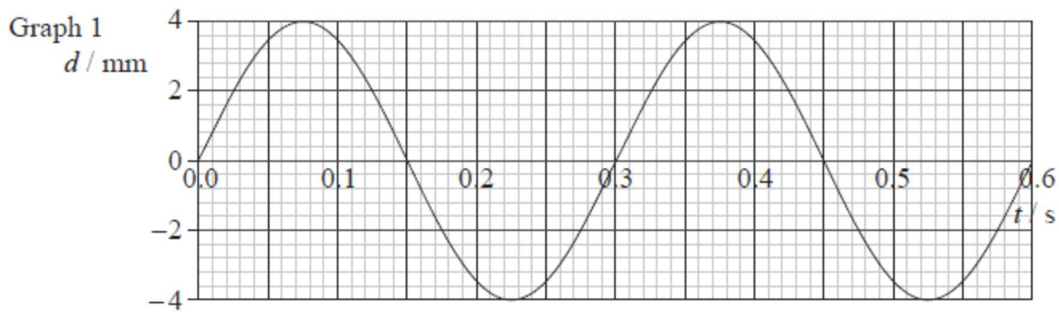
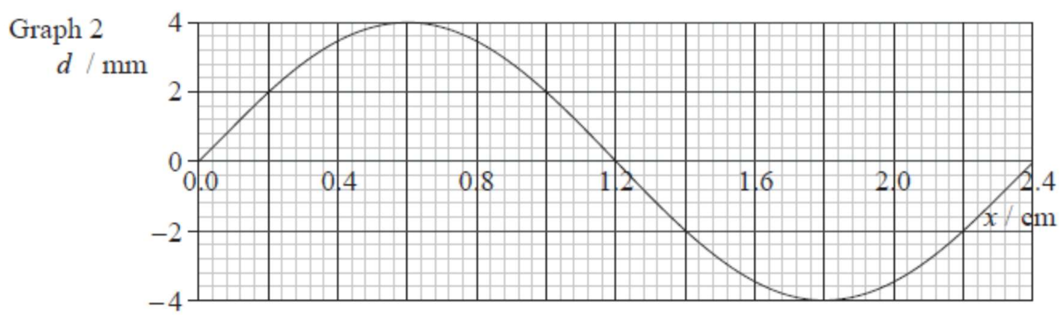
Wave Motion Tutorial

Question 1

In the graphs shown below, Graph 1 shows the variation with time t of the displacement d of a travelling (progressive) wave. Graph 2 shows the variation with distance x along the **same wave** of its displacement d.



Wave number : $k = \frac{2\pi}{\lambda}$



(i) State what is meant by a travelling wave. [1]

(ii) Determine the amplitude, wavelength, frequency and speed of this wave from the two graphs (Graph 1 & Graph 2) provided. [4]

Amplitude = 4mm

frequency = $\frac{1}{0.3}$ Hz

λ = 2.4 cm

$V = 0.024 \times \frac{1}{0.3}$

= 0.08 m/s

Vol of sphere = $\frac{4}{3}\pi R^3$

Question 2

A radio telescope is an instrument consisting of a large parabolic dish aerial to collect and focus radio waves to a radio receiver that is capable of very high amplification. Such a system looks similar to those used at any satellite ground station.

The radio telescopes are used to detect radio-frequency radiation that are emitted by extra-terrestrial sources such as distant galaxies. This is because such sources emit enormous amount of radio waves.

One such galaxy is Cygnus A, which is a very distant galaxy that is too faint to be seen by its visible emission. Its radio emission is enormous, making it *the second brightest object in the sky to the radio eye*.

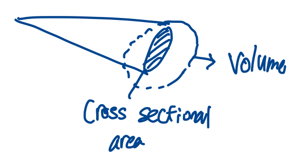
$I = \frac{P_t}{4\pi R^2}$

Total power emitted by Cygnus A, $P_{total} = 10^{37}$ W

Total power received by the Earth, $P_{Earth} = 10$ W.

Diameter of the dish aerial at Jodrell Bank, $d = 80$ m

Diameter of the Earth, $D = 1.3 \times 10^7$ m



(i) What do you understand from the statement '*the second brightest object to the radio eye*'?

Intensity

(ii) Estimate the intensity of the wave received from Cygnus A on Earth.

$I = \frac{\text{Power received by earth}}{\text{Cross sectional area}} = \frac{10}{\pi(0.65 \times 10^7)^2} = 7.54 \times 10^{-14}$

(iii) Estimate the distance to Cygnus A from the Earth.

$I = \frac{P_t}{4\pi R^2} \Rightarrow R = \sqrt{\frac{P_t}{4\pi I}} = 3.25 \times 10^{24}$ m

(iv) Show that the magnitude of the power from Cygnus A collected by the radio telescope's aerial is approximately of the order of 10^{-10} W.

Power Received by telescope

$P_{tele} = I \times \pi\left(\frac{d}{2}\right)^2$

$= (7.54 \times 10^{-14}) \times \pi \times \left(\frac{80}{2}\right)^2$

$= 3.8 \times 10^{-10}$ W

Question 3

State the characteristic features of

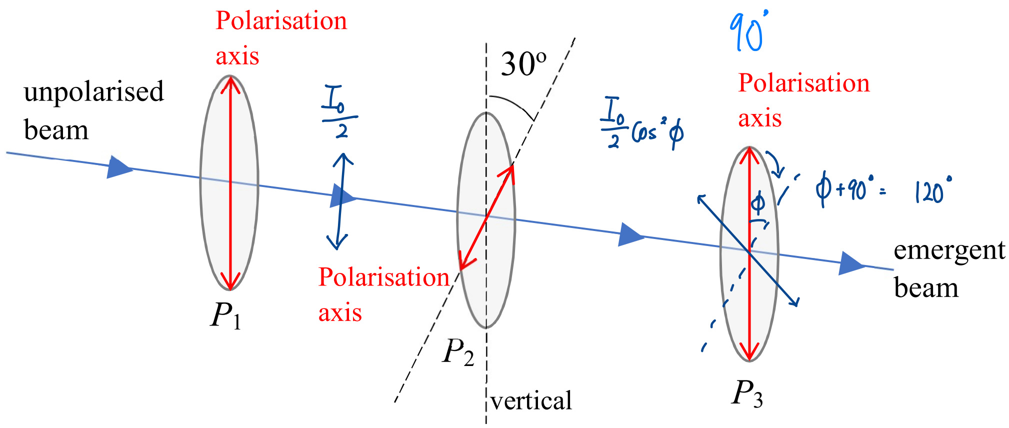
(i) longitudinal wave, and parrallel

(ii) transverse wave. perpendicular

Polarisation can be any direction

Question 4

A beam of unpolarised light passes through Polaroids P_1, P_2 and P_3 as shown below.

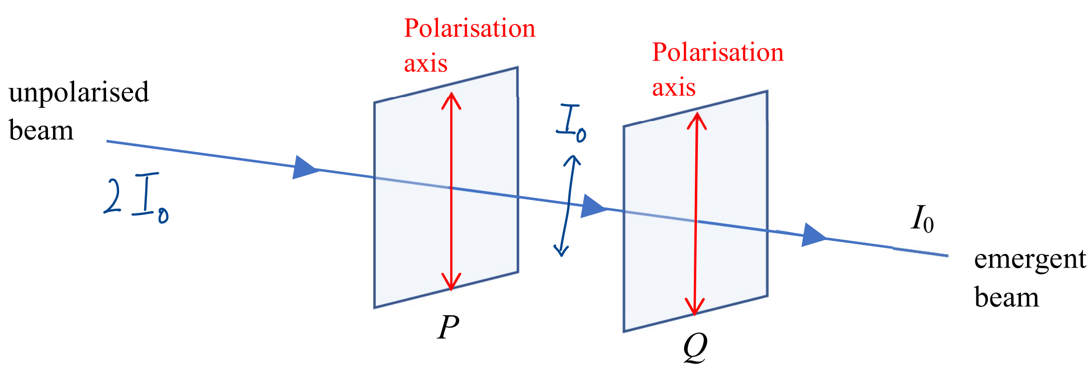


The polarisation axes of both Polaroid P_1 and P_3 are vertical but that of Polaroid P_2 is inclined at an angle of 30° to the vertical. In order to obtain the minimum intensity for the emergent beam, through what angle must Polaroid P_3 be rotated in the clockwise direction?

120°

Question 5

Two pieces of Polaroids, P and Q, are arranged such that their polarisation axes are parallel and vertical, as shown below. The intensity of the emergent light is I_0. Through what angle must Q be rotated so that the intensity of the emergent light decreases to $\frac{1}{2}I_0$?



$$\cos^2\theta = \frac{1}{2}$$

$$\theta = \cos^{-1}\left(\frac{1}{\sqrt{2}}\right)$$

$$= 45°$$

Answers:

Question 1

(ii) amplitude = 4.0mm

wavelength = 2.4 cm

frequency =1/0.3 = 3.3Hz

speed = 3.3 x 2.4 = 8.0cms^{-1}

Question 2

(ii) 7.5 x 10^{-14} W m^{-2}

(iii) 3.25 x 10^{24} m

Question 4

Angle that P_3 must be rotated in clockwise direction = 120 ^{o}.

Question 5

Angle that Q must be rotated = 45 ^{o}.