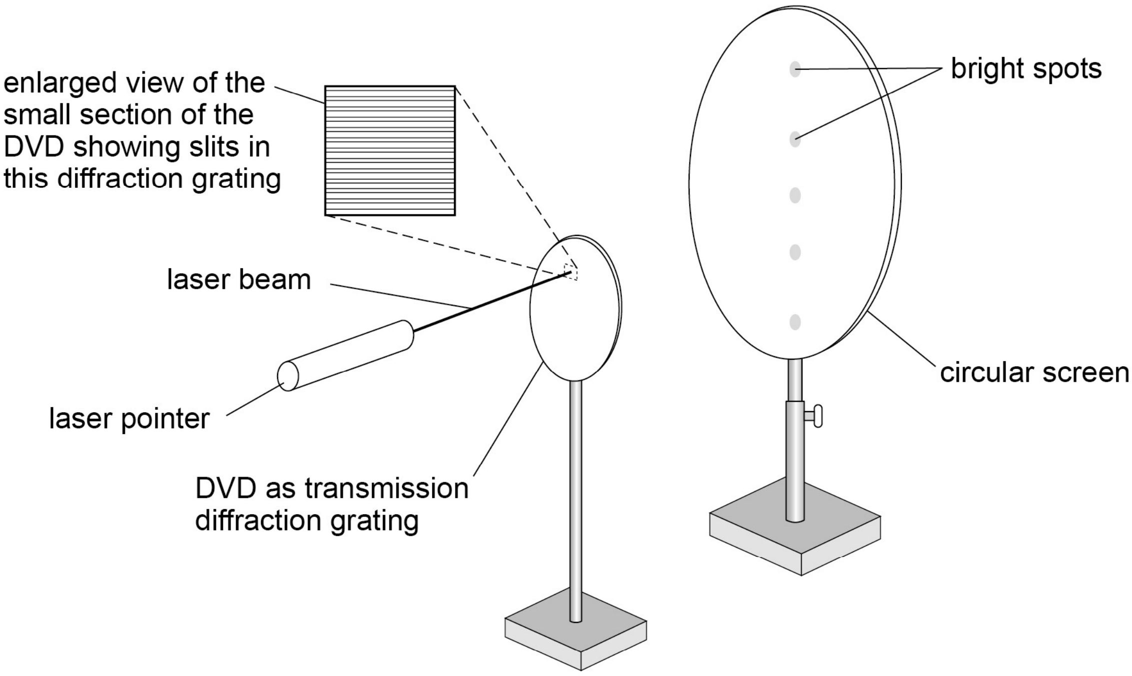
Do not write outside the box

0 2 A student removes the reflective layer from a DVD. She uses the DVD as a transmission diffraction grating.

Figure 3 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 3



0 2 . 1 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.

[1 mark]

___

Do not write outside the box

0 2 . 2 Explain how light from the diffraction grating forms a maximum on the screen.

[3 marks]

Question 2 continues on the next page

Do not write outside the box

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 2 and **Table 3** show information about the discs and the laser pointers.

Table 2

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

Table 3

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

0 2 . 3 Deduce the combination of disc and laser pointer that will produce the **greatest** possible number of interference maxima.

[2 marks]

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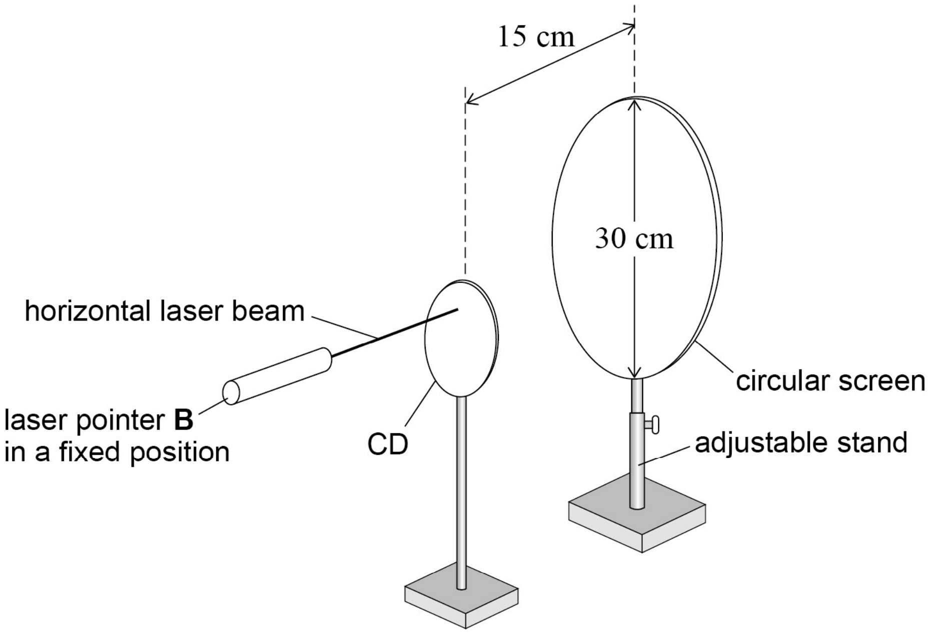
0 2 . 4 The student uses the CD and laser pointer **B** as shown in **Figure 4**. A diffraction pattern is produced on the screen. Laser pointer **B** and the CD are in fixed positions. The laser beam is horizontal and incident normally on the CD. The height of the screen can be adjusted.

Figure 4



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.

[3 marks]

9

Do not write outside the box

0 7 Optical fibres are used to carry pulses of light.

0 7 . 1 Explain what is meant by modal dispersion in an optical fibre.

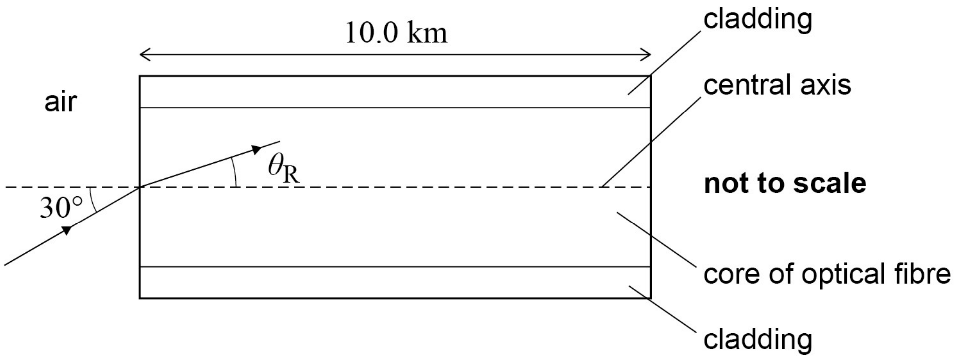
[2 marks]

Question 7 continues on the next page

Do not write outside the box

Figure 15 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.

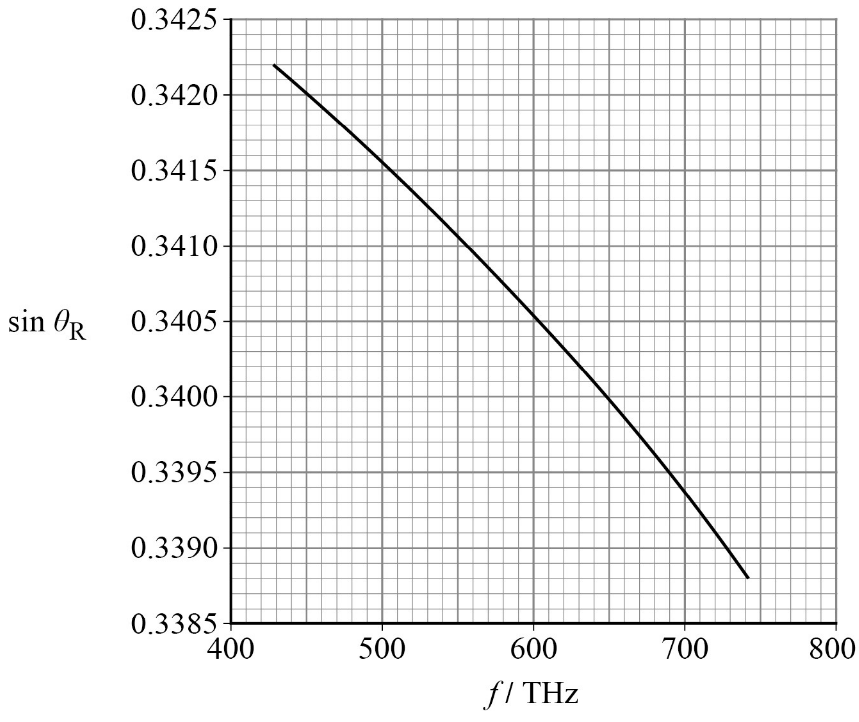
Figure 15



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

Figure 16



Do not write outside the box

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 $10\ \text{km}$ length of the optical fibre is $5.225 \times 10^{-5}\ \text{s}$.

0 7 . 2 Show that the horizontal component of the velocity of the pulse is approximately $1.9 \times 10^{8}\ \text{m s}^{-1}$.

[1 mark]

0 7 . 3 The frequency of the blue light in the pulse is $720\ \text{THz}$.

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

[3 marks]

speed = ____________________ m s^{-1}

Question 7 continues on the next page

Do not write outside the box

0 7 . 4 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.

[2 marks]

0 7 . 5 Another two pulses, identical to the pulses in Question **07.4**, 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 Question **07.4**.

[1 mark]

9

END OF QUESTIONS

Do not write outside the box

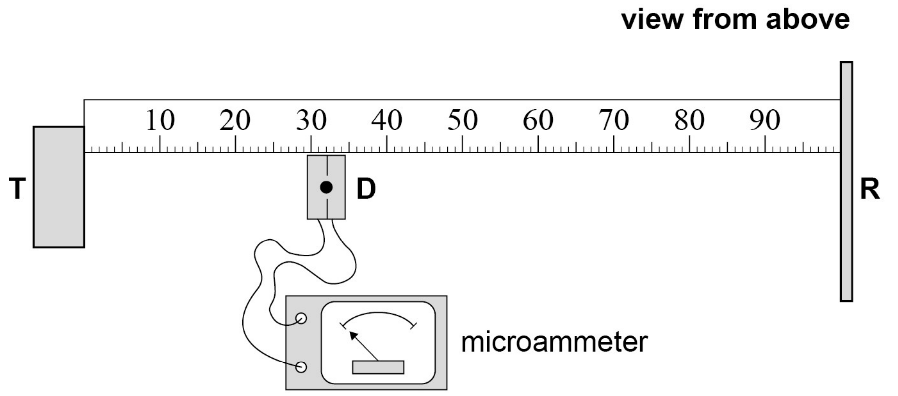
Section A

Answer **all** questions in this section.

0 1 A student investigates stationary waves using microwaves.

Figure 1 shows a metre ruler fixed to a bench. The student places a microwave transmitter **T** at one end of the ruler and a vertical metal reflector **R** at the other end. **R** is at a right angle to the ruler.

Figure 1



The student places a microwave detector **D** approximately one-third of the distance from **T** to **R**. When **T** is switched off, the microammeter connected to **D** reads zero.

When **T** is switched on, stationary waves are produced between **T** and **R**, and the microammeter registers a current. When the student moves **D** along the ruler, the size of the current changes between maximum and minimum values.

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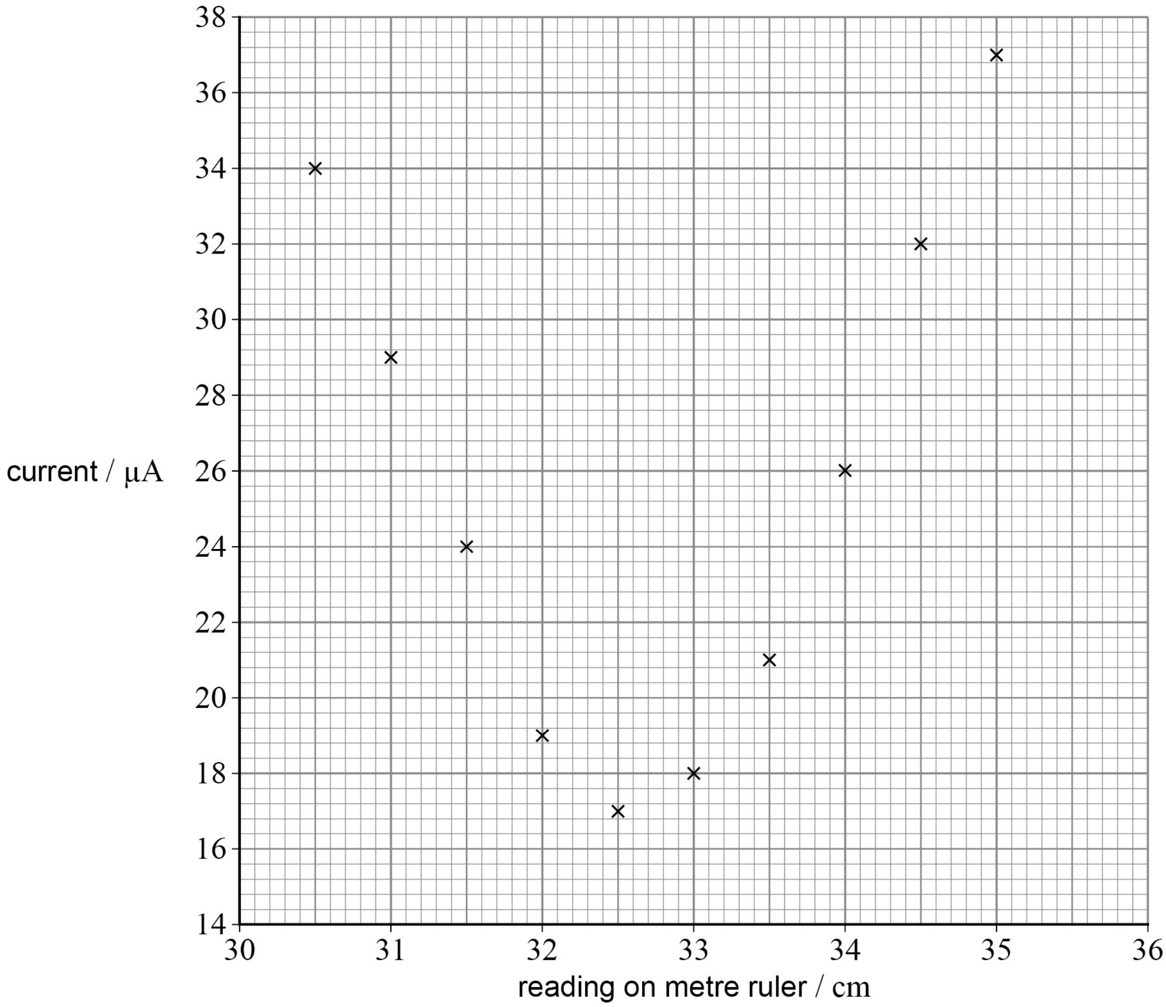
The student measures the current at different positions of **D** along the ruler to identify a position **P** of the minimum current.

Figure 2 is a plot of the measurements taken near **P**.

Figure 2



0 1 . 1 Draw a line of best fit for these data.

[2 marks]

0 1 . 2 State a value for the position of **P**.

[1 mark]

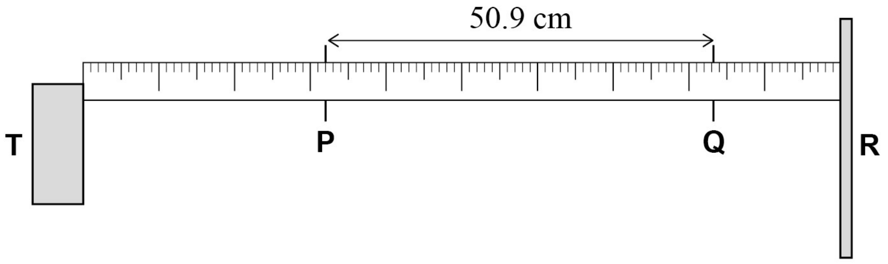
position of **P** = ______________________ cm

Question 1 continues on the next page

Turn over ►

The student moves **D** along the metre ruler towards **R** and observes a series of maximum and minimum readings on the microammeter. He identifies **Q** as the position of the **8th minimum** current from **P**. He measures the distance **PQ** to be 50.9 cm, as shown in **Figure 3**.

Figure 3



0 1 . 3 The absolute uncertainty in identifying any minimum current is ± 0.2 cm.

Determine the percentage uncertainty in the distance **PQ**.

[2 marks]

percentage uncertainty in **PQ** = ____________________ %

0 1 . 4 Deduce the frequency of the microwaves produced by **T**.

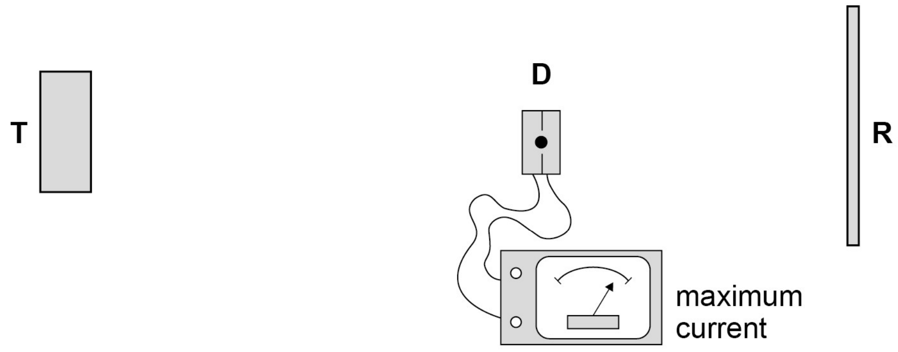
[3 marks]

frequency = ____________________ Hz

Do not write outside the box

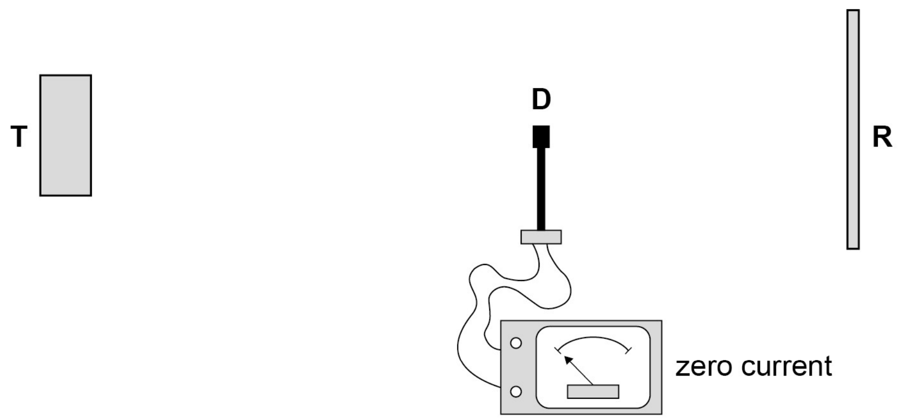
0 1 . 5 **Figure 4** shows **D** placed at a position where the current is a maximum.

Figure 4



The student rotates **D** by $90°$, without changing its distance from **T**, to the position shown in **Figure 5**. The current is now zero.

Figure 5



State the property of microwaves that is shown by this change in current.

[1 mark]

____

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9