8. Oscillations

Definitions

Simple harmonic motion: Simple harmonic motion is defined as the oscillatory motion of a body whose acceleration is directly proportional to its displacement from a fixed equilibrium position and is always directed towards that fixed position.

Damping: Damping is the process in which energy is taken from the system.

Resonance: Resonance occurs when a system responds at maximum amplitude to an external driving force. This occurs when the frequency of the driving force is equal to the natural frequency of the driven system.

Angular frequency: Angular frequency of a body undergoing SHM is a constant of a given oscillator and is related to its natural frequency by $w = 2\pi f$

NOTE

- Spring mass system: F(restoring) = -kx → -kx = ma → a = -(k/m)x and since a = -omega^2 x, omega equals to square root of k/m
- Simple pendulum: F(restoring) = -mgsintheta = -mgtheta (by small angle approximation) → -mgtheta = ma → a = -gtheta = -g(s/L) and therefore omega equals to square root of g/L
- At resonance, there is maximum transfer of energy, at any other frequencies there is energy lost due to overcoming of resistive forces.
- When there is energy lost/damping, amplitude and frequency decreases.
- When mass of a system increases, natural frequency of the system decreases too
- In a system with more than one load, the heavier one will provide the driving force
- As length of pendulum increases, the natural frequency of the rod decreases
- Questions involving two rods with rubber bands connecting them: When more rubber bands are tied, coupling is bettered and there will be a greater rate of transfer from the driver to the other load thus increasing the amplitude of the driving force. (refer to question 7 of chapter 8 revision)
- **CONDITION FOR SHM: ANGLE MUST BE SMALL**

Questions

1. Using energy consideration, explain why total energy of the system increases to another value at a steady rate.

Ans: The periodic force is transferring energy to the oscillating system and hence the total energy of the system increases. When the rate of energy transfer is equal to the rate of energy lost due to resistance, the total energy reaches a new steady value.