Chapter 5: Using Newton's Laws
Thursday February 5th

- Mini Exam – 25 minutes
- Finish friction example from Tuesday
- Spring forces
- Newton's laws and circular motion
- Demonstrations and examples + iclicker problem

Reading: up to page 80 in the text book (Ch. 5)

Static friction

1. In static situations, the static frictional force exactly cancels the component of the applied force parallel to the surface.
2. The heavier an object, the more difficult it is to make it slide. Evidently, the maximum frictional force depends on the normal force between the surface and the object, i.e.

$$f_{s,\max} = \mu_s N$$

where μ_s is the **coefficient of static friction** and N is the magnitude of the normal force. μ_s is a parameter that depends on both surfaces. Once the force component parallel to the surface exceeds $f_{s,max}$, then the body begins to slide along the surface.

Kinetic friction

3. If a body begins to slide along the surface, the magnitude of the frictional force instantly decreases to a value f_k given by

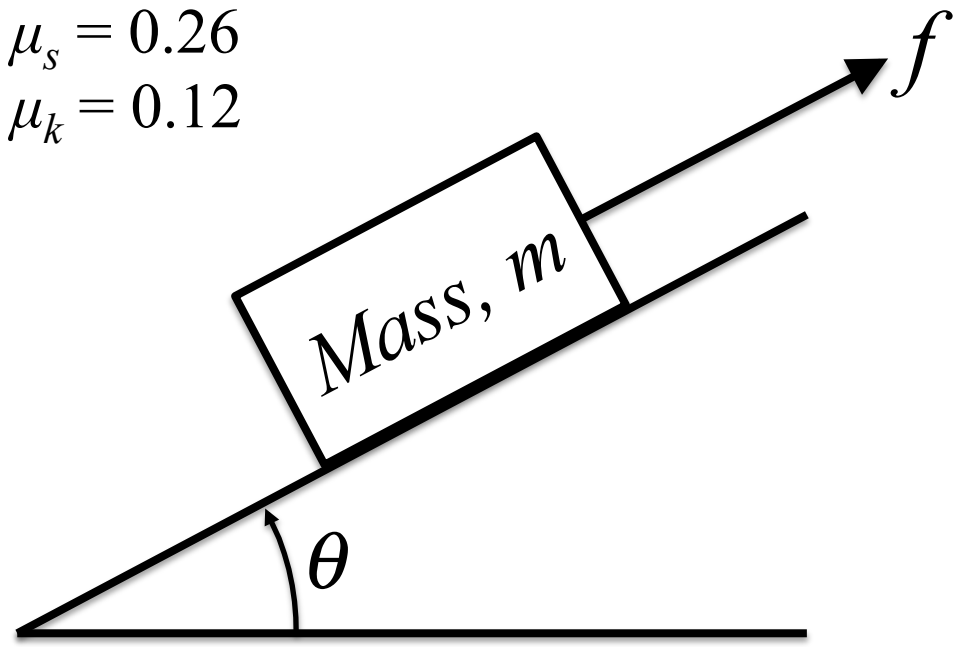
$$f_k = \mu_k N$$

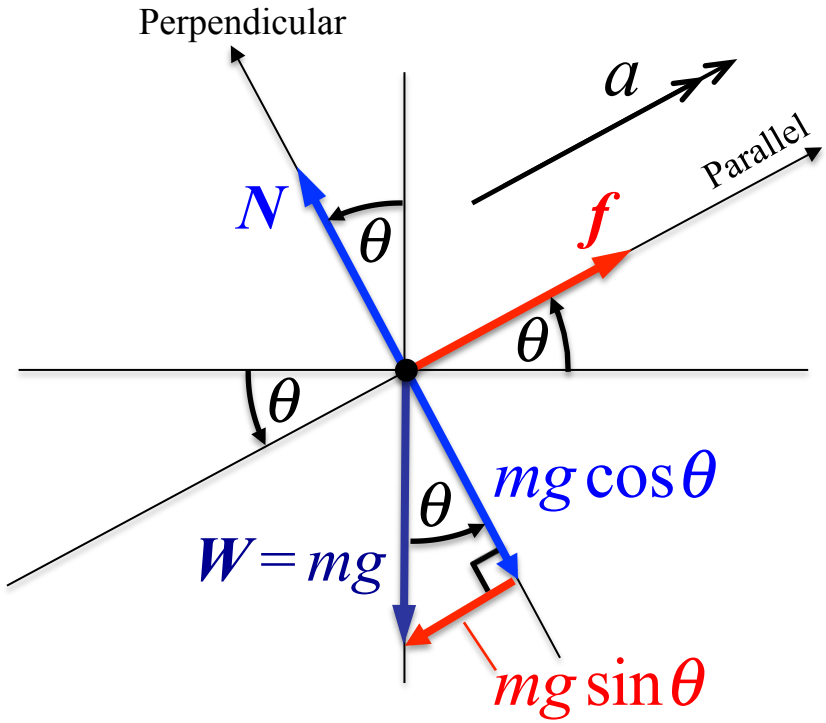
where μ_k is the **coefficient of kinetic friction** and N is the magnitude of the normal force. Therefore, during the sliding, a kinetic frictional force of magnitude f_k opposes the motion.

4. When several agents push in different directions on an object, the frictional force opposes the component of the net force on the object which is parallel to the surface.

Inclined Plane with Friction

1. At what angle does it begin to slide?
2. What is the acceleration at this angle?



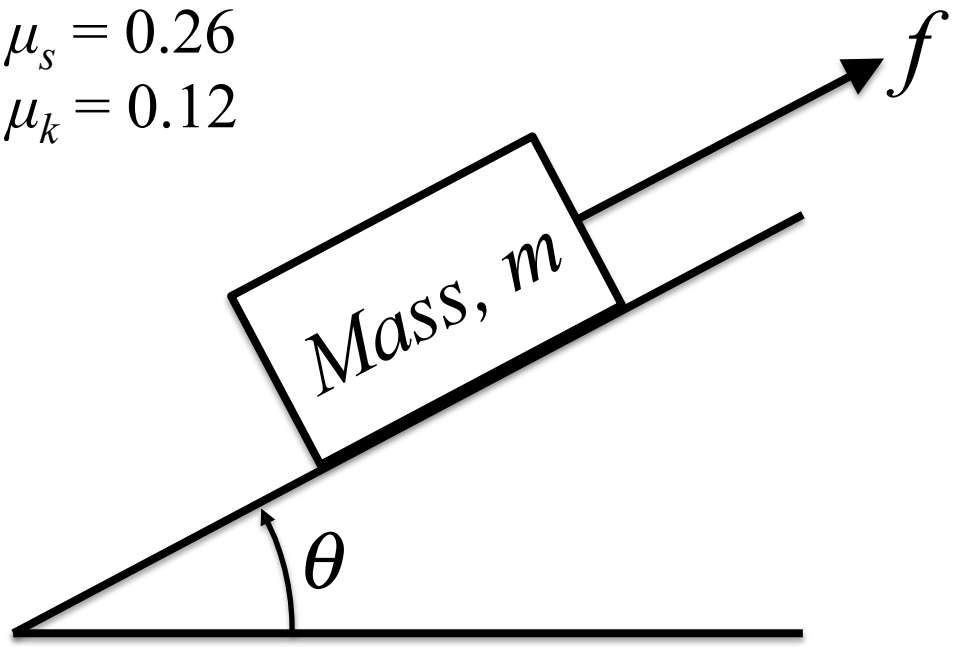


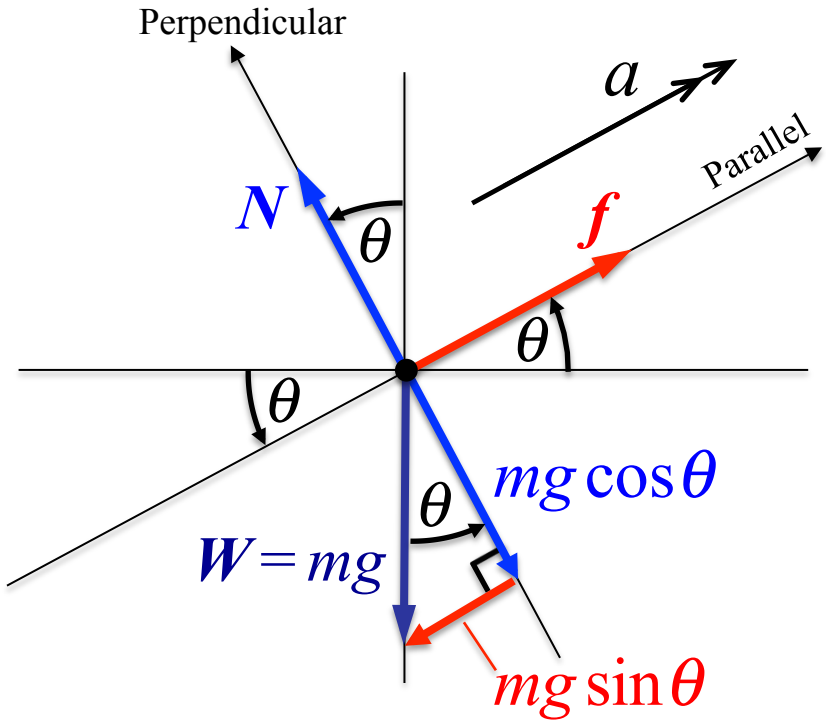
Friction opposes the tendency for the block to slide downhill, so the frictional force must act uphill and parallel to the slope

Inclined Plane with Friction

1. At what angle does it begin to slide?
2. What is the acceleration at this angle?

$\mu_s = 0.26$
$\mu_k = 0.12$



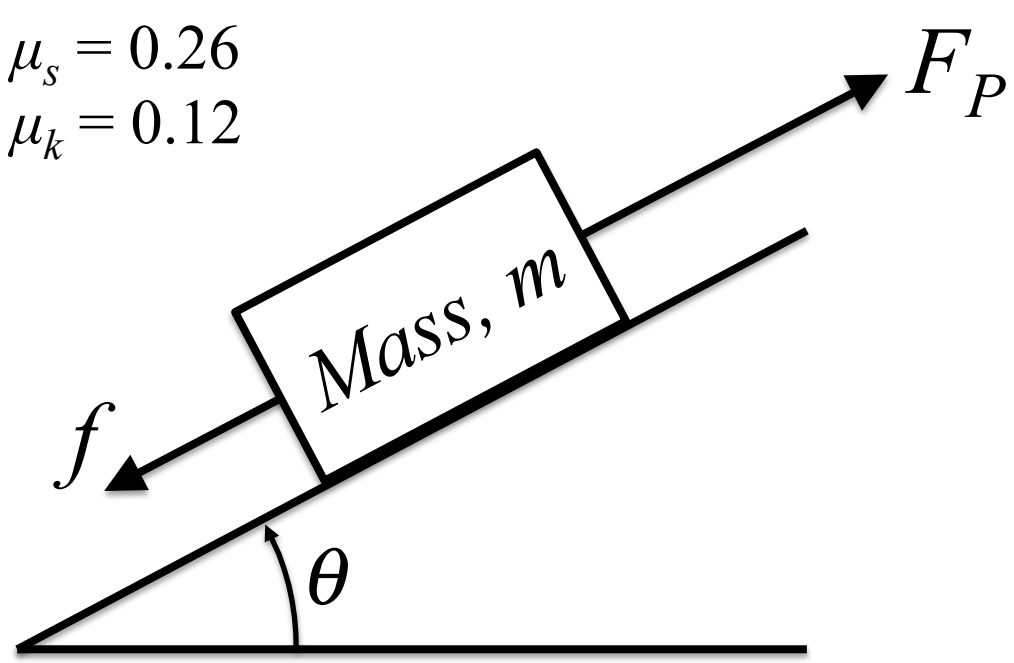


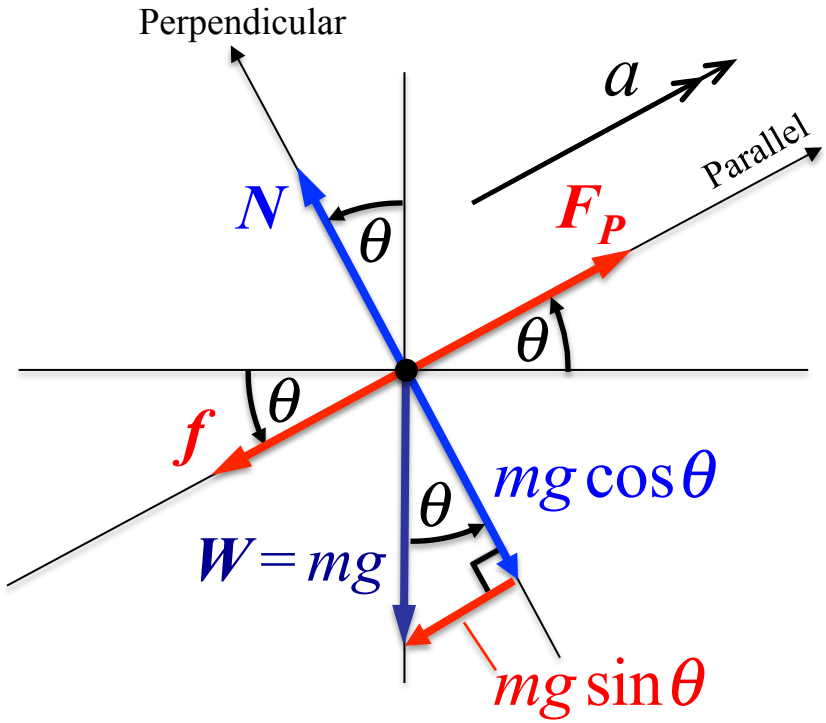
Perpendicular: $N - mg\cos\theta = 0$

Parallel: $f - mg\sin\theta = ma$

Inclined Plane with Friction

What if you try to push the block up the slope with force F_P?

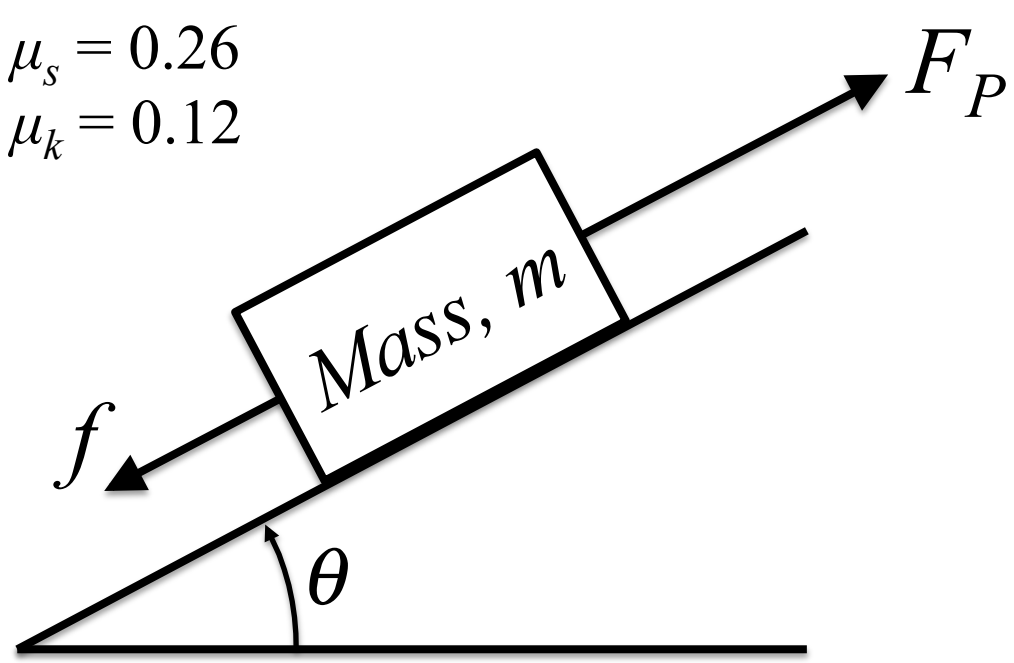


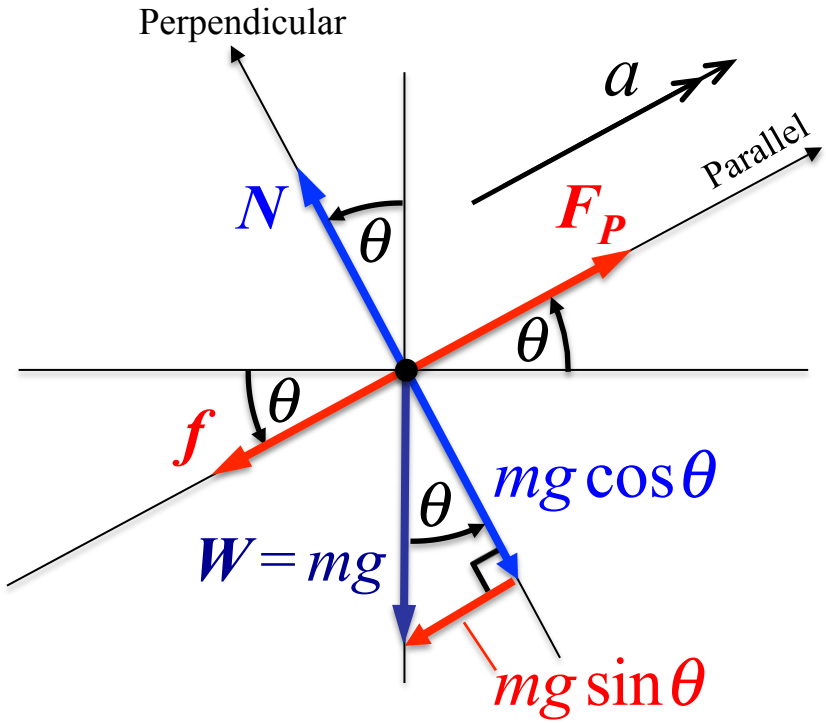


Friction opposes the tendency for the block to slide uphill, so the frictional force must act downhill and parallel to the slope

Inclined Plane with Friction

What if you try to push the block up the slope with force F_P?



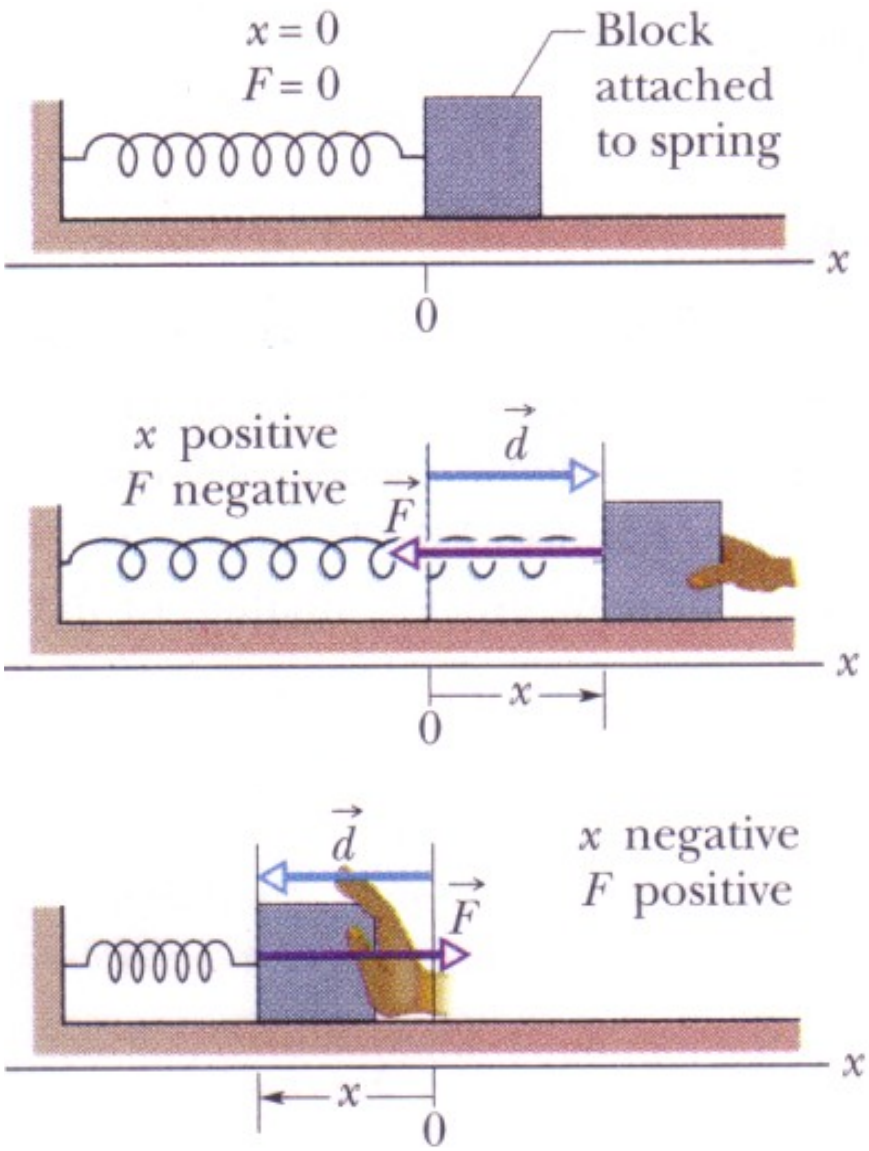


Perpendicular: $N - mg\cos\theta = 0$

Parallel: $F_P - f - mg\sin\theta = ma$

Spring Forces & Hooke's Law

Ut tensio, sic vis — "As the extension, so the force"



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

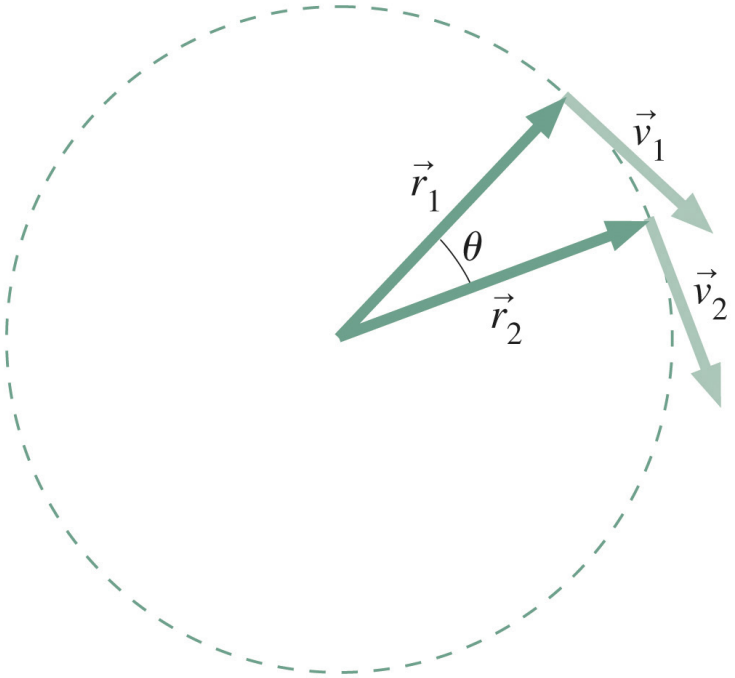
$\vec{d}$ is the displacement of the free end of the spring from its position when in a relaxed, or equilibrium state.

k is the **spring constant**, or **force constant**, and is a measure of the stiffness of the spring. It has dimensions of $N.m^{-1}$.

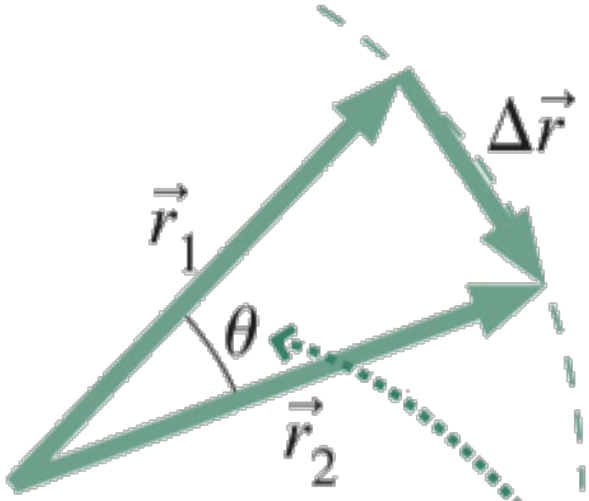
Hooke's law (scalar version):

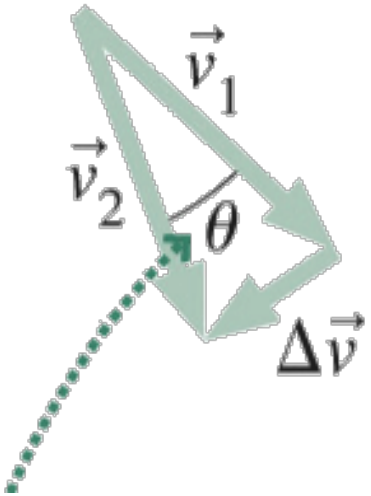
$$F = -kx$$

Uniform circular motion



- Although the speed, v, does not change, the direction of the motion does, *i.e.*, the velocity, which is a vector, does change.
- Thus, there is an acceleration associated with the motion.
- We call this a centripetal acceleration.





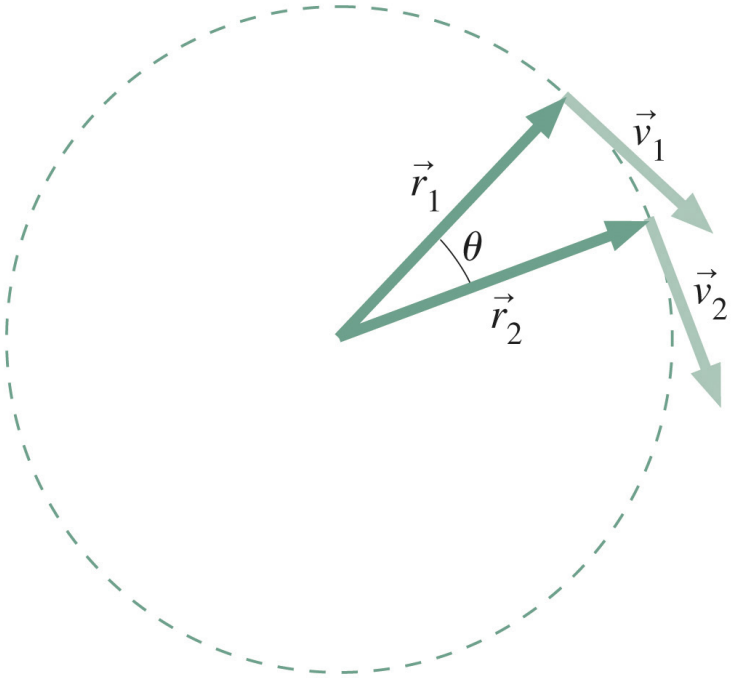
Same angles

$$\Delta r = r\theta$$

$$\Delta v = v\theta$$

$$\Rightarrow \frac{\Delta v}{v} = \frac{\Delta r}{r} = \frac{v\Delta t}{r}$$

Uniform circular motion



- Although the speed, v, does not change, the direction of the motion does, *i.e.*, the velocity, which is a vector, does change.
- Thus, there is an acceleration associated with the motion.
- We call this a centripetal acceleration.

Centripetal acceleration:

$$a_c = \frac{v^2}{r} \qquad \text{(uniform circular motion)}$$

- A vector that is always directed towards the center of the circular motion, i.e., it's direction changes constantly.