



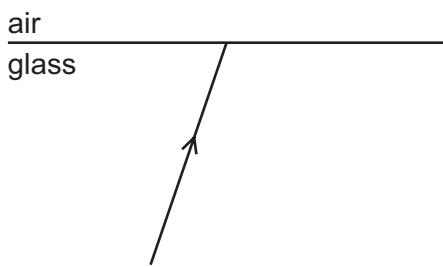
**Cambridge<sup>TM</sup> IGCSE**

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# **Chapter 13: Light**

0625/11 May/June 2024

- 19** The diagram shows a ray of light in glass incident on the surface between the glass and air.



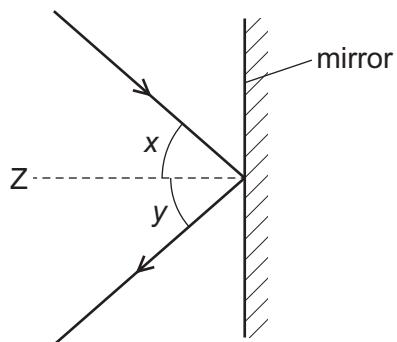
What happens if the angle of incidence is made larger than the critical angle for the glass?

- A** The angle of refraction becomes equal to 90°.
- B** There is a refracted ray and a ray reflected inside the glass.
- C** There is a refracted ray only.
- D** There is only a ray reflected inside the glass.

Answer: D

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- 18** The diagram shows a ray of light reflecting from a mirror.

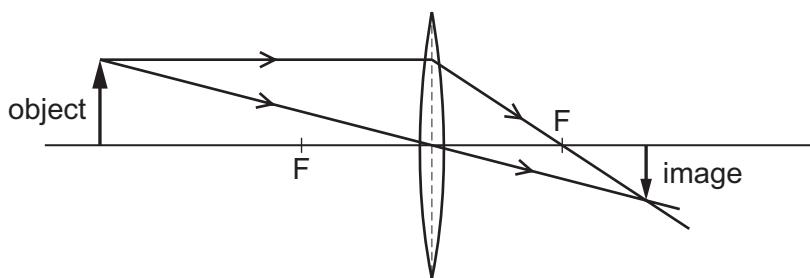


Which row shows the correct names for x, y and Z?

	x	y	z
<b>A</b>	angle of incidence	angle of reflection	normal
<b>B</b>	angle of incidence	angle of reflection	principal focus
<b>C</b>	angle of reflection	angle of refraction	normal
<b>D</b>	angle of reflection	angle of refraction	principal focus

Answer: A

- 19** A converging lens forms an image of an object placed in front of it.



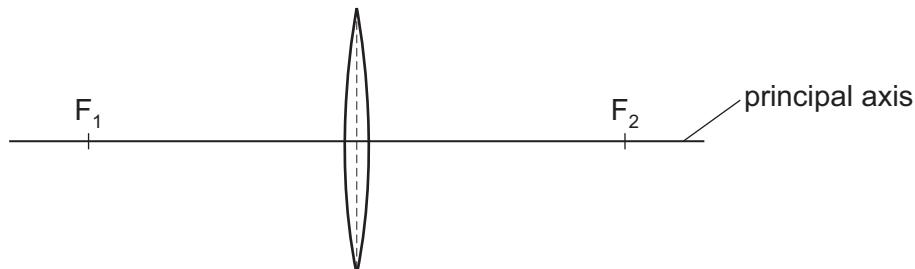
What are the characteristics of the image?

- A** real, inverted, diminished
- B** real, upright, enlarged
- C** virtual, inverted, diminished
- D** virtual, upright, enlarged

**Answer: A**

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- 18** The diagram shows a thin converging lens with principal focuses at  $F_1$  and  $F_2$ .



A small light source is placed at  $F_1$ . A beam of light from the source passes through the lens.

Which statement correctly describes the beam of light emerging from the lens?

- A** The beam converges to  $F_2$ .
- B** The beam converges to a point to the right of  $F_2$ .
- C** The beam diverges from a point to the left of  $F_1$ .
- D** The beam travels parallel to the principal axis.

**Answer: D**

- 19 A student reads the following relationship in his physics book.

$$i = r$$

What is the student reading about?

- A diffraction due to a gap
- B dispersion of light by a prism
- C reflection in a plane mirror
- D refraction as light enters glass

**Answer: C**

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- 17 The angle of incidence of a ray of light incident on a plane mirror is gradually increased.

To the nearest degree, what is the maximum possible angle between the incident and reflected rays?

- A  $0^\circ$
- B  $45^\circ$
- C  $90^\circ$
- D  $180^\circ$

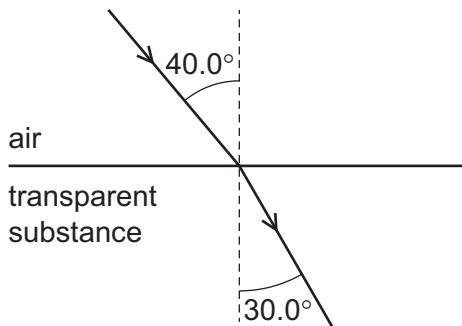
**Answer: D**

- 18 Which conditions are necessary for light to be totally internally reflected?

	incident light	angle of incidence
A	is in the less dense medium	less than the critical angle
B	is in the less dense medium	greater than the critical angle
C	is in the more dense medium	less than the critical angle
D	is in the more dense medium	greater than the critical angle

**Answer: D**

- 19 The diagram shows a ray of light passing from air into a transparent substance.



What is the refractive index of the transparent substance?

- A 1.33
- B 1.29
- C 0.778
- D 0.750

**Answer: B**

- 20** The diagram shows a ray of light in an optical fibre.



Which statement correctly explains the condition for the maximum transmission of light by the optical fibre?

- A** The glass must slow the light as little as possible to make the critical angle for the fibre as large as possible.
- B** The glass must slow the light as little as possible to make the critical angle for the fibre as small as possible.
- C** The glass must slow the light as much as possible to make the critical angle for the fibre as large as possible.
- D** The glass must slow the light as much as possible to make the critical angle for the fibre as small as possible.

**Answer: D**

**0625/22 May/June 2024**

- 19** Diagram 1 shows the page of a book in front of a plane mirror.

An eye is looking at the image of the page.

Diagram 2 shows a large letter G on the page facing the mirror.

diagram 1

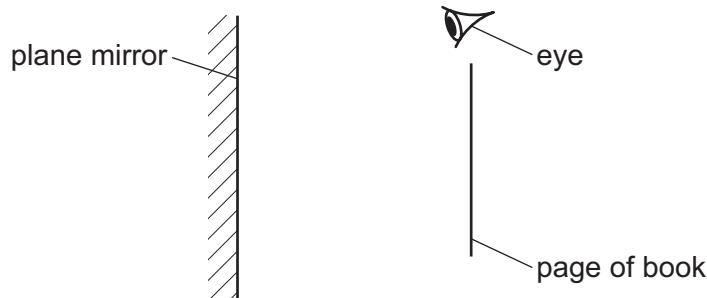


diagram 2



What is the appearance of the image of G seen by the eye?

**A**

**B**

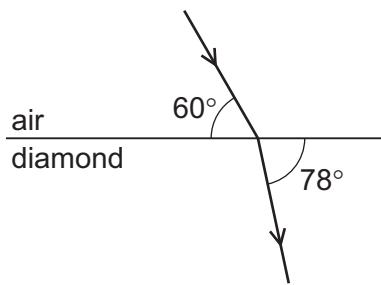
**C**

**D**



**Answer: D**

- 20 The diagram shows a ray of light passing from air into diamond.



What is the refractive index of the diamond?

- A** 0.89      **B** 1.1      **C** 2.4      **D** 2.5

.....  
**Answer: C**  
.....

- 21 The ray diagrams show the formation of an image by two different converging lenses.

diagram 1

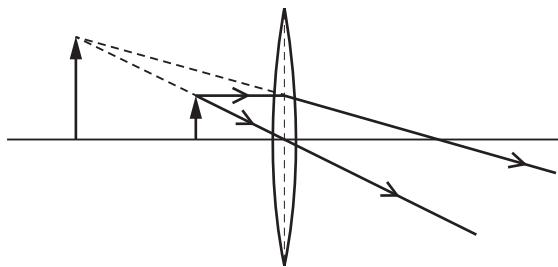
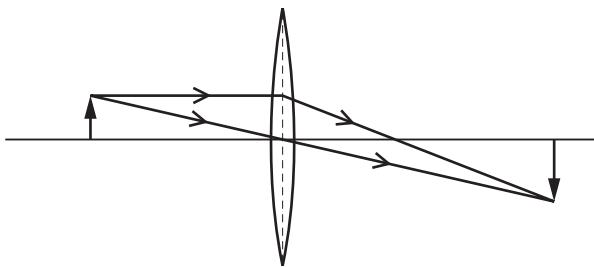


diagram 2



Which row describes the images produced?

	diagram 1	diagram 2
<b>A</b>	real	real
<b>B</b>	real	virtual
<b>C</b>	virtual	real
<b>D</b>	virtual	virtual

.....  
**Answer: C**  
.....

- 22 White light enters a glass prism. The light leaving the other side of the prism is separated into colours.

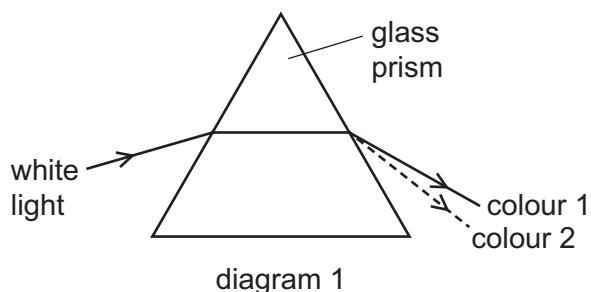


diagram 1

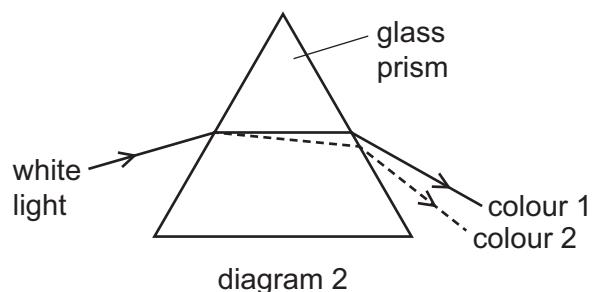


diagram 2

Which row correctly describes what happens?

	path taken by the light	colour 1	colour 2
A	diagram 1	red	violet
B	diagram 1	violet	red
C	diagram 2	red	violet
D	diagram 2	violet	red

.....  
.....  
**Answer: C**  
.....  
.....

**0625/23 May/June 2024**

- 19 A boy is having his eyes tested. A letter is printed on a card placed over his head. He sees the card in a plane mirror placed in front of him.

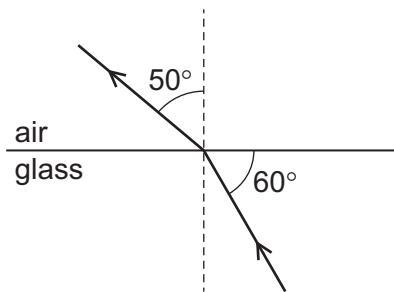
He sees the letter 'R' in the mirror.

How is it printed on the card?



.....  
.....  
**Answer: B**  
.....  
.....

- 20 A ray of light is refracted as it enters air from glass, as shown.



What is the speed of light in the glass?

- A  $2.0 \times 10^8 \text{ m/s}$
- B  $2.2 \times 10^8 \text{ m/s}$
- C  $2.3 \times 10^8 \text{ m/s}$
- D  $2.7 \times 10^8 \text{ m/s}$

**Answer: A**

- 21 A converging lens is being used as a magnifying glass.

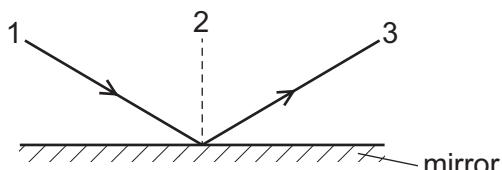
Which statement is correct?

- A The image is further away from the lens than the object is.
- B The image is inverted.
- C The image is real.
- D The object must be placed at the principal focus of the lens.

**Answer: A**

**0625/11 May/June 2023**

- 18 A student draws a diagram to show the directions of a light ray reflecting off a plane mirror.

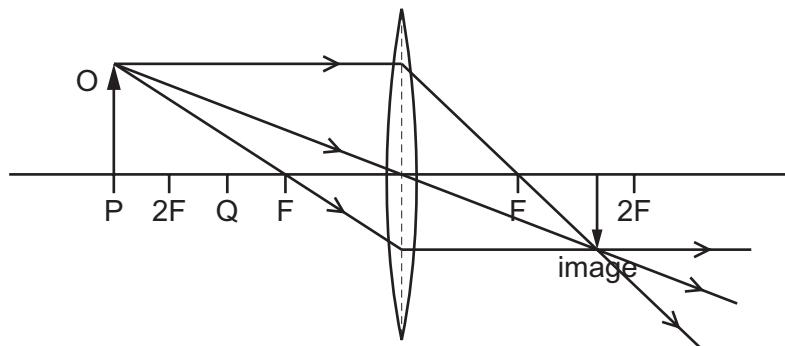


What are the correct terms for the lines drawn?

	normal	incident ray	reflected ray
<b>A</b>	1	2	3
<b>B</b>	1	3	2
<b>C</b>	2	1	3
<b>D</b>	2	3	1

**Answer: C**

- 19 An object O is placed at point P near to a thin converging lens. The diagram shows three rays from the top of O passing through the lens. Each point F is one focal length from the centre of the lens. Each point  $2F$  is two focal lengths from the centre of the lens.



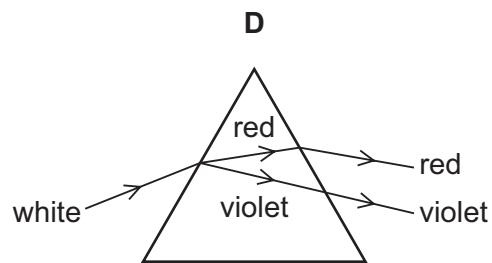
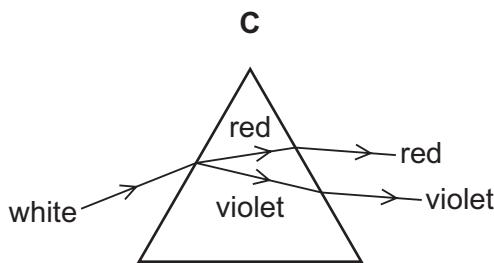
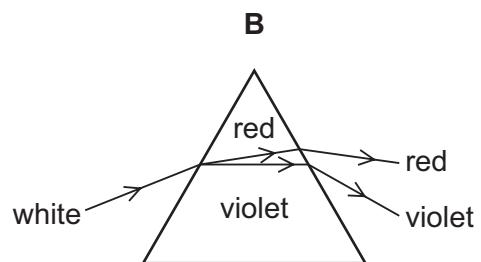
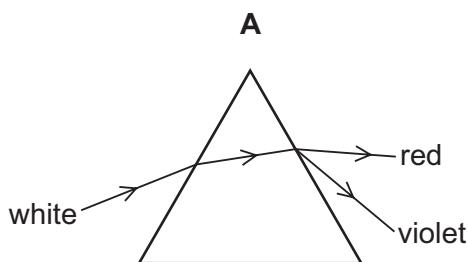
The object O is moved to point Q on the diagram.

Which type of image is produced when the object O is at point Q?

- A inverted and the same size as the object
- B inverted and enlarged
- C upright and the same size as the object
- D upright and enlarged

**Answer: B**

- 20 Which diagram shows the dispersion of white light by a glass prism?



**Answer: B**

18 A light ray strikes a plane mirror and is reflected.

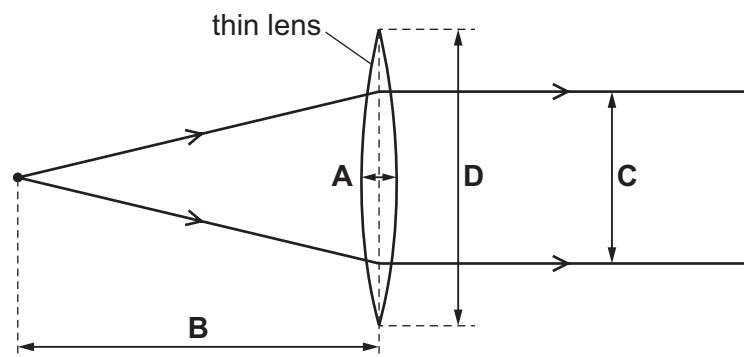
Which angle is always equal in size to the angle of reflection?

- A the angle between the incident ray and the mirror
- B the angle between the incident ray and the normal to the mirror
- C the angle between the reflected ray and the mirror
- D the angle between the reflected ray and the incident ray

**Answer: B**

19 The diagram shows two diverging rays of light passing through a lens and emerging parallel to each other.

Which labelled distance is the focal length of the lens?



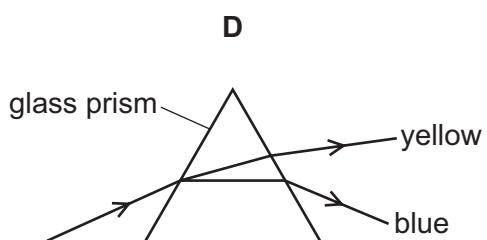
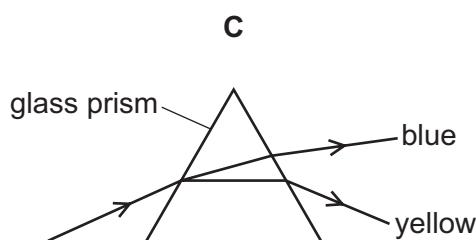
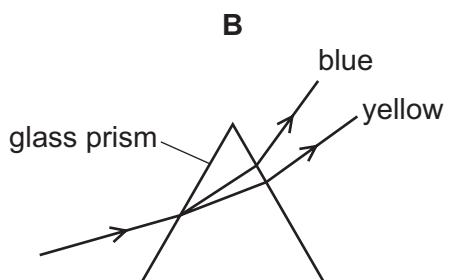
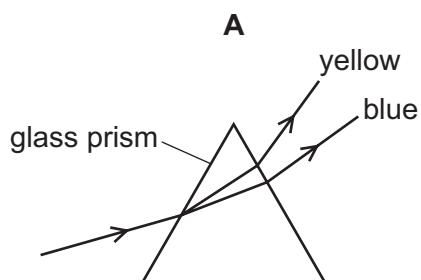
**Answer: B**

20 A beam of light consists of yellow and blue light.

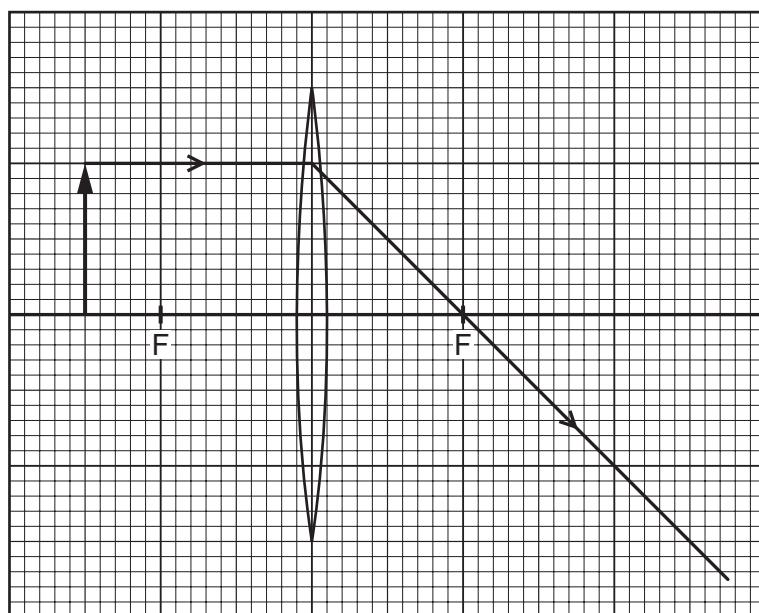
The beam of light is incident on a glass prism.

**Answer: D**

Which diagram is correct?



- 19** The diagram shows a partly completed scale drawing of an upright object placed 3 cm in front of a thin converging lens of focal length 2 cm.

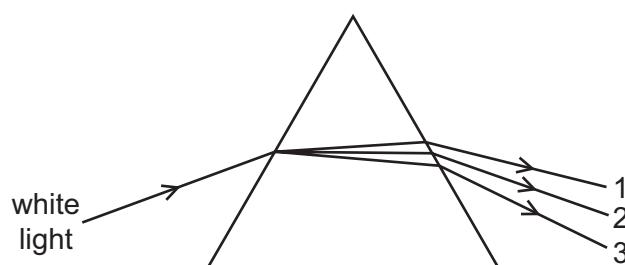


What is the nature of the image formed by this lens?

- A** diminished, inverted and closer to the lens than the object
- B** diminished, upright and further from the lens than the object
- C** enlarged, inverted and closer to the lens than the object
- D** enlarged, inverted and further from the lens than the object

**Answer: D**

- 20** A narrow beam of white light passes through a prism and is dispersed into a spectrum.



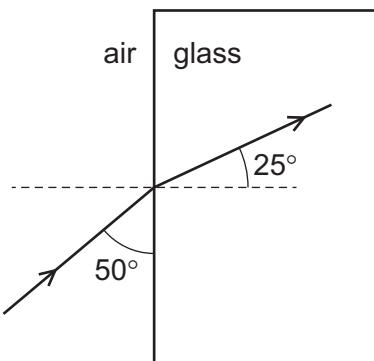
Which row is correct?

	colour 1	colour 2	colour 3
<b>A</b>	blue	yellow	red
<b>B</b>	red	blue	yellow
<b>C</b>	red	yellow	blue
<b>D</b>	yellow	blue	red

**Answer: C**

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- 18 The diagram shows a ray of light entering a glass block.

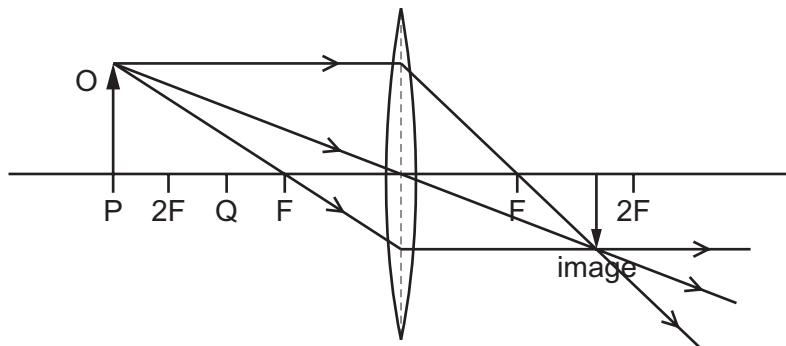


Which calculation gives the refractive index of the glass?

- A  $\frac{\sin 40^\circ}{\sin 25^\circ}$       B  $\frac{\sin 40^\circ}{\sin 65^\circ}$       C  $\frac{\sin 50^\circ}{\sin 25^\circ}$       D  $\frac{\sin 50^\circ}{\sin 65^\circ}$

**Answer: A**

- 19 An object O is placed at point P near to a thin converging lens. The diagram shows three rays from the top of O passing through the lens. Each point F is one focal length from the centre of the lens. Each point 2F is two focal lengths from the centre of the lens.



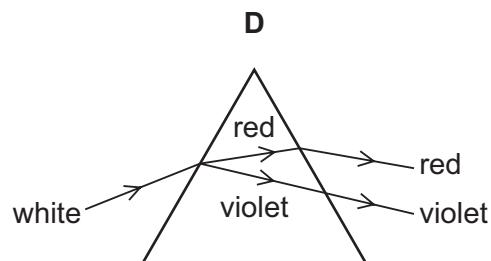
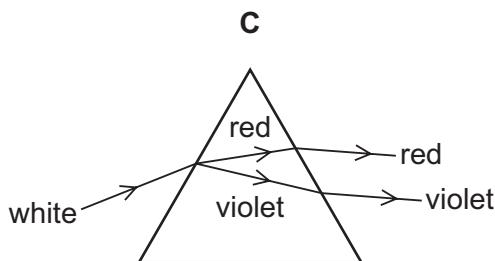
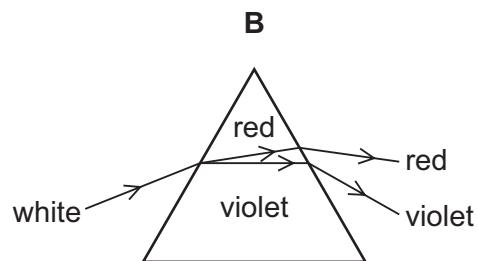
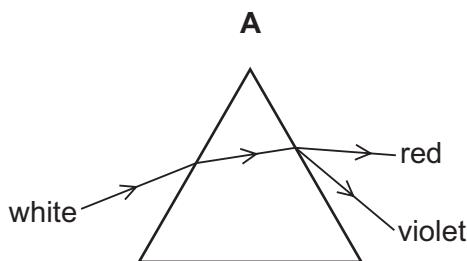
The object O is moved to point Q on the diagram.

Which type of image is produced when the object O is at point Q?

- A inverted and the same size as the object  
 B inverted and enlarged  
 C upright and the same size as the object  
 D upright and enlarged

**Answer: B**

**20** Which diagram shows the dispersion of white light by a glass prism?



**Answer: B**

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**18** Optical fibres are used to transmit digital signals using infrared radiation.

The average refractive index of the fibres is 1.50.

Which row describes a digital signal and gives the speed of infrared radiation in the fibres?

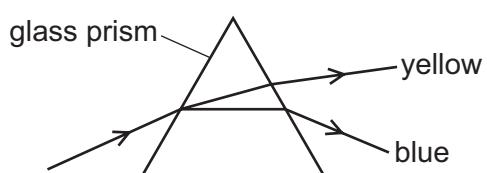
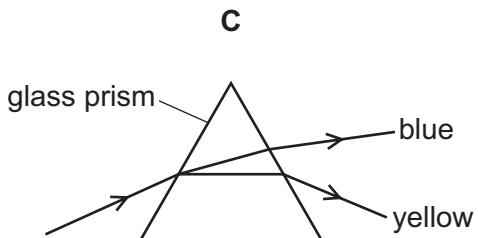
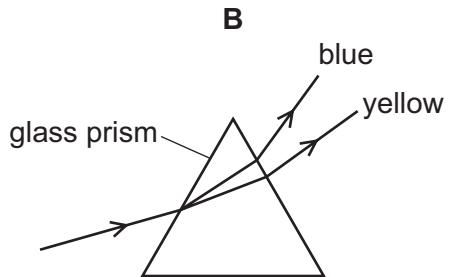
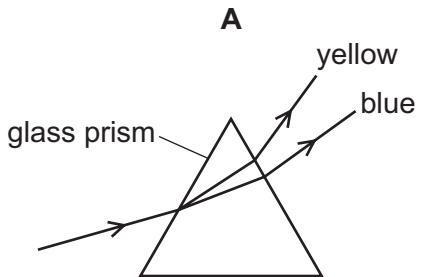
	digital signal	<u>speed of infrared radiation in the fibres</u> m/s
<b>A</b>	a signal that consists of only two values	$2.0 \times 10^8$
<b>B</b>	a signal that consists of only two values	$4.5 \times 10^8$
<b>C</b>	a signal that consists of a continuous range of values	$2.0 \times 10^8$
<b>D</b>	a signal that consists of a continuous range of values	$4.5 \times 10^8$

**Answer: A**

- 20 A beam of light consists of yellow and blue light.

The beam of light is incident on a glass prism.

Which diagram is correct?

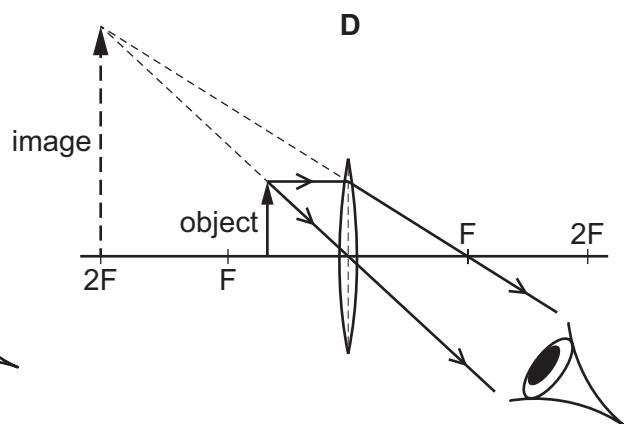
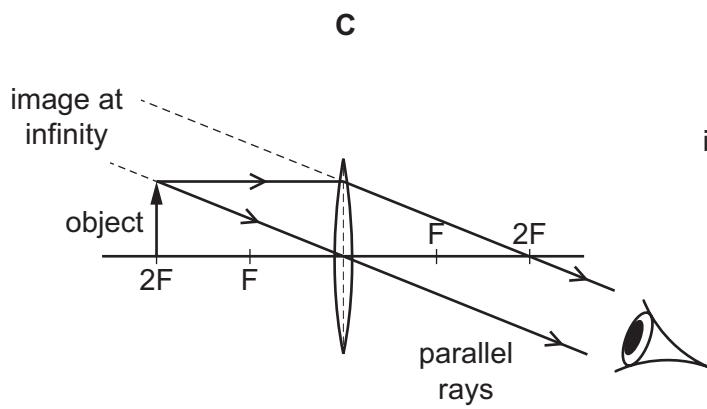
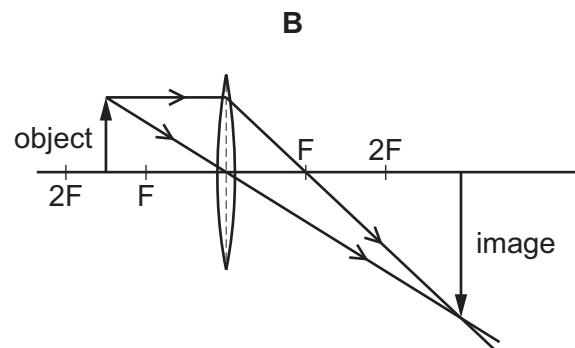
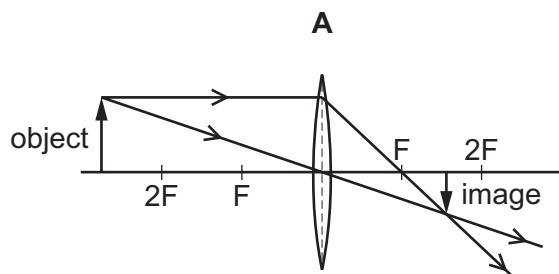


.....  
**Answer: D**  
.....

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- 18** Each point F is one focal length from the centre of the lens. Each point  $2F$  is two focal lengths from the centre of the lens.

Which diagram shows a converging lens being used as a magnifying glass?



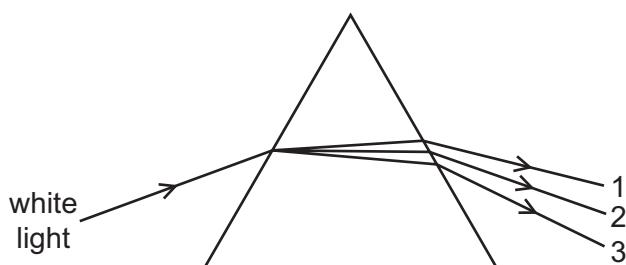
- 19** A monochromatic ray of green light in air enters a block of glass.

Which property of the ray of light always remains the same as it moves from air to glass?

- A** wavelength
- B** speed
- C** frequency
- D** direction

Answer: D

- 20 A narrow beam of white light passes through a prism and is dispersed into a spectrum.



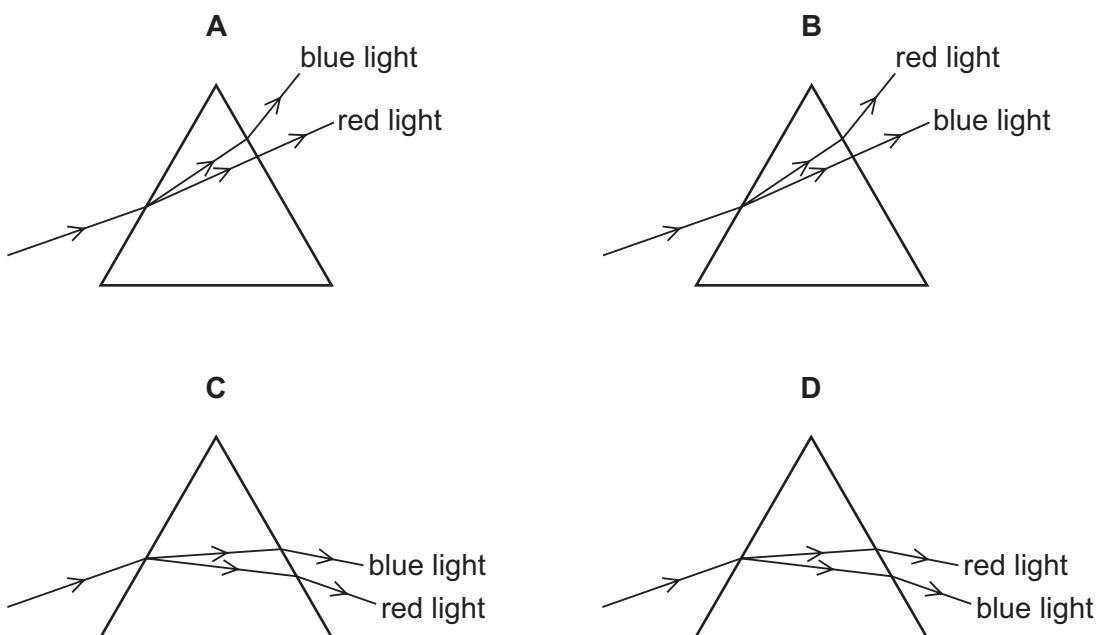
Which row is correct?

	colour 1	colour 2	colour 3
A	blue	yellow	red
B	red	blue	yellow
C	red	yellow	blue
D	yellow	blue	red

**Answer: C**

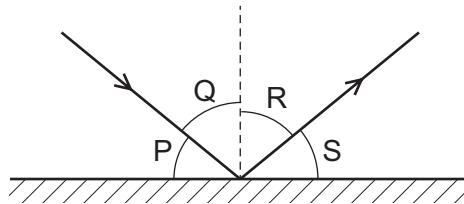
**0625/11 October/November 2023**

- 19 Which diagram correctly shows the dispersion of white light through a glass prism?



**Answer: D**

- 20** A ray of light is reflected by a plane mirror.



Which row shows the angle of incidence and the angle of reflection?

	angle of incidence	angle of reflection
A	P	Q
B	P	S
C	Q	R
D	R	S

- 21** A thin converging lens is used to produce a real image of an object.

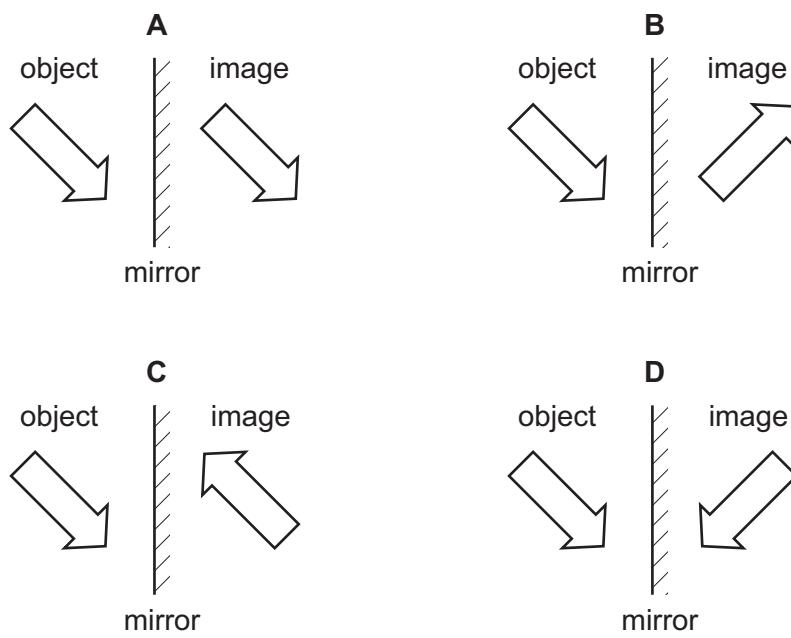
Which statement about the real image is always correct?

- A It is nearer to the lens than the object.
- B It is on the opposite side of the lens to the object.
- C It is the same size as the object.
- D It is upright.

Answer: C

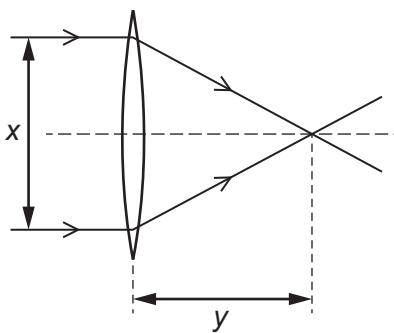
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- 20** Which diagram shows the image correctly formed by reflection?



Answer: D

- 21** A student passes parallel rays of light through four different converging lenses. He measures the distance  $x$  and the distance  $y$  for each experiment.



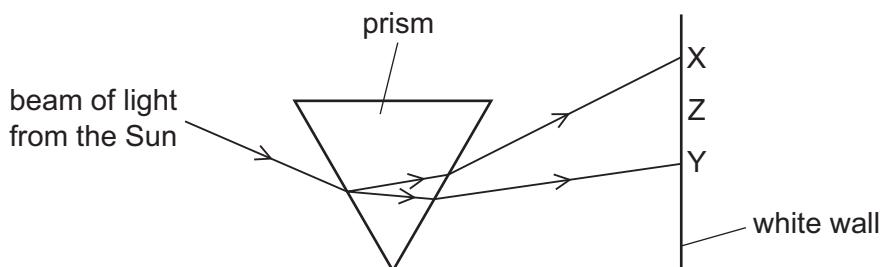
Which lens has the longest focal length?

	$x/\text{cm}$	$y/\text{cm}$
<b>A</b>	4.6	2.0
<b>B</b>	5.1	3.1
<b>C</b>	5.9	2.3
<b>D</b>	6.1	2.4

**Answer: B**

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- 19** A beam of light from the Sun strikes a prism.



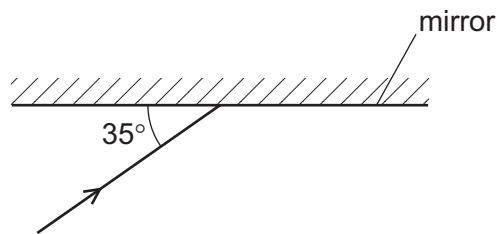
The dispersed beam is incident on a white wall between X and Y.

Which colours are seen at X, Z and Y?

	X	Z	Y
<b>A</b>	red	green	violet
<b>B</b>	red	violet	green
<b>C</b>	violet	green	red
<b>D</b>	violet	red	green

**Answer: C**

- 20** The diagram shows a ray of light incident on a plane mirror.



The angle between the ray and the mirror is  $35^\circ$ .

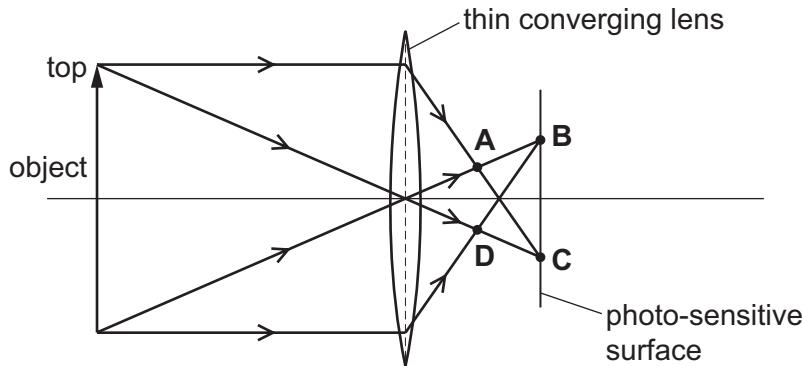
The ray is reflected by the mirror.

What is the angle of reflection?

- A**  $35^\circ$       **B**  $55^\circ$       **C**  $70^\circ$       **D**  $110^\circ$

- 21** A thin converging lens in a camera produces a real image on a photo-sensitive surface, as shown.

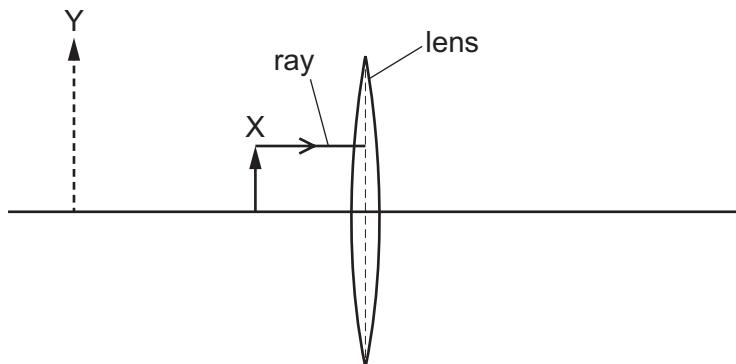
At which position is the image of the top of the object formed?



.....  
**Answer: B**  
.....

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- 19 The diagram shows part of a ray diagram that demonstrates the formation of a virtual image Y of object X by a converging lens.



One ray of light from X is shown approaching the lens.

Which arrow shows the direction of this ray as it leaves the lens?

A



B



C

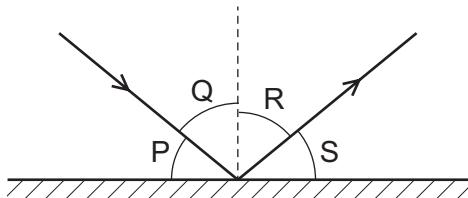


D



**Answer: A**

- 20 A ray of light is reflected by a plane mirror.



Which row shows the angle of incidence and the angle of reflection?

	angle of incidence	angle of reflection
A	P	Q
B	P	S
C	Q	R
D	R	S

**Answer: C**

21 A thin converging lens is used to produce a real image of an object.

Which statement about the real image is always correct?

- A It is nearer to the lens than the object.
- B It is on the opposite side of the lens to the object.
- C It is the same size as the object.
- D It is upright.

**Answer: B**

**0625/22 October/November 2023**

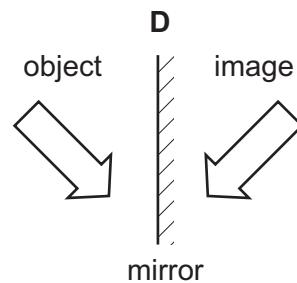
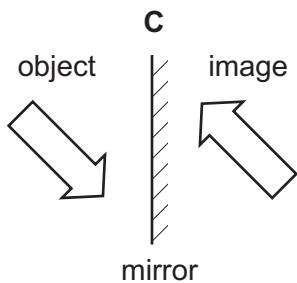
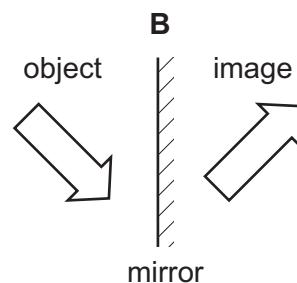
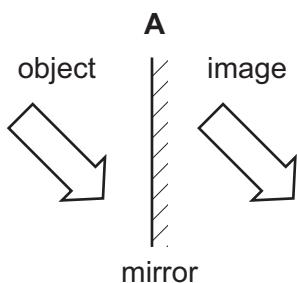
19 Light travels from air into glass.

What is the relationship between the refractive index  $n$  of the glass, the angle of incidence  $i$  and the angle of refraction  $r$ ?

- A  $n = \frac{i}{r}$
- B  $n = \frac{r}{i}$
- C  $n = \frac{\sin i}{\sin r}$
- D  $n = \frac{\sin r}{\sin i}$

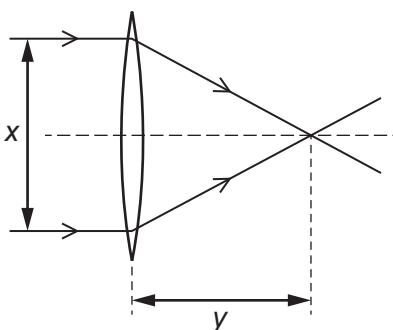
**Answer: C**

20 Which diagram shows the image correctly formed by reflection?



**Answer: D**

- 21** A student passes parallel rays of light through four different converging lenses. He measures the distance  $x$  and the distance  $y$  for each experiment.



Which lens has the longest focal length?

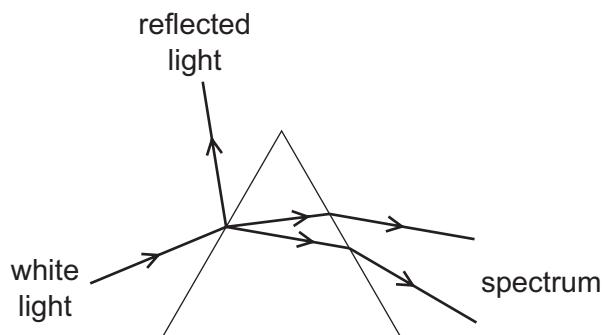
	$x/\text{cm}$	$y/\text{cm}$
A	4.6	2.0
B	5.1	3.1
C	5.9	2.3
D	6.1	2.4

Answer: B

**0625/23 October/November 2023**

- 19** The diagram shows the effect of a prism on white light.

Some light is reflected on striking the prism and some is refracted and dispersed to form a spectrum.

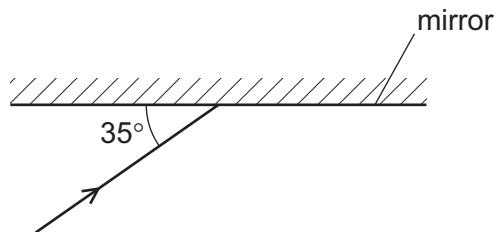


What happens if monochromatic light is used instead of white light?

- A** The light changes colour as it passes through the prism.
- B** The light forms a brighter spectrum.
- C** There is no reflected light.
- D** There is no dispersion of the emerging light.

Answer: D

- 20 The diagram shows a ray of light incident on a plane mirror.



The angle between the ray and the mirror is  $35^\circ$ .

The ray is reflected by the mirror.

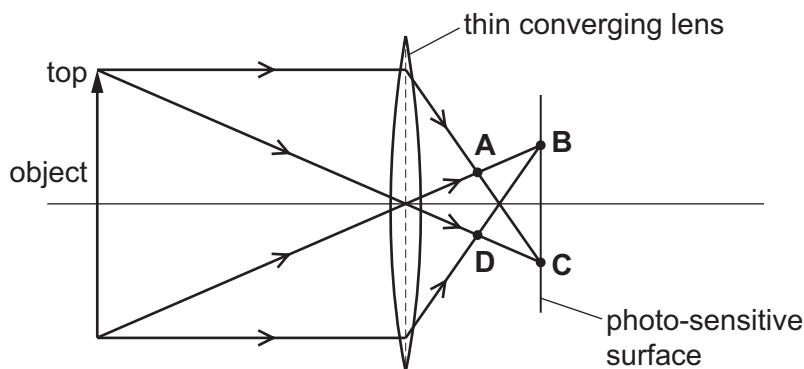
What is the angle of reflection?

- A  $35^\circ$       B  $55^\circ$       C  $70^\circ$       D  $110^\circ$

**Answer: B**

- 21 A thin converging lens in a camera produces a real image on a photo-sensitive surface, as shown.

At which position is the image of the top of the object formed?



**Answer: C**

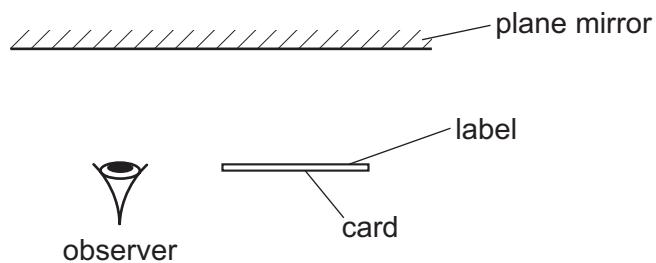
- 22 Light is travelling through air. It strikes a glass block at an angle of incidence of  $45^\circ$ . The glass has a refractive index of 1.4.

What is the angle of refraction of the light as it enters the glass?

- A  $29^\circ$       B  $30^\circ$       C  $32^\circ$       D  $82^\circ$

**Answer: B**

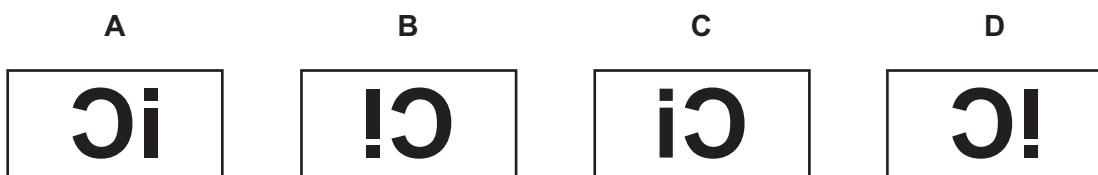
- 22 A card is placed in front of a plane mirror so that its label is facing the mirror, as shown.



The label is shown.

Ci

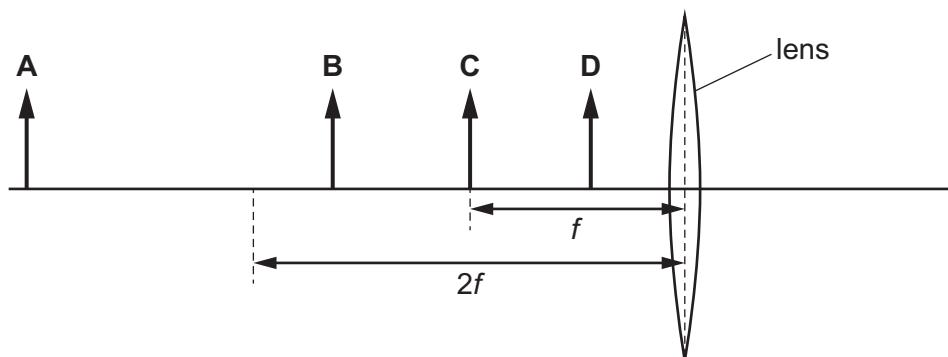
How does the image of the label formed by the mirror appear to the observer?



Answer: C

- 23 An object is placed in front of a converging lens. The lens has a focal length  $f$ .

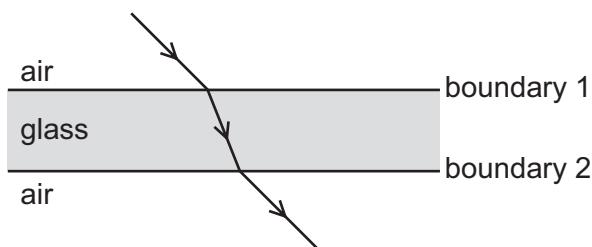
In which labelled position should the object be placed in order to produce a real image that is smaller than the object?



Answer: A

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- 22 A ray of light passes from air through a sheet of glass and out the other side, as shown.



Which two angles are equal to each other?

- A angle of incidence at boundary 1 and angle of incidence at boundary 2
- B angle of incidence at boundary 1 and angle of refraction at boundary 1
- C angle of incidence at boundary 1 and angle of refraction at boundary 2
- D angle of refraction at boundary 1 and angle of refraction at boundary 2

Answer: C

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- 24 A thin converging lens can produce both real and virtual images.

Which row describes a real and a virtual image?

	real image	virtual image
A	rays converge to form the image	image can be projected onto a screen
B	rays converge to form the image	image cannot be projected onto a screen
C	rays diverge to form the image	image can be projected onto a screen
D	rays diverge to form the image	image cannot be projected onto a screen

Answer: B

- 25 The speed of light in air is  $3.0 \times 10^8 \text{ m/s}$ .

The critical angle for light in a transparent plastic material placed in air is  $37^\circ$ .

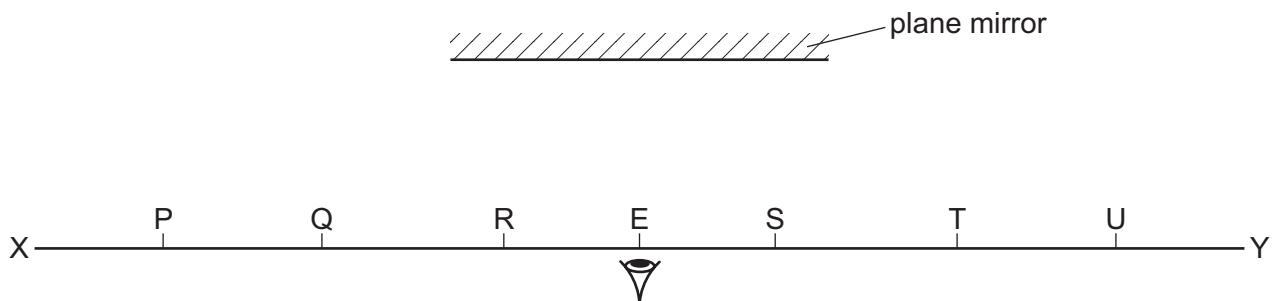
What is the speed of light in the plastic material?

- A  $1.8 \times 10^8 \text{ m/s}$
- B  $2.4 \times 10^8 \text{ m/s}$
- C  $3.8 \times 10^8 \text{ m/s}$
- D  $5.0 \times 10^8 \text{ m/s}$

Answer: A

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- 23** A student uses one eye to look at images in a plane mirror.



Objects are placed on the line XY.

Which objects give rise to images that can be seen by the eye at E?

- A** P, Q, R, S, T and U
- B** Q, R, S and T only
- C** P and U only
- D** R and S only

**Answer: B**

- 24** An object is placed in front of a converging lens of focal length 15 cm.

Which row describes the image of the object?

	distance of object from lens/cm	nature of the image
<b>A</b>	40	real, upright, diminished
<b>B</b>	30	virtual, inverted, enlarged
<b>C</b>	20	real, inverted, diminished
<b>D</b>	10	virtual, upright, enlarged

**Answer: D**

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- 19** What is the correct order of the colours in a spectrum of white light?

- A** blue → green → yellow
- B** blue → yellow → green
- C** yellow → blue → green
- D** green → blue → yellow

**Answer: A**

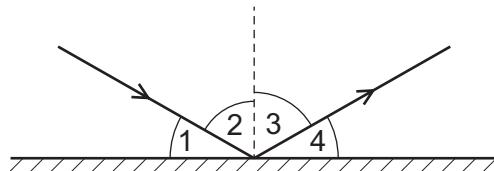
- 20** An object is placed 30 cm in front of a plane mirror.

Which statement describes the image of the object?

- A** The image is the same size and 30 cm from the object.
- B** The image is the same size and 60 cm from the object.
- C** The image is smaller and 30 cm from the object.

**Answer: B**

- 21** A ray of light is shone onto the surface of a mirror.



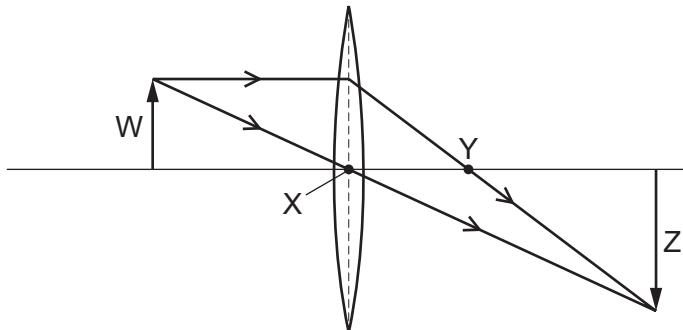
Which two angles represent the angle of incidence and the angle of reflection?

- A** 1 and 2
- B** 1 and 4
- C** 2 and 3
- D** 3 and 4

**Answer: C**

**0625/12 October/November 2022**

- 19** What are the correct labels for the ray diagram?

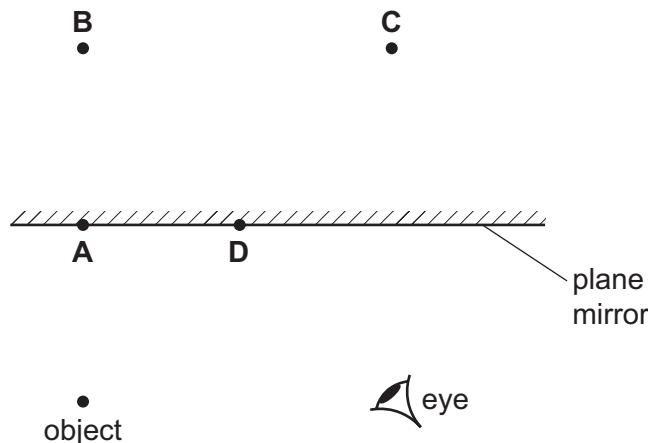


	object	image	principal focus
<b>A</b>	W	X	Y
<b>B</b>	W	Z	Y
<b>C</b>	X	Y	Z
<b>D</b>	X	Z	W

**Answer: B**

- 20** The diagram shows an object in front of a plane mirror.

At which labelled position is the image of the object formed?



**Answer: B**

- 21** The angle between an incident ray and the surface of a plane mirror reflecting the ray is  $70^\circ$ .

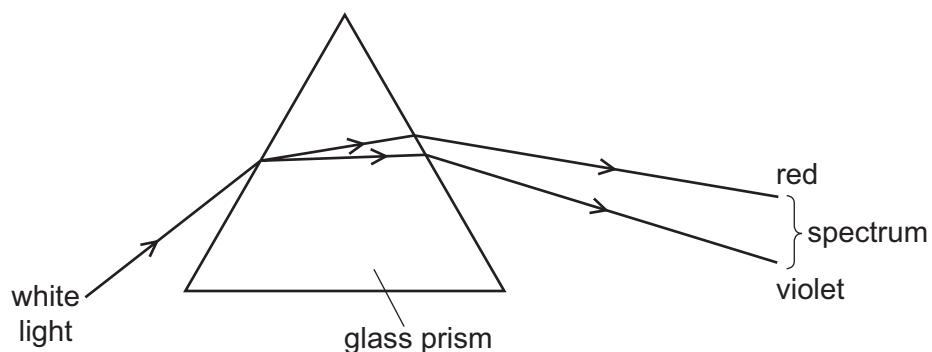
What is the angle of incidence?

- A  $20^\circ$       B  $40^\circ$       C  $70^\circ$       D  $140^\circ$

**Answer: A**

**0625/13 October/November 2022**

- 19** A  $60^\circ$  glass prism disperses white light as shown.



The spectrum can be seen emerging from the prism.

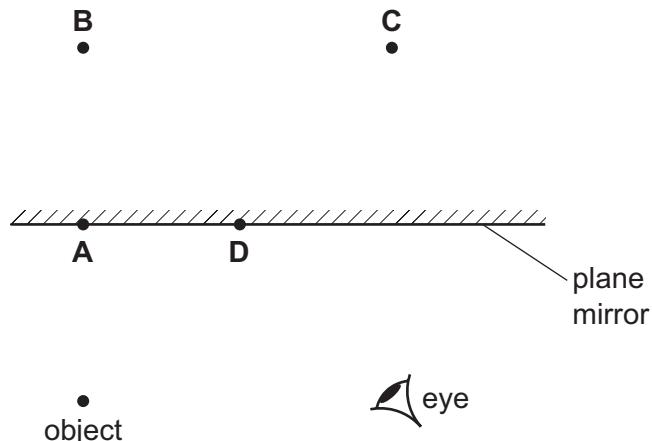
Which spectrum shows the colours in the correct order?

- A violet, green, blue, yellow, orange, red  
 B violet, blue, green, orange, yellow, red  
 C violet, blue, green, yellow, orange, red  
 D violet, green, blue, orange, yellow, red

**Answer: C**

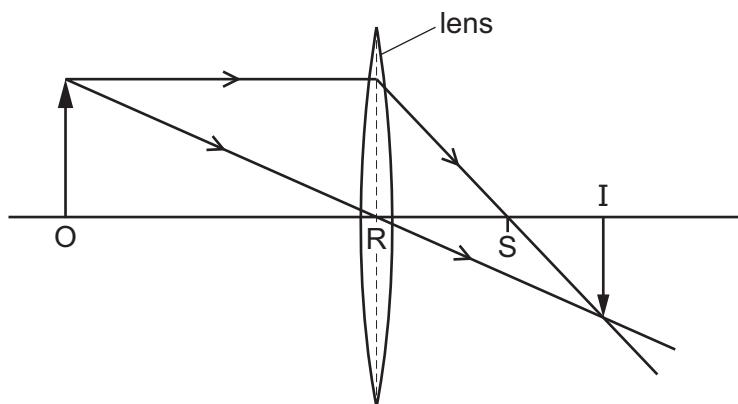
- 20** The diagram shows an object in front of a plane mirror.

At which labelled position is the image of the object formed?



**Answer: B**

- 21** The diagram shows the action of a thin converging lens on two rays of light. The rays are from the top of an object O. An inverted image I is formed.



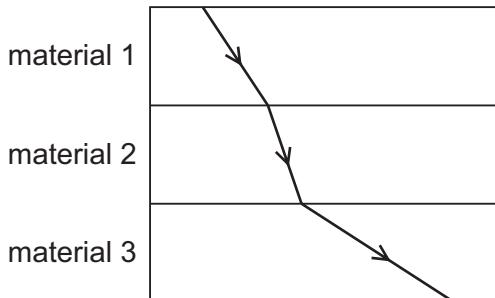
Which name is given to the distance RS?

- A** principal axis
- B** principal focus
- C** focal length
- D** real length

**Answer: C**

- 19 A composite block is made by joining together three transparent materials.

The diagram shows a ray of light passing through the composite block.



Which list gives the three materials in order of the speeds of light in the materials, from slowest to fastest?

- A 1 → 2 → 3      B 1 → 3 → 2      C 2 → 1 → 3      D 2 → 3 → 1

**Answer: C**

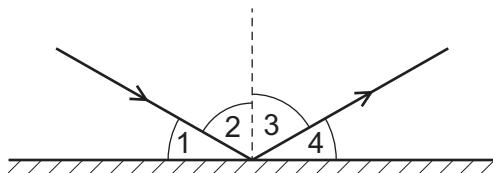
- 20 An object is placed 30 cm in front of a plane mirror.

Which statement describes the image of the object?

- A The image is the same size and 30 cm from the object.  
B The image is the same size and 60 cm from the object.  
C The image is smaller and 30 cm from the object.  
D The image is smaller and 60 cm from the object.

**Answer: B**

- 21 A ray of light is shone onto the surface of a mirror.



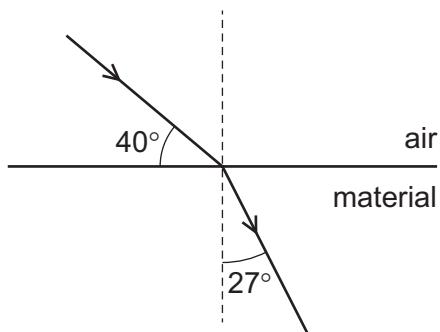
Which two angles represent the angle of incidence and the angle of reflection?

- A 1 and 2      B 1 and 4      C 2 and 3      D 3 and 4

**Answer: C**

## 0625/22 October/November 2022

- 19 A ray of light travels from air into a material, as shown.



What is the refractive index of the material?

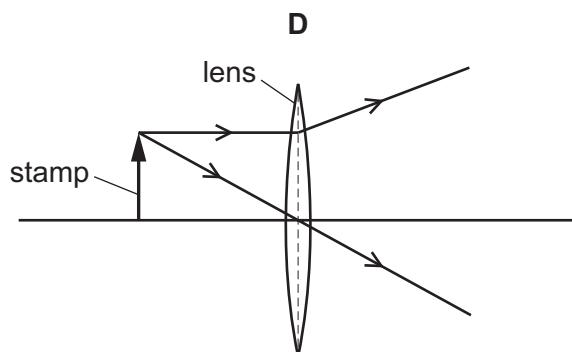
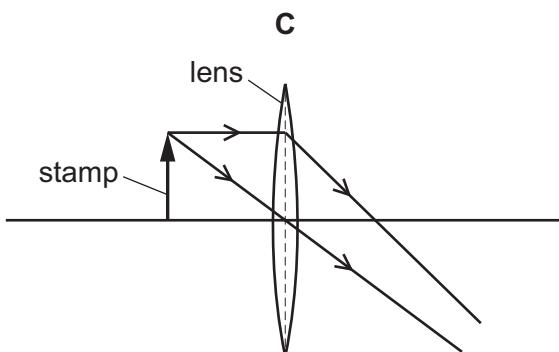
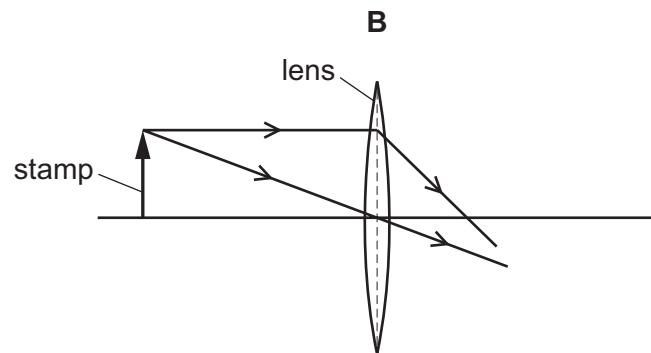
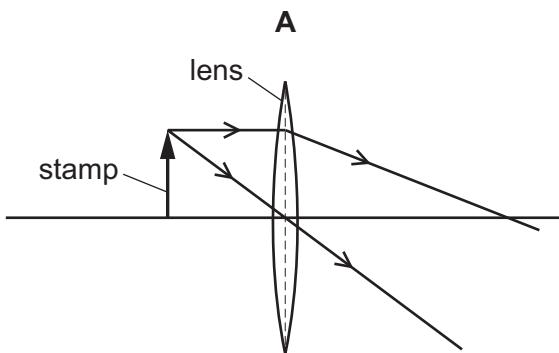
- A 1.4      B 1.5      C 1.7      D 1.9

**Answer: C**

## 0625/23 October/November 2022

- 19 A person uses a magnifying glass to look at a stamp.

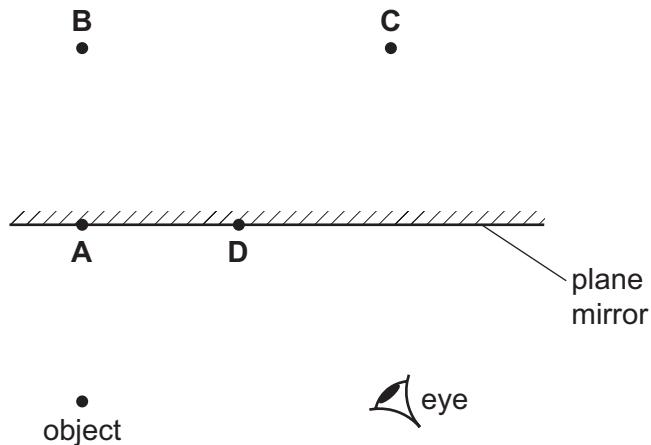
Which ray diagram shows a thin converging lens being used to do this?



**Answer: A**

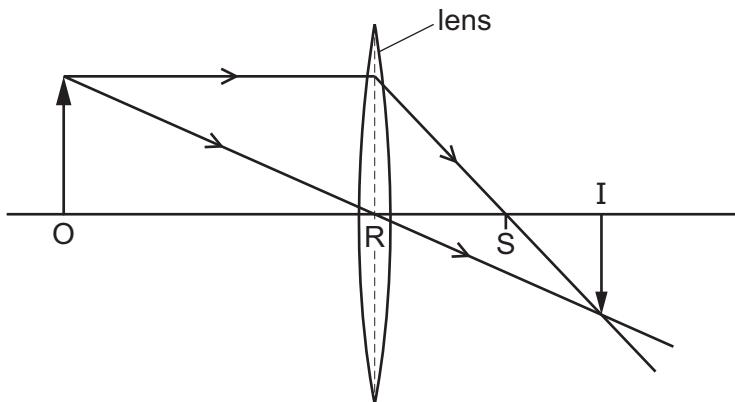
- 20** The diagram shows an object in front of a plane mirror.

At which labelled position is the image of the object formed?



**Answer: B**

- 21** The diagram shows the action of a thin converging lens on two rays of light. The rays are from the top of an object O. An inverted image I is formed.



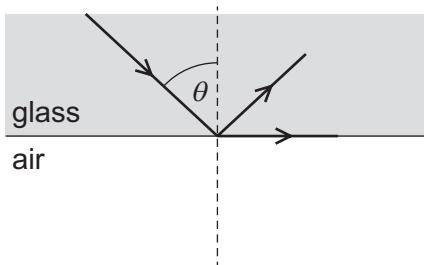
Which name is given to the distance RS?

- A** principal axis
- B** principal focus
- C** focal length
- D** real length

**Answer: C**

0625/11 May/June 2021

- 23 The diagram shows a narrow beam of light incident on a glass-air boundary. Some of the light emerges along the surface of the glass and some is reflected back into the glass.



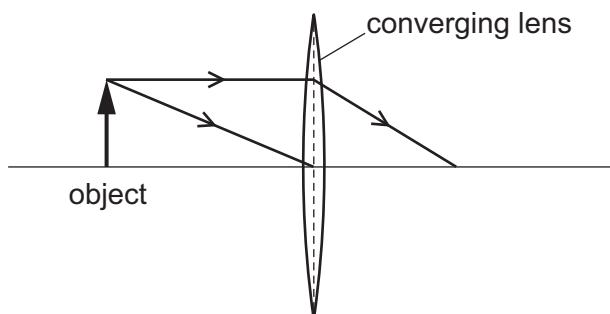
Which row is correct?

	this is an example of total internal reflection	angle $\theta$ is the critical angle
A	no	yes
B	no	no
C	yes	no
D	yes	yes

Answer: A

- 24 An object is placed in front of a thin converging lens.

The diagram shows the paths of two rays from the top of the object.



An image of the object is formed on a screen to the right of the lens.

How does this image compare with the object?

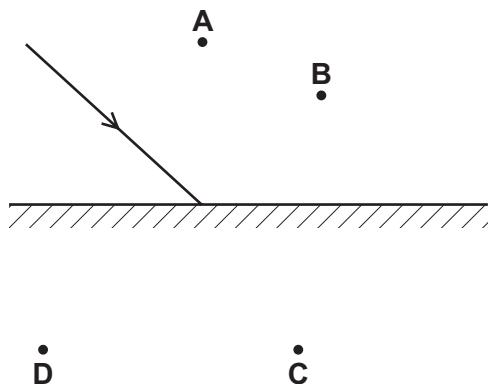
- A It is larger and inverted.
- B It is larger and the same way up.
- C It is smaller and inverted.
- D It is smaller and the same way up.

Answer: A

0625/13 May/June 2021

- 23 The diagram shows a ray of light striking a plane mirror.

Through which point does the reflected ray pass?

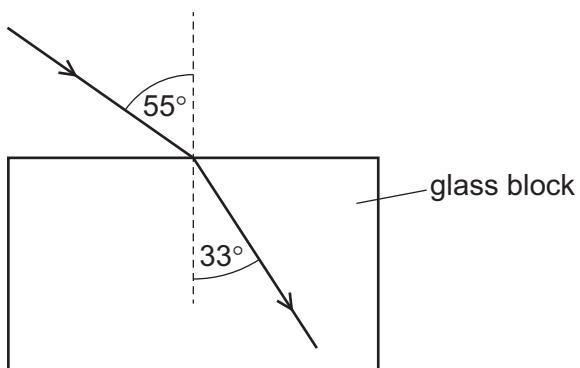


Answer: B

0625/21 May/June 2021

- 22 Light travelling at a speed of  $3.0 \times 10^8 \text{ m/s}$  strikes the surface of a glass block and undergoes refraction as it enters the block.

The diagram shows a ray of this light before and after it enters the block.



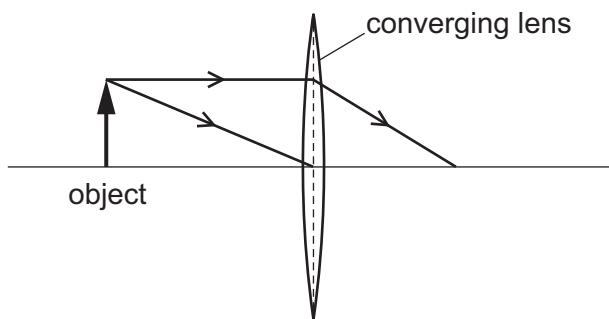
What is the speed of light in the glass?

- A  $1.8 \times 10^8 \text{ m/s}$
- B  $2.0 \times 10^8 \text{ m/s}$
- C  $4.5 \times 10^8 \text{ m/s}$
- D  $5.0 \times 10^8 \text{ m/s}$

Answer: C

- 24** An object is placed in front of a thin converging lens.

The diagram shows the paths of two rays from the top of the object.



An image of the object is formed on a screen to the right of the lens.

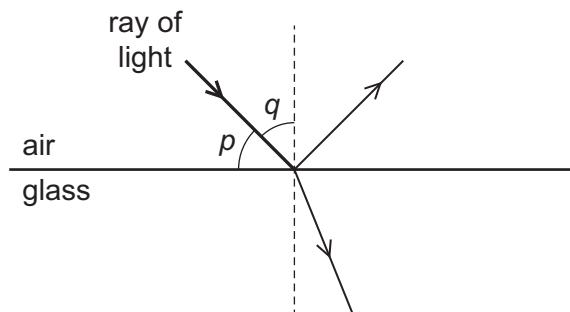
How does this image compare with the object?

- A It is larger and inverted.
- B It is larger and the same way up.
- C It is smaller and inverted.
- D It is smaller and the same way up.

**Answer: A**

**0625/11 October/November 2021**

- 20** The diagram shows a ray of light in air incident on a glass block. Some of the light is refracted and some of the light is reflected. Two angles,  $p$  and  $q$ , are marked on the diagram.

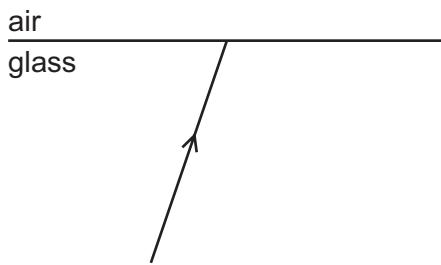


Which row gives the angle of incidence and states whether total internal reflection occurs?

	angle of incidence	total internal reflection
A	$p$	no
B	$p$	yes
C	$q$	no
D	$q$	yes

**Answer: C**

- 21 The diagram shows a ray of light in glass incident on the surface between the glass and air.



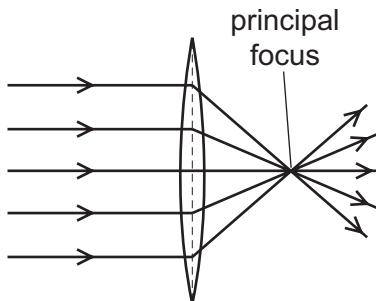
What happens if the angle of incidence is made larger than the critical angle for the glass?

- A The angle of refraction becomes equal to  $90^\circ$ .
- B There is a refracted ray and a ray reflected inside the glass.
- C There is a refracted ray only.
- D There is only a ray reflected inside the glass.

**Answer: D**

**0625/12 October/November 2021**

- 19 A thin, converging lens causes parallel rays of light to converge to a single point known as the principal focus.

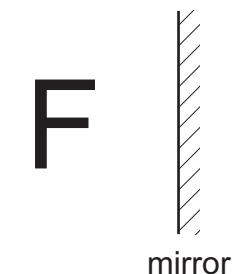


Which statement explains this?

- A The light diffracts.
- B The light disperses.
- C The light reflects.
- D The light refracts.

**Answer: D**

- 21** The letter F is reflected in a mirror.



What does the optical image look like?

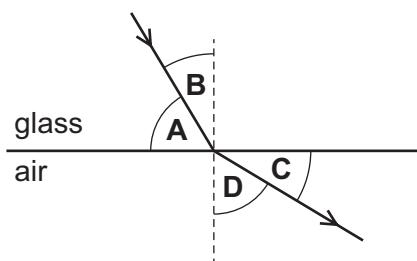


**Answer: B**

**0625/13 October/November 2021**

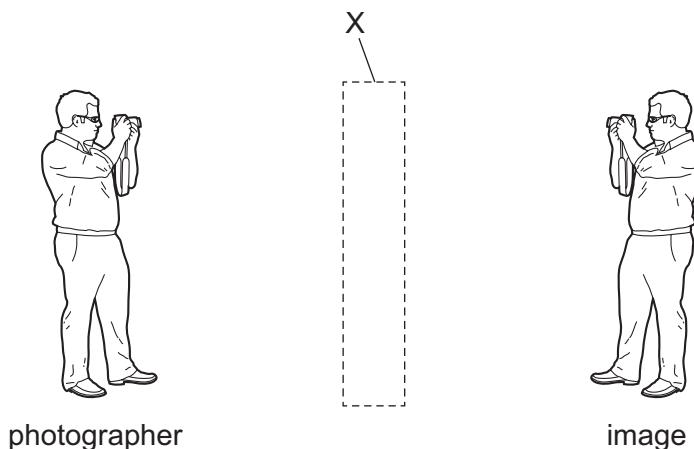
- 19** A narrow beam of light travels through glass. It reaches the edge of the glass and refracts into the air.

What is the angle of refraction?



**Answer: D**

21 A photographer sees his image as shown.



What could X be?

A



mirror

B



translucent  
glass block

C



transparent  
glass prism

D

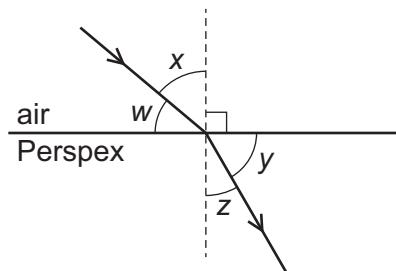


transparent  
semicircular  
glass block

**Answer: A**

**0625/22 October/November 2021**

19 The diagram shows how a ray of light refracts when going from air to Perspex.



The critical angle of Perspex is  $c$ .

Which expression is correct?

A  $\frac{\sin x}{\sin z} = \sin c$

B  $\frac{\sin z}{\sin x} = \sin c$

C  $\frac{\sin w}{\sin y} = \sin c$

D  $\frac{\sin y}{\sin w} = \sin c$

**Answer: B**

## 0625/23 October/November 2021

19 A ray of light travels from air into a glass block.

	in air	in glass
speed of ray	$v_a$	$v_g$
wavelength of ray	$\lambda_a$	$\lambda_g$
frequency of ray	$f_a$	$f_g$

Three suggestions as to how the refractive index of glass  $n$  may be calculated are listed.

$$1 \quad n = \frac{v_a}{v_g}$$

$$2 \quad n = \frac{\lambda_a}{\lambda_g}$$

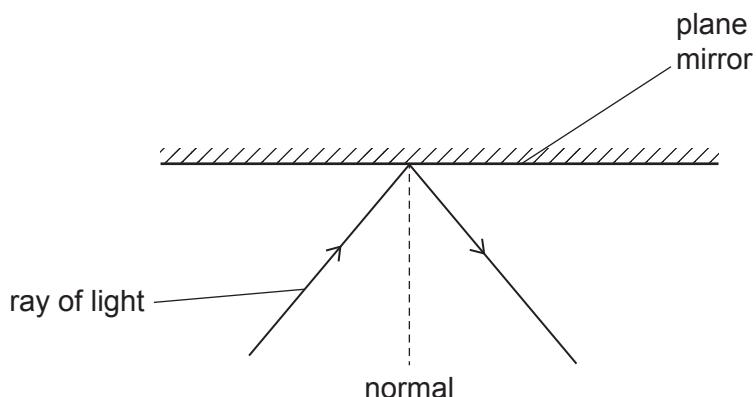
$$3 \quad n = \frac{f_a}{f_g}$$

Which suggestions are correct?

- A 1, 2 and 3      B 1 and 2 only      C 1 and 3 only      D 2 and 3 only

Answer: B

- 7 (a) Fig. 7.1 shows a ray of light striking a plane mirror. The ray is reflected as shown.

**Fig. 7.1**

The angle of incidence for the ray of light is  $40^\circ$ .

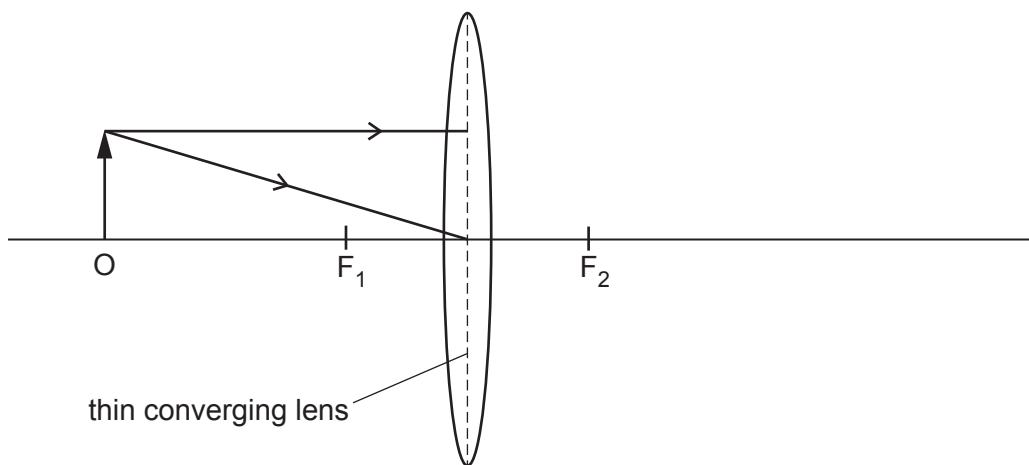
- (i) Indicate the angle of reflection by drawing a letter R on Fig. 7.1. [1]

- (ii) State the size of the angle of reflection in Fig. 7.1.

$$\text{angle of reflection} = \dots\dots\dots^\circ \quad [1]$$

- (b) An object O is placed to the left of a thin converging lens.  $F_1$  is the principal focus on one side of the lens and  $F_2$  is the principal focus on the other side of the lens.

Two rays from the top of the object are incident on the lens, as shown in Fig. 7.2.

**Fig. 7.2**

- (i) On Fig. 7.2, locate the image of O by continuing the path of each ray. [2]

- (ii) Draw an arrow to represent the image of O. [1]

- (c) Fig. 7.3 shows a prism producing a spectrum of colours from a narrow beam of white light.

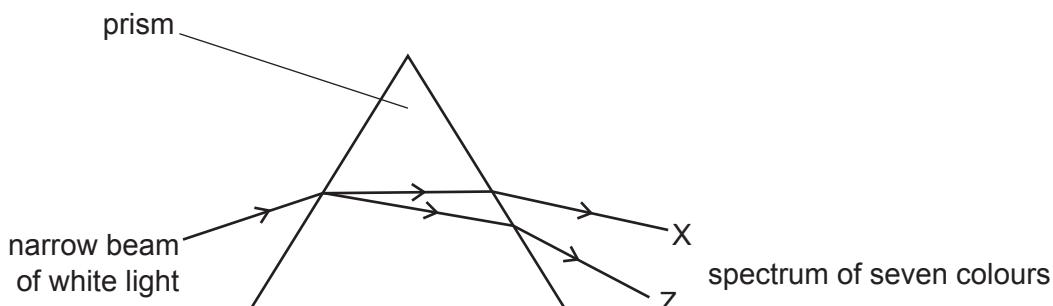


Fig. 7.3

- (i) The prism refracts the white light.

State the name of the effect that produces a spectrum.

..... [1]

- (ii) In the spectrum shown in Fig. 7.3, there are seven colours.

List the seven colours in the order they appear between X and Z.

X .....

.....  
.....  
.....  
.....  
.....

Z .....

[2]

[Total: 8]

0625/31

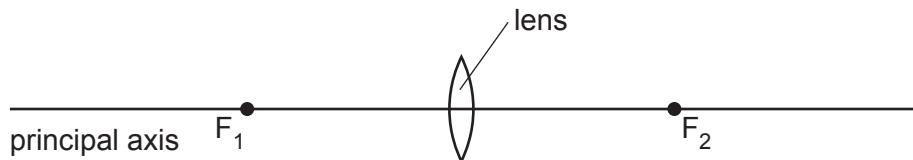
Cambridge IGCSE – Mark Scheme  
PUBLISHED

May/June 2024

Question	Answer	Marks
7(a)(i)	angle of reflection identified	B1
7(a)(ii)	40 ( $^{\circ}$ )	B1
7(b)(i)	horizontal ray drawn to continue through $F_2$	B1
	ray to centre drawn to continue undeviated	B1
7(b)(ii)	(image drawn / identified) where rays cross	B1
7(c)(i)	dispersion	B1
7(c)(ii)	all 7 colours AND in correct order	A2
	6 of the seven colours given	(C1)

4 The lens in a magnifying glass is a converging lens.

- (a) Fig. 4.1 shows the lens of the magnifying glass, its two focal points,  $F_1$  and  $F_2$ , and its principal axis.



**Fig. 4.1**

- (i) State what is meant by 'focal point'.
- .....  
.....  
.....

[2]

- (ii) A student using the magnifying glass sees a magnified image of an object.

On Fig. 4.1, mark:

- a point X on the principal axis for a possible position of the object
- a point E for a possible position of the student's eye.

[1]

- (iii) Underline **two** words in the list that describe the image produced in (a)(ii).

**inverted**

**real**

**upright**

**virtual**

[1]

- (b) The refractive index of the glass used to make the lens is 1.5.

- (i) The speed of light in air is  $3.0 \times 10^8$  m/s.

Calculate the speed of light in the glass.

speed in glass = ..... [2]

- (ii) State what happens to the wavelength of light as it passes into the lens.

.....  
..... [1]

- (c) Converging lenses are used in spectacles (glasses) to correct one problem with vision.

State the name of the problem and explain how a converging lens is used to correct it.  
You may draw a diagram.

name of problem: .....

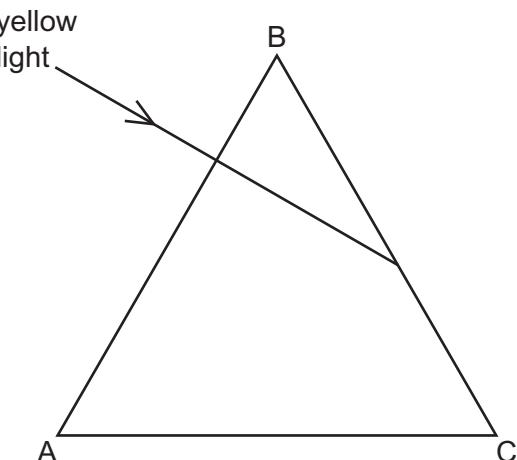
.....  
.....  
.....  
.....

[3]

[Total: 10]

Question	Answer	Marks
4(a)(i)	(point on principal axis) where rays of light parallel (to the principal axis, incident on converging lens)	B1
	(rays) meet / converge after passing through lens / refraction	B1
4(a)(ii)	X marked between one of the focal points and the lens <b>AND</b> E marked on other side of lens	B1
4(a)(iii)	virtual <b>AND</b> upright	B1
4(b)(i)	$2.0 \times 10^8 \text{ m/s}$	A2
	$n = c / v_g$ <b>OR</b> ( $v_g = c / n$ ) <b>OR</b> ( $v_g = 3(0) \times 10^8 / 1.5$ )	C1
4(b)(ii)	(wavelength) decreases	B1
4(c)	long-sightedness	B1
	it moves the image towards the lens / back of the eye / retina <b>OR</b> reduces / shortens focal length of (combined lens)	B1
	(converging lens) focuses image on back of eye / retina	B1

- 5 Fig. 5.1 shows a ray of yellow light incident on a glass prism ABC.



**Fig. 5.1**

- (a) Explain why the ray does **not** change direction when it enters the prism at face AB.

..... [1]

- (b) The critical angle for the glass is  $42^\circ$ .

- (i) Calculate the refractive index of the glass.

Show your working.

refractive index = ..... [2]

- (ii) On Fig. 5.1, continue the path of the light through the prism and after it leaves the prism. [3]

- (c) Internet data can be transferred using infrared waves in optical fibres.

State **two** advantages of using optical fibres to transmit data.

1 .....

2 .....

[2]

Question	Answer	Marks
5(a)	ray travels along the normal <b>OR</b> angle of incidence = $0^\circ$	<b>B1</b>
5(b)(i)	$n = 1 / \sin c$ <b>OR</b> ( $n = 1 / \sin c$ <b>OR</b> ( $n = 1 / \sin 42^\circ$ )	<b>M1</b>
	1.5	<b>A1</b>
5(b)(ii)	ray reflected at BC <b>AND</b> no refracted ray	<b>M1</b>
	ray hits AC with angle of incidence = $0^\circ$	<b>A1</b>
	correct refraction of candidate's ray into air at AC	<b>B1</b>

- 6 Fig. 6.1 shows a thin converging lens used to produce a magnified image of an object AB.

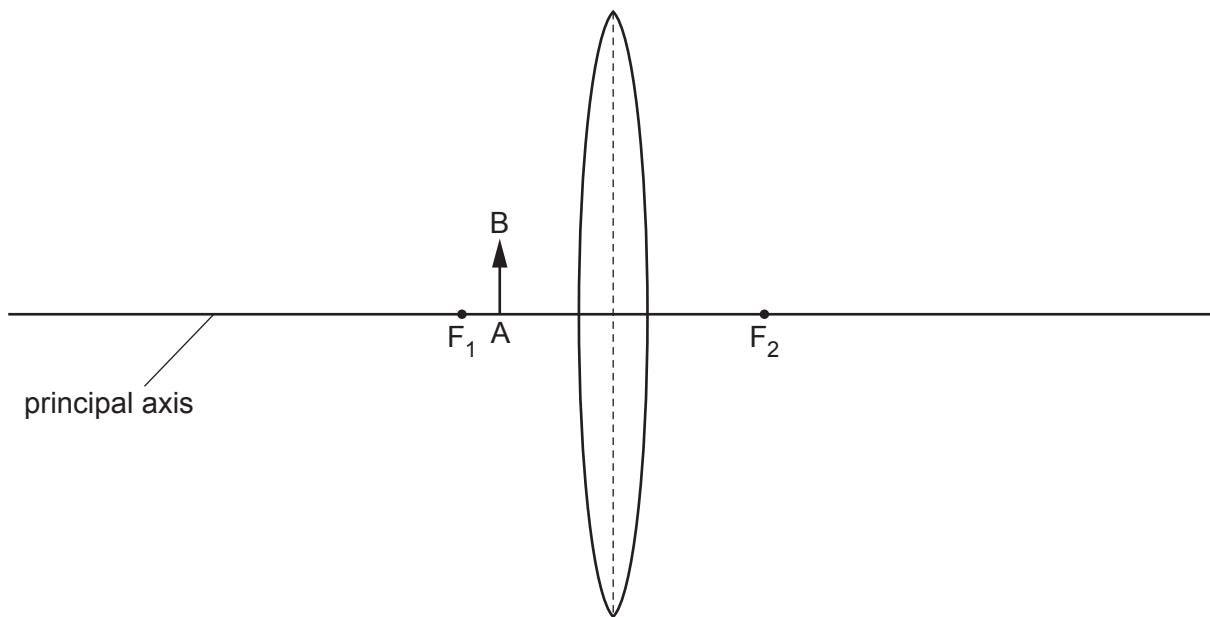


Fig. 6.1

- (a) Explain the meaning of the terms principal focus and focal length.

principal focus .....

focal length .....

[2]

- (b) On Fig. 6.1, draw the magnified image of AB. Show your working.

[4]

[Total: 6]

Question	Answer	Marks
6(a)	where rays of light parallel (to the principal axis) converge after passing through lens	B1
	(focal length is) the distance between (centre of) the lens and principal focus	B1
6(b)	any <b>two</b> from: • ray from top of object to lens, parallel to principal axis, refracted to F <sub>2</sub> • ray from top of object through centre of lens, undeviated • ray from F <sub>1</sub> , through top of object and on to lens, then parallel to principal axis	M2
	rays extrapolated back to converge to the left of F <sub>1</sub>	A1
	image drawn from principal axis to intersection with arrow (to show orientation)	A1

- 7 Fig. 7.1 represents two rays of light striking a thin converging lens. The rays are both parallel to the principal axis.  
 $F_2$  and  $F_1$  are the focal points of the lens.

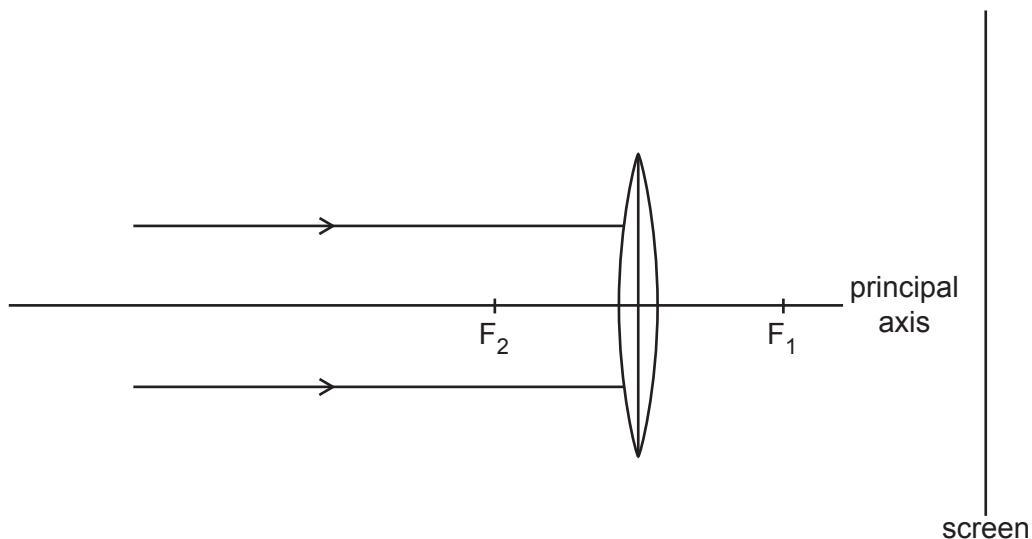


Fig. 7.1

(a) On Fig. 7.1, continue the path of each ray beyond the lens as far as the screen. [2]

(b) Visible light is a region of the electromagnetic spectrum.

State **one** region of the electromagnetic spectrum which has waves of longer wavelength than waves of visible light.

..... [1]

(c) Gamma rays are another region of the electromagnetic spectrum.

(i) Describe **one** use of gamma rays.

..... [1]

(ii) Describe **one** harmful effect on people of excessive exposure to gamma rays.

..... [1]

[Total: 5]

Question	Answer	Marks
7(a)	<b>both</b> rays refracted toward principal axis	B1
	both rays meet at $F_1$	B1
7(b)	infrared (rays / waves) OR microwaves OR radio (waves)	B1
7(c)(i)	any <b>one</b> from: • sterilising food / water • sterilising (medical) equipment • detection of cancer • treatment of cancer • space telescopes	B1
7(c)(ii)	mutation (of cells / DNA) OR damage to cells / DNA	B1

- 6 Fig. 6.1 shows light waves passing from air into a glass block.

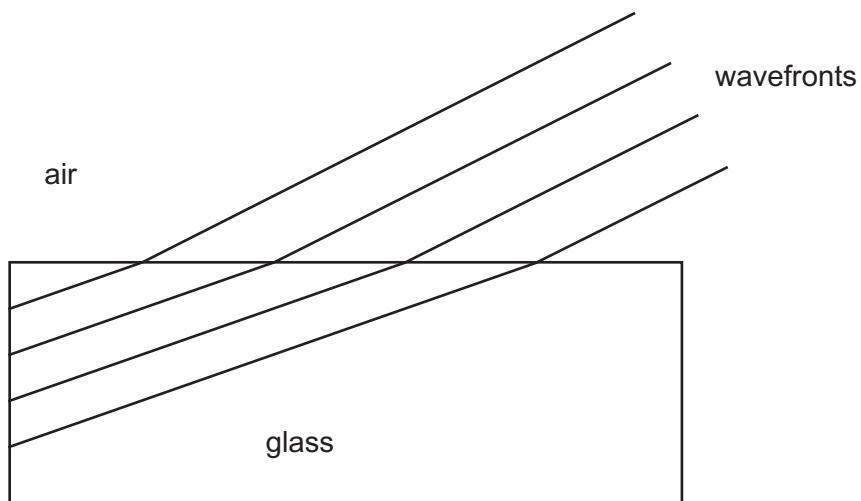


Fig. 6.1 (not to scale)

- (a) (i) State the name of the process shown in Fig. 6.1 as the wavefronts enter the glass block.

..... [1]

- (ii) State **two** changes in the light waves as they pass from air into glass.

1 .....

2 .....

[2]

- (b) Fig. 6.2 shows a ray of red light travelling through a glass fibre. The glass fibre is made of solid glass.

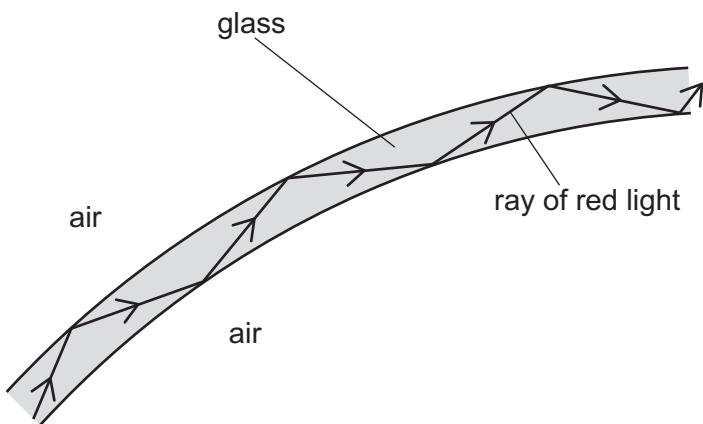


Fig. 6.2

State and explain how the ray of red light travels through the glass fibre as shown in Fig. 6.2.

.....  
.....  
..... [3]

Question	Answer	Marks
6(a)(i)	refraction	B1
6(a)(ii)	any <b>two</b> from: • wavelength • speed • direction	B2
6(b)	total internal reflection	B1
	(red light) travelling from more dense <b>OR</b> into / towards less dense (medium)	B1
	incident on surface at an angle / angle of incidence greater than critical angle	B1

- 7 (a) Students are investigating the refraction of light as it travels from air into glass.

Their task is to measure the angle of incidence and the angle of refraction at the surface of the glass block.

The students have the equipment shown in Fig. 7.1.

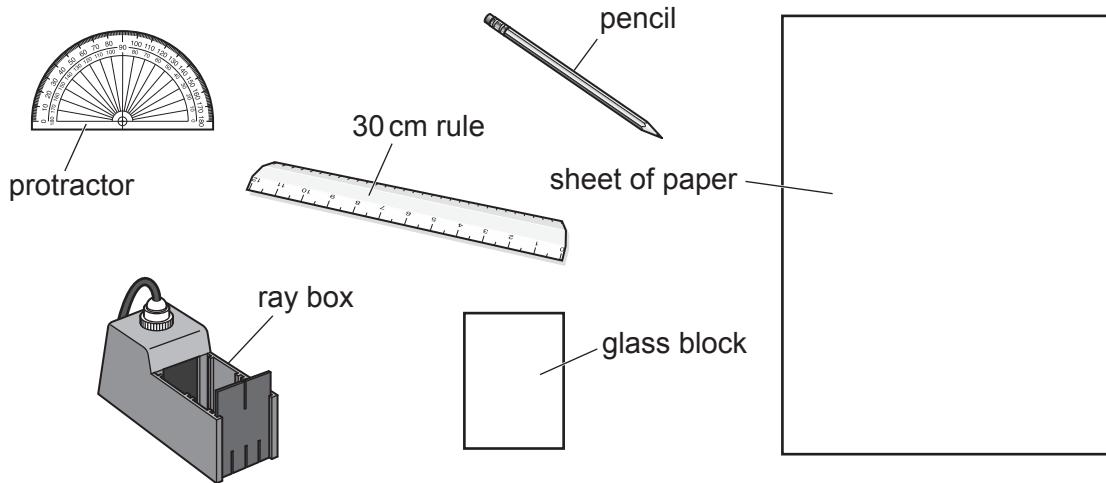


Fig. 7.1

Describe the method for the task.  
You may draw a diagram as part of your answer.

.....

.....

.....

.....

[4]

- (b) Fig. 7.2 and Fig. 7.3 show two identical lenses, each forming an image. The images  $I_1$  and  $I_2$  have different characteristics.

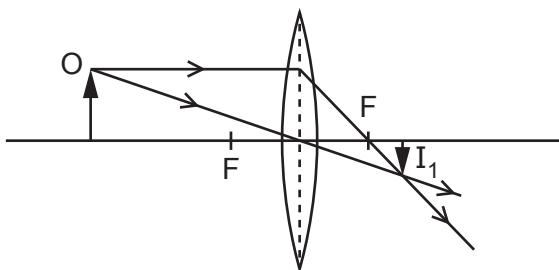


Fig. 7.2

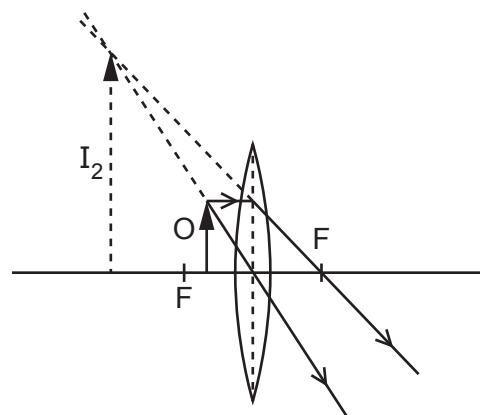


Fig. 7.3

One difference in the characteristics of the two images is:

Image  $I_1$  is ..... diminished ..... but image  $I_2$  is ..... enlarged .....

State **two** more differences in the characteristics of the images:

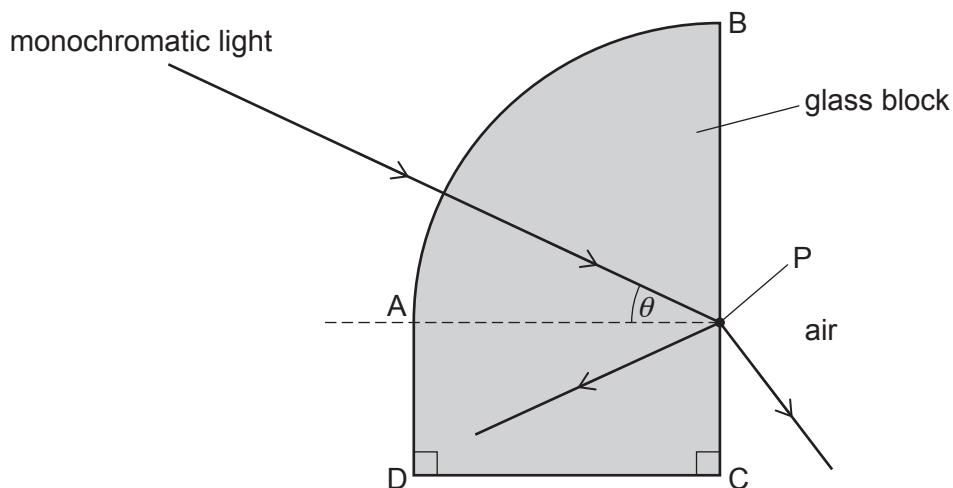
Image  $I_1$  is ..... but image  $I_2$  is ..... .

Image  $I_1$  is ..... but image  $I_2$  is ..... .

[3]

Question	Answer	Marks
7(a)	any <b>four</b> from: • draw round the block (on the paper) • use ray box to shine a ray through block • draw crosses on incident and emergent rays • draw ray through block • draw normals • measure angles between rays and normals	<b>B4</b>
7(b)	Image $I_1$ is <b>real</b> but image $I_2$ is <b>virtual</b> . Image $I_1$ is <b>inverted</b> but image $I_2$ <b>upright</b> .  4 correct – 3 marks 3 or 2 correct – 2 marks 1 correct – 1 mark if no marks scored but all three or four characteristics named, award 1 mark	<b>B3</b>

- 5 Fig. 5.1 shows a block ABCD made of glass that has a refractive index of 1.5. The block has one curved side AB and three straight sides, BC, CD and DA.

**Fig. 5.1**

There are right angles at C and D. The curved side AB is one quarter of the circumference of a circle that has its centre at point P.

A ray of monochromatic light enters the block through the curved side AB and strikes side BC at P. Some light emerges into the air and some is reflected.

- (a) State what is meant by monochromatic.
- ..... [1]

- (b) Explain why the ray of light does **not** change direction when it enters the block through side AB.
- ..... [2]

- (c) Show that the critical angle  $c$  for glass of refractive index 1.5 is  $42^\circ$ .

- (d)** Fig. 5.1 shows that the angle between the ray of light and line AP is  $\theta$ , where line AP is at right angles to side BC.

Angle  $\theta$  increases to  $45^\circ$ .

- (i)** State and explain what happens to the light that strikes P.

.....  
.....  
.....

[2]

- (ii)** When  $\theta = 45^\circ$ , the reflected light strikes side CD.

Describe what happens when this reflected light strikes side CD.

.....  
.....

[1]

[Total: 8]

Question	Answer	Marks
5(a)	(light / electromagnetic radiation) of a single frequency	B1
5(b)	angle of incidence / $i = 0$ <b>OR</b> incident ray along normal <b>OR</b> all of wavefront enters block at same time	B1
	angle of refraction / $r = 0$ <b>OR</b> no refraction <b>OR</b> whole wavefront slows down at same time	B1
5(c)	$(c =) \sin^{-1}\{1/1.5\} (= 42^\circ)$ <b>OR</b> $(c =) \sin^{-1}\{1/n\} = 41.8^\circ$	A2
	$n = 1/\sin c$ <b>OR</b> $(c =) \sin^{-1}\{1/n\}$ <b>OR</b> $(c =) 41.8^\circ$	C1
5(d)(i)	<u>all</u> light is reflected	B1
	$\theta$ / angle of incidence > $c$ / critical angle	B1
5(d)(ii)	<u>all</u> light is reflected <b>OR</b> reflected ray at $90^\circ$ to incident ray <b>OR</b> reflected ray is parallel to original ray	B1

- 7 Fig. 7.1 shows a container of oil.

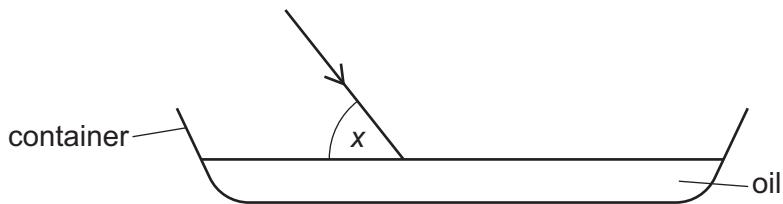


Fig. 7.1

A ray of light shines on the surface of the oil. The refractive index of the oil is 1.47.

- (a) On Fig. 7.1, draw the normal at the point where the ray enters the oil. [1]
- (b) The angle  $x$  is  $56^\circ$ .

Calculate the value of the angle of refraction.

$$\text{angle of refraction} = \dots \quad [3]$$

- (c) State the approximate speed of light in air.

$$\dots \quad [1]$$

- (d) Calculate the speed of light in the oil.

Give your answer to three significant figures.

$$\text{speed} = \dots \quad [2]$$

<b>Question</b>	<b>Answer</b>	<b>Marks</b>
7(a)	normal drawn in correct position and at right angles to the surface	B1
7(b)	22°	A3
	$i = 34^\circ$	C1
	$n = \sin i / \sin r$ OR ( $r = \sin^{-1} \{ \sin i / n \}$ ) OR $\sin r = \sin 34 / 1.47$ OR $\sin r = 0.38$	C1
7(c)	$3.0 \times 10^8$ m/s	B1
7(d)	$2.04 \times 10^8$ m/s	A2
	$n = \text{speed of light in air} / \text{speed of light in oil}$ OR (speed of light in oil =) speed of light in air / $n$ OR (speed of light in oil =) $3.0 \times 10^8 / 1.47$	C1

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- 4 (a) Fig. 4.1 is an incomplete ray diagram showing an object O, a converging lens and the principal axis. The focal points of the lens are each labelled F.

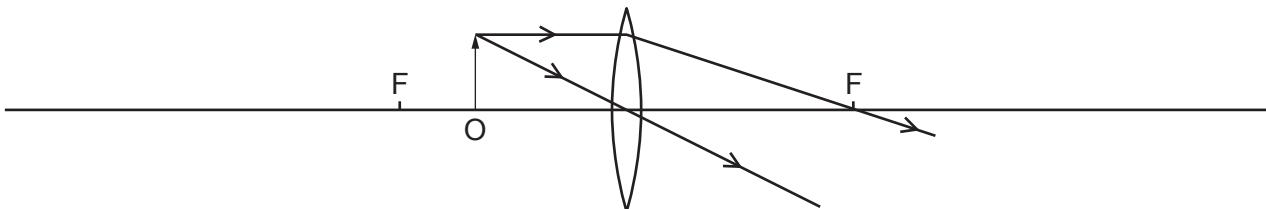


Fig. 4.1

- (i) Complete the ray diagram to draw the image formed by the lens. Label your image I. [3]
- (ii) Circle **three** descriptions in the list which describe the image formed in (i).

**diminished      enlarged      inverted      same size**

**real      upright      virtual**

[3]

- (b) (i) State the name for the defect of vision that can be corrected by a converging lens.

[1]

- (ii) Describe how a converging lens corrects the defect in (i).  
You may find it helpful to sketch a ray diagram.

Question	Answer	Marks
4(a)(i)	two correct rays extended back (towards the intersection)	M1
	extended rays intersect	A1
	image drawn from intersection to principal axis <b>AND</b> base of image lies in correct range	B1
4(a)(ii)	circles around: <ul style="list-style-type: none"><li>• enlarged</li><li>• virtual</li><li>• upright</li></ul>	B3
4(b)(i)	long-sightedness / long sight / far-sighted	B1
4(b)(ii)	converging lens reduces focal length of eye <b>OR</b> converging lens brings focal point forward <b>OR</b> without lens, rays converge behind back of eye	B1
	(so that) rays converge / focus on back of eye / retina	B1

- 7 Fig. 7.1 shows a ray diagram for an object positioned on the principal axis of a thin converging lens.

$F_1$  and  $F_2$  are the focal points of the lens and C is the centre of the converging lens.

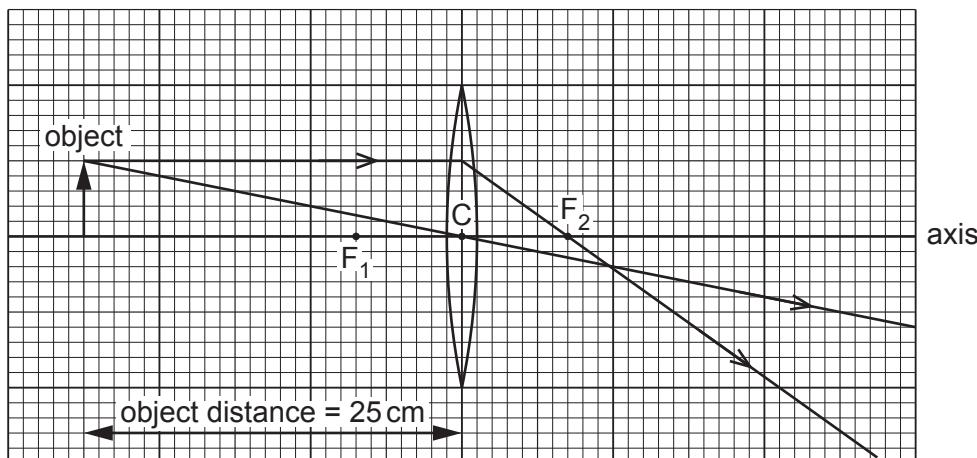


Fig. 7.1

- (a) On Fig. 7.1, each small square of the grid represents 1.0 cm.

Determine the focal length of the converging lens.

$$\text{focal length} = \dots \text{cm} \quad [1]$$

- (b) On Fig. 7.1, draw an arrow to show the position of the image formed by the converging lens. [1]

- (c) State **three** characteristics of the image formed by the converging lens.

1 .....

2 .....

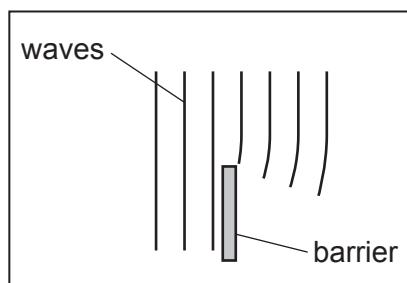
3 .....

[3]

Question	Answer	Marks
7(a)	7 (cm)	B1
7(b)	arrow drawn (perpendicularly) from principal axis to intersection of rays.	B1
7(c)	(image is) real	B1
	inverted	B1

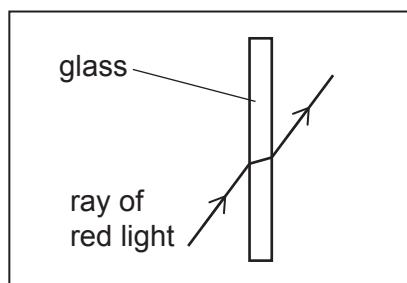
- 8 (a) In Fig. 8.1, each diagram illustrates a wave property.

Draw a line from each diagram to the correct wave property.



reflection

diffraction



dispersion

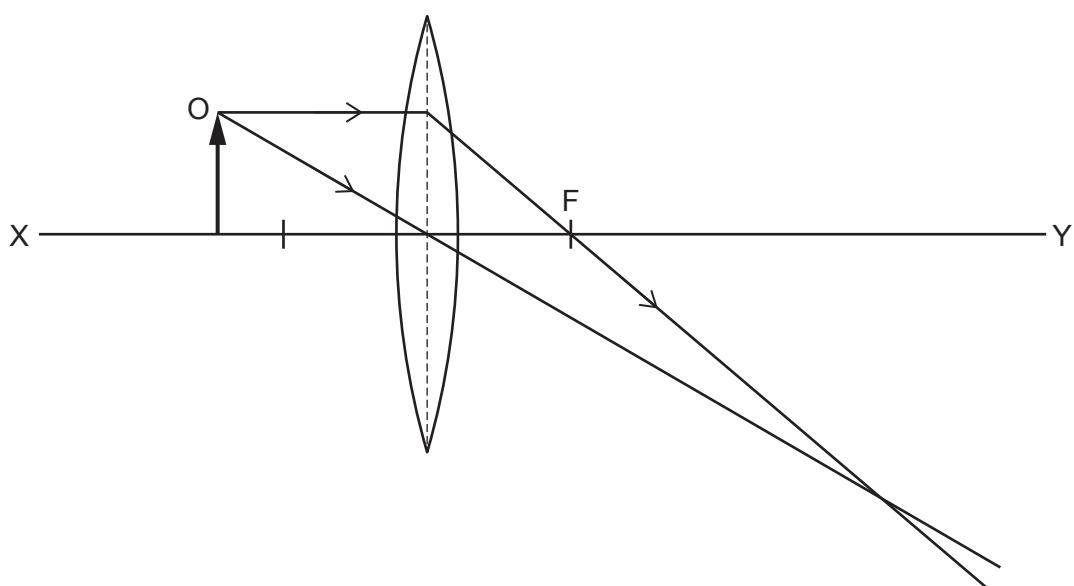
refraction

**Fig. 8.1**

[2]

- (b) An object O is placed in front of a converging lens.

Fig. 8.2 shows two rays of light from the object passing through the lens.



**Fig. 8.2**

- (i) State the name of the line XY in Fig. 8.2.

..... [1]

- (ii) State the name of the point labelled F in Fig. 8.2.

..... [1]

- (iii) On Fig. 8.2, draw an arrow to represent the image of O. [1]

- (iv) Using a ruler, measure the focal length of the converging lens.

focal length = ..... cm [1]

- (v) Describe characteristics of the image in Fig. 8.2.

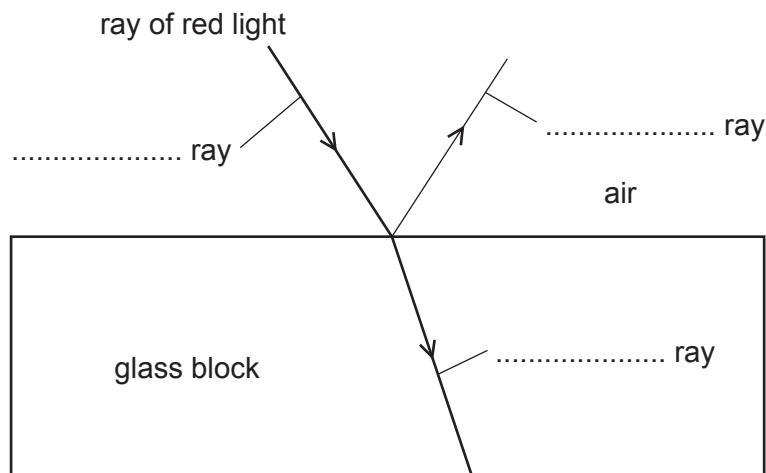
Choose words from the list. Tick () **three** boxes.

enlarged	
diminished	
same size	
inverted	
upright	
virtual	
real	

[3]

Question	Answer		Marks
8(a)	top diagram ----- diffraction		B1
	bottom diagram ----- refraction		B1
8(b)(i)	<u>principal axis</u>		B1
8(b)(ii)	<u>principal focus</u>		B1
8(b)(iii)	vertical line from point where rays cross to the principal axis		B1
8(b)(iv)	1.9 (cm)		B1
8(b)(v)	enlarged	<input checked="" type="checkbox"/>	B1
	diminished		B1
	same size		B1
	inverted	<input checked="" type="checkbox"/>	
	upright		
	virtual		
	real	<input checked="" type="checkbox"/>	

- 6 (a) A student shines a ray of red light into a rectangular glass block, as shown in Fig. 6.1.

**Fig. 6.1**

- (i) Draw the normal at the point where the ray of red light enters the glass block. [1]

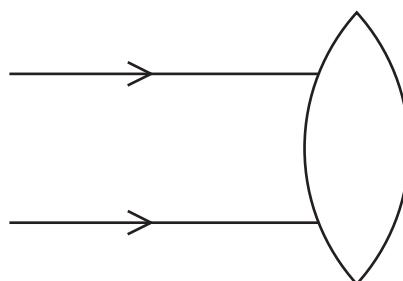
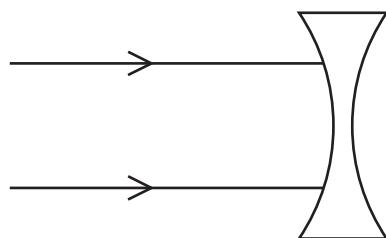
- (ii) On Fig. 6.1, label each ray using words from the list.

**diffracted      diffused      dispersed      incident      reflected      refracted**

[2]

- (b) Fig. 6.2 and Fig. 6.3 each show two parallel rays of light travelling through air towards a lens.

For each lens, draw the path of the two rays as they pass through the lens and back into the air.

**Fig. 6.2****Fig. 6.3**

[2]

- (c) State the **seven** colours of visible light. Give the colours in order of frequency.

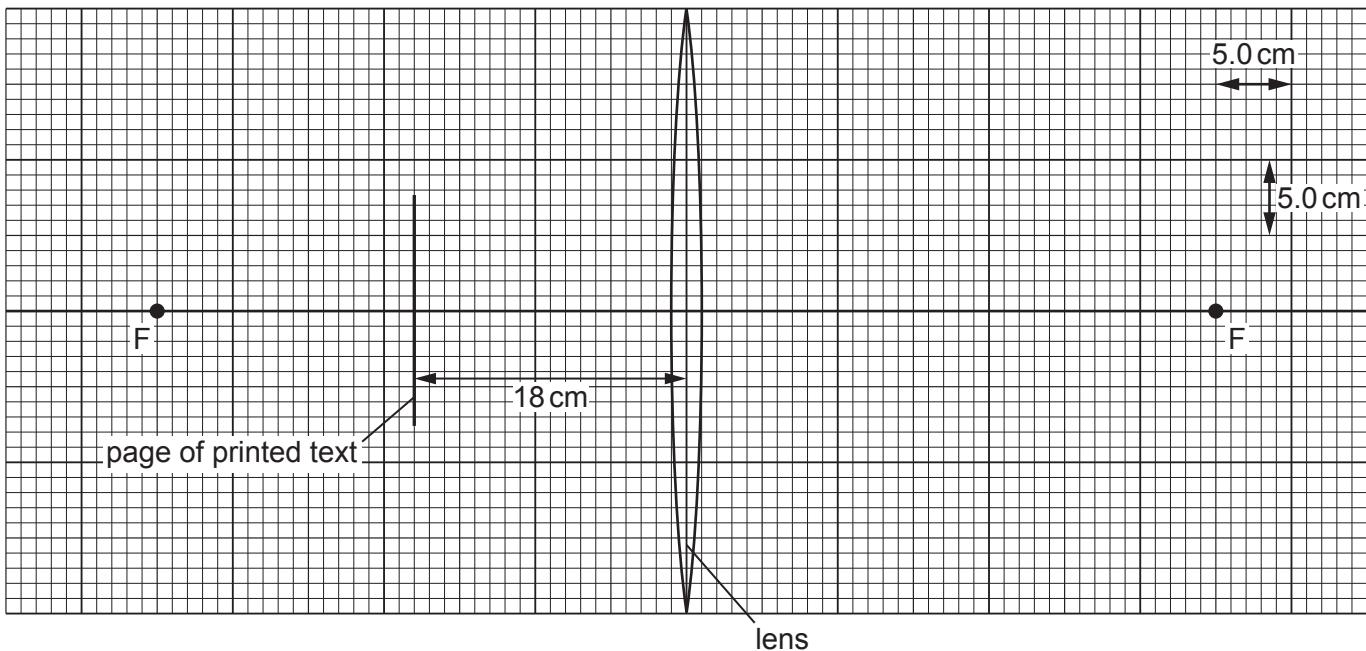
frequency	colour
greatest	
smallest	

[2]

Question	Answer	Marks
6(a)(i)	normal correctly drawn	B1
6(a)(ii)	incident (ray) reflected (ray) refracted (ray)	B2
6(b)	Fig. 6.2. – emerging rays converge	B1
	Fig. 6.3. – emerging rays diverge	B1
6(c)	all 7 colours named	M1
	greatest frequency violet AND in correct order (VIBGYOR)	A1

- 6** A page of printed text is placed 18 cm from a converging lens of focal length 35 cm.

Fig. 6.1 is a scale diagram of the arrangement with each of the two principal focuses (focal points) of the lens labelled F.



**Fig. 6.1**

- (a)** A length of 1.0 cm on the scale diagram represents an actual length of 5.0 cm.

- (i) By drawing on Fig. 6.1, locate the image of the page produced by the lens and label it I. [3]
- (ii) Using Fig. 6.1, determine the actual distance of image I from the lens.

$$\text{actual distance from lens} = \dots \quad [2]$$

- (b)** Converging lenses can be used as magnifying glasses.

State whether the image produced when a lens is used as a magnifying glass is real or virtual. Explain why.

.....  
..... [1]

- (c)** Suggest how someone who is long-sighted may benefit from using a converging lens.

.....  
.....  
..... [2]

Question	Answer	Marks
6(a)(i)	<p>any <b>two</b> from:</p> <ul style="list-style-type: none"> <li>• ray from top / bottom of object, parallel to principal axis, refracted through right-hand principal focus</li> <li>• straight ray from same point on object through optical centre</li> <li>• ray that (seems to) come from left-hand principal focus through same point of object and refracted parallel to principal axis</li> </ul>	<b>M2</b>
	rays traced back to intersection <b>AND</b> intersection / image labelled I	<b>A1</b>
6(a)(ii)	(distance = ) 35.5 cm to 38.5 cm	<b>A2</b>
	7.1 to 7.7 (cm) <b>OR</b> (distance =) 35.0 (cm) to 40.0 (cm)	C1
6(b)	<p>virtual <b>AND</b> <i>any one from</i>:</p> <ul style="list-style-type: none"> <li>• cannot be projected on a screen</li> <li>• (real) light (ray) does not pass through image</li> <li>• light only seems to come from image</li> </ul>	<b>B1</b>
6(c)	<p><i>any one from</i>:</p> <ul style="list-style-type: none"> <li>• long-sightedness focuses image behind retina/back of eye <b>OR</b> longsightedness produces blurry/fuzzy images (of close objects)</li> <li>• converging lens reduces focal length (of eye)</li> <li>• (converging lens) puts image further away (from the eye)</li> </ul>	<b>B1</b>
	(converging lens gives) sharp/focussed image on retina / back of eye <b>OR</b> (with lens) rays converge on retina / back of eye	<b>B1</b>

- 5 Fig. 5.1 shows a road junction, a moving car and a stationary truck. The road has high walls on each side.

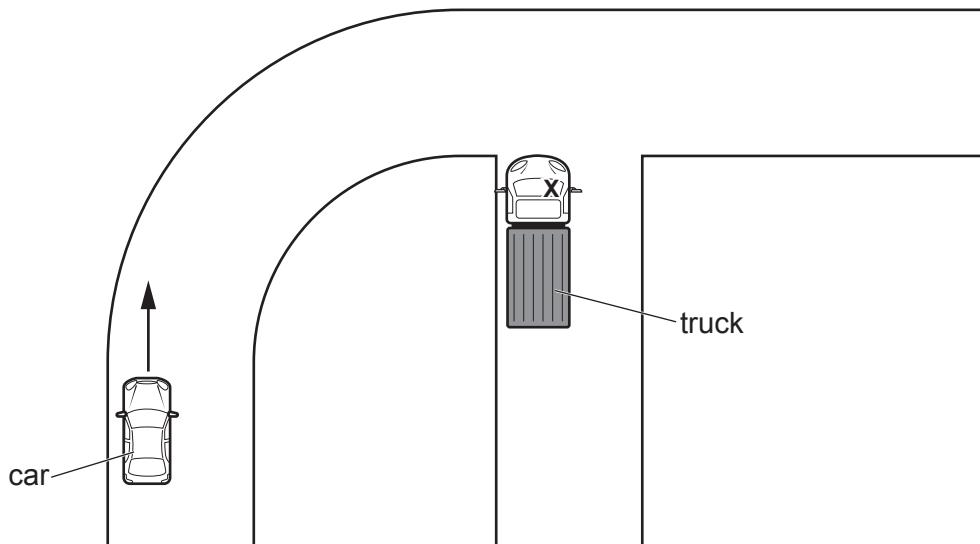


Fig. 5.1

- (a) The driver of the truck is at position X. The car moves around the corner.

On Fig. 5.1, label a point Y on the road where the truck driver first sees the car.

[1]

- (b) A plane mirror is placed at the road junction as shown in Fig. 5.2.

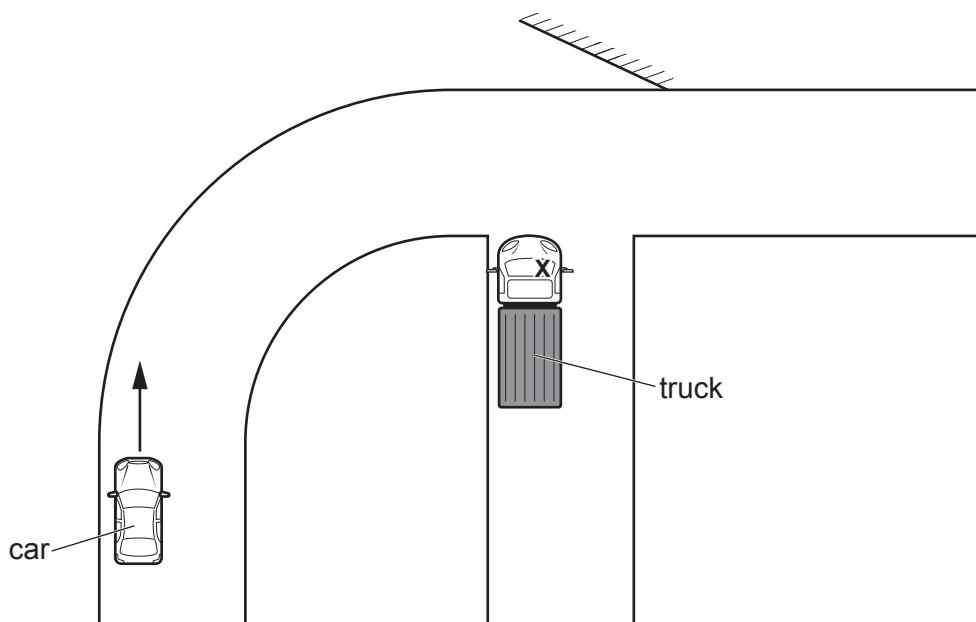


Fig. 5.2

Show how this mirror allows the driver of the truck to see the car when it is at the position shown in Fig. 5.2.

[2]

- (c) The truck driver wears spectacles to correct long-sightedness. Fig. 5.3 shows how a blurred image of an object O forms on the retina. Any effect of the cornea on the rays of light can be ignored.

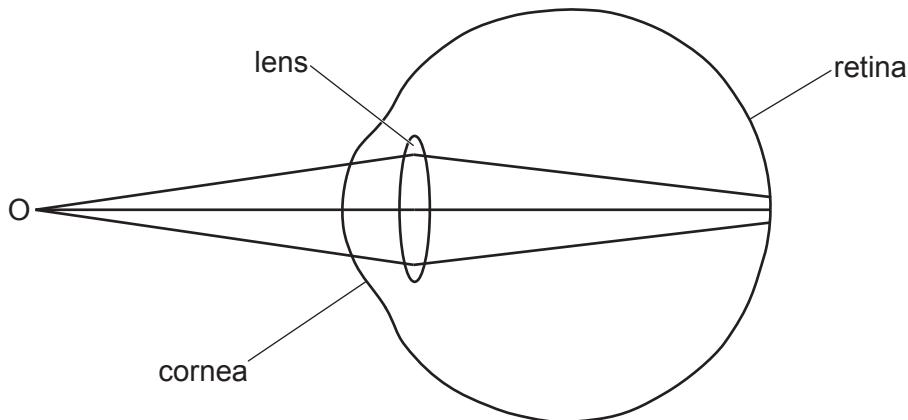


Fig. 5.3

On Fig. 5.4, show how long-sightedness is corrected by:

- adding a suitable lens in front of the eye
- continuing the path of the **three** rays of light until they meet to form an image.

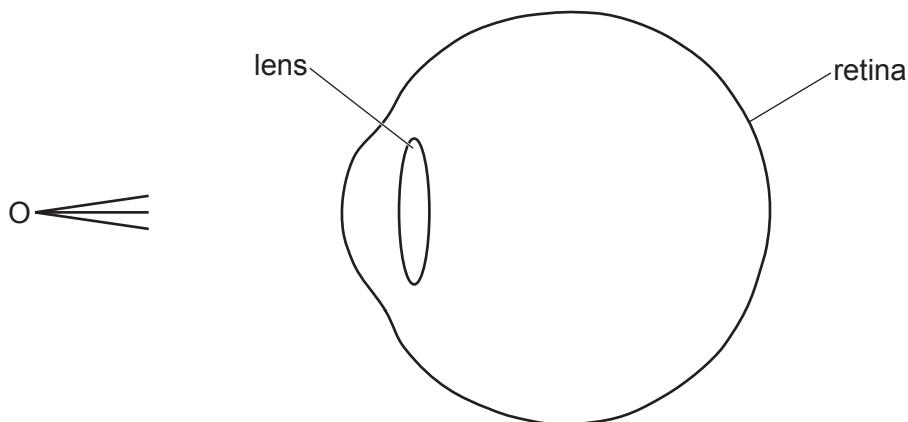


Fig. 5.4

[4]

Question	Answer	Marks
5(a)	indication of position of car along a straight line from X above and to left of road at junction.	B1
5(b)	Incident ray from car to mirror <b>AND</b> reflected ray from mirror towards X	B1
	angle of incidence equal to angle of reflection	B1
5(c)	converging lens (to left of eye)	M1
	rays refracted by additional converging lens	A1
	rays refracted by lens in eye to give converging rays	B1
	focal point of rays / image on retina	B1

- 7 (a) A student investigates refraction through a parallel-sided glass block. Fig. 7.1 shows a ray of red light travelling from the air through the glass block.

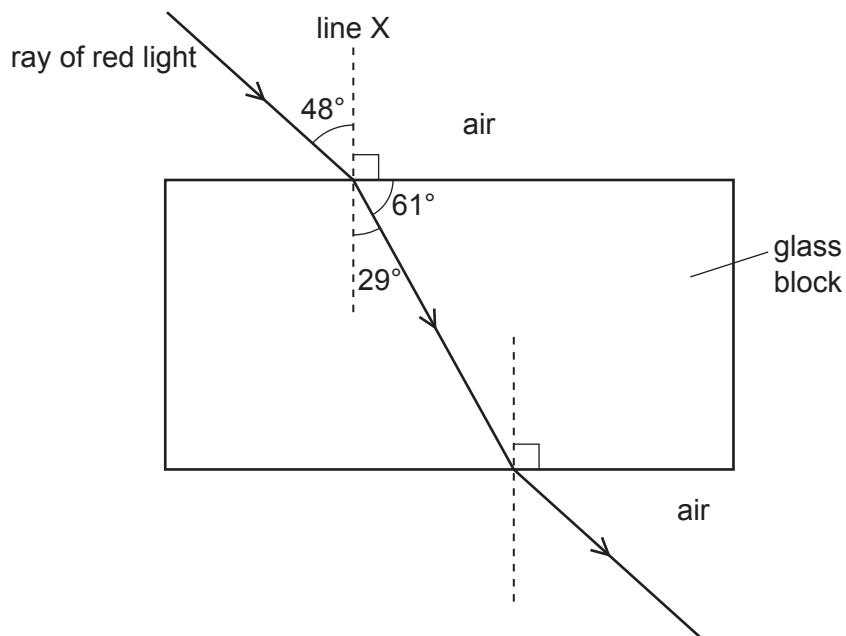


Fig. 7.1

- (i) Using the information in Fig. 7.1, state the angle of refraction for the ray of red light travelling from air into the glass block.

angle of refraction = ..... ° [1]

- (ii) Using the information in Fig. 7.1, state the term used for line X.

..... [1]

- (b) Fig. 7.2 shows an object OX to the left of a thin converging lens. The principal focus on each side of the lens is labelled F.

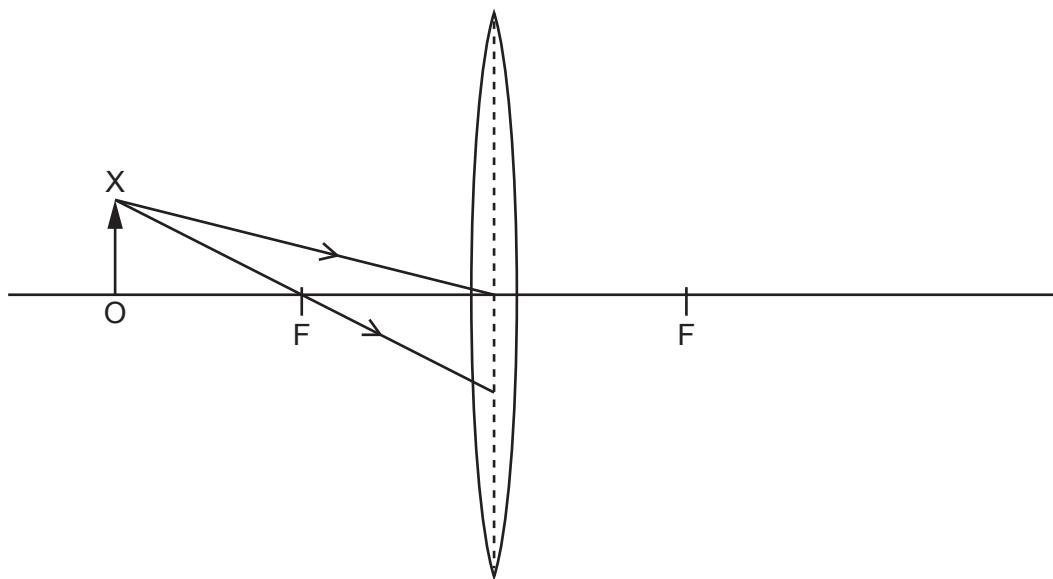


Fig. 7.2

- (i) Two rays from the top of the object are incident on the lens, as shown in Fig. 7.2.

On Fig. 7.2, continue the paths of these two rays to show the position of the image of OX formed by the lens. [2]

- (ii) Draw the image of OX formed by the lens. [1]

Question	Answer	Marks
7(a)(i)	29( $^{\circ}$ )	B1
7(a)(ii)	normal (line)	B1
7(b)(i)	ray through centre continues in straight line	B1
	(ray through F) drawn parallel to principal axis	B1
7(b)(ii)	arrow drawn from principal axis to where rays cross	B1

- 6 A diver is swimming under water. She uses a torch emitting red light. Fig. 6.1 shows three rays of red light coming from the torch.

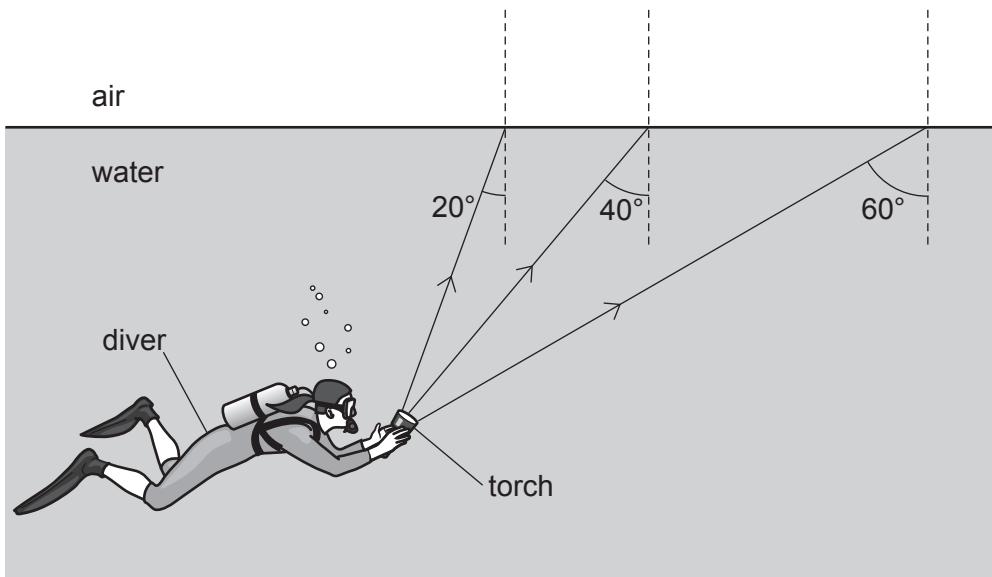


Fig. 6.1

- (a) State the name of the dashed lines in Fig. 6.1.

..... [1]

- (b) The critical angle for red light travelling from water into air is  $48^\circ$ .

- (i) State the meaning of the term critical angle.

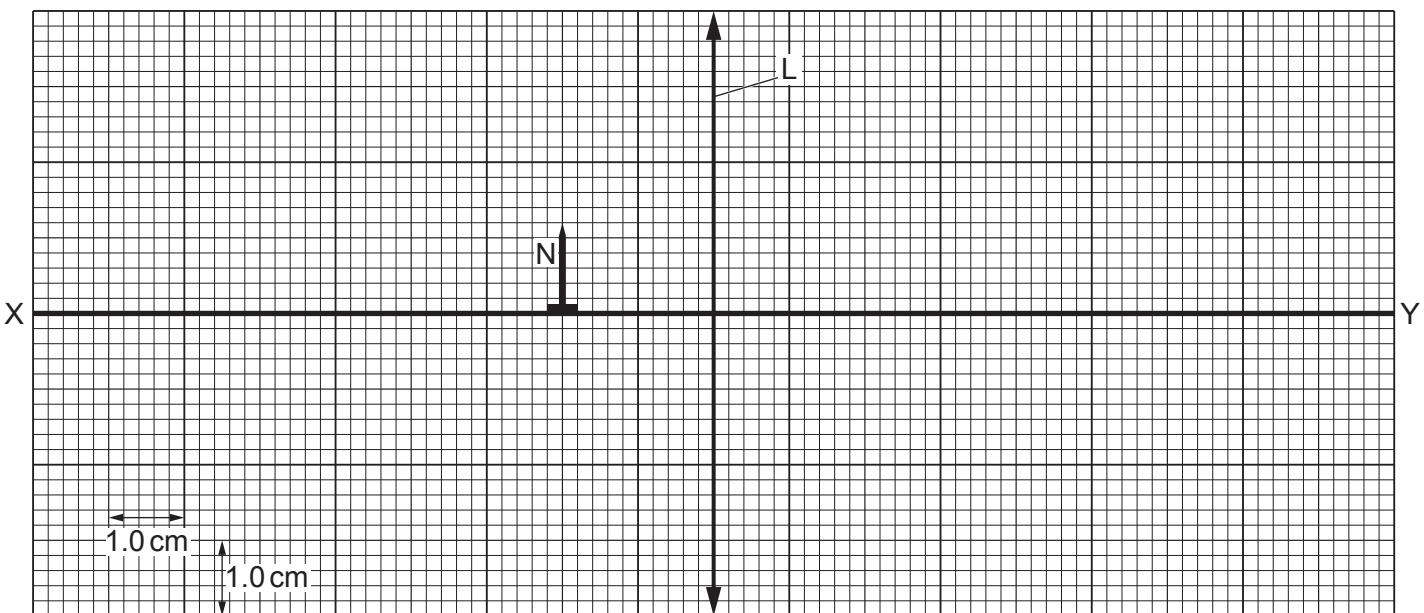
..... [2]

- (ii) On Fig. 6.1, draw the path of each ray after it reaches the water-air boundary. [3]

[Total: 6]

Question	Answer	Marks
6(a)	normal(s)	B1
6(b)(i)	angle of incidence	B1
	that gives an angle of refraction of $90^\circ$	B1
6(b)(ii)	20° – emergent ray is refracted in air	B1
	40° – emergent ray is refracted in air AND greater refraction	B1
	60° – ray is reflected internally	B1

- 7 Fig. 7.1 is a full-scale diagram of a small nail N in front of a thin converging lens. The line L represents the lens.



**Fig. 7.1 (full scale)**

The focal length of the lens is 3.0 cm.

- (a) Rays of light, parallel to XY, are travelling towards the lens.

Describe what happens to the light after it passes through the lens.

.....  
.....  
.....  
..... [3]

- (b) On Fig. 7.1, mark and label with an F each of the **two** principal focuses of the lens. [1]

- (c) The small nail N, of height 1.2 cm, is positioned 2.0 cm to the left of the lens.

- (i) By drawing on Fig. 7.1, find the position of the image I of N and add image I to the diagram. [3]

- (ii) State and explain whether I is a real or a virtual image.
- ..... [1]

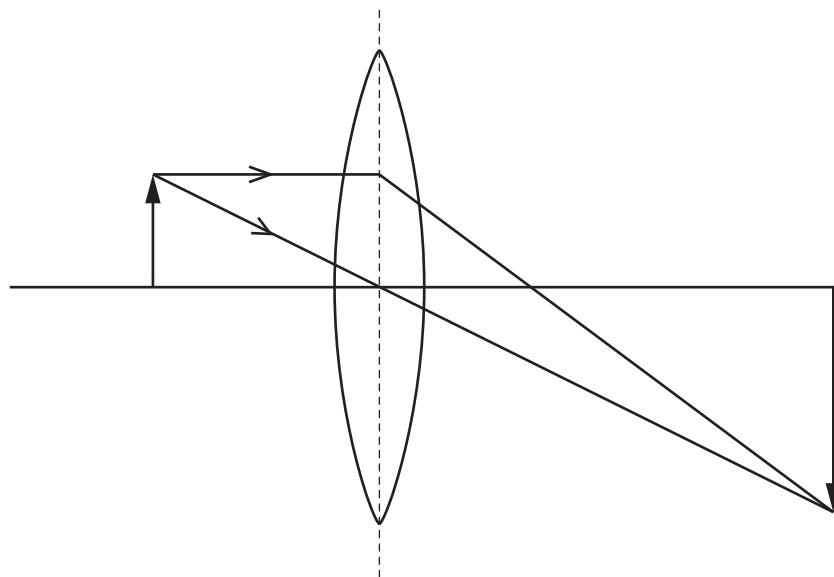
- (iii) State the name given to a lens when it is used in this way.
- ..... [1]

[Total: 9]

### IGCSE Past Papers - Chapter 13

<b>Question</b>	<b>Answer</b>	<b>Marks</b>
7(c)(i)	<b>two</b> of these rays from tip of N drawn: ray (that seems to come) from left-hand principal focus <b>and</b> emerges from lens paraxially paraxial ray to lens <b>and</b> then towards right-hand principal focus ray towards / through centre of lens	<b>M2</b>
	two rays traced back to intersection <b>and</b> line from intersection to axis <b>and</b> line labelled I	<b>A1</b>
7(c)(ii)	virtual <b>and</b> light / rays do not pass through I <b>or</b> virtual <b>and</b> light / rays only seem to come from I <b>or</b> virtual <b>and</b> produced by diverging rays virtual <b>and</b> (real) rays do not meet	<b>B1</b>
7(c)(iii)	magnifying glass	<b>B1</b>

- 6** Fig. 6.1 is a full-size ray diagram showing the formation of an image by a thin glass lens.



**Fig. 6.1 (full size)**

- (a) Determine the focal length of the lens.

focal length = ..... [1]

- (b) Circle **three** items in the list which describe the nature of the image formed.

<b>enlarged</b>	<b>same size</b>	<b>diminished</b>	<b>inverted</b>
<b>upright</b>	<b>real</b>	<b>virtual</b>	[3]

- (c) State **one** feature of a virtual image.

..... [1]

[Total: 5]

Question	Answer	Marks
6(a)	1.9–2.1 cm	B1
6(b)	(circle round) enlarged	B1
	(circle round) inverted	B1
	(circle round) real	B1
6(c)	not an intersection of rays OR cannot be formed on a screen OR cannot be projected on a screen OR light rays do not pass through image OR light rays do not meet OR light rays do not converge	B1

- 7 (a) Fig. 7.1 shows a plan view of a room. There is a plane mirror on one wall and a picture across the whole of wall AB.

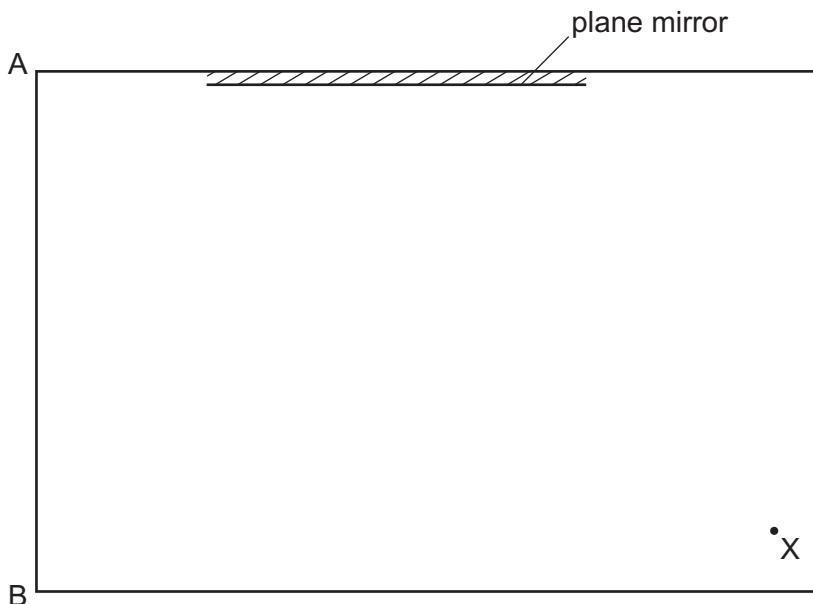


Fig. 7.1 (plan view)

A person is standing at point X and is looking at the mirror. The person cannot see all of the picture on wall AB reflected in the mirror.

There is a point P on wall AB which is the closest point to A that the person can see reflected in the mirror.

On Fig. 7.1, draw a reflected ray and an incident ray to show the position of the point P. [2]

- (b) State **two** properties of the image formed by the mirror.

1. ....

2. ....

[2]

- (c) Visible light is an electromagnetic wave.

State the name of **one** region of the electromagnetic spectrum in which the waves have:

- (i) shorter wavelengths than visible light

..... [1]

- (ii) longer wavelengths than visible light.

..... [1]

[Total: 6]

### IGCSE Past Papers - Chapter 13

Question	Answer	Marks
7(a)	ray from left hand corner of the mirror to the eye	B1
	angle of incidence = angle of reflection	B1
7(b)	any <b>two</b> from: virtual upright same size as object laterally inverted	B2
7(c)(i)	ultraviolet / X-rays / gamma rays	B1
7(c)(ii)	infrared / microwaves / radio (waves)	B1

- 6 (a) Fig. 6.1 shows a ray of light striking a plane mirror.

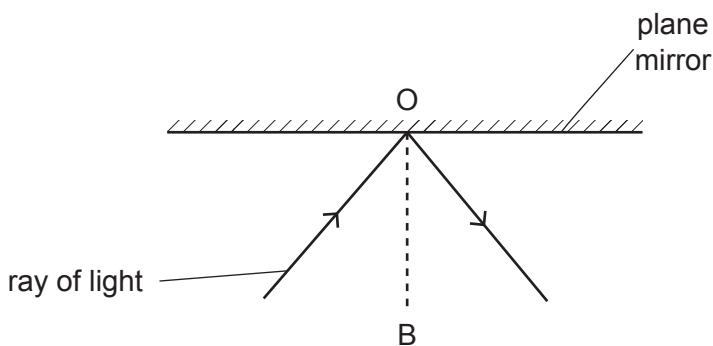


Fig. 6.1

- (i) State the name of the dashed line OB in Fig. 6.1.

..... [1]

- (ii) On Fig. 6.1, indicate the angle of reflection by drawing an X.

[1]

- (iii) State the law of reflection.

..... [1]

- (b) A candle is placed in front of a plane mirror. An image of the candle is formed in the mirror.

Circle the words from the list that describe the image of the candle.

**enlarged**      **diminished**      **same size**      **upside-down**      **upright**      [2]

- (c) Fig. 6.2 shows a ray of red light striking one side of a glass prism.

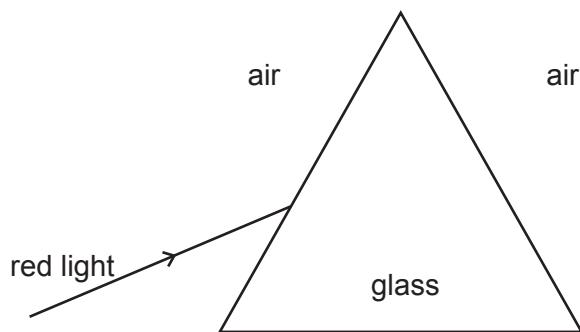


Fig. 6.2

- (i) On Fig. 6.2, draw a line to indicate the path of the red light travelling through the glass prism and emerging into the air.

[2]

- (ii) Explain why the red light follows the path you have drawn in (c)(i).

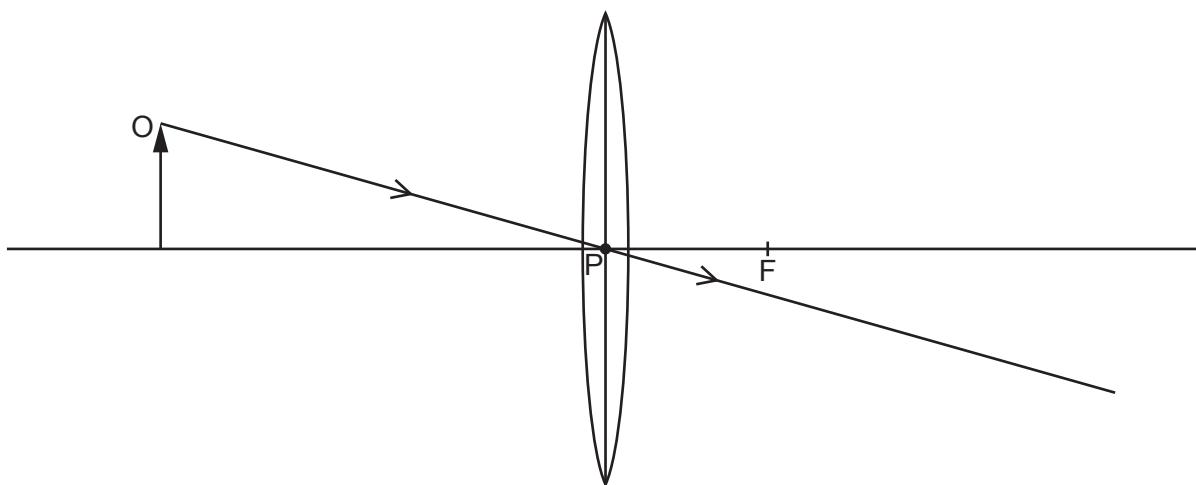
..... [1]

[Total: 8]

Question	Answer	Marks
6(a)(i)	<u>normal</u> (line)	B1
6(a)(ii)	correct angle clearly indicated	B1
6(a)(iii)	angle of incidence = angle of reflection	B1
6(b)	same size	B1
	upright	B1
6(c)(i)	single ray with correct refraction in glass	B1
	emergent ray with correct refraction	B1
6(c)(ii)	<u>refraction</u>	B1

- 6 A vertical arrow O is used as an object for a converging lens.

Fig. 6.1 shows a ray of light from the object passing through the lens.



**Fig. 6.1**

The point labelled F is a principal focus of the lens.

- (a) State the name of the distance labelled PF on Fig. 6.1.

..... [1]

- (b) On Fig. 6.1, draw another ray that enables you to locate the image of O. [2]

- (c) Draw an arrow to indicate the image. Label the image I. [1]

- (d) Circle **two** words from the list which describe the image I.

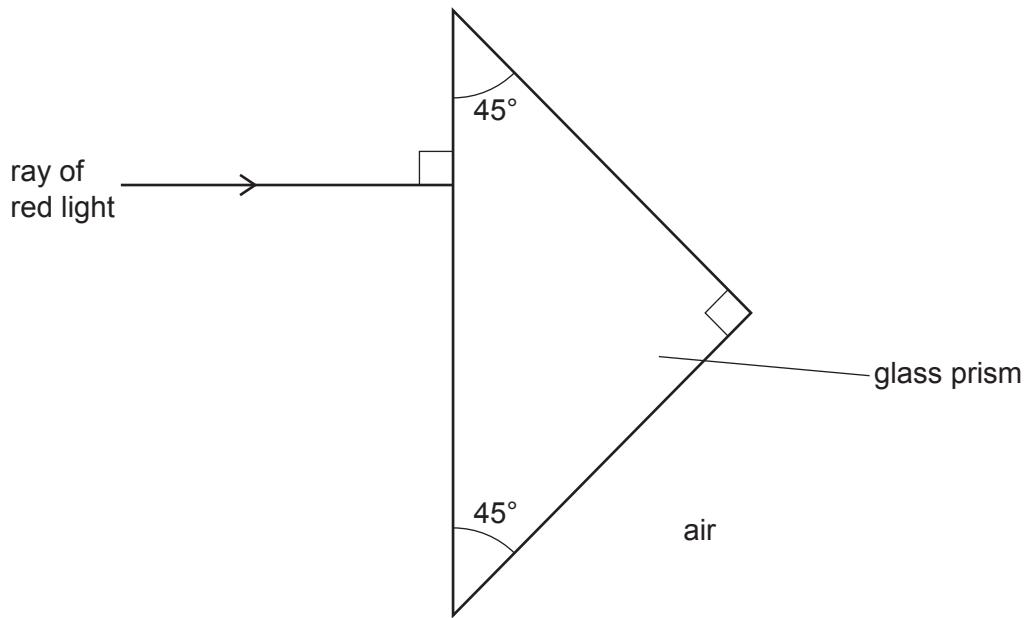
enlarged      diminished      same size      inverted      upright

[2]

[Total: 6]

Question	Answer	Marks
6(a)	<u>focal length</u>	B1
6(b)	paraxial ray to lens ray passes through F OR ray passing through principal focus on lhs paraxial ray on rhs	B1
6(c)	labelled inverted arrow from where (their) rays cross to principal axis	B1
6(d)	diminished inverted	B1

- 5 (a)** A student shines a ray of red light towards a large glass prism, as shown in Fig. 5.1. The angles of the prism are  $45^\circ$ ,  $90^\circ$  and  $45^\circ$ . The critical angle for the glass is  $42^\circ$ .



**Fig. 5.1**

On Fig. 5.1:

- (i) continue the path of the ray in the glass prism to a boundary between glass and air [1]
- (ii) draw and label the normal at the point your ray hits the boundary between glass and air [1]
- (iii) continue your ray until it emerges into the air. [2]

Question	Answer	Marks
5(a)(i)	ray continues normally into glass	B1
5(a)(ii)	one correct normal seen	B1
5(a)(iii)	ray is totally internally reflected at a glass / air boundary	B1
	ray emerging from hypotenuse	B1
5(b)(i)	orange – between red and yellow	B1
	blue – between green and indigo	B1
5(b)(ii)	wavelength	B1

- 6 The red light produced by a laser is monochromatic.

- (a) State what is meant by monochromatic.

.....  
.....  
..... [1]

- (b) The red light from the laser hits the curved surface of a semicircular transparent plastic block at point P and passes into the plastic.

The red light travels through the plastic and hits the straight edge of the block at its midpoint M. Fig. 6.1 shows that some of the light is reflected and that some light travels in the air along the straight edge of the plastic block.

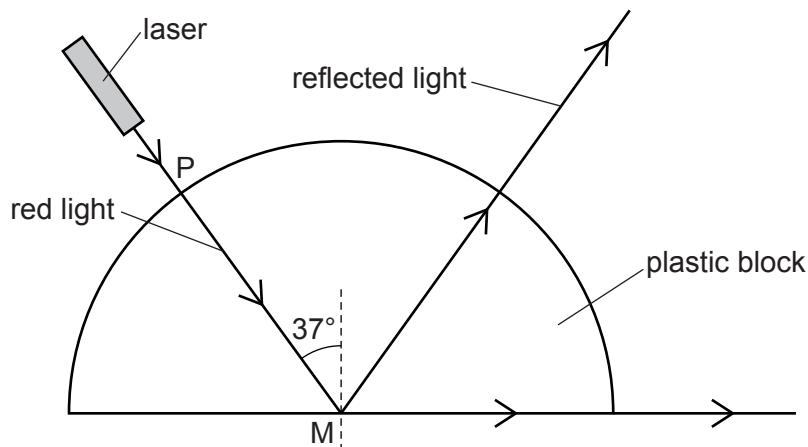


Fig. 6.1

The speed of light in air is  $3.0 \times 10^8$  m/s.

- (i) Explain why the red light does **not** change direction as it enters the plastic block.

.....  
.....  
.....  
..... [2]

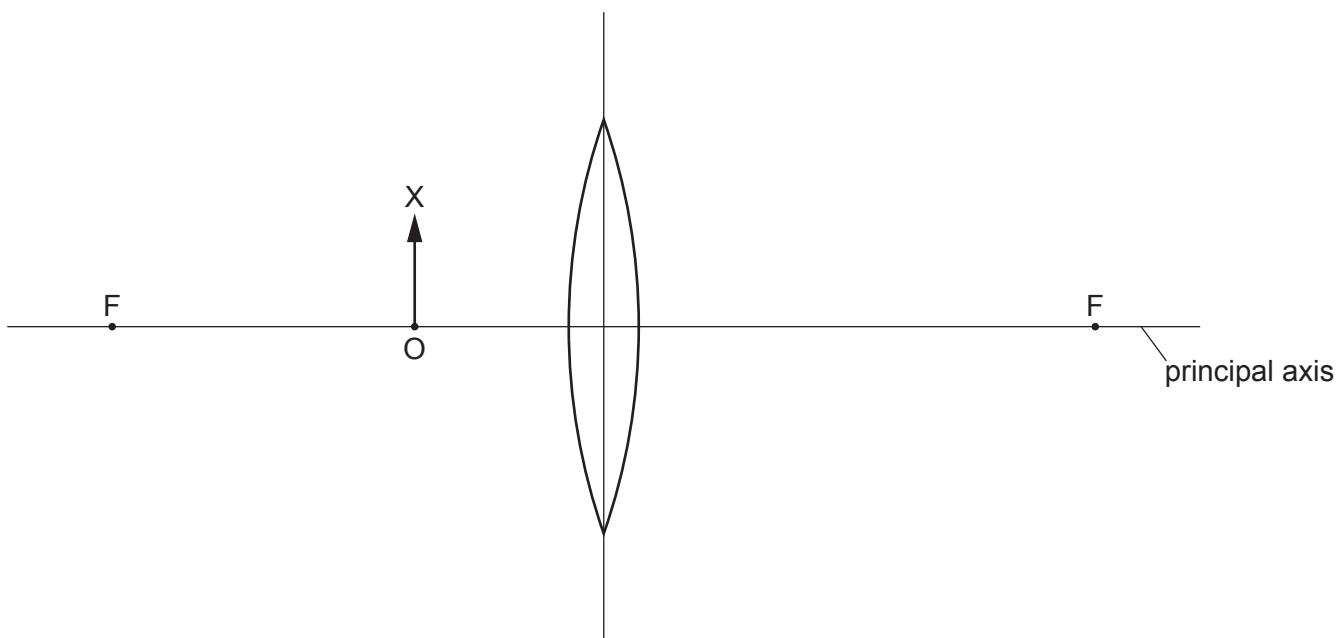
- (ii) At M, the angle between the red light in the plastic and the normal is  $37^\circ$ .

Calculate the speed of the red light in the plastic.

speed = ..... [4]

Question	Answer	Marks
6(a)	(light of a) single frequency	B1
6(b)(i)		B2
	angle of incidence is $0^\circ$ (hence) angle of refraction is $0^\circ$	B1
	<b>or</b> all the wavefront hits the plastic at the same time all slows down at the same time	B1
6(b)(ii)	$1.8 \times 10^8 \text{ m/s}$	A4
	$n = 1 / \sin c$ in any form <b>or</b> $n = 1 / \sin 37^\circ$	C1
	$(n =) 1.7$	C1
	$v_{\text{pl}} = v_0 / n$ in any form <b>or</b> $3.0 \times 10^8 / 1.7$ <b>or</b> $3.0 \times 10^8 \times \sin 37^\circ$	C1
6(b)(iii)		B3
	critical angle (for blue light) $< 37^\circ$ <b>or</b> critical angle for red (light) is $37^\circ$	B1
	angle of incidence (of blue light) greater than its critical angle (in plastic)	B1
	total internal reflection <b>or</b> all the (blue) light reflects <b>or</b> no (blue) light leaves the glass / refracts / travels in air along the straight edge	B1

- 6 (a) Fig. 6.1 shows a converging lens and an object OX. The focuses of the lens are labelled F.



**Fig. 6.1**

- (i) On Fig. 6.1, carefully draw **two** rays from X which locate the image of the object. Draw the image and label it IY.

Measure the distance from IY along the principal axis to the centre line of the lens.

distance = .....  
[4]

- (ii) State **two** reasons why the image IY is virtual.

1. ....  
2. ....  
[2]

Question	Answer	Marks
6(a)(i)	two correct rays from: • ray from X through centre of lens • ray from X to lens, parallel to principal axis, refracted through RH focus F • ray from X (that would pass through LH focus) refracted parallel to principal axis.	M2
	two rays correctly extended back, intersecting to left of object and image labelled	A1
	IY drawn <b>AND</b> $36\text{ mm} \leq \text{distance} \leq 44\text{ mm}$	A1
6(a)(ii)	any two from: • object closer to lens than (one) focal length • (actual) rays do not meet (at image) • image cannot be formed on a screen <b>OR</b> image only visible through lens • object and image on same side (of lens) <b>OR</b> image on LHS of lens/object.	B2

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- 7 (a) State what is meant by total internal reflection.

.....  
..... [2]

- (b) Fig. 7.1 shows a ray of light from a light source in a tank containing a liquid.

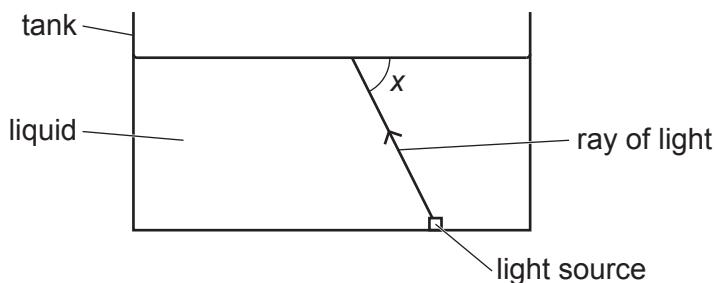


Fig. 7.1

The ray of light strikes the surface of the liquid at an angle  $x$ .

- (i) The refractive index of the liquid is 1.5.

Calculate the largest value of  $x$  for which total internal reflection can occur.

$x = \dots$  [3]

- (ii) The speed of light in air is  $3.0 \times 10^8 \text{ m/s}$ .

Calculate the speed of light in the liquid.

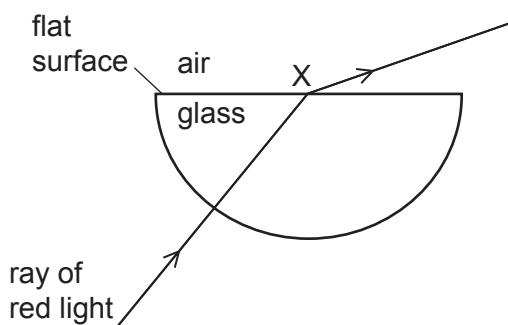
speed = ..... [2]

[Total: 7]

<b>Question</b>	<b>Answer</b>	<b>Marks</b>
7(a)	any <b>two</b> from: • <u>all</u> light is reflected • <u>no</u> light is refracted • (occurs) when light travels in a more dense medium towards a (boundary with a) less dense medium	<b>B2</b>
7(b)(i)	( $x = 48^\circ$ )	<b>A3</b>
	$n = 1 / \sin c$ <b>OR</b> $c = \sin^{-1} (1/n)$ <b>OR</b> $\sin c = 1/1.5$ <b>OR</b> $c = \sin^{-1} (1/1.5)$	C1
	$c = 42^\circ$	C1
7(b)(ii)	(speed =) $2.0 \times 10^8$ m/s	<b>A2</b>
	$n = \frac{\text{speed of light in vacuum}}{\text{speed of light in liquid}}$ <b>OR</b> $n = \frac{(\text{approx.}) \text{ speed of light in air}}{\text{speed of light in liquid}}$	C1
	<b>OR</b> $n = c/v$ <b>OR</b> ( $v = c/n$ )	
	<b>OR</b> $1.5 = \frac{3 \times 10^8}{\text{speed of light in liquid}}$	

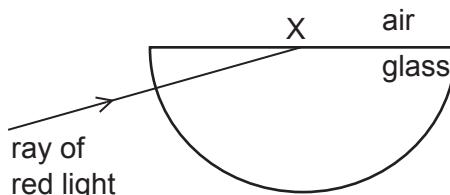
**8** A student uses a semicircular glass block to investigate refraction.

- (a) He shines a ray of red light into the block, as shown in Fig. 8.1.  
X is the middle of the flat surface.



**Fig. 8.1**

- (i) On Fig. 8.1, draw the normal where the ray meets the flat surface at X. [1]
- (ii) On Fig. 8.1, label the angle of refraction. Use the letter R for the label. [1]
- (iii) The student uses a semicircular glass block. State the name of **one** other piece of equipment that he needs for the investigation.
- ..... [1]
- (b) Fig. 8.2 shows a ray of red light incident on the flat surface of the semicircular glass block. The angle of incidence is greater than the critical angle for glass.



**Fig. 8.2**

On Fig. 8.2, draw the path of the ray after it strikes the flat surface.

[2]

[Total: 5]

Question	Answer	Marks
8(a)(i)	normal drawn at X correct by eye	B1
8(a)(ii)	angle of refraction correctly labelled	B1

Question	Answer	Marks
8(a)(iii)	any <b>one</b> from: • pin(s) OR ray box or tte OR (low voltage) power supply OR • protractor OR ruler	B1
8(b)	ray reflected from flat surface ray reflected with angle $i = r$	M1 A1

- 8 (a) Fig. 8.1 shows a ray of light incident on a plane mirror.

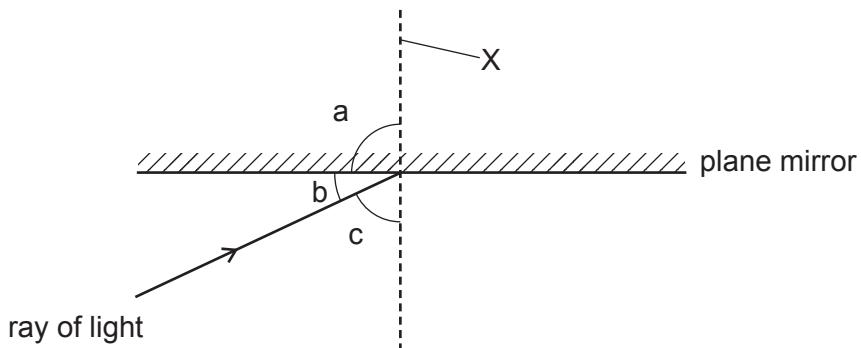


Fig. 8.1

- (i) State which angle, a, b or c, is the angle of incidence.

angle of incidence = ..... [1]

- (ii) State the name of the line labelled X.

..... [1]

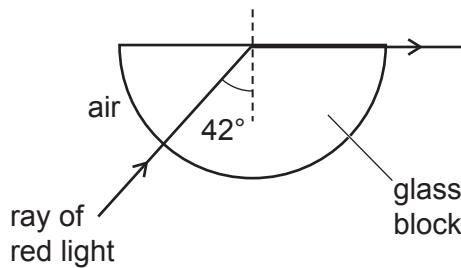
- (iii) The mirror reflects the ray of light.

On Fig. 8.1, draw the reflected ray. [2]

Question	Answer	Marks
8(a)(i)	c	B1
8(a)(ii)	normal	B1
8(a)(iii)	reflected ray a continuation of incident ray AND in correct quadrant	M1
	angle of reflection equals angle of incidence	A1

Question	Answer	Marks
8(b)(i)	continuation of incident ray AND reflected internally in correct quadrant	M1
	angle of reflection equals angle of incidence	A1
8(b)(ii)	continuation of incident ray AND emerging from block in correct quadrant	M1
	angle of refraction larger than angle of incidence	A1

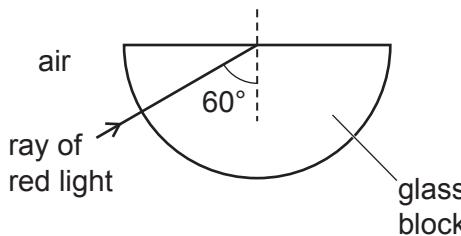
- (b) Fig. 8.2 shows a ray of red light travelling through a semicircular glass block.



**Fig. 8.2**

- (i) Fig. 8.3 shows another ray of red light entering the semicircular glass block at  $60^\circ$ .

Continue the path of this ray through the glass block and into the air.

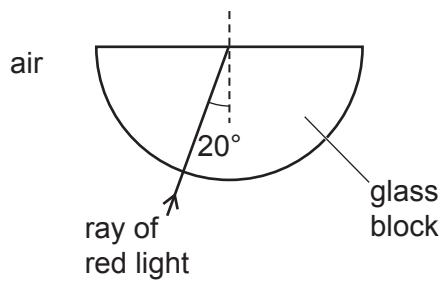


**Fig. 8.3**

[2]

- (ii) Fig. 8.4 shows another ray of red light entering the semicircular glass block at  $20^\circ$ .

Continue the path of this ray through the glass block and into the air.



**Fig. 8.4**

[2]

[Total: 8]

- 6 Fig. 6.1 is a full-scale diagram of a lens and an object O.

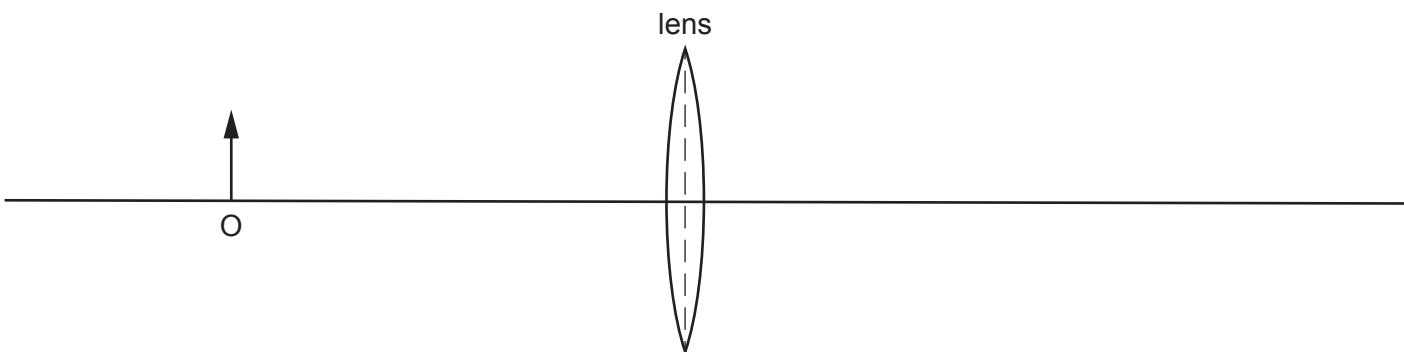


Fig. 6.1

- (a) The focal length of the lens is 3.5 cm.

On Fig. 6.1, mark and label with the letter F the positions of the **two** principal focuses. [1]

- (b) On Fig. 6.1, draw **three** rays to locate the image. Draw an arrow to represent the image and label the image I. [3]

- (c) State **three** properties of the image I.

..... [2]

- (d) A student incorrectly states that this lens is being used as a magnifying glass.

- (i) State how the image produced by a magnifying glass is different from the image I.

..... [1]

- (ii) The student moves the object O to a position P so that the lens shown in Fig. 6.1 acts as a magnifying glass.

On Fig. 6.1, mark a possible position for P. [1]

[Total: 8]

Question	Answer	Marks
6(a)	principal focuses marked in correct position	B1
6(b)	1 mark for each of: • 1 correct ray • 2nd correct ray • 3rd correct ray and image, labelled I, in correct position with arrow at bottom	B3
6(c)	real	B1
	inverted <u>and</u> enlarged	B1
6(d)(i)	(image produced by a magnifying glass is) upright OR NOT inverted OR virtual	B1
6(d)(ii)	position marked between principal focus and lens	B1

- 7 Fig. 7.1 shows a ray of red light entering a semicircular glass block. The ray strikes the flat surface of the block at X and emerges into the air. Fig. 7.1 does not show the path of the refracted ray in the air.

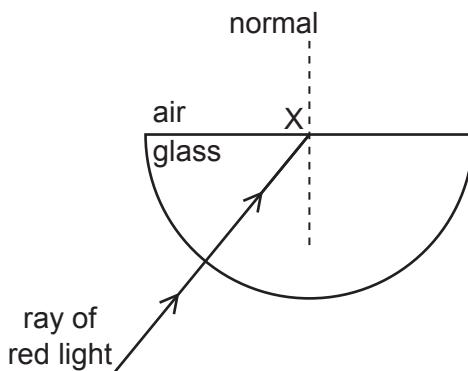


Fig. 7.1

(a) On Fig. 7.1:

- (i) draw the path of the refracted ray in the air [1]
- (ii) mark, and label with the letter  $i$ , the angle of incidence [1]
- (iii) mark, and label with the letter  $r$ , the angle of refraction. [1]

(b) When the angle of incidence at X is  $70^\circ$ , the ray does **not** emerge from the glass into the air.

State what happens to the ray at X and explain why this happens.

.....  
.....  
.....

[2]

Question	Answer	Marks
7(a)(i)	ray drawn refracted away from normal	B1
7(a)(ii)	angle of incidence correctly identified	B1
7(a)(iii)	angle of refraction correctly identified	B1
7(b)	total internal reflection (at flat surface)	B1
	angle (of incidence) is greater than the critical angle	B1
7(c)(i)	(The speed of visible light is) same (as) (the speed of X-rays.)	B1
	(The frequency of visible light is) lower OR smaller (than the frequency of X-rays)	B1
7(c)(ii)	example of medical / security imaging or treatment of cancer	B1

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- 9 (a) Fig. 9.1 shows a ray of light reflected by a plane mirror.

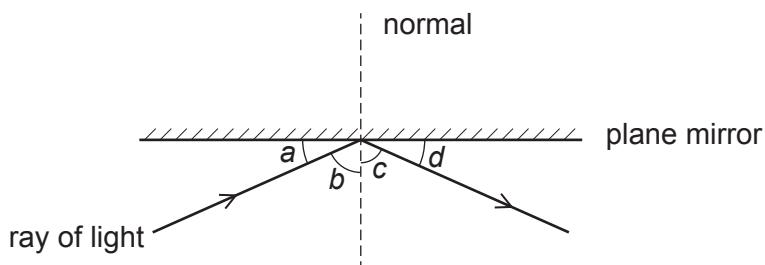


Fig. 9.1

- (i) State which angle,  $a$ ,  $b$ ,  $c$  or  $d$ , is the angle of incidence. ..... [1]
- (ii) State which angle,  $a$ ,  $b$ ,  $c$  or  $d$ , is the angle of reflection. ..... [1]
- (b) Fig. 9.2 shows a road junction viewed from above. A plane mirror allows the drivers of the two cars A and B to see each other.

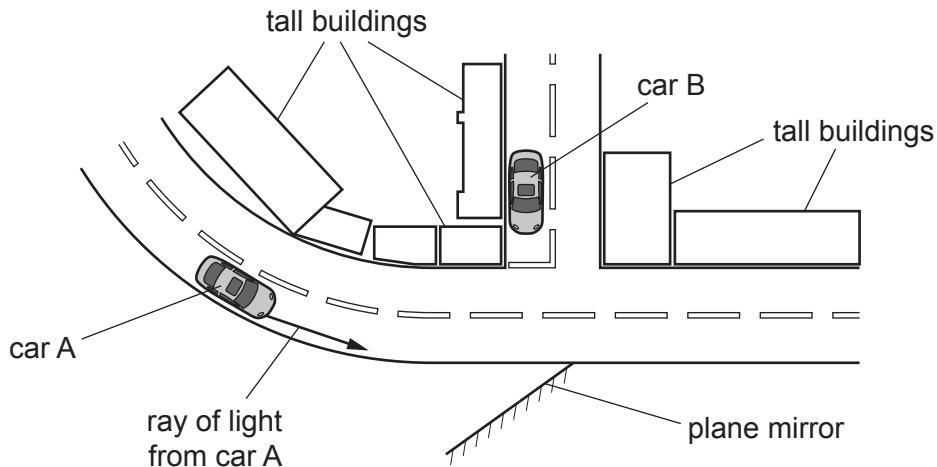


Fig. 9.2

Fig. 9.2 shows a ray of light from car A travelling towards the plane mirror.

On Fig. 9.2, carefully continue this ray to show how the driver of car B can see car A.

[2]

[Total: 4]

Question	Answer	Marks
9(a)(i)	b	B1
9(a)(ii)	c	B1
9(b)	ray from lamp extended to mirror as straight line (by eye)	M1
	ray reflected to car B	A1

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- 8 (a) The diagram in Fig. 8.1 shows a ray of light travelling from a glass block into air.

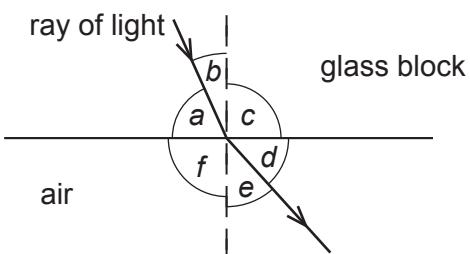


Fig. 8.1

- (i) State the name for the dashed line shown in Fig. 8.1.

..... [1]

- (ii) State the letter,  $a$ ,  $b$ ,  $c$ ,  $d$ ,  $e$  or  $f$ , which indicates the angle of incidence of the ray in Fig. 8.1.

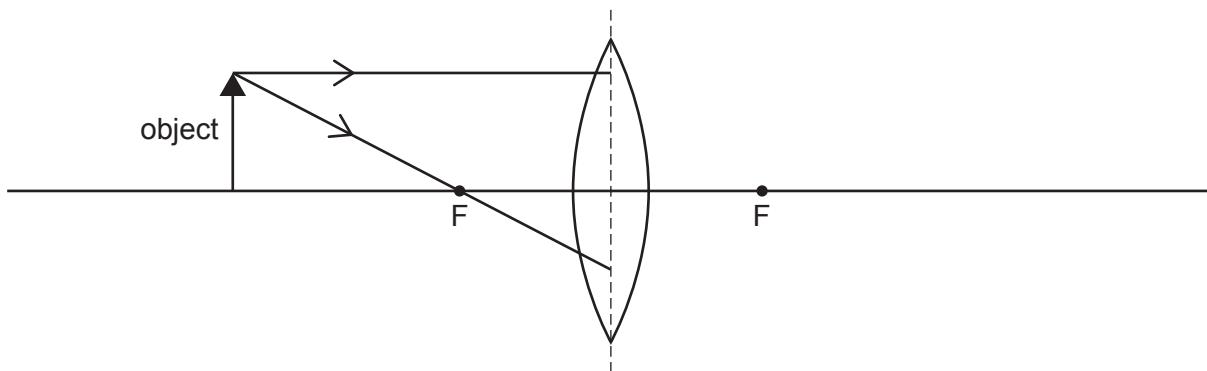
..... [1]

- (iii) State the letter,  $a$ ,  $b$ ,  $c$ ,  $d$ ,  $e$  or  $f$ , which indicates the angle of refraction of the ray in Fig. 8.1.

..... [1]

- (b) The diagram in Fig. 8.2 shows an object and a thin converging lens.

Two rays are drawn from the object to the lens. The points marked F are the principal focuses of the lens.



**Fig. 8.2**

- Continue the paths of the **two** rays in Fig. 8.2 to show how the lens forms an image of the object. [2]
- On Fig. 8.2, draw an arrow to represent the image. [1]
- Tick ( $\checkmark$ ) **two** rows to indicate the nature of the image formed by the lens in Fig. 8.2.

nature of image	tick
enlarged	
the same size	
diminished	
upright	
inverted	

[2]

[Total: 8]

Question	Answer	Marks
8(a)(i)	normal	B1
8(a)(ii)	b	B1
8(a)(iii)	e	B1
8(b)(i)	top ray continued through F on right hand side of lens	B1
	lower ray continued parallel to principal axis (by eye)	B1
8(b)(ii)	arrow drawn from where their rays cross to principal axis	B1
8(b)(iii)	diminished	B1
	inverted	B1

- 5 (a) Explain, in terms of the behaviour of light rays, what is meant by *principal focus* for a thin converging lens.
- .....  
.....  
.....

[2]

- (b) State what is meant by *focal length*.
- .....  
.....  
.....

[1]

- (c) A lens is used to produce a focused image of an object on a translucent screen. Fig. 5.1 shows the object O and its image I.

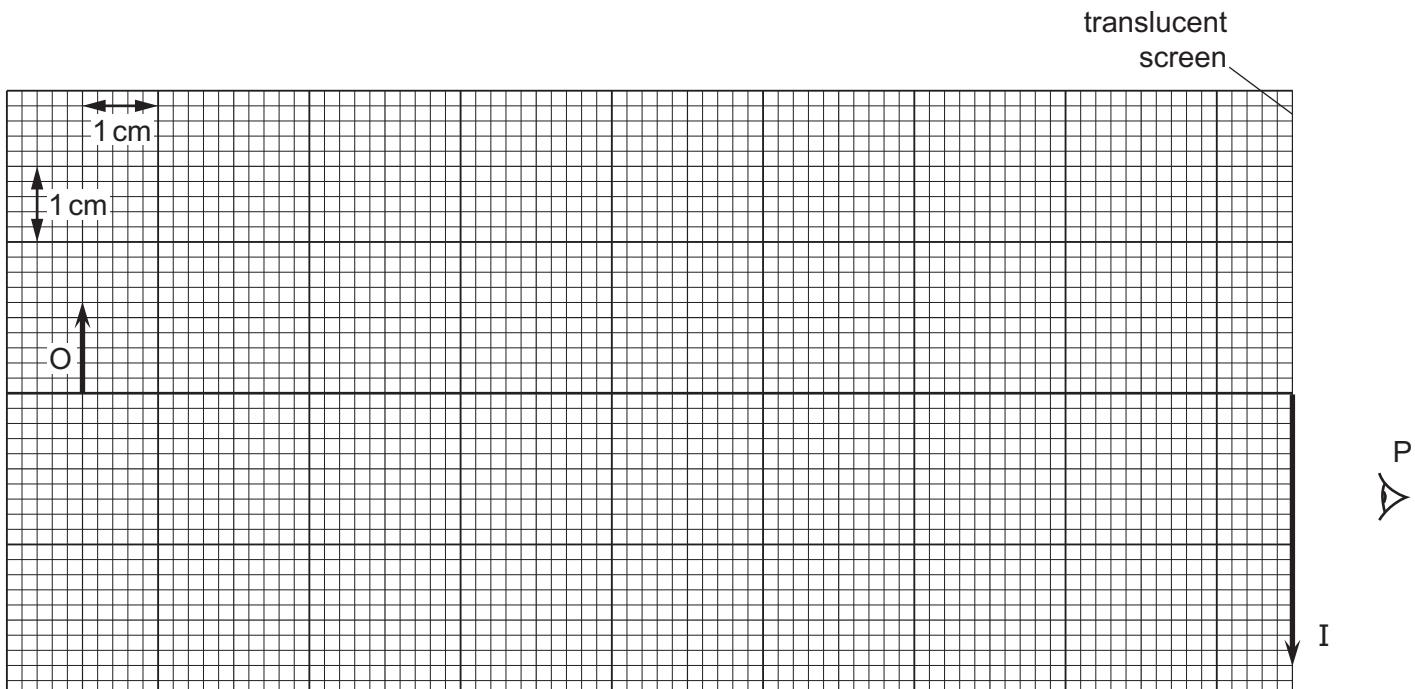
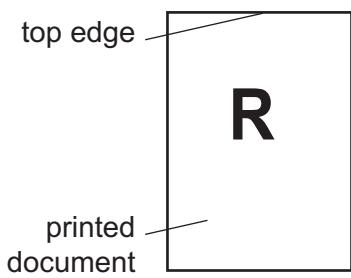


Fig. 5.1

- (i) Consider the straight ray that passes from the tip of O to the tip of I and find the position of the lens. Mark the position of the lens by drawing a vertical line labelled L from the top of the grid to the bottom. [1]
- (ii) On Fig. 5.1, draw a ray that passes through one of the principal focuses and determine the focal length of the lens.

focal length = ..... [2]

- (iii) Object O is a printed document that includes a large letter R on the side facing the lens. The top edge of the document corresponds to the tip of O. Fig. 5.2 shows the printed document.



**Fig. 5.2**



**Fig. 5.3**

On Fig. 5.3, mark a tick in **one** of the boxes () to indicate how the image on the translucent screen appears to someone who is looking at the screen from point P. Explain why the image has this appearance.

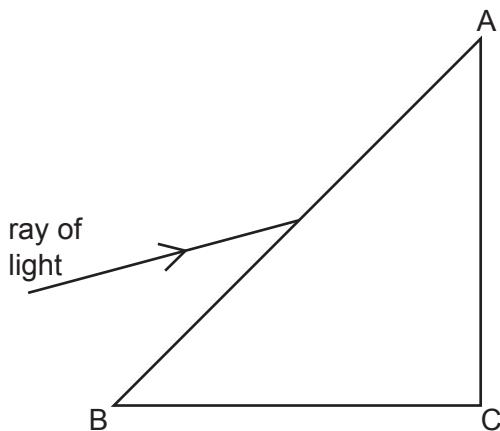
.....  
.....  
.....

[2]

[Total: 8]

Question	Answer	Marks
5(a)	(point) where (parallel) rays (of light) meet (after passing through lens)  (point) where parallel rays (of light) meet / are focussed (after passing through lens) <b>or</b> (point) through which rays (of light) that emerge parallel pass (before reaching lens)	<b>C1</b> <b>A1</b>
5(b)	distance between principal focus / focal point and optical centre / lens	<b>B1</b>
5(c)(i)	vertical line labelled L 4.0 ( $\pm 0.2$ ) cm to the right of O	<b>B1</b>
5(c)(ii)	paraxial ray from tip of O to candidate's lens <b>and</b> from lens to tip of I <b>or</b> paraxial ray from lens to tip of I <b>and</b> from tip of O to candidate's lens  3.0 ( $\pm 0.2$ ) cm	<b>C1</b> <b>A1</b>
5(c)(iii)	fourth box ticked i.e:    reversed / inverted	<b>B1</b> <b>B1</b>

- 7 Fig. 7.1 shows a ray of light approaching face AB of a glass prism of refractive index 1.5.

**Fig. 7.1**

- (a) (i) On Fig. 7.1, accurately draw the path of the ray within the prism from face AB to face AC. You will need to make a measurement from Fig. 7.1 and carry out a calculation.

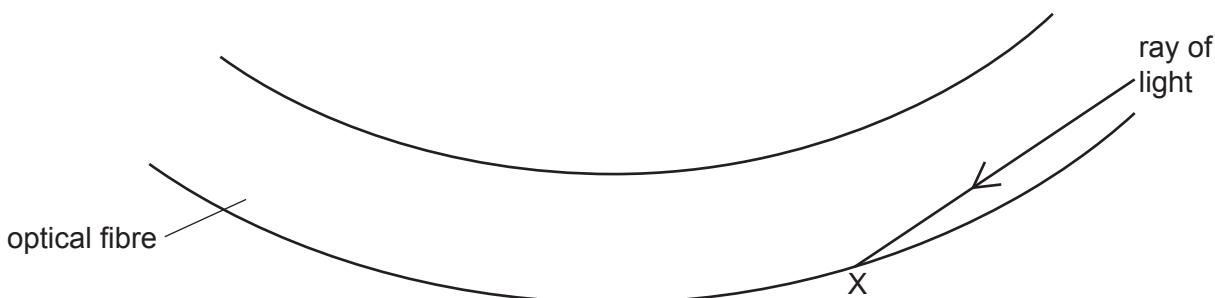
[4]

- (ii) Determine the angle of incidence of this ray when it strikes face AC.

$$\text{angle} = \dots \quad [1]$$

- (b) Without further measurement or calculation, sketch on Fig. 7.1 the approximate path of the ray after passing through the face AC. [1]

- (c) Fig. 7.2 shows a ray of light travelling within an optical fibre.

**Fig. 7.2**

- (i) Complete the path of the ray of light to the left-hand end of the fibre. [2]
- (ii) Name the process taking place at X. .... [1]

[Total: 9]

**IGCSE Past Papers - Chapter 13**

<b>Question</b>	<b>Answer</b>	<b>Marks</b>
7(a)(i)	$i = 60^\circ$ used or seen	<b>C1</b>
	$\sin i / \sin r = n$ in any form	<b>C1</b>
	ray refracted toward normal and toward AC	<b>C1</b>
	ray clearly refracted down in prism reaching AC with $r = 35^\circ$ )	<b>A1</b>
7(a)(ii)	$10^\circ$	<b>B1</b>
7(b)	refracted away from normal	<b>B1</b>
7(c)(i)	(total internal) reflection at X NOT refraction at X or anywhere else	<b>B1</b>
	reaches end of fibre with <u>only one</u> additional reflection (off lower internal edge of fibre)	<b>B1</b>
7(c)(ii)	total internal reflection	<b>B1</b>