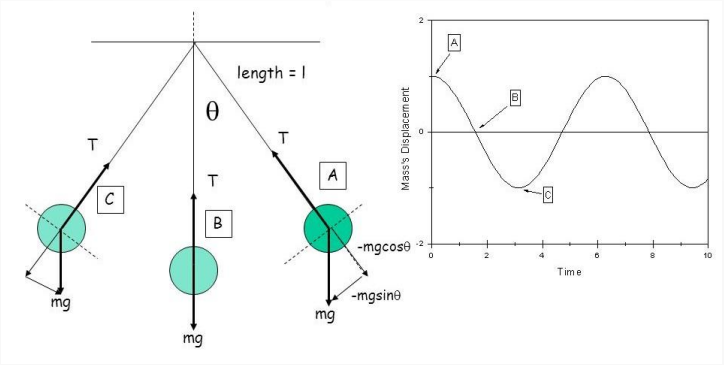
Simple Harmonic Motion

AP Physics

Unit 6



Objectives

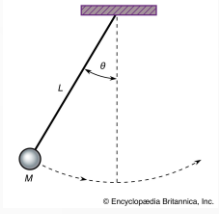
- **Explain** qualitatively and quantitatively, characteristics of oscillations, including the key properties of SHM, and what is required for SHM to occur
- **Explain** what properties determine the period, frequency, and angular frequency of a simple pendulum
- **Quantitatively** describe a system using tensile stress and compressive stress and describe the relationship to Hooke's Law
- **Explain** the connection between Hooke's Law and SHM
- **Predict** qualitatively and quantitatively, how KE and Ug vary during an oscillation of a system

Formula's on AP Equation Sheet

- $T_s = 2\pi\sqrt{\frac{m}{k}}$ Period of spring
- $T_p = 2\pi\sqrt{\frac{L}{g}}$ Period of pendulum
- $T = \frac{1}{f}$ Period and Frequency

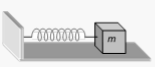
When to use SHM

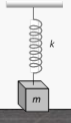
- When determining the **period** of a spring or pendulum
- Determining quantities at critical points, such as max displacement, max force, where the velocity is zero, etc
- Graphing motion/force for a spring or pendulum
- Commonly combined with energy



Common Examples

- Objects oscillation on a spring (horizontally or vertically)
- Objects swinging on a string (pendulum)



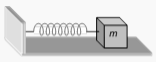


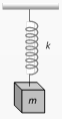
Terms

- **Simple periodic motion** is motion repeated in equal intervals of time.
  - Example: rocking chair, swing, clock, pendulum, metronome, tuning fork, trapeze

- **Simple Harmonic Motion (SHM)** – a special type of periodic motion an object experiences due to a **restoring force** whose magnitude is directly proportional to the distance of the object from an equilibrium positions and acts toward the equilibrium positions

SHM Types
- Pendulum
- Spring
  - Horizontal
  - Vertical





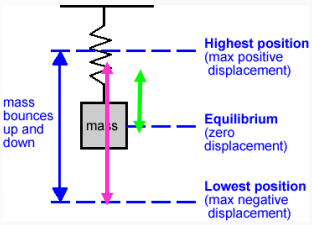
Simple Harmonic Motion

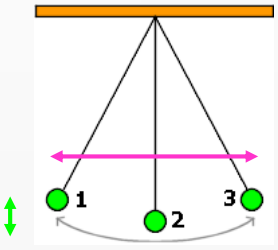
2 Quantities Describe SHM

- **Amplitude(A)** – maximum distance from equilibrium position

- **Period (T)** – time required to complete a full complete cycle or vibration.
  - The number of vibrations/sec is the objects **frequency** (f)
    - f = $\frac{1}{T}$ or T = $\frac{1}{f}$ (AP eqn)
    - Frequency is measured in Hertz (Hz) (1/sec)

One complete cycle – object returns to starting position!!

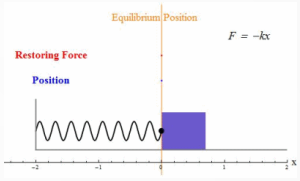


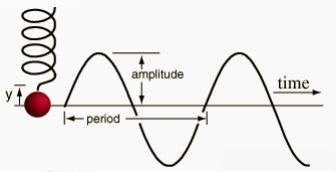


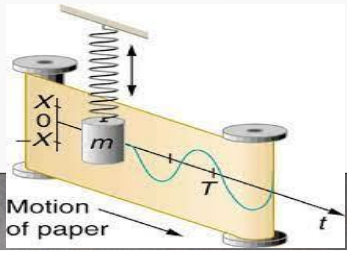
Simple Harmonic Motion (SHM)

There are three main things that define SHM

1. There must be a **restoring force** that is directly proportional to displacement but in the opposite direction
2. The **period** of motion is **independent of amplitude**
3. The graph of position and time is a sine or cosine curve

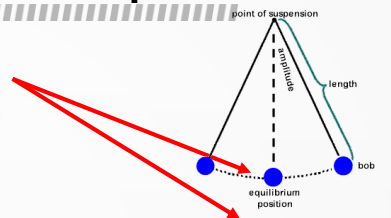


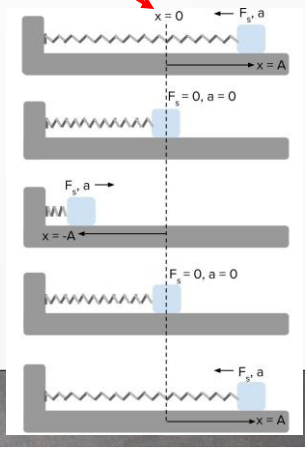




Recap: Restoring Forces and Equilibrium

- **Equilibrium** is the point in the oscillation where there is **zero net force** (acceleration is zero)
- If you displace the object a small amount from equilibrium, a **restoring force** will accelerate the object toward the equilibrium position
- The force (and therefore the acceleration) is not constant, but is directly proportional to the displacement from the equilibrium
- The max displacement from equilibrium is called the **amplitude (A)**





SHM – Linear system – Velocity, Accel, Force