S5 Physics Practice Paper (Set 2): Wave Properties and Wave Speed, Refraction and Total Internal Reflection, Convex Lens Imaging, Standing Waves and Pipes, Sound Intensity Level, Electromagnetic Waves and Doppler Effect

S5 Physics | Time: 75 minutes | Total: 100 marks | 24 questions

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Section A: Wave Properties and Wave Speed (16 marks)

Show all working with units and simplify your answers.

1. A wave has frequency 250 Hz and wavelength 1.36 m. Find its speed.

v = f x wavelength = 250 x 1.36 = 340.0 m/s.

2. A sound wave of the same 250 Hz travels in water at 1500 m/s. Find its wavelength in water.

wavelength = 1500 / 250 = 6.0 m.

3. What is the period of the 250 Hz wave in milliseconds?

T = 1 / 250 = 0.004 s = 4.0 ms.

4. The wave moves from deep to shallow water and slows to 136 m/s. If the frequency is unchanged, find the new wavelength.

Frequency is unchanged, so wavelength = 136 / 250 = 0.544 m.

Section B: Refraction and Total Internal Reflection (16 marks)

Take the refractive index of air as 1.00; give angles in degrees to 1 decimal place.

5. Light enters glass of refractive index 1.50 from air at an angle of 30°. Find the angle of refraction.

Snell law: sin r = sin 30 / 1.50 = 0.3333, so r = 19.5 degrees.

6. Find the critical angle for light going from this glass (n = 1.50) to air.

sin c = 1 / 1.50 = 0.6667, so c = 41.8 degrees.

7. Water has refractive index 1.33. Find the critical angle at a water-air boundary.

sin c = 1 / 1.33 = 0.7519, so c = 48.8 degrees.

8. An optical fibre has core index 1.50 and cladding index 1.45. Find the critical angle at the core-cladding boundary.

sin c = 1.45 / 1.50 = 0.9667, so c = 75.2 degrees.

Section C: Convex Lens Imaging (20 marks)

Use 1/f = 1/u + 1/v and magnification m = -v/u; v is negative for a virtual image.

9. A convex lens of focal length 10.0 cm has an object at 15.0 cm. Find the image distance and magnification, and state whether it is real.

1/v = 1/10 - 1/15 = 1/30, so v = +30.0 cm (real); m = -30.0/15 = -2.0, inverted and twice the size.

10. With the same lens the object is moved to 5.0 cm. Find the image distance and magnification, and describe the image.

1/v = 1/10 - 1/5 = -1/10, so v = -10.0 cm (virtual, same side as object); m = -(-10)/5 = +2.0, upright and twice the size.

11. Same lens, object distance 25.0 cm. Find the image distance and magnification to 3 significant figures.

1/v = 0.1 - 0.04 = 0.06, so v = 16.67 cm; m = -16.7/25 = -0.667 (inverted and diminished).

12. A convex lens of focal length 8.0 cm is used as a magnifier with the object at 4.0 cm. Find the image distance and magnification.

1/v = 1/8 - 1/4 = -1/8, so v = -8.0 cm (virtual); m = 8/4 = +2.0, upright and twice the size, as expected for a magnifier.

Section D: Standing Waves and Pipes (20 marks)

A string is fixed at both ends; an open pipe has antinodes at both ends and a closed pipe has a node at the closed end.

13. A string 0.80 m long is fixed at both ends and has a fundamental frequency of 220 Hz. Find the wave speed on the string.

At the fundamental, wavelength = 2 x 0.80 = 1.60 m; v = 220 x 1.60 = 352 m/s.

14. Find the frequency and wavelength of the third harmonic of the same string.

f3 = 3 x 220 = 660 Hz; wavelength = 1.60/3 = 0.533 m.

15. An open pipe 0.65 m long (open at both ends) with sound speed 340 m/s. Find its fundamental frequency.

For an open pipe the fundamental wavelength is 2 x 0.65 = 1.30 m, so f = 340/1.30 = 261.5 Hz.

16. A closed pipe of the same 0.65 m length (one end closed): find its fundamental frequency and explain the difference.

For a closed pipe the fundamental wavelength is 4 x 0.65 = 2.60 m, so f = 340/2.60 = 130.8 Hz. A closed pipe supports only odd harmonics, so its wavelength is double and its frequency about half that of the open pipe.

Section E: Sound Intensity and Intensity Level (16 marks)

Use L = 10 log(I/I0) with I0 = 1 x 10^-12 W m^-2; give answers to 1 decimal place.

17. The sound intensity at a point is 1 x 10^-4 W m^-2. Find the intensity level in dB.

I/I0 = 10^-4 / 10^-12 = 10^8, so L = 10 log(10^8) = 80 dB.

18. Elsewhere the intensity is 2 x 10^-5 W m^-2. Find the intensity level.

I/I0 = 2 x 10^7, so L = 10 x 7.301 = 73.0 dB.

19. Two identical tuning forks each producing 60 dB sound together. What is the combined intensity level?

Doubling the intensity gives L = 60 + 10 log 2 = 60 + 3.0 = 63.0 dB, not 120 dB.

20. By how many dB does the intensity level fall when the distance from a point source is doubled?

Intensity falls as 1/r^2, so doubling the distance quarters it: the drop is 10 log 4 = 20 log 2 = 6.0 dB.

Section F: Electromagnetic Waves and Doppler Effect (12 marks)

Take c = 3.0 x 10^8 m/s and the speed of sound as 340 m/s.

21. Visible light of frequency 5.0 x 10^14 Hz: find its wavelength in nm.

wavelength = 3.0 x 10^8 / 5.0 x 10^14 = 6.0 x 10^-7 m = 600 nm.

22. A microwave oven uses 0.125 m waves. Find the frequency in GHz.

f = 3.0 x 10^8 / 0.125 = 2.4 x 10^9 Hz = 2.4 GHz.

23. A car sounding a 500 Hz horn approaches a stationary observer at 30 m/s. Find the frequency heard.

f' = 500 x 340/(340 - 30) = 170000/310 = 548.4 Hz, a higher pitch.

24. A sound is sent towards a cliff and the echo returns after 0.60 s. Find the distance to the cliff.

The sound travels there and back: d = 340 x 0.60/2 = 102 m.

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