AQA, Edexcel, OCR

A Level

A Level Physics

WAVES: Wave Properties

(Answers)

Name:

MME
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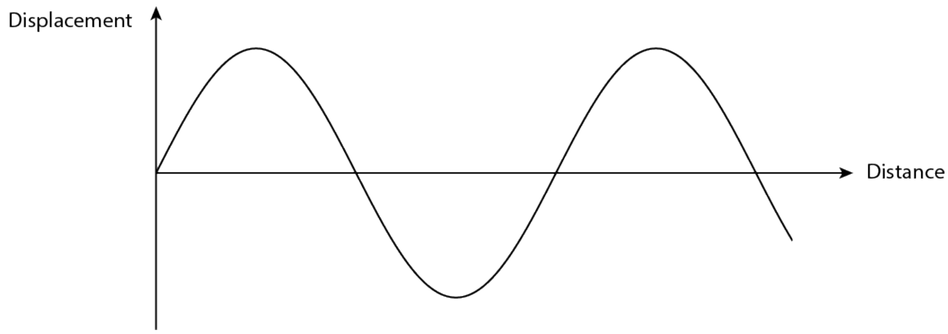
Total Marks: /30

1. Total for Question 1: 8



(a) Is the progressive wave shown in above transverse or longitudinal? [1]

Solution: Transverse.

(b) Annotate the sketch to show the wave's amplitude and wavelength. [2]

Solution: Amplitude: the *displacement* from a crest or a trough to the distance axis.
Wavelength: the *distance* between any two points of identical nature.

(c) How can an oscilloscope be used to calculate a wave's frequency? Sketch any relevant plots. [2]

Solution: For one cell: $\epsilon = 6\ V, I = 0.58\ A$
For parallel: $\epsilon = 6\ V, I = 1.16\ A$
For series: $\epsilon = 12\ V, I = 0.58\ A$
He should combine his cells in parallel: the emf will be the same as for the single cell and the current will be greatest.

(d) Which the of the following statements about are true? When a wave passes through a hole or moves around an object... [3]

1. ... its speed remains constant but both its wavelength and frequency change.
2. ... only an electromagnetic wave will diffract.
3. ... its wavelength, frequency and speed remain constant.
4. ... it will refract irrespective of what type of wave it is.
5. ... it will refract if its wavelength is less than 400 nm.
6. ... significant diffraction will only occur if the size of the gap or obstacle and the wavelength are similar.

Solution: Correct: 3, 4, 6

2. Microscopy exploits the predictable way in which electromagnetic radiation propagates through different media.

Total for Question 2: 10

(a) Which two of the following are correct? [2]

1. Vibrations associated with electromagnetic waves are perpendicular to the direction of energy propagation.
2. All electromagnetic waves travel at 3×10^8 kmhr^{-1}.
3. Electromagnetic waves cannot travel through a vacuum.
4. All electromagnetic waves travel at about 3×10^8 ms^{-1}in a vacuum.
5. Electromagnetic waves are longitudinal waves.

Solution: 1 and 4.

(b) The EM spectrum is divided primarily on the basis of wavelength. Put the following in order of increasing frequency: x-rays, radiowaves, UV, microwaves. [2]

Solution: Radio-micro-UV-X

In an optical microscope, two plane-polarisers are often used. The first polarises light before it enters the region in which a sample can be placed. The second is on the other side of the stage. Their relative orientations are crucial if a useable result is to be obtained.

(c) Consider the case in which the polarisers are at 45° to each other; there is no sample on the stage. By resolving the amplitude of a wave that has passed through the first polariser, show how the amplitude of the light transmitted through both depends on the angle, θ , between the polarisation directions. [2]

Solution: $A \propto \cos\theta$

(d) How would the intensity vary with the angle θ? Sketch a graph of intensity against θ for $0 \leq \theta \leq 360$. [4]

Solution: $I \propto \cos^2 \theta$

3. Seismic surveys are a very useful way to probe Earth's deep structure. However, without understanding the manner in which acoustic waves interact with gradients and discontinuities of velocity, the data obtained is useless.

Total for Question 3: 12

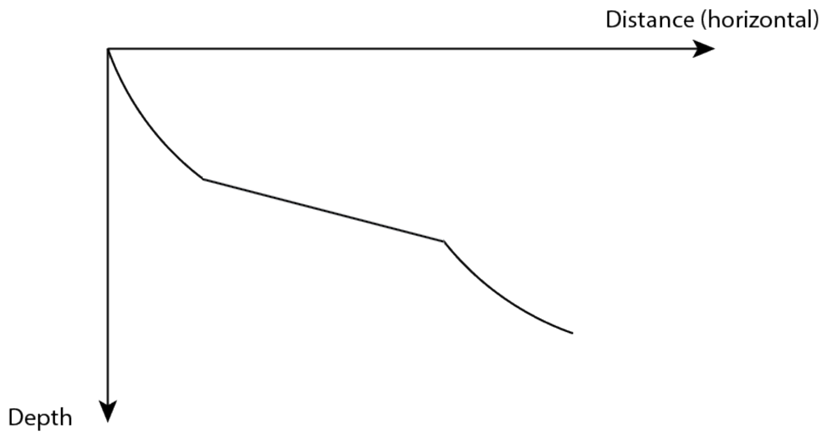


Figure 1: Downward ray path of a wave used in a seismic survey of Earth.

(a) A p-wave (longitudinal) travelling through granite has a velocity of 5 kms^{-1} and a frequency of 1 Hz. What is its wavelength? [1]

Solution: 5000 m

(b) Snell's Law states that $n_1 \sin\theta_1 = n_2 \sin\theta_2$. Explain what is meant by the 'critical angle' and how an expression for it may be obtained from Snell's Law. [3]

Solution: The angle subtended by a ray and the normal, above which no energy is transmitted or refracted; all is reflected at the angle of incidence.
Occurs when $\sin\theta_2 = 1 \rightarrow \sin\theta_c rit = \frac{n_2}{n_1}$.

(c) Figure 1 shows the ray path of a wave in a seismic survey. Describe how the acoustic velocity of the rock changes with depth. [4]

> **Solution:** Maximum velocity when the gradient is shallowest i.e in the obvious layer at intermediate depth.
> Lowest velocity when steepest i.e. at 0,0
> From surface: v gradually increases in a continuous manner; anomalous high and constant velocity layer; gradual increase again thereafter, but from a lower velocity than that immediately above the layer.

Figure 2 is a close-up of an interface at intermediate depth in the figure above. $\theta_1 = 70, \theta_2 = 45$ and $v_2 = 5.4$ kms^{-1}.

(d) Calculate the acoustic velocity of layer 1. [2]

> **Solution:** 7176 ms^{-1}

(e) Can total internal reflection occur at this interface? Justify your answer. [2]

> **Solution:** Not in the downward direction: $\sin\theta_1 \leq 1$ i.e. the ray must be going from a region of low velocity into one of high velocity.

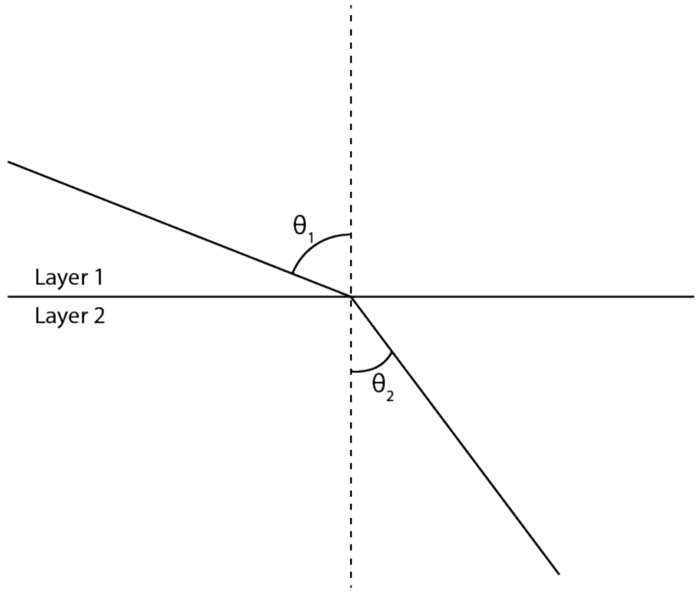


Figure 2: Downward ray path of an acoustic wave used in a seismic survey.