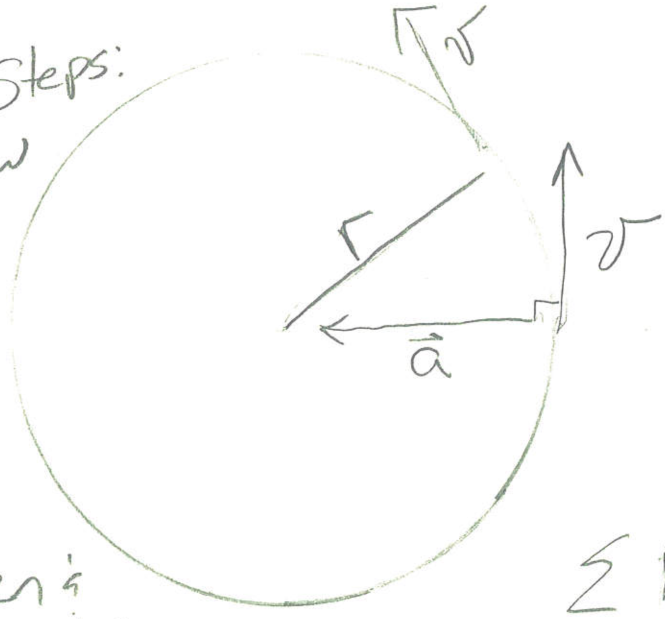
Steps:

1) Draw



Since $\vec{a}$ → we have $\vec{F}_{net}$ towards center

$\vec{F}_{net}$ = f, weight, Tension

2) Given & find statement

$$\sum F_x = \frac{mv^2}{r} \quad \sum F_y = \emptyset$$

or

$$\sum F_y = \frac{mv^2}{r} \quad \sum F_x = \emptyset$$

x or y towards center of Circle

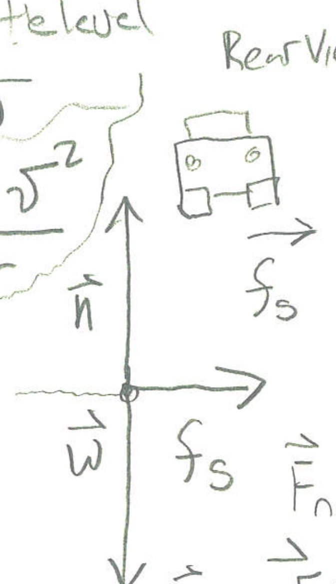
Example 6.7 Max Speed of Car on Corner

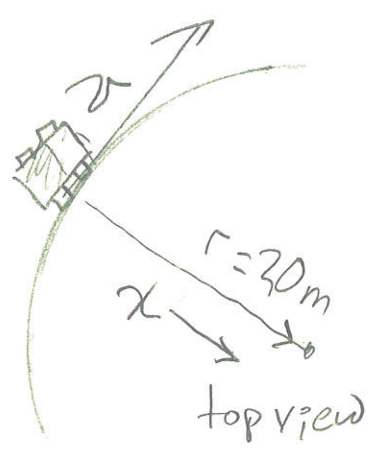
$m = 1500\,kg$ $\mu_s = 1.\emptyset$

$r = 20\,m$ on the level

Find max v

$$\sum F_x = f_x = \frac{mv^2}{r}$$





$$f_{s\,max} = \mu_s n$$
$$= \mu_s mg$$

$\vec{F}_{net} = \vec{f}_s$

$\vec{n} = \vec{w} = F_y = \emptyset$

$$f_{s\,max} = \frac{m v_{max}^2}{r} = \frac{1500\, v_{max}^2}{20}$$

$$\mu_s m g =$$

$$1.0\ \cancel{1500}\ 9.81 = \frac{\cancel{1500}\, v_{max}^2}{20}$$

$$9.81\ \mathrm{m/s^2} = \frac{v_{max}^2}{20\mathrm{m}}$$

$$(20 \cdot 9.81)\frac{\mathrm{m}^2}{\mathrm{s}^2} = v_{max}^2$$

$$\mathrm{sqrt}\left(196.2\frac{\mathrm{m}^2}{\mathrm{s}^2}\right) = v_{max}^{\cancel{2}}$$

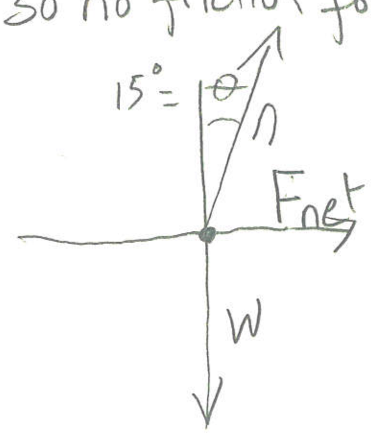
$$\underline{\underline{14\ \mathrm{m/s} = v_{max}}}$$

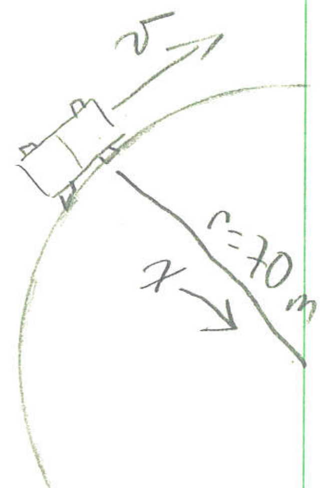
What happens on a banked curve?

<u>Example 6.8</u>

$r = 70$ m
$\theta = 15°$

Consider a 15° degree curve so no friction force





$$\sum F_x = n\sin\theta = \frac{mv^2}{r}$$

$$\sum F_y = n\cos\theta - w = \cancel{0}$$

Don't know mass; but → keep on keeping on...

substitute & cancel the mass

$$n = \frac{w}{\cos\theta} = \frac{mg}{\cos\theta}$$

$$n\sin\theta = \frac{mv^2}{r}$$

$$\frac{\cancel{m}g}{\cos\theta}\sin\theta = \frac{\cancel{m}v^2}{r}$$

$$\left[\tan\theta = \frac{\sin\theta}{\cos\theta}\right]$$

$$g\,\frac{\sin\theta}{\cos\theta}\,\frac{\text{opp}/\cancel{\text{hyp}}}{\text{adj}/\cancel{\text{hyp}}} = \frac{v^2}{r}$$

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

$$\boxed{}\ 9.81\frac{m}{s^2}\tan(15) = \frac{v^2}{70m}$$

$$686.7\frac{m^2}{s^2}(.2679) = v^2$$

$$184\frac{m^2}{s^2} = v^2$$

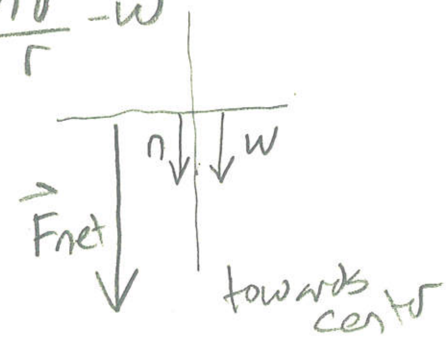
$$\underline{\underline{14\,m/s = v}}$$

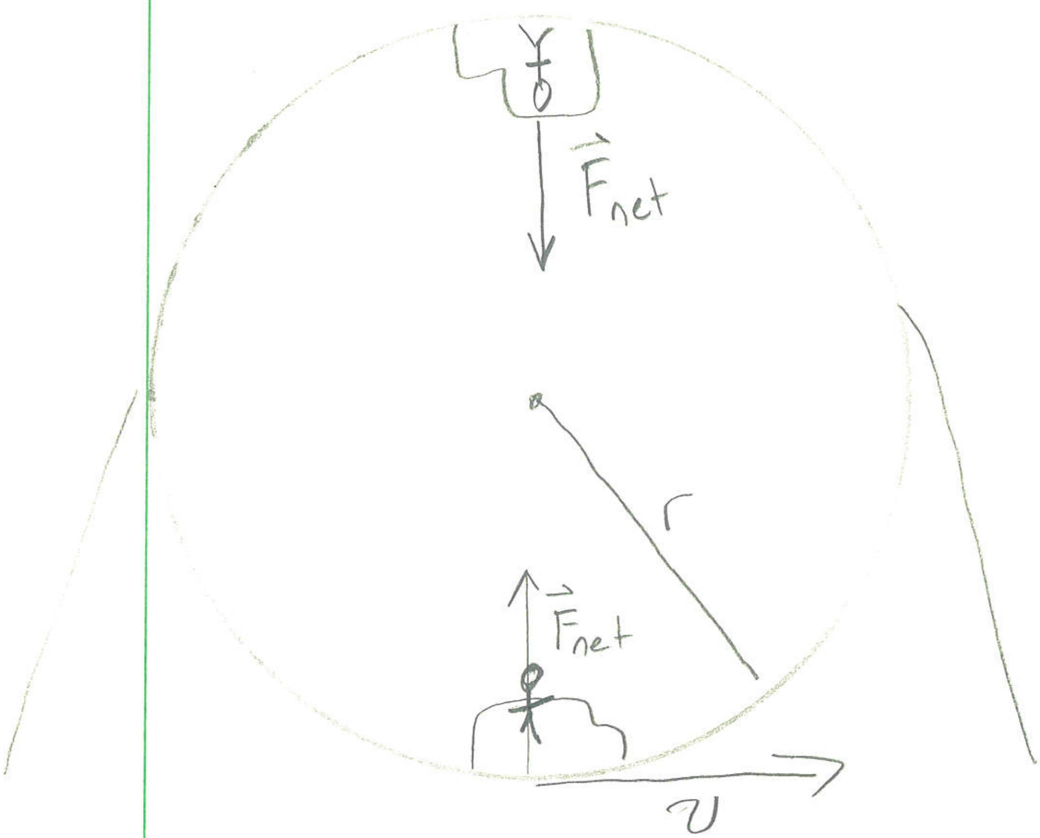
Apparent Force & Circular Motion

feels like being pushed up

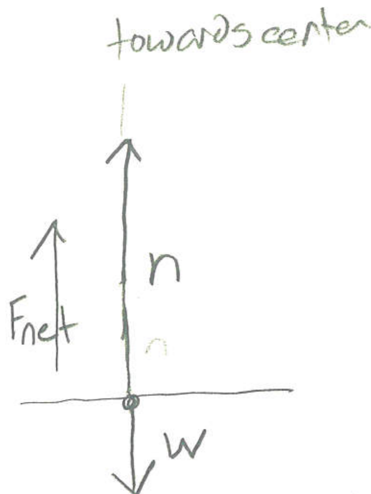
$$\Sigma F_x = \vec{n} + \vec{w} = n + w = \frac{mv^2}{r}$$

$$w_{app} = n = \frac{mv^2}{r} - w$$





Ferris wheel



$$\Sigma F_x = \vec{n} + \vec{w} = n - w = \frac{mv^2}{r}$$

feels like your being pushed down

$$w_{app} = w + \frac{mv^2}{r}$$

Now decrease v^2 for top of circle

$$n = \frac{mv^2}{r} - w \quad \text{as } v \to \emptyset$$

$$n \to \emptyset$$

[weight alone keeps you on the circle] & $\frac{mv^2}{r} = w$

$$\frac{mv^2}{r} = w \quad @ \text{ Critical Speed}$$

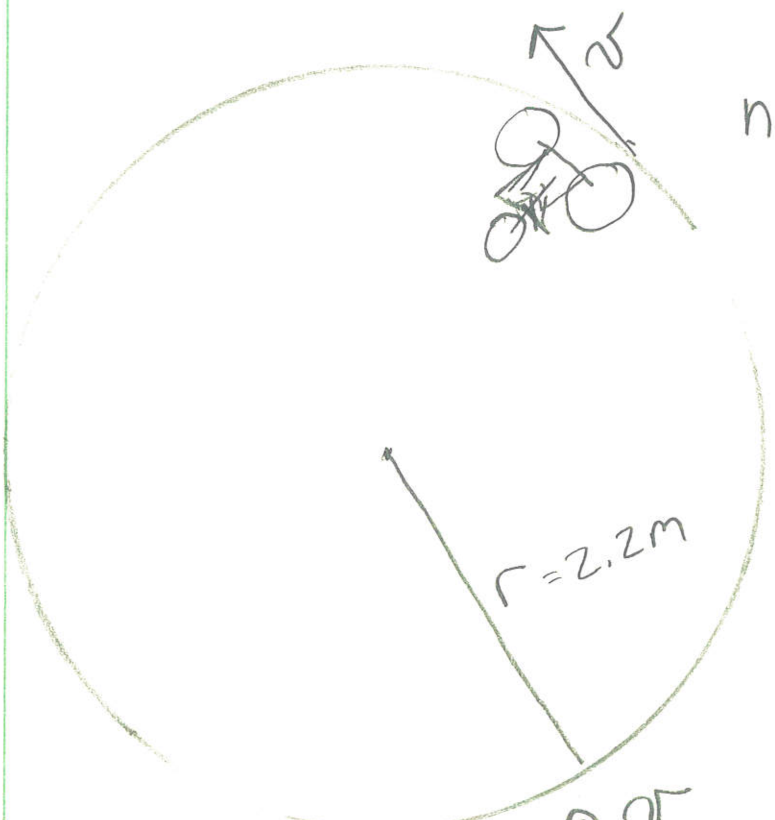
$$\left(\frac{\cancel{r}}{\cancel{m}}\right)\frac{\cancel{m}v^2}{\cancel{r}} = w\left(\frac{r}{m}\right)$$

$$v^2 = \frac{wr}{m} \Rightarrow v_c = \sqrt{\frac{wr}{m}}$$

$$[w = mg] \qquad v_c = \sqrt{\frac{\cancel{m}gr}{\cancel{m}}}$$

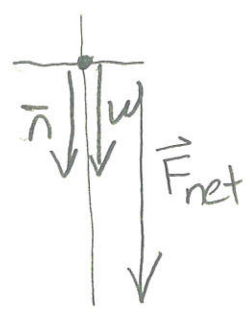
$$\underline{v_c = \sqrt{gr}}$$

Globe of Death Example 6.9



$n \geq w$ - to keep the rider on the circle

Find v_m



At the top

x towards center

$$\Sigma F_x = W + n = \frac{mv^2}{r}$$

@ v_{min} $n = W$ sub w for n

$$2W = \frac{mv^2}{r}$$

$$2w = \frac{\cancel{m}v^2}{r} = 2\cancel{m}g$$ Sub mg for w

$$v^2 = 2gr$$

Solving for v_{min}

$$v = \sqrt{2gr} = \sqrt{2 \cdot 9.8 \cdot 2.2}$$

$$v = \sqrt{43.1}$$

$$v = 6.7 \left[\frac{m}{s}\right]$$

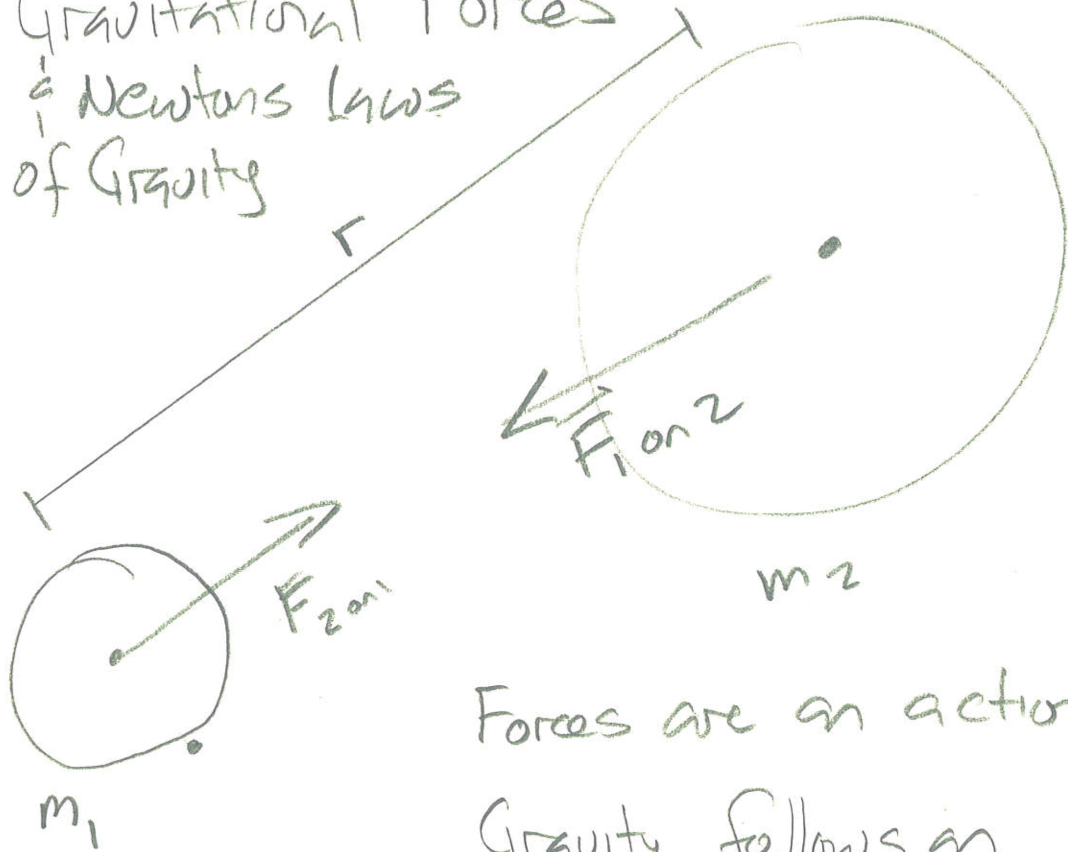
Find T (period)

$$T = 2\pi r / v = 2\left(\frac{22}{7}\right)\frac{2.2\ \cancel{m}}{6.7\ \cancel{m}/\cancel{s}}\ \text{sec}$$

$$T = \frac{96.8}{46.9}\ \text{sec}$$

$$T = 2\ \text{sec}$$

Gravitational Forces
& Newtons laws
of Gravity



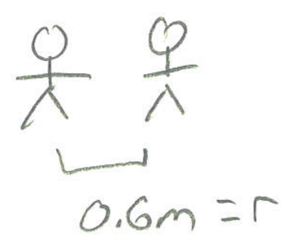
Forces are an action reaction pair

Gravity follows an inverse square law

$$F_{1on2} = F_{2on1} = G\frac{m_1 m_2}{r^2}$$

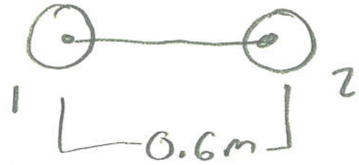
$$G = 6.67 \times 10^{-11}\, Nm^2/kg^2$$

Exmple 6.12



$r = 0.6\,m$

$m = 65\,kg$



$F_{1on2} = F_{2on1}$

$$= G\frac{m_1 m_2}{r^2} = 6.67 \times 10^{-11} \frac{Nm^2}{kg^2} \frac{65\,kg \cdot 65\,kg}{(0.6\,m)^2}$$

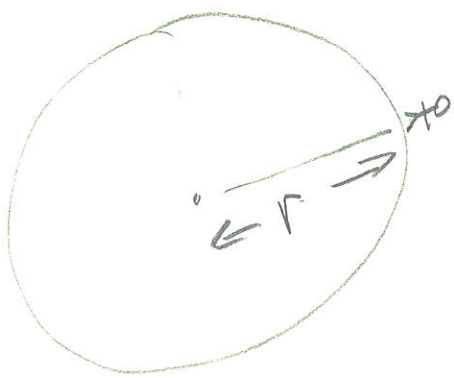
$$\frac{G m_1 m_2}{r^2} = 6.67\times10^{-11} \frac{N \cancel{m^2}}{\cancel{kg^2}} \frac{65\cancel{kg}\ 65\cancel{kg}}{\cancel{0}.36 \cancel{m^2}}$$

$$= 6.67\times10^{-11} \frac{4.225\times10^{3}}{3.6\times10^{-1}} N$$

$$= \frac{6.67}{3.6} \cdot (4.225) \cdot 10^{-11+3+1}$$

$$\vec{F}_{2on1} = \underline{\underline{7.8\times10^{-7} N}}$$

<u>Example 6.13</u> Why use $\vec{g} = m \cdot 9.81$?



$R = 6.37\times10^{6} m$

$m_{earth} = 5.98\times10^{24} kg$

$m_{person} = 60 kg$

$$F_{\substack{earth\ on \\ person}} = G\frac{M_e M_p}{R_e^2}$$

$$F_{\substack{earth \\ on\ person}} = 6.67\times10^{-11} \frac{N m^2}{kg^2} \frac{60\,kg \times 5.98\times10^{24} kg}{[6.37\times10^{6} m]^2}$$

$$= \frac{6.67\times60\cdot5.98}{(6.37)^2} \times 10^{-11+24-12}$$

$$= 58.9\times10^{1} N$$

$$= 590 N$$

$\vec{F} = mg$

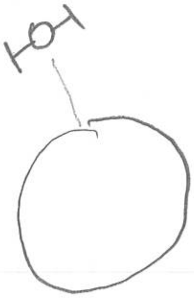
$= 60 kg \cdot 9.81$

$= 588.9 N$

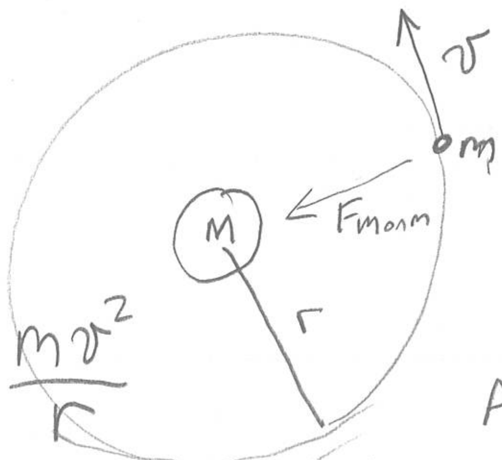
$= 590 N$

Geostationary Sattelites

appear to hover at the same place



What is radius of orbit?



Speed min

$$F_{M on m} = \frac{GMm}{r^2} = \frac{mv^2}{r}$$

Solving for v

$$v = \sqrt{\frac{GM}{r}} = \frac{2\pi r}{T}$$

Angular velocity

Also $v_{ang} = 2\pi r / T$

ReArrange to find Relationship between period, radius, & Mass M

$$T^2 = \left(\frac{4\pi^2}{GM}\right) r^3$$

$$T_{earth} = 24\,\cancel{hr} \left| \frac{3600\,sec}{\cancel{hr}} \right| = 8.64 \times 10^4\,sec$$

$$r = \left[\frac{GM_e T^2}{4\pi^2}\right]^{\frac{1}{3}}$$

$$\left[\frac{6.67\times10^{-11}\ 5.98\times10^{24}\ (8.64\times10^4)^2}{4\pi^2}\right]^{\frac{1}{3}}$$

$$\left[\frac{6.67 \cdot 5.98 \cdot 8.64 \cdot 8.64}{4 \cdot 3.14 \cdot 3.14} \times 10^{-11+24+8}\right]^{\frac{1}{3}}$$

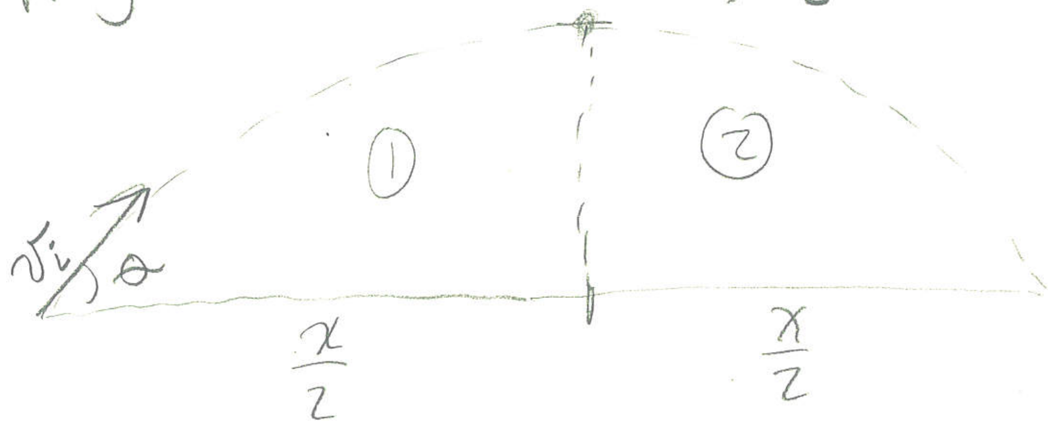
$$\left(\frac{\cancel{36} \cdot 81}{\cancel{36}} \times 10^{21}\right)^{\frac{1}{3}}$$

3×10^{7} m Estimated

[4.23×10^{7} actual]

Projectile motion

@ y_{max}, $v_y = \emptyset$



$$\vec{a} = \frac{\Delta v}{t} = \frac{v_f - v_i}{t}$$

#6

$\uparrow v$ is known

Δt is known

$\Downarrow$

$\vec{a}$

$F = m\vec{a}$

Newtons 3rd

$F_{\text{bug on ground}} = F_{\text{ground on bug}}$

$$\vec{a} = \frac{\Delta v}{\Delta t} \quad \frac{v_f - v_i}{\Delta t}$$

Good :T