A new physics course for students of the Biological Sciences:

PHYS 2270 Physical Topics For Biologists A (3 hrs)

The Department of Physics and Astronomy is offering a **new 3 credit hour course** in the **Winter 2008 term**, designed for students interested in the biological sciences. The course will introduce students to the basic concepts and principles of physics, both classical and quantum, which are fundamental to all biological phenomena and processes. The topics include wave phenomena, light and optics, quantum physics, thermodynamics and bioenergetics, electromagnetic theory, and fluid statics and dynamics. The prerequisites are PHYS 1050 or PHYS 1020. A knowledge of introductory differential and integral calculus is helpful, but not essential.

There is no lab

GENERAL PHYSICS I: PHYS 1020

Schedule - Fall 2007
(lecture schedule is approximate)

10	M	5	25	Chapter 10 exclude 10.7 and 10.8	Simple harmonic motion, sections 10.5 and 10.6, for self study only	Tutorial and Test 3 (chapters 6, 7)
	W	7	26			
	F	9	27	Chapter 11 exclude 11.11	Fluids	
11	M	12		Remembrance Day		Experiment 4: Centripetal Force
	W	14	28	Chapter 11 exclude 11.11	Fluids	
	F	16	29			
12	M	19	30	Chapter 12 sections 1 - 8	Temperature and heat (some small sections, notably thermal stress will be omitted)	Tutorial and Test 4 ~~(chapters 9, 10)~~ Chapters 8, 9, 10
	W	21	31			
	F	23	32			

Week of November 5

Tutorial and Test 3: Chapters 6 & 7

Mastering Physics Assignment 4

Is due Monday, November 12 at 11 pm

Covers material from chapters 6 and 7

There are 8 questions for practice and 6 for credit

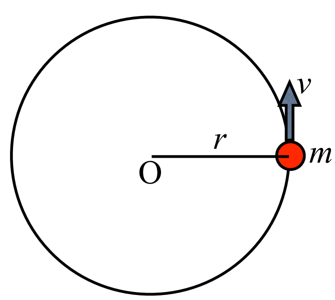
The Final Exam Schedule is Now Final!

PHYS 1020: Monday, December 17, 6 - 9 pm
Frank Kennedy Brown & Gold Gyms
The whole course
30 multiple choice questions
Formula sheet provided

Angular Momentum

The angular momentum of the mass about O is:

L = mvr = $mr^2\omega$, as v = $r\omega$



Define **I = mr^2 = "moment of inertia"** of the mass about centre of circle, then,

angular momentum, L = $I\omega$, and, by applying

F = ma to the mass:

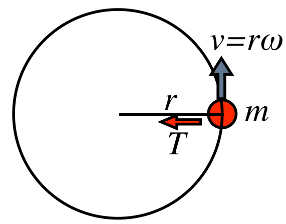
$$\tau = \frac{\Delta L}{\Delta t} = I\frac{\Delta\omega}{\Delta t} \qquad \text{compare } F = ma = m\frac{\Delta v}{\Delta t}$$

Angular momentum is conserved if the net torque acting on an object is zero.

9.60: A small 0.5 kg object moves on a frictionless horizontal table in a circular path of radius 1 m. The angular speed is 6.28 rad/s.

The string is shortened to make the radius of the circle smaller without changing the angular momentum.

If the string breaks when its tension is 105 N, what is the radius of the smallest possible circle in which the object can move?



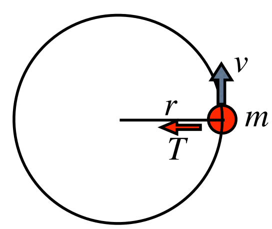
Angular momentum conserved:

$$L = m\,v\,r = \text{ constant}$$

$$v_f\,r_f = v_i\,r_i,\ \text{so},\ v_f = \frac{v_i\,r_i}{r_f} = \frac{r_i^2\,\omega_i}{r_f}$$

$$v_f = \frac{1^2 \times 6.28}{r_f}$$

$$v_f = \frac{6.28}{r_f}$$



The tension in the string is:

$$T = \frac{m\,v_f^2}{r_f} = 105\text{ N} \quad \text{(the maximum before the string breaks)}$$

$$\frac{m}{r_f}\left[\frac{6.28}{r_f}\right]^2 = 105\text{ N}$$

$$r_f^3 = \frac{(0.5\text{ kg}) \times 6.28^2}{105\text{ N}}$$

$$r_f = 0.57\text{ m}$$

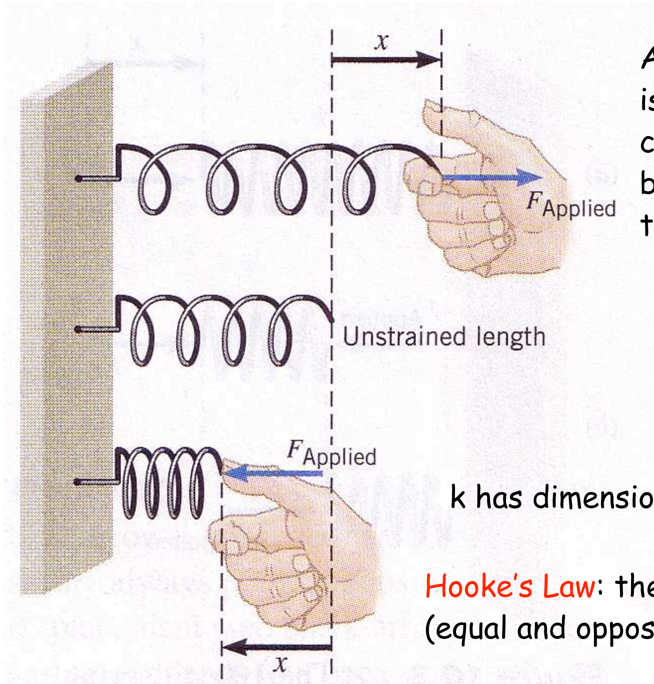
Summary

- Torque, calculated two ways
- First and second conditions of equilibrium
  (1) forces add to zero
  (2) torques add to zero about any point
- Centre of gravity (centre of mass)
  - the point at which the weight of an object may be considered to act
  - torques can be calculated by taking the whole mass to be concentrated at the centre of gravity
- Angular momentum is conserved if the net torque is zero

Chapter 10
Simple Harmonic Motion and Elasticity

- Hooke's Law, motion of a mass on a spring, simple harmonic motion
- Elastic potential energy – the return of the conservation of mechanical energy
- The pendulum and simple harmonic motion
- Read about: (10.5, 10.6, not covered in class)
  damped harmonic motion
  driven harmonic motion
  resonance
- Forget about: 10.7, 10.8, Elastic deformation, stress, strain...

The Ideal Spring



An equal amount of force is required to stretch or compress an ideal spring by the same amount – up to a point.

$$F_{applied} = k\,x$$

k is the spring constant

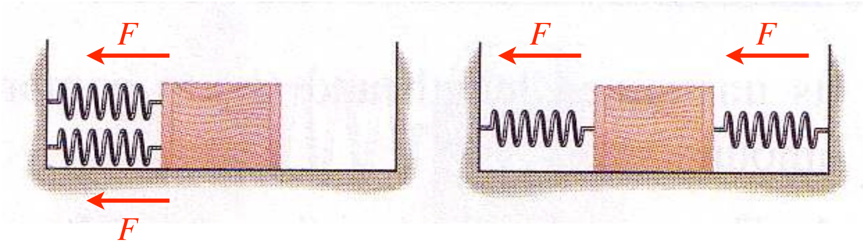
k has dimensions of force/length, N/m

Hooke's Law: the restoring force is –kx (equal and opposite to the applied force)

Clickers!

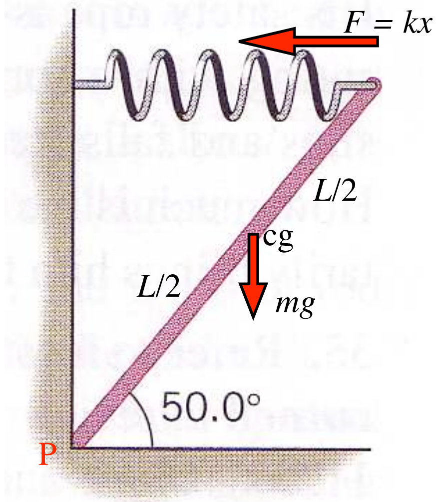
10.C2: The springs are identical and initially unstrained, as shown in the diagram.

The boxes are pulled to the right by the same distance and released. Which box feels the greater force from the springs?



A) box on left feels the greater force
B) box on right feels the greater force
C) the boxes feel the same force

10.8/10: A 10.1 kg uniform board is held in place by a spring. The spring constant is k = 176 N/m.
How much has the the spring stretched at equilibrium?



The length of the plank is L

Torques about P at the floor:

$$-mg(L/2)\cos 50^\circ + FL\sin 50^\circ = 0$$

$$F = \frac{mg}{2\tan 50^\circ} = kx$$

$$\text{So, } x = \frac{mg}{2k\tan 50^\circ} = \frac{10.1 \times 9.8}{2 \times 176\tan 50^\circ}$$

$$x = 0.24 \text{ m}$$

Is a short spring easier to compress?

Imagine the long spring as two half-length springs joined together.

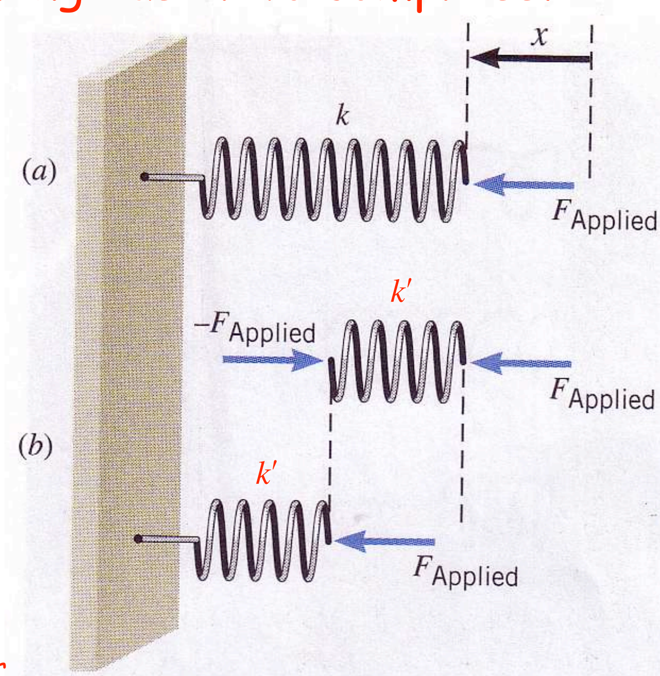
The applied force compresses each half spring by x/2.

The spring constant for the short springs is given by:

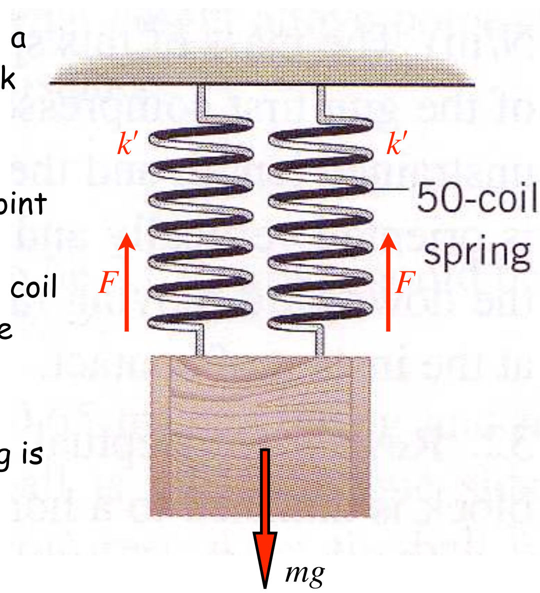
$F_{applied} = k' \times (x/2)$

So $k'x/2 = kx$, and $k' = 2k$

The shorter spring is stiffer



10.10/8: A mass, m, is attached to a 100 coil spring of spring constant k and its equilibrium position noted:



$x_0 = mg/k = 0.16$ m = equilibrium point

The spring is then cut into two 50 coil springs as shown. How much do the springs stretch?

The spring constant of each spring is

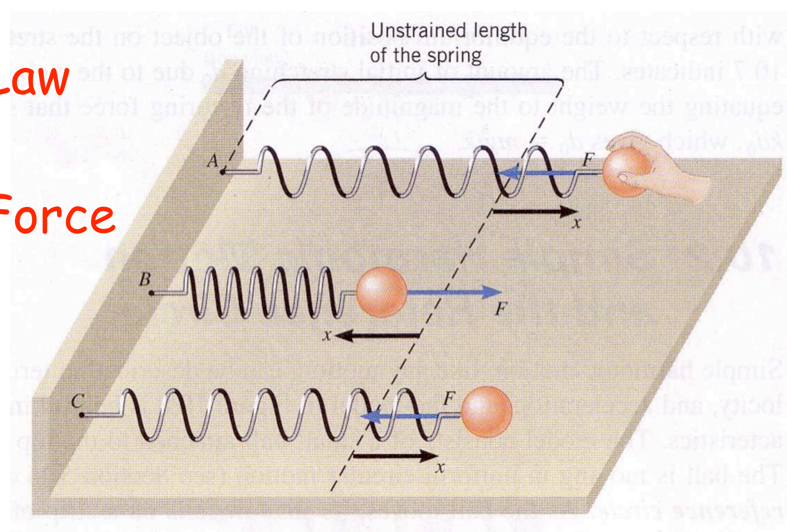
$k' = 2k$

There are two of these springs, so the total restoring force is

$F_{tot} = 2 \times (k'x) = 2 \times (2kx) = mg$, so $x = mg/(4k) = x_0/4 = 0.04$ m

Hooke's Law

Restoring Force

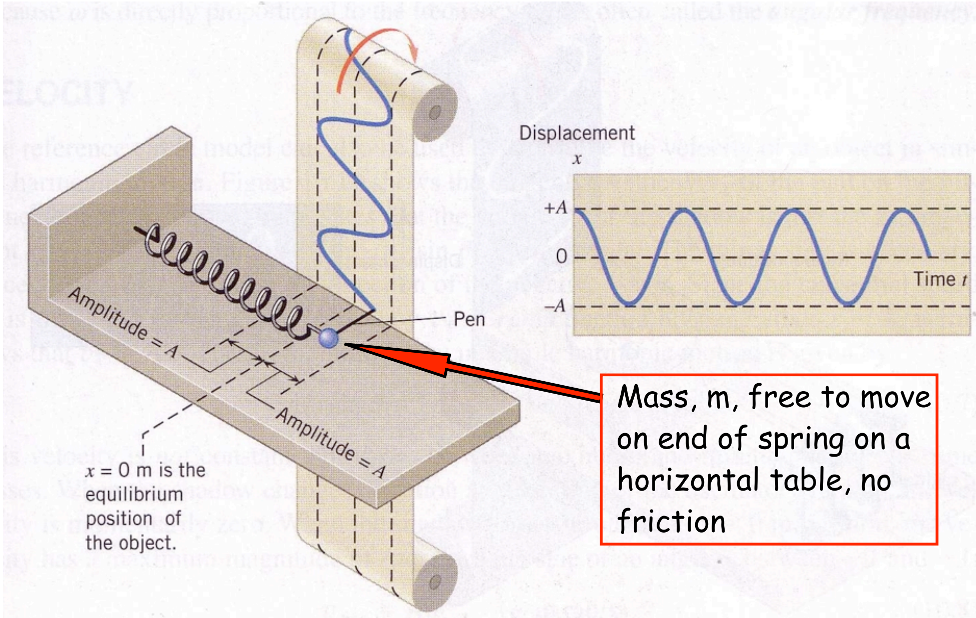


The **restoring force** is the force the spring exerts when stretched or compressed - tries to move spring back to equilibrium state.

Restoring force, $F = -F_{applied} = -kx$

$F = -kx$, Hooke's Law

Simple Harmonic Motion (SHM)



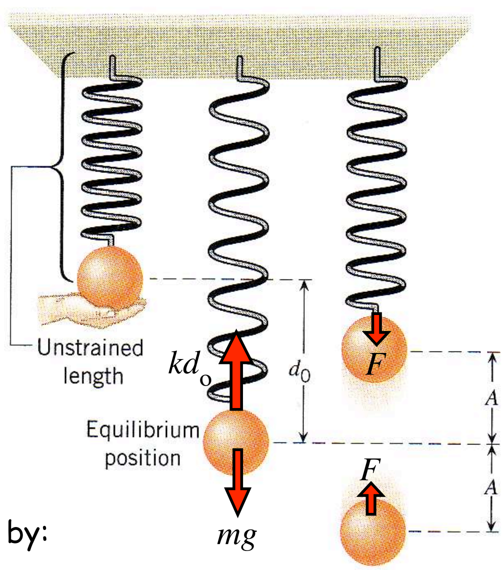
Pull the mass a distance A to the right, release, and observe motion...

Simple Harmonic Motion (SHM)

Simple harmonic motion also seen for a mass suspended from a spring.

SHM is characteristic motion when the restoring force is proportional to the displacement from the equilibrium position

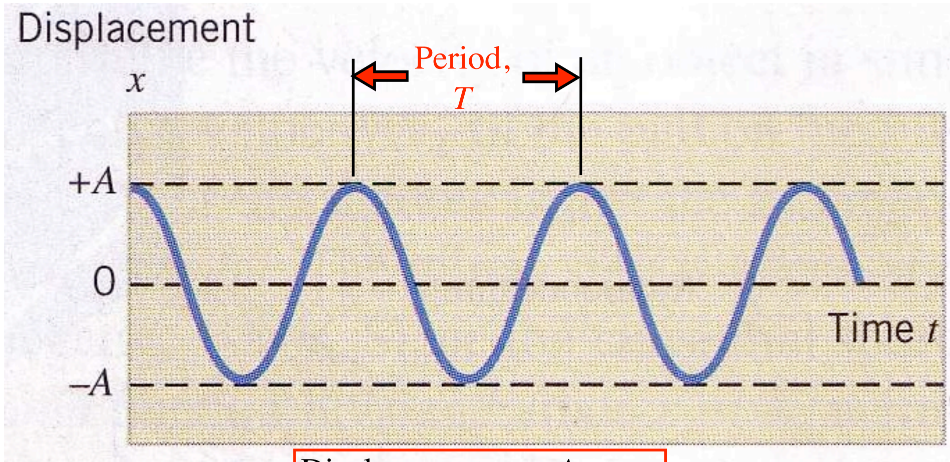
The equilibrium position corresponds to the spring stretched by an amount given by:



$mg = kd_0$, so $d_0 = mg/k$.

SHM is about $x = d_0$ with amplitude A.

Simple Harmonic Motion (SHM)

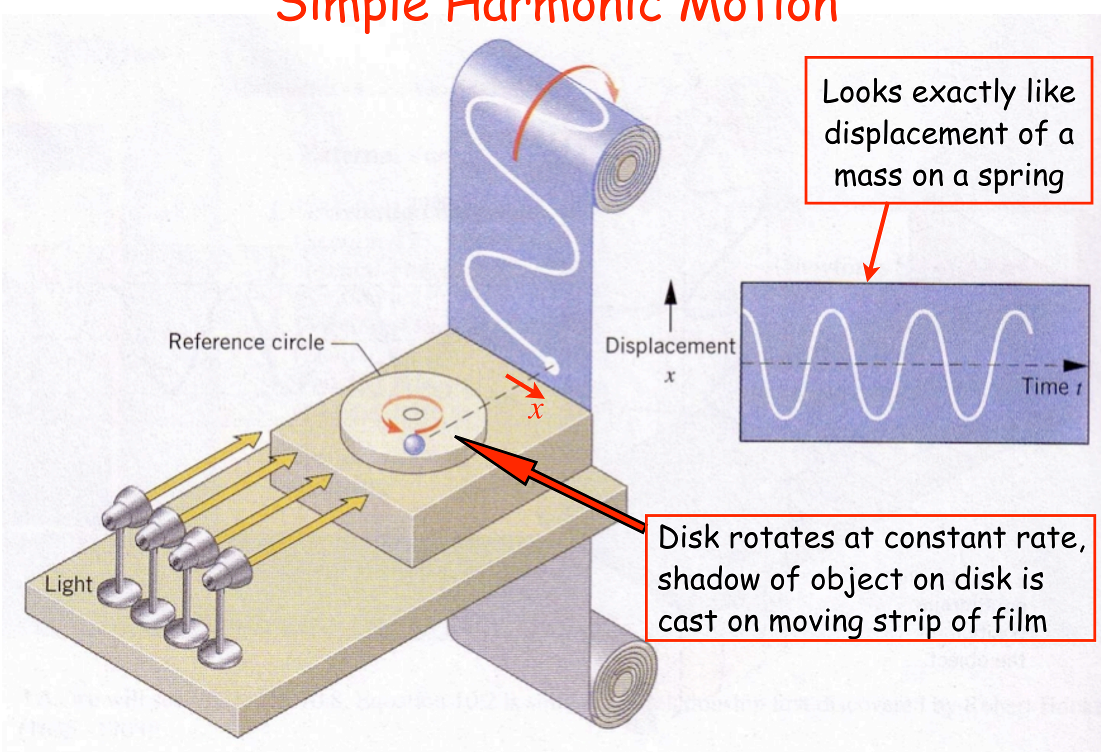


Displacement, $x = A\cos\omega t$

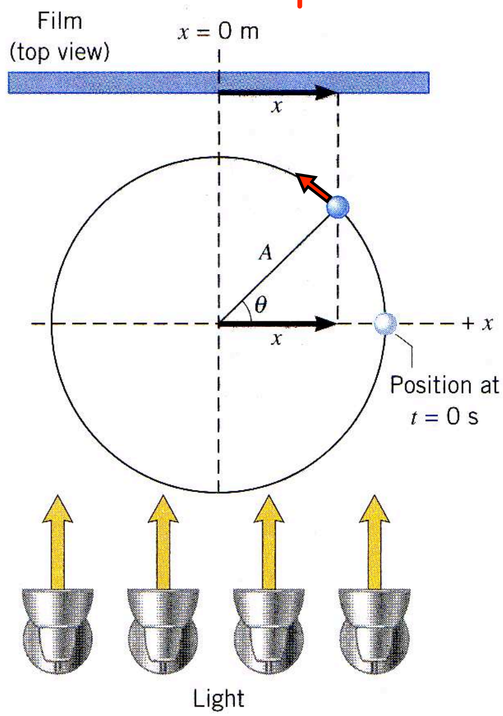
The time for one cycle is the period, T
So $\omega T = 2\pi$ radians (i.e., 360^0, 1 cycle), and $\omega = 2\pi/T = 2\pi f$,

f = frequency of the SHM, cycles/second or Hertz (Hz)

Simple Harmonic Motion



Simple Harmonic Motion



$$x = A\cos\theta$$

and if $\theta = \omega t$

(rotation at constant angular velocity ω), then,

$$x = A\cos\omega t$$

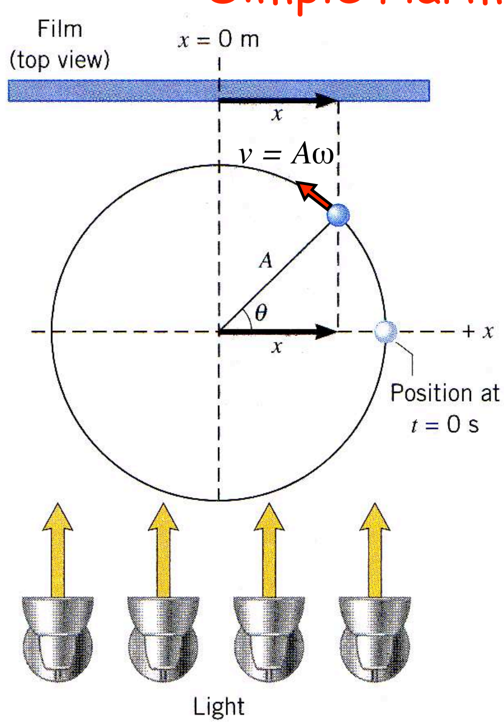
$\theta = \omega t = 2\pi$ (360^0) when $t = T$

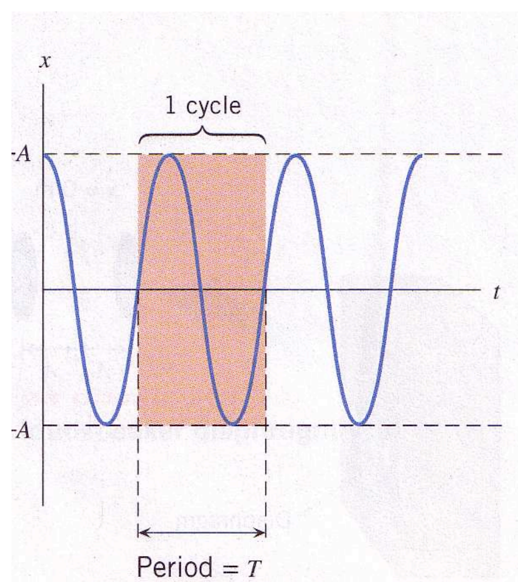
then $\omega T = 2\pi$

$$\boxed{\omega = 2\pi/T = 2\pi f}$$

T = period, f = frequency

Simple Harmonic Motion





Sinusoidal motion – just like the mass on a spring

Simple Harmonic Motion

- Simple harmonic motion results when the restoring force is proportional to the displacement –

  F = –kx

- For the mass on the spring, how is the period of the harmonic motion related to the spring constant, k?

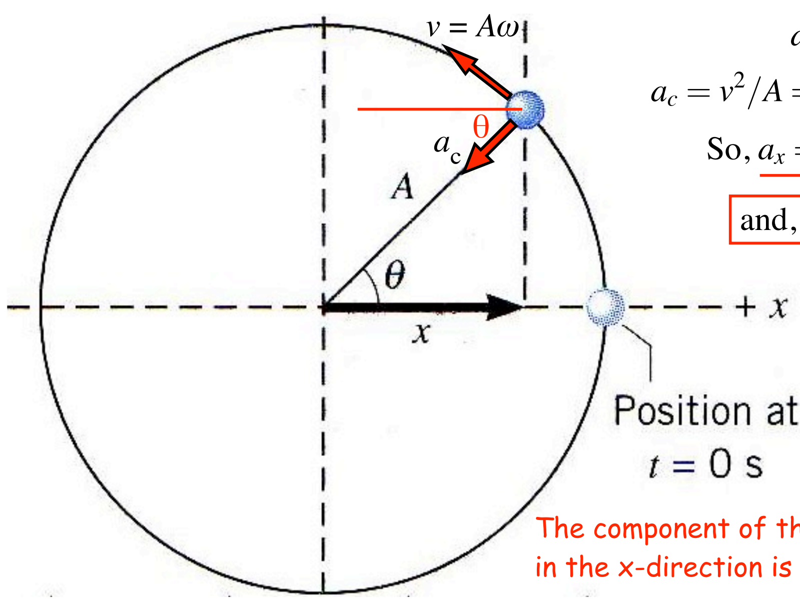
Clue:

- The motion of the mass on the spring looks just like the x component of the motion of the mass on the rotating disk.

Strategy – solve the easier problem:

- Look at the motion in a circle and find out what is the acceleration, a_x, as that can be related to a restoring force and an effective spring constant.

Simple Harmonic Motion
The "Reference Circle"



$$x = A\cos\theta$$

$$a_x = -a_c\cos\theta$$

$$a_c = v^2/A = (A\omega)^2/A = A\omega^2$$

$$\text{So, } a_x = -A\omega^2\cos\theta$$

$$\text{and, } a_x = -\omega^2 x$$

The component of the centripetal force in the x-direction is $F_x = ma_x = -m\omega^2 x$.

Looks just like $F_x = -kx$ for the spring.

Rotating disk: $a_x = -\omega^2 x$ — acceleration is proportional to displacement

Mass on a spring: the restoring force is: $F = -kx = ma_x$

That is, $a_x = -(k/m)x$ — acceleration also proportional to displacement

COMPARE: The mass on the spring **moves in x in the same way** as a mass on a disk that is rotating with $\omega = [k/m]^{1/2}$.

Then: $\omega = 2\pi f = \frac{2\pi}{T}$

$\text{So, } T = 2\pi\sqrt{\frac{m}{k}}$ for the mass on the spring