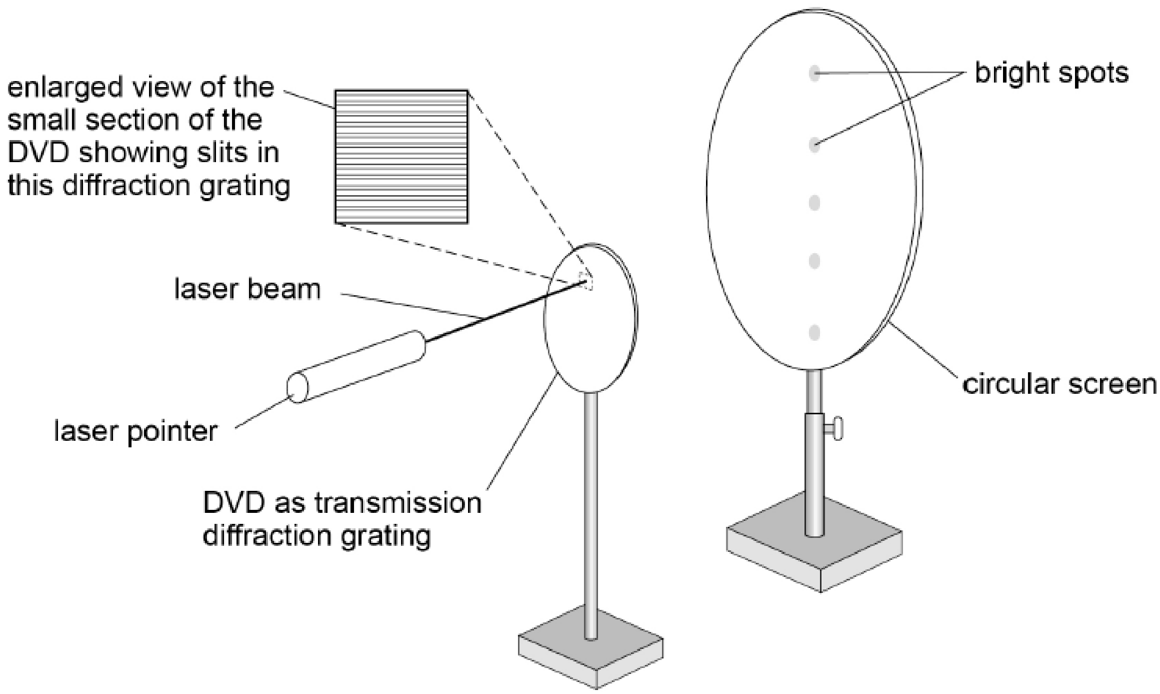
1. June/2021/Paper_7407_01/No.02

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]

___

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

[3 marks]

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

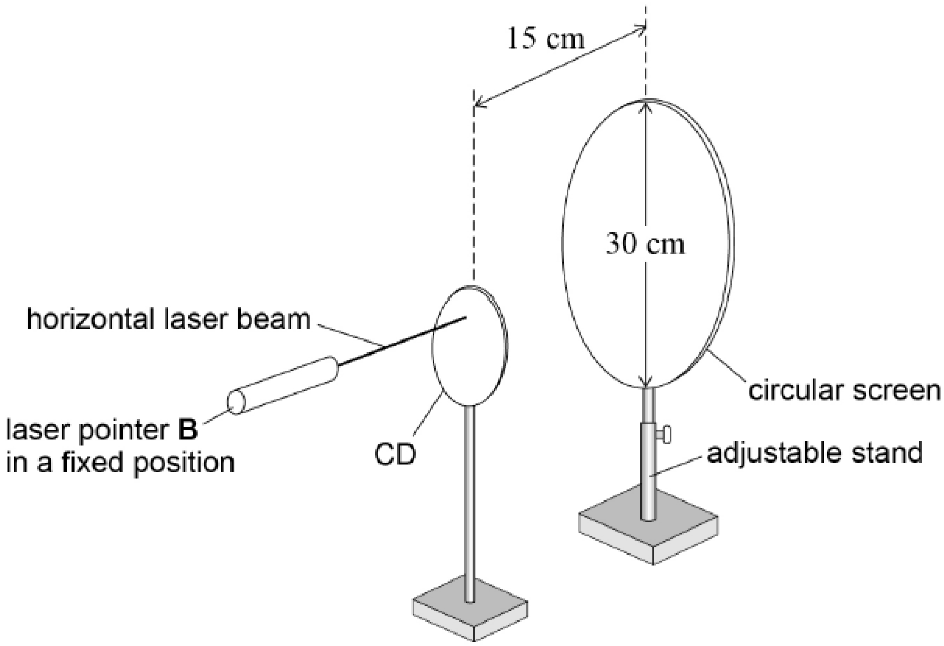
Laser pointer	**Wavelength of light emitted / 10^{-7} m**
A	4.45
B	6.36

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

[2 marks]

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]

2. June/2021/Paper_7407_01/No.07

| 0 | 7 |

Optical fibres are used to carry pulses of light.

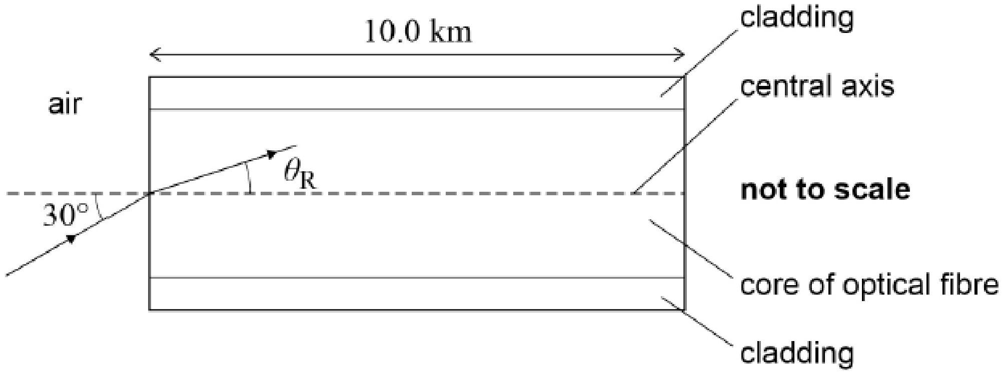
| 0 | 7 | . | 1 |

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

[2 marks]

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.

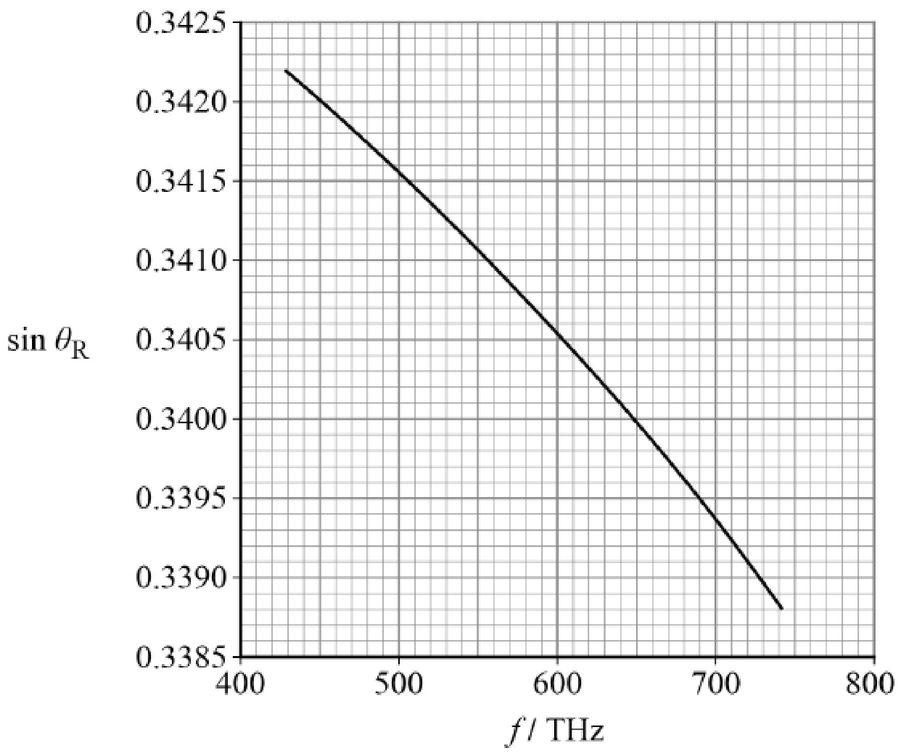
Figure 15



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



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}

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]

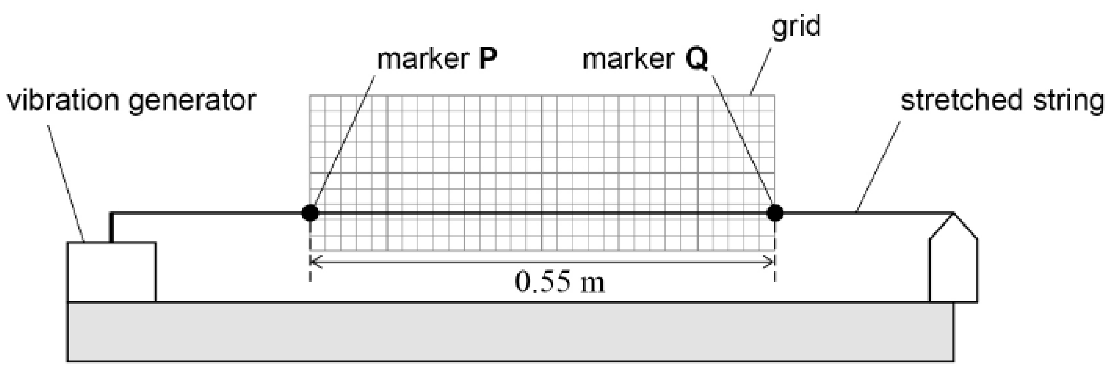
3. June/2020/Paper_7407_01/No.06

0	6

Figure 8 shows the apparatus a student uses to investigate stationary waves in a stretched string.

Two small pieces of adhesive tape are fixed to the string as markers **P** and **Q**. Markers **P** and **Q** are 0.55 m apart and an equal distance from the ends of the string. A graph paper grid is placed behind the string between **P** and **Q**.

Figure 8



not to scale

0	6	. 1

The string is made to vibrate at the second harmonic.

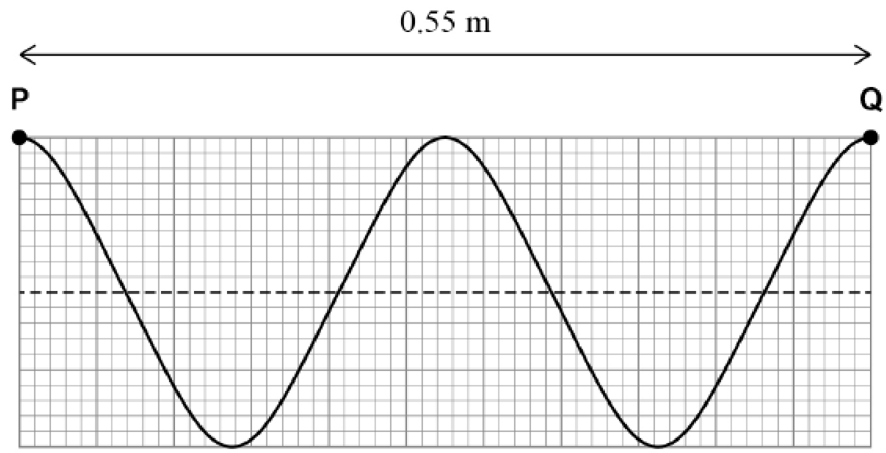
Compare the motion of **P** with that of **Q**.

[2 marks]

0 6 . 2 The frequency of the vibration generator is increased, and a higher harmonic of the stationary wave is formed.

Figure 9 shows the string between **P** and **Q** at an instant in time. The dashed horizontal line indicates the position of the string at rest when the vibration generator is switched off.

Figure 9



The frequency of the vibration generator is 250 Hz.

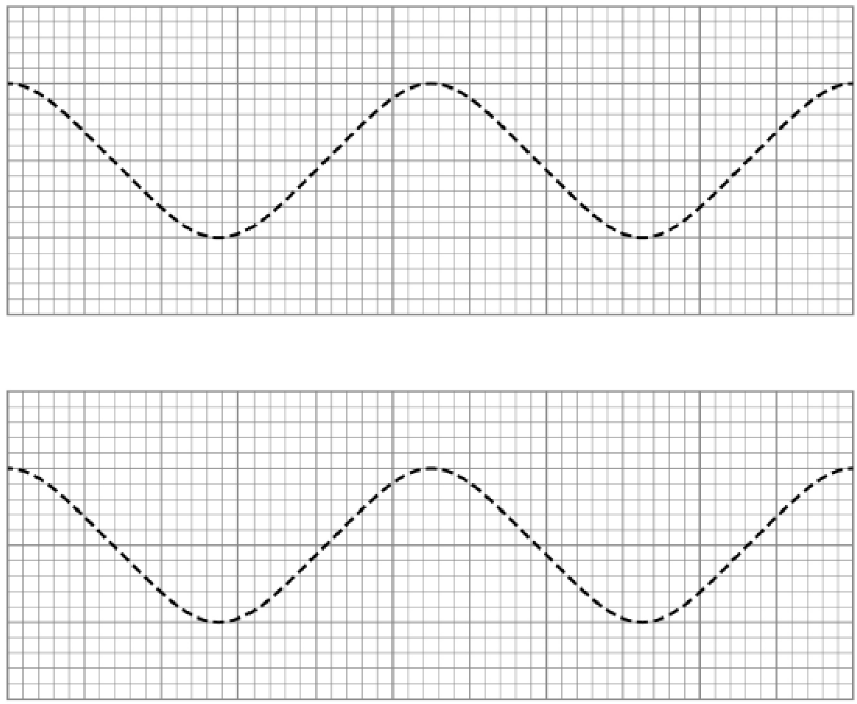
Calculate the wave speed.

[2 marks]

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

0 6 . 3 The instantaneous position of the string in **Figure 9** can be explained by the superposition of two waves. The instantaneous positions of these waves between **P** and **Q** are shown in **Figure 10**.

Figure 10

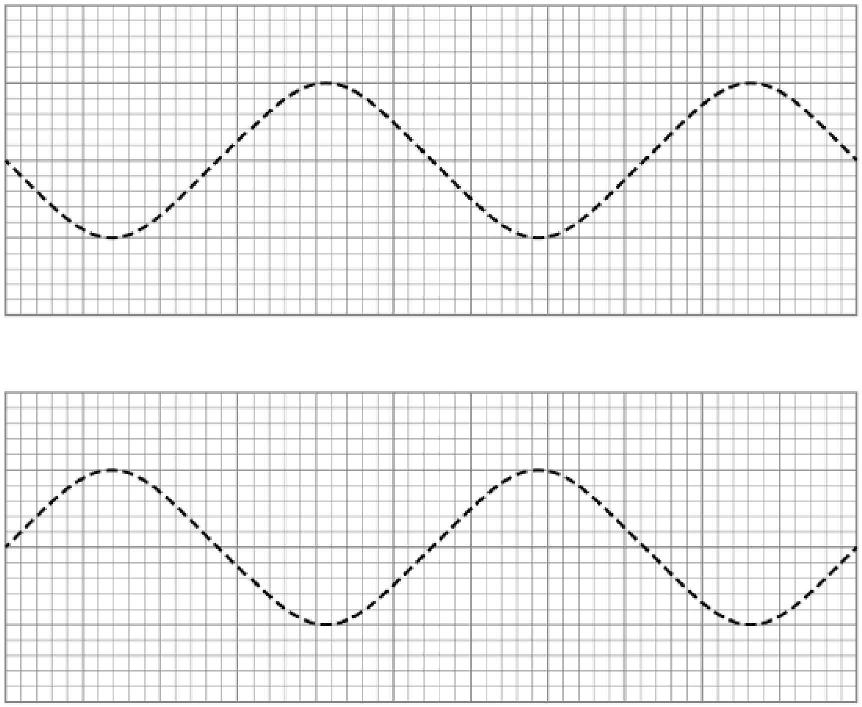


Describe the properties that the waves must have to form the shape shown in **Figure 9**.

[3 marks]

0 6 . 4 **Figure 11** shows the positions of the two waves between **P** and **Q** a short time later.

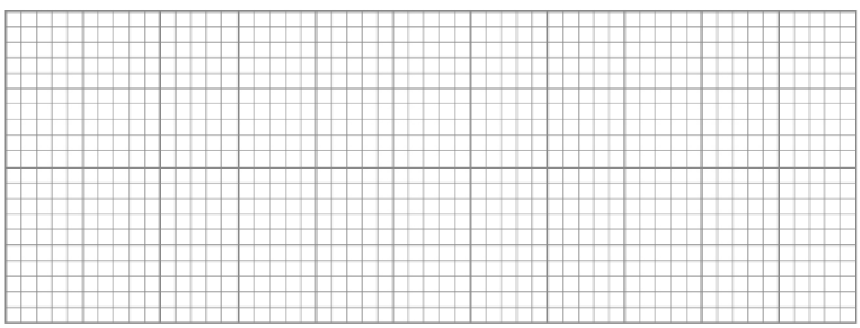
Figure 11



Draw, on **Figure 12**, the appearance of the string between **P** and **Q** at this instant.

[1 mark]

Figure 12

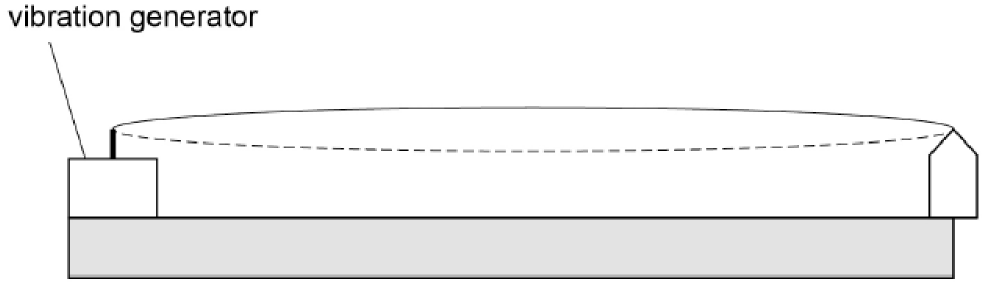


0 6 . 5 Annotate (with an **A**) the positions of any antinodes on your drawing in **Figure 12**.

[2 marks]

0 6 . 6 The frequency of the vibration generator is reduced until the first harmonic is observed in the string, as shown in **Figure 13**.

Figure 13



The string in **Figure 13** is replaced with one that has 9 times the mass per unit length of the original string. All other conditions are kept constant, including the frequency of the vibration generator and the tension in the string.

Deduce the harmonic observed.

[3 marks]