

HW #6: Friction (Due 1 am **central time**, 3/9, Monday).

Lecture on 3/13, Friday, will be given by Prof. Sirenko. (same room)

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Last Friday...

Chapter 4: The Laws of Motion

Static friction and kinetic friction

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Today..

B2. Ch6. Sec.1-2 : Circular Motion

Uniform Circular Motion

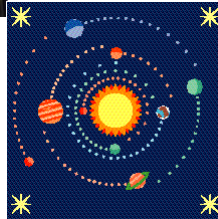
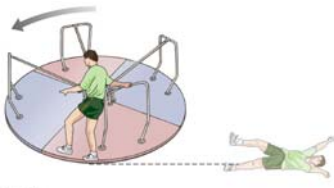
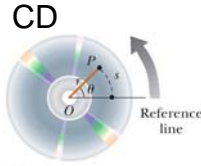
Non-uniform circular Motion

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## B2. Ch6. Sec.1-2 : Circular Motion

### Why do we study circular motions?

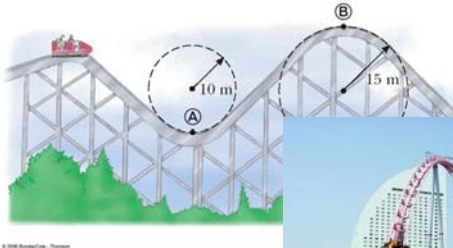
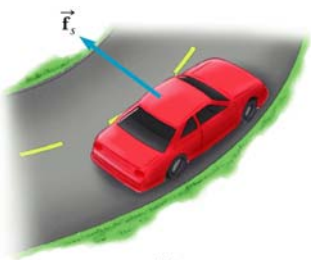
Circular motions are everywhere around us!!!



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### Why do we study circular motions?

Circular motions are everywhere around us!!!



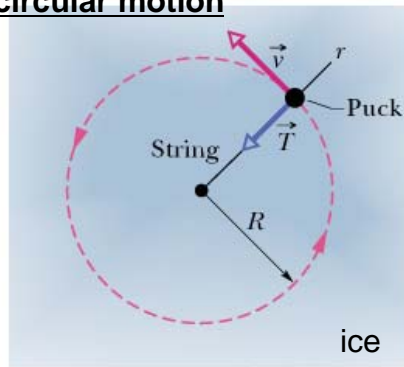
Questions:

How can we describe a circular motion?

What causes a circular motion?

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**First, uniform circular motion**



**Uniform circular motion**

Constant speed, or,  
"constant magnitude" of velocity

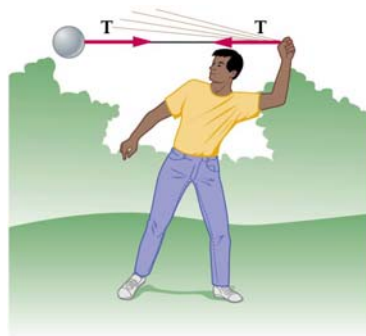
Motion along a circle:  
"changing direction" of velocity

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iClicker Quiz

**Does the velocity change in uniform circular motion?**

- (a) Yes
- (b) No



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## Does the velocity change in uniform circular motion?

→ Direction of velocity: changing

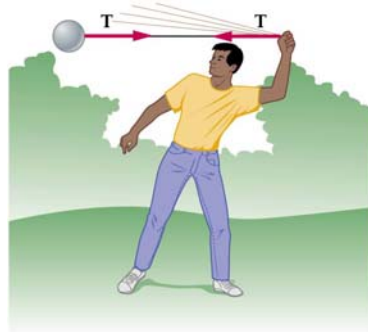
→ **Yes, velocity changes**

→ Acceleration is NOT zero!

$$\vec{F}_{net} = m\vec{a}$$

→ **Net force acting on the object is NOT zero.**

→ The “net” force in circular motion is called “Centripetal force”.



Centripetal force is simply a net force that gives rise to a circular motion, NOT a new type of force.

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## Uniform circular motion

### Acceleration

Magnitude:  $|\vec{a}| = \frac{v^2}{r}$

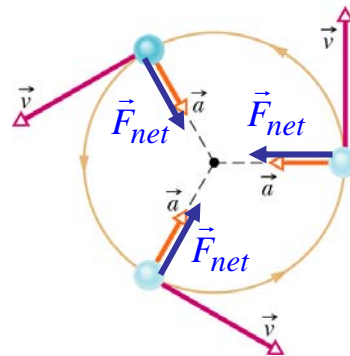
Direction: toward center of circle

### Net force (“Centripetal force”)

Magnitude:  $|\vec{F}_{net}| = \frac{mv^2}{r}$

Direction: toward center of circle

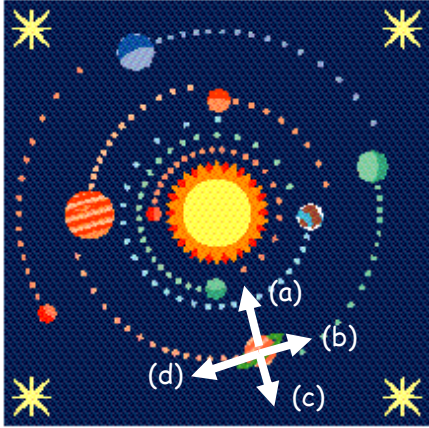
Derivations of the above relations (see textbook)



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iClicker Quiz

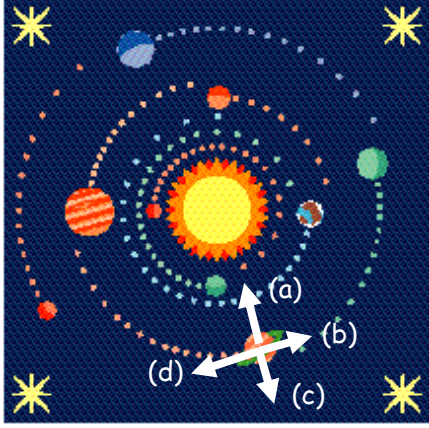
What is the direction of the velocity of the Saturn?



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iClicker Quiz

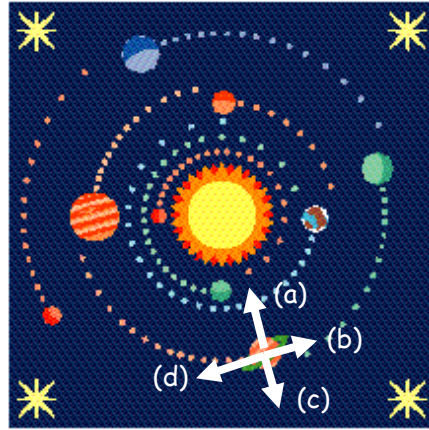
What is the direction of acceleration of the Saturn?



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iClicker Quiz

What is the direction of the net force on the Saturn?



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Example: Circular motion of a hanging ball (see note)

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Some relations for circular motions

T: period, time for 1 revolution

Speed  $v = \frac{2\pi r}{T} = \omega r$

Angular velocity  $\omega = \frac{2\pi}{T}$

Period  $T = \frac{2\pi r}{v}$

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## Non-Uniform circular motion

Changing speed, or,  
changing magnitude of velocity

Motion along a circle:  
Changing direction of velocity

Why do we study non-uniform  
circular motion?

Some exciting motions  
are non-uniform circular motions!

Example →



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Uniform  
Circular motion

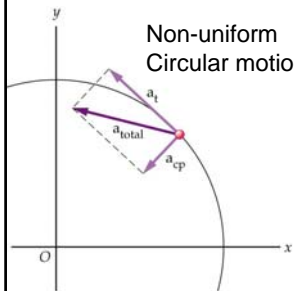
An object moving along a circular path with a **constant speed**:

- Only radial acceleration
- Net force directed toward the center of a curvature (circle).

Non-uniform  
Circular motion

An object moving along the circular path with a **changing speed** :

- Both radial and tangential accelerations
- Net force NOT directed toward the center of a curvature (circle).



**Radial acceleration: changing direction**

**Tangential acceleration: changing speed**

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Even for Non-Uniform circular motion,

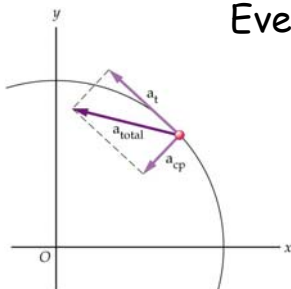
**Radial component of acceleration**

$$|a_r| = \frac{v^2}{r}$$

**Radial component of net force**

$$|F_r| = m \frac{v^2}{r}$$

Radial components follow the same relations as uniform circular motions!



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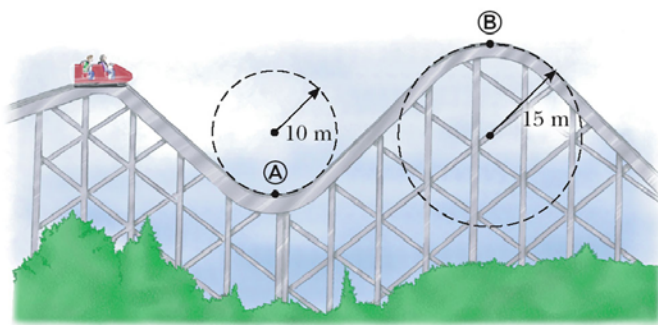
Example: Roller coaster ride (see note)

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iClicker Quiz

For the roller coaster,  
the **magnitude of** normal force at B is \_\_\_\_\_ mg.

- (a) equal to
- (b) less than
- (c) greater than



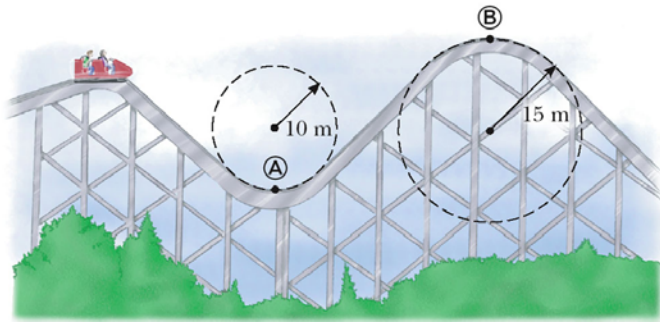
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iClicker Quiz

For the roller coaster,  
the **magnitude of** normal force at A is \_\_\_\_\_ mg.

- (a) equal to
- (b) less than
- (c) greater than

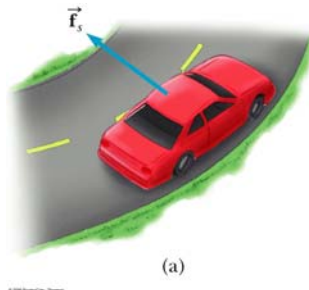


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**Example: Car moving along a curved horizontal road (see note)**

A 1000 kg car moving on a horizontal road negotiates a curve with a radius 20 m. If the coefficient of static friction is 0.5 between the road and tire, what is the maximum speed the car can have to make the turn successfully?



(a)

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