Waves

Standard difficulty · 20 questions · 40 marks · Time: 36 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

Section A — Choose the correct answer — 8 × 1 = 8 marks

1. A sound of frequency 200 Hz travels at 336 m/s. Its wavelength is:

(a) 67,200 m **(b)** 0.60 m **(c)** 0.84 m **(d)** 1.68 m

2. A string with mass per unit length 0.019 kg/m is under a tension of 1,385.1 N. The speed of a transverse wave on it is:

(a) 270 m/s **(b)** 72,900 m/s **(c)** 540 m/s **(d)** 135 m/s

3. A string 0.2 m long, fixed at both ends, carries waves at 170 m/s. Its fundamental frequency is:

(a) 212.5 Hz **(b)** 850 Hz **(c)** 34 Hz **(d)** 425 Hz

4. Two tuning forks of 160 Hz and 168 Hz are sounded together. The number of beats per second is:

(a) 160 **(b)** 328 **(c)** 16 **(d)** 8

5. Sound waves in air are:

(a) stationary only **(b)** transverse
(c) longitudinal **(d)** electromagnetic

6. The fundamental frequency of a pipe 0.6 m long, open at both ends, is (speed of sound 336 m/s):

(a) 560 Hz **(b)** 280 Hz **(c)** 140 Hz **(d)** 840 Hz

7. A wave is described by $y = 6 \sin((\pi/2)x - 570\pi t)$, with x in m and t in s. Its speed is:

(a) 2,280 m/s **(b)** 1,140 m/s **(c)** 570 m/s **(d)** 285 m/s

8. Assertion (A): A pipe 0.95 m long closed at one end (v = 350 m/s) can resonate at 92.11 Hz and at 276.32 Hz.
Reason (R): A pipe closed at one end supports all harmonics.

(a) Both A and R are true, and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false, but R is true.

Section B — Short answer — 8 × 2 = 16 marks

9. A wave is given by $y = 1 \sin(3\pi x - 246\pi t)$ cm, with x in m and t in s. Find the amplitude, wavelength, frequency and speed.

10. A string 0.4 m long fixed at both ends carries waves at 290 m/s. Find the frequencies of its first three harmonics.

11. A pipe is 1 m long (speed of sound 340 m/s). Find the first three resonant frequencies if it is (a) open at both ends, (b) closed at one end.

12. A tuning fork of unknown frequency gives 5 beats per second with a fork of 425 Hz. When the unknown fork is loaded with a little wax, the number of beats increases. Find its frequency.

13. A string 0.8 m long with mass per unit length 0.01 kg/m is to vibrate at a fundamental frequency of 360 Hz. What tension is needed? (2 decimal places where needed.)

14. In a resonance-tube experiment with a 384 Hz tuning fork, the first two resonances occur at air-column lengths of 22 cm and 66 cm. Find the speed of sound (ignore the end correction).

15. A stationary wave has a wavelength of 3.5 m. Find the distance between (a) two neighbouring nodes, (b) a node and the next antinode.

16. Find the speed of sound in a gas of density 1.3 kg/m^3 at a pressure of 2×10^5 N/m^2, if $\gamma = 1.4$ (Laplace's formula). (2 decimal places where needed.)

Section C — Word problems — 4 × 4 = 16 marks

17. A string 1.1 m long with mass per unit length 0.008 kg/m is fixed at both ends under a tension of 320 N. Find (a) the wave speed, (b) the fundamental frequency and its wavelength, (c) the frequencies of the second and third harmonics.

18. Two pipes of the same length 0.1 m are open and closed (at one end) respectively. (a) Find the fundamental frequency of each. (b) Which harmonics does each produce? (c) Why does a closed pipe sound deeper? (Speed of sound 344 m/s)

19. In a resonance tube with a 512 Hz fork, the first resonance is at 15.41 cm and the second at 47.64 cm. Find (a) the wavelength, (b) the speed of sound, (c) the end correction.

20. Fork A (265 Hz) gives 6 beats per second with fork B, and B gives 1 beats per second with fork C. B has a higher frequency than A, and C a higher frequency than B. (a) Find the frequencies of B and C. (b) How many beats per second will A and C give together?

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Answer key

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Q	Answer	Working
1	**(d) 1.68 m**	$\lambda = v/f$
2	**(a) 270 m/s**	$v = \sqrt{(T/\mu)}$
3	**(d) 425 Hz**	$f = v/2L$
4	**(d) 8**	beat frequency = difference of frequencies
5	**(c) longitudinal**	—
6	**(b) 280 Hz**	$f = v/2L$
7	**(b) 1,140 m/s**	$v = \omega/k$
8	**(c) A is true, but R is false.**	A is true: $f_1 = v/4L = 92.11$ Hz; the next resonance is $3f_1 = 276.32$ Hz. R is false.
9	**A = 1 cm; λ = 0.67 m; f = 123 Hz; v = 82 m/s**	$\lambda = 2\pi/k$; $f = \omega/2\pi$; $v = \omega/k$
10	**362.5 Hz, 725 Hz, 1,087.5 Hz**	$f_n = nv/2L$
11	**(a) 170, 340, 510 Hz; (b) 85, 255, 425 Hz**	open: $nv/2L$; closed: $(2n - 1)v/4L$
12	**420 Hz**	it is 425 ± 5; wax lowers its frequency, and the beats increase, so it was below 425 Hz
13	**3,317.76 N**	$v = 2Lf = 576$ m/s; $T = \mu v^2$
14	**337.92 m/s**	$\lambda/2 = L_2 - L_1$; $v = f\lambda = 2f(L_2 - L_1)$
15	**(a) 1.75 m; (b) 0.875 m**	nodes are $\lambda/2$ apart; node to antinode $\lambda/4$
16	**464.1 m/s**	$v = \sqrt{(\gamma p/\rho)}$
17	**(a) 200 m/s; (b) 90.91 Hz, λ = 2.2 m; (c) 181.82 Hz and 272.73 Hz**	$v = \sqrt{(T/\mu)}$; $f_1 = v/2L$
18	**(a) Open 1,720 Hz; closed 860 Hz. (b) The open pipe gives all harmonics; the closed pipe only odd ones. (c) Its fundamental is half that of an open pipe of the same length.**	open $v/2L$; closed $v/4L$
19	**(a) 0.64 m; (b) 330 m/s; (c) 0.7 cm**	$L_2 - L_1 = \lambda/2$; $L_1 + e = \lambda/4$
20	**(a) B 271 Hz, C 272 Hz; (b) 7**	beat frequency = difference of frequencies

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