**Answer on Question #50892-Physics-Mechanics-Kinematics-Dynamics**

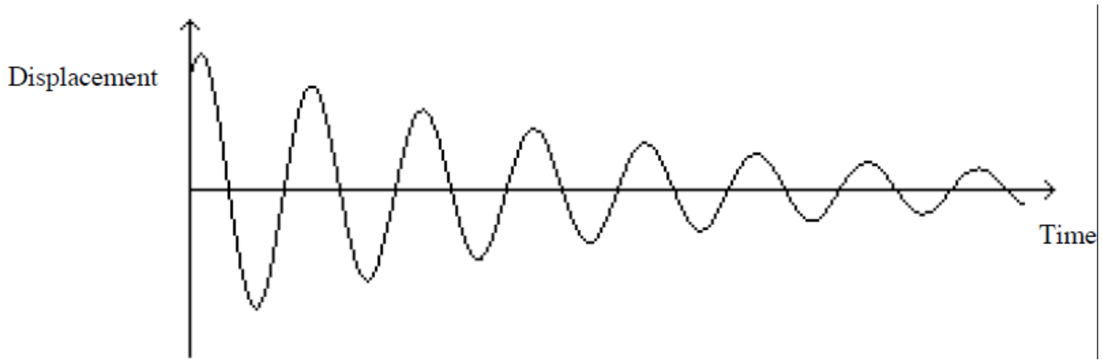
Define and explain forced and damped Oscillation Mathematical analysis.

**Answer**

Damped oscillations

If the total mechanical energy of an oscillating system were conserved, the system would oscillate indefinitely with the same amplitude. In any real situation, however, there are always nonconservative forces such as friction or drag forces present. These dissipative forces decrease the system's total mechanical energy and can be either internal or external to the system. The amplitude will gradually decrease and the oscillations will die out. An oscillation which dies away is an example of *a transient motion*. Examples include pendulums with damping forces.

The frequency, $f_D$, of a damped system is always less than $f_N$, the natural frequency that the system would have if the damping forces could be removed, since the damping forces always act to retard the motion.



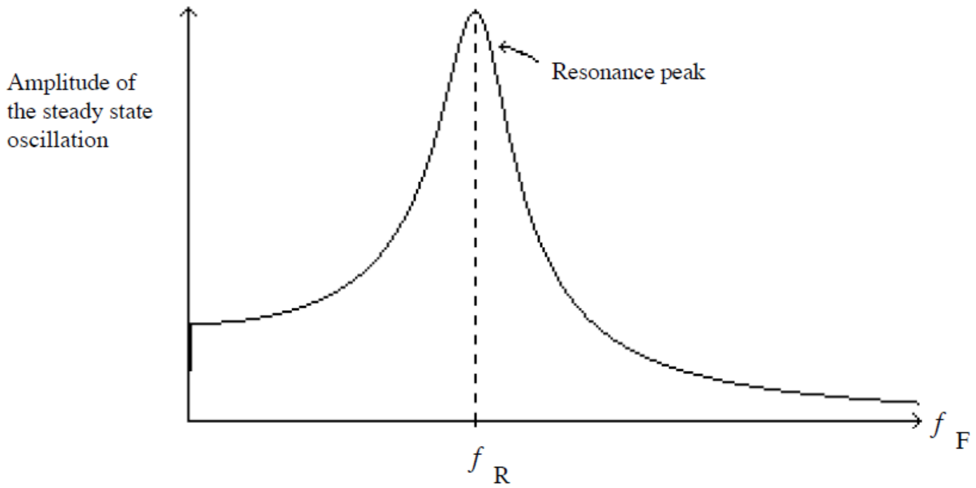

Forced oscillations

When non-conservative forces are present, an oscillation can die out unless energy is continually supplied to the system by *a driving force*. An oscillation which is kept going by a periodic driving force is called a *forced oscillation*. An example is a car engine.

If the driving force is sinusoidal (i.e. if a graph of the driving force against time looks like a sine curve, perhaps shifted along the time axis), there will be *a steady state oscillation* set up at the frequency, $f_F$, of *the driving force*. In general, $f_F$ will be quite different from $f_D$.

For a given amplitude of driving force, the amplitude of the steady state oscillation depends on the driving frequency $f_F$. An example is a vibrating metal rule driven by an electromagnet.

Each time the frequency of the driving force is changed, the new oscillation takes a while to become stable, while the transient oscillations die away. As the driving frequency is increased from zero, the amplitude of the steady state oscillation gradually increases until it reaches a peak and then dies away again (see a figure). This phenomenon is called *resonance*. The frequency ($f_F$) of the driving force at which the amplitude of the oscillation is a maximum is called the *resonance frequency*, $f_R$ , and the region of the graph near $f_R$ is called *the resonance peak*.




For lightly damped systems, $f_N$ , $f_D$ and $f_R$ are all approximately equal. At resonance the driving force adds to the restoring force in the damped system, producing large accelerations and oscillations.

Examples of forced oscillations

• Shivering to heat the body in response to cold.

• Expansion of the chest in breathing.

• Beating of the heart and dilation and contraction of the arteries.

In each case the driving force is provided by the muscles. When these systems relax from high to low potential energy states, their mechanical energy is decreased by the work done by nonconservative forces. The systems are highly damped and require the driving force to cause the motion.