Write short answer questions of the following.

1. Give two applications in which resonance plays an important role.

Ans. APPLICATIONS

1. RADIO AND RESONANCE

Tuning a radio is the best example of electrical resonance. When we turn the knob of a radio, to tune a station, we are changing the natural frequency of the electric circuit of the receiver to make it equal to the transmission frequency of the radio station. When the two frequencies match, energy absorption is maximum and this is the only station we hear.

2. COOKING OF FOOD AND RESONANCE

In a microwave oven, microwave with a frequency similar to the natural frequency of vibration of water or fat molecules are used. When food which contains water molecules is placed in the oven, the water molecules resonates, absorbing energy from the microwaves and consequently gets heated up.

2. What happens to the time period of a simple pendulum if its lengths is doubled?

Ans. The equation for time period of simple pendulum of length "L" is given by;

$$T = 2\pi\sqrt{\frac{L}{g}}$$

When the length of the pendulum is made double i.e. $L' = 2L$, then the new time period is given by;

$$T' = 2\pi\sqrt{\frac{L'}{g}}$$

Or

$$T' = 2\pi\sqrt{\frac{2L}{g}} = 2\pi\sqrt{\frac{L}{g}} \times \sqrt{2}$$

$$T' = T \times \sqrt{2} = \sqrt{2}T$$

Thus the new time period is increased by a factor of $\sqrt{2}$.

3. What will be the frequency of a simple pendulum if its lengths '1m'.

Ans. The equation for the frequency of simple pendulum is given by;

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{L}}$$

For a pendulum of length L = 1 m, the frequency is;

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{1}} = \frac{1}{2\pi}\sqrt{g}$$

$$f = \frac{1}{3.14} \times 3.13 = 0.996 \text{ Hz} \approx 1.00 \text{ Hz}$$

4. **Give one practical example each of free and forced oscillation.**

Ans. **FREE OSCILLATIONS**

A body is said to be executing free vibrations if it oscillates with its natural frequency without the interference of an external force.

Free vibrations are oscillations where the total energy stays the same over time. This means that the amplitude of the vibration stays the same.

EXAMPLES.

i. A simple pendulum vibrates freely with its natural frequency in the absence of external forces.
ii. Oscillations of a swing in the absence of external force.

FORCED OSCILLATIONS

Oscillations that occur under the influence of an external periodic force are known as forced oscillations.

Forced vibrations occur when the object is forced to vibrate at a particular frequency by a periodic input of force. The amplitude of forced oscillations depends upon the external frequency of the periodic force and the natural frequency of the system.

EXAMPLES

i. A simple example is a child's swing that is pushed on each downswing.
ii. Also when the mass of the pendulum is struck periodically, then forced vibrations are produced.
iii. Oscillations of walls and floor of a room due to heavy machinery like generator is also an example forced oscillations.

5. **A simple pendulum set into vibrations and left untouched, eventually stops, why?**

Ans. When a simple pendulum is set into vibrations and left untouched, it comes to rest after sometimes because during the oscillating pendulum must do some work against the resistive or frictional forces of the medium. Because of this work in each cycle, the amplitude of the oscillation decreases with time and therefore it finally comes to rest.

6. **Explain why in S.H.M the acceleration is zero when the velocity is greatest.**

Ans. The equation of acceleration for a body performing SHM is;

$$a = -x\omega^2 \qquad (1)$$

The equation of velocity for a body performing SHM is;

$$V = \omega\sqrt{x_o^2 - x^2} \qquad (2)$$

At mean position, x = 0, and the velocity is maximum i.e.

$$V_o = \omega x_0^2$$

Since acceleration is the rate of change of velocity and the change in velocity at this instant is zero because there is no more increase in the velocity, therefore the acceleration is zero. Also from equation (1), a= 0 at x = 0.

7. **Is there a connection between F and x in mass-spring system? Explain.**

Ans. Yes, the force and displacement in mass-spring system are directly related to each other. From Hook's law; "The force applied on a mass attached to a spring is directly proportional to the displacement from the mean position provided the elastic limits are not violated".

If the spring is stretched or compressed a small distance "x" from its upstretched or equilibrium position and then released, it exerts a force on the object which is related to the displacement by the equation;

$$F = kx$$

It is quite clear from the above equation that the force is zero when displacement is zero and force is maximum when displacement is maximum.

8. **What happens to the frequency of a simple pendulum as it oscillations die down from large amplitude to small?**

Ans. The process by which energy of the oscillating system is dissipated is known as damping.

The energy of a damped oscillating system decreases due to the work done against friction. In real world there are always dissipative forces acting on the system. This is why oscillations die down with the passage of time if energy is not supplied continuously. Damping affects the frequency of oscillation in such a way that as damping increases the frequency decreases and vice versa.

9. **A singer, holding a note of right frequency, can shatter a glass. Explain.**

Ans. **<u>SHATTERING A CRYSTAL GOBLET BY SINGING</u>**

The great Enrico Caruso was said to be able to shatter a crystal goblet by singing a note of just the right frequency at full voice. This is an example of resonance, for the sound waves emitted by the voice act as a forced oscillation on the glass. At resonance, the resulting oscillation of the goblet may be large enough in amplitude that the glass exceeds its elastic limit and breaks.

10. **Find out the phase difference in the following figures:**

Ans. The general way of showing the equation of simple harmonic oscillator is:

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10. Find out the phase difference in the following figures:

Ans. The general way of showing the equation of simple harmonic oscillator is:

$$x = x_0 \cos(\omega t + \Phi) \quad (1)$$

Where $\theta = \omega t + \Phi$ is the phase angle.

The quantity Φ represents the phase difference between the states of motion of two oscillators.

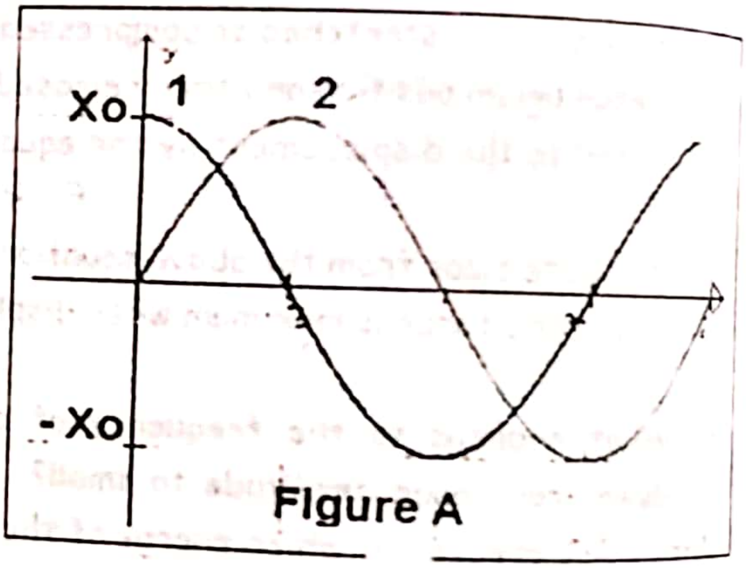

Figure A

For figure A:

The equation of motion of wave 1 is;

$$x = x_0 \cos(\omega t)$$

The equation of motion of wave 2 is;

$$x = x_0 \sin(\omega t)$$

$$x = x_0 \cos(\omega t - \pi/2)$$

$(\sin(\omega t) = \cos(\omega t - \pi/2))$

Therefore the phase difference between the oscillators is $\pi/2$ i.e., 90°.

For figure B:

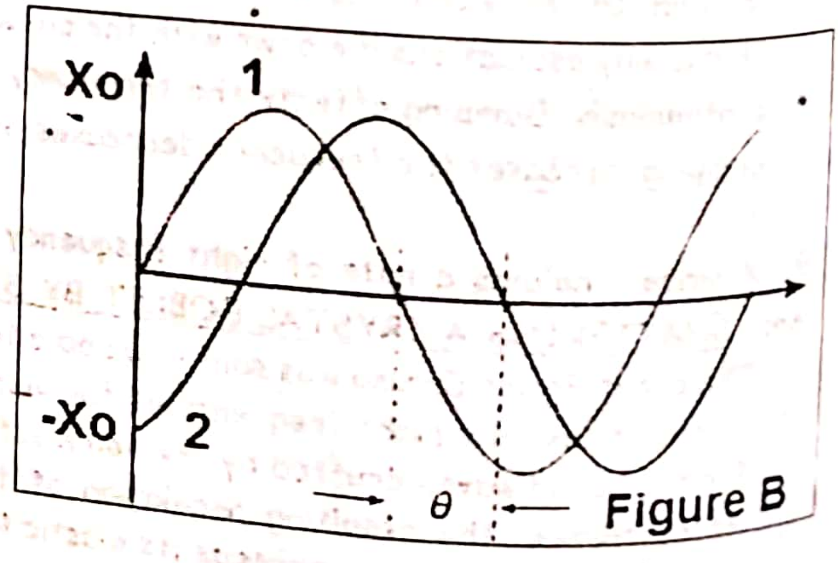

Figure B

The equation of motion of wave 1 is;

$$x = x_0 \sin(\omega t)$$

$$x = x_0 \cos(\omega t - \pi/2)$$

The equation of motion of wave 2 is;

$$x = x_0 \cos(\omega t + \pi)$$

Therefore the phase difference between the oscillators is = $\pi/2$ i.e., 90°.