

Ch11. Vibrations & Waves

11-1. Simple Harmonic Motion

Periodic vibration/oscillation:

A motion that repeats itself back & forth, following the same path

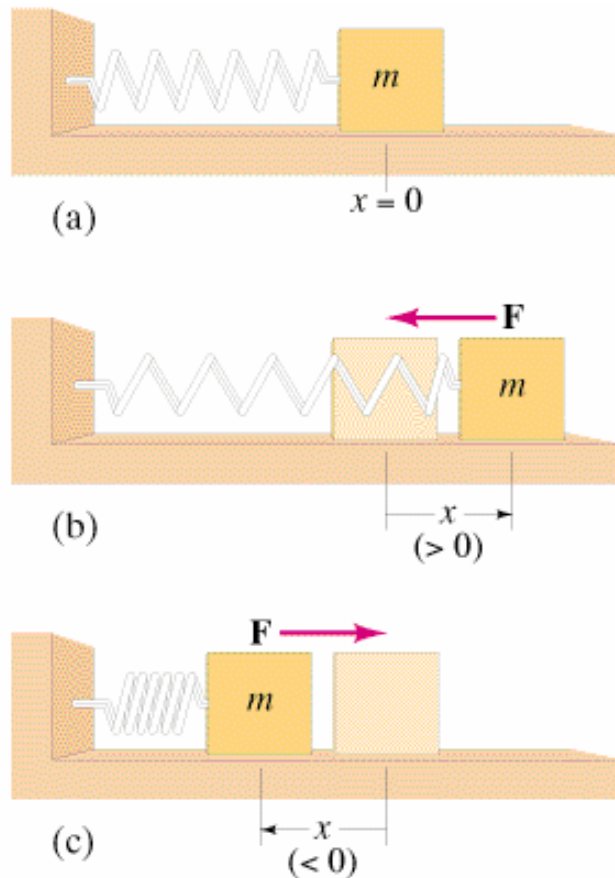
Examples:

Mass attached to a horizontal / vertical spring

Pendulum / swing

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Horizontal Spring with Mass



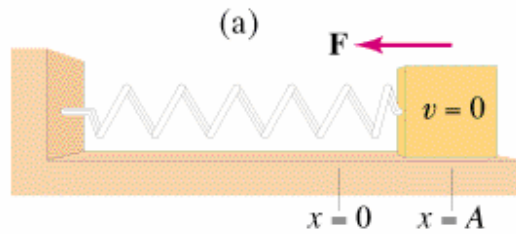
Hooke's Law

$$\vec{F} = -k\vec{x}$$

Spring constant (N/m)

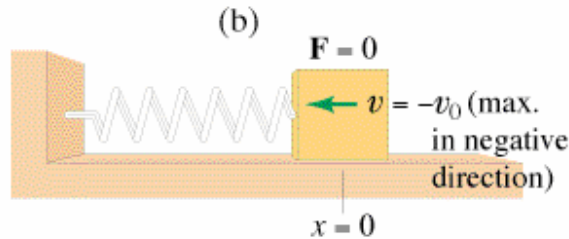
Where is **F** biggest/smallest?
Speed?
Displacement?

Neglect spring mass & friction

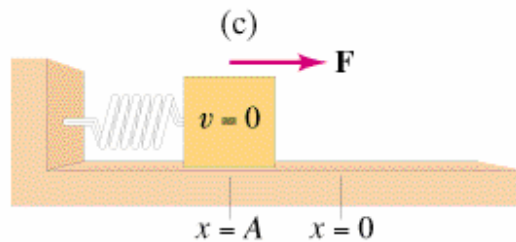


Equilibrium position

$$\sum \vec{F} = 0$$

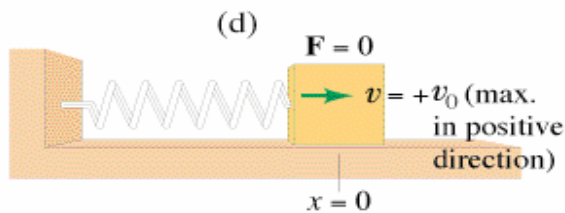


Amplitude A : maximum displacement (m)



Period T

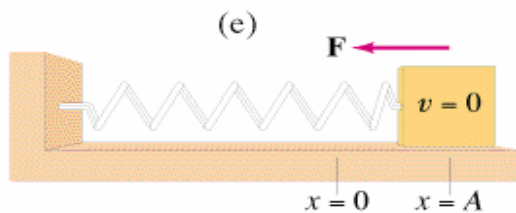
time to finish one cycle (second)



Frequency f

$$f = 1/T$$

1 Hz = 1 cycle/second



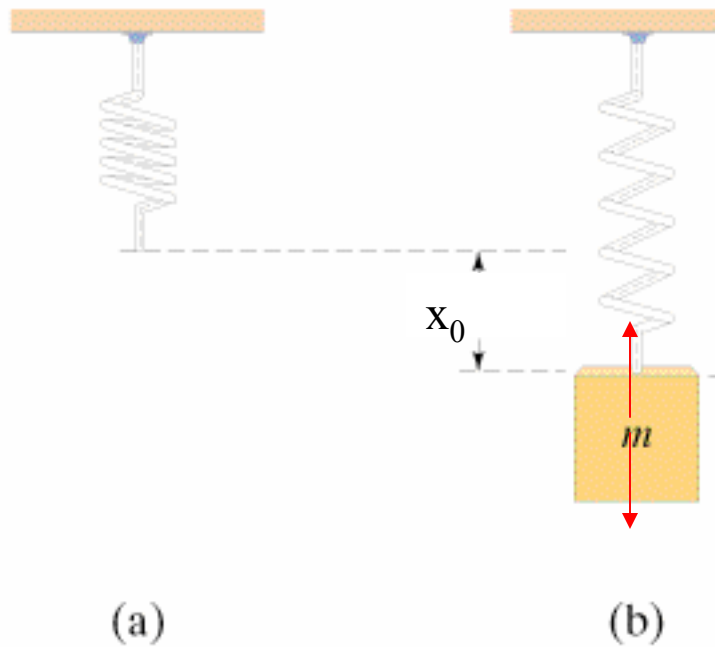
Simple Harmonic Motion

Any vibrating system whose restoring force is directly proportional to the negative of displacement is said to exhibit **Simple Harmonic Motion**

$$\vec{F} = -C\vec{x}$$

Simple Harmonic Oscillator

Another SHO: Weight on Vertical Spring



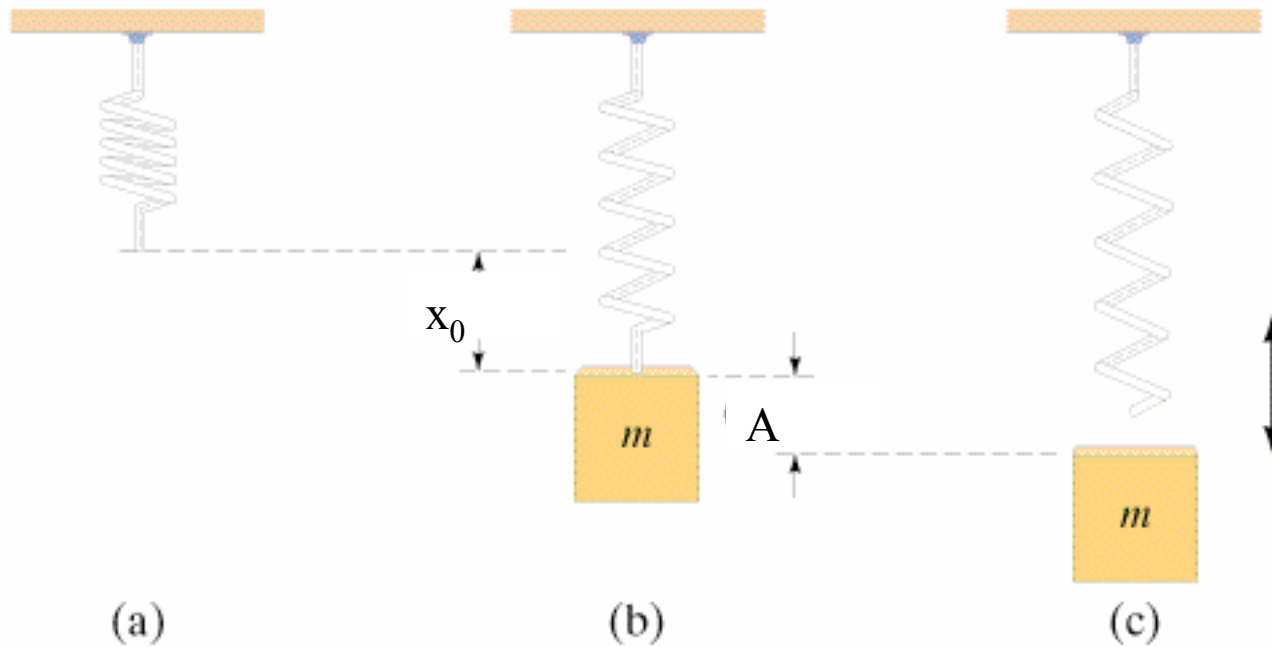
Where is the equilibrium position?

$$\sum \vec{F} = 0$$

$$kx_0 - mg = 0$$

$$x_0 = mg/k$$

Another SHO: Weight on Vertical Spring



11-2. Energy in SHO

Elastic Potential Energy

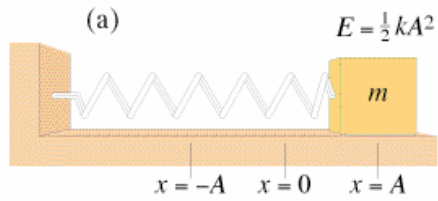
$$PE = \frac{1}{2} kx^2$$

Total Mechanical Energy

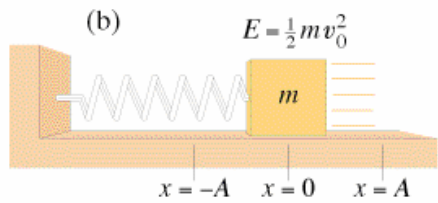
$$E = \frac{1}{2} mv^2 + \frac{1}{2} kx^2$$

Kinetic Potential

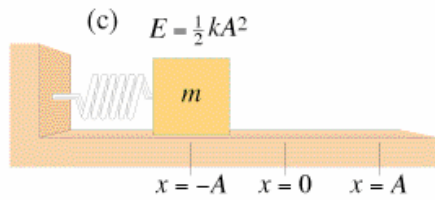
Conserved



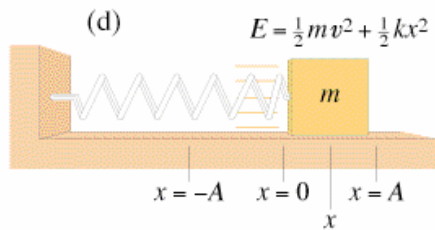
x	v	E
A	0	$kA^2/2$



0	$+/-v_0$	$mv_0^2/2$
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$-A$	0	$kA^2/2$
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x	v	$mv^2/2 + kx^2/2$
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At any point x :

$$\frac{1}{2}mv^2 + \frac{1}{2}kx^2 = \frac{1}{2}kA^2 = \frac{1}{2}mv_0^2$$

$$kA^2 = mv_0^2$$

$$v_0 = \sqrt{\frac{k}{m}}A$$

$$v^2 = \frac{k}{m}(A^2 - x^2) = \frac{k}{m}A^2\left(1 - \frac{x^2}{A^2}\right) = v_0^2\left(1 - \frac{x^2}{A^2}\right)$$

$$v = \pm v_0 \sqrt{1 - \frac{x^2}{A^2}}$$