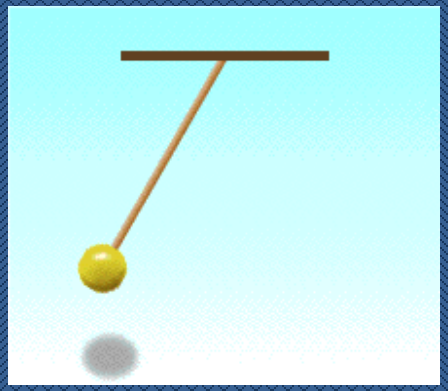
Pre-AP Physics: Unit 7
Vibrations, Waves, and Sound

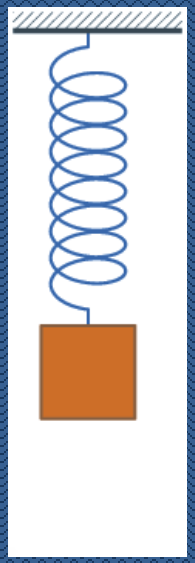
Part 1
Simple Harmonic Motion

Simple Harmonic Motion

- Constant periodic motion of an object.
- An object oscillates "back and forth" along the same path.

- Examples
  1. Mass on a string (pendulum)
  2. Mass on a spring (spring oscillator)

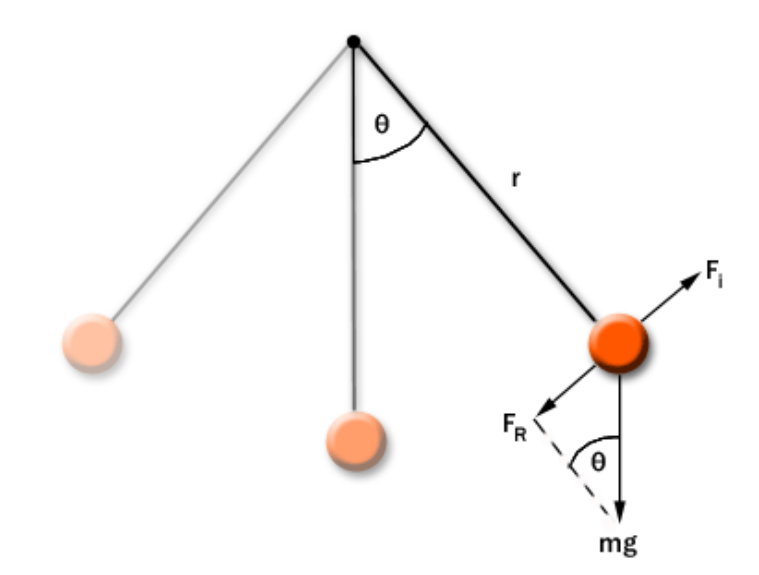


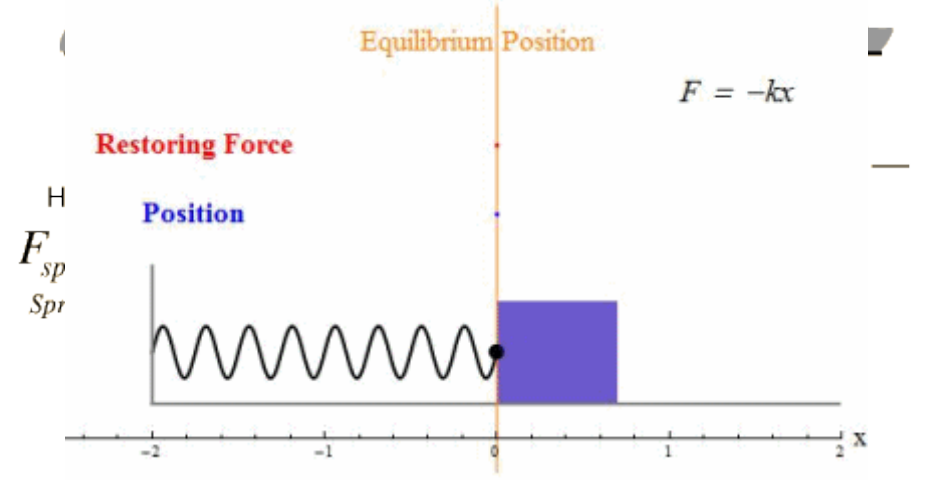


- The maximum displacement of the object from its equilibrium position is the Amplitude.

Simple Harmonic Motion

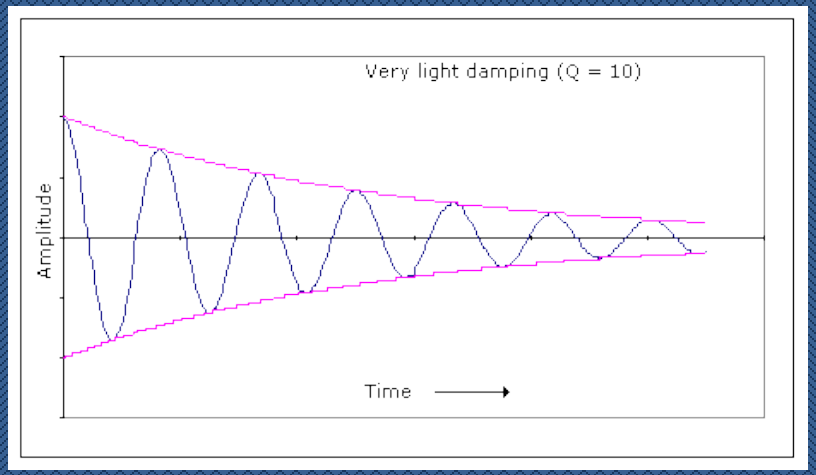
- The restoring force is directly proportional to the displacement of the mass from equilibrium.
  - For springs, the restoring force is determined by Hooke's Law: $F = -kx$
  - For pendulums, the restoring force is a component of the weight of the object.

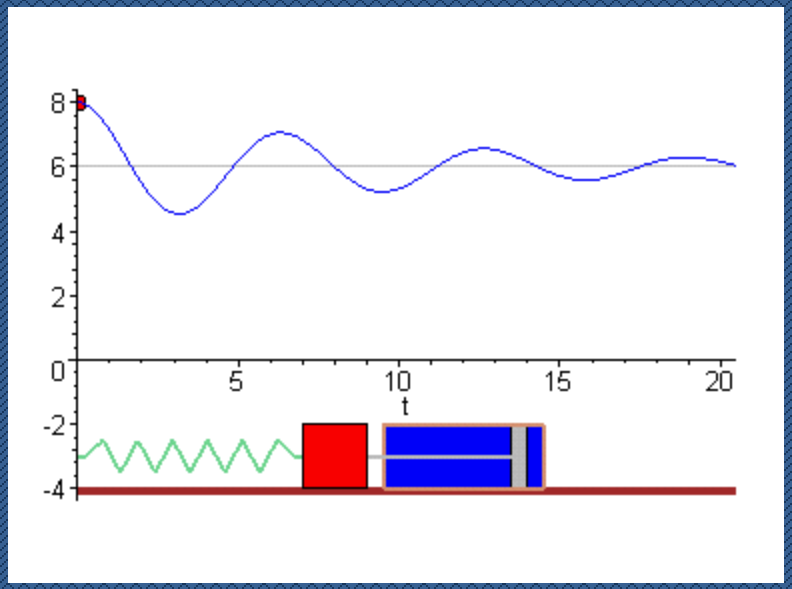




Simple Harmonic Motion

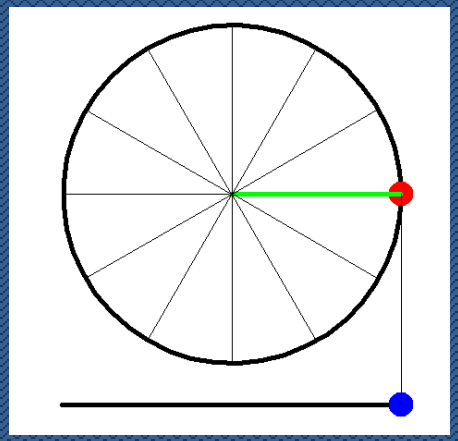
- In a frictionless environment, the motion would continue on indefinitely.
- When friction is present, the motion slows until the object eventually comes to a stop.
- This is called Damping.

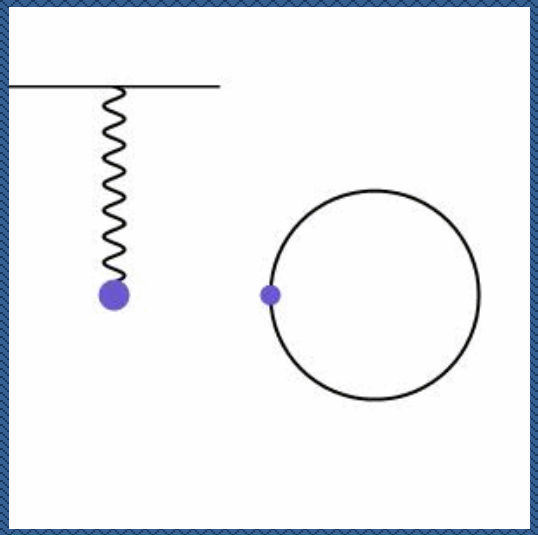




Simple Harmonic Motion

- SHM is similar to circular motion.
- Certain terms can be used to describe both.
  - Frequency
    - # of oscillations (cycles) per second.
    - Measured in Hertz
  - Period
    - The time needed to complete one oscillation.
    - Measured in seconds.





Frequency and Period

- Frequency and period are inversely related:

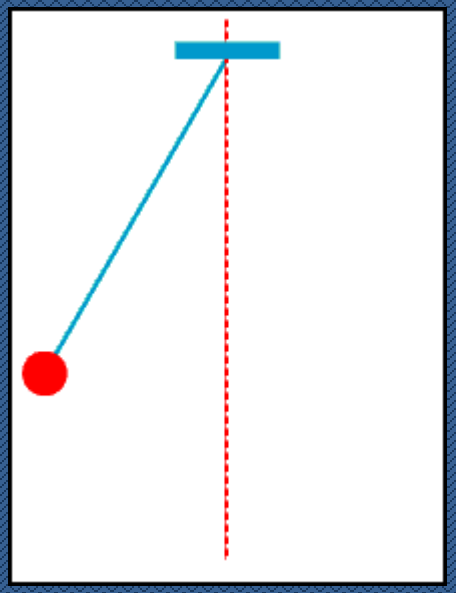
$$f = \frac{1}{T}$$

Frequency and Period

- Example
  A swinging pendulum bob completes 4 oscillations every 2 seconds.
  1. What is the frequency of the pendulum?

     Answer: 2 Hz
  2. What is the period of oscillation?

     Answer: 0.5 seconds



Calculating Period

- Period of oscillation for a pendulum.
  - Only dependent on the length of the pendulum (and gravity).
  - Equation:
    - l: length of pendulum (in meters)
    - g: acceleration due to gravity (9.8 m/s^2)

$$T_p = 2\pi\sqrt{\frac{l}{g}}$$

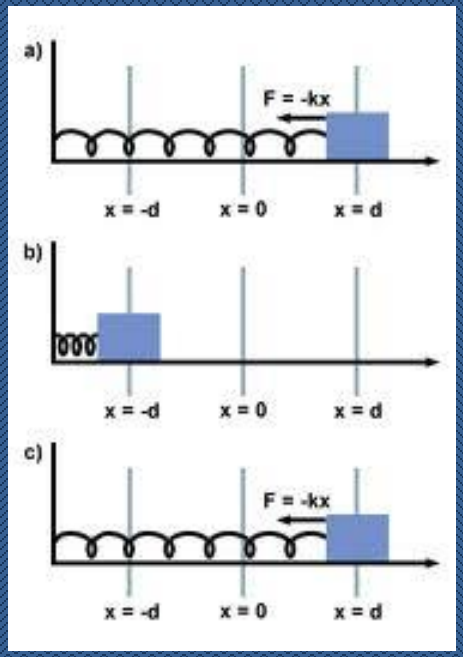
- Period of oscillation for an object attached to a spring.
  - Only dependent on the mass of the object (and the spring constant of the spring).
  - Equation:
    - m: mass of the object (in kg)
    - k: spring constant of the spring (in N/m)

$$T_s = 2\pi\sqrt{\frac{m}{k}}$$

Example 1

A 1.5 kg object is attached to a fixed spring and placed on a horizontal surface that is frictionless. The spring constant is found to be 25 N/m. The object is pulled to a maximum amplitude of 0.25 meters and released. What is the period of the oscillation of the object?

Answer: 1.54 seconds



Example 2

A clockmaker is trying to produce a large grandfather clock for a customer. He would like it to contain a pendulum that will move back and forth once every second. How long should the clockmaker design the pendulum rod for this clock?

Answer: 0.248 meters