Goals

- To describe oscillations in terms of amplitude, period, frequency and angular frequency
- To do calculations with simple harmonic motion
- To analyze simple harmonic motion using energy
- To apply the ideas of simple harmonic motion to different physical situations
- To analyze the motion of a simple pendulum
- To explore how oscillations die out
- To learn how a driving force can cause resonance

Introduction

Many kinds of oscillation (such as a simple pendulum, horizontal elastic pendulum, musical vibrations, and pistons in car engines) repeat themselves. We call such behavior *periodic motion* or *oscillation*.

Oscillations and Mechanical Waves

- *Periodic motion* is the repeating motion of an object in which it continues to return to a given position after a fixed time interval.
- The repetitive movements are called *oscillations*.
- A special case of periodic motion called *simple harmonic motion* will be the focus.
  - Simple harmonic motion also forms the basis for understanding mechanical waves.
- Oscillations and waves also explain many other phenomena quantity.
  - Oscillations of bridges and skyscrapers
  - Radio and television

Periodic Motion

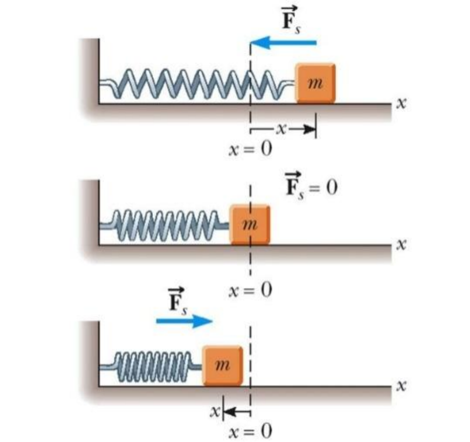
- ***Periodic motion*** is motion of an object that regularly returns to a given position after a fixed time interval.
- A special kind of periodic motion occurs in mechanical systems when the force acting on the object is proportional to the position of the object relative to some equilibrium position.
  - If the force is always directed toward the equilibrium position, the motion is called ***simple harmonic motion.***

Motion of a Spring-Mass System

- A block of mass *m* is attached to a spring, the block is free to move on a frictionless (without friction) horizontal surface.
- When the spring is neither stretched (elongation) nor compressed, the block is at the ***equilibrium position.***

$$x = 0$$

- Such a system will oscillate back and forth if disturbed from its equilibrium position.



Hooke's Law

- Hooke's Law states $F_s = -kx$
  - F_s is the restoring force.
    - It is always directed toward the equilibrium position.
    - Therefore, it is always opposite the displacement from equilibrium.
  - k is the force (spring) constant.
  - The rigidity of a spring is represented by the spring constant k.
  - x is the displacement.

Restoring Force and the Spring Mass System

In fig1, the block is displaced to the right of $x = 0$.

- The position is positive (x>0).
- The restoring force is directed to the left.

$F_s = -kx < 0$

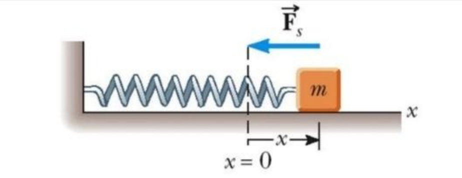


fig1

In fig2, the block is at the equilibrium position.

- $x = 0$
- The spring is neither stretched nor compressed.

$F_s = -k\,x = 0$

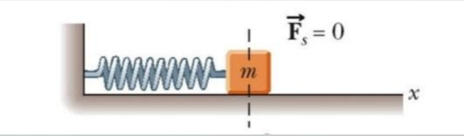


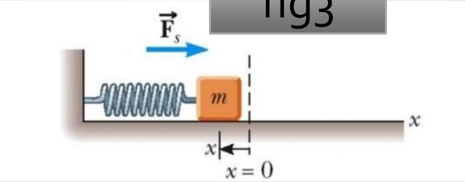
fig2

Restoring Force, cont.

In fig.3, the block is displaced to the left of $x = 0$.

- The position is negative ($x < 0$.
- The restoring force is directed to the right. $F_s = -kx > 0$

fig3



Acceleration

- When the block is displaced from the equilibrium point and released, it is a particle under a net force and therefore has an acceleration.
- The force described by Hooke's Law is the net force in Newton's Second Law.

$$\sum \vec{F} = m\vec{a} \qquad \overrightarrow{W} + \vec{R} + \vec{F}_s = m\vec{a}$$

$$-kx = ma_x \longrightarrow a_x = -\frac{k}{m}x$$

- The acceleration is proportional to the displacement of the block.
- The direction of the acceleration is opposite the direction of the displacement from equilibrium.
- An object moves with simple harmonic motion whenever its acceleration is proportional to its position and is oppositely directed to the displacement from equilibrium.

Acceleration, cont.

- The acceleration is ***not*** constant.
  - If the block is released from some position $x = A$, then the initial acceleration is $-kA/m$.
  - When the block passes through the equilibrium position, $a = 0$.
  - The block continues to $x = -A$ where its acceleration is $+kA/m$.

Motion of the Block

- The block continues to oscillate between –A and +A.
- These are turning points of the motion.
- The force is conservative.
- In the absence of friction, the motion will continue forever.
- Real systems are generally subject to friction, so they do not actually oscillate forever.