3.3 Waves: Test Pack

AQA 7408 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A group of students at a school in Leeds use a ripple tank to study water waves, and then compare their properties with sound waves and light waves.

(a) State one difference between a transverse wave and a longitudinal wave. **(2)**

(b) The dipper of the ripple tank vibrates with a period of 0.20 s. Calculate the frequency of the water waves produced. **(2)**

(c) The students measure the wavelength of the ripples as 8.0 mm. Use $v = f \times \lambda$ to calculate the speed of the water waves in m/s. **(3)**

(d) Sound waves cannot be polarised, whereas light waves can. Explain why this difference occurs, referring to the type of wave that sound and light each are. **(2)**

(e) State the principle of superposition of waves. **(1)**

(Total for Question 1 is 10 marks)

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2 Quickfire recall questions on wave properties. Identify the correct answer for each.

(a) Which of the following is a longitudinal wave? **(1)**

- ☐ A) Light
- ☐ B) Water ripples
- ☐ C) Sound
- ☐ D) Radio waves

(b) Which quantity is measured in hertz (Hz)? **(1)**

- ☐ A) Wavelength
- ☐ B) Amplitude
- ☐ C) Period
- ☐ D) Frequency

(c) Two coherent waves arrive at a point with a path difference of $(n + 1/2) \times \lambda$. What type of interference occurs at this point? **(1)**

- ☐ A) Constructive interference
- ☐ B) Destructive interference
- ☐ C) No interference at all
- ☐ D) Refraction

(d) Which row correctly orders three electromagnetic waves from longest to shortest wavelength? **(1)**

- ☐ A) Gamma, visible, radio
- ☐ B) Radio, visible, γ
- ☐ C) Visible, radio, γ
- ☐ D) Gamma, radio, visible

(Total for Question 2 is 4 marks)

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3 This question tests core definitions used to describe wave interference.

(a) State what is meant by two sources of waves being coherent. **(1)**

(b) Define what is meant by the path difference between two waves arriving at a point. **(1)**

(c) State the principle of superposition of waves. **(2)**

(Total for Question 3 is 4 marks)

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4 An oscilloscope connected to a microphone displays the sound wave produced by a tuning fork. One complete cycle occupies 8.0 divisions on the screen, with the time-base set to 0.50 ms per division. The peak-to-peak height of the trace is 4.0 divisions, with the y-sensitivity set to 10 mV per division.

(a) Calculate the period of the sound wave, in seconds, and hence its frequency. **(3)**

(b) Calculate the peak-to-peak voltage of the trace and hence the amplitude of the signal, in mV. **(2)**

(c) State what property of the oscilloscope trace corresponds to the loudness of the sound. **(1)**

(d) The speed of sound in air is 340 m/s. Use $v = f \times \lambda$ to calculate the wavelength of the sound wave. **(3)**

(e) Calculate the wavelength of a sound wave of the same frequency travelling through sea water, where the speed of sound is 1500 m/s, and comment on how this wavelength compares with the wavelength found in part (d). **(3)**

(Total for Question 4 is 12 marks)

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5 An optical fibre used in a communications link has a core of refractive index 1.485 surrounded by cladding of refractive index 1.462.

(a) Calculate the critical angle for the core-cladding boundary. **(3)**

(b) Explain why a light ray entering the fibre within the acceptance cone undergoes total internal reflection repeatedly as it travels along the fibre. **(2)**

(c) State and explain two reasons why the fibre is manufactured with a cladding layer rather than being left bare (surrounded by air). **(2)**

(Total for Question 5 is 7 marks)

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6 Two tuning forks are sounded together. One fork has a known frequency of 512 Hz. The two notes produce 6 beats per second. A small piece of tape is then added to the 512 Hz fork, which slightly lowers its frequency, and the beat frequency is observed to decrease to 4 beats per second.

(a) Calculate the two possible values of the unknown fork's frequency, based on the initial beat frequency alone. **(2)**

(b) Using the effect of loading the 512 Hz fork on the beat frequency, determine which of the two values is correct, explaining your reasoning. **(3)**

(Total for Question 6 is 5 marks)

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Mark scheme · 3.3 Waves: Test Pack

Question 1

(a) in a transverse wave the oscillations (of the particles or field) are perpendicular to the direction of energy transfer (wave travel) oe **B1**

(a) in a longitudinal wave the oscillations are parallel to the direction of energy transfer, producing compressions and rarefactions oe **B1**

(a) Answer: Transverse: oscillations perpendicular to the direction of travel. Longitudinal: oscillations parallel to the direction of travel.

(b) correct use of f = 1/T = 1/0.20 **M1**

(b) 5.0 Hz (cao) **A1**

(b) Answer: 5.0 Hz

(c) converts wavelength to metres: 8.0 mm = 8.0 x 10^{-3} m **M1**

(c) correct substitution: v = 5.0 x 8.0 x 10^{-3} **M1**

(c) 4.0 x 10^{-2} m/s (awrt, cao, ft from (b)) **A1**

(c) Answer: 4.0 x 10^{-2} m/s (0.040 m/s)

(d) only transverse waves can be polarised, since polarisation restricts oscillations to a single plane perpendicular to the direction of travel oe **B1**

(d) sound is a longitudinal wave (no perpendicular oscillation to restrict) so it cannot be polarised, whereas light is a transverse wave so it can oe **B1**

(d) Answer: Only transverse waves can be polarised. Light is transverse so it can be polarised; sound is longitudinal so it cannot.

(e) when two or more waves meet at a point, the resultant displacement equals the vector sum of the displacements of the individual waves oe **B1**

(e) Answer: The resultant displacement at a point where waves meet is the vector sum of the individual displacements.

Question 2

(a) correct option identified: C **B1**

(a) Answer: C

(b) correct option identified: D **B1**

(b) Answer: D

(c) correct option identified: B **B1**

(c) Answer: B

(d) correct option identified: B **B1**

(d) Answer: B

Question 3

(a) the sources emit waves of the same frequency (and wavelength) with a constant (fixed) phase difference oe **B1**

(a) Answer: The sources emit waves of the same frequency with a constant phase difference between them.

(b) the difference in the distance travelled by the two waves from their sources to the point oe **B1**

(b) Answer: The difference in distance travelled by the two waves from their respective sources to the point considered.

(c) when two or more waves meet at a point, the resultant displacement **B1**

(c) is the vector sum of the individual displacements of each wave at that point oe **B1**

(c) Answer: When two or more waves meet at a point, the resultant displacement at that point is the vector sum of the displacements that each wave would cause individually.

Question 4

(a) period = 8.0 x 0.50 = 4.0 ms **M1**

(a) converts to seconds: 4.0 ms = 4.0 x 10^{-3} s, and uses f = 1/T **M1**

(a) 250 Hz (cao) **A1**

(a) Answer: T = 4.0 x 10^{-3} s, f = 250 Hz

(b) peak-to-peak voltage = 4.0 x 10 = 40 mV **M1**

(b) amplitude = 20 mV (cao) **A1**

(b) Answer: Peak-to-peak = 40 mV, amplitude = 20 mV

(c) the amplitude of the trace oe (a larger amplitude corresponds to a louder sound) **B1**

(c) Answer: Amplitude.

(d) rearranges to λ = v/f **M1**

(d) correct substitution: λ = 340/250 **M1**

(d) 1.4 m (awrt, ft from (a)) **A1**

(d) Answer: 1.4 m

(e) correct substitution: λ = 1500/250 **M1**

(e) 6.0 m (cao, ft from (a)) **A1**

(e) the wavelength in water is much greater (about 4 times greater) than in air, because for the same frequency, wavelength is proportional to speed (v = f x λ, f fixed) oe **B1**

(e) Answer: 6.0 m; the wavelength in water is longer than in air because the speed of sound is greater and frequency is unchanged.

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Question 5

(a) quote $\sin(\theta_c) = n2 / n1$ with n1 = 1.485 (core), n2 = 1.462 (cladding) **M1**

(a) substitute $\sin(\theta_c) = 1.462 / 1.485 = 0.9845$ **M1**

(a) $\theta_c = 79.9$ degrees cao **A1**

(a) Answer: 79.9 degrees

(b) the ray strikes the core-cladding boundary at an angle of incidence greater than the critical angle **B1**

(b) since the core has a higher refractive index than the cladding, all the light is reflected (none is transmitted/refracted into the cladding) at each reflection, so this repeats along the fibre oe **B1**

(b) Answer: Because the ray always meets the core-cladding boundary at an angle greater than the critical angle, and the core is optically denser than the cladding, total internal reflection occurs at every reflection along the length of the fibre.

(c) cladding protects the core from scratches and contamination that would otherwise scatter light out of the core and cause signal loss oe **B1**

(c) cladding prevents light escaping into adjacent fibres (crosstalk) when fibres are bundled together, since with air the critical angle would be much smaller and stray contact points could couple light out oe **B1**

(c) Answer: Cladding protects the core surface from damage and dirt that would scatter light and cause signal loss, and it prevents light coupling between fibres that are in contact when bundled (crosstalk), which would occur more readily with a bare core in air.

Question 6

(a) use beat frequency = |f1 - f2|, so f = 512 ± 6 **M1**

(a) f = 506 Hz or f = 518 Hz cao **A1**

(a) Answer: 506 Hz or 518 Hz

(b) adding tape lowers the frequency of the 512 Hz fork slightly **M1**

(b) if the unknown frequency were 518 Hz, lowering 512 Hz would increase the frequency difference, so the beat frequency would rise, not fall; if the unknown frequency is 506 Hz, lowering 512 Hz reduces the frequency difference, so the beat frequency falls, matching the observation **M1**

(b) the unknown frequency is 506 Hz cao **A1**

(b) Answer: 506 Hz

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