$$\boxed{\tan\theta = \frac{v^2}{gR}}$$

dimension: $\frac{(m/s)^2}{m/s^2 \; m}$ = none.

$$v = 40 \text{ mph} = \frac{40 \cdot 5280}{60 \cdot 60} \frac{ft}{s} = 59 \; ft/s$$

$$1 \text{ meter} = 39.37'', = \frac{39.37}{12} = 3.28 \; ft$$

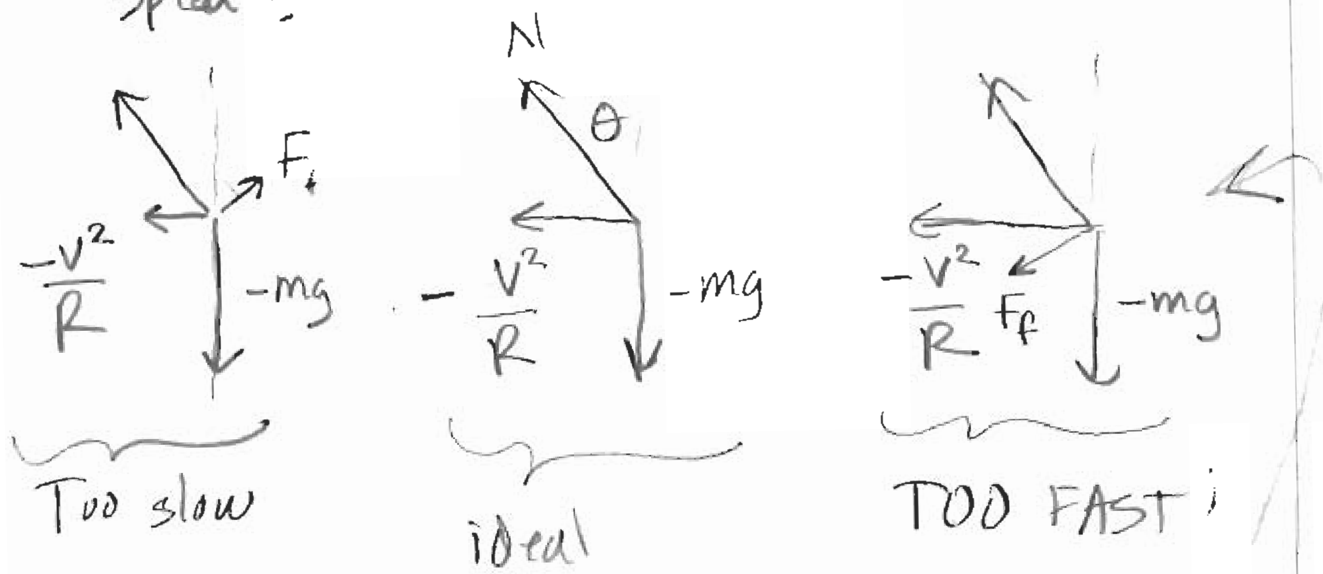
$$\boxed{v = \frac{59}{3.28} = 18 \; m/s}$$

$R = 200$ ft
$= 61$ meters

$$\tan\theta = \frac{18^2}{9.8 \cdot 61} = 0.53$$

$$\rightarrow \boxed{\tilde{\theta} = 28^\circ}$$

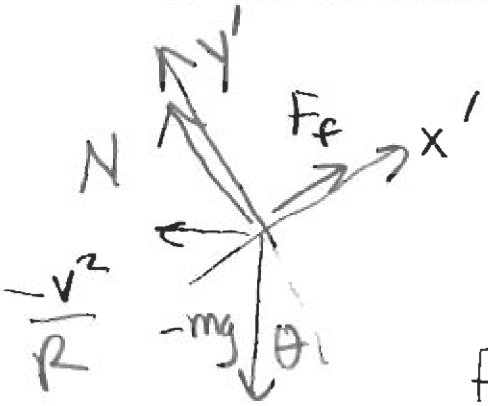
What happens if you drive at a different speed?



Friction comes to the rescue!

note: Normal Force must adapt too!

Tip: change axis, align along unknowns

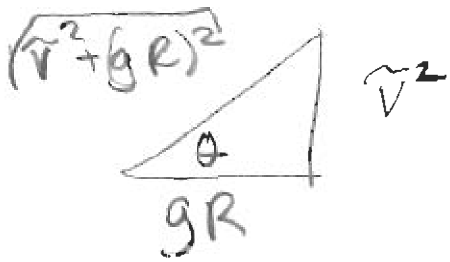


$$m\ddot{x}' = F_f - mg\sin\theta = -\frac{mv^2}{R}\cos\theta$$

$$m\ddot{y}' = N - mg\cos\theta = \frac{mv^2}{R}\sin\theta$$

$$F_f = mg\cos\theta\left(\tan\theta - \frac{v^2}{gR}\right)$$

↑ suppose its banked for $\tilde{v}$



$$\tan\theta = \frac{\tilde{v}^2}{gR}$$

$$F_f = mg\cdot\frac{gR}{\sqrt{\tilde{v}^2+(gR)^2}}\left(\frac{\tilde{v}^2}{gR} - \frac{v^2}{gR}\right)$$

$$\boxed{F_f = mg\cdot\frac{(\tilde{v}^2 - v^2)}{\sqrt{\tilde{v}^2+(gR)^2}}}$$

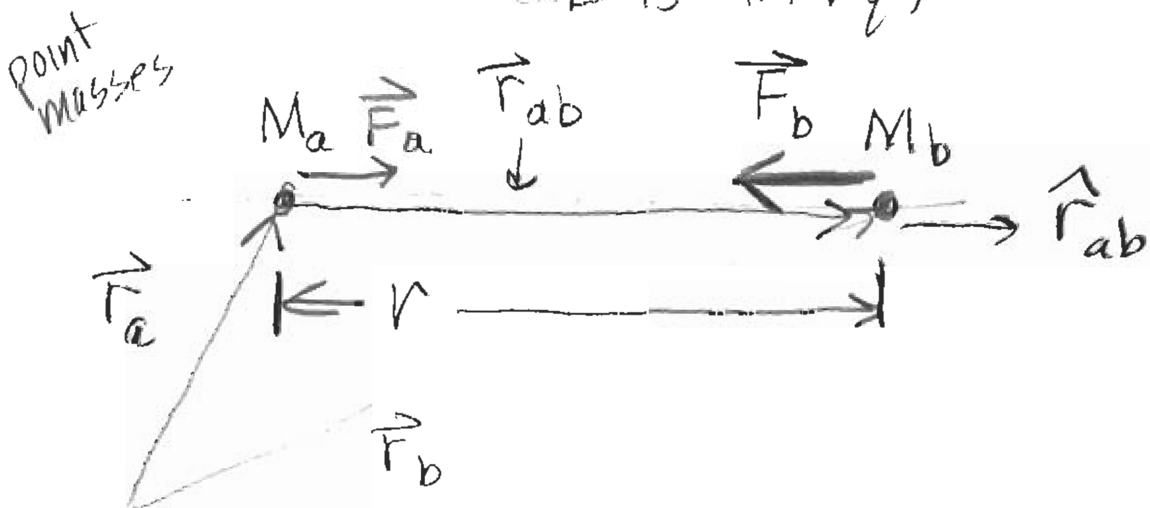
$v < \tilde{v}$ +

$v > \tilde{v}$ −

The 4 Fundamental Forces

1. Gravity — look closer
2. Electrostatic → friction, normal force
3. Weak → causes β decay
4. Strong → holds nuclei together

Gravity (other 4 similar, but Weak is tricky)



$$\vec{r}_a + \vec{r}_{ab} = \vec{r}_b$$

$$\vec{r}_{ab} = \vec{r}_b - \vec{r}_a \quad \text{(note reversal)}$$

$$\hat{r}_{ab} = \frac{\vec{r}_{ab}}{|\vec{r}_{ab}|} \qquad r \equiv |\vec{r}_{ab}|$$

$$\vec{F}_b = -\left(\frac{G M_a M_b}{r^2}\right)\hat{r}_{ab}$$