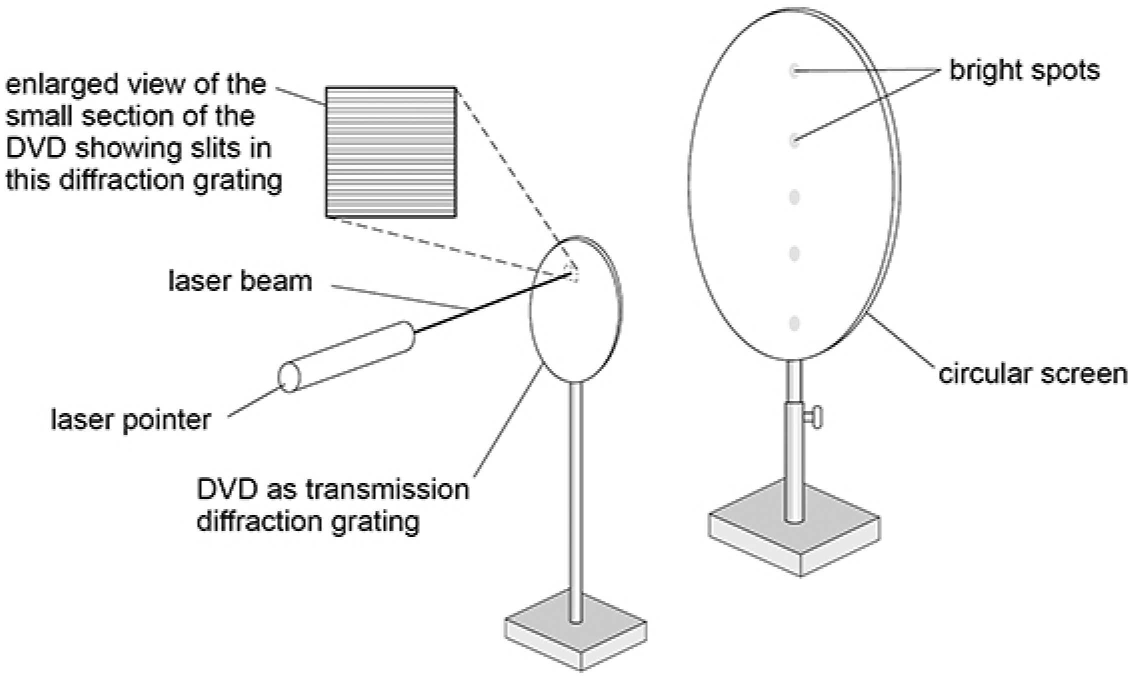
1. A student removes the reflective layer from a DVD. She uses the DVD as a transmission diffraction grating.

Figure 1 shows light from a laser pointer incident normally on a small section of this diffraction grating. The grooves on this section act as adjacent slits of the transmission diffraction grating. A vertical pattern of bright spots (maxima) is observed on a circular screen behind the disc.

Figure 1



(a) Light of wavelength λ travels from each illuminated slit, producing maxima on the screen.

State the path difference between light from adjacent slits when this light produces a first-order maximum on the screen.

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(1)

(b) Explain how light from the diffraction grating forms a maximum on the screen.

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(3)

The student has three discs: a Blu-ray disc, a DVD and a CD. She removes the reflective coating from the discs so that they act as transmission diffraction gratings. These diffraction gratings have different slit spacings.

The student also has two laser pointers **A** and **B** that emit different colours of visible light.

Table 1 and **Table 2** show information about the discs and the laser pointers.

Table 1

Disc	**Slit spacing / μm**
Blu-ray disc	0.32
DVD	0.74
CD	1.60

Table 2

Laser pointer	**Wavelength of light emitted / 10^{-7} m**
A	4.45
B	6.36

(c) Deduce the combination of disc and laser pointer that will produce the **greatest** possible number of interference maxima.

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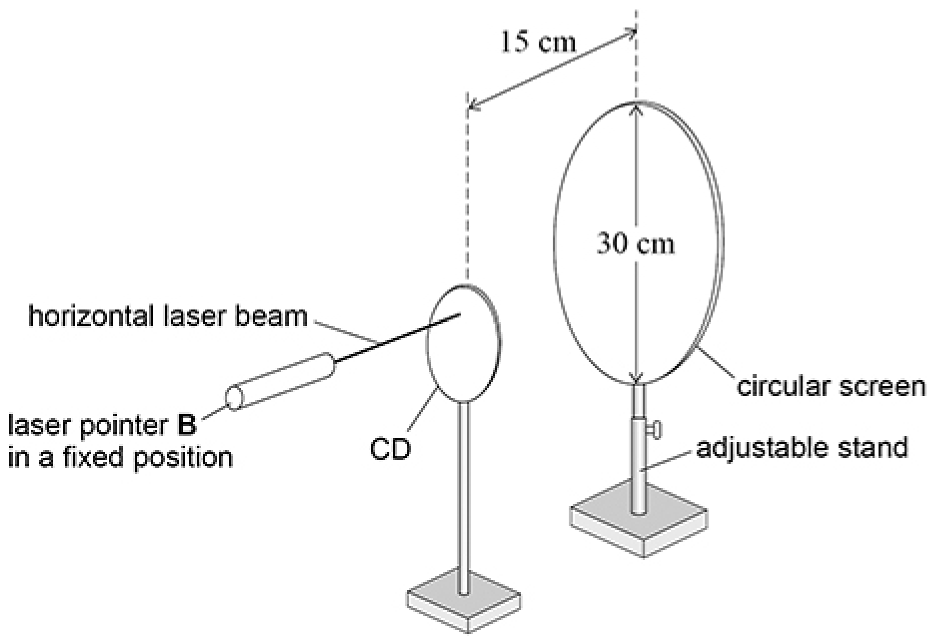
(2)

(d) The student uses the CD and laser pointer **B** as shown in **Figure 2**. A diffraction pattern is produced on the screen. Laser pointer **B** and the CD are in fixed positions. The laser beam is horizontal and incident normally on the CD. The height of the screen can be adjusted.

Figure 2



The screen has a diameter of 30 cm and is positioned behind the CD at a fixed horizontal distance of 15 cm.
The student plans to adjust the height of the screen until she observes the greatest number of spots.

The student predicts that, using this arrangement, the greatest number of spots on the screen will be 3.

Determine whether the student's prediction is correct.

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(3)
(Total 9 marks)

2. Optical fibres are used to carry pulses of light.

(a) Explain what is meant by modal dispersion in an optical fibre.

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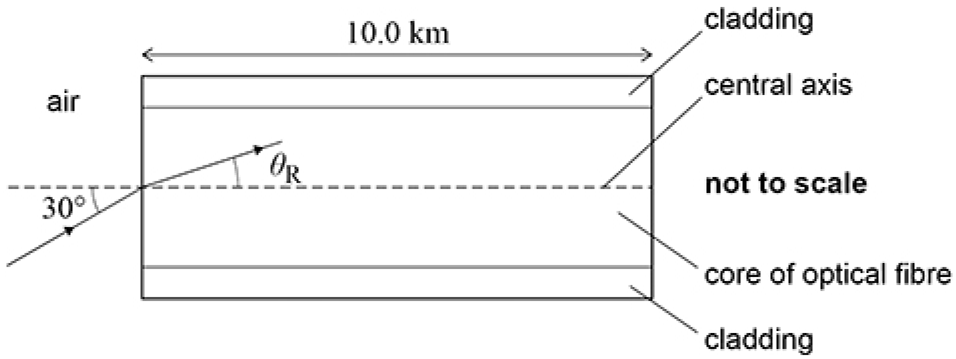
(2)

Figure 1 shows a ray of light incident on the central axis of an optical fibre at an angle of incidence of 30°. The optical fibre is straight and horizontal and has a length of 10.0 km.

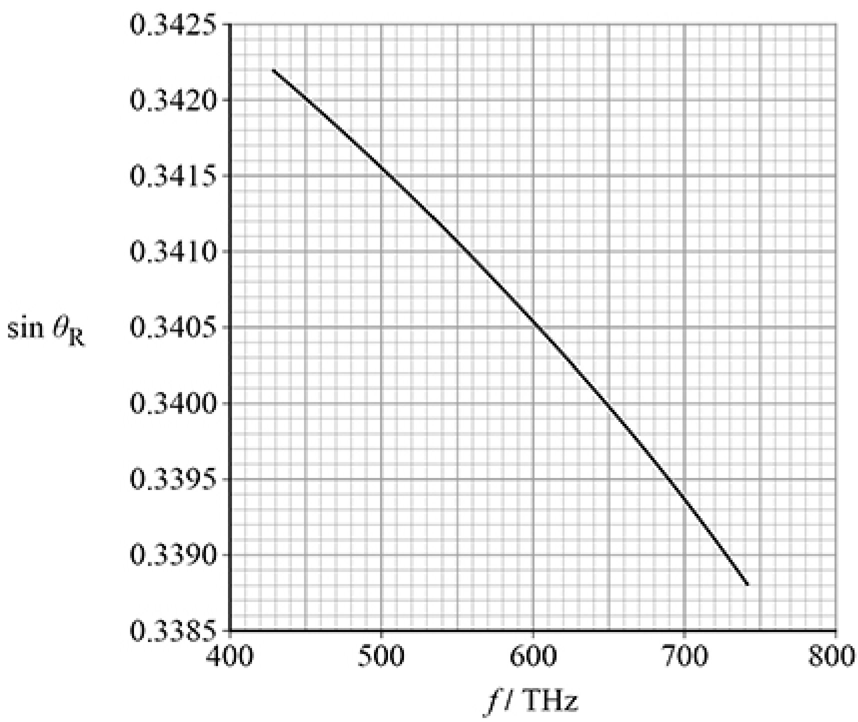
Figure 1



For light incident on the core at a given angle of incidence, the angle of refraction θ_R varies with the frequency f of the light.

Figure 2 shows how sin θ_R varies with f when the angle of incidence is 30°.

Figure 2



The transit time is the time between a pulse of light entering and leaving the optical fibre.
A single pulse of blue light is incident on the air−core boundary at an angle of incidence of 30°.

The transit time of this pulse along the 10 km length of the optical fibre is 5.225×10^{-5} s.

(b) Show that the horizontal component of the velocity of the pulse is approximately 1.9×10^8 m s^{-1}.

(1)

(c) The frequency of the blue light in the pulse is 720 THz.

Calculate the speed of the blue light in the core of the optical fibre.

speed = ________________ m s^{-1}

(3)

(d) Two pulses of monochromatic light are incident normally on the air−core boundary. They then travel along the central axis of the core.
One pulse consists of blue light; the other consists of red light.

Explain, with reference to refractive index, why the pulse of red light has a shorter transit time than the pulse of blue light.

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(2)

(e) Another two pulses, identical to the pulses in part (d), are incident on the central axis of the optical fibre and travel along its length.
However, the pulse of red light and pulse of blue light are now incident on the air−core boundary at an angle of incidence of 30°.

Suggest **one** reason why the difference in their transit times may **not** be the same as in part (d).

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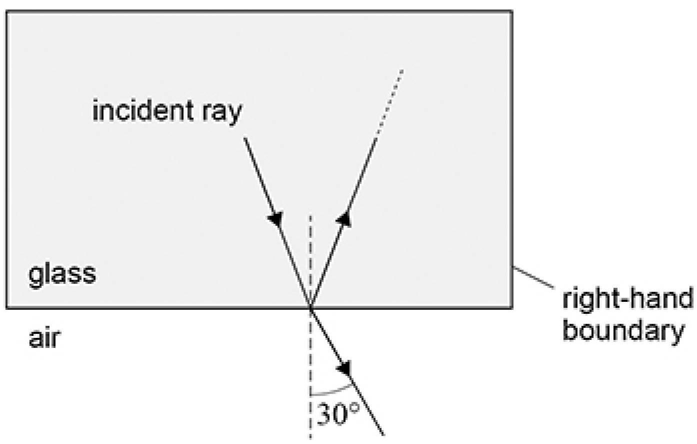
(1)
(Total 9 marks)

3. A ray of light is incident on the internal boundary of a rectangular glass block in air.

Part of the light refracts out of the block at an angle of 30°.

Some of the remaining light reflects within the block to become incident on the right-hand boundary. refractive index of glass = 1.48

not to scale



What is the angle of incidence of the ray at the right-hand boundary?

A 20° ⬭

B 42° ⬭

C 48° ⬭

D 70° ⬭

(Total 1 mark)

4. In a Young's double-slit experiment, monochromatic light is incident on two narrow slits and the resulting interference pattern is observed on a screen.

Which change **decreases** the fringe separation?

A decreasing the separation between the two slits

B increasing the distance between the slits and the screen

C using monochromatic light of higher frequency

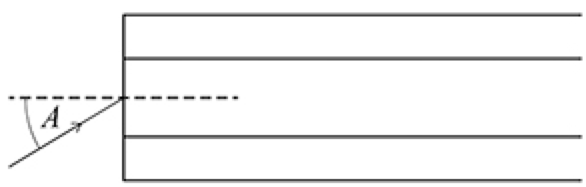
D using monochromatic light of longer wavelength

(Total 1 mark)

5. **Figure 1** shows a ray of monochromatic light incident at angle A from air onto the end of a straight optical fibre.

This ray undergoes total internal reflection at the core−cladding boundary. A ray that enters the optical fibre at an angle greater than A will only be partially reflected at the core−cladding boundary.

Figure 1



The table below shows some properties of the optical fibre.

	Refractive index
cladding	1.41
core	1.47

(a) Calculate the speed of the light ray in the optical fibre.

speed = _______________ m s^{-1}

(1)

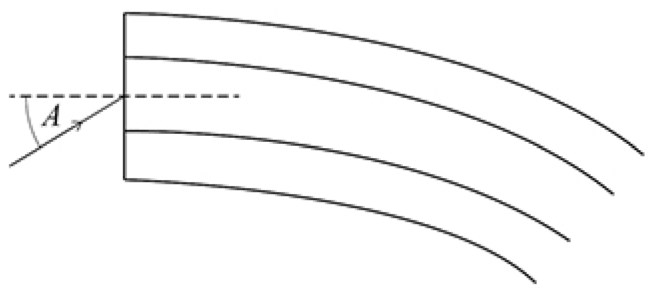
(b) Calculate A, in degrees, for the optical fibre shown in **Figure 1**.

A = ________________ degrees

(3)

(c) A ray is incident on the optical fibre at angle A. The optical fibre is now bent, as shown in **Figure 2**.

Figure 2



Draw, on **Figure 2**, what happens to the ray within the optical fibre. Explain your answer.

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(3)

(Total 7 marks)

6. A diffraction grating is illuminated normally.

The second-order maximum for light of wavelength 650 nm occurs at the same angle as the third-order maximum for light of wavelength λ.

What is λ?

A 217 nm ⬭

B 325 nm ⬭

C 433 nm ⬭

D 975 nm ⬭

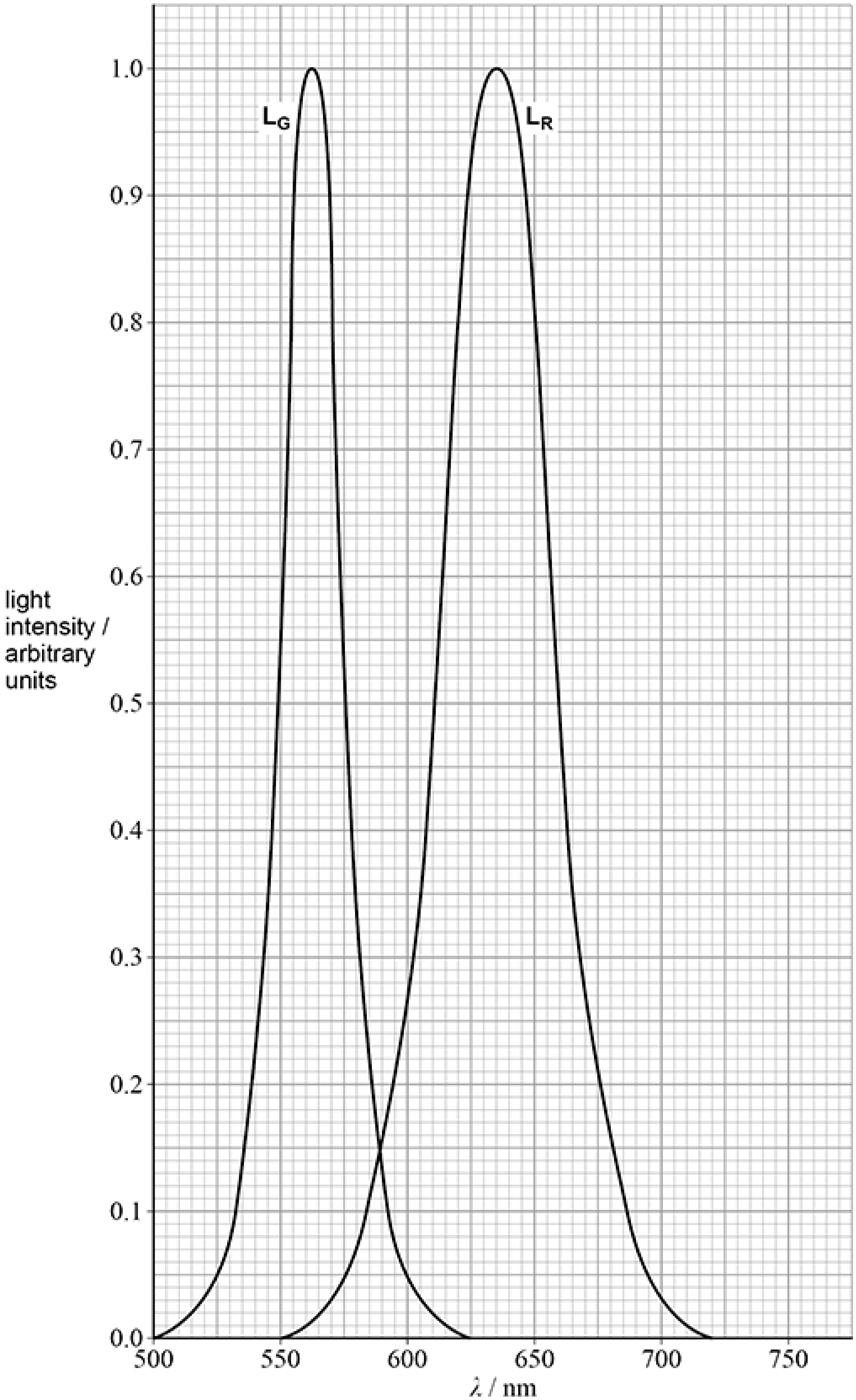
(Total 1 mark)

7. A light-emitting diode (LED) emits light over a narrow range of wavelengths.
These wavelengths are distributed about a peak wavelength λ_p.

Two LEDs $\mathbf{L_G}$ and $\mathbf{L_R}$ are adjusted to give the same maximum light intensity.
$\mathbf{L_G}$ emits green light and $\mathbf{L_R}$ emits red light.

Figure 1 shows how the light output of the LEDs varies with the wavelength λ.

Figure 1


1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
light intensity / arbitrary units
L_G
L_R
500
550
600
650
700
750
λ / nm

(a) Light from $\mathbf{L_R}$ is incident normally on a plane diffraction grating.
The fifth-order maximum for light of wavelength λ_p occurs at a diffraction angle of 76.3°.

Determine N, the number of lines per metre on the grating.

N = ________________ m^{-1}

(3)

(b) Suggest **one** possible disadvantage of using the fifth-order maximum to determine N.

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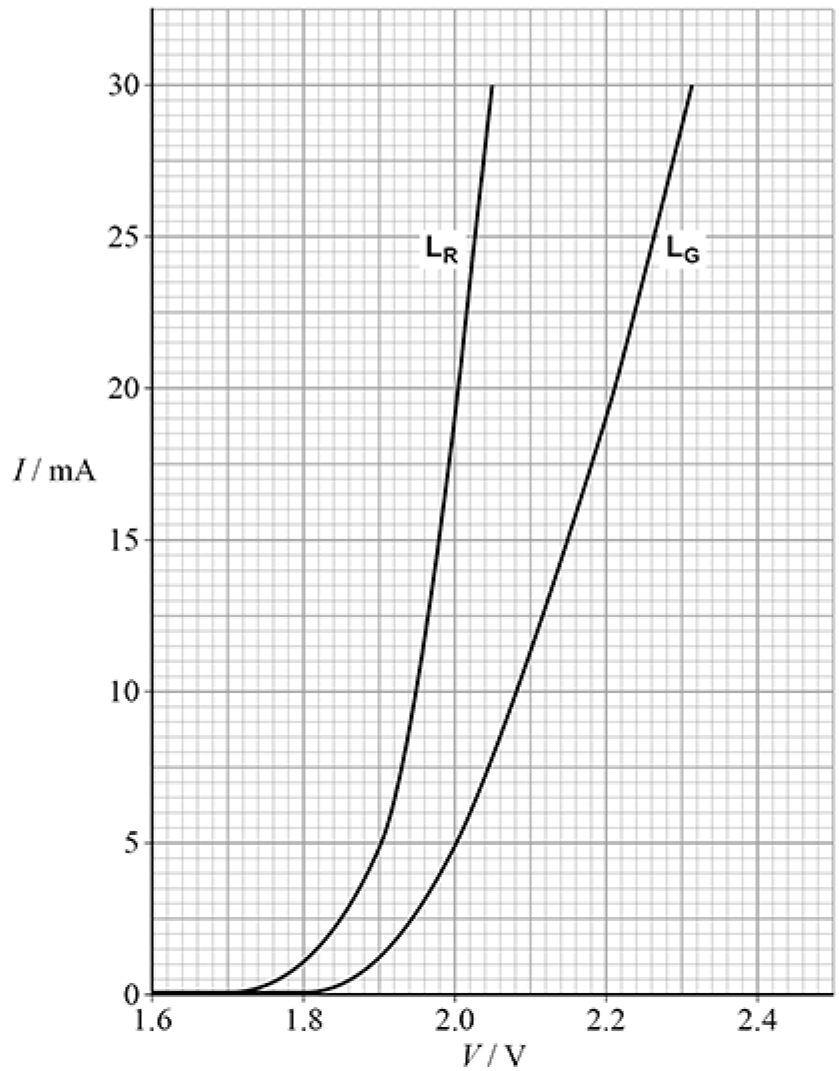
(1)

(c) **Figure 2** shows part of the current−voltage characteristics for $\mathbf{L_R}$ and $\mathbf{L_G}$.

Figure 2



When the linear part of the characteristic is extrapolated, the point at which it meets the horizontal axis gives the activation voltage V_A for the LED.
V_A for $\mathbf{L_G}$ is 2.00 V.

Determine, using **Figure 2**, V_A for $\mathbf{L_R}$.

V_A for $\mathbf{L_R}$ = _______________ V

(2)

(d) It can be shown that:

$$V_A = \frac{hc}{e\lambda_p}$$

where h = the Planck constant.

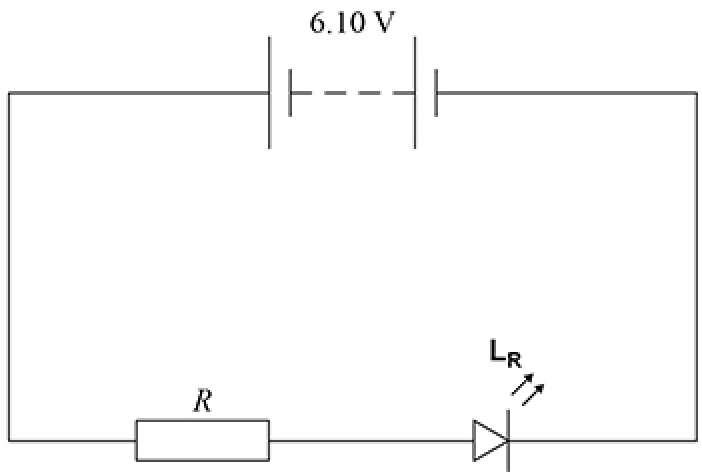
Deduce a value for the Planck constant based on the data given about the LEDs.

h = _______________ J s

(2)

(e) **Figure 3** shows a circuit with $\mathbf{L_R}$ connected to a resistor of resistance R.

Figure 3



The power supply has emf 6.10 V and negligible internal resistance.
The current in $\mathbf{L_R}$ must not exceed 21.0 mA.

Deduce the minimum value of R.

minimum value of R = ______________ Ω

(2)

(Total 10 marks)

8. Light of wavelength λ is incident normally on two parallel slits of separation s. Fringes of spacing w are seen on a screen at a distance D from the slits.

Which row gives another arrangement that produces a fringe spacing of w?

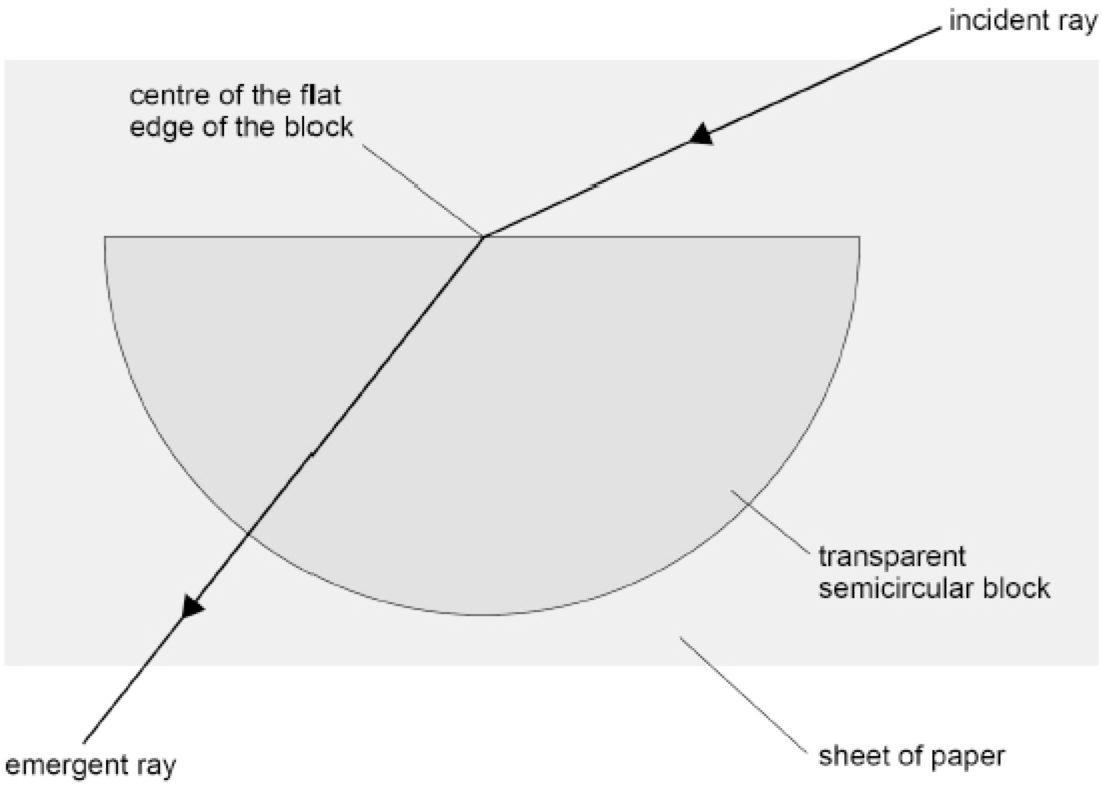
	Wavelength	**Slit separation**	**Distance between slits and screen**	
A	2λ	$2s$	$2D$	⬭
B	2λ	$4s$	$2D$	⬭
C	2λ	$2s$	$4D$	⬭
D	4λ	$2s$	$2D$	⬭

(Total 1 mark)

9. A student places a transparent semicircular block on a sheet of paper and draws around the block. She directs a ray of light at the centre of the flat edge of the block.

Figure 1 shows the path of the ray through the block.

Figure 1



(a) State why the emergent ray does not change direction as it leaves the block.

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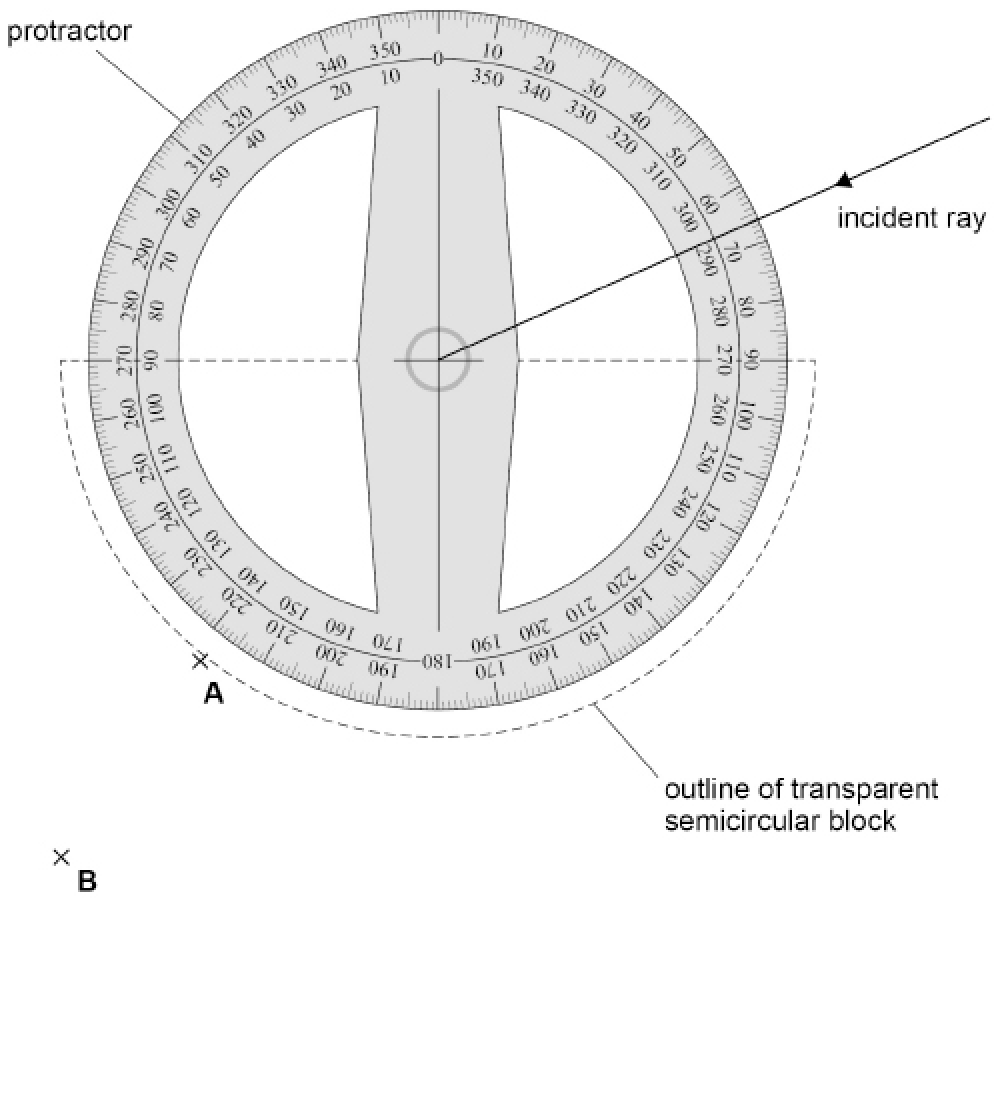
(1)

(b) The student draws an arrow on the paper to mark the incident ray. She marks the path of the emergent ray with crosses **A**, **B** and **C**.

She removes the block from the paper and places a protractor over the outline of the block, as shown in **Figure 2**.

Figure 2



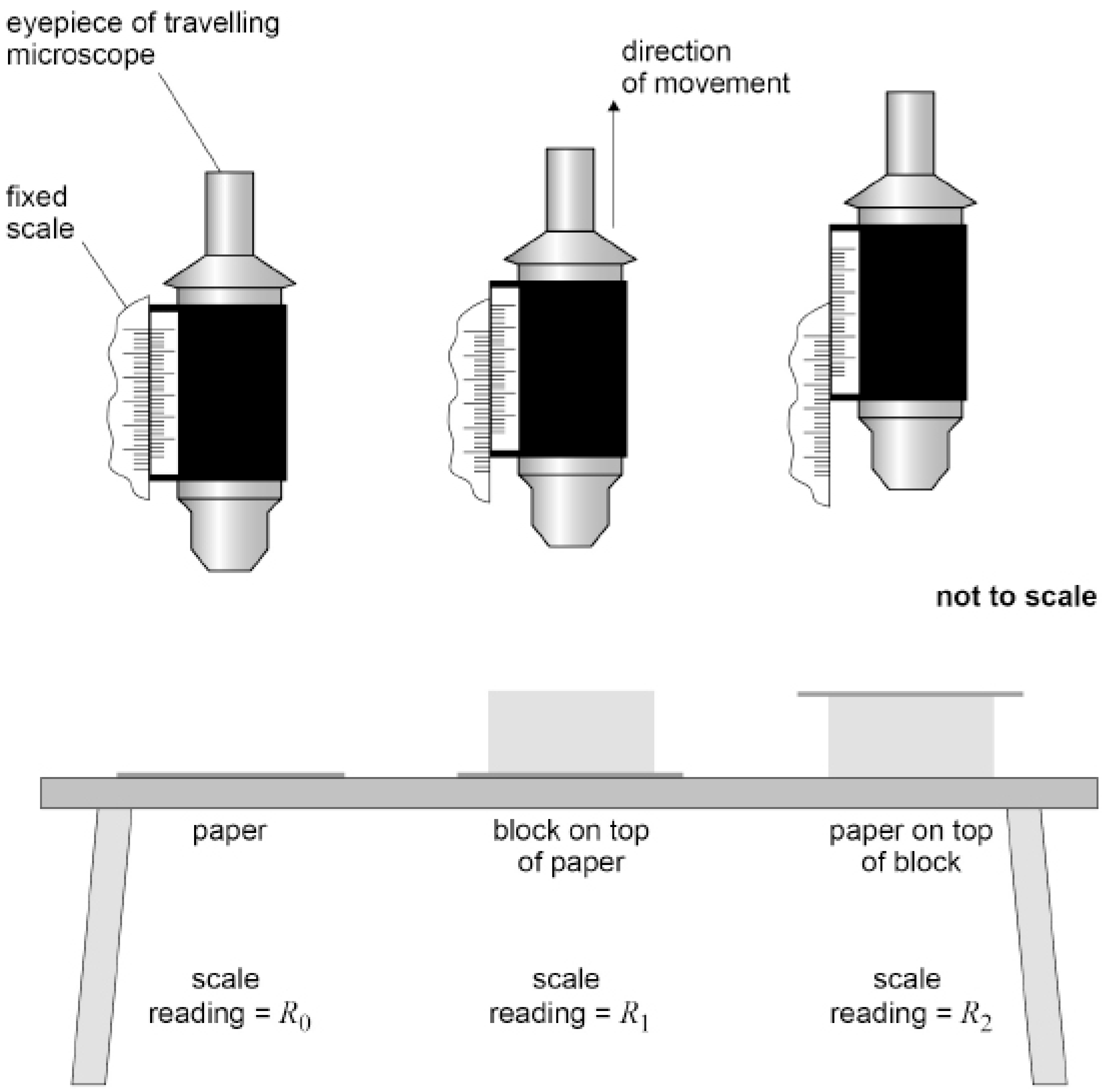
Determine, using **Figure 2**, the refractive index of the block.

refractive index = ________________

(4)

The student uses a different method to determine the refractive index of the block. She focuses a travelling microscope on some dots on a sheet of paper for each of the three situations shown in **Figure 3**.

Figure 3



The table shows the readings made by the student.

R_0 / mm	R_1 / mm	R_2 / mm
5.74	10.31	20.02

(c) The refractive index n of the block is given by

$$n = \frac{R_2 - R_0}{R_2 - R_1}$$

Determine n.

n = ________________

(1)

(d) The absolute uncertainty in each of the readings R_0, R_1 and R_2 is 0.04 mm.

State the absolute uncertainty in $R_2 - R_0$.

absolute uncertainty in $R_2 - R_0$ = ________________ mm

(1)

(e) The absolute uncertainty in $R_2 - R_1$ is the same as the absolute uncertainty in $R_2 - R_0$.

Calculate the percentage uncertainty in n.

percentage uncertainty in n = _______________%

(3)

(Total 10 marks)

10. A narrow beam of monochromatic light is incident normally to a diffraction grating. The first-order diffracted beam makes an angle of 20° with the normal to the grating.

What is the highest order visible with this grating at this wavelength?

A 2

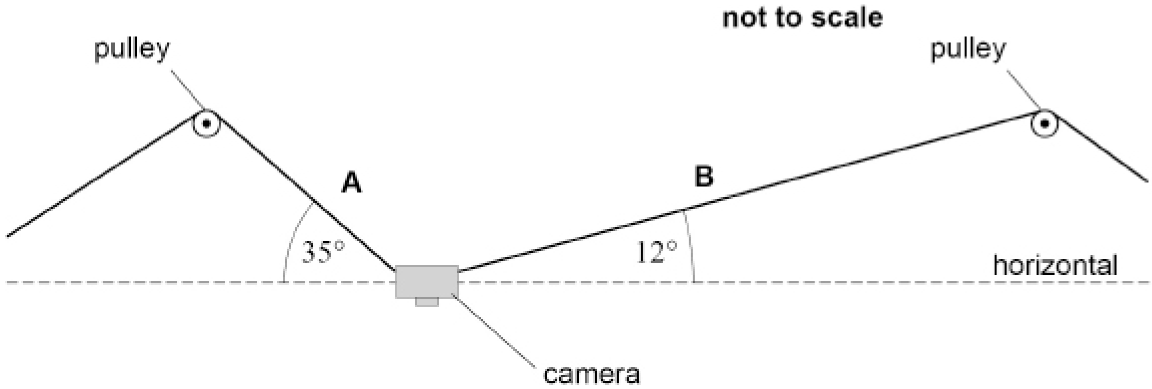
B 3

C 4

D 5

(Total 1 mark)

11. The diagram shows a camera filming a sports event from above. The position of the camera is controlled by two steel cables, **A** and **B**, that pass over fixed, smooth pulleys.



(a) In the diagram above the camera is stationary. The tension in **A** is 430 N and **A** makes an angle of 35° to the horizontal. **B** makes an angle of 12° to the horizontal.

Calculate the tension in **B**.

tension in **B** = _______________ N

(2)

(b) The cross-sectional area of **A** is 7.0×10^{-6} m^2. The unstretched length of **A** is 150 m.

Calculate the extension of **A** when the tension in it is 430 N.

Young modulus of steel = 210 GPa

extension = _______________ m

(2)

(c) The camera is moved horizontally to the right to a new stationary position. The tension in **A** is now different from that in the diagram above.

Deduce whether the tension in **A** has increased or decreased.

(3)

(d) The camera's signal is transmitted as a series of pulses through an optical fibre. The table shows data for two optical fibres **X** and **Y**. Both optical fibres are identical except for their core diameter.

Optical fibre	**Core diameter / μm**
X	8
Y	50

Deduce which fibre allows a greater pulse transmission rate.

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(3)

(Total 10 marks)

12. The speed of light decreases by 40% when it travels from air into a transparent medium.

What is the refractive index of the medium?

A 0.6 ⬭

B 1.4 ⬭

C 1.7 ⬭

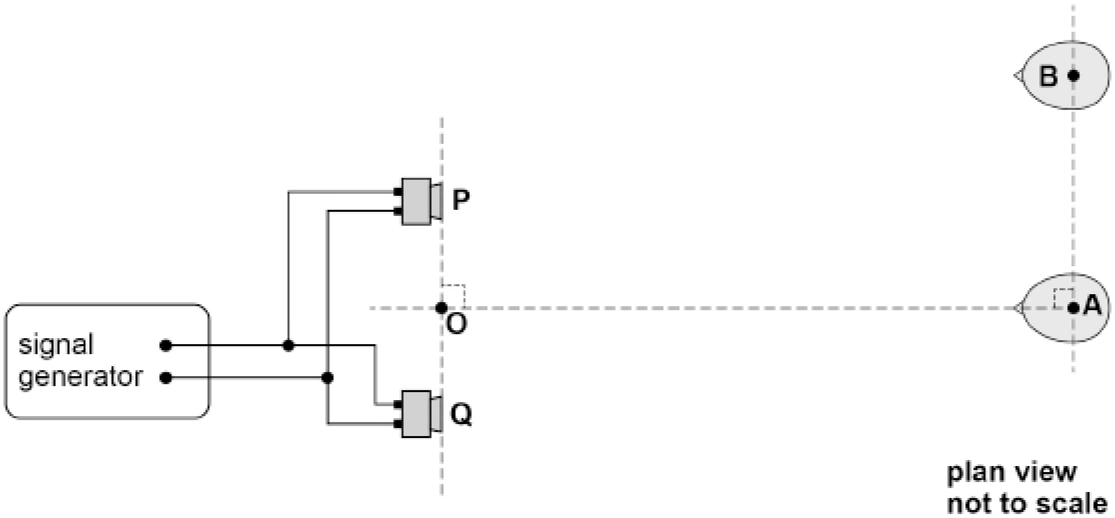
D 2.5 ⬭

(Total 1 mark)

13. A student investigates the interference of sound waves using two loudspeakers, **P** and **Q**, connected to a signal generator (oscillator). Each loudspeaker acts as a point source of sound.

Figure 1 shows the arrangement.

Figure 1



Point **O** is the midpoint between **P** and **Q**.

(a) Explain why the two loudspeakers are coherent sources of sound waves.

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(2)

(b) The student faces the two loudspeakers at point **A**. Point **A** is at equal distances from **P** and **Q**.
He then moves to point **B**, at right angles to the line **OA**, still facing the two loudspeakers.
As his head moves from **A** to **B** the amplitude of the sound wave he hears decreases and then increases. The amplitude starts to decrease again as he moves beyond **B**.

Explain why the variation in amplitude occurs as he moves from **A** to **B**.

(3)

(c) The student records the following data:

separation of the two loudspeakers	= 0.30 m
distance **OA**	= 2.25 m
distance from **A** to **B**	= 0.95 m

Show that the path difference for the sound waves from the two loudspeakers to point **B** is about 0.1 m.

(3)

(d) The frequency of the sound wave is 2960 Hz.

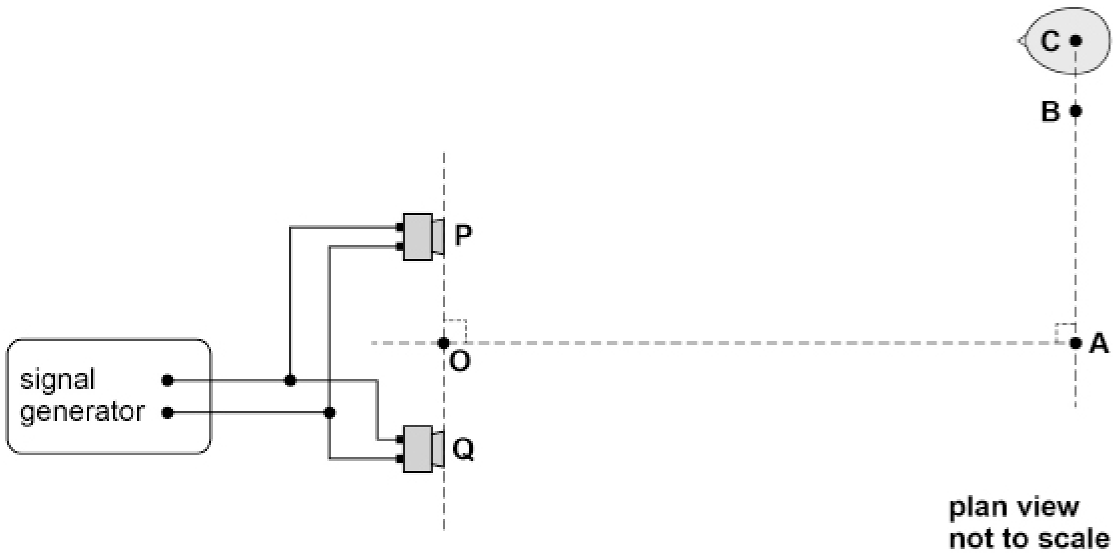
Calculate the speed of sound from the student's data.

speed of sound = ________________ $m\ s^{-1}$

(1)

(e) The student moves his head to point **C** as shown in **Figure 2**. The emitted frequency of the sound from the loudspeakers is then gradually decreased.

Figure 2



Discuss the effect that this decrease in frequency has on the amplitude of the sound wave heard by the student.

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(3)

(Total 12 marks)

14. A monochromatic light wave travels from glass into air.

Which row shows what happens to the wavelength, speed and photon energy?

	Wavelength	Speed	Photon energy	
A	increases	increases	increases	⬭
B	does not change	decreases	does not change	⬭
C	does not change	decreases	increases	⬭
D	increases	increases	does not change	⬭

(Total 1 mark)

15. Monochromatic light is incident normally on a diffraction grating that has 4.50×10^5 lines m^{-1}. The angle between the second-order diffraction maxima is 44°.

What is the wavelength of the light?

A 208 nm ⬭

B 416 nm ⬭

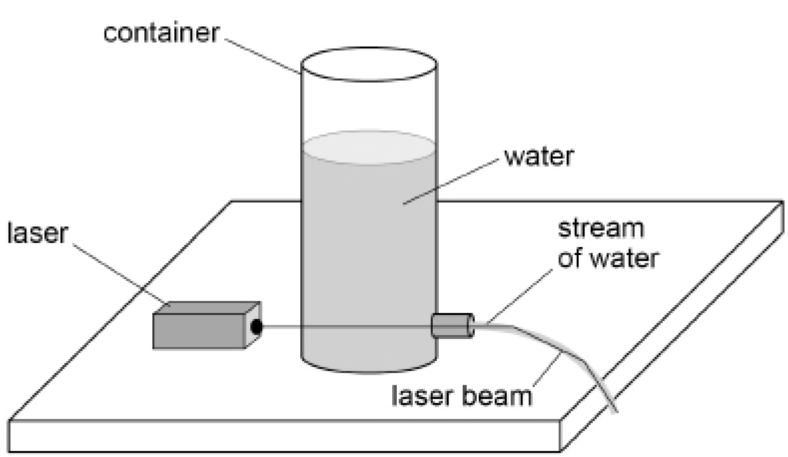
C 772 nm ⬭

D 832 nm ⬭

(Total 1 mark)

16. In 1870 John Tyndall sent a beam of light along a stream of water.
Figure 1 shows a modern version of Tyndall's experiment using a laser beam.
Water has a refractive index of 1.33

Figure 1



(a) Explain why the laser beam stays inside the stream of water.

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(2)

(b) Calculate the speed of the laser light in the water.
Give your answer to an appropriate number of significant figures.

speed = ____________________ $m\ s^{-1}$

(3)

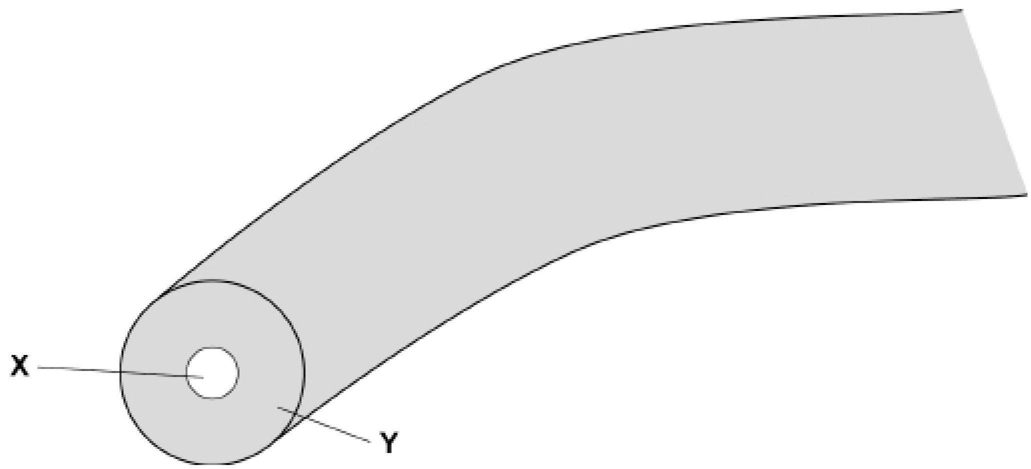
(c) Calculate the critical angle for the water−air boundary.

critical angle = ____________________ degrees

(1)

(d) Tyndall's experiment led to the development of optical fibres.
Figure 2 shows a step-index optical fibre.

Figure 2



Discuss the properties of a step-index optical fibre.

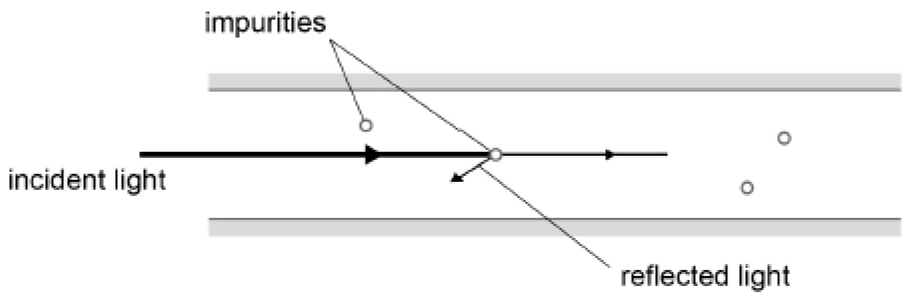
Your answer should include:

- the names of part **X** and part **Y**
- a description of the functions of **X** and **Y**
- a discussion of the problems caused by material dispersion and modal dispersion and how these problems can be overcome.

(6)

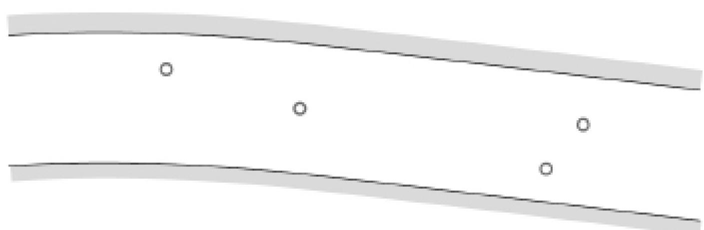
(e) Scientists use optical fibres to monitor earthquakes. Light travelling through an optical fibre can be reflected by impurities in the fibre, as shown in **Figure 3**.

Figure 3



Earthquakes bend the optical fibre slightly, as shown in **Figure 4**. This changes the amount of reflected light.

Figure 4



Suggest why the amount of reflected light changes as the fibre bends.
You may draw on **Figure 4** as part of your answer.

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(2)

(f) The waves caused by earthquakes can be longitudinal or transverse.

Describe the difference between longitudinal waves and transverse waves.

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(2)

(Total 16 marks)

17. In a Young's double-slit experiment, the spacing of the double slits is s and the distance between the slits and the screen on which fringes are formed is D. When monochromatic light of wavelength λ is incident on the slits the distance between adjacent fringes on the screen is w.

Which row shows another arrangement that produces a fringe spacing of w?

	Spacing of double slits	Distance between the slits and the screen	Wavelength of the light	
A	$4s$	$2D$	2λ	⬭
B	$2s$	$4D$	2λ	⬭
C	$2s$	$2D$	4λ	⬭
D	$2s$	$2D$	2λ	⬭

(Total 1 mark)

18. Monochromatic electromagnetic radiation of wavelength 5.8×10^{-7} m is incident normally on a diffraction grating with 3.0×10^{5} lines per metre.

What is the highest order maximum produced?

A 5 ⬭

B 6 ⬭

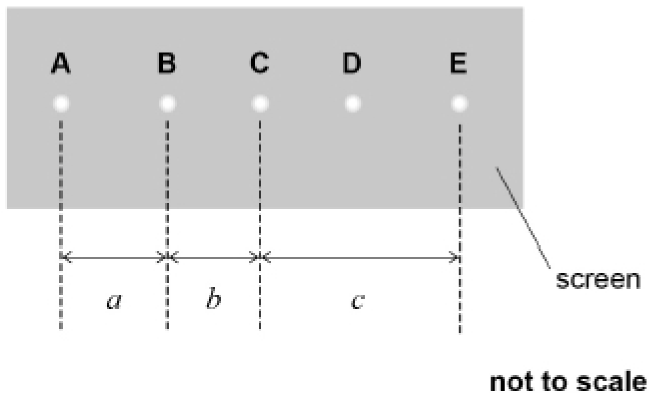
C 10 ⬭

D 13 ⬭

(Total 1 mark)

19. This question is about the measurement of the wavelength of laser light.
The light is shone onto a diffraction grating at normal incidence.
The light transmitted by the diffraction grating produces five spots on a screen. These spots are labelled **A** to **E** in **Figure 1**.

Figure 1



A student uses a metre ruler with 1 mm divisions to take readings. He uses these readings to obtain measurements a, b and c, the distances between centres of the spots as shown in **Figure 1**.
Table 1 shows his measurements and his estimated uncertainties.

Table 1

Measurement	**Distance / mm**	**Uncertainty / mm**
a	289	2
b	255	2
c	544	2

(a) Explain why the student's estimated uncertainty in measurement a is greater than the smallest division on the metre ruler.
You should refer to the readings taken by the student in obtaining this measurement.

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(2)

(b) The distance between the centres of spots **A** and **C** and the distance between the centres of spots **C** and **E** are equal.
That is:

$$a + b = c$$

Calculate the percentage uncertainty in the sum of a and b.

percentage uncertainty = ____________________

(2)

(c) Discuss why the experimental measurements lead to a different percentage uncertainty in c compared to that in $a + b$.

(2)

(d) Eye protection should be used to prevent eye damage when using a laser.

Describe **one** other safety measure to minimise the risk of eye damage when using a laser in the laboratory.

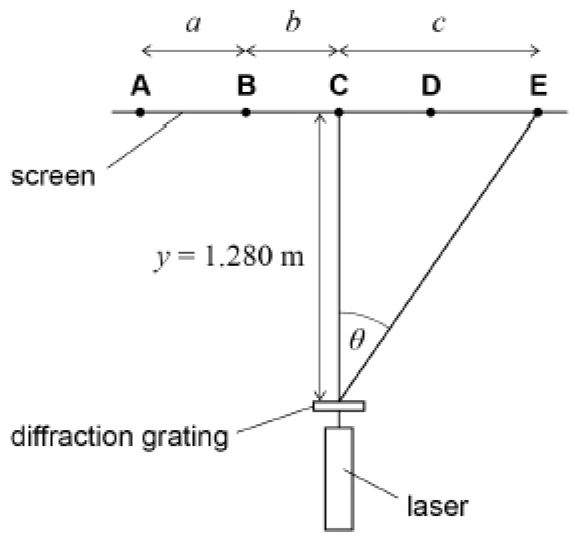
(1)

(e) **Figure 2** shows the experimental arrangement with y, the perpendicular distance between the diffraction grating and the screen, equal to 1.280 m.
Table 2 shows some of the data from **Table 1**.

Table 2

Measurement	**Distance / mm**
a	289
b	255
c	544

Figure 2



Calculate the angle θ shown on **Figure 2**.

θ = ____________________ degrees

(1)

(f) Spot **E** is the second-order maximum.
The diffraction grating has 3.00×10^5 lines per metre.

Calculate the wavelength of the laser light.

wavelength = ____________________ m

(1)

(g) The student plans to repeat the experiment using the same diffraction grating and laser.

State and explain **one** way the student can change the experimental arrangement to reduce the percentage uncertainty in the measurement of the wavelength.

Assume the percentage uncertainty in sin θ is the sum of the percentage uncertainties in y and c.

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(2)

(Total 12 marks)

20. Which characteristics of monochromatic light change when the light passes from air into glass?

A Speed, wavelength and frequency. ☐

B Speed and frequency only. ☐

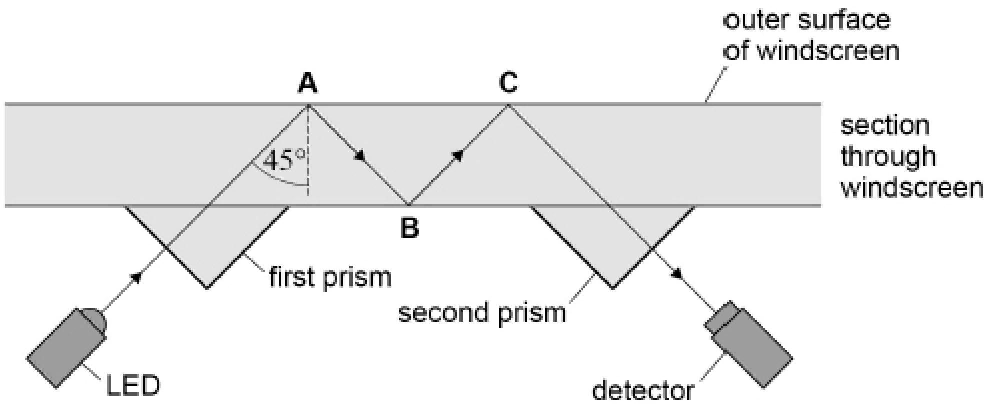
C Speed and wavelength only. ☐

D Wavelength and frequency only. ☐

(Total 1 mark)

21. Some cars are fitted with a water sensor designed to switch on windscreen wipers automatically when it rains. **Figure 1** shows a simplified diagram of the sensor.

Figure 1



A light ray travels from the light-emitting diode (LED) through the first prism and into the windscreen. The ray reflects off the surfaces of the windscreen at **A**, **B** and **C** and then passes through the second prism into the detector.

(a) Suggest how the design ensures that there is no deviation of the ray as it enters the first prism.

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(1)

(b) Suggest **two** features of the design that ensure that there is no deviation of the ray as it leaves the first prism and enters the windscreen glass.

1 ____

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2 ____

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(2)

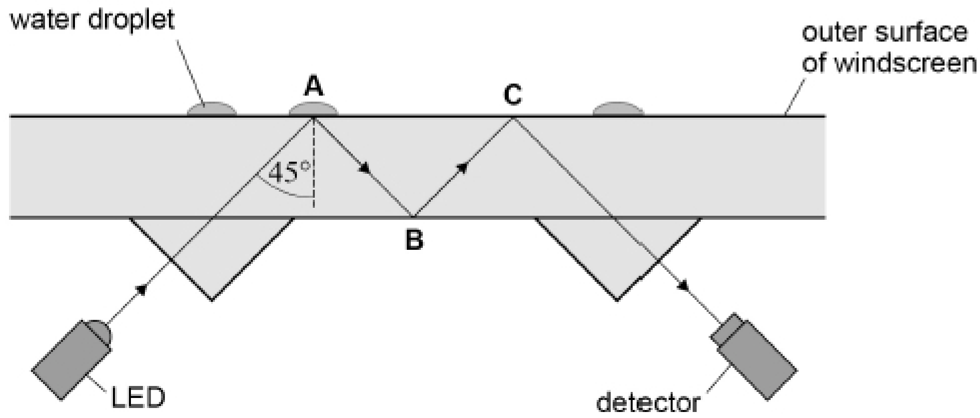
(c) The refractive index of the windscreen glass is 1.52

Explain why the ray follows the path shown inside the windscreen glass in **Figure 1**.
Support your answer with a suitable calculation.

(2)

(d) When it starts to rain, water droplets form on the outside of the windscreen as shown in **Figure 2**.

Figure 2



The refractive index of water is 1.33

Explain why the presence of water at **A** causes the intensity of the light at the detector to decrease.

Support your answer with a suitable calculation.

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(2)

(e) The refractive index of the windscreen glass can vary by a few per cent across the thickness of the glass.

Discuss how this variation may affect the path of the ray through the windscreen glass.

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(2)

(f) A different design has the LED and the detector further apart. The ray undergoes more reflections inside the windscreen glass before reaching the detector.

Discuss **two** ways in which this different design affects the sensitivity of the sensor to the presence of water droplets.

1 ____

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2 ____

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(2)

(Total 11 marks)

22. Which is a description of the pattern produced when monochromatic light passes through a very narrow slit?

A A series of equally-spaced light and dark fringes. ⬭

B A narrow central maximum with wider side fringes. ⬭

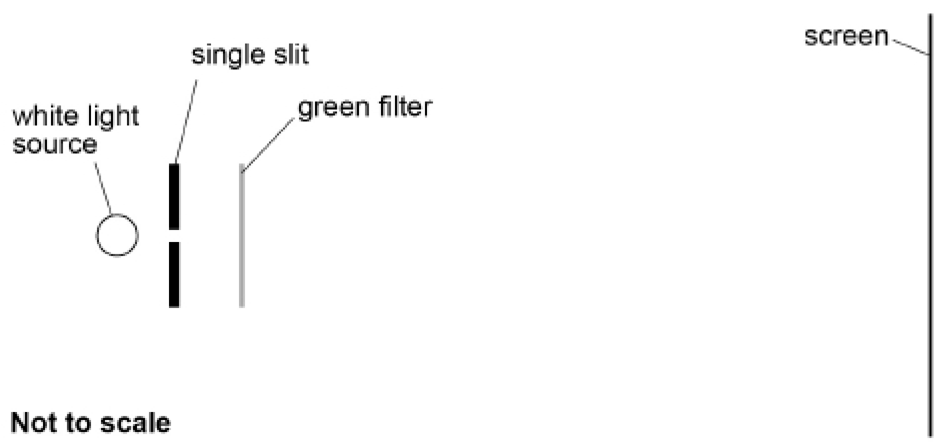
C A few bright fringes that are widely spaced. ⬭

D A wide central maximum with narrower side fringes. ⬭

(Total 1 mark)

23. **Figure 1** shows an arrangement to investigate diffraction. White light is incident on a single slit. After leaving the slit, the diffracted light passes through a green filter to reach the screen.

Figure 1



(a) Describe the pattern produced on the screen.

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(2)

(b) The green filter is replaced with a red filter.

Describe the change in the pattern produced on the screen.

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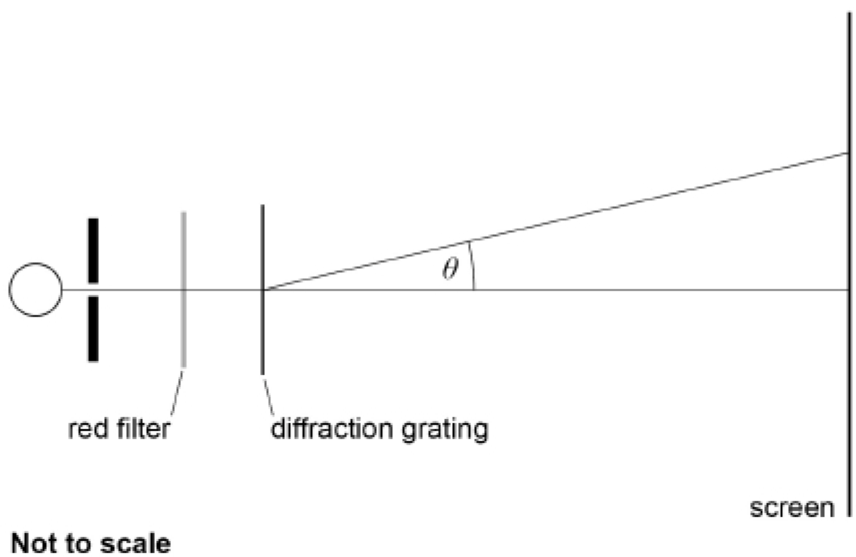
(2)

(c) A diffraction grating is placed between the red filter and the screen. The diffraction grating has 500 lines per millimetre. Light is incident normally on the grating. **Figure 2** shows the arrangement.

Figure 2



The wavelength of the red light is 650 nm.

Calculate the angle θ between a first-order maximum and the central maximum.

θ ____________________ degrees

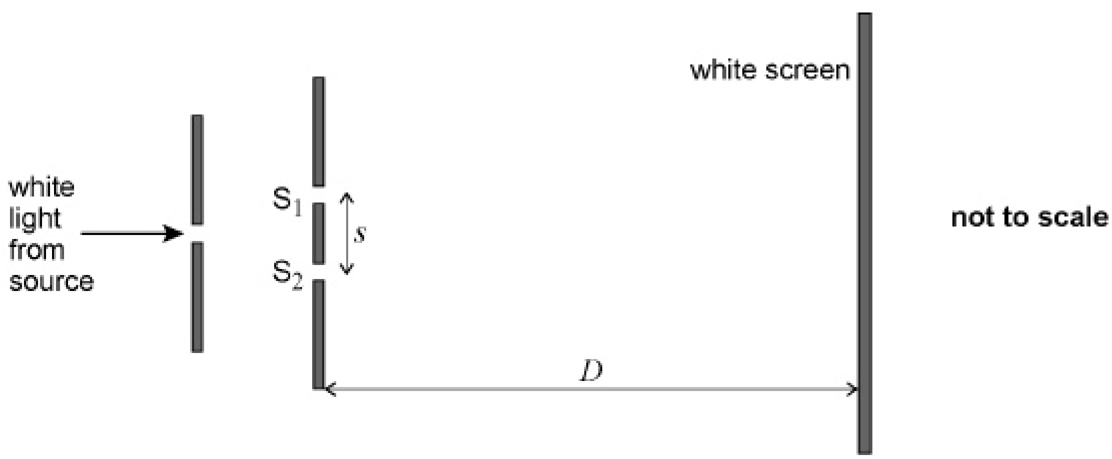
(2)

(d) In practice, the filter transmits red light with wavelengths in the range 600 nm to 700 nm.

Suggest how this affects the appearance of the maxima.

(2)
(Total 8 marks)

24. The figure below shows a diagram of apparatus used to demonstrate the formation of interference fringes using a white light source in a darkened room. Light from the source passes through a single slit and then through two narrow slits S_1 and S_2.



(a) Describe the interference pattern that is seen on the white screen.

(2)

(b) A filter transmits only green light of wavelength λ and red light of wavelength 1.2λ
This filter is placed between the light source and the single slit.

Describe the interference pattern now seen on the white screen.

Use a calculation to support your answer.

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(4)

(c) A student decides to use the apparatus shown in the figure to determine the wavelength of red light using a filter that transmits only red light.

The student suggests the following changes:

- decrease slit separation s
- decrease D, the distance between the slits and the screen.

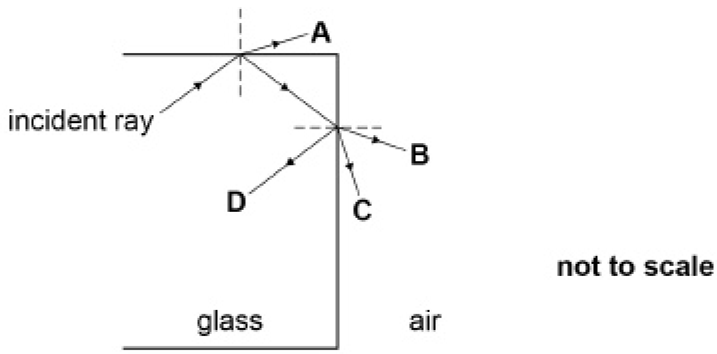
The student decides to make each change independently.

Discuss the effects each independent change has on the interference pattern, and whether this change is likely to reduce uncertainty in the determination of the wavelength.

(6)

(Total 12 marks)

25. A ray of light is incident on a glass–air boundary of a rectangular block as shown.



The refractive index of this glass is 1.5
The refractive index of air is 1.0
The angle of incidence of the light at the first glass–air boundary is 44°

What is the path of the ray of light?

A ⬭

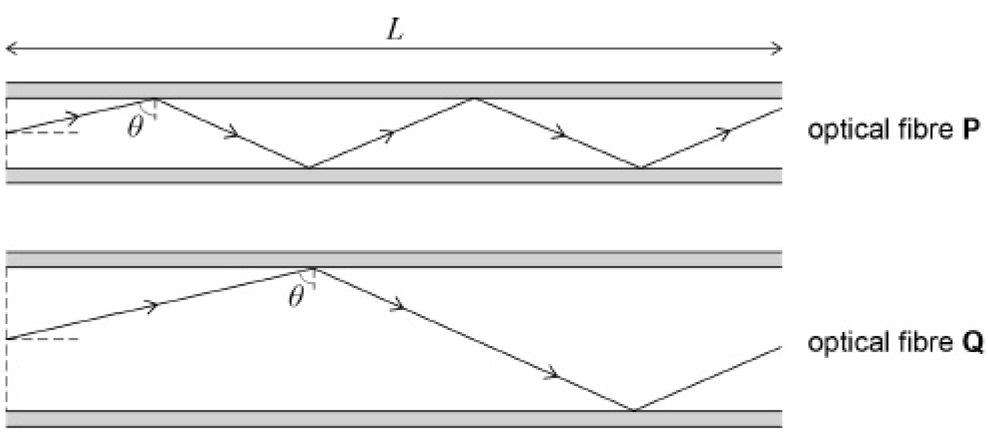
B ⬭

C ⬭

D ⬭

(Total 1 mark)

26. Rays of light are incident at the same angle θ on the core–cladding boundary of optical fibres **P** and **Q**.
The cores of **P** and **Q** have the same refractive index n.
P and **Q** are the same length L.
The core diameter of **P** is half that of **Q**.



The time for the ray to travel along optical fibre **P** is

$$\frac{nL}{c\sin\theta}$$

where c is the speed of light in a vacuum.

What is the time for the ray to travel along optical fibre **Q**?

A $\frac{nL}{c\sin\theta}$ ○

B $\frac{nL}{2c\sin\theta}$ ○

C $\frac{2nL}{c\sin\theta}$ ○

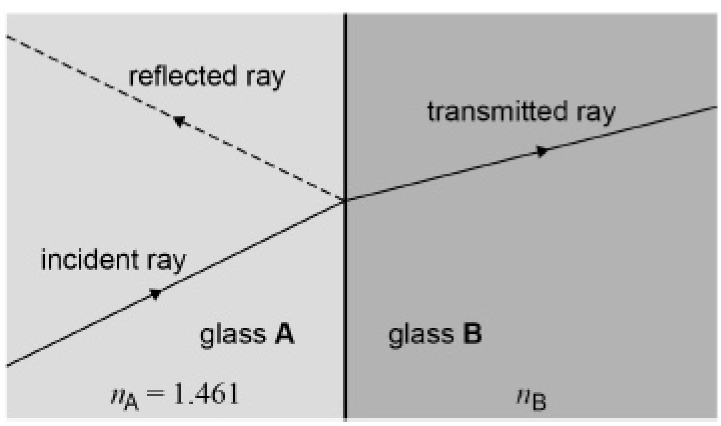
D $\frac{4nL}{c\sin\theta}$ ○

(Total 1 mark)

27. (a) **Figure 1** shows an incident ray of light being partially reflected at the boundary between glass **A** and glass **B**. The refractive index n_A of glass **A** is 1.461

The speed of light in glass **B** is 3.252% less than the speed of light in glass **A**.

Figure 1



Calculate the refractive index n_B of glass **B**.

Give your answer to an appropriate number of significant figures.

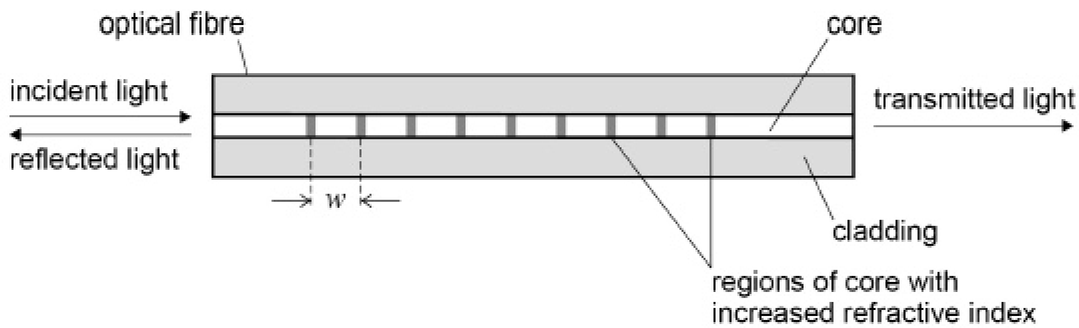
speed of light in a vacuum = 2.998×10^8 m s^{-1}

n_B = ____________________

(3)

(b) **Figure 2** shows a cross-sectional view of an optical fibre strain gauge.

Figure 2

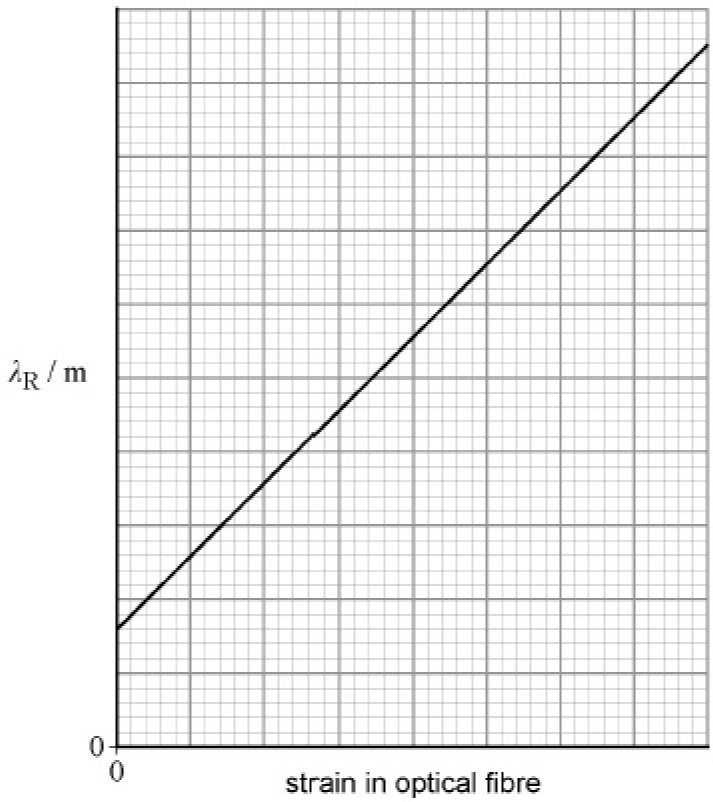


A maximum intensity of the reflected light is produced due to superposition of the light reflected from each of the regions with increased refractive index in the core.

This maximum intensity occurs at a particular wavelength λ_R.

Figure 3 shows the relationship between λ_R and the strain in the optical fibre.

Figure 3



A cable is used to raise and lower a lift. An engineer fixes the optical fibre strain gauge to the cable to monitor changes of the strain in the cable.

The lift is initially at rest and then accelerates downwards for a short time before reaching a constant velocity.

Discuss how the value of λ_R changes.

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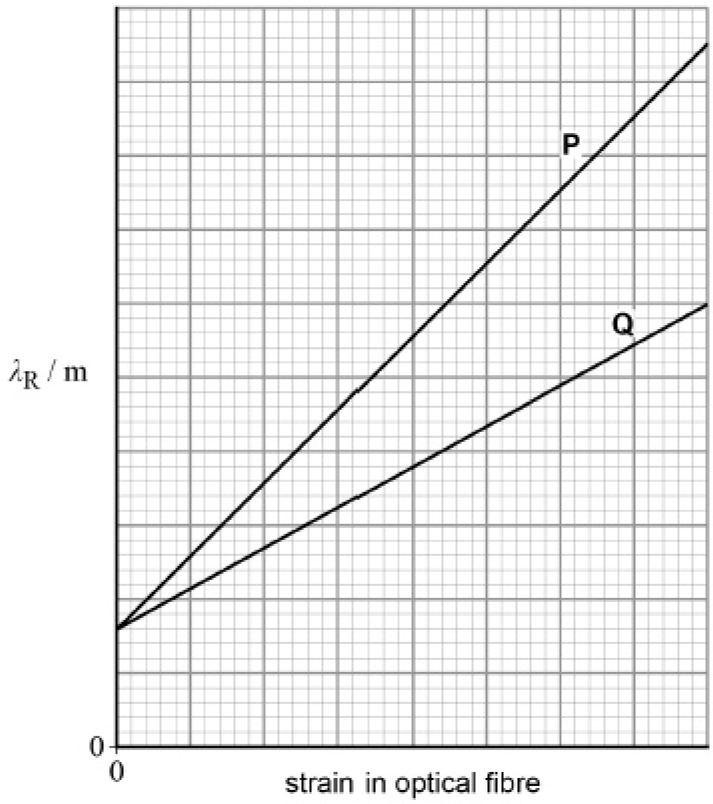
(3)

(c) **Figure 4** shows the relationship between λ_R and the strain in two optical fibre strain gauges **P** and **Q**. The engineer wishes to measure small accelerations in another lift. She can choose to fix either optical fibre strain gauge **P** or optical fibre strain gauge **Q** to the lift's cable.

Figure 4



Explain which gauge the engineer should select.

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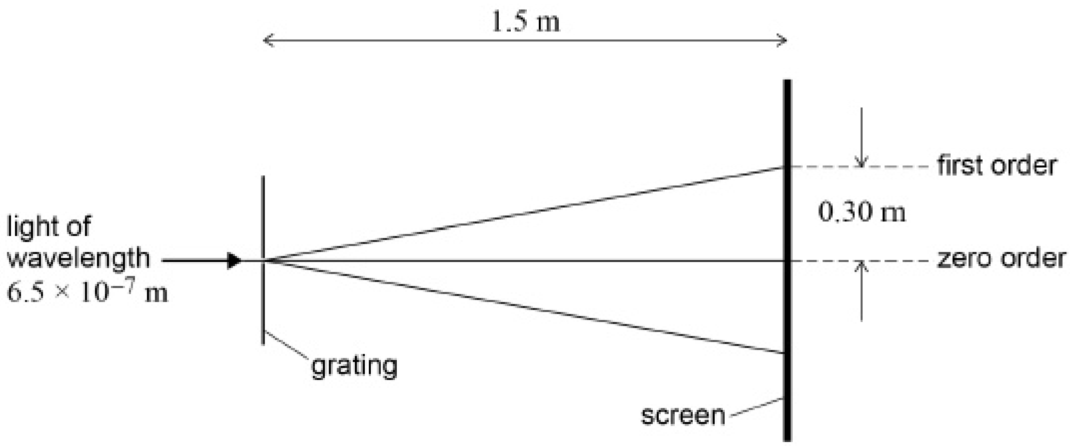
(2)

(Total 8 marks)

28. A diffraction grating is illuminated normally with light of wavelength 6.5×10^{-7} m
When a screen is 1.5 m from the grating, the distance between the zero and first-order maxima on the screen is 0.30 m



What is the number of lines per mm of the diffraction grating?

A 3.3×10^{-6}

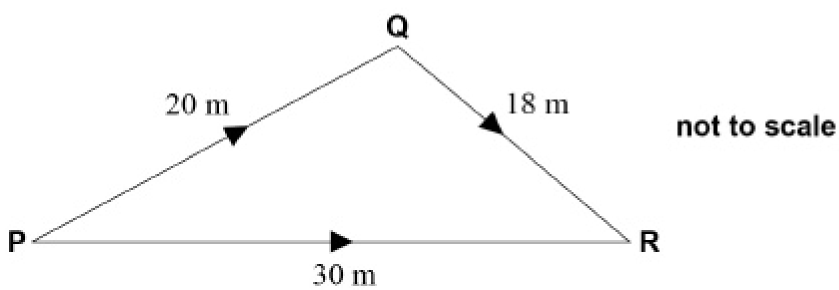
B 3.3×10^{-3}

C 3.0×10^{2}

D 3.0×10^{5}

(Total 1 mark)

29. In the diagram, **P** is the source of a wave of frequency 50 Hz



The wave travels to **R** by two routes, **P** → **Q** → **R** and **P** → **R**. The speed of the wave is 30 m s−1

What is the path difference between the two waves at **R** in terms of the wavelength λ of the waves?

A 4.8λ

B 8.0λ

C 13.3λ

D 20.0λ

(Total 1 mark)

30. An electromagnetic wave enters a fibre-optic cable from air. On entering the cable, the wave slows down to three-fifths of its original speed.

What is the refractive index of the core of the fibre-optic cable?

A 0.67

B 1.33

C 1.50

D 1.67

(Total 1 mark)

31. A diffraction grating has 500 lines per mm. When monochromatic light is incident normally on the grating the third-order spectral line is formed at an angle of 60° from the normal to the grating.

What is the wavelength of the monochromatic light?

A 220 nm

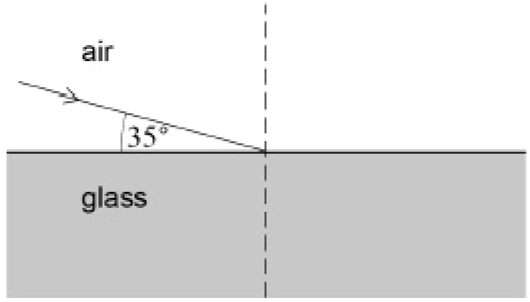
B 580 nm

C 960 nm

D 1700 nm

(Total 1 mark)

32. The diagram shows a ray of light travelling in air and incident on a glass block of refractive index 1.5



What is the angle of refraction in the glass?

A 22.5° ○

B 23.3° ○

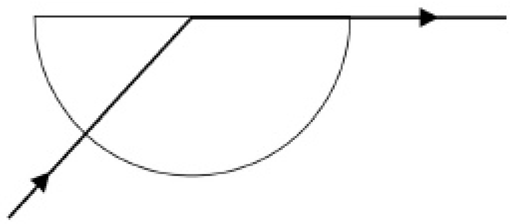
C 33.1° ○

D 59.4° ○

(Total 1 mark)

33. **Figure 1** shows a ray of monochromatic green light incident normally on the curved surface of a semicircular glass block.

Figure 1



(a) The angle of refraction of the ray at the plane surface is 90°.

Refractive index of the glass used = 1.6

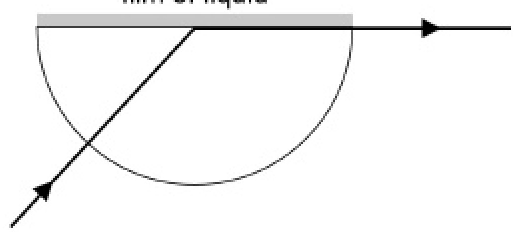
Calculate the angle of incidence of the ray on the flat surface of the block.

angle of incidence = ____________________ degrees

(1)

(b) A thin film of liquid is placed on the flat surface of the glass block as shown in **Figure 2**.

Figure 2



The angle of incidence is changed so that the angle of refraction of the green light ray at the glass-liquid interface is again 90°. The angle of incidence is now 58°.

Calculate the refractive index of the liquid.

refractive index = ______________________

(2)

(c) The source of green light is changed for one that contains only red and blue light. For any material red light has a lower refractive index than green light, and blue light has a higher refractive index than green light. The angle of incidence at the glass-liquid interface remains at 58°.

Describe and explain the paths followed by the red and blue rays immediately after the light is incident on the glass-liquid interface.

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(3)

(Total 6 marks)

34. When light of wavelength 5.0×10^{-7} m is incident normally on a diffraction grating the fourth-order maximum is observed at an angle of 30°.

What is the number of lines per mm on the diffraction grating?

A 2.5×10^{2} ⬭

B 2.5×10^{5} ⬭

C 1.0×10^{3} ⬭

D 1.0×10^{6} ⬭

(Total 1 mark)