KTET · CATEGORY III · PAPER III · PHYSICAL SCIENCE

WAVE MOTION

Part A · Physics · Unit 1

Concept maps · comparison tables · memory aids · worked numericals · KTET-pattern practice

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KTET 2012 SYLLABUS (Category III) — what this note covers

Wave motion: transverse and longitudinal waves, propagation of wave, medium dependence. Sound: loudness, frequency, wavelength, pitch, reflection and refraction of sound waves, echo, beats, Doppler effect, reverberation, SONAR, sound pollution, resonance and musical instruments.

Page	Topic	Syllabus words covered	Memory aid
2	Big picture	whole unit at one glance	mind map · concept map
3	What is a wave?	transverse, longitudinal, propagation, medium dependence	T-vs-L table
4	Wave terms	wavelength, frequency, v = fλ	“Very Fast Lions”
5	Sound basics	speed, medium, infra/audible/ultra	speed ladder
6	Loudness · Pitch · Timbre	loudness, frequency, wavelength, pitch	L-L · P-P · T-T
7	Reflection · Echo · Reverb	reflection, echo, reverberation	the 17 m rule
8	SONAR · Refraction	SONAR, refraction of sound	d = vt/2
9	Beats · Doppler	beats, Doppler effect	Approach → Ascend
10	Resonance · Instruments	resonance, musical instruments	Open vs Closed
11	Sound pollution	sound pollution	dB limits
12	Numericals	all formulas applied	12 solved problems
13–15	KTET-pattern practice	30 questions, match, assertion–reason	self-test
16	Recharge page	mnemonics, traps, formula sheet	last-day revision

Colour code used on every page (only three quiet tones, so it prints well in black-and-white too)

DEFINITION
Core ideas to memorise word-for-word

DAILY LIFE
Examples from home, road and Kerala

RECHARGE TIP
Tricks, mnemonics, exam traps

HOW TO USE THIS NOTE (4 steps)

- **Look** at the mind map (p.2) for 2 minutes, then close it and redraw it from memory.
- **Read** one topic page, cover the right-hand column of each table and test yourself.
- **Solve** the numericals (p.12) without looking, then attempt the 30 questions (p.13–15).
- **Revise** only the Recharge page (p.16) in the last 24 hours before the exam.

2 The Big Picture

Draw this map from memory — if you can, you know the unit

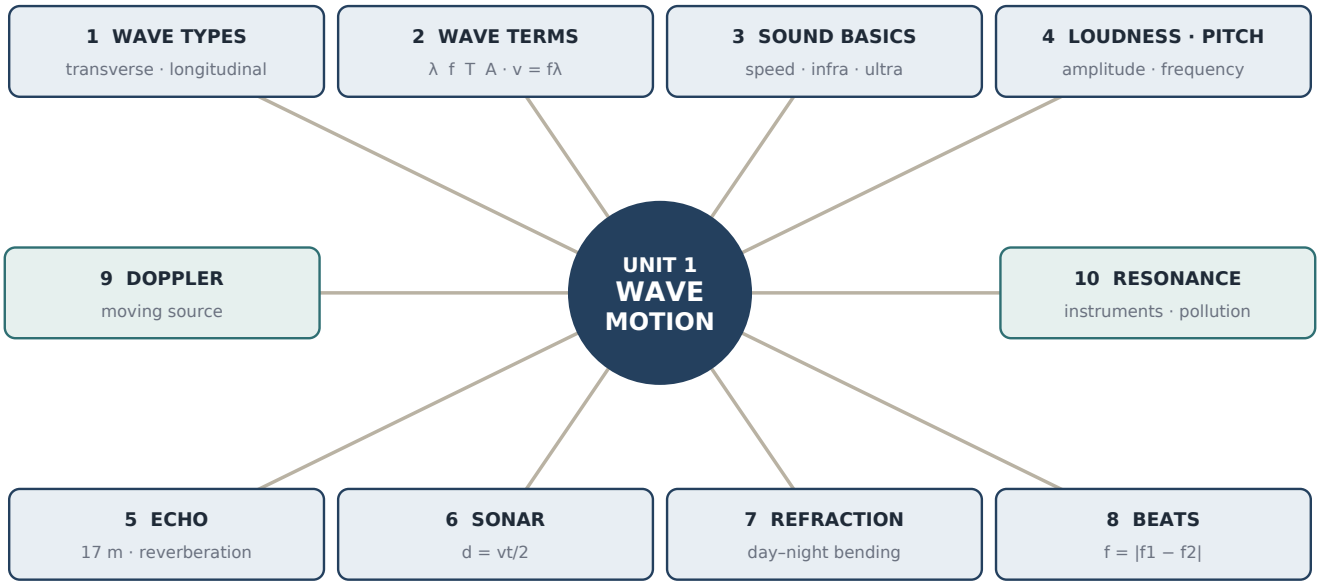


Figure 1 · Mind map of Unit 1 (ten branches = ten syllabus ideas)

Concept map: how the ideas connect

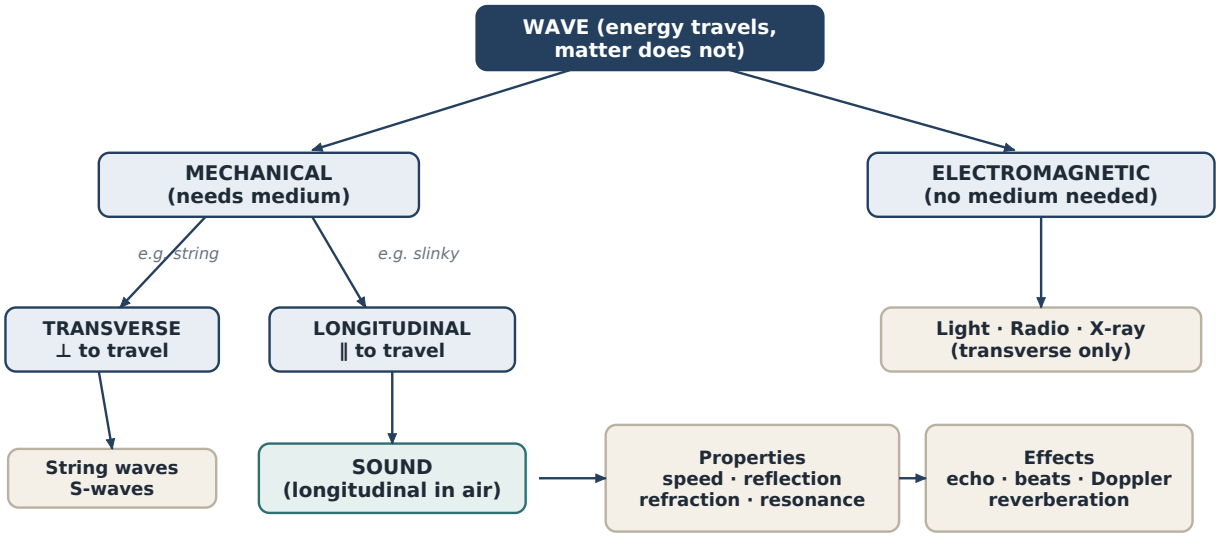


Figure 2 · Concept map: wave → type → example → properties → effects

FIVE QUESTIONS to ask about ANY wave

- **What** is vibrating? (the source)
- **Which way** do particles move compared with the wave? (type)
- **Does it need** a medium? (mechanical or not)
- **What** fixes its speed? (the medium)
- **What happens** at a boundary? (reflect · refract · absorb)

RECHARGE TIP · the "one-sentence unit"

- A vibrating source sends a **longitudinal** disturbance through a **medium**; its speed is fixed by the medium, its pitch by the source, its loudness by the amplitude — and it can **reflect, refract, beat, resonate and Doppler-shift**.

3 What is a Wave?

Transverse · Longitudinal · Propagation · Medium dependence

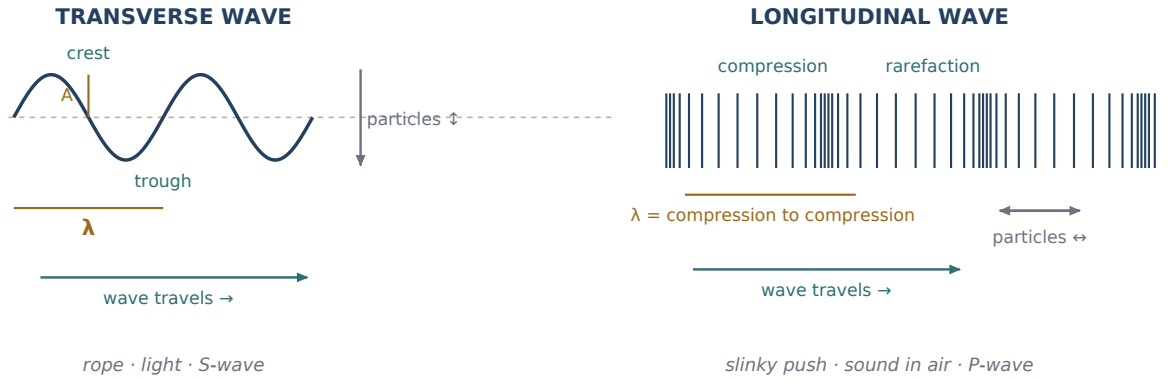
DEFINITION

- A **wave** is a **disturbance that travels through space and transfers energy from one point to another without the transfer of matter**.
- **Propagation** = the disturbance is passed from particle to particle (in a medium) — each particle only vibrates about its mean position; the *pattern* moves.

DAILY LIFE · see the "wave, not matter" idea

- **Stadium (Mexican) wave**: people stand up and sit down; the wave runs round the stadium, but nobody leaves their seat.
- **Floating leaf / paper boat on a backwater ripple**: it bobs up and down, it is not carried to the shore.

Transverse and longitudinal waves



rope · light · S-wave *slinky push · sound in air · P-wave*

Figure 3 · Particle motion versus wave direction

Feature	TRANSVERSE wave	LONGITUDINAL wave
Particle motion	Perpendicular (⊥) to wave direction	Parallel (∥) to wave direction
Shape	Crests and troughs	Compressions and rarefactions
One wavelength	Crest to next crest	Compression to next compression
Needs	Rigid (shear-strength) medium, or none for EM waves	Any elastic medium: solid, liquid, gas
In gas / liquid (bulk)	Cannot travel (mechanical)	Can travel
Examples	Shaken rope, plucked guitar string, light, radio, S-wave	Clap, speaker cone, slinky push–pull, sound in air, P-wave

Medium dependence

Feature	MECHANICAL waves	ELECTROMAGNETIC waves
Medium	Essential (need particles)	Not needed — travel in vacuum
Nature	Vibration of particles of the medium	Oscillating electric and magnetic fields
Type	Transverse or longitudinal	Always transverse
Speed	Depends on medium (elasticity, density)	3×10^8 m/s in vacuum; slower in glass/water
Examples	Sound, water ripples, string waves	Light, radio, microwave, X-ray

RECHARGE TIP · mnemonic

- **T**ransverse = **T**op-and-bottom (⊥). **L**ongitudinal = **L**ong-way, **L**ike the wave (∥).
- Sound in air is **L**ongitudinal — "Sound is Long".

EXAM TRAP

- Sound can be transverse in solids, but in **air and water it is only longitudinal**.
- Water-surface ripples look transverse, but particles actually move in small circles.

4 Wave Terms and v = fλ

Amplitude · wavelength · frequency · time period · speed

Term	Symbol · Unit	Meaning	Picture it as…
Amplitude	A · metre	Maximum displacement of a particle from its mean position	Height of a crest — decides **loudness**
Wavelength	λ (lambda) · metre	Distance between two consecutive crests (or compressions)	Length of one complete "S" of the wave
Frequency	f or ν · hertz (Hz)	Number of complete waves passing a point per second	Decides **pitch**; fixed by the source
Time period	T · second	Time for one complete vibration; T = 1/f	One tick of the swing
Wave speed	v · m/s	Distance the wave travels per second	Fixed by the **medium**
Phase	φ · radian	Stage of vibration of a particle at a given instant	Two crests are "in phase"

THE MASTER FORMULA

- **v = f × λ** (speed = frequency × wavelength)
- **v = λ / T** because f = 1/T
- 1 Hz = 1 vibration per second; 1 kHz = 1000 Hz.

DAILY LIFE · feel the formula

- **Swing**: pushed 1 time every 2 s → f = 0.5 Hz, T = 2 s.
- **Mains supply** in India: 50 Hz → T = 0.02 s.
- **Radio dial** "98.3 MHz": the frequency of the FM wave — the station is chosen by frequency, not by speed.

RECHARGE TIP · "Very Fast Lions"

- **V**ery **F**ast **L**ions → **v = f λ**.
- Cover the letter you want in the triangle: v on top; f and λ at the bottom.
- Higher frequency ⇒ shorter wavelength (in the same medium).

The golden rule: who controls what?

When a wave goes from one medium to another (air → water)	Changes?	Why
Frequency (f)	**No — stays same**	It is fixed by the source, e.g. the tuning fork
Speed (v)	**Yes**	The new medium has different elasticity and density
Wavelength (λ)	**Yes**	v = fλ with f fixed ⇒ λ changes with v

Speed of a wave on a string (extension for sitar, veena, violin questions)

v = √(T / μ) where T = tension and μ = mass per unit length. Tighter or lighter string ⇒ faster wave ⇒ higher note.

WORKED EXAMPLE

- A girl makes ripples on a pond: 5 crests pass a lotus in 10 s, and the crest-to-crest distance is 0.4 m.
- f = 5/10 = 0.5 Hz; v = f λ = 0.5 × 0.4 = **0.2 m/s**.

5 Sound: Nature, Medium and Speed

Production · propagation · speed in different media · frequency bands

DEFINITION

- **Sound** is a **mechanical, longitudinal wave** produced by a vibrating body; it needs a **material medium** and cannot travel through a vacuum.
- Production: vibration of a body (tuning fork, vocal cords, stretched string, air column).

DAILY LIFE · production

- Vocal cords vibrate when you speak — touch your throat.
- Chenda, tabla: the stretched skin vibrates.
- Bee / mosquito: wings beat — you hear a hum.
- Ruler on the desk edge: shorter overhang → quicker vibration → higher note.

Proof sound needs a medium

- **Bell-jar experiment**: an electric bell rings inside a jar; as air is pumped out, the sound fades away, though the hammer still strikes.
- **Astronauts** on the Moon talk by radio, because there is no air to carry sound.

Speed of sound in different media

Medium	Approx. speed (m/s)	Why
Air at 0 °C	331	Particles far apart, low elasticity
Air at 20–25 °C	≈ 343 – 346 (textbooks often use 340)	Warmer ⇒ faster
Water (fresh)	≈ 1480 – 1500	Liquid: much more elastic
Sea water	≈ 1530	Salt raises it a little
Iron / steel	≈ 5000 – 6000	Solid: highest elasticity
Vacuum	0 — no sound	No particles

SPEED RULES

- **Solid > Liquid > Gas**
- Speed rises with **temperature**: $v \approx 331 + 0.6\,t$ (t in °C).
- Speed rises with **humidity** (moist air is lighter).
- Speed does **not** depend on loudness, pitch or pressure (at constant temperature).

RECHARGE TIP

- "**S**olids **L**ove **G**ossip": Solid, Liquid, Gas — fastest to slowest.
- Put your ear on the railway track: you hear the train earlier through steel than through air.
- Light ≈ 10^6 times faster than sound ⇒ lightning is seen first, thunder heard later.

Frequency bands of sound



Figure 4 · Infrasonic · audible · ultrasonic

Who uses what?

- **Infrasonic**: elephants, whales, rhinoceros; earthquakes and volcanoes also produce it.
- **Ultrasonic**: bats, dolphins, porpoises; dog whistle (Galton whistle) is ultrasonic.
- Uses of ultrasound: SONAR, medical scanning, cleaning of jewellery and instruments, flaw detection in metals.

RECHARGE TIP

- **Infra** = below (too low to hear). **Ultra** = beyond (too high to hear).
- Human range: **20 Hz to 20,000 Hz**. Children hear the top end; it shrinks with age.

6 Loudness · Pitch · Timbre

Frequency, wavelength, loudness and pitch — three “faces” of a sound

Characteristic	Depends on	What you hear	Unit	Daily-life picture
Loudness	**Amplitude** (and ear sensitivity); intensity ∝ A^2	Loud or soft	decibel (dB)	Turning up the TV: same pitch, larger vibration
Pitch	**Frequency**	Shrill (high) or flat/grave (low)	hertz (Hz)	Mosquito = high pitch; lion’s roar = low pitch
Quality (Timbre)	**Waveform** — mixture of overtones	Why violin ≠ flute on the same note	—	You recognise a friend on the phone by voice

DEFINITIONS

- **Intensity**: energy passing per second through unit area normal to the wave (W/m²).
- **Loudness**: the *sensation* of intensity in the ear.
- **Pitch**: the sensation of frequency; high f ⇒ high pitch.
- **Threshold of hearing** = 0 dB (10^{-12} W/m²); **pain threshold** ≈ 120 dB.

RECHARGE TIP · L-L, P-P, T-T

- **L**oud = **L**arge amplitude.
- **P**itch = **P**ace (frequency).
- **T**imbre = **T**exture (waveform).
- Doubling the frequency raises the note by **one octave**.

Wavelength and pitch together

In the same medium v is constant, so **λ = v/f**: a shrill sound (high f) has a short wavelength; a deep sound (low f) has a long wavelength. That is why a bass drum is heard around corners more easily than a whistle.

The decibel ladder

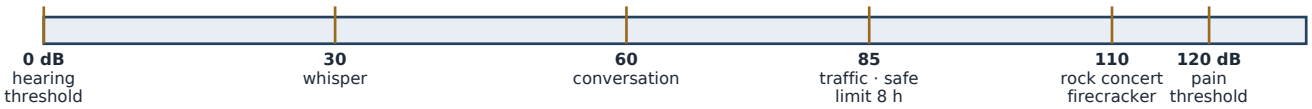


Figure 5 · Typical sound levels (approximate)

Difference table	Loudness	Pitch
Depends on	Amplitude	Frequency
Physical quantity	Intensity (W/m²)	Frequency (Hz)
If increased	Sound becomes louder	Sound becomes shriller
Example	Shouting vs whispering	Female voice vs male voice (usually higher f)
Does it change speed?	No	No

DAILY LIFE

- **Veena**: pluck harder ⇒ louder (amplitude), pressing the string shorter ⇒ higher pitch (frequency).
- **Same “Sa”** on a violin and a harmonium sounds different — that is timbre.
- Women and children usually have higher-pitched voices because their vocal cords are shorter and thinner.

7 Reflection · Echo · Reverberation

How sound bounces and why the hall “rings”

REFLECTION OF SOUND

- Sound bounces from a hard, rigid surface obeying the **laws of reflection**: angle of incidence = angle of reflection; incident sound, reflected sound and the normal lie in the same plane.
- Hard, smooth surfaces (wall, rock, metal) **reflect**; soft, rough surfaces (curtain, carpet, foam) **absorb**.

USES OF REFLECTION (daily life)

- **Megaphone / loudspeaker horn / bullhorn**: cone reflects sound forward as a beam.
- **Stethoscope**: repeated reflection along the tube carries heartbeat to the doctor’s ear.
- **Concert-hall and temple-hall ceilings**: curved so that sound reaches the back rows.
- **Soundboard behind a speaker on stage**: pushes sound towards the audience.
- **Whispering gallery** (Gol Gumbaz, Bijapur): whisper at one wall is heard at the opposite wall.

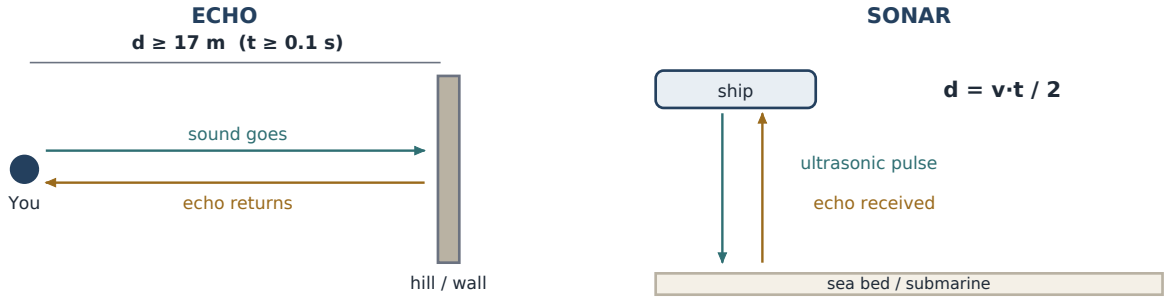


Figure 6 · Echo (left) and SONAR (right) — both use d = v·t / 2

Echo

DEFINITION & THE 17 m RULE

- **Echo** is the **repetition of sound heard distinctly after reflection** from a distant obstacle.
- The ear keeps a sound for about **0.1 s** (persistence of hearing). For the echo to be heard separately, it must come back after at least 0.1 s.
- Total path = v × t = 340 × 0.1 = 34 m ⇒ obstacle at **d = 34/2 = 17 m (minimum)**.
- **d = v × t / 2** (divide by 2 because the sound goes *and* returns).

Reverberation

	ECHO	REVERBERATION
Meaning	Distinct repetition of the original sound	Persistence of sound due to **repeated reflections**
Time gap	More than 0.1 s	Less than 0.1 s — the reflections merge with the original
Distance of obstacle	At least 17 m	Less than 17 m (closed rooms, halls)
Effect	Heard as a separate sound	Sound seems to “linger” and become blurred
Cure	Not a problem in open spaces	Absorbers: curtains, carpets, acoustic tiles, cushioned seats, audience

DAILY LIFE

- Shout near a hill or large empty hall: **echo**.
- Sing in a bathroom: the tiles make your voice **reverberate** (richer, but muddy).
- Cinema halls have wall panels and cushioned seats to control reverberation.

RECHARGE TIP

- **Echo = far (≥ 17 m); Reverb = near (< 17 m)**.
- Echo needs a minimum **distance**; the 0.1 s is the minimum **time**.
- If the temperature rises, v rises, so the minimum distance rises slightly (≈ 17.2 m at 344 m/s).

8 SONAR and Refraction of Sound

Seeing with sound · why sound travels farther at night

SONAR = SOund Navigation And Ranging

- A device that uses **ultrasonic pulses** to find the **depth, direction and distance** of underwater objects.
- **Working**: transmitter sends an ultrasonic pulse ⇒ it strikes the sea bed / submarine / fish shoal ⇒ the echo returns to the detector ⇒ time t is measured ⇒ **d = v·t / 2**.
- Developed by **Paul Langevin** during the First World War to detect submarines.

WHY ULTRASONIC IN SONAR?

- Short wavelength ⇒ travels as a narrow beam, loses less energy by spreading.
- Inaudible ⇒ does not disturb marine life or the crew.
- Can be reflected by small objects.

Daily life & uses

- Fishing boats find fish shoals; ships measure sea depth; underwater archaeology finds wrecks.
- **Bats** and **dolphins** use natural echo-location — nature's SONAR.
- Ultrasound scan (USG) of a baby, kidney stones breaking, jewellery cleaning.

Refraction of sound

DEFINITION

- **Refraction of sound** is the **change in direction of sound when it passes from one medium to another, or through layers of the same medium with different temperatures**, because its speed changes.
- In a slower medium or cooler layer, the wavefront bends toward the slower side.

Time	Air near ground	Speed of sound	Sound bends	Result
Day	Ground hot, upper air cooler	Lower layers faster	Upwards	Sound is lost to the sky; heard less far
Night	Ground cool, upper air warmer	Lower layers slower	Downwards, to the ground	Sound is heard much farther

DAILY LIFE

- At night, a temple festival loudspeaker or the distant train whistle is heard from a much greater distance.
- Thunder is heard only up to a limited distance because of refraction by air layers.
- **Sound lens**: a balloon filled with CO_2 bends sound and focuses it, like a convex lens does for light.

RECHARGE TIP · difference table

- **Reflection**: sound comes *back* into the same medium.
- **Refraction**: sound goes *into* the next medium / layer and bends.
- "Night = Nearer ground = Noise carries": cool ground at night bends sound down.
- Frequency never changes in refraction — only speed and wavelength.

	Reflection	Refraction
Direction change	Returns to the same medium	Bends on entering a new medium / layer
Example	Echo, stethoscope	Sound heard farther at night
Used in	SONAR, megaphone, hall design	Sound lens, atmospheric propagation
What changes	Direction only (speed same)	Direction, speed and wavelength — not frequency

9 Beats and the Doppler Effect

Two close notes · moving source or listener

Beats

DEFINITION

- **Beats** are the periodic rise and fall in the loudness of sound, heard when **two sound waves of nearly equal frequencies** travel in the same direction.
- **Beat frequency = $|f_1 - f_2|$** (number of loud sounds per second).
- The ear can usually distinguish beats only up to about 10 per second.

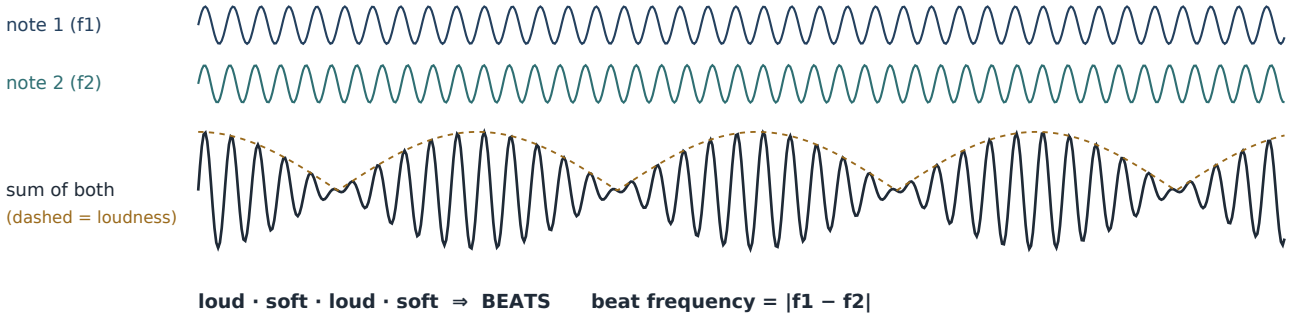


Figure 7 · Two close notes add up: loud — soft — loud — soft

DAILY LIFE & USES

- **Tuning** a violin, veena or tambura: beats vanish when two strings match.
- Two ceiling fans with slightly different speeds produce a slow "wow-wow-wow" hum.
- Detecting small frequency differences; musicians' ear-training.

RECHARGE TIP

- "**Beats = Big minus Small**".
- Loading (waxing) a fork **lowers** its frequency; filing it **raises** it.
- Beats = interference in **time** at one point; need **two** sources.

Doppler effect

DEFINITION

- The **Doppler effect** is the **apparent change in the frequency (pitch) of a wave when there is relative motion between the source and the listener**.
- Frequency actually emitted never changes — only the frequency received does.
- **$f' = f \times (v \pm v_o) / (v \mp v_s)$** — use the upper signs when source and listener move toward each other.
- Source approaching a still listener: **$f' = f \cdot v / (v - v_s)$**; source receding: **$f' = f \cdot v / (v + v_s)$**.

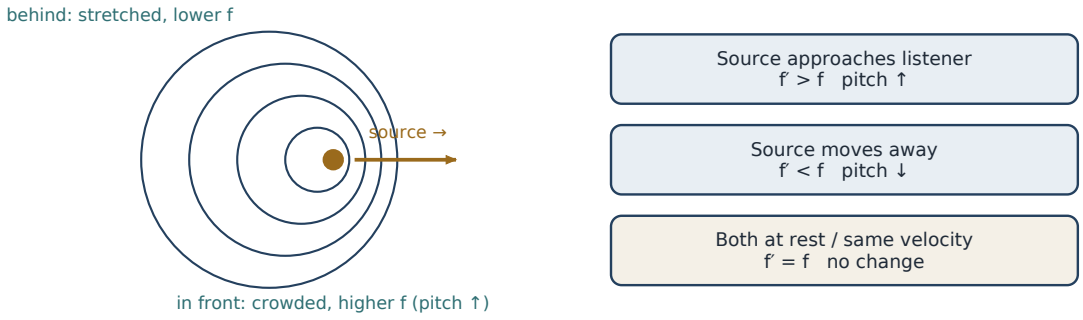


Figure 8 · Wave crests crowd in front of a moving source

DAILY LIFE

- Ambulance / fire-engine siren: pitch is high as it comes, drops sharply as it passes.
- Train whistle at a level crossing.
- **Police radar gun** and speed cameras measure car speed from the Doppler shift of radio waves.
- **Astronomy**: red shift (galaxies receding) and blue shift (approaching).
- Doppler ultrasound checks blood flow.

RECHARGE TIP

- "**A**pproach → **A**scend; **A**way → **A**ground (lower)".
- Loudness at the instant of passing does not give the shift — the **pitch** does.
- **Sonic boom**: when the source moves faster than sound (Mach number = $v_{source} / v_{sound} > 1$), waves pile up into a shock wave — heard as a boom by a supersonic jet.

10 Resonance and Musical Instruments

Natural frequency · strings · pipes · drums

DEFINITION

- **Resonance** is the phenomenon in which a body is set into vibration with **maximum amplitude** when the frequency of an external periodic force (driving frequency) **equals its natural frequency**.

DAILY LIFE EXAMPLES

- **Swing**: push in step with its natural frequency and the swing goes higher.
- **Radio / TV tuning**: the tuner circuit resonates with the chosen station's frequency.
- **Soldiers break step** on a bridge (to avoid resonance).
- **Opera singer** shatters a wine glass by singing its natural frequency.
- **Sound box** of veena, violin and guitar: resonance amplifies the string's note.
- **Resonance column** experiment (closed air column + tuning fork) is used to measure the speed of sound.

RECHARGE TIP

- Same **natural frequency** = same "swing rhythm" ⇒ big response.
- Resonance is "forced vibration with perfect timing".
- Disadvantage example: vibration of a window glass when a heavy lorry passes.
- Note: the Tacoma Narrows bridge collapse is often given as resonance, but strictly it was wind-driven flutter.

Musical instruments

Class	What vibrates	Pitch is changed by	Examples (Kerala and elsewhere)
STRING (chordophones)	Stretched string; sound box resonates	Length, tension, thickness	Veena, violin, tambura, sitar, guitar
WIND (aerophones)	Air column in a pipe	Length of the vibrating air column (finger holes)	Flute, nadaswaram, shehnai, clarinet, kombu (horn)
PERCUSSION	Stretched membrane or solid body	Tension / size of the skin or body	Chenda, maddalam, edakka, thimila, tabla, mridangam, elathalam (cymbals)

Vibrating string: f = (1/2L) √(T/μ)

Laws of a vibrating string (sonometer): **f ∝ 1/L**, **f ∝ √T**, **f ∝ 1/√μ**. Veena or guitar: tighten the peg ⇒ pitch rises; press at a fret (shorter L) ⇒ pitch rises; thick bass strings ⇒ lower pitch.



Same length: closed-pipe fundamental = ½ × open-pipe fundamental (one octave lower)

Figure 9 · Standing waves in open and closed air columns

	OPEN PIPE	CLOSED PIPE
Ends	Both ends open: antinode at each end	One end closed: node at closed end, antinode at open end
Fundamental	f = v / 2L	f = v / 4L
Harmonics present	All: f, 2f, 3f, 4f …	Odd only: f, 3f, 5f …
Example	Flute	Organ pipe closed at one end; resonance tube

RECHARGE TIP · "Closed = Cranky, Open = Open-minded"

- Closed pipe is cranky — it accepts **only odd** harmonics; an open pipe accepts **all**.
- Resonance column: $L_1 = \lambda/4$, $L_2 = 3\lambda/4 \Rightarrow \mathbf{\lambda = 2\,(L_2 - L_1)}$, $v = f\lambda$.

11 Sound Pollution

Unwanted sound that harms health and peace

DEFINITION

- **Sound (noise) pollution** is the presence of **unwanted, loud or harmful sound** in the environment that disturbs people and other living beings. It is measured in **decibels (dB)** by a **sound level meter**.
- Safe-listening rule of thumb: below about 85 dB for a few hours; above 120 dB can cause immediate pain and damage.

SOURCES	EFFECTS on humans	CONTROL measures
• **Road traffic, horns** • **Aircraft, trains** • **Industries, generators** • **Loudspeakers, festivals, fireworks** • **Construction work** • **Headphones at high volume**	• Hearing loss (temporary / permanent) • Headache, irritation, loss of concentration • Sleeplessness, stress • High blood pressure, heart strain • Poor learning in classrooms • Disturbs birds, animals, ill patients	• Silencers in vehicles; ban of pressure horns • “No horn” zones near schools and hospitals • Limits on loudspeaker use and timings • Green belts (dense trees absorb sound) • Sound-proofing and double-glazing • Earplugs in noisy jobs • Awareness and law enforcement

Permissible ambient noise limits in India (Noise Pollution Rules, 2000)

Area	Day (6 am – 10 pm)	Night (10 pm – 6 am)
Industrial	75 dB(A)	70 dB(A)
Commercial	65 dB(A)	55 dB(A)
Residential	55 dB(A)	45 dB(A)
Silence zone (hospital, school, court, 100 m around)	50 dB(A)	40 dB(A)

DAILY LIFE

- Continuous horns near a hospital or school gate.
- High-volume loudspeakers during late-night events.
- Using earphones at full volume in a bus.
- Quiet-hour norms for exam days.

RECHARGE TIP · “SEC”

- **S**ources → **E**ffects → **C**ontrol: learn the three columns in that order.
- Silence zone is the **lowest** limit; industrial is the **highest**: 50 < 55 < 65 < 75 (day).
- Pollution of sound is the only pollution that leaves **no residue** — it stops when the source stops.

TEACHER’S CORNER (pedagogy link)

- Activity idea: students measure classroom noise with a free sound-meter app at different times and plot a bar graph — links physics to environment and graphs.
- Question that tests understanding: “Why is a silence zone near a hospital marked with a lower dB limit?”

12 Twelve Solved Numericals

Take v = 340 m/s in air unless stated — write the formula first, then substitute

No.	Problem	Solution
1	**Wave speed** A wave has frequency 500 Hz and wavelength 0.68 m. Find its speed.	v = fλ = 500 × 0.68 = **340 m/s**
2	**Time period** Mains frequency is 50 Hz. Find T.	T = 1/f = 1/50 = **0.02 s**
3	**Medium change** A 256 Hz fork sounds in air (340 m/s) and then in water (1480 m/s). Find λ in each.	λ_{air} = 340/256 ≈ **1.33 m**; λ_{water} = 1480/256 ≈ **5.78 m**. Frequency stays 256 Hz.
4	**Temperature** Speed of sound at 25 °C?	v = 331 + 0.6 × 25 = **346 m/s**
5	**Echo** You clap and hear the echo after 2 s. How far is the cliff?	d = vt/2 = 340 × 2 / 2 = **340 m**
6	**Minimum echo distance** Minimum distance for a distinct echo?	d = 340 × 0.1 / 2 = **17 m**
7	**SONAR** A SONAR pulse returns after 0.8 s; speed in sea water is 1500 m/s. Depth?	d = vt/2 = 1500 × 0.8 / 2 = **600 m**
8	**Thunder** Thunder is heard 3 s after the flash. How far is the lightning?	d = 340 × 3 = **1020 m** (light's travel time is negligible)
9	**Beats** Forks of 256 Hz and 260 Hz sound together. Beats per second? If the 260 Hz fork is waxed, do beats rise or fall?	|260 − 256| = **4 beats/s**. Waxing lowers 260 Hz (say to 258), so beats **fall** to 2.
10	**Doppler** A train horn of 400 Hz moves at 20 m/s towards a still listener. Heard frequency? And when going away?	Toward: f′ = 400 × 340/(340 − 20) = **425 Hz**. Away: 400 × 340/(340 + 20) ≈ **378 Hz**.
11	**Pipes** A pipe of length 0.85 m: fundamental if open? if closed? (v = 340)	Open: v/2L = 340/1.7 = **200 Hz**. Closed: v/4L = 340/3.4 = **100 Hz**.
12	**Resonance column** Resonances at 17 cm and 51 cm for a 500 Hz fork. Find v.	λ = 2(51 − 17) = 68 cm = 0.68 m; v = fλ = 500 × 0.68 = **340 m/s**

RECHARGE TIP · four steps for any numerical

- **Write** given data with units → **Choose** the formula (v = fλ, d = vt/2, |f1−f2|, v/2L, v/4L).
- **Check units** (cm → m, kHz → Hz) → **Substitute** and box the answer with its unit.
- Options in KTET often differ only by the "divide by 2" — remember it for echo and SONAR.

13 KTET-Pattern Practice: 30 Questions

Cover the Answer column, answer, then check the reason

Part 1 · Waves, sound, characteristics (Q1–Q15)

No	Question	Answer	Why / key idea
1	Waves transfer	**energy only**	Matter does not move with the wave.
2	Which cannot travel through vacuum: light, X-ray, radio wave, sound?	**Sound**	Mechanical wave needs a medium.
3	Sound waves in air are	**Longitudinal**	Compressions and rarefactions.
4	In bulk gas or liquid, which mechanical wave cannot travel?	**Transverse**	No shear strength.
5	Distance between two consecutive compressions is	**One wavelength**	Like crest to crest.
6	f = 200 Hz and λ = 1.5 m. Speed =	**300 m/s**	v = fλ.
7	When sound passes from air to water, which quantity stays unchanged?	**Frequency**	Fixed by the source.
8	Sound travels fastest in	**Steel (solid)**	Solid > liquid > gas.
9	Speed of sound in air increases with	**Rise in temperature (and humidity)**	v ≈ 331 + 0.6t.
10	Audible range of the human ear	**20 Hz – 20,000 Hz**	Below = infra, above = ultra.
11	Bats find prey using	**Ultrasonic waves**	Natural echo-location.
12	Elephants communicate over long distances using	**Infrasonic sound**	Below 20 Hz.
13	Loudness of sound mainly depends on	**Amplitude**	Intensity ∝ amplitude².
14	Pitch of sound depends on	**Frequency**	High f = shrill.
15	A violin and a flute playing the same note differ in	**Quality (timbre)**	Different waveform / overtones.

14 KTET-Pattern Practice (continued)

Echo · SONAR · refraction · beats · Doppler · resonance · pollution

Part 2 · Echo to pollution (Q16–Q30)

No	Question	Answer	Why / key idea
16	Unit used to express sound level	**Decibel (dB)**	Hertz is for frequency.
17	Minimum distance of obstacle for an echo (v = 340 m/s)	**17 m**	340 × 0.1 / 2.
18	Persistence of hearing for sound is about	**0.1 second**	Vision: 1/16 s.
19	Reverberation is caused by	**Repeated reflections of sound**	Distance < 17 m.
20	Reverberation in a hall is reduced by	**Curtains, carpets, acoustic tiles**	Soft materials absorb.
21	SONAR stands for	**SOund Navigation And Ranging**	Uses ultrasonic waves.
22	SONAR measures depth using	**d = vt/2**	Pulse goes and returns.
23	Sound is heard farther at night because of	**Refraction (bending down) in cooler ground layer**	Lower layers slower at night.
24	Beats are produced by	**Superposition of two waves of nearly equal frequency**	Beat frequency = f1 − f2.
25	Forks 256 Hz and 258 Hz: beats per second	**2**	|258 − 256|.
26	Pitch of an approaching ambulance siren appears	**Higher**	Doppler effect.
27	Sonic boom is produced when	**An object moves faster than the speed of sound**	Mach number > 1.
28	Resonance occurs when	**Driving frequency = natural frequency**	Amplitude maximum.
29	A closed pipe produces	**Only odd harmonics**	f, 3f, 5f.
30	Instrument to measure sound level	**Sound level meter**	Reads in dB.

15 More Practice Formats

Match the following · assertion–reason · question styles to expect

Match the following (try these)

Phenomenon	Match with
1. Echo	a. Tuning of a veena
2. Reverberation	b. Siren of an ambulance
3. Beats	c. Sound lingers in a closed hall
4. Doppler effect	d. Voice returns from a hill
5. Resonance	e. Swing pushed in rhythm
6. SONAR	f. Fishing boat finds shoals

Answers: 1–d, 2–c, 3–a, 4–b, 5–e, 6–f.

Assertion–reason practice

Statement	Verdict	Reason
A: Sound cannot travel in vacuum. R: Sound is a mechanical wave.	Both true; R explains A	Mechanical waves need particles
A: Sound is heard farther at night. R: Ground layers are warmer at night.	A true, R false	Ground is cooler; sound bends down
A: Echo needs at least 17 m. R: Persistence of hearing is 0.1 s.	Both true; R explains A	$d = 340 \times 0.1 / 2$
A: Frequency changes when sound enters water. R: Speed is higher in water.	A false, R true	Frequency is fixed by the source

Question styles to expect

Style	Example pattern	How to beat it
Direct fact	Unit of loudness? Range of hearing?	Learn one-line definitions (pages 5–6)
“Which is NOT…”	Which is not a mechanical wave?	Eliminate EM waves (light, radio, X-ray)
Numerical	Echo / SONAR / $v = f\lambda$ / beats	Divide by 2 for echo and SONAR
Match the following	Phenomenon ↔ example	Echo–hill, Doppler–siren, Resonance–swing, Beats–tuning
Statement type	Assertion and reason	Check the “why” on the Recharge page

16 Recharge Page

The last-24-hours sheet: print this one and keep it

Topic	Memory aid	Meaning
Speed order	**S**olids **L**ove **G**ossip	Solid > Liquid > Gas
Formula	**V**ery **F**ast **L**ions	$v = f\lambda$
Sound characteristics	**L-L, P-P, T-T**	Loud–Large amplitude; Pitch–Pace (frequency); Timbre–Texture (waveform)
Echo	Seventeen is the entry fee	17 m minimum; $d = vt/2$
Echo vs reverb	Echo far, Reverb near	≥ 17 m / < 17 m
Doppler	**A**pproach → **A**scend	Approach: pitch ↑; away: pitch ↓
Beats	Big minus Small	$\lvert f1 - f2 \rvert$
Pipes	Closed = Cranky, Open = Open-minded	Closed: odd only (v/4L); open: all (v/2L)
Infra / Ultra	Infra = below, Ultra = up beyond	< 20 Hz / > 20 kHz
Transverse vs longitudinal	T = Top-bottom; L = Long-way	⊥ / ∥ to wave direction

FORMULA SHEET

- $v = f\lambda$ · $T = 1/f$ · $v \approx 331 + 0.6\,t$ · $d = vt/2$ (echo, SONAR) · $f_{beat} = |f_1 - f_2|$
- Doppler (source approaching): $f' = f\,v/(v - v_s)$; receding: $f' = f\,v/(v + v_s)$
- Open pipe $f = v/2L$; closed pipe $f = v/4L$; string $f = (1/2L)\sqrt{(T/\mu)}$; resonance column $\lambda = 2(L_2 - L_1)$
- Audible range 20 Hz – 20 kHz; threshold of hearing 0 dB; pain ≈ 120 dB; persistence of hearing 0.1 s

TOP 8 EXAM TRAPS

- Forgetting to divide by 2 in echo / SONAR.
- Saying frequency changes when sound enters water (it does not).
- Calling sound transverse (in air it is not).
- Mixing loudness with pitch.
- Thinking echo needs 17 s or 17 cm — it is 17 **m**.
- Writing that vacuum carries sound.
- Using v = 330 in one step and 340 in another — stay consistent.
- Confusing beats (interference in time) with the Doppler effect (motion).

ONE-MINUTE REVISION

- Wave = energy moves, matter stays.
- Transverse ⊥, longitudinal ∥; sound is longitudinal.
- Speed from the medium; pitch from the source.
- Loud: amplitude · pitch: frequency · quality: waveform.
- Echo ≥ 17 m; reverb < 17 m; SONAR = echo under water.
- Beats: two close notes; Doppler: moving source.
- Resonance: matching natural frequency.
- Noise: sources, effects, control; keep dB limits.

SELF-TEST IN 5 MINUTES

- Redraw the mind map (p.2) from memory.
- Explain to a friend: why do you hear the ambulance pitch fall as it passes?
- Without looking: 17 m echo, 20–20,000 Hz, Solid > Liquid > Gas, $|f1 - f2|$, f' for approach.
- Score yourself: all correct ⇒ ready for this unit.

Best wishes for KTET Category III. — Bencila Rose Sunny, Assistant Professor, K M College of Teacher Education, Areekode