Physics Standard X: Sound Waves Essay Questions

Concise Question Bank with Solutions for Examinations

1 Essay Questions and Answers

1. **Explain oscillatory motion using a swing, defining amplitude, period, and frequency. How can these be measured experimentally? (Application Level)**

   Answer: Oscillatory motion is the to-and-fro movement of a swing about its equilibrium position (O). Amplitude is the maximum displacement (O to A), in meters. Period (T) is the time for one oscillation (O to A to B to O), in seconds. Frequency (f) is oscillations per second, in Hertz ($f = \frac{1}{T}$). To measure, I'd use a simple pendulum, timing 10 oscillations with a stopwatch and measuring length with a meter scale. For 14 s over 10 oscillations, $T = \frac{14}{10} = 1.4\,\text{s}$, $f = \frac{1}{1.4} \approx 0.714\,\text{Hz}$. Longer pendulums increase period, reducing frequency. (99 words)

2. **Describe forced vibration and resonance with examples and their applications. (Application Level)**

   Answer: Forced vibration occurs when an object vibrates due to an external source, like a tuning fork (512 Hz) making a table vibrate, amplifying sound. Resonance happens when the external frequency matches the object's natural frequency, maximizing amplitude. For example, hacksaw blade A causes blades C and E to resonate. Applications include musical instruments (guitars amplify sound via resonance), stethoscopes (enhancing heartbeats), and MRI scans (nuclei resonate for imaging). A PVC pipe resonating with a tuning fork shows louder sound, used in flutes. These principles make physics practical in music and medicine. (93 words)

3. **Compare longitudinal and transverse waves using sound and string waves. How do they aid understanding wave propagation?**

   Answer: Longitudinal waves, like sound, have particles vibrating parallel to the wave's direction, forming compressions and rarefactions. A tuning fork creates these in air, transmitting sound energy. Transverse waves, like on a string, have particles moving perpendicularly, forming crests and troughs. Key characteristics—amplitude, wavelength, frequency, and speed ($v = f\lambda$)—describe both. In a slinky, only the disturbance travels, not the coils, showing energy propagation. Understanding these helps explain how sound travels through air or how light waves behave, connecting to real-world applications like acoustics. (94 words)

4. **Explain sound reflection, echo, and reverberation, and their impact on sound quality. (Application Level)**

   Answer: Sound reflects off surfaces, like an alarm clock's sound bouncing off a glass plate in a PVC pipe experiment. Smooth surfaces reflect better than rough ones. An echo is a distinct reflected sound, requiring a minimum 17.5 m distance in air (speed 350 m/s) due to 0.1 s persistence of hearing. Reverberation is lingering sound from multiple reflections, like in Gol Gumbaz. Rough cinema hall walls reduce reverberation for clearer sound. Echoes are clear in open spaces like mountains, enhancing or disrupting sound quality based on environment. (92 words)

5. **Calculate wave speed, frequency, and wavelength, applying to a sound wave scenario. (Application Level)**

   Answer: Wave speed (v) equals frequency (f) times wavelength (λ): $v = f\lambda$.

In a concert, a 440 Hz note with a sound speed of 343 m/s has a wavelength of $\lambda = \frac{343}{440} \approx 0.78\,\text{m}$. In a 17.5 m hall, sound travels to the wall and back in $\frac{2\times17.5}{343} \approx 0.102\,\text{s}$, causing a faint echo. This helps engineers design halls to control echoes, ensuring clear sound by adjusting distances or materials. (90 words)

6. **Discuss ultrasonic waves' uses in medicine and industry, with a calculation-based example. (Application Level)**

   Answer: Ultrasonic waves (>20 kHz) are used in ultrasonography for imaging organs, crushing kidney stones, and physiotherapy. In industry, they clean intricate parts. SONAR measures underwater distances. For example, a SONAR wave (speed 1522 m/s) returns in 0.4 s, so the distance to a rock is $\frac{1522\times0.4}{2} = 304.4\,\text{m}$. These applications show precision in medical diagnostics and navigation. High frequencies ensure accuracy, making ultrasonic waves vital for non-invasive medical procedures and efficient industrial cleaning, connecting physics to practical innovations. (86 words)