remember to ask the person about their general health and any medications they are taking. Some general health problems can affect vision and it is better if the health problem is treated first before you prescribe spectacles.

DIABETES	A person with diabetes (too much sugar in their blood) must have an eye health check before you prescribe spectacles. Diabetes can cause bleeding and permanent damage to the retina – this is called diabetic eye disease or diabetic retinopathy. Diabetic eye disease needs to be treated promptly so that the person does not lose their vision forever.  A person with diabetes needs an eye health check at least every 12 months.
STEP 2	Some people with diabetes have blood sugar levels that fluctuate (change all the time) – this is especially true for people who have just been diagnosed with diabetes, or people who are not careful in looking after their diet or taking their medication. When there is a large amount of sugar in the blood, the crystalline lens swells (gets thicker) and changes its focusing power – this will change the person's refractive error temporarily. When the amount of sugar in the blood goes back to normal, the lens will also go back to normal and the person's refractive error will change again. If someone has fluctuating blood sugar levels you should ask them to come for an examination on at least three different days and at different times of the day. You can then look at all the refraction results you have measured and prescribe the average of these results. It is even better if the person can come back to you when they have controlled their blood sugar and it is no longer fluctuating.  If a person with diabetes has fluctuating blood sugar, you should measure their refractive error a minimum of three times on three different days. If the refraction is changing a lot each time, you may even ask them to come back for another check on another day. Take the average of all your refractions and use this for the prescription. In the early stages of diabetic eye disease, the person may not notice a problem with their vision – but they should get their eyes checked anyway. Early diabetic eye disease often has no symptoms, but this is the best time for it to be treated.  A person with diabetes may have bleeding at the back of their eye and not know about it. If the person does not have an eye health examination their eye and vision may become permanently damaged. Routine eye health examinations are essential for all people with diabetes.

BEFORE YOU PRESCRIBE (cont.)

PREGNANCY	When a woman is pregnant the chemicals in her body change. This change in chemicals can affect her eyes and make her refractive error change. Sometimes her refractive error will go back to normal after the baby is born, but sometimes the change is permanent. You should warn pregnant women that they may need to change their spectacles during the course of their pregnancy.
MEDICATIONS	Some drugs (medications) can affect the eye and make a person's refractive error change. These drugs include some anti-depressants and anti-psychotics. Usually the refractive error will stay the same if the dose of the medication stays the same, but if the dose changes or if the person stops taking the medication, the refractive error can also change.  Many people are embarrassed to say that they are taking anti-depressant or anti-psychotic medication. When you take a case history you should reassure the person that the information that they tell you is confidential (secret) and is only to help you give them the best eye examination you can. Sometimes it is helpful to list a few suggestions when you ask someone about their medications. You might say: <i>“Do you take any medications for problems such as diabetes, depression or high blood pressure – or any other medications?”</i> Let the person know that some medications and health problems affect the eyes, so it is important that they tell you about them. Some medications, like steroids, can cause cataracts. Early cataracts can cause a change in refractive error (the person can become more myopic). This change is usually progressive (it gets worse) and permanent – until the cataracts are removed by simple surgery.

PRESCRIBING SPECTACLES

Choosing which spectacles to prescribe for a person is as much an art as it is a science. Two people can have the same refractive error but need different types or powers of spectacles.

The spectacles that you choose to prescribe for a person depends on the:

- person's case history
- person's previous spectacles
- person's sensitivity to visual change (this is different for different people)
- amount of refractive error and symptoms
- type of refractive error
- spectacles and lenses available.

CASE HISTORY



Always tell people that new spectacles take time to get used to. People often feel strange when they first get their new spectacles – this is because their brain is not used to seeing correctly.

You should always tell people to wear their spectacles as much as possible for the first 2 weeks so that they can get used to them more rapidly.

Tell the person that if they still feel bad wearing their spectacles after 2 weeks, they should come back to see you so that you can re-examine their eyes.

Some people are more sensitive than others, and cannot adapt easily to new spectacles or changes in their spectacle prescription.

When you take a case history, the person will tell you what problems they are having. Your main job is to solve the problem that the person is worried about.



The person's chief complaint (the main problem that they tell you about) is the most important thing that you need to talk to the person about after the eye examination.

You need to tell the person what you can do to help them with their problem. This might be prescribing spectacles or, if you cannot solve the problem yourself, you need to tell the person that you are referring them to someone who can help them with this problem.

Listen to what the person says about their vision and their visual needs. This will tell you what sort of spectacles you should prescribe.

During the eye examination you may discover problems that the person did not tell you about in the case history. This may be because the person forgot to tell you, but it may also be because the problem is not important to them. You should discuss these other problems with the person to help you decide what to recommend. If the problem is a refractive error, you can show the person the improvement that you can make to their vision and the person can decide if they want spectacles.

PRESCRIBING SPECTACLES (cont.)

EXAMPLE 1

A 40 year old woman comes to you and tells you that she has trouble seeing the small stones when she is sorting rice for dinner. She tells you that her distance vision is good.

You do the following tests:

- VA: R 6/9 (unaided) 6/6 (PH) L 6/9 (unaided) 6/6 (PH)
- Refraction: R +0.75 D (6/6) L +0.75 D (6/6)
Add +1.00D (N5)

This woman has hyperopia and presbyopia. Her hyperopia is making her distance vision and her near vision blurry, and her presbyopia is making her near vision more blurry.

Using a trial frame you show the woman the improvements that you can make for her:

- Near vision → She tells you that it looks much better.
- Distance vision → She tells you that it looks slightly better, but not a lot.



This woman will be happy if you give her +1.75 D near spectacles to help her see better when doing near tasks.



REMEMBER:

Distance prescription + Near add = Near spectacle prescription



If you give her distance spectacles as well, she will probably not wear them because she feels that her distance vision is good.

EXAMPLE 2

A farmer comes to you and tells you that he has trouble seeing his goats in the field. He tells you that when he is close to his goats he has no problems seeing them.

He also tells you that he never learned how to read and that he likes to watch television in his spare time.

You do the following tests:

- VA: R 6/9 (unaided) 6/6 (PH) L 6/9 (unaided) 6/6 (PH)
- Refraction: R +0.75 D (6/6) L +0.75 D (6/6)
Add +1.00D (N5)

This man has hyperopia and presbyopia. His hyperopia is making his distance vision and his near vision blurry, and his presbyopia is making his near vision more blurry.

Using a trial frame you show the man the improvements that you can make for his:

Near vision → He tells you that it looks much better, but that he cannot read the words on the near VA chart.

Distance vision → He tells you that it looks better, and that objects in the distance are easier to see.



This man will be happy if you give him +0.75 D distance spectacles to help him see his goats.

If you give him near spectacles, he will probably not wear them because he does not have a need to see well at near.

PRESCRIBING SPECTACLES (cont.)

EXAMPLE 2 (cont.)	Look again at the two examples.  Did you notice that the woman and the man in these examples have the same refraction? Although they have the same refraction they have different visual needs so they are prescribed different spectacles.
PREVIOUS SPECTACLES	If a person has worn spectacles before you must measure their old spectacles so that you know how much the person's prescription has changed. You must also measure the person's VA with their old spectacles so that you know how much improvement your prescription will make. <i>Usually:</i> - We do not change the person's prescription if: → the VA improvement is less than one line on the VA chart → the person prefers the vision they get with their old spectacles compared with the vision they get from the lenses in the trial frame. - If the distance refraction has changed by more than 1.00 D: → we usually only prescribe a maximum of 1.00 D change → otherwise the new spectacles may be too difficult to adapt to.  EXAMPLE: Your distance refraction for a man is: R -3.50 D L -4.00D You measure his old spectacles and find that they are: R -1.75 D L -2.25D You should probably prescribe: R -2.75 D L -3.25D - Reading spectacles usually need to be changed every 2 years. - If the near refraction has changed by more than 0.50 D: → we usually only prescribe a maximum of 0.50 D change → otherwise the new spectacles may be too difficult to adapt to.  EXAMPLE: Your distance refraction for a woman is: R plano L plano Her near add is: Add +1.75 D You measure her old spectacles and find that they are: R +1.00 D L +1.00 D You should probably prescribe reading spectacles: R +1.50 D R +1.50 D

PRESCRIBING SPECTACLES (cont.)

PREVIOUS SPECTACLES (cont.)	- If the person has not worn spectacles before, you should think about prescribing weaker spectacles than their full refractive error correction, especially if their prescription is high. → this will make it easier for them to adapt to their new spectacles → you can make the spectacles stronger the next time you see them → but think about the cost of this and how difficult it is for the person to travel to see you again.  EXAMPLE: A woman comes to see you for her first eye examination. She has never worn spectacles before. Your distance refraction for a woman is: R +5.50 D L +6.00D You should probably prescribe: R +3.00 D L +2.50 D You tell the woman to come to see you in 12 months and warn her that she will probably need stronger spectacles then.
SENSITIVITY TO CHANGE	Different people react differently to changes in their vision. Some people have no difficulty at all adjusting to changes in their vision – even if there is a very big change in their prescription. Other people have sensitive eyes and even small changes in their vision can make them feel sick or dizzy, even if it makes their vision clearer! They might also tell you that things around them look like they are distorted (the wrong shape). These people can take a very long time to get used to their new spectacles. This is because the brain has to learn a new way of seeing things: the brain was used to seeing things the wrong way, now it has to learn to see things the right way. It is hard to know who will react badly to a new pair of spectacles, but testing the prescription in a trial frame before you make the new spectacles is a very good idea.  TESTING THE PRESCRIPTION: - Put the lenses that you want to prescribe in the trial frame. - For distance spectacles: - Ask the person to look around the room. <i>“Do the walls, window and door seem straight?”</i> <i>“Does the floor seem flat or does it look like it is sloping?”</i> - Ask the person to walk around the room (wearing the trial frame with the new prescription lenses). <i>“How do you feel walking?”</i> <i>“How does everything outside the door look?”</i> - Ask the person how their eyes feel. <i>“Do your eyes feel relaxed looking through these lenses, or do they feel uncomfortable?”</i> - For near spectacles: - Ask the person to look at the near VA chart. <i>“Does the chart look straight and normal, or does it seem to be a strange shape?”</i> - Ask the person how their eyes feel. <i>“Do your eyes feel relaxed looking through these lenses, or do they feel uncomfortable?”</i> If the person tells you that their vision does not seem normal or that their eyes are not comfortable, you will need to adjust the prescription.

PRESCRIBING SPECTACLES (cont.)

SENSITIVITY TO CHANGE (cont.)	Before you give a person new spectacles you should tell them: • “Your spectacles might make you feel strange or uncomfortable for the first 2 weeks, this is because your eyes need to get used to them.” • “Try to wear your new spectacles as much as possible during these first 2 weeks – this will help you get used to them.” • “If you still feel uncomfortable wearing your spectacles after 2 weeks, you should come back to see me.”  You can tell the person that: → Some people get used to their new spectacles more quickly than other people. → This is because some people have more sensitive eyes than other people. → It is hard to know whether a person has sensitive eyes or not until they try their new prescription. This way, you are being honest with the person and the person will understand if they have problems adjusting. After 2 Weeks: If the person comes back to you after 2 weeks and says that they are still having problems getting used to their spectacles, there may be several reasons: • Your refraction may be incorrect → Recheck your refraction. • The spectacles may have been made incorrectly → Measure the power and optical centres (interpupillary distance [PD]) of the spectacle lenses again (this should always be done before dispensing spectacles). • The person may have sensitive eyes and may be having too much trouble adapting to the full new prescription → Change your prescription (this usually means prescribing less power) and remake the spectacles.  If you have to change the prescription of the spectacles the person’s VA will probably get worse. This compromise might be the only option. You may like to discuss this with the person so they understand. They may notice that their vision is not as clear with the re-made spectacles.
AMOUNT OF REFRACTIVE ERROR AND SYMPTOMS	Small Amounts of Refractive Error: People who have a small amount of refractive error are often happy to be without spectacles. <i>Generally:</i> If the hyperopia, myopia or astigmatism is less than 0.75 D, the person may not notice any problems with their vision and will probably not need spectacles. If the person tells you that they have no trouble seeing, and their vision is better than 6/12, they probably do not need spectacles.  It is very common for young hyperopes to see clearly and comfortably at all distances. This is because young people have a lot of accommodation that they can use to compensate for their hyperopia and make their vision clear.

PRESCRIBING SPECTACLES (cont.)

AMOUNT OF REFRACTIVE ERROR AND SYMPTOMS (cont.)

Large Amounts of Refractive Error:

People who have a large amount of refractive error will usually need spectacles prescribed for them.

If one eye has more refractive error than the other, you must be careful. Sometimes wearing spectacles which have a different prescription for each eye can make a person uncomfortable. This is because different powered lenses make things look different sizes. A high powered plus lens will make things look larger and a high powered minus lens will make things look smaller. If the two eyes see images that are different sizes it will cause asthenopia (eye strain).

Generally:

If there is more than 2.00 D difference between the right and left eyes, you should change the prescription so that there is less difference between the lenses you prescribe. An exception to this is when the person has worn spectacles before and is used to this difference between their two eyes.

Example:

You refract a man and find that his refractive error is: R +5.00 D L +2.00 D. He has not worn spectacles before.

You put these lenses in a trial frame and ask the man to walk around with the trial frame – you ask him to look at the walls and floor of the room, and outside the window.

The man tells you that he feels a bit dizzy and sick wearing these lenses.

You could prescribe R +3.00 D, L +2.00 D and the man should feel more comfortable with the prescription.

Tell the man that it might take 2 weeks for him to get used to his spectacles, but also tell him that he should come back to you if he is still having problems after 2 weeks.



Remember to tell people that it will take a few weeks to get used to their new spectacles – especially if they have a high prescription or a large change from their previous spectacles.

Tell the person to wear their spectacles as much as possible in the first few weeks so that their eyes can get used to the spectacles. Tell them to return to you after 2 weeks if they still feel uncomfortable.

Symptoms:

Sometimes a person with a small amount of uncorrected refractive error will have symptoms of asthenopia (eye strain). This can happen because the eye needs to accommodate too much to compensate for the refractive error. This is especially common for younger people with small amounts of hyperopia or astigmatism who have active accommodation.



It is more common for smaller amounts of refractive error to cause asthenopia (eye strain) than larger amounts of refractive error.

This is because small amounts of refractive error (hyperopia and astigmatism) can be compensated for with accommodation. When accommodation is used too much the ciliary muscle gets tired and causes asthenopic symptoms (sore, tired eyes or headaches).

PRESCRIBING SPECTACLES (cont.)

AMOUNT OF REFRACTIVE ERROR AND SYMPTOMS (cont.)	Large amounts of refractive error are usually too hard for the person to compensate for – they do not even try to use their accommodation because it does not make much difference. People with large amounts of refractive error will tell you that their vision is blurry, but they do not usually complain of sore or tired eyes.  If a person has a refractive error that is symptomatic, they should be prescribed spectacles. Symptoms of refractive error include: – blurry vision, and/or – asthenopia.
TYPE OF REFRACTIVE ERROR	A person with astigmatism will probably have more trouble getting used to their spectacles than a person with a spherical refractive error (hyperopia, myopia or presbyopia). This is especially true if the axis of the astigmatism is not at 90° or 180°.  For astigmatic prescriptions you may need to: – reduce the amount of cylinder that you give a person (remember to change the amount of sphere by 0.25 D for every 0.50 D change of cyl that you make!) – change the axis of the cylinder by a small amount → towards 90° or 180° (whichever is closest), <i>or</i> → towards the axis of the cylinder that the person was wearing in their old spectacles.
AVAILABILITY OF LENSES AND SPECTACLE FRAMES	If possible, and where appropriate, you should offer readymade spectacles as an option, especially for presbyopes who only need near vision spectacles: → Made-to-order spectacles (that are tailor-made for the person) are more expensive than readymade spectacles (that can be bought immediately). <i>Generally:</i> Readymade spectacles will be fine to use if: • there is less than 1.00 D spherical difference between the two eyes • there is less than 1.00 D of astigmatism in either eye • the person's PD is appropriate for the size of the readymade spectacles available • the person's vision feels comfortable when they wear the readymade spectacles.  Even if the person's prescription is not within these guidelines, readymade may still be fine to use In some circumstances. The best test is to let the person try the readymade spectacles on and decide for themselves – it is their vision and their money!

EXPLANATION OF EXAMINATION RESULTS

EXPLANATION OF EXAMINATION RESULTS	When you have finished your eye examination, you need to tell the person: • what you found • what you can do for them.  Use simple language when you explain eye problems to people. If you use technical terms the person will be confused. Example: Instead of telling a person that they have <i>“myopia which results in distance blur unless it is corrected with minus spheres”</i> You can tell them that they have <i>“a distance vision problem that makes it hard to see far away – but that can be easily fixed with distance glasses”.</i> Your explanation should include: • A simple explanation of the person’s eye problems (including their chief complaint): - cause of the problem - how it can be treated - what might happen in the future (including changes in vision caused by changes in refractive error). • An explanation of the spectacles that you prescribe for them: - when to wear the spectacles - when not to wear the spectacles - how to look after their spectacles - reassurance that the spectacles will not make their eyes worse. • When the person should come back to you for another eye examination: - if the person has a problem getting used to their spectacles they should come back to see you so you can check their prescription - if the person has any eye problems including vision changes or sore eyes - a routine eye examination is recommended at least every 2 to 3 years.
WILL SPECTACLES MAKE MY EYES WORSE?	Many people think that wearing spectacles will make their eyes get worse. This is not true. People usually say this because about 2 years after a new presbyope gets their first pair of reading spectacles their vision changes and they need a new, stronger pair of spectacles. This is not because the spectacles made their eyes worse, but because the crystalline lens inside their eye is getting harder. This is a natural process which would happen even if the person was not wearing spectacles.  You can tell people this story of two twins who have the same vision problem: If you give the first twin spectacles to read with, but not the second twin, their eyes will keep changing by the same amount. If the twins come back to you in 2 years time, the first twin may need stronger spectacles to see clearly. If you measure the refractive error of the second twin you will find that he still has the same refractive error as his brother. Both twins will need the same stronger power of spectacles to see clearly.

WRITING A SPECTACLE PRESCRIPTION

If you recommend that a person needs to wear spectacles, you need to write their spectacle prescription. You may have a printed form that you can fill in, or you may just use a piece of paper with your letterhead on it.

Sometimes people choose to have their eyes examined by you, but they want their spectacles to be made by someone else – maybe they have seen a frame that they like in another clinic. When this happens you must give them a copy of their spectacle prescription.

PRESCRIPTION INFORMATION



If a person takes their spectacle prescription to be made at another clinic or optical shop, it may be a good idea to remind the person that you cannot be sure that their spectacles will be made correctly by that clinic or shop.

The person must understand this, but in the end it is their own choice where to buy their spectacles, and you must be helpful and professional.

A prescription must include:

- name of your clinic, hospital or optical shop (this can also be the letterhead)
- date of the eye examination
- name of the person who you have examined
- distance prescription for right and left eyes
- reading addition (if needed)
- PD (distance PD / near PD)
- type of spectacles recommended (*Example*: Distance spectacles)
- your name and signature
- prescription expiry date (usually 2 years after refraction date).

Example:

Mountain Vision Centre
Top Health Clinic, Mountain Town

3 August 2008

Mrs Flower Garden

R -4.00 L -3.50 Add +2.25 PD 67/63

Near spectacles and bifocal spectacles.



Ms Isabelle See (Vision Technician)

Exp 3/8/2010

SUMMARY: PRESCRIBING SPECTACLES

REFRACTION CHECK

When you have finished your refraction, you need to double check your results.

Ask the person

- Is your vision (distance/near) clear?
- Are your eyes comfortable?
- Do you see a difference between these lenses and your old spectacles?
 - If the person tells you that there is no difference (or that their spectacles are better), you do not need to prescribe new spectacles for the person.
- If distance vision is not clear:
 - check the sphere
 - check the cylinder.
- If near vision is not clear:
 - check the add.

Show the person:

- Demonstrate the limitations of the new spectacles
 - perhaps distance vision is clear but near vision is blurry; perhaps near vision is clear but distance vision is blurry.

BEFORE YOU PRESCRIBE

Diabetes:

- People with diabetes must have an eye health check before they have a refraction.
- A diabetic person needs an eye health check at least every 12 months.
- Refractive error can change daily in a person with diabetes who has uncontrolled blood sugar levels
 - you must recheck their refraction on different days.

Pregnancy:

- Chemicals in the body of a pregnant woman can cause her refractive error to change.
- Sometimes this change is permanent, but sometimes the refractive error goes back to normal after the baby is born.

Medications:

- Some drugs (like anti-depressants and anti-psychotics) can change the eye's refractive error.
This is usually dependant on the dose – if the dose changes, the refractive error usually changes too.
- Some drugs (like steroids) can cause cataracts. Early cataracts can change a person's refractive error.
This is usually progressive and the vision will slowly get worse until the person has a cataract operation.

PRESCRIBING SPECTACLES

- Deciding what to prescribe can be considered an art – it depends on many things and is not the same for every person
 - Two people can have the same refractive error, but need different spectacle prescriptions.
- Always tell the person that new spectacles can take some time to get used to
 - Allow 2 weeks for adaption.
 - Tell the person to come back after 2 weeks if they are still having difficulties with their new spectacles.

SUMMARY: PRESCRIBING SPECTACLES (cont.)

Your prescribing decision will depend on the person's:

Case History:

- Listen to and address the person's chief complaint.
- Understand the person's visual needs.

Previous Spectacles:

- Compare the difference between your refraction and the person's old spectacles.
- Do not change the person's prescription if:
 - there is less than one line VA improvement.
 - the person prefers their old spectacles to the new lenses.
- Reduce the spectacle power you prescribe if:
 - the distance refraction has changed by more than 1.00 D.
 - the reading refraction has changed by more than 0.50 D.
- Reading spectacles usually only need changing every 2 years.
- If the person has not worn spectacles before, consider giving them a weaker prescription.
- All these rules are flexible and you can make exceptions if you are careful.

Sensitivity to Change:

- Some people easily adapt to changes in their vision.
- Other people have a lot of difficulty getting used to their new spectacles
 - they may feel sick or dizzy or things might look distorted.
- You should always test the prescription in a trial frame before prescribing:
 - encourage the person to move around and look at different things.
 - if the person is uncomfortable with these lenses you may need to change the prescription.
- Always warn the person that their spectacles will take a few weeks to adjust to. Tell the person that some people take longer than other people to adapt to new spectacles, because they have sensitive eyes.
- If you have to change or reduce the prescription of the spectacles, the VA will probably not be as good as the best corrected visual acuity with the full spectacle prescription.

Amount of Refractive Error and Symptoms:

- People who have only a small amount of refractive error may not need spectacles.
- If a person has a high refractive error in one eye compared with the other eye, they may need their prescription adjusted.
- Prescribe spectacles for people with symptomatic refractive error (large or small).

Type of Refractive Error:

- People with astigmatism (especially if the axis is not at 90° or 180°) will have more difficulty adjusting to a new prescription.

Availability of Lenses and Spectacle Frames:

- Prescribe readymade spectacles when appropriate.

SUMMARY: PRESCRIBING SPECTACLES (cont.)

EXPLANATION OF EXAMINATION

- At the end of the eye examination explain:
 - what you found
 - what you can do to help.
- Use simple language.
- Your explanation should include:
 - A simple explanation of the person's problem (including the chief complaint, cause of the problem, treatment options and future expectations).
 - A simple explanation of the spectacles that you are prescribing (use, care, and reassurance).
 - When the person should return for another eye examination.
- Spectacles will not make the person's eyes get worse
 - although the person's refractive error may change naturally.

WRITING A SPECTACLE PRESCRIPTION

A spectacle prescription should include:

- Letterhead or name of your clinic / hospital / optical shop
- Date of the eye examination
- Name of the person
- Distance prescription for both eyes
- Add
- Type(s) of spectacles recommended
- Your name and signature
- Prescription expiry date.

TEST YOURSELF QUESTIONS

1. What are some questions that you can ask a person to make sure that spectacles you want to prescribe for them give clear and comfortable vision?

2. Why must you be careful when prescribing spectacles for the following people, and what can you do to make sure you prescribe the best spectacle prescription for them?

a) A person with diabetes:

b) A pregnant woman:

c) A man who is taking anti-psychotic medication:

3. What should you tell a person about getting used to their new spectacles?

4. Why should you always remember to give the person an answer to their chief complaint?

5. You do a distance refraction for a person and find: R -2.00 D L -1.75 D
You measure their previous distance spectacles: R -0.75 D L -0.50 D
What should you prescribe?

6. A woman comes to you and tells you that she has difficulty sewing, but that her distance vision is good.

Your refraction: R -1.25 L -1.00 Add +3.00

What should you prescribe?

Distance:

Near:



PRESCRIBING SPECTACLES FOR PRESBYOPIA

THINK

A 45 year old man comes to see you for an eye examination. He tells you that he is worried because he cannot see things that are close to him as well as he used to. You know that this is probably because he has presbyopia.

You do a refraction and find that the man has a small amount of astigmatism, but not enough to disturb his distance vision. You do a near refraction and find that he also has presbyopia, which is the cause of his poor near vision. How will you decide what power spectacles to prescribe for him so that he can see clearly at near?

AIM

This unit explains how to prescribe a near lens addition for a person with presbyopia so that they can have clear and comfortable near vision.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- prescribe near spectacles for a person by looking at their refraction results and by considering their case history, visual needs and previous spectacles
- adjust the add power to make it stronger or weaker depending on the person's needs
- describe the advantages and disadvantages of different types of spectacle lenses for near
- tell a person what they need to know about their new near spectacles.

REVIEW: PRESCRIBING SPECTACLES FOR PRESBYOPIA

PRESBYOPIA	- The gradual (slow) loss of accommodation as we get older is called presbyopia. - Presbyopia affects everyone and usually starts around the age of 40. - People with presbyopia usually find it difficult to read or do other near tasks. - If a presbyope also has hyperopia or myopia, it will affect them when they need to get spectacles for close work. Some people who have myopia may never need to wear reading spectacles.
CAUSE OF PRESBYOPIA	- As we get older, the crystalline lens gradually gets harder and cannot change shape easily when the ciliary muscle contracts – this is a normal, natural aging process. - This means that an older person cannot accommodate as much or as easily as a younger person.
PRESBYOPIA SYMPTOMS	People with presbyopia may have trouble doing near tasks such as reading, sewing, and sorting rice. This is because they have blurry vision when they look at things that are close to them.
CORRECTION OF PRESBYOPIA	- Presbyopia is corrected with a near addition (or “add”). - The add is a positive spherical lens power that is added to the distance correction that a person needs so that they can see their near work clearly. - Distance Spectacle Prescription + Near Addition = Reading / Near Spectacle Prescription.
TYPES OF PRESBYOPIA SPECTACLES	- Reading spectacles: - are only worn for close work - make close vision clear, but distance vision blurry - must be taken off for clear distance vision. - Bifocal spectacles: - have two parts divided by a line: the top part has power for distance vision, while the bottom part (the “seg”) has power for near vision - allow a presbyopic person to see clearly both at near and in the distance. - Progressive addition spectacles: - do not have a line like bifocals: the distance prescription at the top of the lens gradually blends with the near prescription at the bottom of the lens - allow a presbyopic person to see clearly both at near, far away, and at an intermediate distance.
LENS ADDITION	- Near addition (add) is not the same as near spectacle prescription. - The add is the extra amount of plus power that must be added to the person’s distance prescription so that they can see clearly at near. - Distance prescription + Near add = Near spectacle prescription.
STRENGTH OF THE NEAR ADD	The near add strength depends on: - age - preferred working distance - best corrected distance VA.

REVIEW: PRESCRIBING SPECTACLES FOR PRESBYOPIA (cont.)

PREFERRED WORKING DISTANCE	• This is the distance that a person likes to keep between their eyes and their close work. It is usually 40 cm, but may be closer or further away. • Smaller people usually have closer working distances than larger people. • A stronger add is needed for people who have closer working distances than for people who have working distances further away. • The preferred working distance needs to be determined during the case history.
RANGE OF CLEAR VISION	• A presbyope who wears near spectacles has a limit to how close and how far away they can see when they are wearing their spectacles. • The range of clear vision describes the distances where the person's near vision is clear. • A good pair of near spectacles is prescribed so that the person's preferred working distance is in the centre of the range of clear vision. • A person's range of clear vision decreases as they get older.
REFRACTION CHECK	• When you have finished your refraction, you need to double-check your results – is the person's vision clear and comfortable? • Show the person the limitations of their new spectacles → perhaps distance vision is clear but near vision is blurry → perhaps near vision is clear but distance vision is blurry.
BEFORE YOU PRESCRIBE	• Some conditions and medication can cause a person's refraction to change. These include: – people with diabetes – women who are pregnant – people taking some medications (including some anti-depressants, anti-psychotics and steroids).
PRESCRIBING SPECTACLES	• Always tell people that new spectacles take time to get used to: → Allow 2 weeks for adaptation → Tell the person to come back after 2 weeks if they are still having difficulties with their new spectacles.

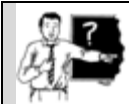
PRESCRIBING SPECTACLES FOR NEAR

At the end of your near refraction, you will have decided:

- if the person's chief complaint and symptoms are caused by a near vision problem
- whether or not near spectacles can be used to correct the person's problem
- what the spectacles should be used for (such as near tasks only).

Based on the person's case history, their visual needs, and their previous spectacles you will decide whether or not to prescribe:

- spectacles for all of the person's refractive error or only some of the person's refractive error
- more than one pair of spectacles for the person's different visual needs.

CASE HISTORY	The case history tells you what problems a person is having with their near vision. • What the person tells you about their near vision will help you decide what power near spectacles to prescribe. • Most people who are older than 40 years old will need spectacles to see clearly at near – but some do not.  If the person does not think that they have a problem seeing things that are close to them: Do not prescribe near spectacles!
VISUAL NEEDS	A person probably does not need near spectacles if: • they do not need to see things that are close to them well • they can see N8 without spectacles • they have a near prescription of less than +1.00 D. A person probably needs spectacles if: • they cannot see N8 without spectacles • they say that their near vision looks better with the new spectacle prescription for near. You also need to consider what type of near spectacle lenses a person may need: • single vision lenses • bifocal lenses • progressive lenses • readymade spectacles.  Sometimes a person needs more than one pair of spectacles for different tasks. Example: A man might like to wear bifocal spectacles to wear during the day, but he might also like another pair of single vision near spectacles to wear when he reads the newspaper in the evening.
PREVIOUS SPECTACLES	Always ask the person whether they have had spectacles for near work before: • Ask how old these spectacles are • Ask about their vision with these spectacles • Ask whether they like the spectacle frame • Measure the power of the spectacles • Let the person compare their vision with the new near prescription and with their previous spectacles. If the person already has near spectacles, usually you will prescribe new spectacles if: • the person cannot read N8 on the near chart with their previous spectacles • there is more than 0.50 D change in their prescription • their spectacles are more than 2 years old • the person says their vision is worse with their previous spectacles.

PRESCRIBING SPECTACLES FOR NEAR (cont.)

PREVIOUS SPECTACLES (cont.)	If the person has never worn near spectacles before, you may need to adjust their prescription: If their near prescription is quite high, you may need to prescribe weaker lenses initially, to make it easier for them to adapt to their new spectacles.
EXAMPLE	A woman comes to you and tells you that she is having trouble seeing at near to sew. She has never had spectacles before. Her refraction is: R plano L plano Add +2.25 You should think about prescribing only R +1.75 D L +1.75 D Her vision will still be much better, and she will be able to adjust to her new spectacles more easily than she would if you had prescribed the full near add – since this is her first time wearing spectacles.

THE NEAR ADD AND THE WORKING DISTANCE

PREFERRED WORKING DISTANCE	Although we usually measure the near addition at 40 cm (or the person's preferred working distance), we need to remember that usually people also need to see things that are a little further away from them.
EXAMPLES	- A carpenter needs to see the wood and tools that he is working with, but he also needs to see other things that are on his work table. - An office worker needs to be able to do her paperwork, but she also needs to be able to see the other things on her desk and her computer screen. - A cook needs to be able to see the vegetables that he is cutting, but he also needs to be able to watch the pot on the stove next to him.
PRESCRIBING WEAKER AND STRONGER ADDS	Sometimes you will need to prescribe a weaker or a stronger add. This usually depends on the person's visual needs. A weaker add may be prescribed if the person: - will only use their spectacles for a computer screen (this is usually further away than their normal reading distance) - has a special job where they need to be able to see things that are a bit further away clearly. A stronger add may be prescribed if the person: - wants to see things closer than their normal reading distance. → <i>For example:</i> A woman might like to hold her embroidery closer to her eyes than she would normally hold a book. - wants to see very small objects. If the add is increased the range of clear vision will move closer to the person – and when we hold things closer to our eyes they appear to be larger. This is like using a magnifying glass. → <i>For example:</i> A watch repairer may need to hold the watch 20 cm away from him to see the mechanics clearly. - has low vision. A high add may be necessary if the person cannot see clearly at a normal working distance. → <i>For example:</i> An elderly man can only see N12 with a +2.50 D add at 40 cm. If his add is increased to a high add of +4.00 D he can see N6 if he holds the reading card at 25 cm. The man will have to learn to hold things closer if he wants to wear a high add to see near objects clearly.

CHOICE OF LENS FOR SPECTACLES



Spectacles for near vision are sometimes called “reading” spectacles because they can help a person read.

However, near spectacles can also be used for other near tasks such as sewing, cooking, carving wood, weaving or making jewellery.

Different people use their vision for different tasks. This is why no one type of spectacle lens is right for every person. You need to discuss the different types of spectacle lenses that are available with the person; tell them about the advantages and disadvantages of each type of lens – then let them decide what type of lens they prefer.

SINGLE VISION LENSES

- These can be spherical lenses or astigmatic lenses, and have just one power.
- These spectacle lenses let a person see clearly at near, but if they look in the distance with these lenses, it will look blurry.
- Near spectacles with single vision lenses must be taken off if the person wants to look in the distance.
- Sometimes, instead of taking their spectacles off, the person can look over the top of their spectacles. If the person wants to do this, it is better if they have a small spectacle frame. Spectacles like this are sometimes called “look-overs”.
- If a person decides to get single vision near spectacles, you should show the person that their vision will be blurred in the distance by using the trial frame, otherwise the person might be surprised by and disappointed with their new spectacles.



Figure 24.1: A man wearing look-over reading spectacles. He looks through the near spectacle prescription lenses to read his book and looks over them to see things that are in the distance.

CHOICE OF LENS FOR SPECTACLES (cont.)

BIFOCAL LENSES

Bifocal spectacles have two powers in the same lens: the top part of the lens is for distance vision and the bottom part of the lens is for near vision.

The bottom part of the lens is often called a “segment”, or simply a “seg”.

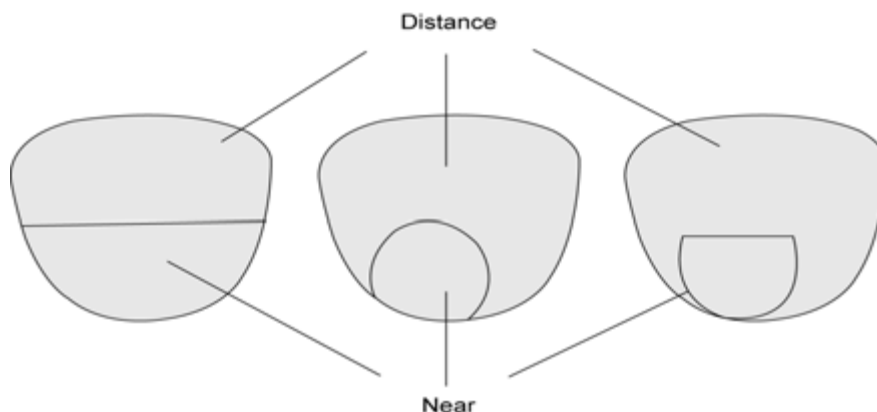


Figure 24.2: Bifocal lenses come in several different seg sizes and shapes

- Bifocal spectacles are more expensive than single vision spectacles.
- Bifocal lenses are useful if the person has a distance refractive error as well as needing a near add. Sometimes people have one pair of single vision spectacles for distance and one pair for near – but it can be inconvenient to change from one pair to the other throughout the day. Bifocal spectacles are more convenient because they can be left on all day.

Example: A teacher needs to see both her students and the book she reads from. Her distance refraction is -1.00 D and her add is $+2.50$ D. She will need to have -1.00 D in the top part of her bifocal lenses, and a total power of $+1.50$ D in the seg of her bifocal lenses.

- Bifocal spectacles can also be worn by people who have no distance refractive error. In this case, only the seg has focusing power – the top part of the lens has no power (plano).

Example: A ticket collector on the train needs to see both the passengers who get on the train, and the tickets that he needs to write. His distance refraction is plano and his add is $+2.00$ D.

He will need to have no power (plano) in the top part of his bifocal lens, and $+2.00$ D in the seg of his bifocal lens.

- Trifocal lenses are like bifocal lenses, but instead of having two focusing powers they have three. Trifocals have an intermediate section that is between the distance and near parts of a bifocal lens. The intermediate section can be useful for people who also want to see things that are at an intermediate distance (like a computer screen that is arm’s length away).

CHOICE OF LENS FOR SPECTACLES (cont.)

PROGRESSIVE LENSES	Progressive lenses are sometimes called “multifocal” or “graduated” lenses. • Progressive lenses are more expensive than both single vision and bifocal lenses. • Like a bifocal lens, a progressive lens has power for distance at the top of the lens and power for near at the bottom of the lens – but unlike a bifocal lens a multifocal lens has no lines on it (if you do not check carefully you may think it is a single vision lens!). • A progressive lens also has an intermediate section that is between the distance and the near parts of the lens. • Progressive lenses are useful for people who do not like the appearance of the line on bifocal lenses, and for people who wish to have clear intermediate, distance and near vision. • Progressive lenses must only be fitted by a trained spectacle technician. If the spectacle technician does not fit the lenses very carefully the person will not be able to see properly with their new spectacles. • People who wear progressive spectacles for the first time will usually need some time to adapt to their new spectacles. If the lenses have been fitted in the frame correctly they will usually adapt within 2 weeks. However, some people can never get used to wearing progressive lenses.
READYMADE SPECTACLES	• Custom-made spectacles (like single vision, bifocal or progressive spectacles) can be expensive. Readymade spectacles can be a good alternative for people who cannot afford expensive spectacles. • Readymade spectacles can be prescribed if: - both eyes have a similar refractive error - the person has comfortable vision when they wear the readymade spectacles - custom-made spectacles are not available. • There are no firm rules about when readymade spectacles are appropriate. The best idea is to let the person see the difference between the vision they get with readymade spectacles and the vision they get with their full refraction in the trial frame.

TELLING PEOPLE ABOUT THEIR NEW NEAR SPECTACLES

You have written a prescription for the person and the new spectacles are now ready to be given to the person. Before they leave with their new spectacles:

- Make sure the spectacles have been fitted correctly to the person's face.
Ask the person if the spectacle frame feels comfortable.
- Check the person's vision
 - Single vision spectacles:
 - ask the person to hold a near VA chart at their preferred working distance
 - ask the person if their vision is clear and comfortable
 - show the person that their distance vision is blurred with the spectacles and tell them that this is normal for this type lens
 - tell the person that they need to take their spectacles off if they are walking or if they want to see clearly in the distance.
 - Bifocal and progressive spectacles:
 - ask the person to hold a near VA chart at their preferred working distance
 - tell the person to look at the near VA chart, but not to lower their chin
(they must lower their eyes to look through the bottom part of the lens)
 - ask the person if their near vision is clear and comfortable
 - ask the person to look at a distance VA chart
 - ask the person if their distance vision is clear and comfortable.
- Tell the person it can take up to 2 weeks for people to get used to their new spectacles
 - especially if they have not worn spectacles previously.
- Tell the person how to look after their new spectacles:
 - show the person how to clean the spectacles
 - wash the spectacles with gentle soap and rinse in cold water
 - wipe them with a soft, clean cloth
 - tell the person not to put their spectacles down on their lenses
 - tell the person to keep their spectacles in a case or a safe place when they are not being used.
- Ask the person to come back and see you if they have any concerns.

SUMMARY: PRESCRIBING SPECTACLES FOR PRESBYOPIA

PRESCRIBING SPECTACLES FOR NEAR

Case history:

- What the person tells you about their near vision will help you decide what power near spectacles to prescribe.
- Most people who are older than 40 years old need spectacles to see clearly at near – but some do not.
- If the person does not think that they have a near vision problem – do not prescribe near spectacles.

Visual needs:

- A person probably does not need near spectacles if:
 - they do not need to see things that are close to them well
 - they can see N8 without spectacles
 - they have a near prescription of less than +1.00 D.
- A person probably needs near spectacles if:
 - they cannot see N8 without spectacles
 - they say that their near vision looks better with your near spectacle prescription.
- You need to consider what type of spectacles would best suit the person's lifestyle:
 - single vision spectacles
 - bifocal spectacles
 - progressive spectacles
 - readymade spectacles.
- Sometimes a person needs more than one pair of spectacles with different types of spectacle lenses.

Previous spectacles:

- Ask:
 - how old the previous spectacles are
 - what the vision is like with the previous spectacles
 - whether the person likes the spectacle frame.
- Measure the power of the previous spectacles.
- Let the person compare their vision with their previous spectacles and your near refraction findings.
- The person probably needs their spectacles changed if:
 - they cannot read N8 on the near chart with their previous spectacles
 - there is more than 0.50 D change in their prescription
 - their spectacles are more than 2 years old
 - the person says their vision is worse with their previous spectacles.
- If the person is wearing spectacles for the first time you may need to adjust the prescription.

THE NEAR ADD AND THE WORKING DISTANCE

Preferred working distance:

- Depending on the person's needs you may want to prescribe a weaker or stronger add to move the range of clear vision closer to or further away from the person.

Prescribing weaker and stronger adds:

- A weaker add may be necessary if the person wants to use their spectacles to see things that are further away than a normal working distance.
- A stronger add may be necessary if someone wants to see very small objects
 - a stronger add will let the person see clearly at a closer working distance
 - objects that are closer to our eyes appear bigger.
- A high add may be necessary for someone who has low vision
 - a high add will make it easier for the person to read, BUT they will have to use a closer working distance.

SUMMARY: PRESCRIBING SPECTACLES FOR PRESBYOPIA (cont.)

CHOICE OF LENS FOR NEAR SPECTACLES

Spectacles for near vision are sometimes called reading spectacles, but they can be used for many other near tasks too.

Single vision lenses:

- have just one power
- let a person see clearly at near, but the distance will be blurry.

Bifocal lenses:

- have a top part for distance vision and a bottom part ("seg") for near vision
- are more expensive than single vision lenses
- are useful for people who want to see clearly in the distance and at near without removing their spectacles.

Progressive lenses:

- also called "multifocal" or "graduated" lenses
- more expensive than bifocal and single vision lenses
- useful for people who do not like the appearance of the bifocal line, and for people who want to have clear intermediate vision too
- require careful fitting of the lenses.

Readymade spectacles:

- are much less expensive than custom-made spectacles (single vision, bifocals, progressives)
- can be prescribed if they are suitable and give comfortable vision to the person, and if they are happy with the vision that they get with them.

TELLING PEOPLE ABOUT THEIR NEW NEAR SPECTACLES

Before the person leaves with their new spectacles:

- make sure the spectacles are properly fitted
- make sure the spectacles give clear vision at near (and distance if appropriate)
- tell the person that it can take up to 2 weeks to adapt to new spectacles
- explain how to look after the new spectacles
- ask the person to come back to you if they have any concerns.

TEST YOURSELF QUESTIONS

1. Why is the case history important when deciding whether or not to prescribe near spectacles?

2. Write down two examples where people might need to be prescribed more than one pair of spectacles.

3. Why should you always let the person compare their previous spectacles and the new near prescription?

4. Give three examples of where a stronger add might need to be prescribed.

5. A person who cannot read does not need reading spectacles – true or false? Explain your answer.

☐ True ☐ False (please tick correct answer and explain below)

6. Complete the following table:

Lens or Spectacle Type	Advantages	Disadvantages
<i>Single Vision</i>		
<i>Bifocals</i>		
<i>Progressives</i>		
<i>Readymades</i>		



PRESCRIBING SPECTACLES FOR ASTIGMATISM

THINK

You do a refraction on a 25 year old woman and discover she has high astigmatism. She tells you that she wore spectacles when she was a small girl, but when they broke she was unable to get them replaced. She is hoping that you will be able to give her spectacles so she can see well again.

You know that people with astigmatism often have difficulty adjusting to their new spectacles. You know that this woman will probably feel uncomfortable if you prescribe her full prescription, so you decide to modify it to make her feel more comfortable. But how do you do this?

AIM

This unit explains how to prescribe astigmatic lenses for a person with astigmatism, so that they can have clear and comfortable vision.

LEARNING OUTCOMES

When you have completed this unit you should be able to:

- modify the cylinder power to make an astigmatic correction more comfortable for a person
- modify the cylinder axis to make an astigmatic correction more comfortable for a person.

REVIEW: PRESCRIBING SPECTACLES FOR ASTIGMATISM

ASTIGMATISM	Definition of astigmatism: - The light from an object does not focus evenly at one point in an eye with astigmatism. - Astigmatism may occur just by itself, or in an eye which also has another type of refractive error. Causes of astigmatism: - An astigmatic eye does not have the same curvature in all meridians (directions). - It is helpful to imagine the corneal surface of an eye with astigmatism to be shaped like the surface of a rugby ball or an egg (this is called a toric surface) – even though if you look at the eye of a person with astigmatism it will seem round. - There are two principal meridians in an astigmatic eye and these meridians are perpendicular to each other. Accommodation and astigmatism: - If the amount of accommodation is small and the person is young, the eye can accommodate to make the vision clearer. This can cause asthenopia and/or headaches. Symptoms of astigmatism: - Distance and near vision may be blurred. - Vision may be clear but the person may have asthenopia or headaches – especially in young people with only a small amount of astigmatism. Correction for astigmatism: - Corrected with astigmatic lenses. - Astigmatic lenses can be cylindrical or sphero-cylindrical. - Cylindrical lenses correct eyes with only astigmatism. - Sphero-cylindrical lenses correct eyes with astigmatism and another refractive error. - The axis of an astigmatic lens must be correct in front of the eye to give clear vision – especially for high powered astigmatic lenses. - It is often difficult for people with astigmatism to get used to wearing their new spectacles. Usually a person will adapt to their new glasses within 2 weeks. - Sometimes it is better to give a newly-diagnosed astigmat only a partial correction to help them adapt.
REFRACTION CHECK	- When you have finished your refraction, you need to double check your results. → is the person's vision clear and comfortable? - Show the person the limitations of their new spectacles → perhaps distance vision is clear but near vision is blurry → perhaps near vision is clear but distance vision is blurry.
BEFORE YOU PRESCRIBE	- Some conditions and medication can cause a person's refraction to change. These include: – people with diabetes – women who are pregnant – people taking some medications (including some anti-depressants, anti-psychotics and steroids).
PRESCRIBING SPECTACLES	- Always tell people that new spectacles take time to get used to → Allow 2 weeks for adaptation → Tell the person to come back after 2 weeks if they are still having difficulties with their new spectacles.

PRESCRIBING SPECTACLES FOR ASTIGMATISM

Spectacles that have astigmatic lenses are more difficult for people to adapt to than spectacles that only have spherical lenses. For this reason you must be especially careful when choosing which lenses to prescribe for a person who has astigmatism.

How well a person will adapt to their astigmatic lenses depends on the:

- cylindrical power → high powers are more difficult to adapt to
- cylindrical axis → oblique axes are more difficult to adapt to
- person's previous spectacles
- person's sensitivity.

CYLINDER POWER	Depending on a person's previous spectacles and sensitivity, you can prescribe: • their full astigmatic correction • no astigmatic correction • a partial astigmatic correction.
CYLINDER AXIS	Depending on a person's previous spectacles and sensitivity, you can prescribe the cylindrical power at: • its exact axis • a modified axis.  Sometimes you will need to modify the cylinder power, the cylinder axis, or both, in order to make the person's vision comfortable.

CYLINDER POWER

PRESCRIBING THE FULL ASTIGMATIC CORRECTION

- The full astigmatic correction is the total cylindrical or sphero-cylindrical power that you found during your sphero-cylindrical refraction.
 - Prescribing the full astigmatic correction will give the person the clearest vision possible – but it will not always be comfortable for the person.
- A full astigmatic correction can be prescribed for a person who:
- has previously worn spectacles with the same amount of cylindrical power
 - has previously worn spectacles with cylindrical power that is less than 1.00 DC different from their current refraction
 - has never worn spectacles before, but has less than 1.00 DC astigmatism
 - is comfortable wearing the full astigmatic correction when they walk around and try it in the trial frame
- make sure you let them look at different things at different distances and give them enough time to decide
- you believe will adapt to their new spectacle prescription.



Let the person wear the trial frame and look at different things.

Encourage the person to:

- walk around your refraction clinic: look at the floor, walls and ceiling
- look outside your refraction clinic: look at the street, the people, the horizon and the sky.

Ask the person if they feel comfortable wearing these lenses:

- Do the walls and ceiling look smooth and straight? Or do they look like they are curved or on an angle?
- Does the floor look flat? Or does it look like it is sloping?
- Does the street outside seem regular? Or does it look strange?

PRESCRIBING NO ASTIGMATIC CORRECTION

Sometimes you will prescribe spherical lenses only for a person – even though they have astigmatism. This may be because:

- the person only has a small amount of astigmatism
- you do not have astigmatic lenses to give the person
- you wish to prescribe or the person may want readymade spectacles (readymade spectacles come with spherical lenses only)
- the person has had problems adapting to even small amounts of cylindrical power in the past.

If you choose to prescribe spherical lenses only:

- Only the person's myopia or hyperopia will be corrected
 - astigmatism cannot be corrected by spherical lenses
 - astigmatism can only be corrected by astigmatic lenses (cylindrical or sphero-cylindrical lenses).
- The person's visual acuity (VA) will probably not be as good as it would be with their full astigmatic correction.

If you decide to prescribe no astigmatic correction, you must:

- convert your refraction to an equivalent sphere
- prescribe the equivalent sphere.

CYLINDER POWER (cont.)

CALCULATING EQUIVALENT SPHERE	To calculate the equivalent sphere you must add half the power of the cylinder to the power of the sphere: Equivalent Sphere = Power of Sphere + $\frac{1}{2}$ Power of Cylinder
EXAMPLES	- Refraction is +3.00 / -1.00 x 90 Equivalent sphere = +3.00 + ($\frac{1}{2}$ x -1.00) = +2.50 D sphere - Refraction is -2.00 / -2.00 x 135 Equivalent sphere = -2.00 + ($\frac{1}{2}$ x -2.00) = -3.00 D sphere - Refraction is +0.75 / -1.50 x 155 Equivalent sphere = +0.75 + ($\frac{1}{2}$ x -1.50) = plano - Refraction is -0.50 / -0.75 x 180 Equivalent sphere = -0.50 + ($\frac{1}{2}$ x -0.75) = -0.50 - 0.375 → round down to less minus = -0.50 - 0.25 = -0.75 D sphere.  BE CAREFUL! If the person has previously worn a full astigmatic correction and you decide not to give them any astigmatic correction: → they may feel uncomfortable in their new spectacles → they may have problems adapting to their new spectacles. Always trial frame the prescription you want to give the person first!
PRESCRIBING A PARTIAL ASTIGMATIC CORRECTION	Sometimes you will prescribe a partial astigmatic correction for a person – instead of their full correction. This may be because: - you are concerned that the person will not adapt to their full refraction - you want to give them some of their astigmatic correction to improve their vision. If you choose to prescribe only a partial correction: - only some of the person's astigmatism will be corrected - the person's VA will probably be → worse than their VA with their full astigmatic correction → better than their VA with no astigmatic correction. If you choose to prescribe only a partial correction you must: - convert the cylinder amount that you do not prescribe into an equivalent sphere - add this equivalent sphere to the spherical part of your prescription=/*

CYLINDER POWER (cont.)

EXAMPLES

- **Refraction is +4.00 / -3.00 x 90**
 - You decide to only prescribe -1.00 DC of the cylindrical power
 - This leaves -2.00 DC that you must convert to an equivalent sphere.
$$\begin{aligned}\text{Equivalent sphere of } -2.00 \text{ DC} &= \frac{1}{2} \times -2.00 \\ &= -1.00 \text{ D}\end{aligned}$$

Add the equivalent sphere to the spherical part of your prescription:
 $+4.00 + -1.00 = +3.00$

Your partial correction is: +3.00 / -1.00 x 90
- **Refraction is -2.50 / -2.50 x 45**
 - You decide to only prescribe -1.50 DC of the cylindrical power
 - This leaves -1.00 DC that you must convert to an equivalent sphere.
$$\begin{aligned}\text{Equivalent sphere of } -1.00 \text{ DC} &= \frac{1}{2} \times -1.00 \\ &= -0.50 \text{ D}\end{aligned}$$

Add the equivalent sphere to the spherical part of your prescription:
 $-2.50 + -0.50 = -3.00$

Your partial correction is: -3.00 / -1.50 x 45
- **Refraction is +1.25 / -3.50 x 180**
 - You decide to only prescribe -1.00 DC of the cylindrical power
 - This leaves -2.50 DC that you must convert to an equivalent sphere.
$$\begin{aligned}\text{Equivalent sphere of } -2.50 \text{ DC} &= \frac{1}{2} \times -2.50 \\ &= -1.25 \text{ D}\end{aligned}$$

Add the equivalent sphere to the spherical part of your prescription:
 $+1.25 + -1.25 = \text{plano}$

Your partial correction is: plano / -1.00 x 180
- **Refraction is +3.25 / -2.25 x 60**
 - You decide to only prescribe -1.00 DC of the cylindrical power
 - This leaves -1.25 DC that you must convert to an equivalent sphere.
$$\begin{aligned}\text{Equivalent sphere of } -1.25 \text{ DC} &= \frac{1}{2} \times -1.25 \\ &= -0.62 \\ &\rightarrow \text{round down to less minus} \\ &= -0.50\end{aligned}$$

Add the equivalent sphere to the spherical part of your prescription:
 $+3.25 + -0.50 = +2.75$

Your partial correction is: +2.75 / -1.00 x 60



If you prescribe a partial correction tell the person that:

- you are giving them a weaker version of their full correction so that it will be easier for them to get used to their new spectacles
- next time they need new spectacles you will be able to give them more (or all) of their full correction
- their partial correction is like a stepping stone to their full correction.

Show the person their partial correction in the trial frame to make sure that the person:

- feels comfortable with the lenses
- is happy with the vision they get with the lenses.

CYLINDER AXIS

Astigmatic lenses that are at an oblique axis are more difficult for people to adapt to than astigmatic lenses that have a vertical or horizontal axis.

→ an oblique axis is an axis that is at an angle (not at 90° or 180°).

Depending on the person's previous spectacles and sensitivity, you may choose to rotate an oblique axis so that it is closer to 90° or 180° .

PRESCRIBING A CYLINDER AT ITS EXACT AXIS	This will give the person the clearest vision, but if the person's exact axis is at an oblique angle they may have difficulty adapting to it. A cylinder can be prescribed at its exact axis if: - the person is comfortable wearing the lenses in a trial frame - the cylinder axis of the person's previous spectacles was also at (or close to) this axis.
PRESCRIBING A CYLINDER AT A MODIFIED AXIS	- If the cylinder lens is rotated away from its exact axis the vision will not be as clear – but it may be necessary to help a person feel more comfortable wearing their spectacle lenses. - The amount that you choose to rotate the axis will need to be a compromise between vision and comfort: → the more you rotate the cylinder away from the exact axis, the worse the vision will be → most people will feel more comfortable if the axis is rotated towards 90° or 180° (whichever is closest).  Cylinders with a low power can be rotated more than cylinders with a high power, whilst still maintaining good vision. Usually we do not rotate the axis of the cylinder more than 20 to 30 degrees – even for low cylinder powers.

SUMMARY: PRESCRIBING SPECTACLES FOR ASTIGMATISM

- Spectacles that have astigmatic lenses are more difficult for people to adapt to than spectacles that only have spherical lenses.
- A person will have more difficulty adapting to a spectacle lens that has a high cylinder power and an oblique axis of astigmatism, especially if they have not had a similar astigmatic prescription before.

CYLINDER POWER

Prescribing the full astigmatic correction:

- Will give the clearest vision possible – but it will not always be comfortable for the person.

Prescribing no astigmatic correction:

- Can make the person feel more comfortable, but the vision will not be as good.
- If you decide to prescribe no astigmatic correction you must prescribe the equivalent sphere of the spherocylindrical refraction.

$$\text{Equivalent Sphere} = \text{Power of Sphere} + \frac{1}{2} \text{Power of Cylinder}$$

Prescribing a partial astigmatic correction:

- Prescribing a partial astigmatic correction is a compromise between making the person feel comfortable and giving them good vision.
- If you decide to prescribe a partial astigmatic correction you must:
 - convert the cylinder that is not prescribed into an equivalent sphere
 - add this equivalent sphere to the spherical part of your prescription.

CYLINDER AXIS

- Astigmatic lenses at an oblique axis are more difficult to adapt to than those at 90° or 180°.

Prescribing a cylinder at its exact axis:

- Will give the best vision, but if the person's exact axis is at an oblique angle they may have difficulty adapting to it, especially if they have not worn an astigmatic prescription like this before.

Prescribing a cylinder at a modified axis:

- If the cylinder lens is rotated away from its exact axis the vision will not be as clear – but it may be necessary to help a person feel more comfortable wearing their spectacle lenses.
- Most people will feel more comfortable if the axis is rotated towards 90° or 180° (whichever is closest).

TEST YOURSELF QUESTIONS

1. Which astigmatic corrections are the most difficult for people to adapt to?
-
-
-

2. When can you prescribe the full astigmatic correction for a person?
-
-

3. When should you prescribe a partial astigmatic correction for a person?
-

4. You refract a person and find that his refractive error is: R $+3.50 / -2.00 \times 180$ L $+3.75 / -2.50 \times 180$. Because he has never had astigmatic lenses before, you decide to only prescribe -1.00 DC of the cylindrical power for both eyes. What is your final prescription for this person?

5. A person's refraction is: R $-1.00 / -1.25 \times 160$ L $-1.25 / -1.50 \times 20$
This person has never worn spectacles before, so you decide to rotate the axis of the cylinder lenses make the prescription more comfortable for the person to wear. Do you rotate the lenses towards 90° 180° ? Why?
-
-

6. It is always important to allow a person to try your final prescription by wearing the lenses in a trial frame. What activities should you ask the person to do while wearing the trial frame? What should you ask them to pay attention to?
-
-
-

NOTES



PRESCRIBING READYMADE SPECTACLES

THINK

A 55 year old woman sees perfectly in the distance, but needs to get spectacles to help her sew. She looks at the spectacle frames that you have on display in your clinic, but she is worried when you tell her how much custom-made spectacles cost. She thinks that she will not be able to get spectacles after all.

You show the woman the readymade spectacles that you have available and she is delighted that you have a low cost option for her.

AIM

This unit provides recommendations and guidelines for prescribing readymade spectacles.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- explain the situations when you can prescribe readymade spectacles
- prescribe readymade spectacles
- select a readymade spectacle frame that best fits a person.

REVIEW: PRESCRIBING READYMADE SPECTACLES

REFRACTION CHECK	- When you have finished your refraction, you need to check your results to make sure that the person's vision is clear and comfortable. - Show the person the limitations of their new spectacles → perhaps distance vision is clear but near vision is blurry → perhaps near vision is clear but distance vision is blurry.
BEFORE YOU PRESCRIBE	- Some conditions and medication can cause a person's refraction to change. These include: – people with diabetes – women who are pregnant – people taking some medications (including some anti-depressants, anti-psychotics and steroids).
PRESCRIBING SPECTACLES	- Always tell people that new spectacles take time to get used to → Allow 2 weeks for adaptation → Tell the person to come back after 2 weeks if they are still having difficulties with their new spectacles.
READYMADE SPECTACLES	- Much less expensive than custom-made spectacles (such as single vision, bifocal, and progressive spectacles). - Can be prescribed if they give comfortable vision to the person, and if the person is happy with the vision that they get with them.
PRESCRIBING CORRECTION FOR A PERSON WHO HAS ASTIGMATISM	- There are several prescribing options for astigmatism: – full astigmatic correction – partial astigmatic correction – no astigmatic correction. - If you decide to prescribe a partial astigmatic correction or no astigmatic correction the person's vision will not be as clear as it would be with a full astigmatic correction. - If you decide to prescribe no astigmatic correction you must calculate the equivalent sphere of the cylinder and add it to the sphere of your final prescription. - Equivalent Sphere = Power of Sphere + $\frac{1}{2}$ Power of Cylinder
INTERPUPILLARY DISTANCE (PD)	- PD is the distance (in mm) between a person's pupils. - Spectacles must be made with the correct PD. If spectacles are made with the wrong PD, the person's eyes will not be comfortable and they might not be able to wear them.

READYMADE SPECTACLES

WHAT ARE READYMADE SPECTACLES (RMS)?	• Mass-produced spectacles that are not made individually to suit each person. • Available in a limited range of powers and styles. Usually: → ± 1.00 D to ± 4.00 D: in 0.50 D steps → ± 4.00 D to ± 6.00 D: in 1.00 D steps • Both the right and the left lenses are the same power • Use spherical lenses only – no astigmatic correction • The interpupillary distance (PD) of ready-made spectacles cannot be changed to suit each person • Usually made with single vision lenses only • Occasionally bifocal lenses are available – but these are rare: → top part (for distance vision) is always plano → bottom “seg” part (for near vision) is a plus sphere.
ADVANTAGES OF RMS	• Much less expensive than custom-made spectacles because they are mass-produced. • Stock of RMS can be kept in the clinic so that they can be given to the person immediately – the person does not need to wait for their spectacles to be made, or come back to collect them. • Will adequately correct the refractive errors of a large percentage of people.
DISADVANTAGES OF RMS	• Do not always fully correct a person's refractive error → in most cases RMS will be good enough → in some cases RMS will not help the person and they must get custom-made spectacles. • If the distance between the optical centres of the lenses and the person's PD is very different (especially for higher powered RMS) the person may get asthenopia or double vision. • Available in a limited range of powers and styles; not suitable for high power prescriptions. • Have the same powers for right and left lenses, so may not be suitable for people with anisometropia. • Not available in astigmatic correction.  You can ask the person to try the RMS in your clinic: – Ask the person if their vision is clear – Ask the person if their eyes feel comfortable – Show the person the difference between the RMS and their prescription lenses in the trial frame; ask the person if they notice much difference – Tell the person the cost of RMS compared with custom-made spectacles. If the person tells you that their vision is clear and their eyes feel comfortable, you can prescribe RMS – but let the person make the final decision.

PRESCRIBING RMS

WHEN TO PRESCRIBE RMS	You can prescribe RMS for a person if: - the person's prescription is less than ± 6.00 D (unless there are no custom-made spectacles available) - there is less than 1.00 D of anisometropia (difference in power between the right and left eyes) - there is less than -1.00 DC of astigmatism - the person says that they see clearly with the RMS, they are happy with the look of the RMS and that their eyes feel comfortable when they wear them.
IF REFRACTIVE ERROR IS SPHERICAL AND THE SAME IN BOTH EYES	- Choose the exact RMS power that the person needs. - If the exact RMS power is not available, choose the power that is slightly weaker than the person needs.
IF REFRACTIVE ERROR IS SPHERICAL AND DIFFERENT IN EACH EYE	- If anisometropia is greater than 1.00 D the person probably cannot wear RMS – they will need custom-made spectacles instead. - If anisometropia is less than 1.00 D the person can probably wear RMS. Readymade spectacles have the same lens power for both eyes. If a person has a different refractive error for each of their eyes only one of the eyes can be fully corrected. You can: - fully correct the eye needing the weaker lens, and under-correct the other eye (give less power than is needed), or - fully correct the eye needing the stronger lens, and overcorrect the other eye (give more power than is needed). To decide which power of RMS to prescribe, think about: - Refractive error → usually we correct the eye that needs the weakest power - Visual acuity (VA). → if one eye has poor VA, always give the RMS power that best corrects the "good" eye. - Age → if a presbyopic person needs distance spectacles, you might decide to give them the exact power for one eye and more plus for the other eye (this can give them a small amount of monovision and help them see things that are closer to them as well as things in the distance).  If you have trouble deciding between two RMS powers: - let the person try two pairs of RMS with the two different powers - ask the person which pair of RMS they prefer (based on vision and comfort). Be careful! If you show the person two different frame styles they may think that you want them to choose based on the appearance of the frames, not the vision they get with the lenses! Good communication is extremely important!

PRESCRIBING RMS (cont.)

EXAMPLE 1	A 30 year old man has this refractive error: R +3.00 D (6/6-) L +3.75 D (6/6-) You need to choose whether to correct the right eye or the left eye: → You would probably choose to correct the right eye because we usually correct the eye that needs the weakest power. You decide to prescribe +3.00 D RMS.
EXAMPLE 2	A 25 year old woman has this refractive error: R -3.00 D (6/6) L -2.25 D (6/6) You need to choose whether to correct the right eye or the left eye: → You would probably choose to correct the left eye because we usually correct the eye that needs the weakest power. You do not have a pair of -2.25 D RMS, but you do have -2.00 D RMS and -2.50 D RMS. You let the woman try on both the -2.00 D RMS and -2.50 D RMS, and ask her which one she prefers, since both could be suitable. → The -2.00 D would be good as we usually correct the eye that needs the weakest power → The -2.50 D would also be good as it is still weaker than the power needed for the other eye. You give the woman a pair of each to try on: → The woman tells you that she prefers her vision with the -2.50 D RMS and her eyes feel comfortable. You prescribe the -2.50 D RMS preferred by the woman.
EXAMPLE 3	A 26 year old woman has this refractive error: R -3.50 D (6/18) L -4.00 D (6/6) Her right eye was damaged by a stone when she was a child and she was told she would never see well with it. You need to choose whether to correct the right eye or the left eye: → You would probably choose to correct the left eye because even though it needs a stronger power, it has the best VA. → Because the vision in her right eye is poor, she will be unaffected by the overcorrection in that eye. You decide to prescribe -4.00 D RMS.
EXAMPLE 4	A 45 year old man has this refractive error: R +2.00 D (6/6-) L +2.50 D (6/6-) Add +1.50 You decide to give him two pairs of spectacles: one pair for near work and one pair for distance. • Near spectacles: You need to choose whether to correct the right eye or the left eye: - +3.50 D RMS will fully correct his near vision for his right eye - +4.00 D RMS will fully correct his near vision for his left eye. → You would probably choose to correct the right eye because we usually correct the eye that needs the weakest power. You prescribe +3.50 D RMS for near work.

PRESCRIBING RMS (cont.)

EXAMPLE 4 (cont.)	• Distance spectacles You need to choose whether to correct the right eye or the left eye: – +2.00 D RMS will fully correct his distance vision for his right eye – +2.50 D RMS will fully correct his distance vision for his left eye. → Usually you would choose to correct the right eye (the eye that needs the weakest power), BUT → This man is a presbyope so: - if you fully correct his left eye (with +2.50 D RMS) his right eye will be over-corrected by +0.50 D - An over-correction in his right eye is like a “mini-Add” - With a +0.50 Add the man may be able to see things that are at an intermediate distance (like people standing close to him) - This is a type of monovision. You are still not sure whether to prescribe +2.00 D RMS or +2.50 D RMS so you give the man a pair of each to try on: → The man tells you that he prefers his vision with the +2.50 D RMS and his eyes feel comfortable. You prescribe +2.50 D for distance.
IF REFRACTIVE ERROR IS ASTIGMATIC	• If the person has more than –1.00 DC astigmatism, they probably cannot wear RMS and will need custom-made spectacles instead. • If the person has less than –1.00 DC astigmatism they can probably wear RMS – but their vision will not be as good as it would be if they wore custom-made spectacles. To prescribe RMS for a person with astigmatism, you must use the: • best vision sphere (BVS), or • equivalent sphere. To calculate equivalent sphere use this formula: <i>Equivalent Sphere = Power of Sphere + ½ Power of Cylinder</i>
EXAMPLE 5	You decide that RMS are suitable for a 35 year old man who has this refractive error: R +3.25 / –0.50 x 170 (6/6) L +3.25 / –0.75 x 10 (6/6) Calculating equivalent sphere for the right eye: Equivalent sphere = +3.25 + (½ x –0.50) = +3.25 – 0.25 = +3.00 D sphere Calculating equivalent sphere for the left eye: Equivalent sphere = +3.25 + (½ x –0.75) = +3.25 – 0.375 = +2.875 D → round down to less minus = +2.75 D sphere You need to choose whether to correct the right eye or the left eye: → You would probably choose to correct the left eye because we usually correct the eye that needs the weakest power. You do not have a pair of +2.75 D RMS, but you do have: → +2.50 D RMS and +3.00 D RMS. You are still not sure whether to prescribe +2.50 D RMS or +3.00 D RMS so you give the man a pair of each to try on: → The man tells you that he prefers his vision with the +3.00 D RMS and his eyes feel comfortable. You prescribe +3.00 D RMS.

PRESCRIBING SPECTACLES

INTERPUPILLARY DISTANCE (PD) AND OPTICAL CENTRES	• Custom-made spectacles should be made so that the optical centres of the lenses are the same distance apart as the pupils of the person's eyes. • If the optical centres of the lenses are not the same distance apart as the pupils of the eyes, prism will be created in the spectacles. • If there is unwanted prism in a pair of spectacles, it can cause the person to have asthenopia or double vision. • Problems with unwanted prism are more likely to occur for lens powers greater than ± 3.00 D.
READYMADE SPECTACLES AND OPTICAL CENTRES	• The optical centres of RMS lenses are usually in the centre of each lens. (For custom-made spectacles the optical centres can be anywhere, not just in the centre.) • If the optical centres are in the middle of the lenses, you can measure the distance between the optical centres of a pair of RMS by using a rule to measure the distance between the two lenses. An easy way to do this is to position your rule as shown below: Figure 26.1: Measuring the distance between the optical centres of RMS using a rule. This pair of RMS probably has 64 mm between the optical centres of each lens. BUT BE CAREFUL! Not all RMS are manufactured this way. Some RMS do not have their optical centres in the centre of each lens. If you want to be sure of the distance between the optical centres you must use hand neutralisation or vertometry. → This is good to do if you have ordered a new type of RMS and you want to be sure that the optical centres are in the centre of the lens.
CHOOSING THE BEST RMS FRAME FOR A PERSON	The best RMS frame for a person is a frame that is the correct size for them: → The person's PD should be similar to the distance between the optical centres of the lenses of the RMS. → This means that the person is most likely to be looking through the optical centres of the lenses. → If the frame is too big or too small, the person may not be looking through the optical centres and may get asthenopia or double vision.

SUMMARY: PRESCRIBING READYMADE SPECTACLES

READYMADE SPECTACLES

What are Readymade Spectacles?

- Mass-produced spectacles that are not made individually to suit each person.
- Have a limited range of powers and styles.
- Right and left lenses have the same powers.
- Spherical lenses only.
- Distance between the optical centres of the lenses cannot be changed.

Advantages of RMS:

- Less expensive than custom-made spectacles.
- Easy to keep in stock and dispense at the time of the eye exam.
- Person does not have to wait for them to be made or come back to collect them.
- Correct a vast percentage of people's refractive errors.

Disadvantages of RMS:

- Usually will not perfectly correct a person's refractive error.
- If the distance between the optical centres of the lenses and the person's PD is very different the person may get asthenopia or double vision.

Ask the person to try the RMS in your clinic and decide for themselves:

- Ask if the vision is clear and if their eyes feel comfortable.
- Show the difference between the RMS and your refraction lenses in a trial frame.
- Tell the person the difference in cost.

PRESCRIBING RMS

When to Prescribe RMS:

- If the person's refraction is ± 6.00 D.
- If there is less than 1.00 D anisometropia.
- If astigmatism is less than -1.00 DC.
- If the person says that they see clearly and comfortably with the RMS.

If Refractive Error is Spherical and the Same in Both Eyes:

- Choose the exact RMS power the person needs.
- If the exact power is not available, choose a RMS power that is slightly weaker than the person needs.

If Refractive Error is Spherical and Different in Each Eye:

Think about:

- Refractive error → correct eye that needs the weakest power.
- Visual acuity → correct the "good" eye.
- Age → consider over-plusing one eye for distance to give more near vision.

SUMMARY: PRESCRIBING READYMADE SPECTACLES (cont.)

PRESCRIBING RMS (cont.)

If Refractive Error is Astigmatic:

To prescribe RMS use the:

- BVS
- or
- Equivalent sphere.

If you have trouble deciding:

- Let the person try on the two powers of RMS.
- Ask them which one they prefer.

PD AND RMS FRAME SELECTION

PD and Optical Centres:

- Spectacles should be made so the distance between the optical centres of each lens is similar to the person's PD.
- If this is not done, unwanted prism can be created which can give the person asthenopia or double vision.

RMS and Optical Centres:

- The optical centres of RMS lenses are usually in the centre of each lens.
- If so, the distance between the optical centres can be measured with a rule.
- If the optical centres of the RMS are not in the centres of the lenses, only hand neutralisation or vertometry can measure the distance between the two optical centres.

Choosing the Best RMS Frame for a person:

- The person's eyes should look through the centres of the RMS lenses.
- If the frame is too big or too small; the person may not be looking through the optical centres and may get asthenopia or double vision.

TEST YOURSELF QUESTIONS

1. Complete the following table:

ADVANTAGES OF RMS	DISADVANTAGES OF RMS

2. Usually, if the right and left eyes have different refractive errors, we choose to correct the eye that needs the weaker powered lens – but there are some exceptions:

a) When would you choose to over-correct one eye with too much plus?

Why?

b) When would you choose to over-correct one eye with too much minus?

Why?

3. A 34 year old woman has this refractive error: R +3.50D (6/6-2) L +4.25D (6/6-2)

What power of RMS would you prescribe for distance? _____

Why? _____

4. A 35 year old man has this refractive error: R -3.00D (6/6) L -2.50D (6/24)

He had an operation on his left eye a year ago, but was told that he would always see badly with his left eye. What power of RMS would you prescribe? _____

Why? _____

5. A 20 year old man has this refractive error: R -2.50D (6/6) L -1.75D (6/6)

What power of RMS would you prescribe? _____

Why? _____

6. A 25 year old woman has this refractive error: R -1.75/-0.25x40 (6/6) L -2.25/-0.75x125 (6/6)

What power of RMS would you prescribe? _____

Why? _____

ADJUSTMENT AND CARE OF SPECTACLES

THINK

A man comes to your clinic with the spectacles that you made for him. He tells you that although he sees well with his new spectacles, he cannot wear them because they hurt the backs of his ears too much.

A person may see well with spectacles, but if they do not fit comfortably they will not want to wear them.

AIM

This unit will show you how to adjust spectacle frames so that they fit a person comfortably, and what to tell people about caring for their spectacles.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- name the different parts of a spectacle frame and describe what each part is for
- help a person choose a spectacle frame that fits them well
- adjust a new spectacle frame for a person
- re-adjust an old spectacle frame for a person
- tell people how to care for their spectacles.

OPTICAL SPECTACLES

- Optical spectacles (or simply, “spectacles” or “glasses”) are made by fitting optical lenses into a spectacle frame.
- Spectacle frames come in a variety of sizes, styles and frame materials.

SPECTACLE FRAME MATERIALS

Spectacle frames can be made from many different materials.

The most common spectacle frame materials are:

- metal
- plastic.

Metal Frames

Advantages:

- Light to wear.
- Easy to adjust the fit.
- Adjustable nose pads, so comfortable on the nose.

Disadvantages:

- Can corrode (turn green) or rust.
- Corroded surfaces can cause skin problems.

Plastic Frames

Advantages:

- Available in bright colours.
- Can be light to wear.

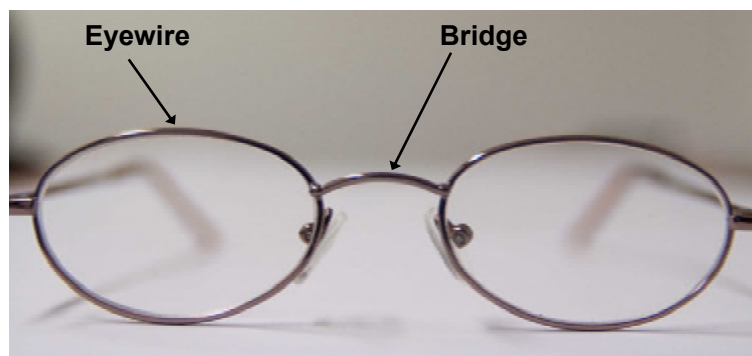
Disadvantages:

- Become brittle with age – can break easily when the frames become old.
- Require heat to adjust the fit.

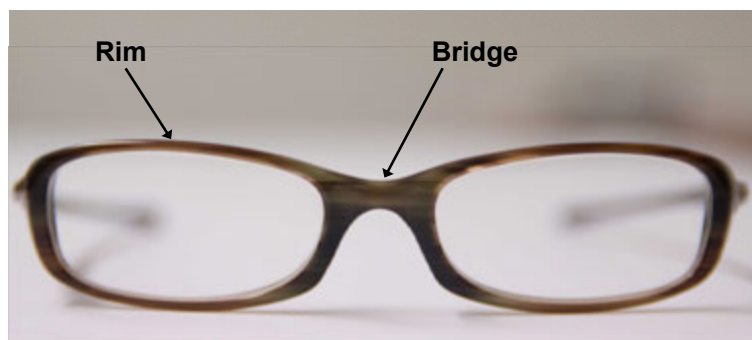
SPECTACLE FRAME PARTS

FRAME FRONT

- The frame front is the largest part of a spectacle frame.
- It is made up of the
 - eyewire or rim
 - bridge.



Metal spectacle frames



Plastic spectacle frames

Figure 27.1: The frame front of metal and plastic spectacles

EYEWIRE OR RIM

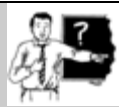
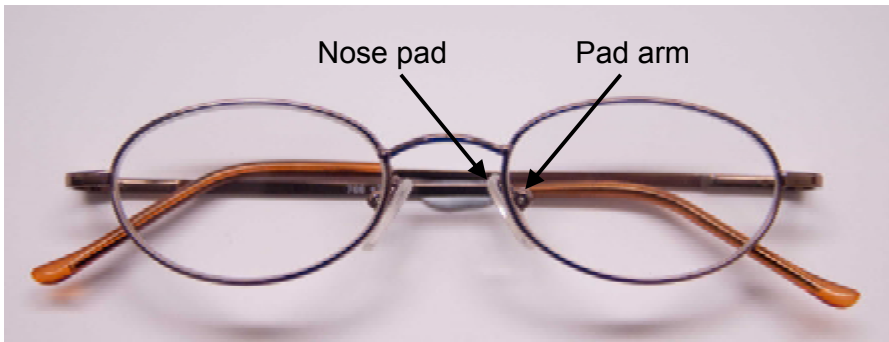
- This part of the frame has a different name depending on whether the frame is metal or plastic:
 - A metal frame has an eyewire
 - A plastic frame has a rim.
- Every spectacle frame has two eyewires or rims – one for each eye.
- The eyewires or rims hold the spectacle lenses in the spectacle frame.
- To fit a lens into a metal spectacle frame:
 - a screw is loosened on the side of the eyewire
 - the eyewire opens
 - the lens is fitted inside the eyewire
 - the screw is tightened to keep the lens in place.
- To fit a lens into a plastic spectacle frame:
 - the frame must be heated carefully to allow it to stretch
 - the lens is pushed into the rim
 - the frame is allowed to cool.



Some metal readymade spectacle frames do not have screws on the eyewires.

Readymade spectacle frames are not usually suitable for fitting new spectacle lenses into. They are only used with the lenses they come with.

SPECTACLE FRAME PARTS (cont.)

BRIDGE	The bridge is the part of the frame that joins the two eyewires or rims together.  The bridge of a pair of spectacles is the middle part of the frame that joins the two eyewires or rims together. The bridge of a person's nose is the top of their nose (between their eyes and below their forehead).
NOSE PADS	Nose pads are the only part of the spectacle frame that should touch a person's face. Metal Frames - Two nose pads are attached to the front of metal frames below the bridge. Some nose pads are attached by screws, while other nose pads are simply pushed into position. - Each nose pad is attached to one of the eyewires by a small pad arm. The pad arm allows the angle of the nose pad to be adjusted to suit the shape of a person's nose. Each nose pad should lie flat against the side of the wearer's nose. - Nose pads are usually made of plastic or silicone and they come in different shapes and sizes. - Nose pads are translucent (clear) in colour when they are new. - Perspiration (sweat) and time will discolour the nose pads – usually they will become brown or green. - Nose pads can easily be replaced if necessary. Plastic Frames - Plastic frames do not have separate nose pads. - Plastic frames have the sides of their rims shaped so that they rest comfortably on the nose. - If the plastic frame does not rest comfortably on the person's nose, the nose pad area cannot be adjusted. - The person will need to choose a different spectacle frame.  Figure 27.2: Metal spectacle frames with nose pads attached to the eyewires with pad arms

SPECTACLE FRAME PARTS (cont.)

TEMPLES

- The temples are the side parts of the spectacle frame that hold the frame front to the sides of the person's head
 - They are sometimes called the "arms" of the frame.
- The temples extend from the frame front along the sides of the person's head and wrap around their ears.
 - The temples attach to the frame front with hinges.
 - The part of the temple that wraps around the ears is called the temple tip.
- Metal frames usually have metal temples, but the temple tip is typically coated in plastic.
- Plastic frames usually have plastic temples, but they typically have a metal wire inside them to make them stronger.

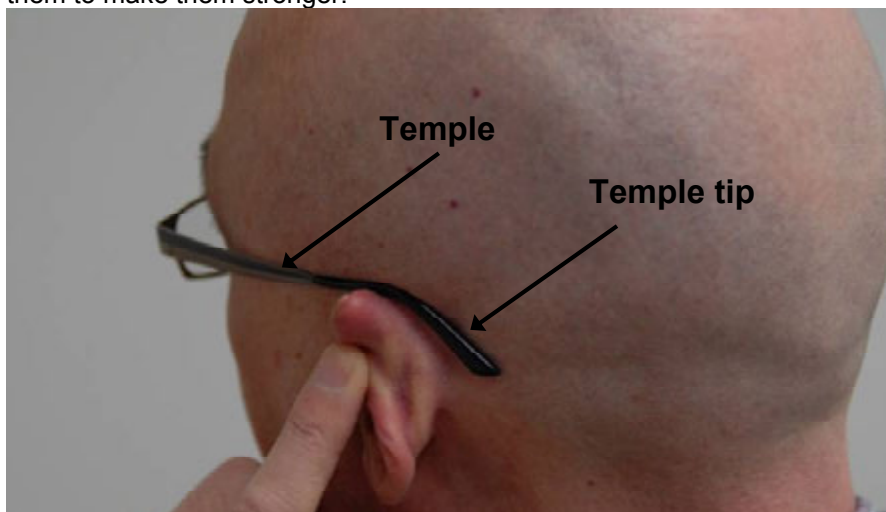


Figure 27.3: The left temple of a pair of spectacles

HINGES

- Each spectacle frame has two hinges that join the frame front to the temples
 - They are sometimes called the "joints" of the frame.
- The hinge allows the temples of the frame to fold in so that they rest against the frame front.
 - This allows the spectacles to be put in a spectacle case.
- Some hinges have springs in them while others only have a screw.
- Spectacles that have spring-loaded hinges:
 - are usually stronger than those that only have hinges with a screw.
 - allow the temples to bend out slightly, as well as letting them fold in.
- Spectacles that have a screw hinge only:
 - do not allow the temples to bend outwards – they can only fold inwards.
 - must have the screw tightened correctly
 - If the screw is too loose, it may fall out and the temples will fall off the frame.
 - If the screw is too tight, the temples will not fold inwards (if they are forced, the hinge can be damaged).



Spectacle screws come in many sizes (lengths and thicknesses). Spectacle screw sizes can vary between:

- different spectacle frames
- different parts of the same spectacle frame (hinges and nose pads).

SPECTACLE FRAME PARTS (cont.)

HINGES (cont.)

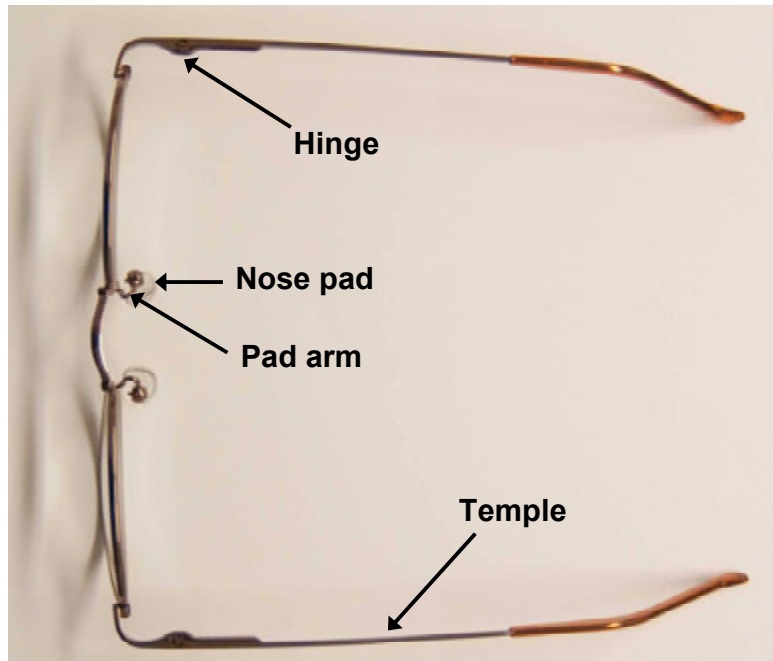


Figure 27.4: Looking at a pair of spectacles from above

CHOOSING A SPECTACLE FRAME

SPECTACLE FRAME SIZES AND STYLES

- Spectacle frame sizes and styles change with changing fashions, but there will always be a variety of frames to choose from. Not every frame is suitable for every person, or for every type of spectacle prescription.
- The size and shape of a person's head and face must be considered when choosing a frame size.
- If a frame is too small or too large for a person it will not be comfortable to wear and may affect the person's vision through the spectacle lenses.



Dean Saffron, courtesy of Brien Holden Vision Institute Foundation

Figure 27.5: A child playing with spectacles that are much too large for him



Just like we must choose shoes that fit our feet, we must also choose frames that fit our head and face.

Spectacle frames will only do their job properly if they are the correct size for a person.

The appearance of the spectacle frame and spectacle fashions should be a secondary consideration.

Important factors to consider when helping a person choose a spectacle frame are the:

- distance between the person's face and ears
→ think about the temple length needed.
- shape of the person's nose
→ think about the distance between the nose pads
→ think about the angle that the nose pads need to make.
- width of the person's face and distance between their eyes
→ think about the frame front width.

CHOOSING A SPECTACLE FRAME (cont.)

TEMPLE LENGTH	• If the temple is too short, it will not be long enough to wrap around the person's ear. • If the temple is too long, it will extend too far behind the person's ear.
NOSE PADS	• The distance between the nose pads affects how high the frame will be on the person's face: - If the distance between the nose pads is too wide, the frame will be too low on the person's face. - If the distance between the nose pads is too narrow, the frame will be too high on the person's face. • The nose pads must be angled so that they sit flat against the person's nose: - If the nose pads cannot be adjusted to do this, a different frame must be selected.
FRAME FRONT WIDTH	• An ideal frame width is one where the person's pupils are in the centre of the frame eyewires or rims. • The width of the frame front will affect how tightly the frame fits the person: - If the frame front is too wide, the frame will be too loose for the person. - If the frame front is too narrow, the frame will be too tight for the person.

TOOLS USED TO ADJUST SPECTACLES

Spectacles require special tools for fitting lenses and adjusting their fit.

A spectacle tool kit is shown below.

Each of these tools has a special purpose.

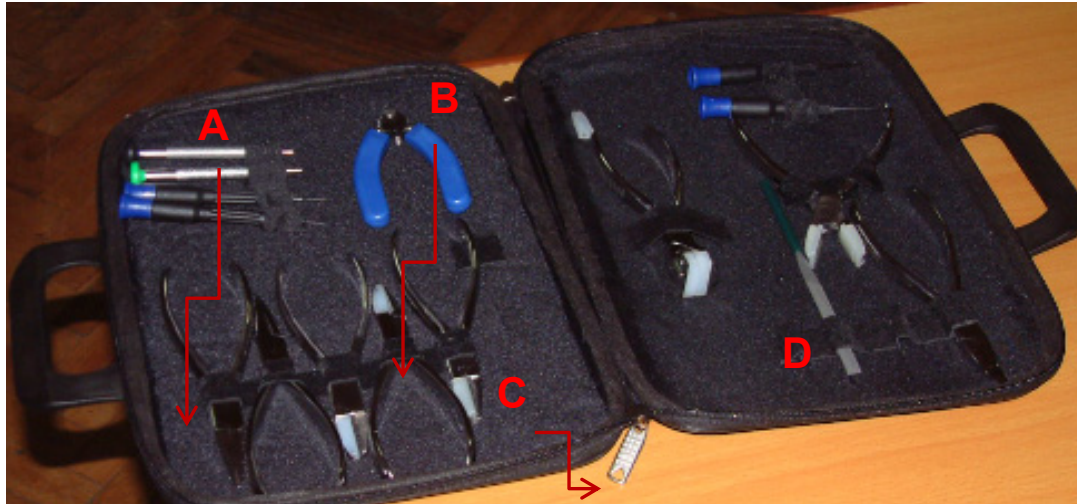


Figure 27.6: Tools used to adjust spectacles

TOOLS	A. Screwdrivers • Screwdrivers are used to tighten and loosen screws. • They can be flat-head or Phillips-head (cross-shaped) and come in a variety of sizes. B. Wire cutters • Wire cutters are used to cut metal parts of spectacle frames. • They are useful for cutting the ends off screws that are too long, and for cutting temple wires that need to be made shorter. C. Pliers • Pliers are used to change the shape of the spectacle frame. • They come in different shapes and sizes. Different types of pliers are used for different parts of the spectacle frame. • Pliers for spectacle frames often have a plastic or padded covering so that the frame does not get scratched or damaged when it is adjusted. D. Nail File • A nail file is used to smooth sharp edges or rough parts of a spectacle frame. • It is especially useful for shortening or blunting the ends of screws.

TOOLS USED TO ADJUST SPECTACLES (cont.)

FRAME HEATER

- Frame heaters are used to heat both plastic and metal frames. This makes them easier to adjust.

Plastic Frames:

- The heater makes the plastic softer, allowing a smoother bend.
- If plastic frames are not heated before they are adjusted, the frame can break.

Metal Frames:

Plastic temple tips and other plastic parts of a metal frame should be heated before adjusting.



Figure 27.7: Using a frame heater to adjust a plastic spectacle frame

- When using a frame heater you must keep moving the frame. If the frame is overheated in one place it can burn or be damaged.
- Make sure that the frame is not too hot before putting it back on the person's face.
 - Warn the person that it might feel slightly warm.
- If you do not have a frame heater, a hairdryer can sometimes be a useful alternative.

TOOLS USED TO ADJUST SPECTACLES (cont.)

Spectacle frames need to be adjusted several times during their lifetime:

- New spectacle frames always need to be adjusted to fit each person individually.
- Spectacle frames change shape with time and use. A spectacle frame may need to be re-adjusted every few months.

GOALS OF SPECTACLE ADJUSTMENT

- The spectacles must be comfortable for the person to wear.
 - The pressure should be distributed between the three points of the fitting triangle.
- The spectacles should look good on the person.
 - They should be straight and aligned with the person's face and head shape.

A well adjusted spectacle frame will put pressure on the person's face and head in only three places:

- the bridge of the person's nose
- the sides of the person's head above their ears
- the top of each of the person's ears.

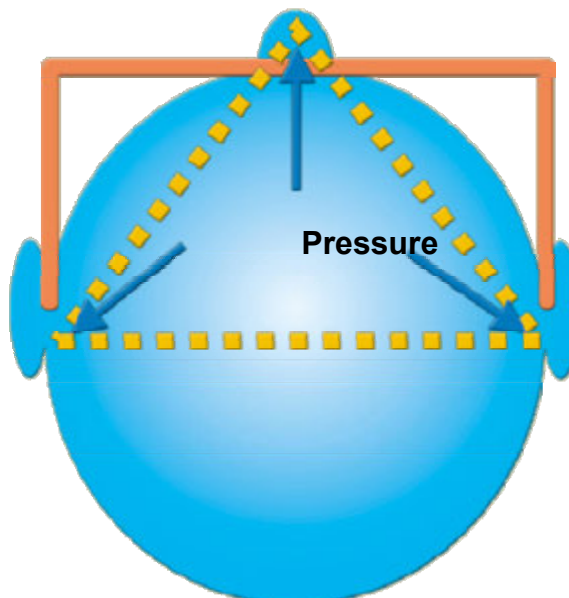


Figure 27.8: The fitting triangle

- If the frame puts pressure on other parts of the person's head or face, the frame is not fitted correctly and the person will be uncomfortable. In this case the frame will need to be adjusted again.

TOOLS USED TO ADJUST SPECTACLES (cont.)

The different parts of a spectacle frame must be adjusted in the correct order – from the front to the back:

- Adjust the front of the frame first
- Adjust the back of the frame last.

HORIZONTAL ALIGNMENT

- The frame must be perfectly horizontal on the person's face.
 - Look at how the top of the frame looks compared to the person's eyes and eyebrows.
- If the frame is not horizontally aligned the temples will need to be bent with pliers:
 - If the right side of the frame is too low
 - bend the right temple down.
 - If the left side of the frame is too low (*as seen in the photograph below*)
 - bend the left temple down.

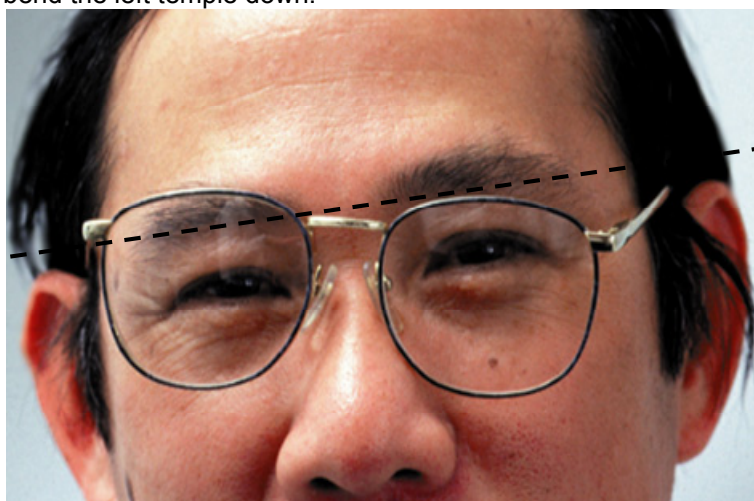


Figure 27.9: This frame needs its horizontal alignment adjusted

FACIAL WRAP

- The frame front should curve so that it follows the shape of the person's face.
 - The frame front should never be completely straight – it should always be less than 180°.
- To adjust facial wrap use your hands, put gentle pressure on the bridge until you get the shape you want.

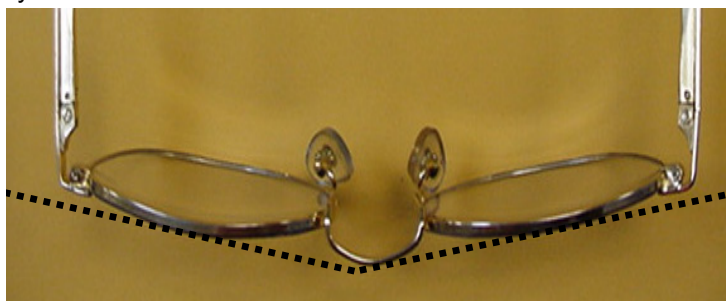


Figure 27.10: A spectacle frame with good facial wrap

TOOLS USED TO ADJUST SPECTACLES (cont.)

FACIAL WRAP (cont.)



Figure 27.11: A spectacle frame with bad facial wrap



You must adjust the horizontal alignment of the frame front and the facial wrap before you adjust the temples.

BRIDGE FITTING

- A person's nose supports most of the weight of their spectacles.
 - The nose pads rest on the nose and provide pressure on the nose (the first point of the fitting triangle).
 - The nose pads must be adjusted carefully to make sure that the frame fits the person well.
- Plastic frames do not have adjustable nose pads so these frames will need to be chosen very carefully.
 - A plastic frame will only fit the noses of some people, not everyone.
 - It is very difficult to find a plastic frame that will fit a person who has a wide and flat nose bridge. These people usually need to wear metal frames.
- Metal frames usually have nose pads on adjustable pad arms. These nose pads must be adjusted to the correct:
 - distance between the nose pads
 - frontal angle
 - splay angle.

DISTANCE BETWEEN NOSE PADS

- The distance between the nose pads affects how high the frame front will sit on a person's face.
- The closer together the nose pads are:
 - the higher the frame will sit.
 - The further apart the nose pads are:
 - the lower the frame will sit.

TOOLS USED TO ADJUST SPECTACLES (cont.)

FRONTAL ANGLE

- The frontal angle is the angle that the nose pads make when looked at from the front.
- The nose pads should follow the shape of the person's nose. They should be:
 - closer together at the top
 - further apart at the bottom.
- A person who has a nose that is very wide or very flat at the bridge will need a larger frontal angle than a person with a narrower nose.

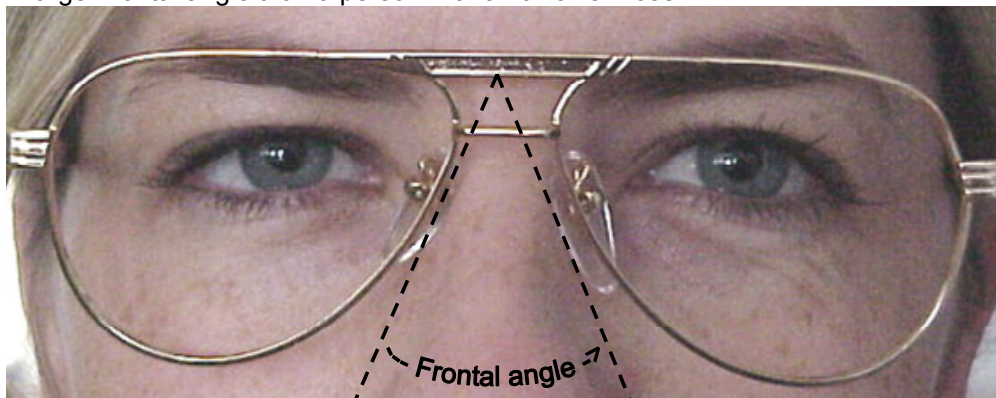


Figure 27.12: Frontal angle of nose pads on a metal spectacle frame

SPLAY ANGLE

- The splay angle is the angle that the nose pads make when looked at from above.
- The nose pads should follow the shape of the person's nose. They should be:
 - closer together at the front
 - further apart at the back.
- A person who has a nose that is very wide or very flat at the bridge will need a larger splay angle than a person with a narrower nose.

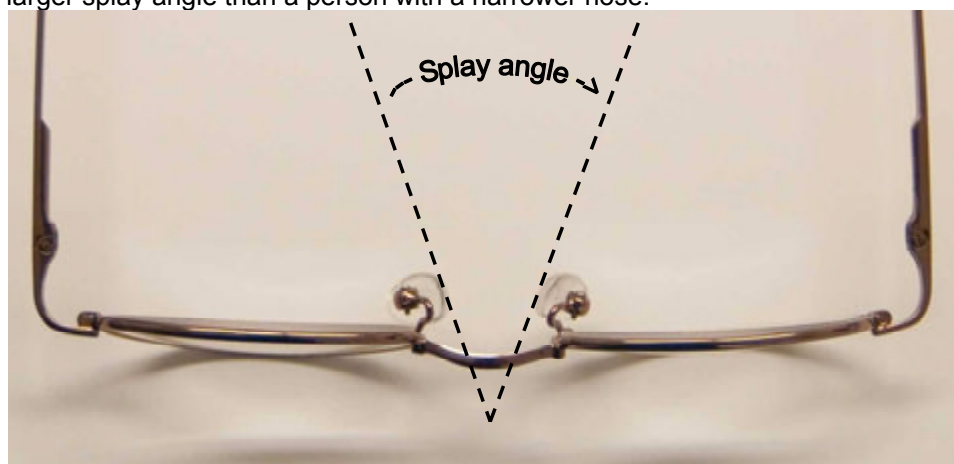


Figure 27.13: Splay angle of nose pads on a metal spectacle frame



If the bridge of a person's nose is very wide or flat they may not be able to wear plastic frames, because the nose pads of plastic frames cannot be adjusted.

If they wear metal frames the nose pads will need to be adjusted carefully. They will need a larger:

- frontal angle
- splay angle.

TOOLS USED TO ADJUST SPECTACLES (cont.)

PANTOSCOPIC TILT

- The pantoscopic tilt is the forward vertical tilt of the lenses in the spectacle frame. It is needed to give the person good vision through their spectacle lenses.
- The pantoscopic tilt should never be completely vertical – it should always be less than 90°.

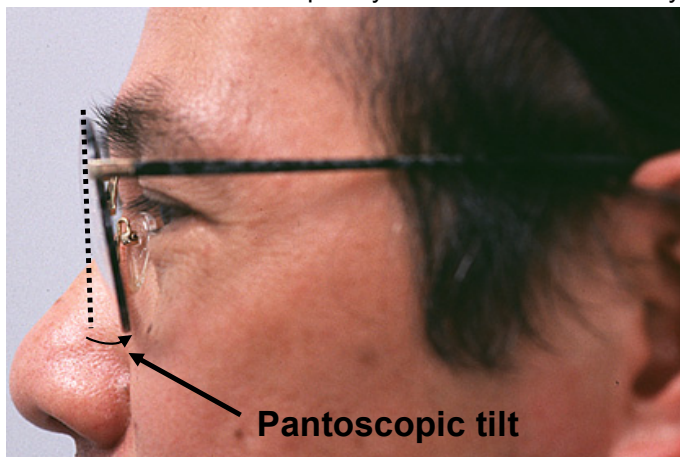


Figure 27.14: Good pantoscopic tilt

- You may have to reduce the pantoscopic tilt if the frame touches the person's cheeks. However, you cannot reduce it too much – you may have to choose a different frame.
- To adjust the pantoscopic tilt, use angling pliers to bend the temples near the hinge.
 - To increase the pantoscopic tilt → bend the temples down.
 - To decrease the pantoscopic tilt → bend the temples up.

TEMPLE WIDTH

- The sides of the temples should not touch the sides of the person's head – except at the ears.
- There are two ways to increase the temple width:
 - use a file to remove a small amount of the temple edge near the hinge
 - bend the temples out slightly (approximately 1 cm) with pliers
 - this is usually easier to do for a metal frame
 - plastic frames usually need to be heated before bending the temples.
- To decrease the temple width:
 - bend the temples in slightly (approximately 1 cm) with pliers.
- Be careful not to bend the frame at the hinge itself. If you do this the hinge may be damaged or become loose.
- Make sure that both temples are symmetrical (the same on both sides). If the temples are not symmetrical, one temple may cause pressure on one side of the person's head and make them feel uncomfortable.

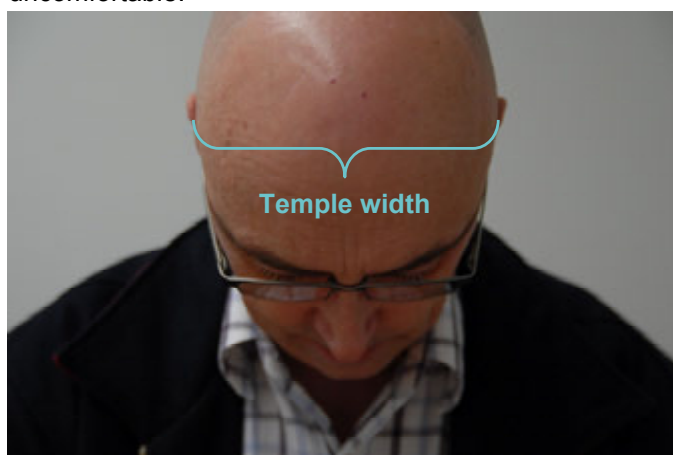
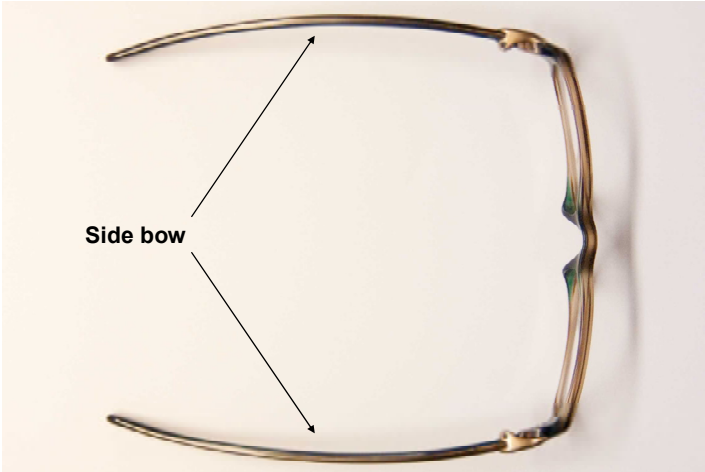
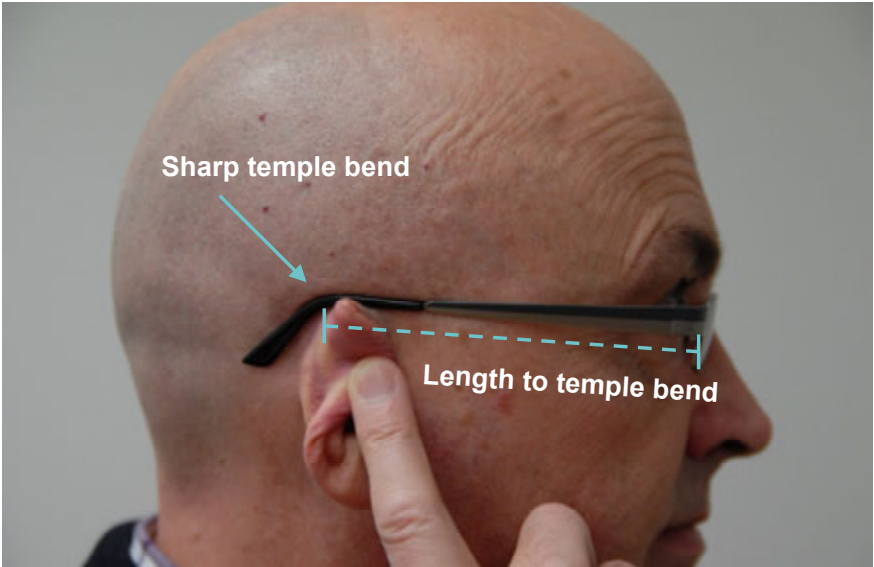


Figure 27.15: Temple width

TOOLS USED TO ADJUST SPECTACLES (cont.)

SIDE BOW	- After the temple width has been adjusted correctly, the ends of the temples must be bent inwards slightly. This is to create pressure at the ears (two points of the fitting triangle) and keep the spectacles firmly positioned on the person's head. - To adjust the side bow: - use your hand to put gentle pressure along the temple length until you get the shape you want. - a plastic frame will need to be heated before the side bow can be adjusted.  <i>Figure 27.16: This plastic spectacle frame has a lot of side bow</i>
LENGTH TO TEMPLE BEND	- The length to the temple bend (or simply, the "length to bend") is the distance between the frame front and the place where the temple starts to bend down around the person's ear. - The bend should start 2 mm behind the place where the ear joins the head. This lets the frame move slightly, and makes it more comfortable for the person when they smile or make other facial expressions. - If the bend starts in front of the ear, or more than 2 mm behind the ear, the spectacles will slide forwards. The person will need to keep pushing them back onto their face with their finger.
TEMPLE BEND	The bend on the temple tip should be a sharp bend (like the bend that the temple has when it comes from the manufacturer), not a gradually curving round bend.  <i>Figure 27.17: A correctly adjusted spectacle temple</i>

TOOLS USED TO ADJUST SPECTACLES (cont.)

TEMPLE BEND (cont.)

- To make the temple bend, use your hands:
 - Heat the temple tip so that it is easier to bend.
 - Straighten the temple to remove the manufacturer's bend.
 - Put the spectacles on the person and ask their permission to look behind their ear to see where the temple bend should begin.
 - Remove the spectacles and make a sharp bend at this place.
 - use one of your fingers to support the temple under the bend.
 - Put the spectacles back on the person and check that the temple bend is in the correct place.
- The bent part of the temple tip should follow the shape of the back of the ear (where the ear joins the head) for at least half its length.
- Once the temple has been bent at the correct angle downwards, it then needs to be bent at the correct angle inwards or outwards.
 - The bent part of the temple should follow the shape of the bone at the side of the person's head (behind the ear).
 - This part of the temple needs to press very gently into the sides of the person's head.
 - It should not be angled in towards, or away from, the person's head.

PROBLEM SOLVING GUIDE

WHAT IS THE PROBLEM?	WHAT CAN YOU DO?
Sore nose	- Adjust nose pads so they sit flat against the sides of the nose - distance between the nose pads - frontal angle - splay angle. - Adjust temples. Check: - temple width - side bow - length to temple bend.
Red marks on the nose (one side or both sides)	- Adjust nose pad(s) so they sit flat against the sides of the nose - distance between the nose pads - frontal angle - splay angle. - Adjust temple(s). Check: - temple width (make sure it is even on both sides) - side bow - length to temple bend.
Sore behind ear(s)	- Adjust temple(s). Check: - temple width - side bow - length to temple bend - temple bend.
Sore on top of ear(s)	- Adjust temple(s). Check: - temple width - side bow - length to temple bend - temple bend.
Spectacle frame touches cheek	- Decrease pantoscopic tilt - Decrease distance between nose pads.
Eyelashes touch spectacle lenses	- Adjust pantoscopic tilt - Decrease distance between nose pads.
Spectacles slip down nose (and the frame is loose)	- Decrease temple width - Tighten hinge screws - Adjust temple(s). Check: - temple width - side bow - length to temple bend - temple bend.
Spectacles slip down nose (and the frame is tight)	- Increase temple width - Increase side bow
Frame is not straight	Adjust horizontal alignment.

ADJUSTING OLD SPECTACLE FRAMES

- Older spectacle frames are more fragile than newer spectacle frames.
 - This is especially the case for plastic frames which become brittle with age.
- A spectacle frame that has been bent out of shape and fixed several times, will be more fragile than a frame that has never been damaged.
 - Take care when fixing damaged frames.
 - Warn the person that the frame may break when you try to fix it.



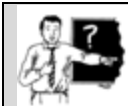
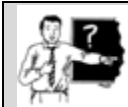
When you adjust an old or damaged frame, warn the person that the frame might break during the adjustment.

Tell the person that you will be very careful, but if the frame breaks you cannot take responsibility for the damage.

CASE STUDY EXAMPLES

CASE 1	A woman tells you that when she wears her spectacles both sides of her head (near her ears) get sore. - This usually happens because the temple width is too narrow. - To make the temple width wider you can either: - use a file to remove a small amount of the temple edge - use pliers to change the angle between the frame front and the temples.
CASE 2	An artist tells you that when he wears his spectacles they keep slipping down his nose. - This can happen if: - the temples do not give enough pressure on the sides of the head, or - the temple bend is incorrect. - To correct the pressure on the sides of the head: - make the temple width narrower → use pliers to change the angle between a metal frame front and its temples → heat a plastic frame before changing the angle between the frame front and its temples. - increase the side bow → use your hands to make the temples curve in towards the head more → plastic temples may need to be heated slightly.  After a person has been wearing their spectacles for some time, the temple width often needs to be re-adjusted. This is because the bends between the frame front and the temples get stretched each time the person puts their spectacles on or takes them off. Tell the person that it is better to use two hands when putting their spectacles on or taking them off.

CASE STUDY EXAMPLES (cont.)

CASE 2 (cont.)	- To correct the temple bend: – heat the temple tip – straighten the temple – put the spectacles on the person and see where the temple bend should start (ask their permission to look behind their ear) → 2 mm behind where the ear joins the head is best – Remove the spectacles and make a sharp bend – Put the spectacles back on the person's face to see if your bend is correct.  If the temple bend is adjusted properly in the beginning, it usually does not need to be re-adjusted in the future.
CASE 3	You notice that there are lines on the side of a young man's head after he has been wearing his spectacles. He tells you that they sometimes slip forward when he leans forward. - This usually happens because the temples are pressing too hard on the side of the head in front of the ears. - To correct this: – increase the temple width – increase the side bow.
CASE 4	You notice that an old man's spectacle frame is not sitting straight on his face. - This happens if: – one ear is higher than the other – one temple is bent down further than the other (this often happens when spectacles are sat on or squashed). - To correct the horizontal alignment: – If the right side of the frame is too low → bend the right temple down, or the left temple up. – If the left side of the frame is too low → bend the left temple down, or the right temple up.  If the spectacles have been bent out of shape by accident, don't forget to warn the person that they may break when you try to fix them.

CARING FOR SPECTACLES

Spectacle frames and lenses must be cared for if the person wants them to last for several years.

You must teach people the correct way to look after their spectacles.

WHAT TO TELL PEOPLE ABOUT CARING FOR THEIR SPECTACLES

- If the spectacles are not being worn (if they are not on the person's face) they should always be kept in their case.
 - A hard case is best.
 - A soft case or a piece of soft fabric is also good
 - Material from an old T-shirt is useful
 - it can be sewn into a small bag to keep spectacles safe.



Figure 27.18: Spectacles should always be stored in their case

- Never put spectacles on a table (or other surface) with the lenses facing down
 - This will scratch the lenses.
- To clean spectacles:
 - Use clean water and soap (or dishwashing detergent)
 - Use cold water; never use hot water
 - Rinse with clean water
 - Dry with a clean, soft cloth.



Figure 27.19: Wash spectacles with cold water and soap

CARING FOR SPECTACLES (cont.)

WHAT TO TELL PEOPLE ABOUT CARING FOR THEIR SPECTACLES (cont.)

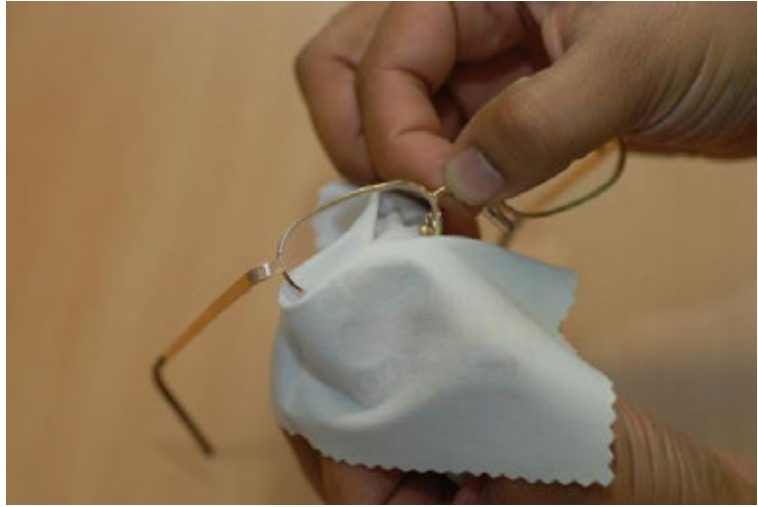


Figure 27.20: Dry spectacles with a soft cloth

- Never leave spectacles where they can get hot
 - Heat can damage the lenses and the frame
 - Never leave spectacles in the hot sun or inside a hot car.
- Tell the person to come back to see you if their spectacles need to be re-adjusted, or if they have any questions.

SUMMARY: ADJUSTMENT AND CARE OF SPECTACLES

OPTICAL SPECTACLES

- Also called “spectacles” or “glasses”.
- Are made by fitting optical lenses into a spectacle frame.

Spectacle Frame Materials:

- Most common materials are metal and plastic.

Metal Frames:

- Advantages:
 - Light to wear
 - Easy to adjust the fit
 - Adjustable nose pads.
- Disadvantages:
 - Can corrode or rust
 - Corroded surfaces can cause skin problems.

Plastic Frames:

- Advantages:
 - Available in bright colours
 - Can be light to wear.
- Disadvantages:
 - Become brittle with age
 - Require heat to adjust the fit.

SPECTACLE FRAME PARTS

Frame Front:

- Front of the spectacle frame.
- The bridge connects the two eyewires or rims.

Eyewire or Rim:

- Optical lenses are fitted into the eyewires or rims.
- Metal frames have eyewires, and plastic frames have rims.

Bridge:

- Joins the two eyewires or rims together.

Nose pads:

- Only part of the spectacle frame that should touch a person's face.
- Metal frames have nose pads attached to the eyewires by pad arms.
 - These can be adjusted to match the shape of the person's nose.
- Plastic frames do not have separate nose pads.
 - The sides of the rims are shaped to sit comfortably on the person's nose.
 - If the frame does not fit the person's nose, they will have to choose a different frame.

Temples:

- Also called the “arms” of the frame.
- Attach to the frame front and wrap behind the ears.
- Metal frames have metal temples, but the temple tips are coated in plastic.
- Plastic frames have plastic temples, but metal wires inside them give them strength.

SUMMARY: ADJUSTMENT AND CARE OF SPECTACLES (cont.)

Hinges:

- Also called the “joints” of the frame.
- Allow the temples to fold against the frame front for storage.
- Hinges can be spring-loaded or may only have a screw.

CHOOSING A SPECTACLE FRAME

Spectacle Frame Sizes and Styles:

- Not every frame is suitable for every person.
- A comfortable frame that gives good spectacle vision is a frame that fits the size and shape of a person's head and face.
- You must consider:
 - distance between the person's face and ears (temple length).
 - shape of the person's nose (distance between the nose pads).
 - width of the person's face (frame front width).

Temple Length:

- If the temple length is too short it will not wrap around the person's ear.
- If the temple length is too long it will extend too far behind the person's ear.

Nose Pads:

- If the distance between the nose pads is too wide, the frame will be too low on the person's face.
- If the distance between the nose pads is too narrow, the frame will be too high on the person's face.
- The nose pads must sit flat against the person's nose.

Frame Front Width:

- An ideal frame front is one where the person's pupils are in the centre of the eyewires or rims.

TOOLS USED TO ADJUST SPECTACLES

Screwdrivers:

- For tightening or loosening screws.
- Can be flat-headed or Phillips-head and come in many sizes.

Wirecutters:

- For cutting metal parts of spectacle frames.
- Useful for cutting the ends of screws or temple wires that are too long.

Pliers:

- For changing the shape of spectacle frames.
- Different types of pliers are used for different parts of the spectacle frame.

Nail File:

- For smoothing sharp edges or rough parts.
- Useful for shortening or blunting the edge of screws.

Frame Heater:

- For heating spectacle frames to make them easier to adjust.
- Must be careful not to burn or damage the frame.
- You must keep the frame moving when heating it.

SUMMARY: ADJUSTMENT AND CARE OF SPECTACLES (cont.)

ADJUSTING SPECTACLES

- Spectacles need to be adjusted when:
 - they are new.
 - they have changed shape (after time and use).

Goals of Spectacle Adjustment:

- Should be comfortable to wear.
- Should look good on the person.

The Fitting Triangle:

A well-adjusted frame applies pressure in only three places:

- bridge of the person's nose.
- sides of the person's head above their ears.
- top of the person's ears.

METHOD

- The parts of a spectacle frame must be adjusted in the correct order – from front to back:
 1. Horizontal alignment
 2. Facial wrap
 3. Bridge fitting: distance between nose pads, frontal angle, splay angle
 4. Pantoscopic tilt
 5. Temple width
 6. Side bow
 7. Length to temple bend
 8. Temple bend.

PROBLEM SOLVING GUIDE

- The Problem Solving Guide will help you to know what part of the frame needs to be adjusted.

ADJUSTING OLD SPECTACLE FRAMES

- Older spectacle frames are more fragile.
 - Plastic frames especially become brittle with age.
- If a spectacle frame is repeatedly bent out of shape and then re-adjusted, it is much more fragile
 - and much more likely to break.
- Always warn people of the possibility of breakage before you adjust their old spectacle frame.

CARING FOR SPECTACLES

- You must teach people how to look after their spectacles.

What to tell people about caring for their spectacles:

- If spectacles are not being worn, they should be kept in their case.
- Never put spectacles with their lenses face down – this will scratch the lenses.
- To clean spectacles:
 - use clean water and soap (or washing detergent)
 - only use cold water
 - rinse with clean water
 - dry with a clean, soft cloth.
- Never leave spectacles where they can get hot.
- Tell the person to come back to see you if they need their spectacles re-adjusted or if they have any questions.

TEST YOURSELF QUESTIONS

1. What is the part of a spectacle frame that holds the lens called?
_____ or _____
2. What are the parts of a frame that are attached to the frame front by the joints and curl down behind the ears called?

3. Why should frames not press against the person's temples?

4. Give two reasons why spectacles may slip down a person's nose.

5. A well adjusted frame applies pressure in only three places, namely:

6. What should you tell people about cleaning their spectacles?

7. Name some advantages and disadvantages of metal spectacle frames:

ADVANTAGES OF METAL FRAMES	DISADVANTAGES OF METAL FRAMES

8. Name some advantages and disadvantages of plastic spectacle frames:

ADVANTAGES OF PLASTIC FRAMES	DISADVANTAGES OF PLASTIC FRAMES
- Bright colours available - Can be light to wear	- Become brittle with age - Require heat to adjust the fit

9. Name one function for each of the following tools for adjusting spectacles:

Screwdrivers: _____

Wirecutters: _____

Pliers: _____

Nail file: _____

Frame heater: _____



BLINDNESS AND VISUAL IMPAIRMENT

THINK

Blindness and visual impairment is a disability suffered by millions of people around the world. The great tragedy is that most blindness and visual impairment is avoidable, preventable or treatable.

Every individual who is working to eliminate avoidable blindness and visual impairment is a part of a remarkable global team. Together we will work towards eliminating avoidable blindness and visual impairment by the year 2020.

AIM

This unit introduces you to the leading causes of blindness and visual impairment, and discusses treatment and prevention strategies.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- define blindness, visual impairment and low vision
- describe the major causes of avoidable blindness and visual impairment
- list the barriers to prevention and treatment of blindness or visual impairment
- explain the cost of avoidable blindness and the savings that can be made by preventing or treating it
- state the goal of *VISION 2020: The Right to Sight*
- discuss how uncorrected refractive error contributes to avoidable blindness and visual impairment
- explain how vision can be restored to millions of people by correcting their refractive error.

REVIEW: NEAR REFRACTION FOR PRESBYOPIA

REFRACTIVE ERROR	• A person who has a refractive error will need to wear spectacles (glasses) or contact lenses so that they can see clearly and comfortably. This is because their eye is not the correct size and shape. • There are four main types of refractive error: myopia, hyperopia, astigmatism and presbyopia. • A person with a refractive error will have eyes that look normal, but they will not see well. • An eye examination that tests for refractive error is called a refraction.
VISUAL ACUITY	• Visual acuity (VA) is a measure of how clearly a person sees when they are looking directly (straight) at an object. • Common causes of poor VA are: – Refractive error (this person needs spectacles to see clearly) – Eye health problem (this person has a health problem with their eyes). • There are several types of VA measurements: → Unaided VA: VA without the person's spectacles. → Aided VA: VA with the person's spectacles – distance spectacles for distance VA testing – near spectacles for near VA testing. → Presenting VA: The person's VA when they arrive to have their eyes examined. This will be the same as: – aided VA if they arrive wearing their spectacles – unaided VA if they arrive not wearing their spectacles. → Habitual VA: VA that the person usually has. This will be the same as: – aided VA if they usually wear their spectacles – unaided VA if they do not usually wear their spectacles. → Best corrected VA: The best possible VA that a person can have with spectacle lenses. → Monocular and binocular VA: Monocular VA is the VA that a person gets when just one eye is used (when the other eye is covered). Binocular VA is the VA that a person gets when both eyes are open and uncovered. Binocular VA is usually better than monocular VA. • VA must be measured at different distances: distance and near → distance VA is usually measured at 6 m → near VA is usually measured at 40 cm. • Distance VA is measured using a distance VA chart → Snellen notation is usually used (a VA measurement of 6/6 means that the person has good vision). • If the person cannot see the distance VA chart you can: → Reduce the test distance (and change the top number of the Snellen fraction accordingly) → Ask the person to count your fingers at different distances → Move your hand in front of the person's face → Check for light perception or no light perception with pentorch. • Near VA is measured using a near VA chart (or reading card) → Most near VA charts use N point measurements → Normal near vision is usually N6.

VISUAL IMPAIRMENT, BLINDNESS AND LOW VISION

The definitions of visual impairment, blindness and low vision are regularly reviewed and changed. Future definitions may include linking functional status to visual acuity (VA).

As at August 2008, the following definitions were recommended by the International Agency for the Prevention of Blindness Refractive Error Program Committee (REPCoM) based on World Health Organization (WHO) policy, published evidence, and REPCoM consensus:

Table 28.1: Blindness and visual impairment for distance.

Definition	Presenting VA in better eye worse than	Presenting VA in better eye equal to or better than
No visual impairment	–	6/18
Visual impairment for adults	6/18	–
Visual impairment for children	6/12	–
Moderate visual impairment	6/18	6/60
Severe visual impairment	6/60	3/60
Blind	3/60	–

Table 28.2: Blindness and visual impairment for near.

Definition	Presenting VA in better eye worse than	Presenting VA in better eye equal to or better than
No visual impairment	–	N8
Visual impairment	N8	–
Blind	N64	–

Table 28.3: Low vision.

Definition	Best corrected VA in better eye worse than	Presenting VA in better eye equal to or better than
Low vision	6/18 or binocular visual field less than 10° from fixation	Light perception

VISUAL IMPAIRMENT	Visual impairment describes presenting VA in the better eye (the eye that sees best) that is: – for distance vision → worse than 6/18 (or for children, worse than 6/12) – for near vision → worse than N8.  Visual impairment is sometimes referred to as “vision impairment”. The WHO refers to visual impairment. REPCoM refers to vision impairment.
BLINDNESS	Blindness describes presenting VA in the better eye that is: – for distance vision → worse than 3/60 – for near vision → worse than N64  Blindness does not always mean that the person sees nothing. Some blind people only see darkness, but others can see large shapes or can tell the difference between light and dark.
LOW VISION	Low vision describes best corrected VA in the better eye that is worse than 6/18 for distance or which has a binocular visual field less than 10° from fixation, but better than light perception. This means that a person with low vision either: • cannot see the 6/18 line on a VA chart even when they are wearing spectacles to correct their refractive error, or • have a binocular visual field that is constricted to less than 10° from their fixation point. People with low vision can be prescribed low vision devices, such as magnifiers, to help them see better.

BLINDNESS AND VISUAL IMPAIRMENT FACTS

- The WHO estimates that 314 million people globally have visual impairment for distance:
 - including 45 million people who are blind
 - including 1.4 million children (younger than 15 years old) who are blind
 - including 124 million people who have low vision.
- Most blindness is avoidable
 - At least 75% of adult blindness can be prevented or treated
 - Approximately 50% of childhood blindness can be prevented or treated.
- More than 90% of all visually impaired people live in developing countries.
- Most visually impaired people are aged 50 years and over.
- Most blind people are women.
- More than 161 million people are visually impaired due to eye diseases, such as cataracts, glaucoma and macular degeneration:
 - including 37 million people who are blind from eye disease
 - including 124 million people who have low vision.
- 153 million people have significant distance visual impairment due to uncorrected refractive error (because they do not have spectacles)
 - including 8 million people who are blind from uncorrected refractive error.
- In 2005, 1.04 billion people were estimated to have visual impairment for near due to uncorrected refractive error (presbyopia) and 517 million of these people were without adequate near spectacles or had no spectacles at all.
- Compared to the other major causes of visual impairment, refractive error develops at a younger age
 - If left uncorrected, refractive error is responsible for significantly more blind years than most other causes.
- The number of blind people worldwide is expected to increase to 76 million by 2020 if no action is taken.

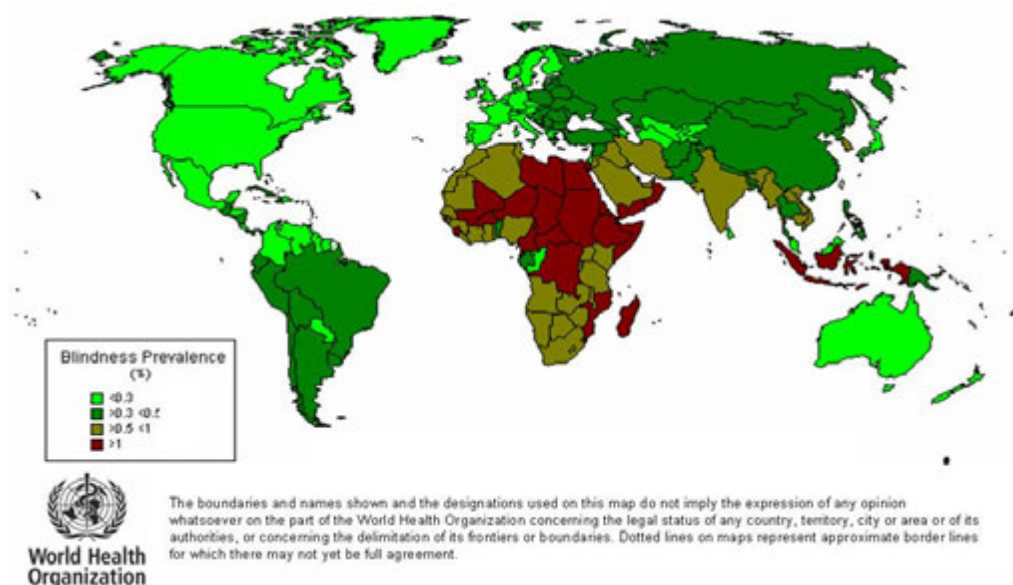


Figure 28.1: Prevalence of global blindness map. (Source: WHO)

CAUSES OF BLINDNESS AND VISUAL IMPAIRMENT

Globally, the most common causes of blindness are:

CATARACTS	→ Cataracts form in the eye's crystalline lens causing it to become opaque (cloudy). → In developing countries cataracts are the leading cause of blindness. → Cataracts can be removed by cataract surgery – a relatively simple eye operation.
UNCORRECTED REFRACTIVE ERROR	→ Refractive error includes hyperopia, myopia, astigmatism and presbyopia. → Uncorrected refractive error is the second most common cause of blindness, and the leading cause of visual impairment. → Uncorrected refractive error is the easiest cause of blindness to manage and treat: an eye examination and a pair of spectacles are all that is required.
GLAUCOMA	→ Glaucoma is a disease of the optic nerve. → In its early stages glaucoma is usually asymptomatic (the person has no symptoms), but if it is left untreated this condition results in irreversible (permanent) blindness. → Glaucoma can be detected by a routine eye examination which includes examination of the optic nerve head and measurement of intraocular pressures.
AGE-RELATED MACULAR DEGENERATION (ARMD)	→ ARMD is a degenerative condition of the macula (central part of the retina). → It is most common in people aged 50 years and over. → ARMD is the most common cause of blindness in developed countries. → ARMD permanently affects central vision, but peripheral vision is not affected.
CORNEAL OPACITY	→ A corneal opacity (a clouding of the cornea) occurs when the cornea is scarred by an eye disease or trauma. → Treatment options are limited, but sometimes surgery can help.
DIABETIC RETINOPATHY	→ Diabetic retinopathy is a complication of diabetes mellitus. → 15 years after diagnosis: – 15% of diabetic people have severe vision loss – 2% of diabetic people become blind. → Diabetic retinopathy is characterised by bleeding and ischemia (not enough oxygen) of the retina. → In its early stages diabetic retinopathy is usually asymptomatic (the person has no symptoms), but if it is left untreated this condition results in irreversible (permanent) blindness. → People with diabetes should have regular eye examinations because detection and prompt treatment (usually laser photocoagulation) can reduce the risk of vision loss by 90%.
TRACHOMA	→ Trachoma is the most common cause of infectious blindness – it is caused by a bacteria. → This condition typically affects poor communities who have poor sanitation, limited access to clean water, and poor health services.

CAUSES OF BLINDNESS AND VISUAL IMPAIRMENT (cont.)

ONCHOCERCIASIS

- Onchocerciasis (also called river blindness) is caused by a parasitic worm that enters the body and causes a strong immune system response.
 - This can result in a variety of health problems, including eye disease and blindness.
- The diagram below shows the different eye conditions that cause blindness and visual impairment in the world today. Note that only visual impairment for distance from uncorrected refractive error is shown (presbyopia is not included here).

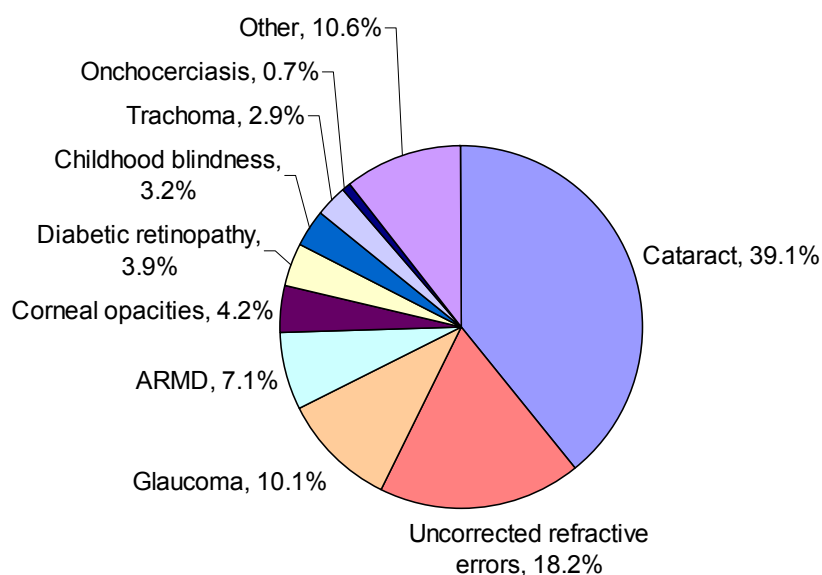


Figure 28.2: Global causes of blindness (not including near refractive error) as a percentage of total blindness, 2004. (reproduced from Resnikoff et al)¹

¹ Resnikoff S, Pascolini D, Mariotti SP, Pokharel GP. Global magnitude of visual impairment caused by uncorrected refractive errors in 2004. *Bulletin of the World Health Organization*. 2008;86(1):63–70.

CHILDHOOD BLINDNESS

The main causes of blindness in children are not the same as in adults. Childhood blindness in developing countries is often caused by preventable conditions. Management of childhood blindness must include the participation of children's families and their communities.

- The WHO estimates that 1.4 million children (aged 15 years or younger) are blind, including:
 - 1 million children in Asia
 - 300,000 children in Africa.
- Half a million children become blind each year – that is nearly one child per minute.
- Most blind children are either born blind or become blind before the age of 5 years.
- The most common causes of childhood blindness are:
 - Corneal opacities – corneal scarring from Vitamin A deficiency, measles or trauma
 - Cataracts – congenital (at birth) or traumatic
 - Glaucoma – congenital (at birth) or traumatic
 - Retinopathy of prematurity – affects some babies who are born prematurely
 - Refractive error – typically in school-age children, but can be congenital (at birth).



Figure 28.3: Corneal scarring following trauma

- 40% of the causes of childhood blindness are treatable or preventable.
- Corneal opacities caused by Vitamin A deficiency and measles are the most preventable cause of childhood blindness.
- Uncorrected refractive error is the easiest cause of childhood blindness to treat – an eye examination and a pair of spectacles are all that is required. However, child compliance with spectacle wear can be low.
 - Common causes for poor compliance include:
 - Uncomfortable spectacle frames
 - Poor vision or asthenopia (headaches or eye strain) when wearing spectacles
 - Need for spectacles not understood
 - Poor cosmesis (dislike the way the spectacles look)
 - Social pressure (teasing from other children).
 - Compliance can be significantly improved with parental support and community education.

CHILDHOOD BLINDNESS (cont.)

- Amblyopia is a common cause of childhood monocular (one eye) visual impairment:
 - Amblyopia occurs when a child's eye does not receive a clear visual image and as a result the visual pathways to the brain fail to develop.
 - Uncorrected refractive error and cataracts are the main causes of amblyopia
 - these conditions can usually be treated with spectacles or surgery.
 - Amblyopia can only be treated in children; adults with amblyopia have permanent visual impairment.
 - Monocular visual impairment is more significant for children than for adults because they have a greater number of life years yet to live, and so more chance of developing a problem with their other eye (their “spare” eye).
- Visual impairment affects a child's learning and participation in the classroom and in their community. This restricts their overall education and limits their future employment opportunities.
- Effective treatment of childhood blindness and visual impairment requires more careful monitoring than is required for adult blindness. This is because children are more likely than adults to have:
 - complications following treatment, including amblyopia
 - poor compliance with treatment.
- Elimination of childhood blindness is a challenge because there is often:
 - a lack of awareness among parents and communities about how to prevent eye problems.
 - a lack of awareness that the vision of blind children can often be improved.
 - difficulty accessing eye care including: lack of awareness, distance, cost, fear and limited resources.
 - a shortage of eye care providers who are trained to detect, diagnose and manage eye problems in children.

BARRIERS TO PREVENTION AND TREATMENT

Even when eye care services are available for people, there are many reasons why they may not be used. These reasons include practical, social, financial and psychological factors.

ACCESSIBILITY AND AVAILABILITY	Eye care services may not be available in an area, or there may not be enough trained eye care providers. If eye care services are too far away, people may not be able to reach them. Problems of accessibility and availability are common in rural or remote areas.
ACCEPTABILITY	Different communities expect and require different eye care services and methods of care. An eye care service must address the needs of the community it is serving.
AFFORDABILITY	Eye care services may cost too much. Costs may include the cost of the: - eye examination - treatment (including spectacles) - travel - lost earnings of the person and their carer.
AWARENESS	People may not know that their eye problem can be treated, or they may fear treatment. Other people just accept their poor vision as something that is part of life and cannot be changed – this is often especially true for elderly people who may think that their poor vision is a normal consequence of getting old.
GENDER AND AGE	Globally, more women than men are blind, but women get treatment less frequently. The elderly are also more likely to be blind and have difficulty accessing treatment. Reasons for this difference in accessibility may include family demands and gender and age inequalities within some communities.
SOCIO-ECONOMIC CONDITIONS	Many of the causes of avoidable visual impairment are directly related to poverty (including malnutrition, access to clean water and sanitation, education levels and access to health care). Equally, visual impairment also increases the risk of becoming poor.

COST AND BURDEN OF BLINDNESS AND VISUAL IMPAIRMENT

- Visual impairment is one of the leading causes of disability worldwide, and it affects people:
 - Physically (unable to see or move around)
 - Functionally (unable to work, study or drive)
 - Socially (limits social contact and relationships with others)
 - Psychologically (increases frustration, sadness and isolation).
- In Australia, visual impairment has been shown to:
 - double the risk of falls (2X)
 - triple the risk of depression (3X)
 - increase the risk of hip fractures by 4X to 8X
 - more than double the risk of death.
- The cost of global blindness and low vision was estimated at US\$42 billion in 2000. Unless the prevalence of blindness and low vision is reduced, the total annual cost is projected to increase to US\$110 billion by 2020.
- The cost of eliminating avoidable blindness and vision impairment in the world is significantly less than the cost to communities and countries if it is not eliminated.
 - For every US\$1 that is invested in eye care or prevention of vision loss, there is a US\$5 return to the community.
- Many eye care interventions are simple and cost-effective. Developed countries and developing countries alike cannot afford avoidable vision loss.

VISION 2020: THE RIGHT TO SIGHT

- The *VISION 2020* goal:



VISION 2020 aims to eliminate the main causes of avoidable blindness by the year 2020 – to give all people in the world the right to sight.

- VISION 2020* was jointly established in 1999 by the World Health Organization (WHO) and the International Agency for the Prevention of Blindness.
- VISION 2020* aims to:
 - provide technical support and advocacy to blindness prevention activities globally
 - work with Ministries of Health in governments, professional associations, national and international non-government organisations and civil society groups to create and introduce new eye care programs in all countries.
- VISION 2020* is based on three core strategies, namely:
 - disease control
 - human resource development (training and motivation)
 - infrastructure development (facilities, technology, consumables, funds).



Figure 28.4: The *VISION 2020* Concept (Source: *VISION 2020*)

- The guiding principles of *VISION 2020* are:
 - Integrated into existing health care systems
 - Sustainable in terms of money and other resources
 - Equitable care and services available to all, not just the wealthy
 - Excellence – a high standard of care throughout.

These can be summarised by: “ISEE”.

- Currently 45 million people in the world are blind. Without major intervention, the number of blind people is projected to increase to 76 million by the year 2020.
 - If the *VISION 2020* initiative is successful in eliminating the causes of avoidable blindness by the year 2020, the number of blind people will be limited to 24 million.

VISION 2020: THE RIGHT TO SIGHT (cont.)

VISION 2020 PRIORITIES	• Cataract • Refractive errors • Low vision • Trachoma • Childhood blindness • Onchocerciasis • Glaucoma • Diabetic retinopathy • Age-related macular degeneration
VISION 2020 FOCUS AREAS	• Increasing awareness of blindness as a major public health issue - Governments, communities and individuals must be made aware of blindness as a major public health issue. - Education on how to prevent and treat many of the causes of blindness. - Supporting blindness prevention activities. • Creating an infrastructure to manage the problem - Ensuring availability of eye care facilities and services, particularly in underprivileged areas. - Appropriate technology development for surgical and eye examination equipment, local production of eye medicines, spectacles and low vision devices. • Training eye care personnel to provide appropriate eye care - Improving quality of training for eye care professionals. - Performing school screening and working with the community. - Providing referrals for people needing eye care. - Training to identify and manage common eye conditions. - Performing refractions and prescribing low vision aids. - Special training for the management of childhood blindness. • Implementing specific programs to control the major causes of blindness Example: - Vitamin A global initiative → aiming to eliminate Vitamin A deficiency by the year 2010. - Measles Initiative → aiming to decrease deaths caused by measles by the year 2010.

REFRACTIVE ERROR

- The WHO has only recently recognised uncorrected refractive error as a major cause of blindness and visual impairment. This is because the traditional definition of blindness was based on best corrected VA instead of presenting VA.
- On World Sight Day in 2006, the WHO revealed its updated estimates of blindness and visual impairment:
 - An estimated 153 million people are visually impaired (presenting VA $<6/18$ in the better eye) as a result of uncorrected refractive error at distance
 - of which at least 8 million are blind (presenting VA $<3/60$ in the better eye).
 - Around 45 million working age adults and 13 million children globally are affected by uncorrected refractive error
 - 90% of these people live in low or middle income countries.
- These WHO figures do not include visual impairment that is a result of uncorrected presbyopia, which is estimated to affect 517 million people over the age of 45.
- We know now that uncorrected or under-corrected refractive error:
 - is a major cause of blindness and the leading cause of visual impairment in the world
 - affects people of both sexes, as well as all age and ethnic groups
 - may result in lost education and employment opportunities, lower productivity and impaired quality of life for otherwise healthy people
 - requires simple and very cost-effective treatment – in most cases an eye examination and an appropriate pair of spectacles can provide an immediate solution to the problem
 - is the most treatable of all causes of visual impairment.
- It is a great tragedy then, that millions of people, especially in the developing world, are visually impaired simply because they do not have access to basic eye care services and affordable spectacles.

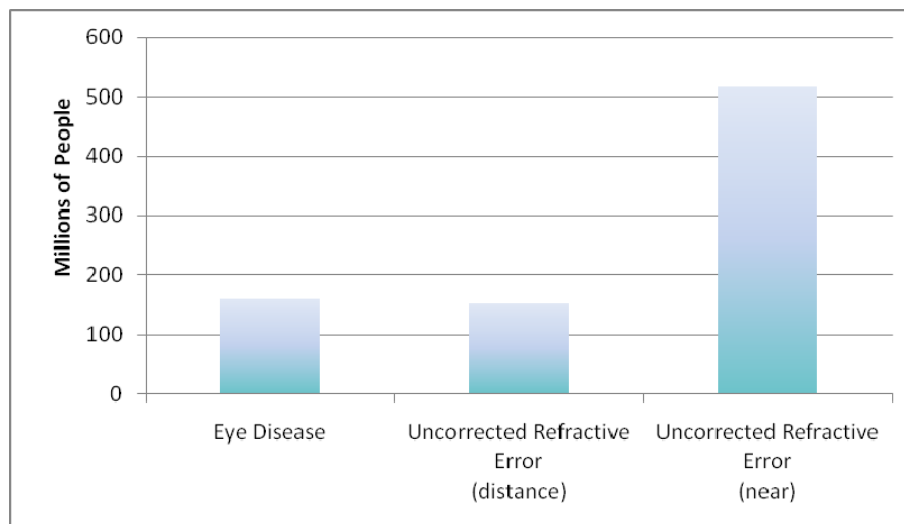


Figure 28.5: Number of people affected globally by blindness and visual impairment as a result of eye disease and uncorrected refractive error

ELIMINATION OF REFRACTIVE ERROR VISUAL IMPAIRMENT

- Providing an appropriate pair of spectacles to those in need would decrease global blindness by approximately 25% and decrease visual impairment by approximately 50%.
- The elimination of uncorrected refractive error requires:
 - trained eye care personnel to provide refractive error services
 - infrastructure (a refraction clinic containing eye examination and dispensing equipment)
 - supply of quality affordable spectacles
 - advocacy (a well-informed community and government support).

**Trained eye care personnel + Infrastructure + Affordable spectacles + Advocacy
= PEOPLE WHO CAN SEE**

TRAINED EYE CARE PERSONNEL	Elimination of refractive error requires people who are trained to do refraction eye examinations and dispense spectacles. Most eye care providers live and work in developed countries – not many provide eye care services in the developing world. Eye care personnel are also typically concentrated in urban areas.  Countries should aim to have at least one refractionist for every 100,000 people by 2010, and then increase the number of refractionists to one for every 50,000 people by 2020. Both mid- and low-level cadres of eye care personnel are required for refractive error services. Eye care providers should be trained to provide one or more of the following services: • Screening for refractive error visual impairment • Best vision sphere refraction • Sphero-cylindrical refraction (for astigmatism) • Prescribing, dispensing and distributing spectacles • Recognition of potentially blinding eye disease • Referral of people for further treatment where necessary • Visual health promotion.  Appropriately trained mid-level personnel can diagnose and manage uncorrected refractive error. This means that eye care personnel who are trained to correct refractive error can meet 70% or more of the overall eye care needs of a community. An eye care provider who has been trained to do refractions only must also know when to refer people who require further examination or treatment. If the person has an eye health problem this should be managed before spectacles are prescribed. Where possible, eye care providers should receive continuing education (“refresher courses”) to maintain their knowledge and learn about new techniques, equipment and eye care procedures.

ELIMINATION OF REFRACTIVE ERROR VISUAL IMPAIRMENT (cont.)

EYE CARE INFRASTRUCTURE	In order to provide quality refraction services, eye care providers need: • a clinic or centre that is suitable for eye examinations and allows privacy for patients if required • access to appropriate refraction and dispensing equipment • a good spectacle supply • referral locations (a list of eye care providers who can provide other eye care services if more than a refraction is required) • standard operating procedures to ensure that the clinic or centre runs efficiently.  <i>Figure 28.6: Measuring visual acuity in a refraction clinic</i>
SPECTACLE SUPPLY	The elimination of refractive error visual impairment requires access to new, affordable and good quality spectacles. However, in many areas of the world, the spectacles needed for refractive error correction are too expensive or not available at all. Depending on the situation there are different types of spectacles that can be prescribed: • Readymade spectacles • Custom-made spectacles • Donated recycled spectacles (not recommended). Readymade Spectacles → Mass produced spectacles – Inexpensive (low cost) – Variable quality (care must be taken to ensure that only high quality readymade spectacles are dispensed). → Convenient (after a refraction, the person can receive their spectacles immediately). → Provide spherical correction (both plus and minus) of the same power in both eyes – Give good vision to approximately 75% of people with distance refractive errors, and to most people with presbyopia. – Not suitable for people with high refractive errors, significant amounts of anisometropia or astigmatism. Custom-Made Spectacles → Made in optical workshops staffed by personnel trained to edge and fit lenses into spectacle frames. → Correct all refractive errors. → Provide more spectacle correction options – Allow people to choose a lens design that best suits their needs (Examples: bifocals, tinted lenses) – Provide a greater range of spectacle frame options. → Facilitate capacity building for sustainable delivery systems – can generate money for other refraction services.

ELIMINATION OF REFRACTIVE ERROR VISUAL IMPAIRMENT (cont.)

SPECTACLE SUPPLY (cont.)



Figure 28.7: Edging lenses in an optical workshop

Donated Recycled Spectacles

- Not cost-effective.
- Difficult to match frames and lenses with people who have specific refractive errors and face shapes.
- Quality control of frames and lenses problematic
 - the majority of donations are unusable.
- Must rely on constant donations from other countries
 - sustainability cannot be achieved.
- The use of donated spectacles is not recommended.



Recycled spectacles can be thought of as being like a set of false teeth: they are made especially for one person, and cannot easily be used for someone else. It is difficult to find a person with a refractive error who needs exactly the same prescription and same frame size.

ADVOCACY

Health care providers and policy makers frequently under-estimate the impact of uncorrected refractive error in the community. This is why advocacy is so important. People need to be told about the problems associated with uncorrected refractive error and what can be done to manage it.

Advocacy for refractive error should aim to:

- increase awareness of refractive error blindness and visual impairment
- mobilise resources to address the refractive error problem
- increase the quality of eye care services
- promote the VISION 2020 initiative.

People you should talk to include:

- at-risk groups and their communities
- Governmental and health officials
- eye care professionals
- corporations (businesses) in the eye and vision care industry
- international not-for-profit organisations
- donor agencies and donor communities.

Community awareness:

- It is very important to involve local communities and to educate them about eye care.
- Even if eye care services are available, these services may not be used if the community does not appreciate their value.
- Talk with the community leaders, parents, and teachers to find out which visual problems are most important to people.
- Educate the community about the importance of eye and vision care and let them know that many eye and vision problems can be prevented or treated.

YOU ARE A PART OF THE SOLUTION

- Even though providing appropriate spectacles is one of the simplest and most cost-effective ways to improve vision, many people with uncorrected refractive error are still unnecessarily blind or vision impaired.
- The reasons why many people in need are still living with uncorrected refractive error include:
 - inadequate service delivery → not enough eye care services.
 - inadequate human resources → not enough people trained to examine eyes.
 - limited affordable technology → expensive examination methods.
 - inadequate equipment → equipment not suitable for refraction examination and spectacle dispensing.
 - inadequate infrastructure → clinic or vision centre unavailable or not good enough to perform eye examinations and spectacle dispensing.
 - poor community awareness → people in the community do not know how or when to access eye care services.
- You are part of the global effort to eliminate avoidable blindness and vision impairment.
- You can provide:
 - vision screenings at schools and community centres to detect refractive error and other eye and vision problems
 - refraction services for people with refractive error
 - spectacles which are culturally acceptable, attractive, comfortable and durable
 - referrals for other eye problems that may cause visual impairment or blindness
 - community education about eye and visual health
 - what eye care services are available to the community
 - what these services are for
 - who should use these services
 - how often these services should be used
 - how to prevent eye and vision problems from occurring or getting worse.
- In order to achieve the goals of VISION 2020, individuals around the world are providing refraction services, spectacle correction, and other eye care services. You are one of these individuals and you are part of a global team. Together we will eliminate avoidable blindness and vision impairment by the year 2020.

SUMMARY: BLINDNESS AND VISUAL IMPAIRMENT

VISUAL IMPAIRMENT, BLINDNESS AND LOW VISION

- Visual impairment describes presenting visual acuity (VA) in the better eye that is:
 - for distance vision: worse than 6/18
 - for near vision: worse than N8
- Blindness describes presenting VA in the better eye that is:
 - for distance vision: worse than 3/60
 - for near vision: worse than N64
- Low vision describes best corrected VA in the better eye that is:
 - worse than 6/18 for distance (or a binocular visual field that is less than 10° from fixation), but better than light perception.

BLINDNESS AND VISUAL IMPAIRMENT FACTS

- 314 million people have visual impairment for distance.
- 90% of visually impaired people live in developing countries.
- Most blindness is avoidable
 - 75% of adult blindness is avoidable
 - 50% of childhood blindness is avoidable.
- 153 million people have visual impairment for distance as a result of uncorrected refractive error.
- 517 million people have visual impairment for near as a result of uncorrected refractive error.
- Refractive error develops at a younger age compared with the other major causes of visual impairment – this means that uncorrected refractive error causes significantly more blind person years than most other causes.

CAUSES OF BLINDNESS AND VISUAL IMPAIRMENT

- Cataracts
- Uncorrected refractive error
- Glaucoma
- Age-related macular degeneration
- Corneal opacity
- Diabetic retinopathy
- Trachoma
- Onchocerciasis

CHILDHOOD BLINDNESS

- 1.4 million children are blind and 0.5 million more children become blind each year.
- 40% of the causes of childhood blindness are treatable or preventable.
- The most common causes of childhood blindness are:
 - corneal opacities
 - cataracts
 - glaucoma
 - retinopathy of prematurity
 - refractive error.
- Visual impairment affects a child's learning and participation in the classroom and in their community. This restricts education and limits their future employment opportunities.

SUMMARY: BLINDNESS AND VISUAL IMPAIRMENT (cont.)

BARRIERS TO PREVENTION AND TREATMENT

- Accessibility and availability
- Acceptability
- Affordability
- Awareness
- Gender and age
- Socio-economic conditions.

COST AND BURDEN OF BLINDNESS AND VISUAL IMPAIRMENT

- Global cost of blindness was estimated to be US\$42 billion in 2000. Unless action taken this cost will more than double by 2020.
- The cost of eliminating avoidable blindness and visual impairment is less than the cost of no action:
 - for every US\$1 that is invested in eye care there is a US\$5 return.

VISION 2020: THE RIGHT TO SIGHT

- Goal is to eliminate the main causes of avoidable blindness by the year 2020.
- Joint initiative of World Health Organization and International Agency for the Prevention of Blindness
 - provides technical support and advocacy
 - works multilaterally
 - three core strategies: disease control, human resource development, infrastructure development.

VISION 2020 priorities:

- Cataracts
- Refractive errors
- Low vision
- Trachoma
- Onchocerciasis
- Childhood blindness
- Onchocerciasis
- Glaucoma
- Diabetic retinopathy
- Age-related macular degeneration

REFRACTIVE ERROR

- Leading cause of visual impairment globally.
- Affects people of both sexes, and all age and ethnic groups.
- Often results in lost education and employment opportunities, lower productivity and impaired quality of life.
- Requires simple and cost-effective treatment: an eye examination and an appropriate pair of spectacles
 - the most treatable of all causes of visual impairment.

SUMMARY: BLINDNESS AND VISUAL IMPAIRMENT (cont.)

ELIMINATION OF REFRACTIVE ERROR VISUAL IMPAIRMENT

- Providing spectacles to those in need would reduce:
 - global blindness by 25%
 - global visual impairment by 50%.
- Elimination of uncorrected refractive error requires:
 - trained eye care personnel
 - infrastructure
 - quality affordable spectacles
 - advocacy.

Trained eye care personnel
 +
Infrastructure
 +
Affordable spectacles
 +
Advocacy
 =
PEOPLE WHO CAN SEE

Trained eye care personnel:

- Countries should aim to have:
 - 1 refractionist for every 100,000 people by 2010
 - 1 refractionist for every 50,000 people by 2020.
- Eye care providers should be trained to provide one or more of these services:
 - vision screening
 - best vision sphere refraction
 - sphero-cylindrical refraction
 - prescribing, dispensing and distributing spectacles
 - recognition of potentially blinding eye disease
 - referral of people for further treatment as necessary
 - visual health promotion.
- Eye care personnel who are trained to correct refractive error can meet more than 70% of a community's eye care needs.

Eye care infrastructure:

- Required infrastructure includes:
 - a clinic or centre for eye examinations
 - refraction and dispensing equipment
 - good spectacle supply
 - referral locations
 - standard operating procedures.

Spectacle supply:

- Recommended spectacle types:
 - readymade spectacles
 - custom-made spectacles.
- Not recommended:
 - donated recycled spectacles.

SUMMARY: BLINDNESS AND VISUAL IMPAIRMENT (cont.)

ELIMINATION OF REFRACTIVE ERROR VISUAL IMPAIRMENT (cont.)

Advocacy:

- Advocacy should aim to:
 - increase awareness of refractive error blindness and visual impairment
 - mobilise resources
 - increase the quality of eye care services
 - promote the VISION 2020 initiative.
- People you should talk to include:
 - at-risk groups and their communities
 - Governmental and health officials
 - eye care professionals
 - eye care corporations and industry
 - international not-for-profit organisations
 - donors.

YOU ARE PART OF THE SOLUTION

- In order to achieve the goals of VISION 2020, individuals around the world are providing refraction services, spectacle correction, and other eye care services.
- You are one of these individuals and you are part of a global team.

TEST YOURSELF QUESTIONS

1. Define blindness and visual impairment.

2. a) What is the leading cause of visual impairment in the world?

b) How many people are estimated to be affected by this condition (for distance and near)?

3. List the barriers that may prevent people from receiving treatment for an eye or vision problem.

4. What is the goal of *VISION 2020*?

5. What are the main *VISION 2020* priorities?

6. Briefly explain what is required to eliminate blindness and visual impairment as a result of uncorrected refractive error.

NOTES



ESTABLISHING A REFRACTION CLINIC

THINK

A person comes to see you at your clinic. To examine the person's eyes you need to have the correct equipment and your clinic needs to be designed so that you can give the person the best service possible.

AIM

This unit explains how to set up a well organised and efficient refraction clinic to ensure that people can receive the best refraction services possible.

LEARNING OUTCOMES

When you have completed this unit you should be able to:

- describe the various areas needed in a refraction clinic and state their ideal sizes
- list all the furniture and equipment needed in a refraction clinic
- describe the proper places for various pieces of equipment and the necessary lighting of the various areas
- describe the standard operating procedures for a refraction clinic
- identify a proper and efficient layout for your refraction clinic.

THE REFRACTION CLINIC

A refraction clinic has several purposes including:

- to provide professional eye examinations
- to provide quality spectacles to people who need them
- to refer people who have eye diseases.

SETTING UP A REFRACTION CLINIC

ROOMS	A refraction clinic is usually made up of three areas including: • a Waiting room or space for people to sit comfortably while waiting for their eye examination • an Eye examination room where the eye care practitioner performs an eye examination • a Dispensing area where spectacles are dispensed and adjusted. Ideally, the average size of the whole refraction clinic, including both the waiting room and eye examination room is 7.5 metres (m) x 4 m. However this can vary depending on the shape of the building where the refraction clinic is located. The dispensing area can be located in the eye examination area or the waiting room area.
WAITING ROOM	The size of this space will depend on the expected capacity or in-flow of patients waiting for an examination. If the refraction clinic is part of a larger clinic that already has a waiting room, the refraction clinic may not need to have its own waiting room or space. If there is no room available for waiting patients, a space should be made for them. The waiting room should be approximately 3.75 m x 4 m in size. The waiting room needs to be clean, tidy and comfortable. Waiting patients need to be able to sit down and wait comfortably. Information about eye examinations and general eye health should be visible for people to look at while they are waiting. People waiting should also be able to look at a display of spectacle frames that they may order from. Waiting Room Furniture Suggested furniture includes: • Chairs for waiting patients. • Reception desk – 1.5 m x 0.8 m. On top of the reception desk will be: - A welcome sign to patients asking them to kindly wait - General information for patients to read about refractive error and other eye health promotion materials - Eye examination record cards. • Two frame display units attached to a wall. • Promotional and educational eye health posters on the walls. • Filing cupboard for eye examination record cards. • Computer.

SETTING UP A REFRACTION CLINIC (cont.)

EYE EXAMINATION ROOM

This room should be approximately 3.75 m x 6.5 m. This size will allow you to arrange equipment and furniture so that you are able to work comfortably. The examination chair should be either in front of or next to your chair, so that you are facing the person being examined. There should be enough room to move around the person without difficulty. See Figure 29.4 for a suggested layout.

Eye Examination Room Equipment

The eye examination room must be clean, tidy and ideally contain this equipment:

- Distance Visual Acuity (VA) Chart (6 m direct or 3 m indirect with mirror)
- Trial lens set
- Trial frame – for children and adults
- Jackson Cross Cylinder
- Retinoscope and Ophthalmoscope (with spare globes)
- PD ruler
- Slit-lamp with a table
- Tonometer
- Near Vision Chart
- Focimeter (also called a lensmeter or vertometer)
- Mirror
- Posters - two posters of basic eye anatomy and eye health
- Pen torch
- Occluder and Pinhole
- Spare batteries
- Eye examination record cards
- Prescription forms
- Referral forms
- Desk lamp
- A sink with hot and cold running water (for hygiene).

Eye Examination Room Furniture

The furniture you should include in the eye examination room includes:

- Large bench space
 - Used to hold your trial lens set, retinoscope, focimeter and near VA chart
 - 0.5 m x 2 m and L-shaped (following the wall around a corner of the room)
 - Metal / stainless steel – easy to keep clean and tidy
 - Storage shelves underneath the bench top.
- One examination chair.
- Two stools on wheels – important for the examiner so they can easily move around to examine the patient.
- Small cupboard (for soap, detergent, fresh hand towels, toilet paper, paper roll) underneath the sink.
- Enclosed storage / bookshelf 1.8 m x 1 m. This will store patient files, reference books, stationery (see list below), cash (in a safe box) and stock of spectacle frames, lenses and readymade spectacles.
- Hygiene cupboard 0.75 m x 0.5 m x 10 cm - Attached to the wall and containing:
 - gloves
 - cotton wool / cotton tips
 - sterile pads
 - saline
 - alcohol swabs
 - tissues
 - fluorescein Strips and other drugs (for appropriately trained eye care workers)
 - first-aid kit.

Equipment and furniture should be looked after and serviced regularly.

Supplies in the refraction area should be checked monthly and re-ordered if necessary.

SETTING UP A REFRACTION CLINIC (cont.)

EYE EXAMINATION ROOM (cont.)

Lighting

The lighting in the examination room should be adjustable in order to suit the needs for different tests.

For example: To measure VA, the VA chart must be well lit. To do retinoscopy, the room must be dim but the person still needs to be able to see the visual acuity chart.

A small desk lamp that you can easily switch on or off is useful.

If there is a window, you will need curtains to block the sunlight.

The room should also be set-up to avoid glare and reflections from lights or windows which may result in less reliable examination results.

Vision Chart – Indirect

Although refraction is usually performed at a distance of 6 m, a room that is a minimum of 3.5 m in length can be used for refractions with the use of a mirror (Figure 29.1).

This is called an “indirect” refraction room. The light from the chart travels 3 m to the mirror and then another 3 m to the person’s eyes through the reflection. The light has travelled a total of 6 m from the chart to the person’s eyes just as if the room were 6 m long. (The extra 0.5 m is needed to account for the distance between the chair where the patient sits and the wall behind them).

When an indirect refraction room is used, a “Tumbling E chart” (Figure 29.1) or a special “Reverse Snellen chart” (Figure 29.2) must be used.

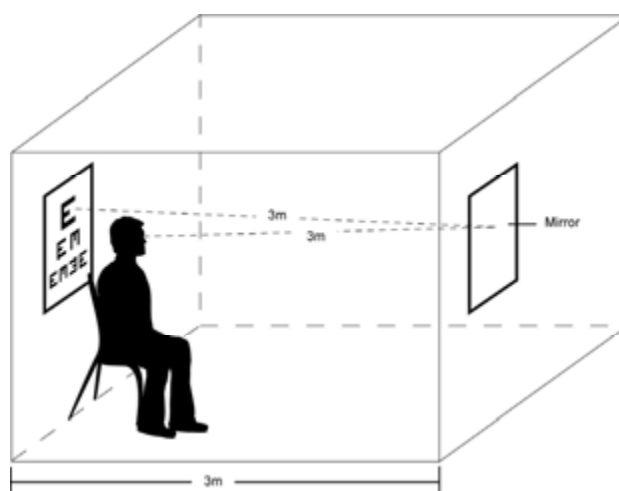


Figure 29.1: A mirror lets you use a 6 m VA chart in a room that is only 3 m long. The person looking in the mirror will see the chart as if it is 6 m away ($3\text{ m} + 3\text{ m} = 6$).

SETTING UP A REFRACTION CLINIC (cont.)

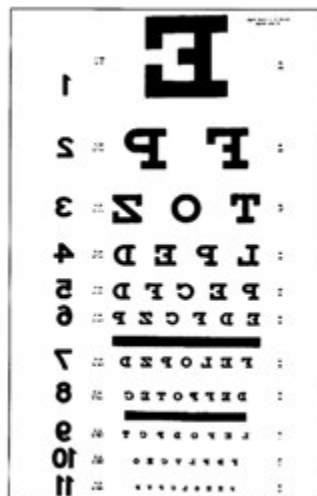


Figure 29.2: Reverse Snellen chart

EYE EXAMINATION ROOM (cont.)

The height and size of the mirror will depend on the position of the person's eyes when they sit in the examination chair. The mirror should be set at a height so that the whole chart is visible when the patient is sitting in the examination chair. The mirror should be large enough to account for the height of both adults and children. If the mirror is small it will need to be on a hinged joint so that the angle of the mirror can be changed to allow people of different heights to see the whole chart.

Vision Chart – Direct

A direct refraction room can be 6.5 m or 3.5 m in length.

- **6.5 m room:**

In this situation the examination chair is placed at one end of the room and the VA chart is placed on the wall 6 m away at the other end of the room. The examination chair is 0.5 m away from the wall behind it.

- **3.5 m room:**

If you only have a 3.5 m room and you do not have a mirror or a reverse VA chart, you can use a VA chart that has been especially designed for use at 3 m. The examination chair will be at one end of the room (0.5 m away from the wall behind it) and the VA chart will be on the other wall 3 m away.

Not all VA charts can be used at 3 m. You must make sure that you have the correct VA chart for your needs.

Most 3 m VA charts require that you add -0.25 D to the sphere of the final distance refraction result, to compensate for the shorter refraction distance.

EYE EXAMINATION ROOM (cont.)

1. You use a 3 m chart and do a refraction for a person at a distance of 3 m. Your refraction findings are:

To compensate for the shorter refracting distance you add -0.25 D to the sphere power of each eye.

2. You use a 3 m chart and do a refraction for a person at a distance of 3 m. Your refraction findings are:

To compensate for the shorter refracting distance you add -0.25 D to the sphere power of each eye.

The true refraction for this person is: R -2.50 / -1.00 x 180
L -3.25 / -0.75 x 20.

If you do not have a chart that has been made especially for use at 3 m, you could use a 6 m chart **but** at 3 m:

- the 6/60 letter would become 6/120
- the 6/6 line would become 6/12
- the 6/5 line would become 6/10.

SETTING UP A REFRACTION CLINIC (cont.)

DISPENSING AREA

All refraction clinics must have an area for dispensing spectacles. Ideally, this space will be in a separate area of its own, but if space is limited it may be combined with the waiting room or eye examination room.

Lighting should be good so that the dispenser can fit and adjust spectacles comfortably.

Dispensing Area Equipment

Equipment and tools include:

- Focimeter (also called a lensmeter or vertometer)
- Screwdrivers and wrench kit
- Pliers set
- Rulers
- Frame heater
- Ditest Parallel Rule
- Tool rack mounted on the wall
- Marking pens (permanent and water-based)
- Pupillometer
- Progressive lens layout chart (optional)
- Geneva Lens Measure
- Frame displays (minimum of two) mounted on the wall
- Seed stock of frames and readymade spectacles
- Spare batteries
- Spare parts: screws, nose pads, frame arms and fine wire
- Computer

Dispensing Area Furniture

The furniture that you should include is:

- a table (100 cm x 75 cm), where all equipment should be kept
- two chairs, one for the patient and a height adjustable chair for the eye examiner or the spectacle dispenser
- spectacle display units - they should display a range of frames and readymade spectacles.

Dispensing Area Stock

A refraction clinic should stock, and have on display, a range of spectacle frames of different styles, sizes and colours. Also available should be a variety of readymade spectacles of different powers, styles and sizes.

Seed stock refers to the initial stock of frames and readymade spectacles and care must be taken to ensure that this seed stock is of an adequate amount.

As the seed stock reduces each month (through the sale of spectacles) new spectacle frames and readymades should be re-ordered to maintain the size and variation of the seed stock. You will begin to notice a pattern of locally preferred styles of frames and/or readymade spectacles in each area. Once you know which frames and lens powers are the most popular, you should order more of them and less of the others. Different clinics have different needs depending on location and community needs.

Each clinic will develop a unique relationship with their spectacle suppliers. A good relationship should be developed so that ordering and payment negotiations can be made to suit the needs of both the clinic and the supplier.

All clinics must make sure their frame and readymade spectacle supply is well stocked to serve their patient's needs. Stock should be re-ordered regularly to make sure that the clinic never runs out of necessary frames or readymade spectacles. The most efficient way of keeping track of stock is through an inventory system in a computer.

SETTING UP A REFRACTION CLINIC (cont.)

COMPUTER	A computer allows you to record information including: stock details, finances, sales, and patients. By entering in stock details it will be easy to know how much stock is available and when you need to order more. A monitoring and evaluation system set up on a computer allows data from the clinic to be quickly recorded and assessed. This data will show information relating to the progress of clinic, number and types of people using the refraction clinic, and number of prescriptions written and spectacles dispensed. The information that is collected by a monitoring and evaluation system will allow changes and improvements to be made as needed. Information should be entered into the computer at the end of every working day. This will keep the clinic system running efficiently. Data that is saved in the computer should be backed-up weekly, to make sure no data is accidentally lost. The back-up should be on a separate device (like a CD ROM, memory stick or pen drive, or an external hard drive). Back-ups should be kept in a safe place separate from the computer. Even when the information has been entered into the computer, paper documents and records should never be thrown away. The paper documents can be very important if computer data is lost or destroyed.
STATIONERY	Enough stationery must be kept in the clinic to make sure that it maintains a high standard of service. As the stationery stock decreases each month, orders should be made to refill the stock. Stationery supplies in the eye examination room should also be checked monthly and re-ordered if needed. Stationery includes: Blank pads of paper, spare examination record cards, spare referral forms, spare prescription forms, business cards, envelopes, rulers, paperclips, stapler and staples, post-it notes, sticky tape ("Scotch" tape), scissors, spare light bulbs for ceiling lights.

Date	Name DOB M/F	Chief Compliant	Case history General health Family history Occupation /Tasks	Presenting Distance and Near VA aided/unaided		Distance and Near VA aided/unaided		PH VA		Eye health	PD	Refraction and VA		Diagnosis Treatment Spectacles	Advice	Referral
				R	L	R	L	R	L			R	L			

Figure 29.3: Example of a patient record card

SETTING UP A REFRACTION CLINIC (cont.)

The size and layout of a refraction clinic will depend on the amount of space available. If a pre-existing building is being used for the refraction clinic, the layout will need to be adapted.

Below (Figure 29.4) is an example of an ideal layout for a refraction clinic.

CLINIC LAYOUT

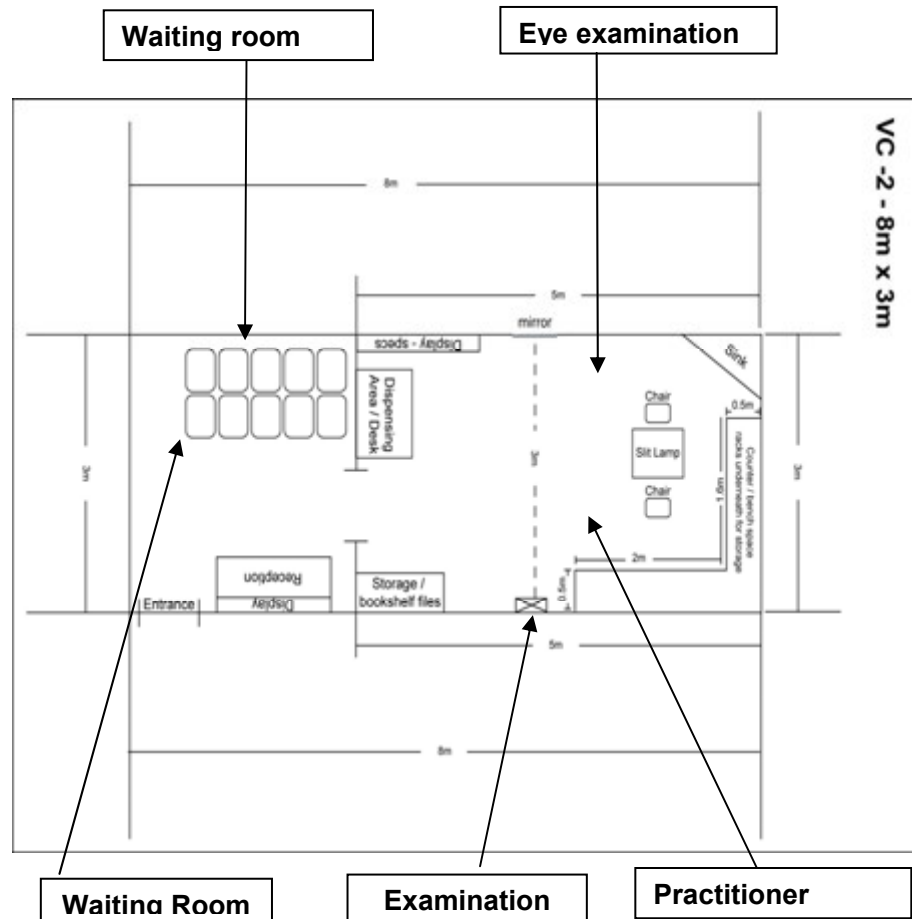


Figure 29.4: An ideal layout for a refraction clinic

STANDARD OPERATING PROCEDURES

CLINIC OPERATIONS	To make sure the refraction clinic functions well and provides a good service to people who have eye problems, some standard rules include: • Opening and closing times of the clinic must be displayed on a sign on the front door of the clinic. • The eye care practitioner must be at the clinic 15 minutes before the opening time to make sure they are ready to see patients as soon as the clinic opens. • The clinic must open and close at the stated times. • The clinic must be clean and tidy. All areas of the clinic, including the waiting room, eye examination room and toilet area (if applicable) must be thoroughly cleaned every day with disinfectant. There must be soap at the sink and it must be used routinely for washing hands. • All equipment must be returned to its correct place at the end of each day. • All equipment must be turned off, wiped down, and covered with dust-protectors at the end of each day. • All patient record cards must be filed alphabetically in the storage cupboard at the end of each day. • All stationery must be stored in the storage cupboard at the end of each day. • At the end of each week, all clinic rooms must have their stock checked and re-ordered when necessary. • When you sell spectacles, you must give a receipt to the person. You must also keep a copy of the receipt in the receipt book. • A set amount of cash money (a "float") will be left in the safe box; this amount must always be kept in the safe. When a sale is made, the money must be put into the safe box immediately. • At all times, all cash must be locked in the safe box and locked in the storage cupboard.
HYGIENE	Good hygiene must be maintained throughout the clinic to have a safe working environment. A refraction clinic is a health clinic so it is very important to prevent the spread of diseases to people who are having their eyes examined and staff who work there. Standard rules include: • All eye care practitioners must dress neatly in clean clothes and must be well groomed. Finger nails must be kept short, hair must be clean (and tied up if it is long) and shoes must be worn at all times. • Eye care practitioners must wash their hands with antiseptic soap before and after examining every person. Hands must be rinsed well and dried completely with a clean towel or paper towel. • Equipment must be wiped down with alcohol swabs between each eye examination. • All waste from the clinic must be put into the allocated rubbish bins – all internal rubbish bins must be lined with plastic rubbish bags. At the end of each day all internal rubbish must be emptied into the allocated rubbish bin outside.

SUMMARY: ESTABLISHING A REFRACTION CLINIC

THE REFRACTION CLINIC

A refraction clinic has several purposes including provision of a: professional eye examination, quality spectacles, referral if needed for eye diseases.

SETTING UP A REFRACTION CLINIC

Rooms:

A refraction clinic has three main areas:

- Waiting room or waiting space for people to sit comfortably and wait for their eye examination.
- Eye examination room where the eye care practitioner performs an eye examination.
- Dispensing area where spectacles are dispensed and adjusted.

Lighting:

- Needs to be adjustable in the eye examination room.
- Needs to be bright in the waiting and dispensing areas.

Vision charts:

- Indirect chart used at 3 m with a 6 m reversed Snellen chart and mirror.
- Direct chart used at 6 m with a 6 m chart.
- Direct chart used at 3 m with a 3 m chart.
 - Need to add -0.25 D to the sphere power of final refraction results
 - If a 6 m chart is used at 3 m, the VA measurement needs to be adjusted.

Computer:

- Is the easiest way to keep details on stock, finances, sales and patient information.
- Data should be entered in at the end of every working day.
- Monitoring and evaluation data is important to assess and improve the clinic.

Dispensing stock:

- “Seed stock” is the initial number of spectacle frames and readymade spectacles.
- Stock should be monitored by putting stock details into a computer system and should be re-ordered as needed.

Clinic layout:

- Depends on existing infrastructure.
- Must be designed to allow efficient operation of the clinic.
- Refer to Figure 29.4.

STANDARD OPERATING PROCEDURES

Standard operating procedures are rules that must be followed for:

- Clinic operations
- Hygiene.

EQUIPMENT LIST

	Waiting Room	Eye Examination Room	Dispensing Area
Furniture	Four chairs	Large bench space	Desk
	Reception desk	One chair	Two chairs
	Frame display units	Two stools with wheels	One adjustable height chair
	Posters / brochures on eyes	Sink	Frame display units
	Cupboard for patient records	Hygiene cupboard	
		Bookshelf / storage space	
		Sink cupboard	
Equipment	Patient record cards	Distance VA Chart	Focimeter (or lensmeter)
	Computer	Trial lens set	Screwdrivers and wrench kit
		Trial frame	Pliers set
		Jackson Cross Cylinder	Rulers
		Retinoscope / Ophthalmoscope	Frame heater
		PD ruler	Ditest Parallel Rule
		Slit-lamp with table	Tool rack mounted on wall
		Tonometer	Marking pens
		Near VA Chart	Pupillometer
		Focimeter (or lensmeter)	Progressive lens chart
		Mirror	Geneva Lens Measure
		Posters	Seed stock - frames and RMS
		Pen torch	Batteries
		Occluder / Pinhole	Frame spare parts
		Batteries	Computer
		Examination record cards	
		Prescription forms	
		Referral forms	
		Desk lamp	
Stationery and Hygiene Items	Blank pads of paper	Gloves	
	Spare examination record cards	Cotton wool / cotton tips	
	Spare referral forms	Sterile pads	
	Spare prescription forms	Saline	
	Business cards	Alcohol swabs	
	Envelopes	Tissues	
	Printing paper	Fluorescein strips and other drugs	
	Pens, pencils, markers	First-aid kit	
	Highlighters and rubber		
	Rulers		
	Paperclips		
	Stapler and staples		
	Post-it notes		
	Sticky tape		
	Scissors		
	Spare light globes		

TEST YOURSELF QUESTIONS

1. What are the three main spaces needed in a refraction clinic?

2. What is the ideal size of the waiting room and the eye examination room?

3. What type of lighting is needed in the eye examination room?

4. Describe what is meant by an Indirect VA chart? What is needed in this set-up?

5. Describe the process of maintaining dispensing stock in the clinic.

6. List five different Clinic Standard Operating Procedures.

7. Why is it important to have good hygiene in a refraction clinic?



NOTES

MANAGING A CLINIC FOR REFRACTION SERVICES

AIM

This unit will teach you how to manage stock and cash flow in a refraction clinic.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- record and maintain inventory of spectacles, frames and lenses and stationery items
- keep accurate records all sales (spectacles sold)
- order spectacles, spectacle frames and lenses
- order stationery and other goods required to maintain an effective clinic
- write appropriate receipts for monies received
- keep accurate records of monies received
- perform thorough banking procedures.

STOCK AND INVENTORY

Stock and inventory are different words that mean the same thing. When we refer to stock or inventory, we mean everything in a clinic that gets used or sold and needs to be restocked. In a refraction clinic this may include:

- readymade spectacles
- spectacle frames and lenses
- referral and prescription pads
- eye examination record cards
- stationery items
- consumables and equipment parts

Examples:

- fluorescein strips
- globes for equipment
- dispensing parts, such as screws and nose pieces
- low vision aids (where applicable).

INITIAL STOCK AND COMMON STOCK

“Initial stock” or seed stock is a list of the original stock that is in the clinic. This can be made when:

- opening a new clinic
- ordering the first lot of stock, or
- when taking over an existing clinic that already has stock.

When stocking readymade spectacles and frames, the initial stock should consist of a broad range of styles that will suit most people.

“Common stock” is the stock that is preferred by people in the local area. Once you have been working in a specific area for a while you will have an idea of what inventory needs to be stocked to suit local people’s preferences and needs.

This includes the:

- powers of spectacle lenses or readymade spectacles that you use the most
- frame styles that are most popular in your area.

In different areas, certain styles of frames will be more popular than others. When you know what they are, then you should stock more of that style. Also, some powers of lenses in an area will be more common than others, so you should stock your lens supply with more of the common powers and fewer of the less common powers. These lenses are referred to as “stock lenses”.

ORDERING STOCK

You will usually re-order stock once every month. To make sure you do not run out of stock during the month it is important that you plan carefully.

STOCK AUDIT	When ordering stock you need to know how much of each item you will need. This is done through a “stock audit”. A stock audit is a stock-take (counting) of all inventories in the clinic. A stock audit should take place on the last working day of every month. This will give you the most accurate calculation of how much stock you have used in the past month and help you calculate how much you will need for the following month. Once you have been working in the clinic for a few months, you will find it easier to estimate the stock required each month.
ORDERS	Orders for new stock should be made on the same day as the stock audit. Once you know what stock you still have, you can decide how much new stock you need for the following month. You should write the order for new stock in the “order book” and order the stock. To order stock you should complete a stock order form and fax, email, mail or telephone it to your local suppliers. You must consider how long it will take for the stock to be sent to you – if you are located in a rural or remote area, it may take more than a week to receive stock. It is important not to have too many of the same style of frames and power of lenses in stock. Sometimes it is easier to order stock as it runs low.
ORDER BOOK	All stock orders should be written in an “order book”, or recorded on a computer if that is available. This is the best way to watch the movement of stock. Each page is split in half with “order out” on the first half of the page and “order in” on the other half of the page. All columns in the order book should be completed (see Table 30.1). The order book or computerised file should always be used together with the “Monthly Stock Sales Sheet” (see Table 30.2). This sheet keeps a monthly tally of the sale of spectacles. Orders can be easily calculated from this sheet, as it shows the most popular spectacle styles that are sold.

Table 30.1: Example of the Order Book

ORDER OUT					ORDER IN				
Date	Item	Code No.	Quantity	Company	Received date	Item	Code No.	Quantity	Invoice No.
29/02/08	Specs	66213	3	Mirisol	04/03/08	Specs	66213	3	63
29/02/08	Specs	66452	2	Mirisol	04/03/08	Specs	66452	2	63
29/02/08	Prescription pads	212	2	Hallmark	05/03/08	Prescription pads	212	2	274
29/02/08	Referral pad	286	1	Hallmark	05/03/08	Referral pad	286	1	274
29/02/08	Globes for retinoscope	11274	1 box	SunSun	06/03/08	Globes for retinoscope	11274	1 box	23

RECORD KEEPING

Record keeping is a very important part of running an efficient refraction clinic. Accurate and consistent record keeping is the best way of knowing:

- how much stock you have
- how much stock you need, and
- how much stock you do not need.

Records must be kept of all sales and stock movements on a daily, weekly and monthly basis. All sales must be recorded in the yearly “sales book” and all stock orders must be written in the yearly “order book”. If you have a computer available, that could also be used for recording sales and orders.

Loose paper records of all sales and orders should be kept in the proper monthly folder and filed in the correct yearly file. For example, all sales and orders for February 2010 must be placed in the February folder and put in the 2010 file.

DAILY	• All stock movements, including sales and orders, must be recorded in the “spectacle sales” and/or “orders” book (or in the computer) at the time of the sale or the order. • Additional referral and prescription pads must be recorded in the “order book” (or computer) so that new ones can be ordered. • Receipts must be written and given, at the time of purchase, to everyone who purchases spectacles.
WEEKLY	• All sales must be totalled and balanced so they add up at the end of every week. • Banking must be recorded in the “banking” ledger at the time of banking. • Banking must be done on the same day of every week.
MONTHLY	• If you need more stock for the next month it should be recorded and dated in the monthly “order book” or in the computer. Orders can only be made after this is done. • All new orders received should be marked against the order made in the “order book” or computer file to make sure everything has arrived. • Mark the number of sales in “tally” form on the monthly sales stock sheet (Table 30.2) against each frame style.

Table 30.2: Example of the Order Book

March 2009													Total
Power	+1.50	+1.50	+1.50	+1.50	+2.50	+2.50	+2.50	+2.50	+3.50	+3.50	+3.50	+3.50	3
Style	A	B	C	D	A	B	C	D	A	B	C	D	
No. of Specs In store	10	8	6	4	12	10	8	7	8	6	6		
No. of Specs Sold - tally													

SPECTACLE SALES BOOK

All sales need to be recorded in a spectacle sales book, or into a special a computer program if that is available. This book (or computerised file) helps you keep track of all the spectacles you have in the clinic and the spectacles you have sold. This is the easiest way to keep an accurate account of the cash flow in the clinic.

- You need to record:
- Date of sale
 - Spectacle name / code
 - Spectacle colour
 - Power of spectacles
 - Price
 - Amount paid
 - Receipt number
 - Name of eye care practitioner.

RECEIPT BOOK

Whenever somebody makes a purchase, a receipt must be given to that person. Receipts must be given for all money received, so whenever you sell a pair of spectacles you **must** provide a receipt. It is important that you keep a copy of the receipt in the clinic for your own records.

Receipts can also be used as proof that the person has bought and owns the spectacles. Receipts are also proof that you have received the money. This is especially important if you have only received part of the payment for the spectacles and you need to confirm the final amount owing for the spectacles.

HOW TO WRITE A RECEIPT	When the person buys a pair of spectacles, take the money and write a receipt for the exact amount of money received. → If the person pays only part of the amount and wishes to pay the balance of the amount the following week, then a receipt must be written for that part payment at the time you received the money. When the person pays the rest of the money the following week, you then write another receipt for that payment. The amount of money written on the receipt is exactly the same amount of money that you received. If a person makes a part payment for a pair of spectacles and wishes to pay the rest of the money later in the week, they can only collect their spectacles once full payment has been made. → Give the original receipt to the person who gives you the money. → Keep the copy in your receipt book for your files. Each receipt is numbered. You should record the number of every sale. A receipt should have the following information: • Date of money received • Full name of person who paid the money • Power and style of the spectacles • Amount of money in words followed by the word "only" • Amount of money in figures (numbers) • Name of the person who received the money and wrote the receipt.												
EXAMPLE	<table border="0"> <tr> <td>Date: 14/10/2009</td> <td>Name: Mrs B. Seegood</td> </tr> <tr> <td>Spectacle style:</td> <td>PrettyFace – Model 87-4, Gold, Size 50-14</td> </tr> <tr> <td>Spectacle power:</td> <td>R +3.25 D L +3.00 D</td> </tr> <tr> <td>Amount paid (in words):</td> <td>Fifty four dollars only.</td> </tr> <tr> <td>Amount paid (in figures):</td> <td>\$54.00</td> </tr> <tr> <td>Receipt No: 987</td> <td>Received by: Isabelle See (Vision Technician)</td> </tr> </table> After you have received the money for the spectacles and you have given the person a receipt, you need to write the information of the sale in the spectacles sales book and include the receipt number for your records.	Date: 14/10/2009	Name: Mrs B. Seegood	Spectacle style:	PrettyFace – Model 87-4, Gold, Size 50-14	Spectacle power:	R +3.25 D L +3.00 D	Amount paid (in words):	Fifty four dollars only.	Amount paid (in figures):	\$54.00	Receipt No: 987	Received by: Isabelle See (Vision Technician)
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Amount paid (in words):	Fifty four dollars only.												
Amount paid (in figures):	\$54.00												
Receipt No: 987	Received by: Isabelle See (Vision Technician)												

BANKING

All money received for spectacles must be deposited into the bank. Banking should be done a minimum of once a week and preferably on the same day of each week. This will help you plan your days and weeks so that certain responsibilities are completed each day. This will also help you maintain a well organised workplace.

Remember to keep some “float” money locked in the cash box. The float should be in small denominations and will be used to give people change when they make purchases with big notes. The float is never banked and the same amount must be kept in the float every week. Because the float is always the same amount, you can calculate exactly how much money you have received from purchases and you will know the exact amount you need to bank.

BANKING LEDGER	You must record all money deposited at the bank by writing the details in a “banking ledger”. Even though your banking deposit book shows all bank transactions, this is the best way for you to keep track of your own banking. You can then measure this amount against the sales you have made, the receipts you have written and the actual money you have received. They should all balance. If money is missing, it will show up here. In the banking ledger you should include the following information: • Date of banking • Amount of money deposited • Brief description of what the money was for (usually this will be for spectacle purchases, BUT, there may be an unusual purchase or payment that a person has made). Bulk amounts should be written next to different purchases • Name and signature of the person who is banking the money.

EXAMPLE:

Banking date	Amount deposited	Description	Name	Signature
12/09/09	\$165.00	Total spectacle sales: \$70 Total low vision aids sold: \$85 Total spectacle accessories sold: \$10	Isabelle See	

BILLS AND ACCOUNTS

BILLS	All clinics will receive bills that must be paid to continue effective operations. Bills for different services will vary for each clinic as it depends on where they are located. Bills may be for the services such as: • Electricity • Water • Rent • Telephone/fax line • Internet connection. Paying bills for these services may vary due to the clinic's location. If a clinic is located in a hospital or health centre, many of these services may be provided by the hospital or health clinic. However, if the clinic is situated in its own premises, all services will have to be paid for by the clinic.
ACCOUNTS	An account is not always a bank account. An account can also be opened with a company that supplies your clinic with stock. Example: your supplier of readymade spectacles will make an account for you so that when you order your spectacles, you will not need to pay for them immediately. Instead the supplier will send you an account with your spectacle order. You will be given a certain time frame to pay that account (usually 14 or 30 days). Once you have established a good working relationship with your suppliers, you can often negotiate a payment time that suits you.
PAYING BILLS AND ACCOUNTS	Each bill and account will show a "due date". This is the latest date that you can pay your account. It is important that all bills and accounts are paid by the due date. You must keep track of all payments to be made – which is easy to do if you are properly organised.
TO PAY	The best way to keep track of payments is to have a tray for bills and accounts called "To Pay". You should highlight or circle the due date on every bill and account and file it in this tray with the latest date for the month on the bottom and the earliest date to pay on the top. Every day you should go through this tray and arrange payments.
PAID BILLS AND ACCOUNTS	Once bills and accounts have been paid, they should be filed in the corresponding supplier's file. You should keep a copy of every paid bill for the clinic records as proof of payment.

FILING

A well organised clinic has a good filing system.

A filing cupboard is the best place to store your files. You should have a file for each:

- month
- supplier
- service provider (Examples: electricity, water, telephone/fax, rent, Internet service provider).

All the files for each year can be kept in a larger folder that is labelled with the date of that year.

SUMMARY: MANAGING A CLINIC FOR REFRACTION SERVICES

STOCK AND INVENTORY

Stock and inventory are different words meaning the same thing.

They refer to everything in a clinic that gets used or sold and needs to be restocked.

This includes:

- readymade spectacles
- spectacle frames and lenses
- referral and prescription pads
- eye examination record cards
- stationery items
- consumables and equipment parts
- dispensing parts
- low vision aids.

INITIAL STOCK AND COMMON STOCK

- Initial stock is the list of the original stock that is in the clinic.
- Common stock is the stock that is preferred by people in the community where the refraction clinic is located.

ORDERING STOCK

- Usually you will order new stock once every month.
- You should do a stock audit on the last day of every month.
- Order new stock on the same day as the stock audit.
- Write each new order in the order book or record it in the computer.
- Email, fax, mail or telephone your order to your suppliers.
- Complete a monthly stock sales sheet when you do each order.

RECORD KEEPING

- Records let you know:
 - how much stock you have
 - how much stock you need
 - how much stock you do not need.
- Records should be kept daily, weekly and monthly → depending on what they are for.
- Spectacle Sales Book / Computerised file – records all spectacle sales and helps you keep track of spectacles in the clinic. This should be completed after every sale.
- Monthly Stock Sales sheet / Computerised file – records spectacle sales for each month.
- Receipt Book – a receipt must be written for and given to every person who has made a purchase at the time of purchase.

SUMMARY: MANAGING A CLINIC FOR REFRACTION SERVICES (cont.)

BANKING

- Banking should be done at least once every week.
- A “float” should be kept in the cash box and not banked.
- All money that is banked must be recorded in the banking ledger.
- Only money received for sales of goods should be banked.

BILLS AND ACCOUNTS

- A bill is provided for a service (such as electricity, water, rent, telephone or Internet service provider).
- An account is provided by a supplier. It may give you a certain time frame to pay for ordered stock.
- All bills and accounts must be paid on time.
- You must be organised and pay bills and accounts by the due date. The best way to do this is by filing bills in a “To Pay” tray.
- Paid bills should be filed in each supplier’s file.

FILING

- A good filing system is essential to run an organised clinic.

TEST YOURSELF QUESTIONS

1. What is the difference between “initial stock” and “common stock”?

2. Imagine it is the last day of the month and you need to order more stock. What must you do?

3. Mrs Garden has ordered some spectacles from you today.

She has ordered a new Priceline spectacle frame: Model number – 8765
 Colour – Pink
 Size – 47-18

With these lenses: R +2.25 D L +2.50 D

The total cost of these new spectacles is: \$100

She pays you: \$80

She tells you that she will pay the remaining money that she owes when she returns to collect her spectacles.

Write a receipt for Mrs Garden:

Date: Name:

Spectacle Style:

Spectacle Power:

Amount paid (in words):

Amount paid (in figures):

Receipt Number: 3456 Received by:

4. What is the “float” money for?
