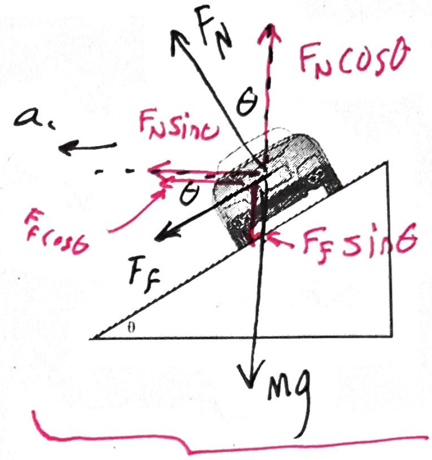
7. If a curve with a radius of 60 m is properly banked for a car traveling 60 km/h (for no friction), what must the coefficient of friction for a car not to skid when traveling at 90 km/h?
[Ans: 0.393]



PART A: FIND θ ... No Friction.

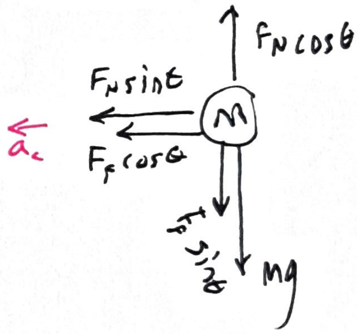
$F_N\cos\theta - mg = 0$ | $F_N\sin\theta = \frac{mv^2}{r}$

$F_N = \frac{mg}{\cos\theta}$ | $F_N = \frac{mv^2}{r\sin\theta}$

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

$$\tan\theta = \frac{v^2}{gr} \Rightarrow \theta = \tan^{-1}\left(\frac{v^2}{gr}\right)$$

$$\theta = 25.28°$$



$F_f = \mu F_N$

PART B: with friction

$F_N\cos\theta - mg - \mu F_N\sin\theta = 0$ | $F_N\sin\theta + \mu F_N\cos\theta = \frac{mv^2}{r}$

① $F_N(\cos\theta - \mu\sin\theta) - mg = 0$ | $F_N(\sin\theta + \mu\cos\theta) = \frac{mv^2}{r}$

~~$F_N(\cos\theta) - F_N\mu\sin\theta = mg$~~

~~$-\mu F_N\sin\theta = mg - F_N\cos\theta$~~

② $F_N = \frac{mv^2}{r(\sin\theta + \mu\cos\theta)}$

sub. ② into ① solve for μ.

$$\frac{mv^2(\cos\theta - \mu\sin\theta)}{r(\sin\theta + \mu\cos\theta)} = mg$$

$$v^2(\cos\theta - \mu\sin\theta) = gr(\sin\theta + \mu\cos\theta)$$

$$v^2\cos\theta - \mu v^2\sin\theta = gr\sin\theta + \mu gr\cos\theta$$

$$v^2\cos\theta - gr\sin\theta = \mu(v^2\sin\theta + gr\cos\theta)$$

$$\mu = \frac{v^2\cos\theta - gr\sin\theta}{(v^2\sin\theta + gr\cos\theta)} \approx 0.393 \checkmark$$

$\frac{314.0439444}{798.5846}$ ✓

$v = 25$ m/s
$\theta = 25.28°$
$r = 60$