AQA Physics A Level

10.1 Physics of the eye

Flashcards

How do lenses change the direction of light rays?

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By refraction: light changing speed and direction as it enters a medium with a different refractive index.

What shape is a converging lens and what effect do they have on light rays?

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Convex, they bulge outwards and bring light rays together.

Define the principal axis, principal focus and focal plane of a converging lens?

Define the principal axis, principal focus and focal plane of a converging lens?

Principal axis: A straight line perpendicular to the lens surface that passes through the lens centre.

Principal Focus: Rays parallel to the principal axis converge on a point on the axis after the lens called the principal focus.

Focal Plane: A plane on which the principal focus lies that is perpendicular to the principal axis.

What is meant by focal point and focal length of a converging lens?

What is meant by focal point and focal length of a converging lens?

Focal point:The point at which waves meet for a diverging lens it is the point from which they appear to come from.

Focal length: The distance between the lens axis and the focal plane, it is positive as the focal point is in front of the lens, it is represented by ‘f’.

What shape is a diverging lens and what effect do they have on light rays?

What shape is a diverging lens and what effect do they have on light rays?

Concave, they cave inwards.

They cause parallel light rays to spread out (diverge).

What is the principal focus and focal length of a diverging lens?

What is the principal focus and focal length of a diverging lens?

Principal focus: The point that the rays parallel to the principal axis appear to have come from.

Focal Length: The distance between the lens axis and the principal focus, it is negative as it is behind the lens.

How is a ray diagram for an object sitting on the principle axis of a converging lens drawn?

How is a ray diagram for an object sitting on the principle axis of a converging lens drawn?

- One ray from the top of the object is drawn parallel to the principal axis and refracts in the lens to go through the principle focus on the other side.
- One ray from the top of the object passes straight through the centre of the lens.

How is a ray diagram for an object sitting on the principle axis of a diverging lens drawn?

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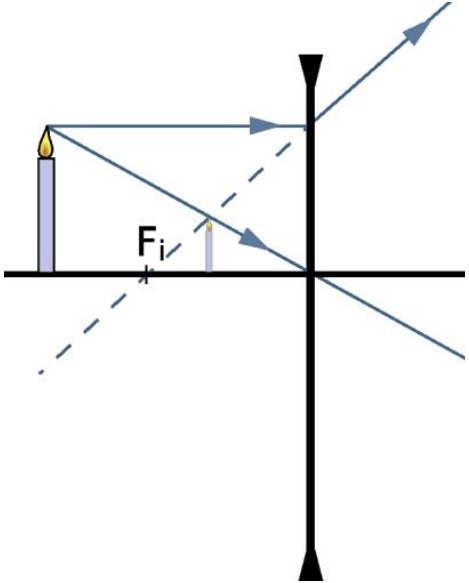

Ray parallel to principal axis refracts and appears to come from principal focus.

Ray passing through lens centre doesn't change direction.

https://commons.wikimedia.org/wiki/File:Lentediv_1.png

What are real and virtual images?

What are real and virtual images?

A real image can be captured on a screen and is formed when light rays from an object pass through another region in space, they form on the opposite side of the lens.

A virtual image can’t be captured on a screen and is formed when light rays appear to have come from another point in space, they form on the same side of the lens as the object.

What do ‘u’ and ’v’ represent in lens diagrams and equations?

What do ‘u’ and ‘v’ represent in lens diagrams and equations?

u: The distance between the object and lens axis, u is always positive.

v:The distance between the image and lens axis, v is positive for real images and negative for virtual images.

Draw a table showing the properties of an image formed when an object is placed at different distances from a converging lens

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u	Real or virtual	orientation	size	v
Beyond 2f	real	inverted	diminished	Between f and 2f
At 2f	real	inverted	Same size	2f
Between f and 2f	real	inverted	magnified	Greater than 2f
Smaller than f	virtual	upright	magnified	negative

What type of image do diverging lenses **always** produce?

What type of image do diverging lenses **always** produce?

Virtual, upright, diminished, on the same side of the lens.

v is always negative, these properties are true no matter where the object is.

What is the lens equation?

What is the lens equation?

$$1/f = 1/u + 1/v$$

f = focal length

u = distance from object to lens axis

v = distance from image to lens axis

An object is placed 0.18m from a diverging lens with a focal length of -0.35m, calculate the distance from the lens to the image formed.

An object is placed 0.18m from a diverging lens with a focal length of -0.35m, calculate the distance from the lens to the image formed

f= -0.35m u=0.18m

1/-0.35 - 1/0.18=1/v

-530/63=1/v

v=-63/530 v=-0.12m (2sf)

How can the linear magnification produced by a lens be calculated?

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Magnification (m)

$$m = \text{image height} / \text{object height} = v / u$$

What is the relationship between the power of a lens and its focal length?

What is the relationship between the power of a lens and its focal length?

power = 1 / focal length

Diverging lenses have negative power

Power units = dioptres, D

Focal length units= metres,m

A lens has a focal length of -3cm, find its power

A lens has a focal length of -3cm, find its power

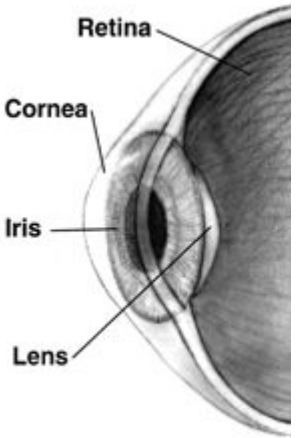
-3cm = -0.03m

Power = 1/-0.03 = -30D (1sf)

What is the cornea?

What is the cornea?

A transparent outer layer on the front of the eye with a convex shape and high refractive index, it focuses most of the light.



https://commons.wikimedia.org/wiki/Cornea#/media/File:Human_eye_cross-sectional_view_grayscale.png

What is the eye lens?

What is the eye lens?

The lens acts as a fine focus, muscles change its shape which affects its focusing power by altering the focal length of the eye.

Where do images form in the eye?

Where do images form in the eye?

On the retina which contains light sensitive rods and cones.

What is the region in the centre of the yellow spot known as and why is it the most sensitive part of the retina?

What is the region in the centre of the yellow spot known as and why is it the most sensitive part of the retina?

The fovea, It contains the highest concentration of cones.

What is meant by ‘the far point’ and ‘the near point’?

What is meant by ‘the far point’ and ‘the near point’?

Far point: The furthest distance the eye can focus comfortably - for normally sighted people it’s infinity.

Near point: The closest distance the eye can focus on.

Draw a ray diagram to show how images form in the eye.

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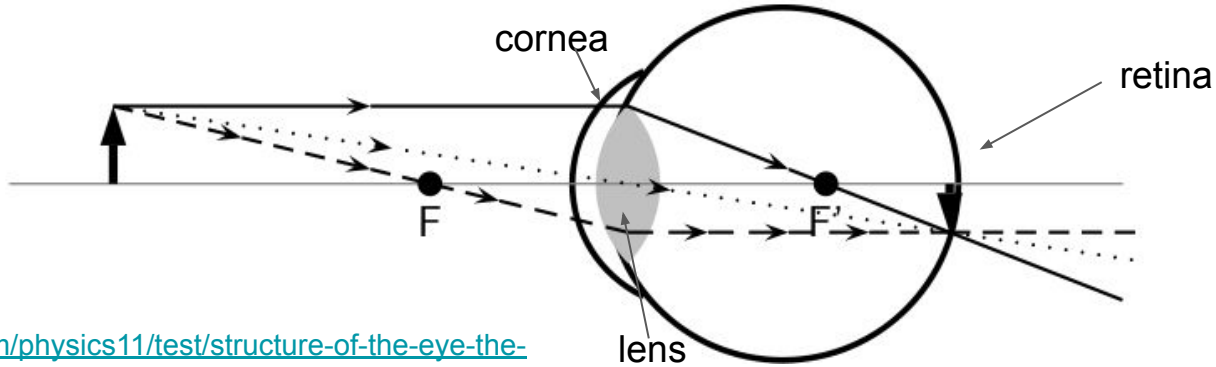

https://www.jobilize.com/physics11/test/structure-of-the-eye-the-human-eye-by-openstax#uid115

The light rays converge on the retina and both the cornea and lens focus the rays.

Why are rods and cones called photoreceptors?

Why are rods and cones called photoreceptors and how are they activated?

They are specialised cells that detect light and convert it into an electrical signal. They contain chemical pigments which bleach when light falls on them stimulating the cell to send a signal to the brain by the optic nerve.

How are rods and cones reset? Do rods detect colour and how many types of cone are there in the human eye?

How are rods and cones reset?Do rods detect colour and how many types of cone are there in the human eye?

They’re reset as enzymes unbleach them using vitamin A from the blood. Rods are more sensitive to light so help us see in the dark but don’t detect colour. There are 3 types of cone they detect red,blue and green light.

Sketch 3 curves to show the spectral response of the eye as a photodetector

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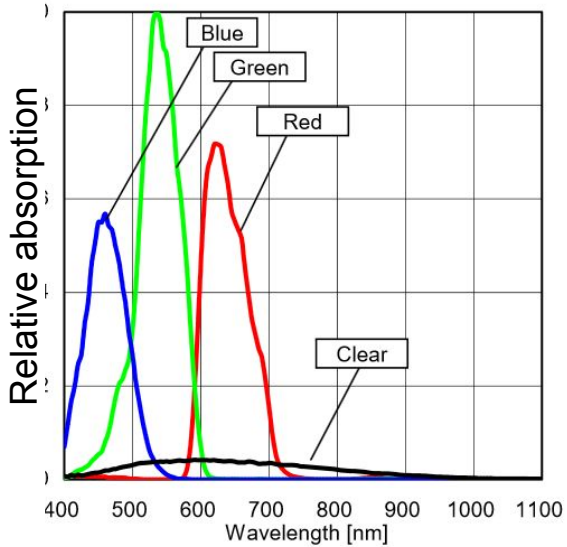


The curves show that the eye is less responsive to blue light than green or red.

https://www.allaboutcircuits.com/projects/design-a-color-sensor-with-measurements-displayed-via-an-rgb-led-module/

What is spatial resolution?

What is spatial resolution?

The ability to discern objects that are close together as separate images.

2 objects can be distinguished if there's only 1 rod/cone between the light from each of them so long as the rod/cone doesn't share an optic nerve with those detecting the images.

Spatial resolution is best at the yellow spot as the cones are densely packed and each has its own nerve fibre.

What does myopia mean and when does it occur?

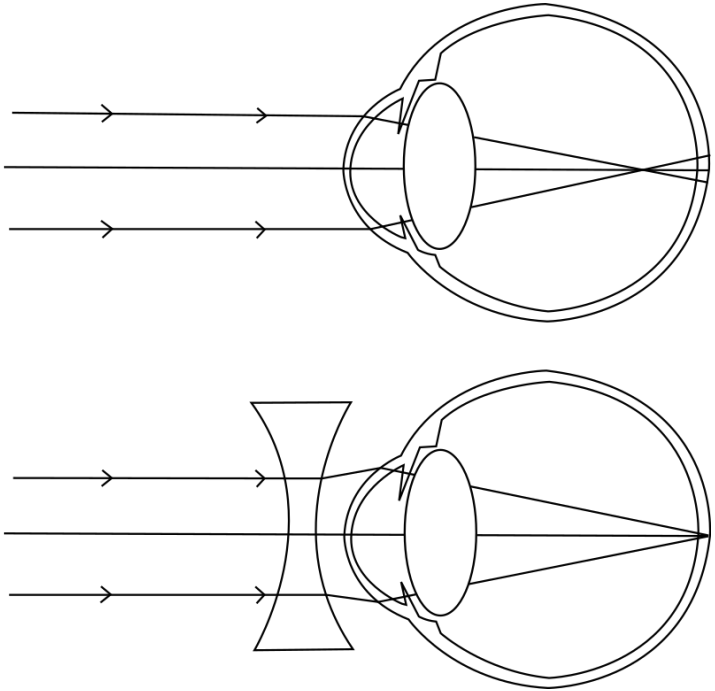
What does myopia mean and when does it occur?

Short-sightedness, it occurs when the cornea and lens are too powerful or the eyeball is too long, images of distant objects are focused in front of the retina.

Draw a ray diagram to show how correction lenses for myopia work.

Draw a ray diagram to show how correction lenses for myopia work.

A **diverging** lens causes the light to focus on the retina.



https://commons.wikimedia.org/wiki/File:Myopia-2-2.svg

Where should the principal focus of a diverging lens used to correct myopia be?

Where should the principal focus of a diverging lens used to correct myopia be?

At the eye's faulty far point.

The lens must have a negative focal length equal to the distance to the eye's far point, this focuses objects at infinity.

A myopic person has a far point of 4.3m, find the lens power needed to correct their vision.

A myopic person has a far point of 4.3m, find the lens power needed to correct their vision.

Focal length = far point = -4.3m

(Diverging lenses always have negative focal length)

Power = 1/-4.3 = -0.23 D (2sf)

What is meant by ‘hypermetropia’ and when does it occur?

What is meant by ‘hypermetropia’ and when does it occur?

Long-sightedness, images are brought to focus behind the eyeball.

The near point is further away than normal (>25 cm) because the eyeball is too short or the focusing system (cornea and lens) are too weak.

Draw a ray diagram to show how a **converging** lens corrects hypermetropia

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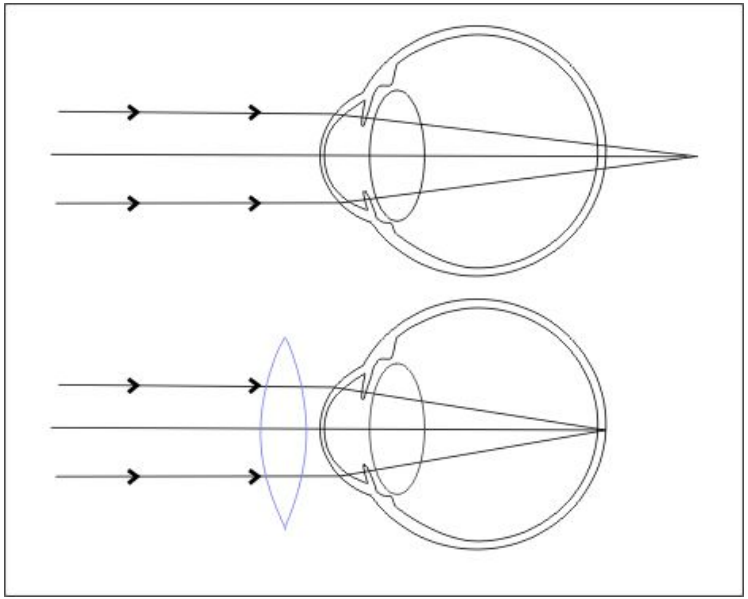

https://commons.wikimedia.org/wiki/File:Hypermetropia.png

The overall focusing power is increased so the rays are brought closer together before entering the eye.

Where does a converging lens produce a virtual image in people with hypermetropia?

Where does a converging lens produce a virtual image of an object 25cm away in people with hypermetropia?

At the eye's uncorrected near point so it appears in focus.

A long sighted person has a near point of 5.2m, what power of lens is needed to correct this?

A long sighted person has a near point of 5.2m, what power of lens is needed to correct this?

$$1/f = 1/u + 1/v$$

v= -5.2m (image is virtual so v is negative)

u=0.25m (correction is for objects 0.25m away)

power=1/f= 1/0.25 + 1/-5.2 = 3.8D

What is astigmatism and what causes it?

What is astigmatism and what causes it?

A refractive error that causes objects at all distances to be blurry.

Caused by an irregularly shaped lens or cornea which has different focal lengths depending on the plane.

E.g. when horizontal lines are focused, vertical lines may be blurry, it is corrected with a cylindrical lens which only adds power in one plane.

What is the format of a prescription for astigmatism?

What is the format of a prescription for astigmatism?

- The power needed to correct long/short sightedness known as the sphere (SPH)
- The power needed to correct astigmatism known as the cylinder (CYL)
- The angle (0-180°) to the horizontal of the plane that doesn't need correcting for astigmatism (known as the axis)