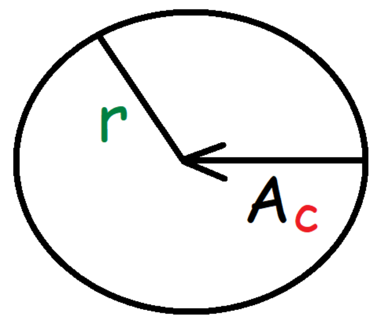
Circular Motion Formula Sheet:



Centripetal Acceleration:

$$A_c = \frac{v^2}{r} \qquad A_c = \frac{4\pi^2 r}{T^2}$$

Note: A_c always point toward the center of the circle.

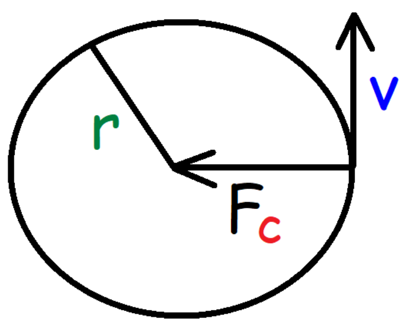
Revolving Speed:

$$v = \frac{2\pi r}{T} \qquad c = 2\pi r$$

Frequency:

$$f = \frac{1}{T} \qquad f = \frac{\#\ of\ Cycles}{time}$$

The frequency represents the number of cycles that occur in 1 second.



Period:

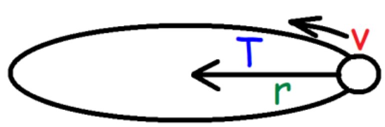
$$T = \frac{1}{f} \qquad T = \frac{time}{\#\ of\ cycles}$$

The period is the time it takes to complete 1 cycle.

Centripetal Force:

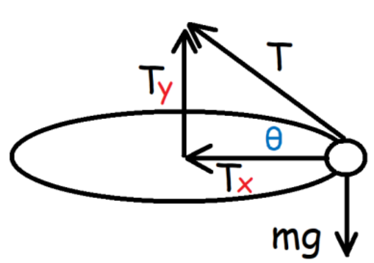
$$F_c = \frac{mv^2}{r} \qquad F_c = mA_c$$

Note: F_c always point toward the center of the circle.



Tension Force – Horizontal Circles: $(when\ v\ is\ high)$

$$T \approx F_c = \frac{mv^2}{r}$$



Horizontal Circle – Tetherball: $(when\ v\ is\ low)$

$$T_y = mg \qquad T_x \approx F_c = \frac{mv^2}{r}$$

$$T = \sqrt{{T_x}^2 + {T_y}^2} \qquad \theta = tan^{-1}\left(\frac{T_y}{T_x}\right)$$

$$T_x = T\cos\theta \qquad T_y = T\sin\theta$$

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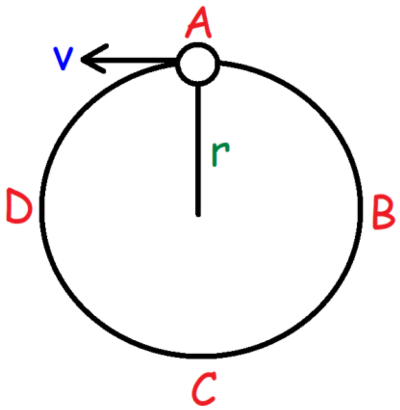
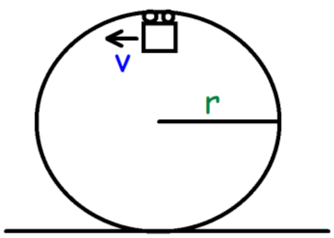
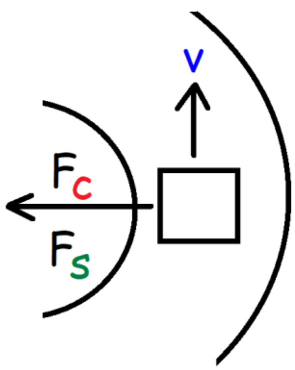
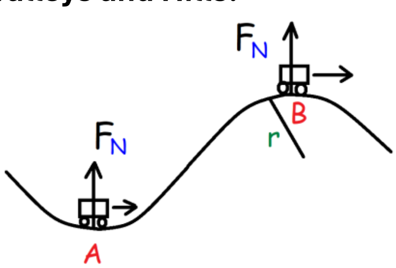
Vertical Circle:  	**Tension Force – Point A:** $$\boldsymbol{T} = \frac{mv^2}{r} - mg$$ **Points B & D:** $$\boldsymbol{T} \approx \frac{mv^2}{r} \quad \textit{when v is high}$$ $$\boldsymbol{T} = m\sqrt{g^2 + \left(\frac{v^2}{r}\right)^2} \quad \textit{when v is low}$$ **Tension Force - Point C:** $$\boldsymbol{T} = \frac{mv^2}{r} + mg$$
 	**Minimum Rollercoaster Speed:** $$\boldsymbol{v} = \sqrt{rg}$$
 	**A Car Rounding a Curve on a Flat Road:** $$F_s = F_c$$ **Maximum Speed:** $$\boldsymbol{v} = \sqrt{u_s rg}$$ **Coefficient of Static Friction:** $$\boldsymbol{u_s} = \frac{v^2}{rg}$$
Valleys and Hills:  	**Normal Force – Point A:** $$\boldsymbol{F_N} = \frac{mv^2}{r} + mg$$ **Normal Force – Point B:** $$\boldsymbol{F_N} = mg - \frac{mv^2}{r}$$ **Note:** If $F_N < 0$, the object will lose contact with the road at point B.

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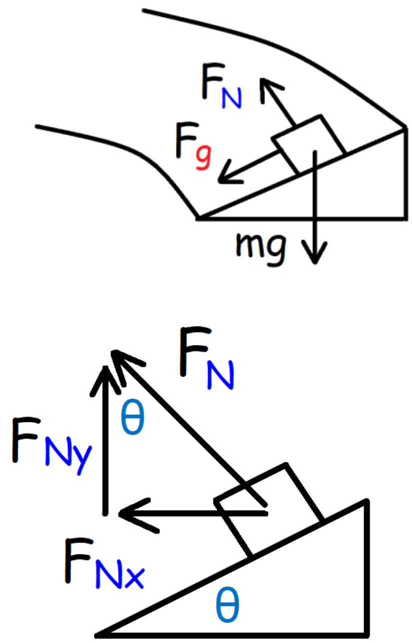


Banked Turn:

$$F_g = mg\sin\theta \qquad F_N = \frac{mg}{\cos\theta}$$

Speed and Angle Needed to Avoid Sliding Up or Down: (No Friction)

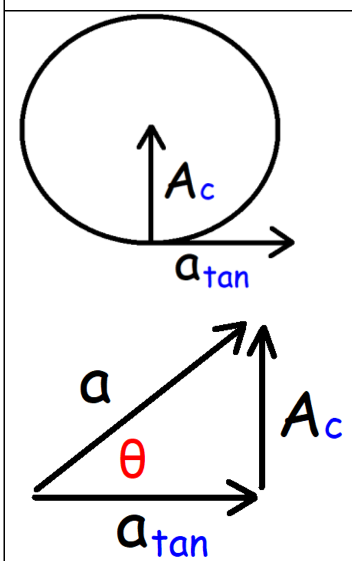
$$v = \sqrt{rg\tan\theta} \qquad \theta = tan^{-1}\left(\frac{v^2}{rg}\right)$$

Maximum Speed Needed to Avoid Sliding Up: (With Friction)

$$v = \sqrt{\frac{rg(\sin\theta + u_s\cos\theta)}{\cos\theta - u_s\sin\theta}}$$

Minimum Speed Needed to Avoid Sliding Down: (With Friction)

$$v = \sqrt{\frac{rg(\sin\theta - u_s\cos\theta)}{\cos\theta + u_s\sin\theta}}$$



Non-Uniform Circular Motion:

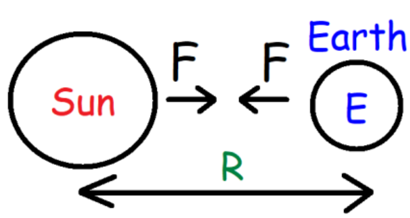
$$A_c = \frac{v^2}{r} \qquad \theta = tan^{-1}\left(\frac{A_c}{a_{tan}}\right)$$

Tangential Acceleration:

$$a_{tan} = \frac{v_F - v_0}{t}$$

Net Acceleration:

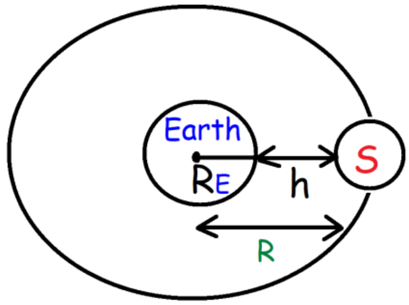
$$a = \sqrt{{a_{tan}}^2 + {A_c}^2}$$



Gravitational Force of Attraction:

$$F = \frac{GM_1M_2}{R^2}$$

Universal Gravitation Constant: $G = 6.67\ x\ 10^{-11} N * m^2/kg^2$
Mass of the Sun: $M_S = 1.99\ x\ 10^{30}\ kg$
Earth to Sun Distance: $R_{ES} = 1.496\ x\ 10^{11}\ m$



$M_E = 5.97 \; x \; 10^{24} \; kg$
$R_E = 6.38 \; x \; 10^{6} \; m$

Satellite Speed:

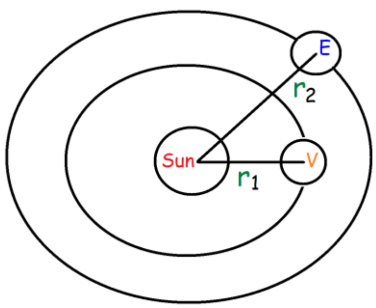
$$v = \sqrt{\frac{GM_E}{R}} \qquad R = R_E + h$$

Period:

$$T = \frac{2\pi R}{v}$$

Gravitational Acceleration:

$$g = \frac{GM_E}{R^2}$$



Kepler's Third Law:

$$\left(\frac{T_1}{T_2}\right)^2 = \left(\frac{r_1}{r_2}\right)^3$$

Period:

$$T = 2\pi\sqrt{\frac{R^3}{GM}}$$

Orbital Radius:

$$R = \sqrt[3]{\frac{GMT^2}{4\pi^2}}$$

Planetary Mass:

$$M = \frac{4\pi^2 R^3}{GT^2}$$