

- Car will slide down hill at F_{Hill} . But f_{static} holds it up
- f_s acts up the hill. $f_s \cos \theta$ is the component of static friction acting along x -axis.
- N acts \perp to the plane of the ramp and is equal to $\frac{mg}{\cos \theta}$
- $N \sin \theta$ is the component of Normal force acting along x -axis
 $\therefore F_c$ is the sum of all forces acting along x -axis

$$F_c = f_s \cos \theta + N \sin \theta = \frac{mv^2}{r}$$

Recall $N = \frac{mg}{\cos \theta}$ (see diagram). We can substitute $\frac{mg}{\cos \theta}$ for N

Recall f_s by definition = $\mu_s N$

$$F_c = \mu_s N \cos \theta + N \sin \theta$$

$$F_c = \mu_s \left(\frac{mg}{\cos \theta} \right) \cos \theta + \left(\frac{mg}{\cos \theta} \right) (\sin \theta)$$

$$F_c = \mu_s mg + mg \tan \theta \quad (\text{factor out } mg)$$

$$F_c = mg (\mu_s + \tan \theta) = \cancel{\frac{mv^2}{r}} \quad \leftarrow \text{This is } a_c$$

$$\therefore a_c = \frac{v^2}{r} = g (\mu_s + \tan \theta)$$

\nwarrow if frictionless surface, $\mu_s = 0$

$$\text{Solve for } a_c = \frac{v^2}{r} = g(\mu_s + \tan \theta)$$

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Solve for V:

$$V = \sqrt{gr(\mu_s + \tan \theta)}$$

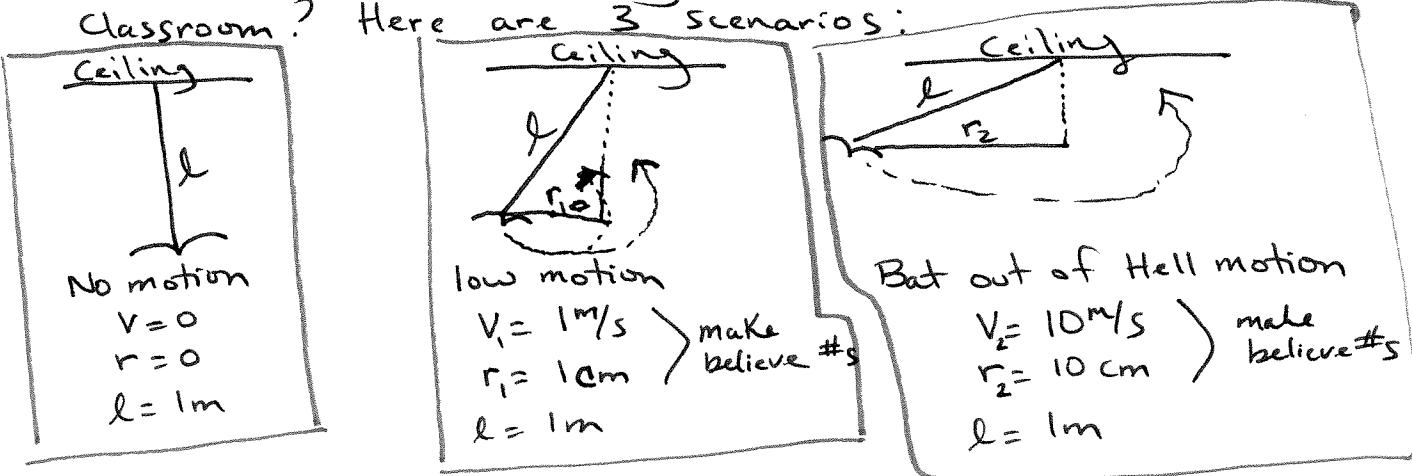
Solve for $\tan \theta$:

$$\tan \theta = \frac{V^2}{gr} - \mu_s$$

What can we conclude from this?

- As V increases, ~~stays~~ since g always remains 9.8 m/s^2 and μ_s is constant and θ is constant, The radius must increase (in other words, if you step on the gas, you'll climb the wall) $V = \sqrt{gr(\mu_s + \tan \theta)}$
 ↑ ↑
 constant value

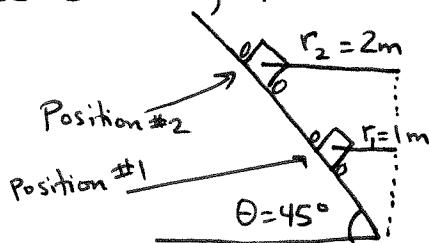
- How about the flapping bat I have in the classroom? Here are 3 scenarios:



\therefore The faster he flaps, The greater his Tangential Velocity and The greater his radius. l remains constant.

Scenario: you have a car on an angled track ($\theta = 45^\circ$). Position #1 of the car has it with a radius of 1m, Position #2 has a radius of 2m (see diagram)

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The cars are coming out of the page at you.

What we know to be True:

a_c is a constant value. v_{Tangent} and r will change, but a_c and θ and μ_s are constant.

$$a_c = \frac{v^2}{r} = r\omega^2 = g(\mu_s + \tan\theta)$$

What we will assume: let's set $\mu_s = 0$ (No Friction)

What this tells us:

$$a_c = g(0 + \tan 45)$$

$$a_c = g(1)$$

$$a_c = g = 9.8 \text{ m/s}^2$$

constant value for a_c
Never changes!

(So long as θ , μ_s are also
constant)

Let's play w/ this info:

$$\text{Scenario #1} \rightarrow a_{c1} = \frac{v_1^2}{r_1} = 9.8 \text{ m/s}^2 = \frac{v_1^2}{1 \text{ m}} \quad v_1 = 3.13 \text{ m/s}$$

$$\text{Scenario #2} \rightarrow a_{c2} = \frac{v_2^2}{r_2} = 9.8 \text{ m/s}^2 = \frac{v_2^2}{2 \text{ m}} \quad v_2 = 4.43 \text{ m/s}$$

$$\text{Scenario #1} \quad v_1^2 = (r_1 \omega_1)^2 = (1 \text{ m}) \omega_1^2 \quad \omega_1 = 3.13 \frac{\text{rad}}{\text{s}}$$

$$\text{Scenario #2} \quad v_2^2 = (r_2 \omega_2)^2 = (2 \text{ m}) \omega_2^2 \quad \omega_2 = 2.22 \frac{\text{rad}}{\text{s}}$$

$\therefore v_{\text{Tangent}} \uparrow$, but $\omega \downarrow$. In other words, you step on the gas and speed up. This makes you climb the wall (r increases) but your revolutions/sec decreases.

Scenario: You are in a
Spacecraft orbiting ~~a planet~~
a Planet

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$$F = mg, g = \frac{Gm_E}{r_E^2}$$

$$g = \frac{Gm_E}{(r_E)^2}$$

let's call this value 1
just to make life easy

lets say $r_{E1} = 1m$
and $r_{E2} = 2m$ just for fun

$$g_1 = \frac{1}{(1m)^2} = 1m/s^2$$

$$g_2 = \frac{1}{(2m)^2} = 0.25m/s^2$$

∴ Spacecraft #1 has a g of $1m/s^2$
Spacecraft #2 has a g of $0.25m/s^2$

$$a_c = \frac{v_1^2}{r_1} = 1m/s^2 = \frac{v_1^2}{1m} \quad v_1 = 1m/s$$

$$a_c = \frac{v_2^2}{r_2} = 0.25m/s^2 = \frac{v_2^2}{2m} \quad v_2 = 0.707$$

As you increase radial distance:

v_{Tangent} decreases

a_c decreases

(p. 239 Table 7.3)

U decreases

KE decreases

U increases (smaller negative value)

As you increase v_{Tangent} (fire retro booster rockets):

Radius must grow to satisfy a_c . But, by virtue of the fact that r grows, a_c will decrease and therefore, when you go to engine shut-down, your v_{Tangent} at your new, higher orbit, will be less than it was before you fired your boosters).

