Answer on Question #50967, Physics, Mechanics | Kinematics | Dynamics

Define and explain free and forced oscillations.

Answer:

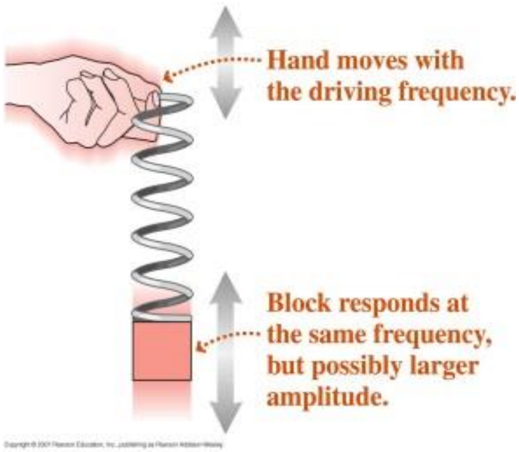
Free oscillation is the oscillation of a body or system with its own natural frequency and under no external influence other than the impulse that initiated the motion.

When an object is in free oscillation, it vibrates at its natural frequency. For example, if you strike a tuning fork, it will begin to vibrate for some time after you struck it, or if you hit a pendulum, it will always oscillate at the same frequency no matter how hard you hit it. All oscillating objects have a natural frequency, at which they will vibrate at once they have been moved from the equilibrium position.

The amplitude remains constant as time passes, there is no damping. This type of oscillation will only occur in theory since in practice there will always be some damping. The displacement will follow the formula $\boldsymbol{x = A sin\omega t}$ where A is the amplitude.

Forced oscillation is an oscillation imposed upon a body or system by and with the frequency of some external vibrator of sensibly different frequency.

Imagine a building in an earthquake. The ground is moving side to side, and the building (assuming that it is strong enough to not be completely destroyed by the forces) will be moving side to side with the ground. In this case, this oscillation is not the buildings natural frequency, but it is being forced to vibrate with the ground. This is a forced oscillation. Another simple example of forced vibrations is a child's swing: as you push it the amplitude increases and if the driving frequency is the same as the natural frequency of the swing resonance occurs. A loudspeaker is also an example of forced oscillations; it is made to vibrate by the force on the magnet on the current in the coil fixed the speaker cone.



For example, in the case of the (vertical) mass on a spring the driving force might be applied by having an external force (F) move the support of the spring up and down. In this case the equation of motion of the mass is given by,

$$m\frac{d^2x}{dt^2} + b\frac{dx}{dt} + kx = F_0 \cos \omega_D t$$

where b is the damping constant, ω_D is the (angular) frequency of the driving force F.

This equation has solutions of the form

$$x = B\sin(\omega_D t + \phi)$$

where the amplitude of these oscillations, B, depends on the parameters of the motion

$$B = \frac{F_0/m}{\sqrt{(\omega^2 - \omega_D^2)^2 + b^2\omega_D^2/m^2}}$$

The amplitude, B, has a maximum value when $\omega = \omega_D$. This is called the resonance condition. Note that at resonance, B, can become extremely large if *b* is small.