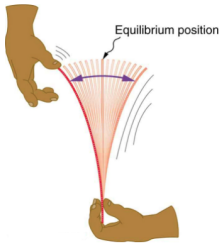
Introduction to Physical Science

Oscillations

Presented by Robert Wagner

Oscillations

- An object oscillating back and forth must be experiencing a force
  - Recall Newton's first law
  - Deformation of ruler causes a force in the opposite direction
- Restoring force:
  -
  - x is the displacement from equilibrium
  - k is the force constant (N/m)



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Example

- What is the force constant for the suspension system of a car that settles 1.20 cm when an 80.0 kg person gets in.
  - Draw a sketch (if applicable)
  - Identify known values
  - Identify equation
  - Enter values in the equation and solve

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$x = 1.20\ cm = -0.012\ m\ ;\ m = 80.0\ kg$

$F = w = mg = (80.0\ kg)(9.80\ m/s^2)$

$F = 784\ N$

$F = -kx\ ;\ k = -\frac{F}{x}$

$k = -\frac{784\ N}{-0.012\ m}$

$k = 6.53x10^4\ N/m$

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Elastic Potential Energy

- Work must be done to produce a deformation
  - Work is stored as potential energy
  -

Example

- How much energy is stored in the spring of a tranquilizer gun that has a force constant of 50.0 N/m? Neglect friction and the mass of the spring to calculated the speed with which the 2.00 g projectile will be ejected.
  - Draw a sketch (if applicable)
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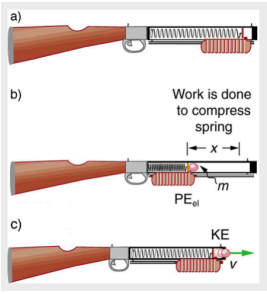

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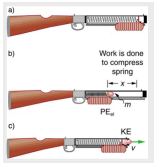

$k = 50.0\ N/m\ ;\ x = 0.150\ m\ ;\ m = 2.00\ g = 0.002\ kg$

$$PE_{el} = \frac{1}{2}kx^2 = \frac{1}{2}(50.0\ N/m)(0.150\ m)^2$$

$$PE_{el} = 0.563\ N \cdot m$$

$$KE = PE_{el} = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2PE_{el}}{m}} = \sqrt{\frac{2(0.563\ J)}{(0.002\ kg)}} = 23.7 m/s$$

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Periodic Motion

- A periodic motion is a motion that repeats itself at regular intervals
  - Time to complete one oscillation is the period, T
- The frequency is defined to be the number of oscillations per unit time
  -
  - SI unit - Hertz (Hz). 1 Hz = 1 cycle/s or 1/s

Example

- A medical imaging device produces ultrasound by oscillating with a period of 0.400 μs. What is the frequency? The frequency of middle C is 264 Hz. What is the time for one complete oscillation?
  - Draw a sketch (if applicable)
  - Identify known values
  - Identify equation
  - Enter values in the equation and solve

$$T = 0.400\ \mu s = 0.400x10^{-6}\ s$$

$$f = \frac{1}{T} = \frac{1}{0.400x10^{-6}\ s}$$

$$f = 2.50x10^{6}\ Hz = 2.50\ MHz$$

$$f = 264\ Hz$$

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

$$T = \frac{1}{264\ Hz} = \frac{1}{264\ cycles/s} = 3.79x10^{-3}\ s = 3.79\ ms$$

Summary

- Oscillations result from a restoring force that works opposite to the deformation
- The force constant measures the stiffness of a spring
- The period and frequency of an oscillation are inversely related