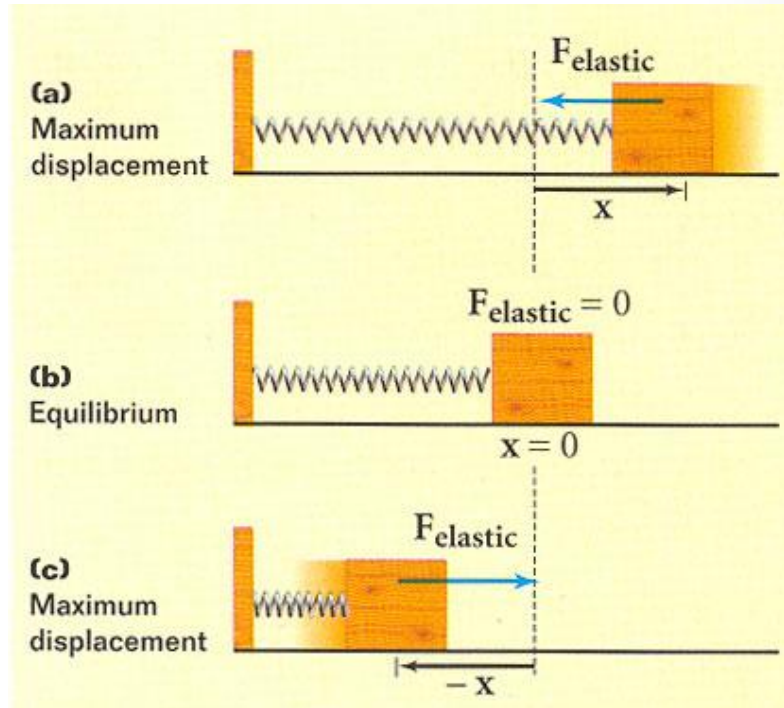
# Simple Harmonic Motion

# Section 12-1
## Simple Harmonic Motion

- Force is maximum at maximum displacement.
- Force is zero at equilibrium



# Simple Harmonic Motion con't

- Simple Harmonic Motion–vibration about an equilibrium position in which a restoring force is proportional to the displacement from equilibrium.
- Hooke's Law–Discovered in 1678 by Robert Hooke. The relationship between the force and displacement in a mass-spring system.

$$F_{elastic} = -kx$$

# Some problems

1. A 76 N crate is attached to a spring (k = 450 N/m). How much displacement is caused by the weight of the crate?

Given:

F = 76 N

k = 450 N/m

$$F_{elastic} = -kx$$

$$76\,N = -(450\,N/m)x$$

$$x = -0.17m$$

# Some Problems con't

2. A spring of k = 1962 N/m loses its elasticity if stretched more than 50.0 cm. What is the mass of the heaviest object the spring can support without being damaged?

Given:

k = 1962 N/m

x = 50.0 cm = 0.50 m

$$F_{elastic} = -kx$$

$$F_{elastic} = -(1962\,N/\ m)(0.50\,m)$$

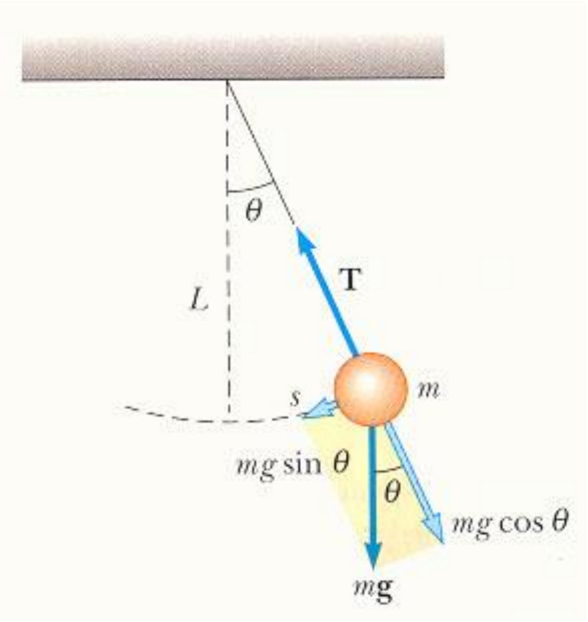
$$F_{elastic} = -981\,N$$

$$F = ma$$

$$981\,N = m\left(9.81\frac{kgm}{s^2}\right)$$

$$m = 100\,kg$$

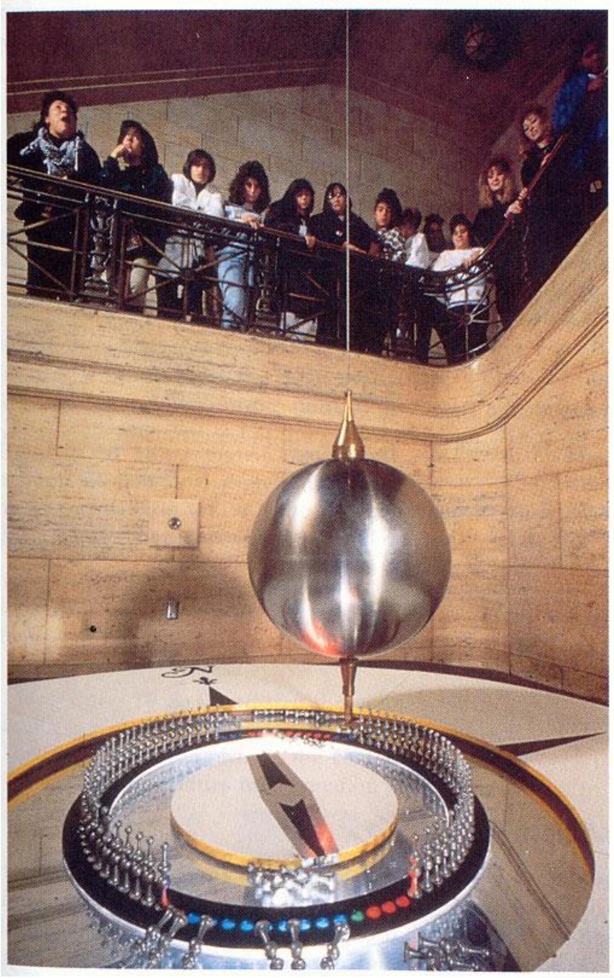
# Simple Pendulum




- A simple pendulum consists of a mass called a bob, which is attached to a fixed string.

# Foucault Pendulum

- This type of pendulum was first used by the French physicist Jean Foucault to verify the Earth’s rotation experimentally. As the pendulum swings, the vertical plane in which it oscillates appears to rotate as the bob successively knocks over the indicators arranged in a circle on the floor.



# Section 12-2

## Measuring Simple Harmonic Motion

- Amplitude–maximum displacement from equilibrium.
- Period–the time it takes to execute a complete cycle of motion.
- Frequency–number of cycles or vibrations per unit of time.

# Period of Pendulum and Spring

$$T = 2\pi\sqrt{\frac{L}{g}} \quad T = 2\pi\sqrt{\frac{m}{k}}$$

# A Couple of Problems

1. What is the period of a 3.98 m long pendulum?

Given :

$L = 3.98\,\mathrm{m}$

$g = 9.81\frac{\mathrm{m}}{\mathrm{s}^2}$

$$T = 2\pi\sqrt{\frac{L}{g}}$$

$$T = 2\pi\sqrt{\frac{3.98\,\mathrm{m}}{9.81\,\mathrm{m}\,/\,\mathrm{s}^2}}$$

$$T = 4.00\,\mathrm{s}$$

# Problems con't

2. What is the free-fall acceleration at a location where a 6.00 m long pendulum swings through exactly 100 cycles in 492 s?

$$f = \frac{100\,\text{cycles}}{492\,\text{s}} \quad f = 0.203\,\text{Hz}$$

Given :

$L = 6.00\,\text{m}$

$100$ cycles in $492\,\text{s}$

$$T = \frac{1}{f} = \frac{1}{0.203\,\text{Hz}} = 4.92\,\text{s}$$

$$T = 2\pi\sqrt{\frac{L}{g}}$$

$$4.92\,\text{s} = 2\pi\sqrt{\frac{6.00\,\text{m}}{g}}$$

$$g = 9.79\,\frac{\text{m}}{\text{s}^2}$$

# Spring Problem

3. A 1.0 kg mass attached to one end of a spring completes one oscillation every 2.0 s. Find the spring constant.

$$\text{Given}:$$

$$m = 1.0\,\text{kg}$$

$$T = 2.0\,\text{s}$$

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

$$2.0\text{s} = 2\pi\sqrt{\frac{1.0\,\text{kg}}{k}}$$

$$k = 9.9\,\frac{\text{N}}{\text{m}}$$

# Pendulum Problem

4. A man needs to know the height of a tower, but darkness obscures the ceiling. He knows, however, that a long pendulum extends from the ceiling almost to the floor and that its period is 12.0 s. How tall is the tower?

Given :

$$T = 12.0\,\mathrm{s}$$

$$g = 9.81\frac{\mathrm{m}}{\mathrm{s}^2}$$

$$T = 2\pi\sqrt{\frac{L}{g}}$$

$$12.0\,\mathrm{s} = 2\pi\sqrt{\frac{L}{9.81\,\mathrm{m}/\mathrm{s}^2}}$$

$$L = 35.8\,\mathrm{m}$$