

November 5, 2010    Physics 121    Prof. E. F. Redish

■ **Theme Music: Mary Chapin Carpenter**  
*Down at the Twist and Shout*

■ **Cartoon: Mort & Greg Walker**  
*Beetle Bailey*

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### Outline

- Recap of forces in circular motion
- Rotational Kinematics
  - angles (radians)
  - angular velocity and angular acceleration
  - trig for large angles
- Thinking about balance:  
 The Rotational Effect of Forces

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### Uniform Circular Motion

Position    Velocity    Acceleration

$\frac{v \Delta t}{R} = \frac{a \Delta t}{v}$      $\frac{a}{v} = \frac{v}{R}$      $a = \frac{v^2}{R}$

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### Uniform Circular Motion: Forces



$\vec{a} = \frac{\vec{F}^{net}}{m}$       always

$\vec{a} = -\frac{v^2}{R} \hat{r}$       in order for the object to move in a circle with constant speed.

$\frac{\vec{F}^{net}}{m} = -\frac{v^2}{R} \hat{r}$       Therefore, to do this we need a net force.

$\vec{F}^{net} = -\frac{mv^2}{R} \hat{r}$

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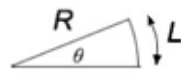
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### Radians

**■** The radian is an angle measure defined as the ratio of the arc length of the circle spanned by the angle to the radius of the circle.



$\theta = \frac{L}{R}$       (in radians)

$\theta_{\text{whole circle}} = \frac{2\pi R}{R} = 2\pi$

$\Rightarrow \frac{\theta_{\text{rad}}}{\theta_{\text{deg}}} = \frac{2\pi}{360}$

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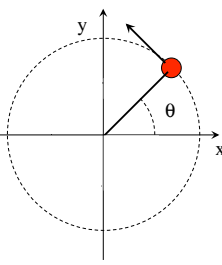
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### Rotational Kinematics: Polar Description of Motion

**■** Describing the angular position of an object.

- Angle (radians)  $\theta$
- Angular velocity  $\omega$
- Angular acceleration  $\alpha$



$\theta$  (in radians) =  $\frac{2\pi}{360} \theta$  (in degrees)

$\langle \omega \rangle = \frac{\Delta\theta}{\Delta t}$        $\langle \alpha \rangle = \frac{\Delta\omega}{\Delta t}$

Uniform motion:  $\Delta\theta = \omega_0 \Delta t$

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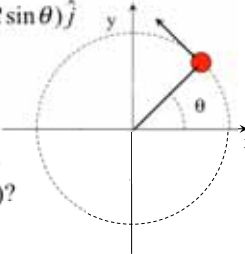
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### Trigonometry for big angles

$\vec{r} = x\hat{i} + y\hat{j} = (R \cos\theta)\hat{i} + (R \sin\theta)\hat{j}$   
 $\theta = \theta_0 + \omega_0(t - t_0)$



What happens as  $t$  (and  $\theta$ ) gets large (bigger than  $2\pi$ )?

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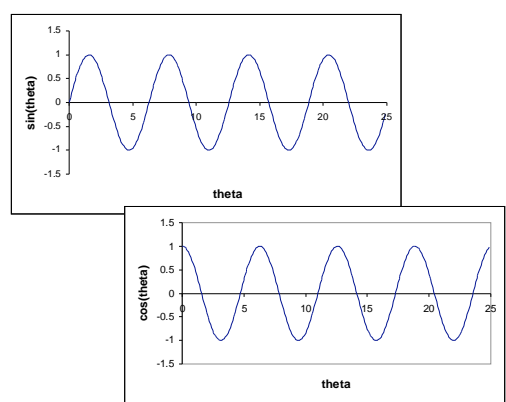
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