Class 9 Sound Mind Maps

PRODUCTION OF SOUND

What is Sound?

- Form of energy that produces sensation of hearing
- Cannot be produced without utilizing energy
- Requires mechanical energy for production
- Conservation of energy principle applies

How Sound is Produced

- Sound requires VIBRATION of objects
- Vibration = rapid to-and-fro motion
- No vibration = No sound

Methods to Produce Sound

- Striking (tuning fork on rubber pad)
- Plucking (stretched rubber band)
- Scratching
- Rubbing
- Blowing
- Shaking

Examples in Nature

- Human voice → vibrations in vocal cords
- Bird flapping wings → sound production
- Bee buzzing → wing vibration
- Musical instruments → specific parts vibrate
  - Drums: membrane
  - Guitar: strings
  - Flute: air column

Demonstration Activities

- Tuning Fork Experiment
  - Striking produces vibration
  - Vibrating prong creates sound
  - Touching stops vibration → sound stops
  - Table tennis ball moves when touched by vibrating fork
- Water Surface Experiment
  - Vibrating fork creates ripples in water
  - Visual proof of vibration transfer

Key Principle

- Sound ALWAYS requires a vibrating object
- No exception to this rule

PROPAGATION OF SOUND

Transverse Waves (Comparison)

- Particles oscillate PERPENDICULAR to wave direction
- Example: water ripples in pond
- Light is transverse (but not mechanical)
- Sound is NOT transverse

Medium Requirement

- Sound needs material medium to travel
- Medium types: Solid, Liquid, or Gas
- Cannot travel in vacuum (e.g., no sound on moon)
- Most common medium: Air

Longitudinal Wave Characteristics

- Particles oscillate PARALLEL to wave direction
- Particles oscillate back and forth about rest position
- Particles don't move from place to place
- Disturbance carries forward, not particles
- Compare with slinky demonstration

How Sound Travels

- Source vibrates particles of medium vibrate
- Particles don't travel forward
- Only DISTURBANCE/ENERGY travels
- Each particle displaces adjacent particle
- Chain reaction through medium

Pressure-Density Relationship

- More particles per volume Higher pressure
- Fewer particles per volume Lower pressure
- Sound = propagation of density/pressure variations

Wave Nature of Sound

- Sound is a WAVE
- Wave = disturbance moving through medium
- Sound waves are MECHANICAL WAVES
- Require medium for propagation

Compressions and Rarefactions

- Compression (C)
  - Region of HIGH pressure
  - Particles crowded together
  - Higher density
  - Vibrating object moves forward
- Rarefaction (R)
  - Region of LOW pressure
  - Particles spread apart
  - Lower density
  - Vibrating object moves backward
- Series of C and R form sound wave

CHARACTERISTICS OF SOUND WAVES

Graphical Representation
- Crest = peak (maximum compression)
- Trough = valley (maximum rarefaction)
- Wave oscillates above and below average value

Three Main Characteristics
- Frequency
- Amplitude
- Speed

QUALITY/TIMBRE
- Distinguishes sounds of same pitch and loudness
- Enables identification of different sources
- Tone: Single frequency sound
- Note: Mixture of frequencies, pleasant
- Noise: Unpleasant sound
- Music: Pleasant, rich quality sound

WAVELENGTH (λ lambda)
- Distance between two consecutive compressions
- OR distance between two consecutive rarefactions
- SI Unit: metre (m)
- Graphical: crest to crest or trough to trough distance

TIME PERIOD (T)
- Time for one complete oscillation
- Time for density to go: max → min → max
- Time between two consecutive C or R passing a point
- SI Unit: second (s)

INTENSITY
- Sound energy passing per second through unit area
- Physical quantity (not physiological)
- Related to but different from loudness
- Equal intensity sounds may not sound equally loud

FREQUENCY (ν nu)
- Number of complete oscillations per unit time
- Number of C or R crossing a point per second
- Formula:
  - $\nu = \frac{1}{T}$
- SI Unit: Hertz (Hz)
- 1 Hz = 1 cycle per second
- Relationship: Frequency and Time Period are INVERSELY related

LOUDNESS
- Physiological response to sound
- Determined by AMPLITUDE
- Greater amplitude → Louder sound
- More force on object → More amplitude → Louder
- Decreases as sound travels away from source
- NOT same as intensity

PITCH
- How brain interprets frequency
- Higher frequency → Higher pitch
- Lower frequency → Lower pitch
- More C and R per second → Higher pitch
- Different objects produce different pitches

SPEED OF SOUND (v)
- Distance traveled per unit time
- Formula:
  - $v = \frac{\lambda}{T}$
- Therefore:
  - $v = \lambda \nu$
    - (MOST IMPORTANT)
- Speed = Wavelength × Frequency
- Remains same for all frequencies in given medium
- Depends on medium properties and temperature

AMPLITUDE (A)
- Maximum disturbance from mean position
- Magnitude of density/pressure variation
- Unit: density or pressure units
- Determines LOUDNESS

SPEED OF SOUND IN DIFFERENT MEDIA

Practical Observation
- Sound travels much faster in solids than air
- Used for detecting sound through structures
- Example: Hearing through aluminium rod vs air

Factors Affecting Speed
- Nature of medium (most important)
- Temperature of medium
- State of matter

Key Formula
- $v = \lambda \nu$
- Speed remains constant for all frequencies in same medium
- Under same physical conditions

Speed Variation by State
- SOLIDS: Fastest
- LIQUIDS: Medium
- GASES: Slowest
- General trend: Solid > Liquid > Gas

Speed in Common Media (at 25°C)
- GASES
  - Hydrogen: 1284 m/s
  - Helium: 965 m/s
  - Air: 346 m/s
  - Oxygen: 316 m/s
  - Sulphur dioxide: 213 m/s
- SOLIDS
  - Aluminium: 6420 m/s
  - Nickel: 6040 m/s
  - Steel: 5960 m/s
  - Iron: 5950 m/s
  - Brass: 4700 m/s
  - Glass (Flint): 3980 m/s
- LIQUIDS
  - Sea Water: 1531 m/s
  - Distilled Water: 1498 m/s
  - Ethanol: 1207 m/s
  - Methanol: 1103 m/s

Temperature Effect
- Higher temperature □ Higher speed
- Example in Air:
  - At 0°C: 331 m/s
  - At 22°C: 344 m/s
  - At 25°C: 346 m/s

Comparison with Light
- Sound speed << Light speed
- Thunder heard after lightning seen
- Same distance, different arrival times

REFLECTION OF SOUND

REVERBERATION

- Persistence of sound due to repeated reflections
- Common in big halls and auditoriums
- Excessive reverberation is undesirable
- Reduction Methods
  - Compressed fibreboard on walls/roof
  - Rough plaster
  - Draperies/curtains
  - Sound-absorbent seat materials
  - All materials chosen for absorption properties

Basic Principle

- Sound bounces off solids and liquids
- Like rubber ball bouncing off wall
- Follows same laws as light reflection

Laws of Reflection

- Angle of incidence = Angle of reflection
- Both angles measured from normal
- Incident ray, reflected ray, normal in same plane
- Requires large obstacle (polished or rough)

Uses of Multiple Reflection

- 1. Megaphones and Horns
  - Direct sound in specific direction
  - Tube + conical opening design
  - Successive reflections guide sound forward
  - Examples: loudhailers, trumpets, shehanais
- 2. Stethoscope
  - Medical instrument for internal body sounds
  - Multiple reflections carry heart/lung sounds
  - From patient's body to doctor's ears
- 3. Curved Ceilings
  - Concert halls, conference halls, cinema halls
  - Sound reaches all corners after reflection
  - Ensures uniform sound distribution
- 4. Sound Boards
  - Curved board behind stage
  - Reflects sound across hall width
  - Even spread of sound to audience

ECHO

- Reflected sound heard distinctly
- Requires suitable reflecting surface
- Examples: tall building, mountain, cliff
- Conditions for Hearing Echo
  - Minimum time gap: 0.1 s (persistence of sound in brain)
  - Speed of sound (at 22°C): 344 m/s
  - Total distance:
    - $344 \times 0.1 = 34.4\, m$
  - Minimum distance from obstacle:
    - $\frac{34.4}{2} = 17.2 m$
  - Distance varies with temperature
- Multiple Echoes
  - Due to successive reflections
  - Thunder rolling = multiple echoes from clouds and land
- Echo Calculation Formula
  - $Distance = \frac{v \times t}{2}$
  - Divide by 2 because sound travels twice the distance

Practical Applications

- Distance measurement using echo
- Architectural acoustics design
- Detecting obstacles at distance

RANGE OF HEARING

ULTRASONIC SOUND (Ultrasound)

- Frequencies ABOVE 20 kHz (20,000 Hz)
- Above human audible range
- Cannot be heard by humans
- Animals Using Ultrasound
  - Dolphins
  - Bats (for echolocation)
  - Porpoises
  - Certain moth families (sensitive hearing)
  - Rats (for playing/communication)
- Properties
  - High frequency waves
  - Can travel in well-defined paths
  - Can travel even with obstacles present
  - Used extensively in industry and medicine

AUDIBLE RANGE (Humans)

- Frequency range: 20 Hz to 20,000 Hz (20 kHz)
- Average human ear capability
- Children under 5: can hear up to 25 kHz
- Dogs: can hear up to 25 kHz
- Sensitivity decreases with age
- Older people: less sensitive to higher frequencies

Frequency Comparison

- Below 20 Hz: INFRASOUND
- 20 Hz - 20 kHz: AUDIBLE SOUND
- Above 20 kHz: ULTRASOUND

INFRASONIC SOUND (Infrasound)

- Frequencies BELOW 20 Hz
- Below human audible range
- Cannot be heard by humans normally
- Examples
  - Pendulum vibrations
  - Rhinoceroses communication: as low as 5 Hz
  - Whales produce infrasound
  - Elephants produce infrasound
- Earthquake Connection
  - Earthquakes produce infrasound before main shock
  - Animals can detect these
  - Animals get disturbed before earthquakes
  - Acts as early warning system for animals

HEARING AID

- For people with hearing loss
- Electronic, battery-operated device
- Working Principle
  - Microphone receives sound waves
  - Converts to electrical signals
  - Amplifier increases signal strength
  - Speaker converts back to amplified sound
  - Delivers to ear for clear hearing

APPLICATIONS OF ULTRASOUND

Advantages of Ultrasound

- Non-invasive
- Safe for human tissue
- Precise and accurate
- Real-time imaging possible
- No radiation exposure (unlike X-rays)

Properties Making Ultrasound Useful

- High frequency
- Travels in well-defined paths
- Works even with obstacles
- Can penetrate materials
- Reflects from boundaries

INDUSTRIAL APPLICATIONS

1. Cleaning
   - Cleans hard-to-reach places
   - Examples: spiral tubes, odd-shaped parts, electronic components
   - Method:
     - Place objects in cleaning solution
     - Send ultrasonic waves into solution
     - High frequency detaches dust, grease, dirt
     - Particles drop out
     - Thorough cleaning achieved
2. Defect Detection in Metals
   - Detects cracks and flaws in metal blocks
   - Used in: buildings, bridges, machines, scientific equipment
   - Principle:
     - Cracks/holes reduce structural strength
     - Invisible from outside
     - Ultrasound passes through metal
     - Detectors receive transmitted waves
     - Defects cause reflection back
     - Indicates flaw location
   - Why not ordinary sound?
     - Longer wavelength bends around corners
     - Cannot pinpoint defects accurately
     - Ultrasound's short wavelength is crucial

MEDICAL APPLICATIONS

1. Echocardiography
   - Images of heart structure
   - Ultrasound reflects from heart parts
   - Forms detailed heart image
   - Non-invasive technique
2. Ultrasound Scanner/Ultrasonography
   - Gets images of internal organs
   - Organs imaged: liver, gall bladder, uterus, kidney, etc.
   - Detects abnormalities:
     - Stones in gall bladder
     - Kidney stones
     - Tumors in various organs
   - Working:
     - Waves travel through body tissues
     - Reflect from regions of density change
     - Converted to electrical signals
     - Generate organ images
     - Displayed on monitor or printed
3. Prenatal Examination
   - Examination of fetus during pregnancy
   - Detects:
     - Congenital defects
     - Growth abnormalities
     - Fetal development stages
   - Safe, non-invasive method
4. Breaking Kidney Stones
   - Non-surgical method
   - Ultrasound breaks stones into fine grains
   - Grains flush out with urine
   - Avoids invasive surgery