ICSE CLASS 10 · PHYSICS

Chapter 7 : SOUND

STEP-BY-STEP SOLUTIONS & MARKING SCHEME (40 MARKS)

Maximum Marks: 40 · Section A (20) compulsory · Section B: any two of three questions (2 × 10 = 20) · $V = f\lambda$ · $f = 1 \div T$ · $d = Vt \div 2$ (echo) · loudness $\propto$ (amplitude)²

Marks for each step are shown in square brackets on the right. Parts added in the solution diagrams are drawn in red (or blue for the transmitted pulse).

SECTION A (20 Marks)

Question 1 — Multiple choice [8 marks, 1 mark each]

No.	Answer	Reason
(i)	**(a)** ultrasonic	The audible range is 20 Hz to 20 kHz; sound of frequency above 20 kHz is ultrasonic.
(ii)	**(b)** 17 m	Echo is heard if the reflected sound arrives at least 0.1 s later: d = (340 × 0.1) ÷ 2 = 17 m.
(iii)	**(c)** frequency	Pitch depends on the frequency of the sound (loudness on amplitude, quality on wave form).
(iv)	**(b)** 20 dB	$L = 10 \log_{10}(I \div I_0) = 10 \log_{10} 100 = 10 \times 2 = 20$ dB.
(v)	**(c)** Both (A) and (R) are true, and (R) is the correct explanation for (A).	Both are true: if the steps match the natural frequency of the bridge, resonance builds a large amplitude and the bridge may collapse; (R) explains (A).
(vi)	**(b)** four times	Loudness $\propto$ (amplitude)²; doubling the amplitude gives $2^2 = 4$ times the loudness.
(vii)	**(d)** wave form	Same amplitude (loudness) and same frequency (pitch) but different mixtures of subsidiary notes give different wave forms, i.e. different quality (timbre).
(viii)	**(d)** decreases gradually	In a medium, friction (resistive force) dissipates energy, so the amplitude decreases gradually until the body stops.

Question 2 [6 marks]

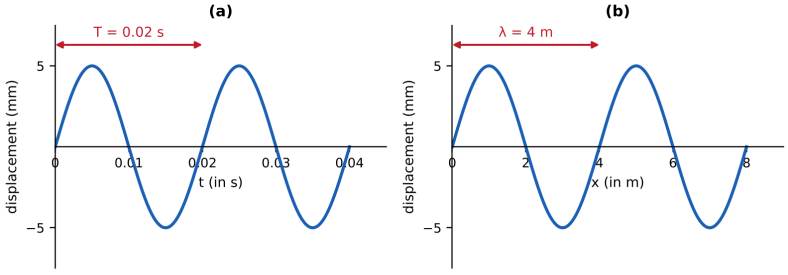
(a) **Echo**: the sound heard after reflection from a distant obstacle (cliff, wall, etc.) after the original sound has ceased. [1] **[2]**

Condition (any one): the obstacle must be at least 17 m from the source in air (so that the reflected sound arrives at least 0.1 s later); or the reflecting surface must be large compared with the wavelength; or the reflected sound must be intense enough to be heard. [1]

(b) (i) From graph (a), two complete waves occupy 0.04 s, so **T = 0.02 s** and f = 1 ÷ T = 1 ÷ 0.02 = **50 Hz**. [1] **[3]**

(ii) From graph (b), one complete wave occupies 4 m, so **λ = 4 m**. [1]

(iii) $V = f\lambda = 50 \times 4 =$ **200 m s⁻¹**. [1]



Solution to Q2(b)

(c) The unit is the **decibel (dB)**; the safe limit is **below 80 dB**. [½ + ½] **[1]**

Question 3 [6 marks]

(a) Given: d = 51 m, V = 340 m s^{-1}. **[3]**

(i) t = 2d ÷ V = (2 × 51) ÷ 340 = **0.3 s**. [1]

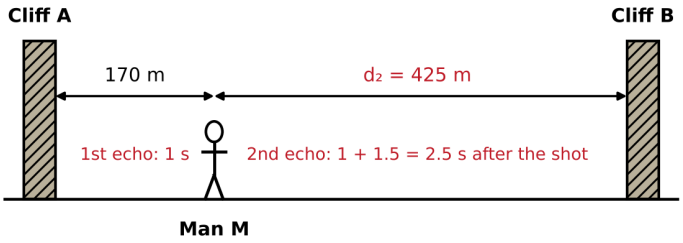
(ii) **Yes**: the echo arrives 0.3 s after the original sound, which is more than 0.1 s (the sensation of sound persists for 0.1 s), so it is heard separately. [1]

(iii) d = Vt ÷ 2 = (340 × 0.5) ÷ 2 = **85 m**. [1]

(b) (i) The first echo comes from the nearer cliff A: 2 × 170 = 340 m in 1 s, so V = 340 ÷ 1 = **340 m s^{-1}**. [1] **[3]**

(ii) The second echo is heard 1 + 1.5 = 2.5 s after the shot, so $2d_2$ = V × t = 340 × 2.5 = 850 m and **d_2 = 425 m**. [1]

(iii) Distance between the cliffs = 170 + 425 = **595 m**. [1]



Solution to Q3(b)

SECTION B (20 Marks) — any two questions

Question 4 [10 marks]

(a) Given: f = 500 Hz, λ = 0.68 m. **[3]**

(i) V = fλ = 500 × 0.68 = **340 m s^{-1}**. [1]

(ii) T = 1 ÷ f = 1 ÷ 500 = **0.002 s**. [1]

(iii) The frequency does not change in water, so λ′ = V′ ÷ f = 1450 ÷ 500 = **2.9 m**. [1]

(b) (i) Ultrasonic waves can travel undeviated over long distances, can be confined to a narrow beam and are not easily absorbed by the medium (any one). [1] **[3]**

(ii) The air in the hollow box has a large surface area; the strings set it into forced vibrations (it resonates), which sends out more energy and makes the sound louder. [1]

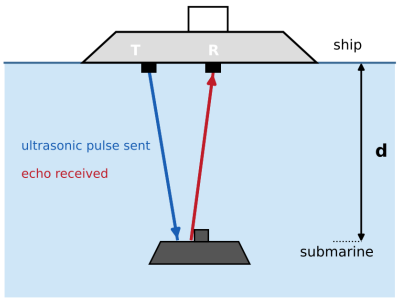
(iii) Marching steps are a periodic force; if their frequency equals the natural frequency of the bridge, resonance makes it vibrate with a large amplitude and it may collapse. [1]

(c) (i) A line from T down to the submarine (the pulse sent) and a line from the submarine up to R (the reflected pulse), both with arrows. [1] **[4]**

(ii) SONAR = **SO**und **N**avigation **A**nd **R**anging; it is based on the **reflection of sound (echo)**. [1]

(iii) Given: V = 1450 m s^{-1}, t = 1.2 s. The pulse covers 2d: 2d = V × t = 1450 × 1.2 = 1740 m. [1]

d = 1740 ÷ 2 = **870 m**. [1]



Solution to Q4(c)

Question 5 [10 marks]

(a) Any three (1 mark each): **[3]**

• Natural vibrations keep a constant amplitude and last forever (in vacuum); in damped vibrations the amplitude decreases gradually and finally becomes zero.

• Natural vibrations have no loss of energy; in damped vibrations some energy is lost as heat in each vibration.

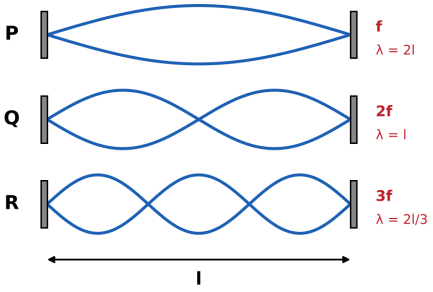
• In natural vibrations only the restoring force acts; in damped vibrations a frictional (resistive) force also acts.

• The frequency of natural vibrations is constant and depends on the size and shape of the body; the frequency of damped vibrations is slightly less than the natural frequency.

(b) (i) **P** (a single loop) gives the principal note; since l = λ ÷ 2, its wavelength is **λ = 2l**. [1] **[3]**

(ii) Frequencies are in the ratio f : 2f : 3f, so **P : Q : R = 1 : 2 : 3**. [1]

(iii) **R**: it has the highest frequency (3f), and the higher the frequency the more shrill the sound. [1]

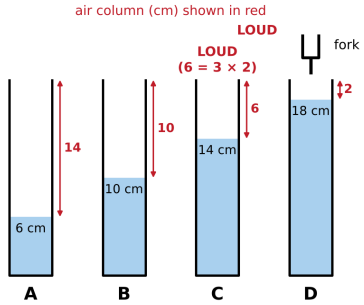


Solution to Q5(b)

(c) (i) **Tube C**. The air column in D is 20 − 18 = 2 cm. A loud sound is heard again when the air column becomes three times the first length, 3 × 2 = 6 cm, which is the air column of tube C (20 − 14 = 6 cm). [1 + 1] **[4]**

(ii) **Resonance**. [1]

(iii) The frequency of the air column must be **exactly equal** to the frequency of the vibrating tuning fork (its natural frequency equals the frequency of the applied periodic force). [1]



Solution to Q5(c)

Question 6 [10 marks]

(a) (i) Intensity of sound is measured in **watt per metre² (W m⁻²)**. [1] **[3]**

(ii) $a_1 : a_2 = 2 : 5$. (1) Loudness ∝ (amplitude)², so $L_1 : L_2 = 2^2 : 5^2 =$ **4 : 25**. [1]

(2) Pitch depends only on frequency, not on amplitude, so the ratio of pitch is **1 : 1**. [1]

(b) Any three (1 mark each): **[3]**

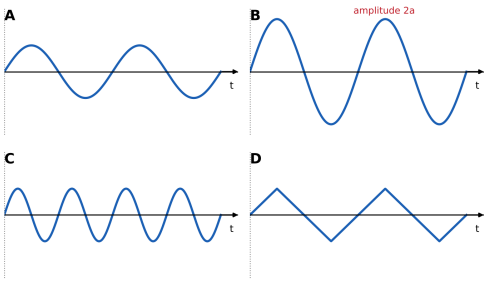
- Music is pleasant to the ear; noise is harsh and unpleasant.
- Music is produced by regular, periodic vibrations; noise is produced by an irregular succession of disturbances.
- The wave form of music is regular; that of noise is irregular.
- The sound level of music is low (10 to 30 dB); that of noise is high (above 120 dB).
- Examples: a violin, piano or flute (music); an aeroplane or road roller (noise).

(c) (i) **A and B**: same wave form and number of waves (same frequency, so same pitch) but different amplitudes. [1] **[4]**

(ii) **C**: it has the greatest number of waves in the same time, i.e. the highest frequency. [1]

(iii) **A and D**: same amplitude and frequency but different wave forms (sine and triangular), so a different quality. [1]

(iv) Loudness ∝ (amplitude)²: $L_B : L_A = (2a)^2 : a^2 =$ **4 : 1**. [1]



Solution to Q6(c)

Marks summary	
Section A: Q1 (8) + Q2 (2 + 3 + 1 = 6) + Q3 (3 + 3 = 6)	**20**
Section B: any two of Q4 – Q6 (10 marks each)	**20**
Total	**40**