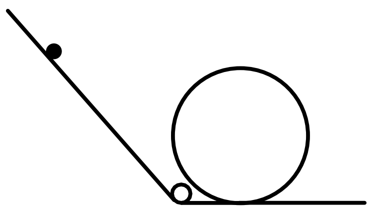
Even More Circular Motion



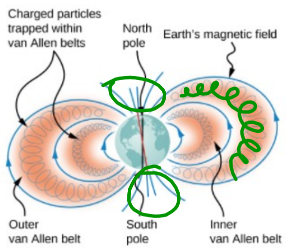
Ex. 1 A marble is released on a frictionless inclined plane that changes into a vertical loop at the bottom of the incline. The radius of the loop is 7.0 cm. What is the minimum speed the marble needs in order for it to make a complete loop? Draw a FBD.

Ex. 2: Banked Curves

A bus travels along a banked curve at a speed of 120 km/h. Friction is not required to keep it on the track. If the curve is banked at 25 ° to the horizontal, what is the radius of the rotation?

Ex. 3: Spiral Motion

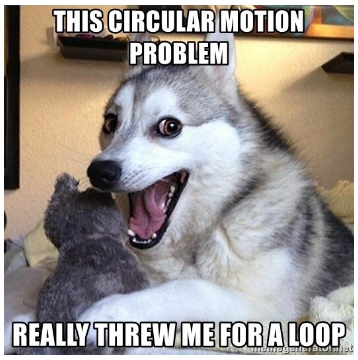
The Aurora Borealis (Northern Lights) occurs when charged particles from space enter the Earth's atmosphere and get caught in the Earth's magnetic field. The particles move linearly while also getting caught in circular motion around the magnetic field, creating a spiral motion.



A charged particle rotates around the magnetic field 21 times in about 16 ms. The radius of the circular motion is 2.4 km.
a) What is the tangential speed of the particles?
b) What is the linear speed of the particles if they travel 550 km in that same amount of time?

Ex. 4: Banked Curves with Friction - Enrichment (optional)

A race car is going around a banked curve at 19^0 from the horizontal and a radius of curvature of 12.6 m. Coefficient of static friction between the wheels and the road is 0.56
a) What is the maximum speed allowed to go around without slipping?
b) What is the minimum speed needed to go around the track with out sliding down?



Ex 1

$r = 7.0$ cm

$\vec{g} = 9.81\ m/s^2$ [down]

$v = ?$

at top at min speed, $F_N = 0N$ momentarily left contact with surface

$$F_{Net,y} = F_g = ma_c$$

$$mg = ma_c$$

$$g = a_c = \frac{v^2}{r}$$

$$v = \sqrt{gr} = \sqrt{(9.81\ m/s^2)(0.070\ m)}$$

$$= 0.82867\ m/s$$

$$\boxed{= 0.83\ m/s}$$

Ex 2

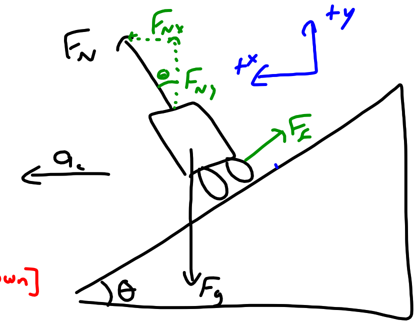
$v = 120\ km/h$

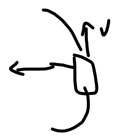
$\theta = 25°$

$\vec{g} = 9.81\ m/s^2\ [down]$

$\vec{a}_y = 0\ m/s^2$

$r = ?$





$$F_{Net,x} = \boxed{F_{Nx} = ma_c}$$

$$F_{Net,y} = F_{Ny} - F_g = ma_y = 0\ N$$

$$\boxed{F_{Ny} = F_g}$$

$$F_N \sin\theta = \frac{mv^2}{r} \quad \rightarrow F_N = \frac{mv^2}{r\sin\theta}$$

$$\div \qquad\qquad \div$$

$$F_N \cos\theta = mg$$

$$\frac{\cancel{F_N} \sin\theta}{\cancel{F_N} \cos\theta} = \frac{\cancel{m}v^2/r}{\cancel{m}g} \qquad \frac{v^2}{r} \times \frac{1}{g}$$

$$\tan\theta = \frac{v^2}{g r}$$

$$r = \frac{v^2}{g\tan\theta}$$

$$v = 120\ km/h \times \frac{1000\ m}{1\ km} \times \frac{1\ h}{3600\ s} = 33.333\ m/s$$

$$r = \frac{(33.333\ m/s)^2}{(9.81\ m/s^2)\tan 25°} = 242.86\ m$$

$$= \boxed{240\ m}$$

Ex 3

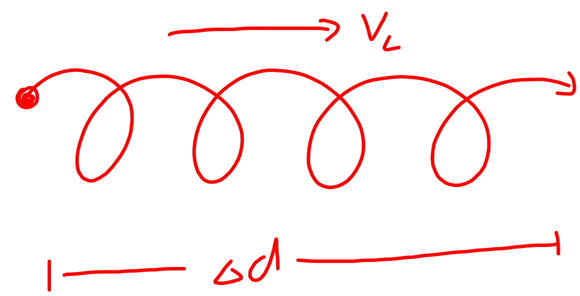
$n = 21$

$\Delta t = 16\ ms$

$r = 2.4\ km$

$V_T = ?$

$\Delta d =$



a) $f = \dfrac{n}{\Delta t} = \dfrac{21}{16\times10^{-3}\ s} = 1312.5\ Hz$

$$V_T = 2\pi r f = 2\pi(2.4\times10^3)(1312.5\ Hz)$$
$$= 1.979\times10^7\ m/s$$
$$\boxed{= 2.0\times10^7\ m/s}$$

b) $V_L = \dfrac{\Delta d}{\Delta t} = \dfrac{550\times10^3\ m}{16\times10^{-3}\ s}$

$$= 3.4375\times10^7\ m/s$$
$$\boxed{= 3.4\times10^7\ m/s}$$