O Level Physics
Unit 15: Sound

Sound Waves

1) Sound is produced by vibrating sources placed in a medium. The medium is usually air but can be any matter.

2) Production of sound waves by a loudspeaker- TB/294
   - Initially, layers of air are in undisturbed positions.
   - Vibration of the diaphragm of the loudspeaker causes the air layer in front of it to vibrate. A compression is produced (air pressure rises above surrounding air pressure).
   - This is turn causes the next air layer to vibrate through the transfer of energy.
   - As a result of the vibration, a series of alternating compressions (higher pressure regions, relative to surroundings) and rarefactions (lower pressure regions) are produced. As the vibration continues, the **longitudinal** sound waves propagate outwards.

   - At any one region along the pipe where sound waves travel, air pressure rises above the surrounding air pressure, and then falls below the surrounding air pressure. This changing of air pressure (series of compressions and rarefactions) in the medium is continuous as long as sound is produced.
   - In this example, energy from the source of vibration is propagated through the air by the vibration if air layers.

3) Interpretation of graph
   - Wavelength: the distance between two successive compressions/rarefactions.
   - Frequency: frequency of vibration of loudspeaker's diaphragm/ of air layers.
   - Amplitude: Maximum pressure change.

4) Worked example 15.1
   TB/296

Transmission & Speed of Sound

5) Sound waves require a medium for its transmission. Unlike electromagnetic waves, sound waves cannot pass through a vacuum.
   Proof: Bell jar experiment (TB/298)

6) Any medium which has particles that can vibrate will transmit sound.

7)
   - Sound travels fastest in solids due to the close packing of the particles in the solid state.
     - Speed of sound in air: 330m/s
     - Speed of sound in water: 1400m/s
     - Speed of sound in steel: 5000m/s
   - Speed of sound in gases are affected by two physical conditions
     - Temperature: Higher temp = higher speed
     - Humidity: Higher humidity = higher speed

8) Measuring the speed of sound in air through direct method
   TB/299

Echo

9) An echo is formed when a sound is reflected off hard, flat surfaces such as a large wall or a distant cliff. The laws of reflection apply to sound waves.

10) Uses of echoes- Echolocation
- Used for measuring of large distances/detection of location of objects
- By calculating the time lapse between the transmission of a signal and the reception of the reflected signal (echo), the depth of an ocean or the position of shoals of fish can be found. [not ultrasound]

Ultrasound

11)
- For the human ear, the range of audibility (range of frequencies which can be heard) is 20 Hz to 20 000 Hz.
- Ultrasound is sound waves that have frequencies above 20 kHz. Ultrasound is undetected by humans because its frequency exceeds the upper limit of our range of audibility.
- Infrasound is sound waves that have frequencies below the lower limit of the human's range of audibility.

12) Applications of ultrasound
   a. In quality control
      It is used to detect the level of liquid, powder or any material in a container. A pulse of ultrasound is transmitted from a sensor fixed at a height. If the level of the content in the container is lower than normal, the time between transmission and reception of the ultrasound pulse is increased, and the container is rejected.
   b. Pre-natal scanning
      Ultrasound is used to examine the development of a foetus by sending ultrasound pulses into the body through a transmitter. The echoes reflected from any surface within the body are received, and the depth of the reflecting surface within the body may be known. A real-time image of the foetus can be produced.

13) Advantages of ultrasound in medicine over
   a. X-rays
      X-rays can damage cells, while ultrasound is less hazardous due to its lower energy and does not produce adverse effects.
   b. Audible sound waves
      Ultrasound has a shorter wavelength, so there is less diffraction. Hence ultrasound can be used to detect smaller objects and produce sharper images.

Pitch and Loudness (TB/306-307)

14. Pitch and loudness are characteristics of sound that helps us determine if a sound is pleasant.

15.
- Pitch is related to the frequency of a sound wave. The lower the frequency, the lower the pitch.
- Loudness is related to the amplitude of a sound. The larger the amplitude, the louder the sound.

Notes: