AP Physics Study Guide

Oscillatory Motion and Waves

From Simple Studies, https://simplestudies.edublogs.org & @simplestudiesinc on Instagram

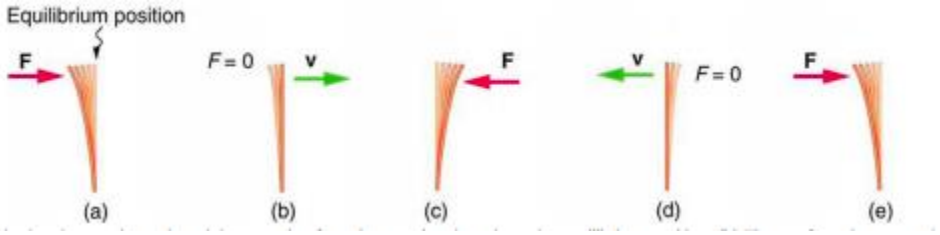
All images are from the Openstax college physics textbook

Something that **oscillates** moves back and forth between two points

- Ex: a child on a swing, an ocean buoy, the beating of a heart
- All oscillations involve force and energy
- Some oscillations create **waves** - disturbances that move from its source and carry energy
    - Ex: earthquakes, visible light

A **restoring force** is a force acting in opposition to the force caused by a deformation

- Hooke's law: $F = -kx$
    - F is the restoring force
        - The restoring force is in the direction opposite to the displacement
    - x is the displacement from equilibrium of **deformation**
    - k is a **force constant** related to the difficulty in deforming the system
        - The larger the force constant, the greater the restoring force, and the stiffer the system



Elastic potential energy is potential energy stored as a result of deformation of an elastic object (ex: the stretching of a spring)

- $PE_{el} = .5kx^2$

Periodic motion is a motion that repeats itself at regular time intervals

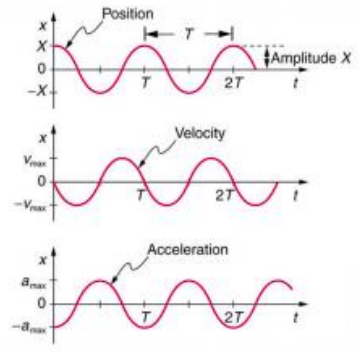
- The **period** (T) is the time to complete one oscillation (it remains constant)
- **Frequency** (f) is the number of events per unit time
    - $f = 1/T$

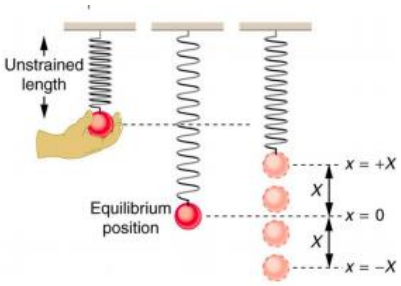
Simple Harmonic Motion is the name given to oscillatory motion for a system where the net force can be described by Hooke's Law

- This system is called a **simple harmonic oscillator**
    - If the net force can be described by Hooke's law, and there is no damping by friction or other non-conservative forces, then a simple harmonic oscillator will oscillate with equal displacement on either side of the equilibrium position
- The maximum displacement from equilibrium is called the **amplitude** (X)
    - Period and frequency are independent of amplitude
        - $T = 2\pi\sqrt{\frac{m}{k}}$
        - $f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$

Simple harmonic motion can be related to sine and cosine curves

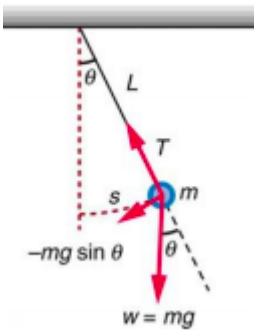
- $x(t) = X\,cos\frac{2\pi t}{T}$
- $v(t) = -v_{max}\,sin(\frac{2\pi t}{T})$
- $a(t) = -\frac{kX}{m}\,cos\frac{2\pi t}{T}$





A **simple pendulum** is defined to have an object that has a small mass suspended from a light wire or string

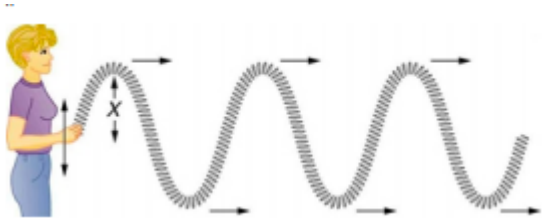
- $T = 2\pi\sqrt{\frac{L}{g}}$
    - The only things that affect the period of a simple pendulum are its length and the acceleration due to gravity
    - It is independent of other factors such as mass



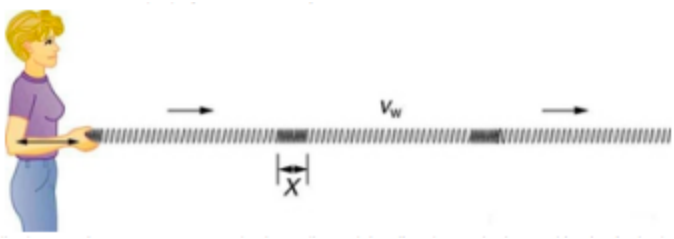
Energy in the simple harmonic oscillator is shared between elastic potential energy and kinetic energy, with the total being constant

- $.5mv^2 + .5kx^2 =$constant
- Maximum velocity depends on three factors:
    - $v_{max} = \sqrt{\frac{k}{m}}X$
        - It is directly proportional to amplitude
        - It is greater for stiffer systems
        - It is smaller for objects that have larger masses

A **transverse wave** is a wave in which the disturbance is perpendicular to the direction of propagation



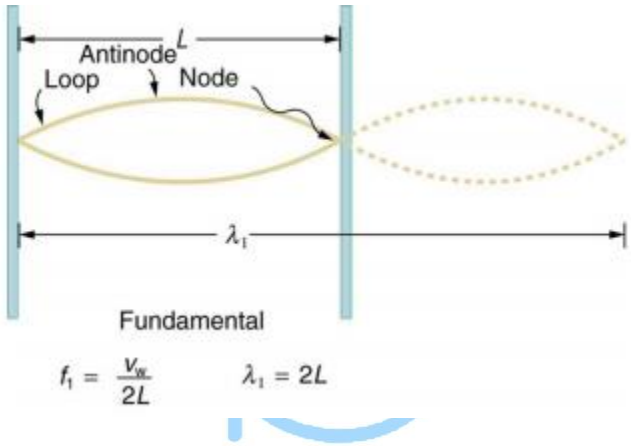
A **longitudinal wave** has a disturbance parallel to its direction of propagation



- Waves can be the combination of the two(Ex: water waves)

In waves, the **fundamental frequency** is the longest wavelength

- The **overtones** of harmonics are multiples of the fundamental frequency



Beat frequency is the frequency of the amplitude fluctuations of a wave

- Beats occur when waves of similar frequencies are superimposed
- $f_B = |f_1 - f_2|$