Questions

Q1.

A student investigated how a converging lens can be used to project a magnified image onto a whiteboard.

In a darkened room, the student placed a smartphone 9.0 cm from the converging lens. The phone's display was projected onto the whiteboard. The converging lens was 75.0 cm from the whiteboard when a clear image was produced.

The image projected onto the whiteboard was real.

State what is meant by a real image.

(1)

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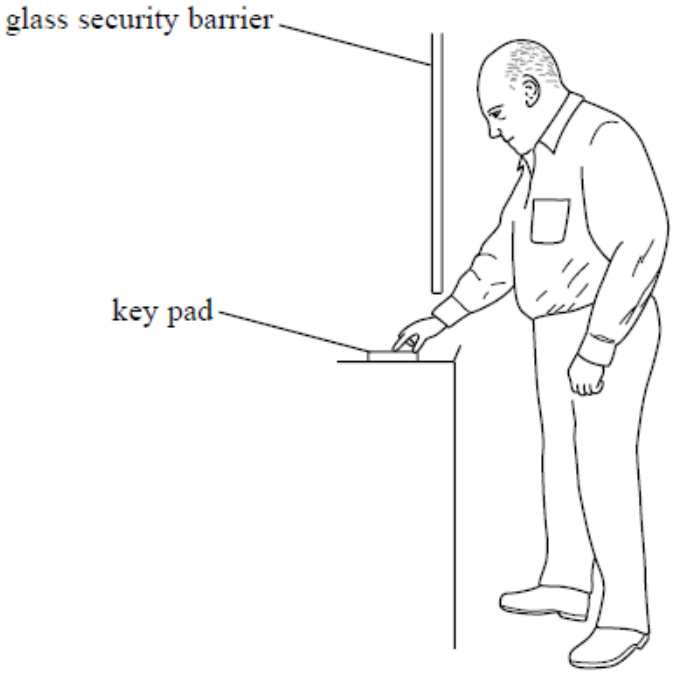
(Total for question = 1 mark)

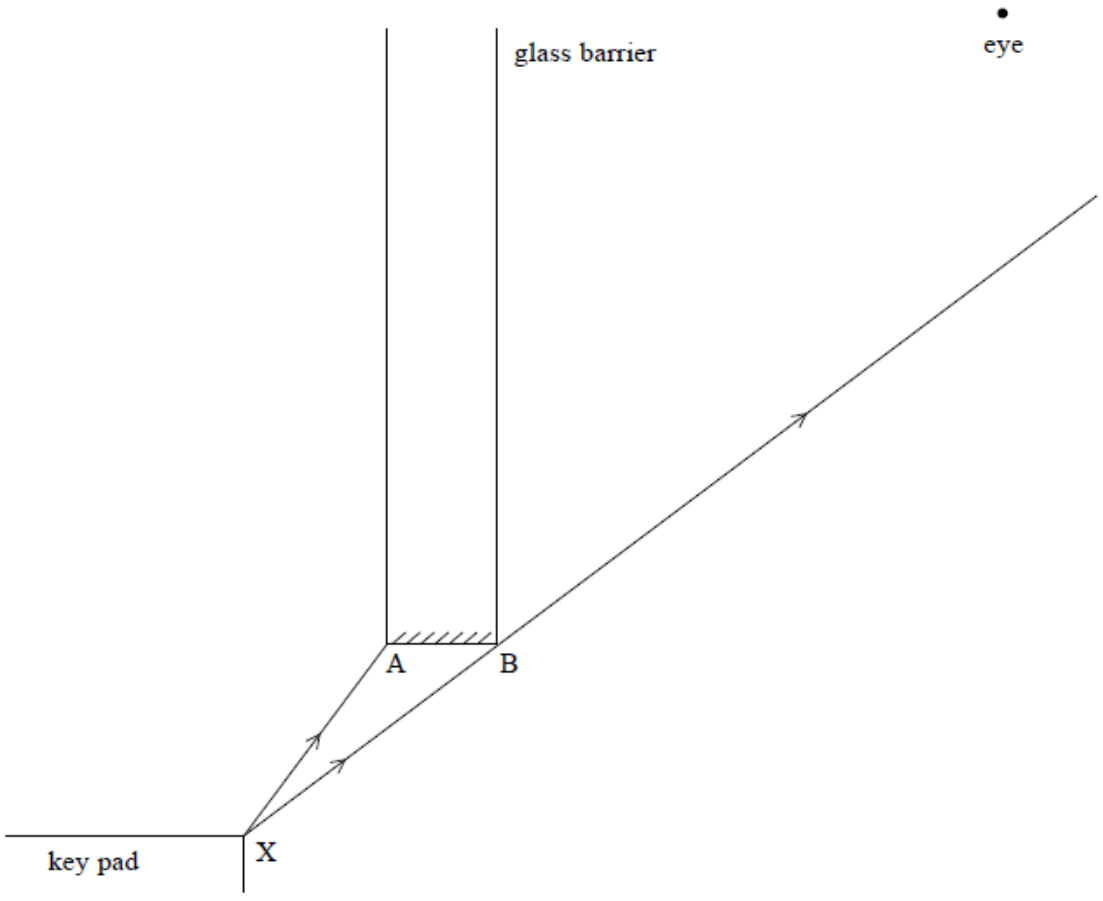
Q2.

A motorist pays for petrol at a filling station using a bank card for which a personal identification number must be entered on a key pad.

There is a thick sheet of glass between the cashier and the motorist, with a gap at the bottom to give access to the key pad.



When standing as shown in the diagram, refraction of light through the glass means that the motorist is unable to see the key pad without moving his head to see under the glass.



The diagram shows rays from the key pad. The light travelling initially along the path XA, which then passes through the glass, does not reach the motorist's eye. Assume no light passes through the surface AB.

(i) Measure the angle of incidence for the ray travelling along XA and calculate the angle of refraction in the glass.

refractive index of glass = 1.5

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(ii) Add to the diagram to show that light travelling initially along the path XA does not reach the eye of the motorist.

(1)

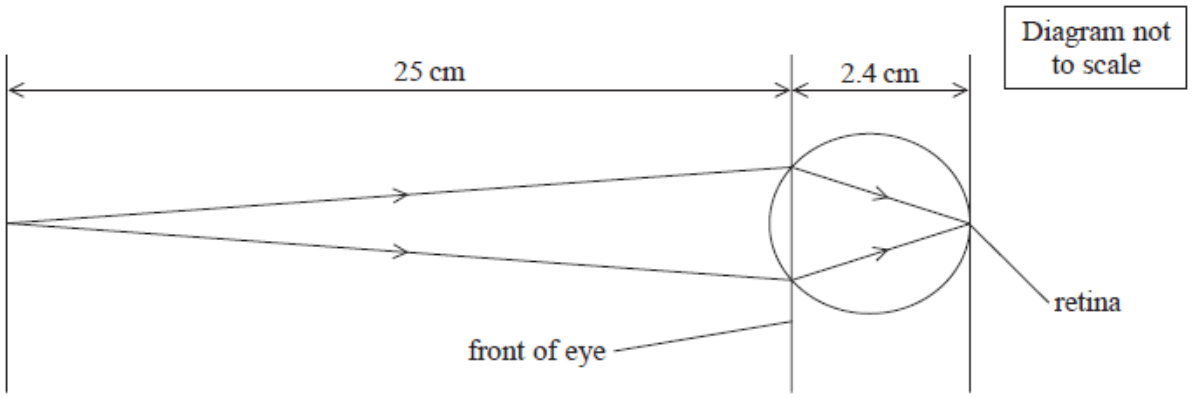
(Total for question = 4 marks)

Q3.

Converging and diverging lenses may be used in glasses to correct problems with eyesight.

The eye acts as a converging lens system.

The diagram shows light rays from an object 25 cm in front of an eye converging to a point on the retina at the back of the eye. The eye has a depth of 2.4 cm.



Calculate the optical power of the eye.

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Power = ...

(Total for question = 3 marks)

Q4.

The photograph shows a child's nature observation kit used for observing small creatures such as flies.

The lid has a built-in lens and an additional optional lens to allow the magnification to be increased.

The photographs below show the appearance of a fly using no lens, a single lens and two lenses respectively.



A student reads that the power of a combination of lenses is equal to the sum of the powers of the individual lenses.

$$\text{power}_{\text{combination}} = \text{power}_{\text{lens1}} + \text{power}_{\text{lens2}}$$

The student investigates this relationship using the lenses in the observation kit.

The student records the method and measurements as shown below.

Method

Set up a bulb on one side of the laboratory.
Hold the lens near the opposite wall and vary the distance from the wall until a clear image of the bulb is seen on the wall.
With the other hand, use a ruler to measure the distance of the lens from the clear image formed.
This is the focal length.

Results

Lens	Focal length/cm
Lens in the lid	12
Optional lens	17.5
Combination of both lenses	7

The distance between the light and the opposite wall was 6 m.

The distance of an object from the combined lenses is 5.0 cm.

Calculate the magnification of the lens.

Focal length = 7.0 cm.

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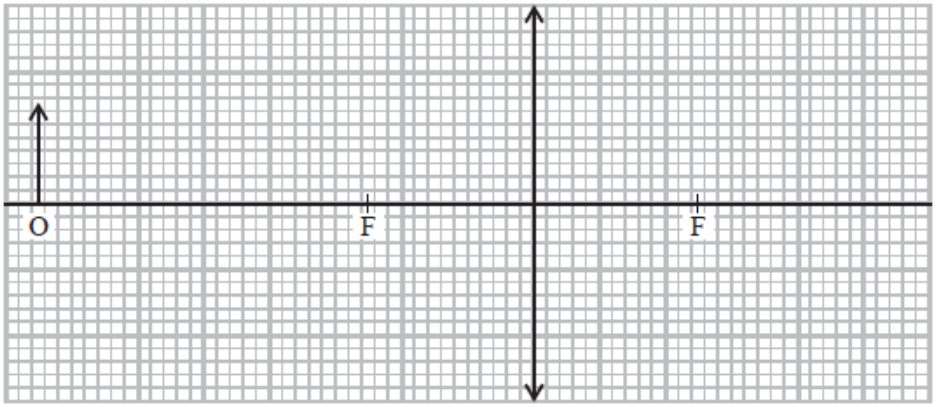
Magnification = ...

(Total for question = 3 marks)

Q5.

A camera uses a converging lens to produce an image.

The diagram represents an object O and a converging lens.



(i) Complete the ray diagram to determine the position of the image.

(3)

(ii) Determine the magnification of this image.

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Magnification = ...

(iii) State, with justification, whether the image is real or virtual.

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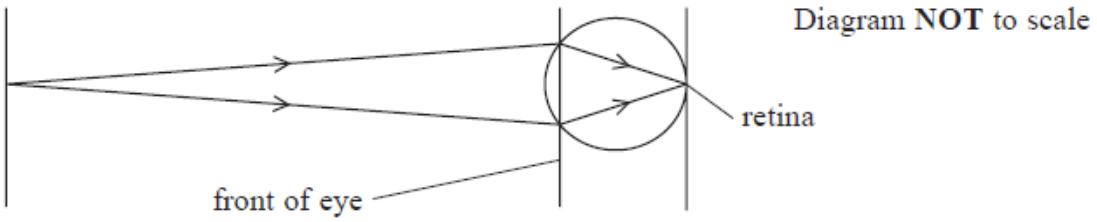
(Total for question = 6 marks)

Q6.

The human eye acts as a converging lens system that produces an image on the retina at the back of the eye as shown.



A person with eyesight problems may wear either diverging or converging contact lenses.

A short-sighted eye cannot focus on distant objects, because the power of the eye is too great.

One student with short sight cannot focus on objects further than 1.5 m without wearing her contact lenses.

To view distant objects, it is determined that the combined power of her eye and her contact lens should be 41.7 D.

Determine the power and type of lens needed to correct her vision. Assume the equations for thin lens apply to both lenses.

distance from eye lens to retina = 2.4 cm

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Power = ...

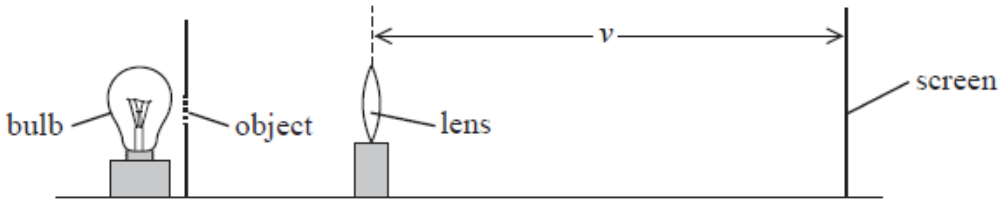
Type of lens .....

(Total for question = 4 marks)

Q7.

A student carried out an experiment to determine the focal length of a converging lens. The student used a bulb to illuminate an object as shown. The converging lens produced an image of the object on a screen. The student adjusted the position of the screen until the image was in focus.

He repeated the procedure for different distances between the object and the lens. The distance *v* from the lens to the screen was measured for each lens position.



The student measured the height h_o of the object and the height h_i of the corresponding image on the screen for each lens position. The magnification m was calculated.

To determine the focal length *f* of the lens the student used the equation

$$m = \frac{v}{f} - 1$$

If the distance from object to the lens is less than a certain value, no image is produced on the screen.

Explain why.

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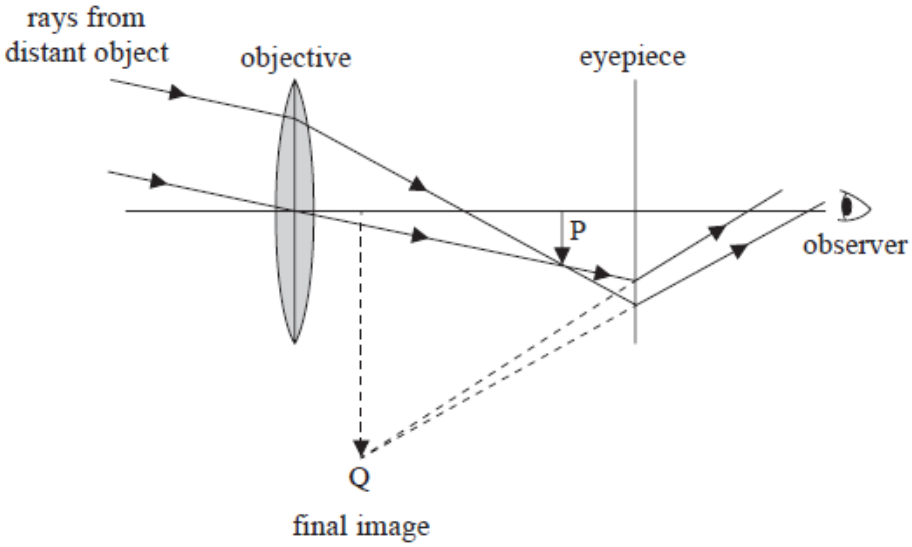
(Total for question = 3 marks)

Q8.

A telescope consists of a convex lens (objective) of power 0.820 D and a second lens (eyepiece) as shown.



The objective produces an image at P. This image becomes the object of the eyepiece, which produces a final image at Q.

The eyepiece is at a distance of 100 mm from the image at P. To give a reasonable magnification, the final image at Q should be a virtual image at a distance of 300 mm from the eyepiece.

The following lenses are available:

diverging lens focal length 150 mm,
converging lens focal length 150 mm,
diverging lens focal length 100 mm,
converging lens focal length 100 mm.

Deduce which lens should be used for the eyepiece.

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(Total for question = 3 marks)

Q9.

The distance of the near point from the eye increases as people get older. Because of this, older people use reading glasses to enable objects closer than the near point to be seen clearly.

A person wants to buy reading glasses so that they can read text clearly at a distance of 27.5 cm from their eye. The minimum focal length for this person's eye is 1.93 cm and the distance from the centre of the lens to the retina is 2.0 cm.

The available powers of lenses are +1.0 D, +1.5 D, +2.0 D, +2.5 D, +3.0 D and +3.5 D.

Show that the appropriate lens needed has a power of +2.0 D. You may ignore the distance between the lens of the glasses and the eye.

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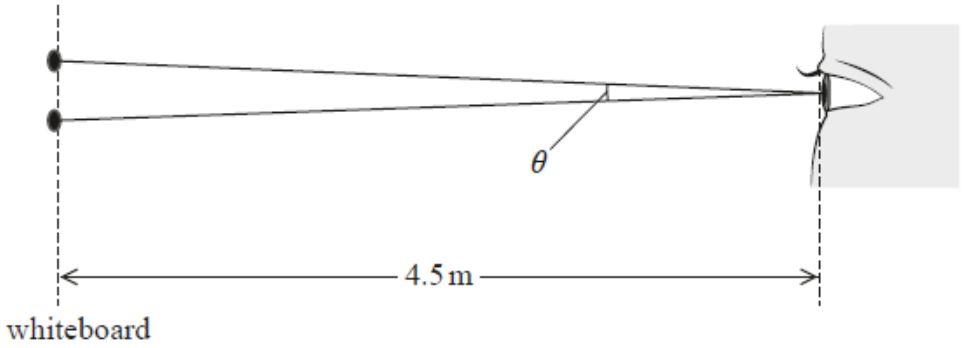
Q10.

A student investigated how a converging lens can be used to project a magnified image onto a whiteboard.

In a darkened room, the student placed a smartphone 9.0 cm from the converging lens. The phone's display was projected onto the whiteboard. The converging lens was 75.0 cm from the whiteboard when a clear image was produced.

The display on the phone contained two dots that were 5.0 mm apart. The student stood 4.5 m from the whiteboard and viewed the image of the dots.

Rays of light from the images of the two dots on the whiteboard were incident at the student's eye with an angle θ between them as shown.



The student could distinguish the two dots if the angle θ was greater than 0.0003 radians.

Deduce whether the student could distinguish the two dots clearly.

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(Total for question = 5 marks)

Q11.

A magnifying glass consists of a converging lens and is used to magnify the details of an object.

A biologist is studying a flower using a magnifying glass. The anther of the flower has a width of 0.2 mm. The magnifying glass is placed 5.0 cm from the flower and an image of the anther is produced that is 3.5 mm wide.

Calculate the power of the lens in the magnifying glass.

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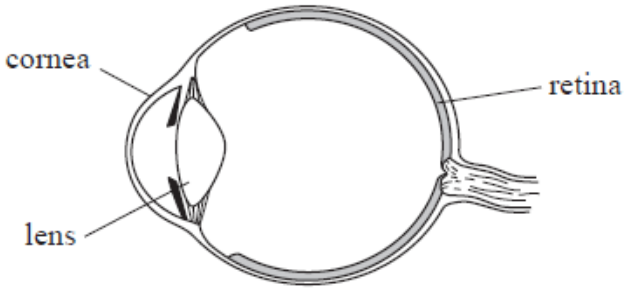
Power of lens = ...

(Total for question = 5 marks)

Q12.

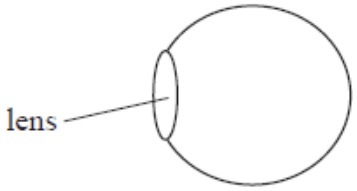
The diagram shows a cross-section through a human eye.



Light from an object is refracted by the cornea and lens to form an image on the retina.

The shape of the lens is altered by muscles in the eye to allow images of objects at different distances to be focused on the retina. The closest position at which people can clearly see an object is called the near point.

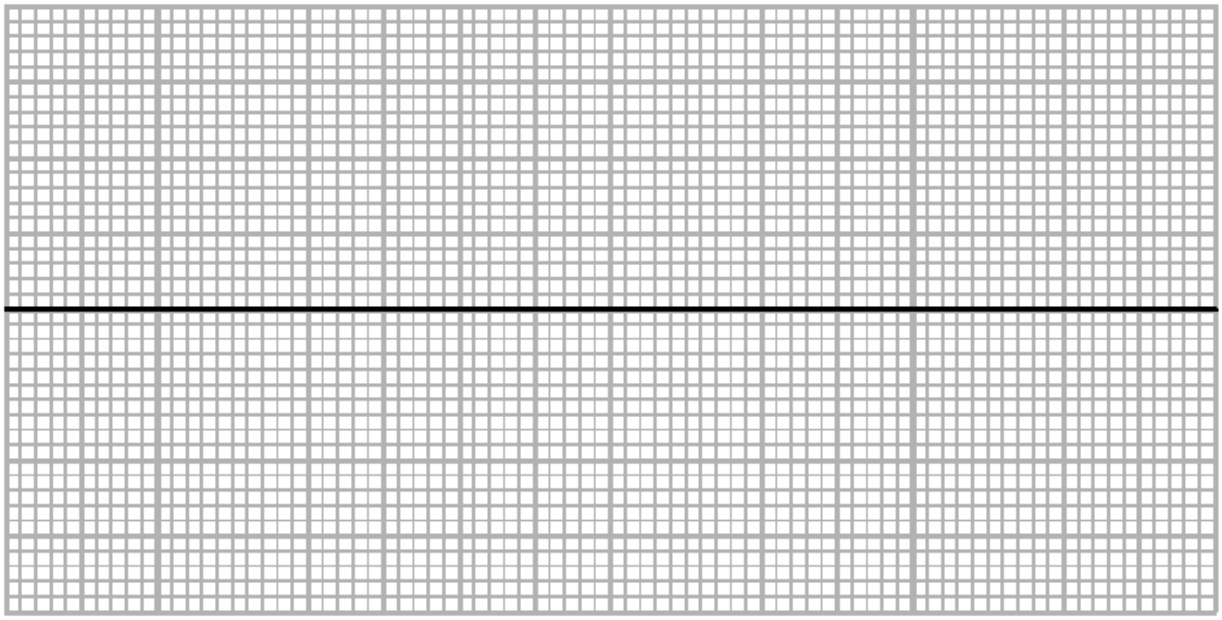
The eye may be modelled as a sphere with a single thin lens as shown. The distance from the centre of the lens to the retina is 2.0 cm.



(i) When the eye of a 10 year-old child is focused on an object that is at the near point, the focal length is 1.5 cm.

Complete a ray diagram to scale, on the grid below, to determine the distance to the near point for the child.

(3)



Distance to near point = ...

(ii) Calculate the magnification for this image.

(2)

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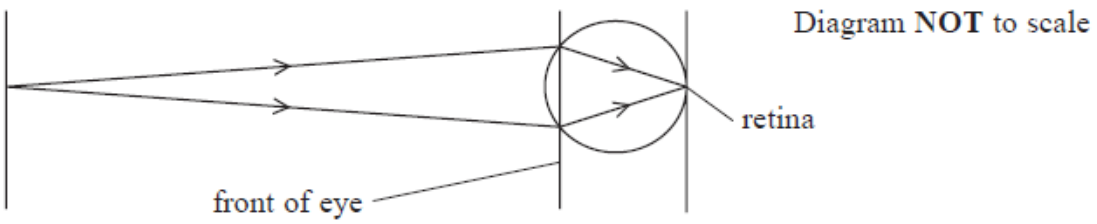
Magnification = ...

Q13.

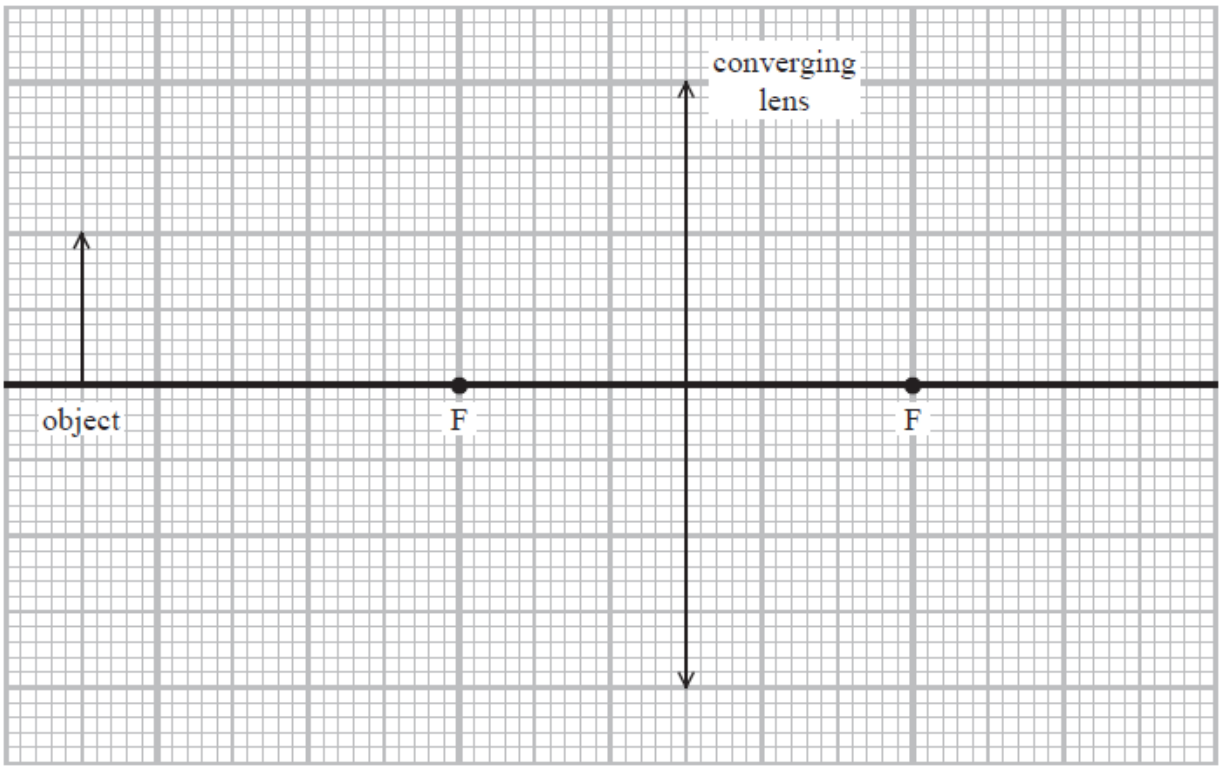
The human eye acts as a converging lens system that produces an image on the retina at the back of the eye as shown.



A person with eyesight problems may wear either diverging or converging contact lenses.

The diagram below shows an object in front of a converging lens.

F is the principal focus.



Determine the position and magnification of the image produced by the lens, by completing a ray diagram.

(4)

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Magnification = ...

(Total for question = 4 marks)

Q14.

On sunny days a mirage can sometimes be observed when a virtual image of the sky is seen on the surface of a road.

The Sun's rays heat up the surface of the road. The heated road then heats the surrounding air so that the layer of air just above the road is at a higher temperature than the air above it. Warm air has a lower refractive index than cool air.

State what is meant by a virtual image.

(1)

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(Total for question = 1 mark)

Mark Scheme

Q1.

Question Number	Acceptable Answers	Additional guidance	Mark
	• Light rays pass through the image **Or** Light rays converge to a point where the image is formed (1)		1

Q2.