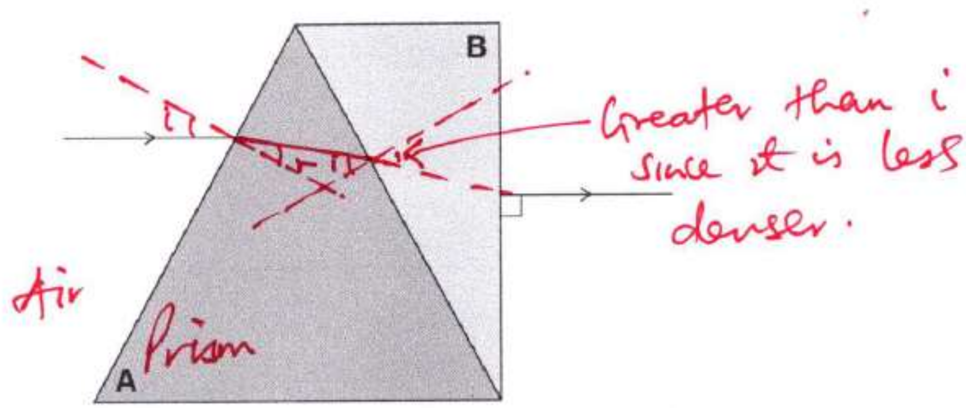
Waves – A2 Physics P1

1. June/2024/Paper_7408/1/No.3

0 3 Figure 1 shows two prisms **A** and **B** of different refractive indices joined to make a block.
A ray of monochromatic light is shown entering and then leaving the block.

Figure 1



0 3 . 1 Complete, on **Figure 1**, the path of the ray of light inside the block.

[1 mark]

η = refractive index

0 3 . 2 Deduce which prism, **A** or **B**, has the greater refractive index.

[2 marks]

From air to prism → η of A is more
From A to B → η is greater for A than B

The block is used with a telescope to investigate stars.
The block can be replaced with a diffraction grating.

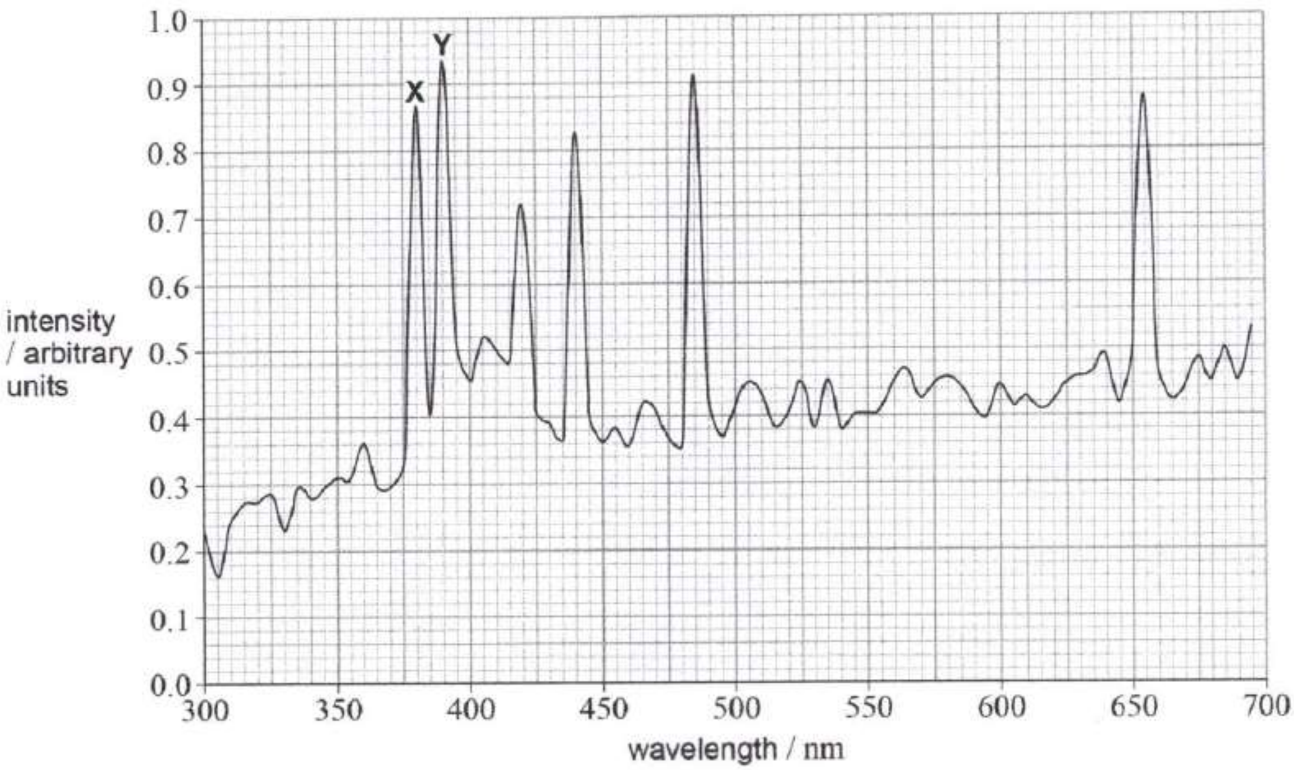
0 3 . 3 Describe **one** non-astronomical application of a diffraction grating.

[1 mark]

Since $d \sin\theta = n\lambda$, we can find wavelength which can help us identify elements in planets and stars.

0 3 . 4 **Figure 2** shows a spectrum of light. Two lines in the spectrum are labelled **X** and **Y**.

Figure 2



The light passes at normal incidence through a diffraction grating. The number of lines per metre for the grating is G.

The first-order diffraction angle of **X** is at 28.2° to the normal.

Calculate G.

[3 marks]

$n = 1$

$\lambda = 380 \times 10^{-9}$ m

G = No. of lines/m = ?

Then

$d \sin\theta = n\lambda$

$d \sin 28.2 = 1 \times 380 \times 10^{-9}$

$d = \dfrac{380 \times 10^{-9}}{\sin 28.2} = 803 \times 10^{-9}$

Then

$G = \dfrac{1}{d} = \dfrac{1}{803 \times 10^{-9}}$

$= 1.2 \times 10^{6}$ /m

$G =$ 1.20×10^{6} m^{-1}

0 3 . 5 A scientist wants to obtain an accurate value for the difference in wavelength between line **X** and line **Y**.

She has two options:

$n=2$ G

- option 1: to analyse the second-order spectrum from the original grating
- option 2: to analyse the first-order spectrum from a grating with $2G$ lines per metre.

$n=1$ $2G$

Discuss which option she should choose.

[3 marks]

option 1

$G = G$ then $d\sin\theta = n\lambda$

$n = 2$ $\frac{1}{G}\sin\theta = 2\lambda \Rightarrow \sin\theta = 2G\lambda$

option 2

$n=1$ then $d\sin\theta = n\lambda$ $\Rightarrow \sin\theta = 2G\lambda$

$G = 2G$ $\frac{1}{2G}\sin\theta = 1\lambda$

So angular separation is same in both cases, so no information obtained

In option 1 ⇒ we have 2^{nd} order which are dimmer images, so not good to distinguish X and Y

Turn over for the next question

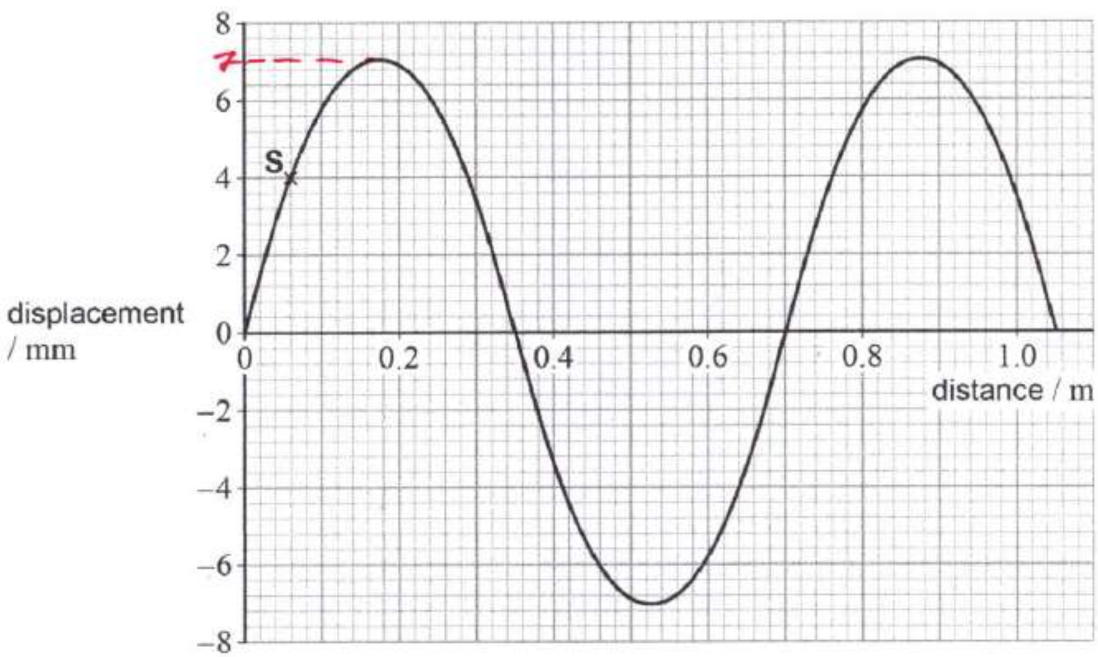
In option 2 ⇒ we have double lines and first order will be very bright and the others can be little dimmer and can be helpful to identify X and Y

2. June/2024/Paper_7408/1/No.7

0 7 An experiment is done to investigate stationary waves on a string.
A string of length 1.05 m is attached between a clamp stand and a vibration generator. A stationary wave is formed on the string when the vibration generator frequency is 625 Hz.

Figure 6 shows the variation of displacement with distance from one end of the string at time $t = 0$
At this time all points on the string have their maximum displacement.
S is one point on the string.

Figure 6



The stationary wave is produced by two progressive waves travelling in opposite directions on the string.

0 7 . 1 Deduce the amplitude of one of the progressive waves.

[1 mark]

2 waves Combine to give Maximum Amplitude due to Superposition of 7mm
So for each A = 3.5mm

amplitude = 3.5 mm

0 7 . 2 Determine, in m s^{-1}, the speed of one of the progressive waves.

[2 marks]

$v = f\lambda$

$= 625 \times 0.7\,m$

$= 440\,m/s$

speed = 440 m s^{-1}

0 7 . 3 State the phase relationship between the two waves when $t = 0$

[1 mark]

In phase or 2π or $360°$ or $0°$

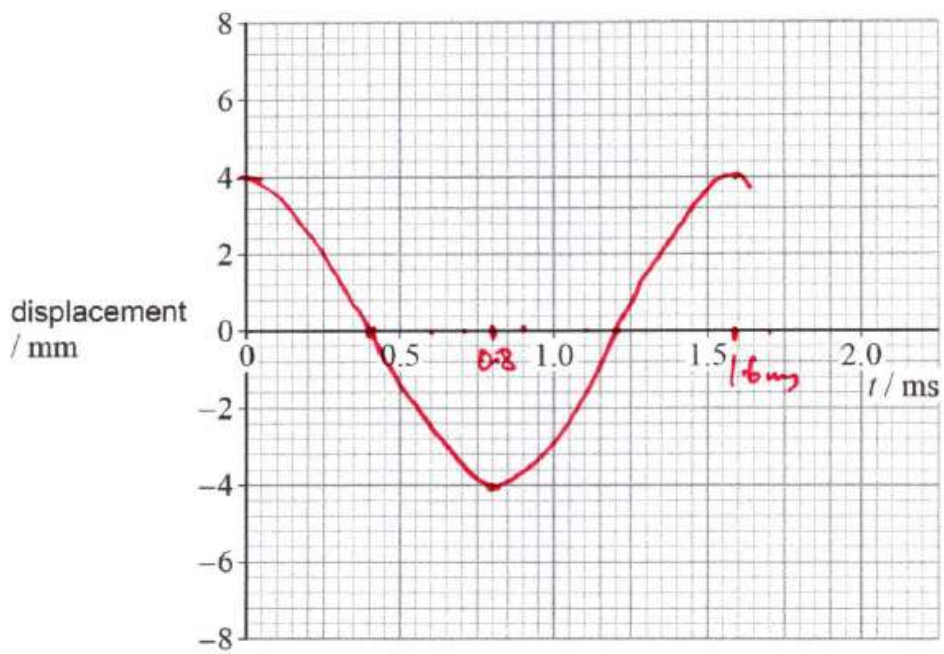
0 7 . 4 Sketch, on **Figure 7**, a graph to show how the displacement of **S** varies with t.

[3 marks]

Figure 7

$f = 625\,Hz$

$T = \frac{1}{f} = \frac{1}{625} = 1.6\,ms$



3. June/2024/Paper_7408/1/No.13

A laser emits light of wavelength 600 nm for 10 ns.

What is the number of complete waves emitted by the laser?

[1 mark]

A 5×10^{17} ☐

B 5×10^{12} ☐

C 5×10^{8} ☐

D 5×10^{6} ☒

$\lambda = 600 \times 10^{-9}$ m

$t = 10$

$c = f\lambda$

$f = \frac{c}{\lambda} = \frac{3 \times 10^{8}}{600 \times 10^{-9}}$

$= 5 \times 10^{14}$ Hz

No of waves $= f \times t$

$= 5 \times 10^{14} \times 10^{-9}$ s

$= 5 \times 10^{6}$ waves

4. June/2024/Paper_7408/1/No.14

A detector measures the intensity of light from a source S_1.

Polaroid material is placed between source S_1 and the detector. When the material is rotated through a small angle, the detected intensity does not change.

When this procedure is repeated for a source S_2, the detected intensity decreases.

Which is correct?

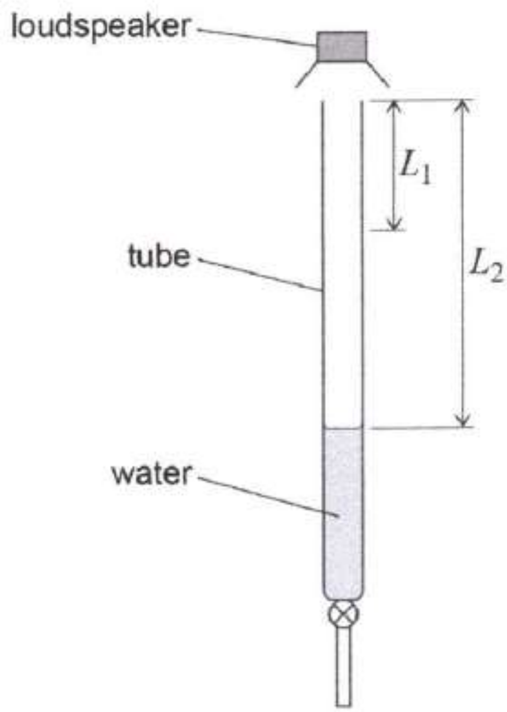
[1 mark]

	Light waves from S_1	Light waves from S_2	
A	unpolarised	polarised	☒
B	unpolarised	unpolarised	☐
C	polarised	polarised	☐
D	polarised	unpolarised	☐

If no change, then the Source does not stop light on any plane hence unpolarized
If there is change, then it is polarised.

5. June/2024/Paper_7408/1/No.15

A loudspeaker producing a single-frequency sound is mounted above a tube filled with water. A tap at the bottom of the tube is opened to allow the water to run out.



A student observes the change in loudness of the sound emitted by the tube as the water runs out.
When the length of the column of air in the tube reaches L_1, the loudness is at its first maximum.
The next maximum is reached when the length of the column of air is L_2.

What is the wavelength of the sound emitted by the loudspeaker?

[1 mark]

A L_2 ☐

B $2L_1$ ☐

C $L_2 - L_1$ ☐

D $2(L_2 - L_1)$ ☒

$L_1 = \frac{\lambda}{4}$

$L_2 = \frac{3\lambda}{4}$

$L_2 - L_1 = \frac{3\lambda}{4} - \frac{\lambda}{4} = \frac{\lambda}{2}$

$2 \times \frac{\lambda}{2} = (L_2 - L_1) \times 2$

$\lambda = 2(L_2 - L_1)$

6. June/2024/Paper_7408/1/No.16

Point sources of sound of the same frequency are placed at S_1 and S_2.

A sound detector is moved slowly along the line **PQ**. Consecutive maxima of sound intensity are detected at **W** and **Y** and consecutive minima are detected at **X** and **Z**.

What is the wavelength of the sound?

[1 mark]

Path difference is $(S_1P - S_2P)$

At W & Y there is a Maxima

So $\lambda = (S_1Y - S_2Y) - (S_1W - S_2W)$

and at X and Z, there is a Minima

So $\lambda = (S_1Z - S_2Z) - (S_1X - S_2X)$

A $(S_1Y–S_2Y) – (S_1W–S_2W)$ ☒

B $(S_1X–S_2X) – (S_1W–S_2W)$ ☐

C $(S_1Y–S_2Y) – (S_1X–S_2X)$ ☐

D $(S_1Z–S_2Z) – (S_1W–S_2W)$ ☐

7. June/2024/Paper_7408/1/No.17

Monochromatic light is used in a Young's double-slit interference experiment after passing through a single slit. The resulting fringe pattern is observed on a screen.

The separation of the fringes can be increased by

$\Delta y = \frac{\lambda D}{d}$

you need a longer wavelength so lower frequency to increase separation of fringes.

[1 mark]

A using monochromatic light of lower frequency. ☒

B decreasing the width of the single slit. ☐

C increasing the separation of the double slits. ☐

D decreasing the distance between the double slits and the screen. ☐