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

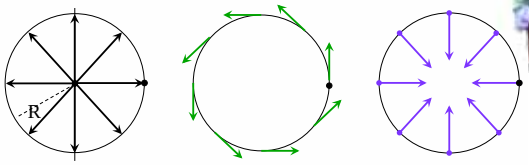
11/5/10 Physics 121 **1**

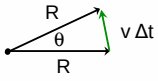
Outline

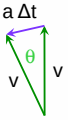
- Recap of forces in circular motion
- Rotational Kinematics
  - angles (radians)
  - angular velocity and angular acceleration
  - trig for large angles
- Thinking about balance:
  The Rotational Effect of Forces

11/5/10 Physics 121 **2**

Uniform Circular Motion







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

11/3/10 Physics 121 **3**

Uniform Circular Motion: Forces

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

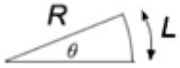
$$\vec{a} = -\frac{v^2}{R}\hat{r}$$ in order for the object to move in a circle with constant speed.

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

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

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.



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

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

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

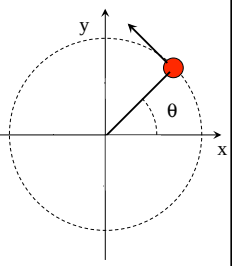
Rotational Kinematics: Polar Description of Motion

- Describing the angular position of an object.
  - Angle (radians) θ
  - Angular velocity ω
  - Angular acceleration α

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

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

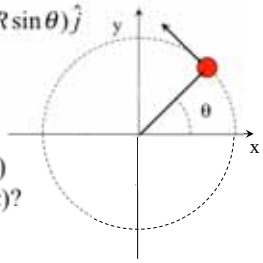
Uniform motion: $\Delta\theta = \omega_0 \Delta t$



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 θ) gets large (bigger than 2π)?