InkPhysics

ANSWER BOOK

Longitudinal, transverse and polarisation

Waves · Year 12

AQA 3.3.1.2 · CIE 7.2.1, 7.2.2, 7.4.1, 7.4.2, 7.4.3, 7.5.1, 7.5.2
OCR A 4.4.1(a), 4.4.1(e), 4.4.1(f)(i), 4.4.2(a), 4.4.2(b), 4.4.2(c)

17 questions · 49 marks

NAVY EDITION

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SECTION A · Warm-up

A1 In a transverse wave the particles oscillate at right angles to the direction of energy transfer (1); in a longitudinal wave they oscillate parallel to it (1). [2]

A2 $\lambda = c/f = 340/170$ (1)
$\lambda = 2.0$ m (1) [2]

A3 Transverse: light (or any electromagnetic wave, or a wave on a string) (1).
Longitudinal: sound (or a compression wave on a spring) (1). [2]

A4 A compression is a region where the air particles are bunched together, so the pressure is a maximum (1). A rarefaction is a region where the particles are spread apart, so the pressure is a minimum (1). [2]

A5 3.00×10^8 m s^{-1} (1). Visible light runs from about 400 nm (violet) to about 700 nm (red) (1). [2]

SECTION B · Standard

B1 Plane-polarised light has its oscillations confined to a single plane (1). Only transverse waves can be polarised because their oscillations are perpendicular to the travel direction, so a plane can be selected (1); longitudinal oscillations are along the travel direction, so there is no such choice (1). [3]

B2 For unpolarised light the transmitted brightness stays roughly constant as the single filter rotates (1), because about half the light passes at any angle (1). For already-polarised light, the brightness varies from a maximum to zero and back as the filter rotates, being zero when its axis is perpendicular to the polarisation (1). [3]

B3 $\lambda = c/f = (3.0 \times 10^8)/(3.0 \times 10^9)$ (1)
$\lambda = 0.10$ m (1)
Rotating a metal grille (or receiver) between transmitter and detector changes the received signal, which shows the microwaves are polarised (1) [3]

B4 The wave drives oscillations (a current) in the aerial only when the rods lie along the plane of oscillation of the wave (1). As the aerial is rotated away from this plane the received signal strength falls (1), reaching a minimum (near zero) when the rods are at 90° to the plane of polarisation (1). [3]

B5 $f = c/\lambda$ (1). At 400 nm: $f = (3.00 \times 10^8)/(400 \times 10^{-9}) = 7.5 \times 10^{14}$ Hz; at 700 nm: $f = 4.3 \times 10^{14}$ Hz (1). Visible frequencies run from about 4.3×10^{14} Hz up to 7.5×10^{14} Hz (1). [3]

B6 (a) North–south only: sound is longitudinal, so the particles oscillate parallel to the direction of travel (1). (b) Any direction perpendicular to north (for example vertical, or east–west): radio waves are transverse (1). [2]

SECTION C · Stretch

C1 Each filter transmits the component of the oscillation along its axis (1). The first filter polarises the light; the 45° filter transmits a component at 45°, re-orienting the polarisation (1); that light then has a component along the final filter's axis, so some passes (1). Without the middle filter the light reaching the last filter is perpendicular to its axis and is blocked (1). [4]

C2 Light reflected from such surfaces is partially polarised in the horizontal plane (1). Polarising sunglasses have a vertical transmission axis (1), so they block much of this horizontally-polarised reflected glare while still letting other light through (1). [3]

C3 Sound is longitudinal: its oscillations are along the direction of travel, not perpendicular to it (1). There is no plane of oscillation to select (1), so a filter cannot restrict it and sound cannot be polarised (1). [3]

C4 Place the filter in each beam in turn and rotate it in its own plane through at least 90° (1). For the unpolarised beam the transmitted brightness stays roughly constant at every angle (1). For the plane-polarised beam the brightness varies from a maximum to near zero, the minimum occurring when the transmission axis is at 90° to the plane of polarisation (1). The beam whose brightness varies on rotation is the plane-polarised one (1). [4]

C5 Point the receiver at the transmitter and record the meter reading (1). Rotate the receiver (or a metal grille placed between them) about the line joining transmitter and receiver, recording the signal at intervals (1). The signal falls to a minimum (near zero) when the receiver has turned through 90° and returns to a maximum at 180° (1). The signal depends on orientation, so the oscillations are confined to a single plane: the microwaves are plane polarised (1). Only oscillations perpendicular to the direction of travel can be selected by orientation in this way, so microwaves must be transverse (1). [5]

C6 Q is visible light: 550 nm lies in the visible range, about 400 nm to 700 nm (1). P is a microwave: 3.0 cm lies between about 10 cm and 1 mm (1). $f = c/\lambda = (3.00 \times 10^8)/(550 \times 10^{-9}) = 5.5 \times 10^{14}$ Hz (1). [3]