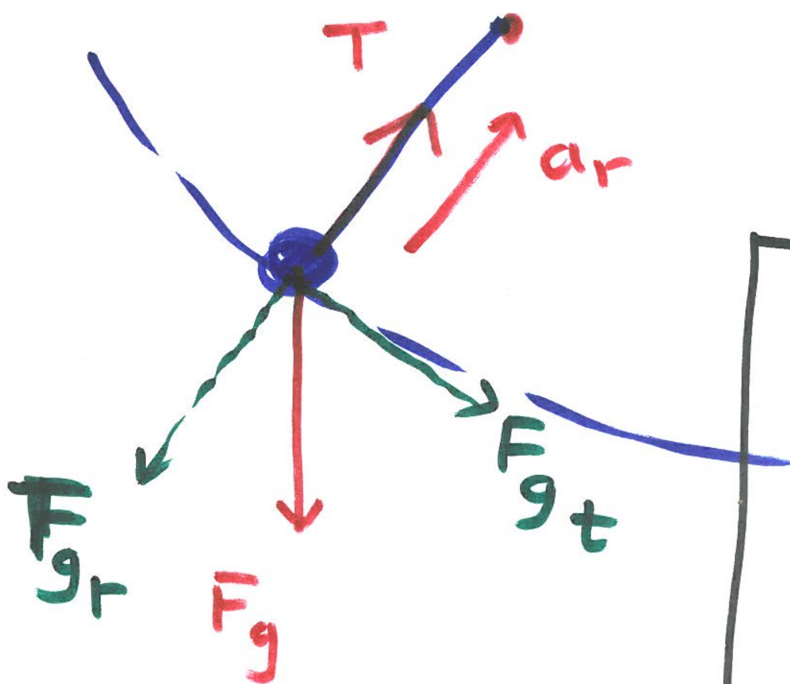
WB 8-1



radial

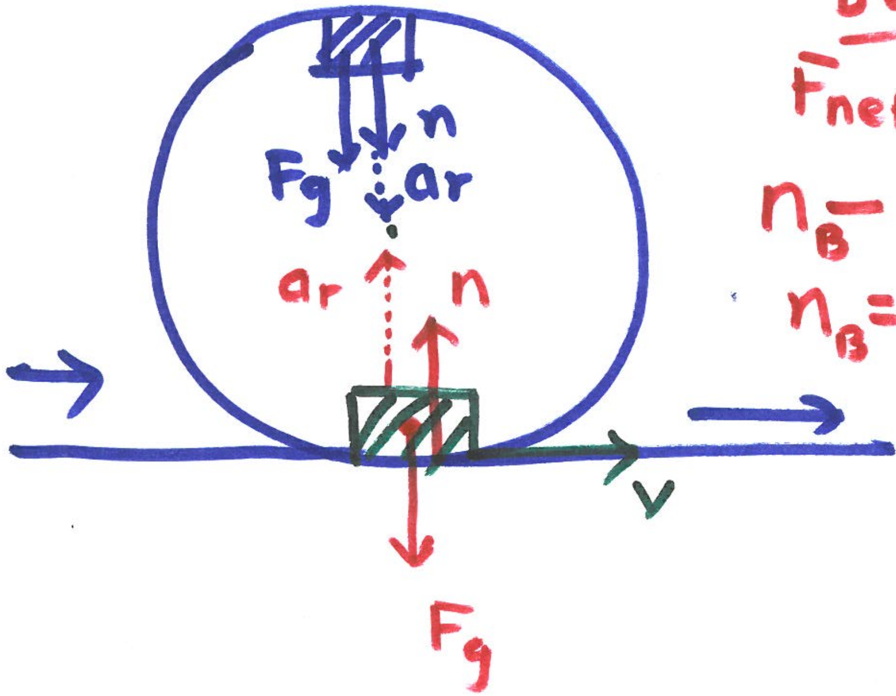
$$(F_{net})_r = ma_r$$

$$T - F_{g_r} = ma_r$$

tangential

$$F_{g_t} = ma_t$$

MAKES THIS NON-UNIFORM CIRCULAR MOTION



BOTTOM

$F_{net} = ma$

$n_B - F_g = ma_r$

$n_B = mg + ma_r$

FEEL HEAVIER AT BOTTOM

TOP

$F_{net} = ma$

$n_T + F_g = ma_r$

$n_T = ma_r - mg$

FEEL LIGHTER AT TOP

$n_T = 0$ corresponds to v_{min} @ top.

STOP-TO-THINK

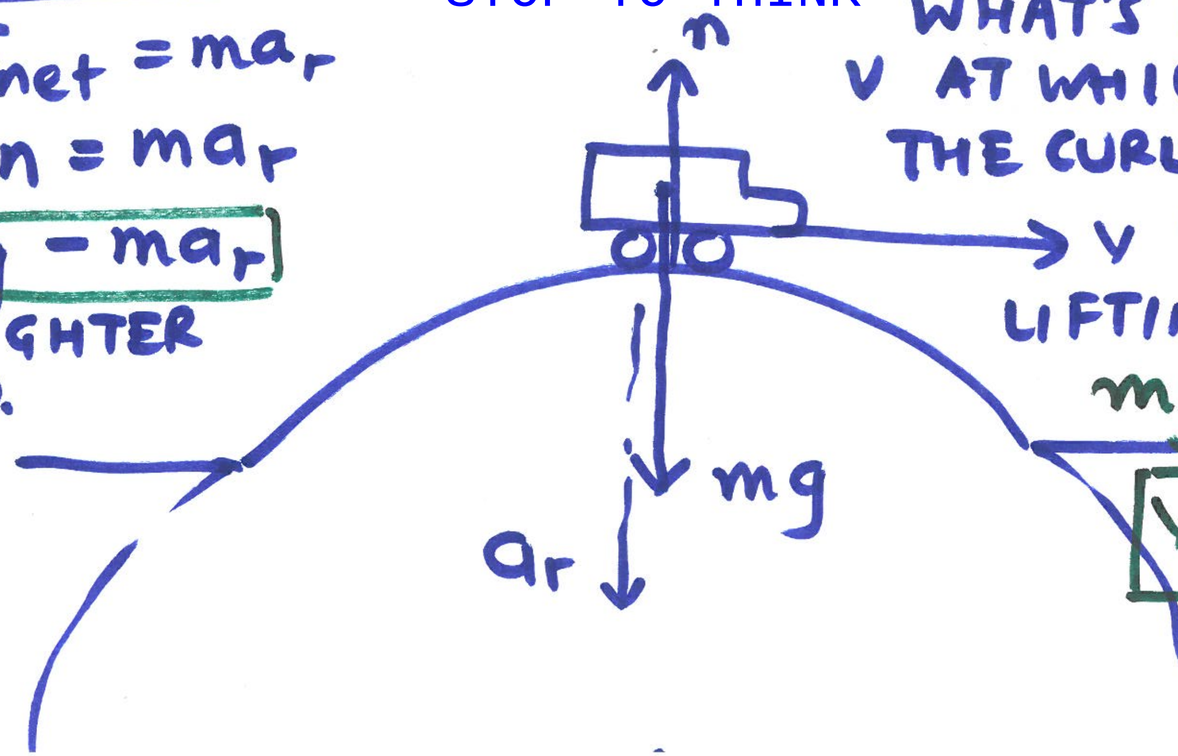
WHAT'S MAXIMUM V AT WHICH CAN ROUND THE CURVE W/O LIFTING OFF?

$F_{net} = ma_r$

$mg - n = ma_r$

$$\boxed{n = mg - ma_r}$$

FEEL LIGHTER AT TOP.

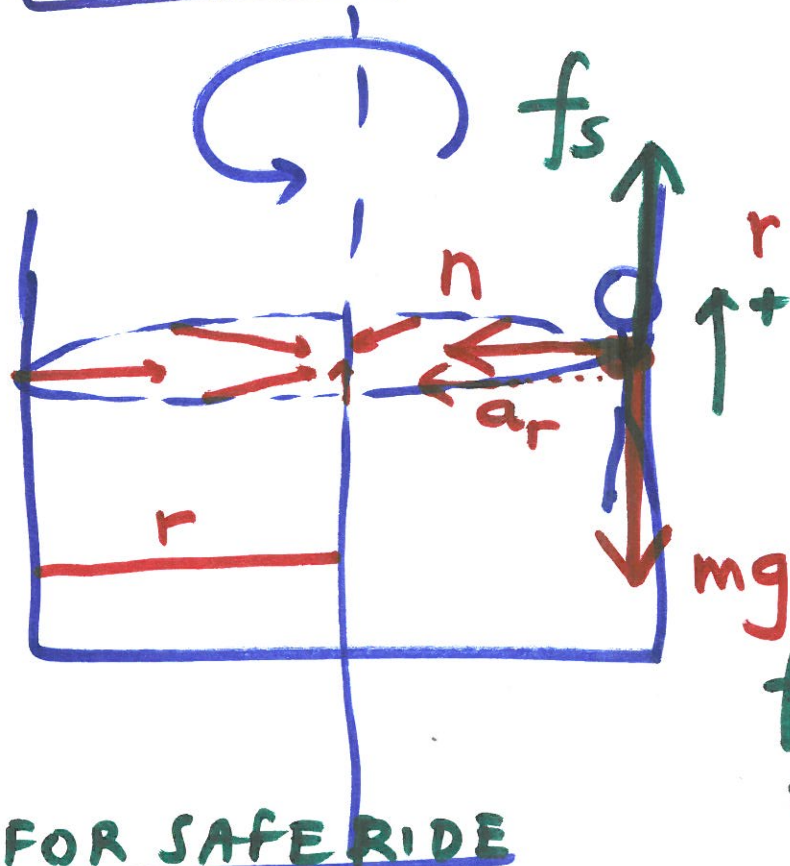


LIFTING OFF $\Rightarrow n = 0$

$mg = ma_r = \frac{mv_{max}^2}{r}$

$$\boxed{v_{max} = \sqrt{gr}}$$

WB 8-3



$F_{net} = ma$

r: $n = ma_r$

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

z: $F_{net} = ma$

$f_s - mg = 0$

~~$mg = \mu$~~

MIN. VEL. FOR SAFE RIDE

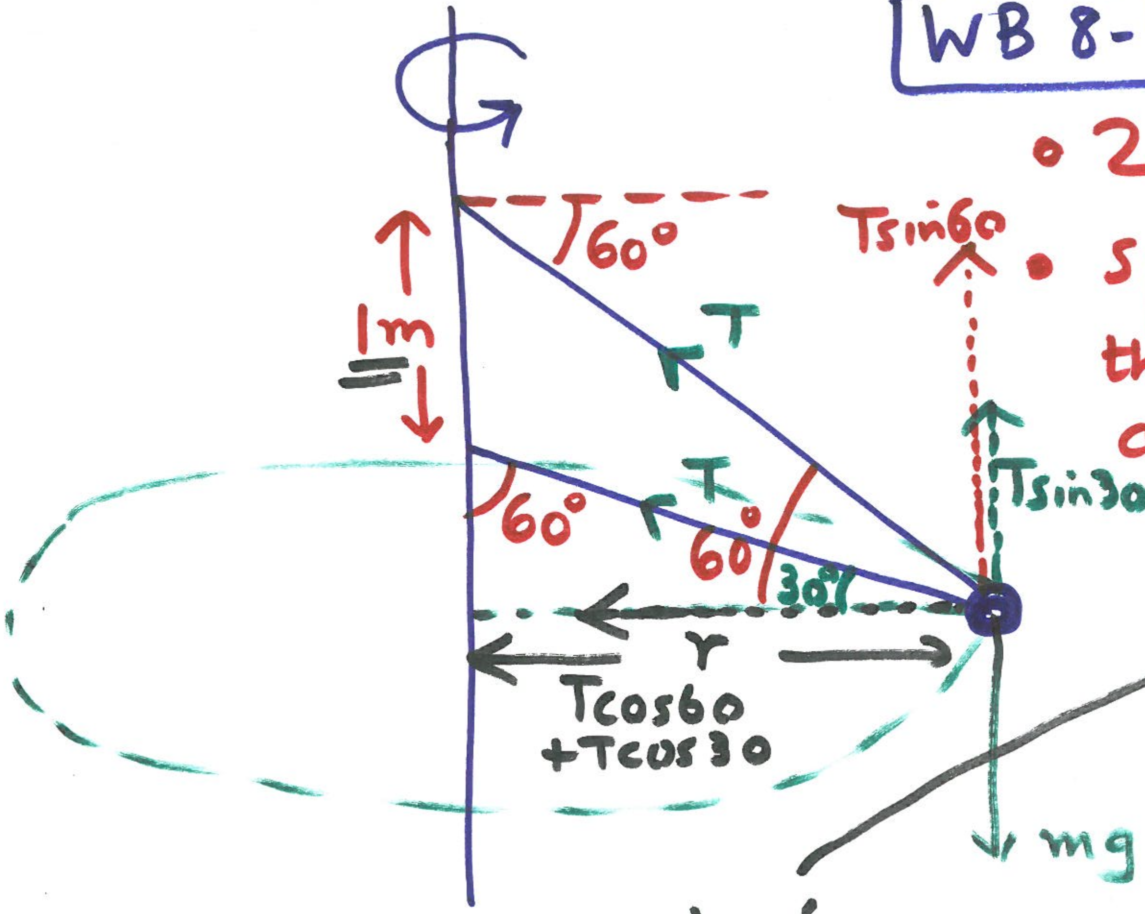
$(f_s)_{max} = mg$ BARELY SAFE!

$\mu_s n = mg$

$$\mu_s \frac{\cancel{m}v^2}{r} = \cancel{m}g \Rightarrow \frac{\mu_s v^2}{r} = g \Rightarrow v_{min} = \sqrt{\frac{gr}{\mu_s}}$$

max μ!

WB 8-4



- 2 kg sphere
- Speed of rotation is such that tensions in two wires are equal

FIND TENSION

$(F_{net})_r = ma_r$

$(F_{net})_z = ma_z = 0$

$T\sin 60 + T\sin 30 - mg = 0$

$$T = \frac{2(9.8)}{\sin 60 + \sin 30} = 14.3\text{N} ✓$$

FIND SPEED 'v'

$T\cos 60 + T\cos 30 = ma_r$

$= \frac{mv^2}{r}$ → SOLVE FOR 'v'.

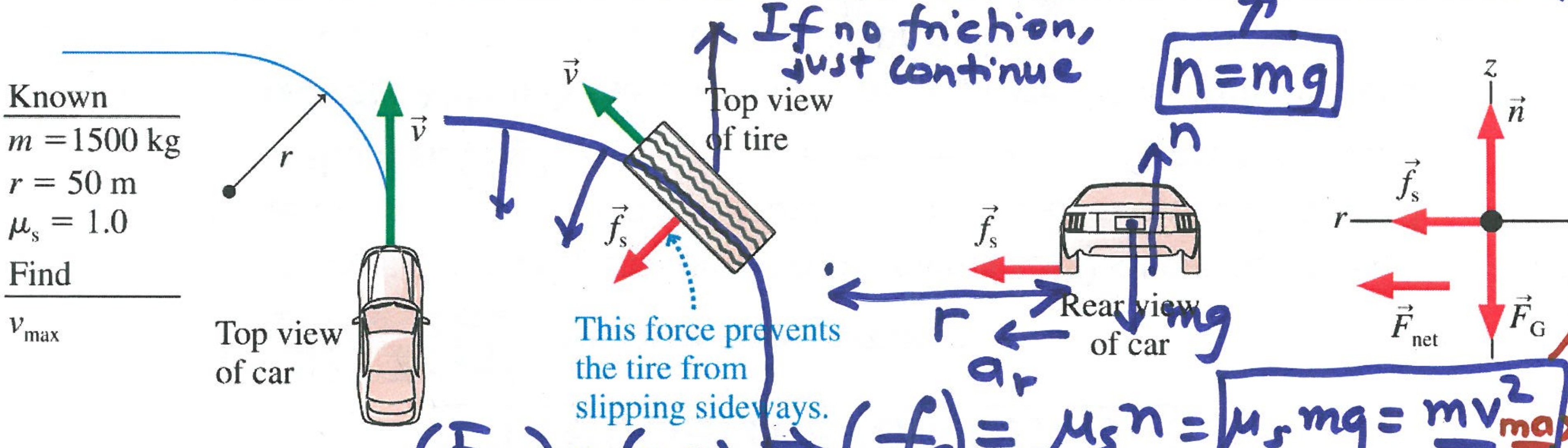
WB 8.5 Making a turn on a flat road

$\mu_s mg = \frac{mv_{max}^2}{r} \Rightarrow v_{max} = \sqrt{\mu_s g r}$

VISUALIZE

- The second figure below shows the top view of a tire as it turns a corner.
- The force that prevents the tire from sliding across a surface is *static friction*.
- Static friction pushes sideways on the tire, perpendicular to the velocity, since the car is not speeding up or slowing down.
- The free-body diagram, drawn from behind the car, shows the static friction pointing toward the center of the circle.

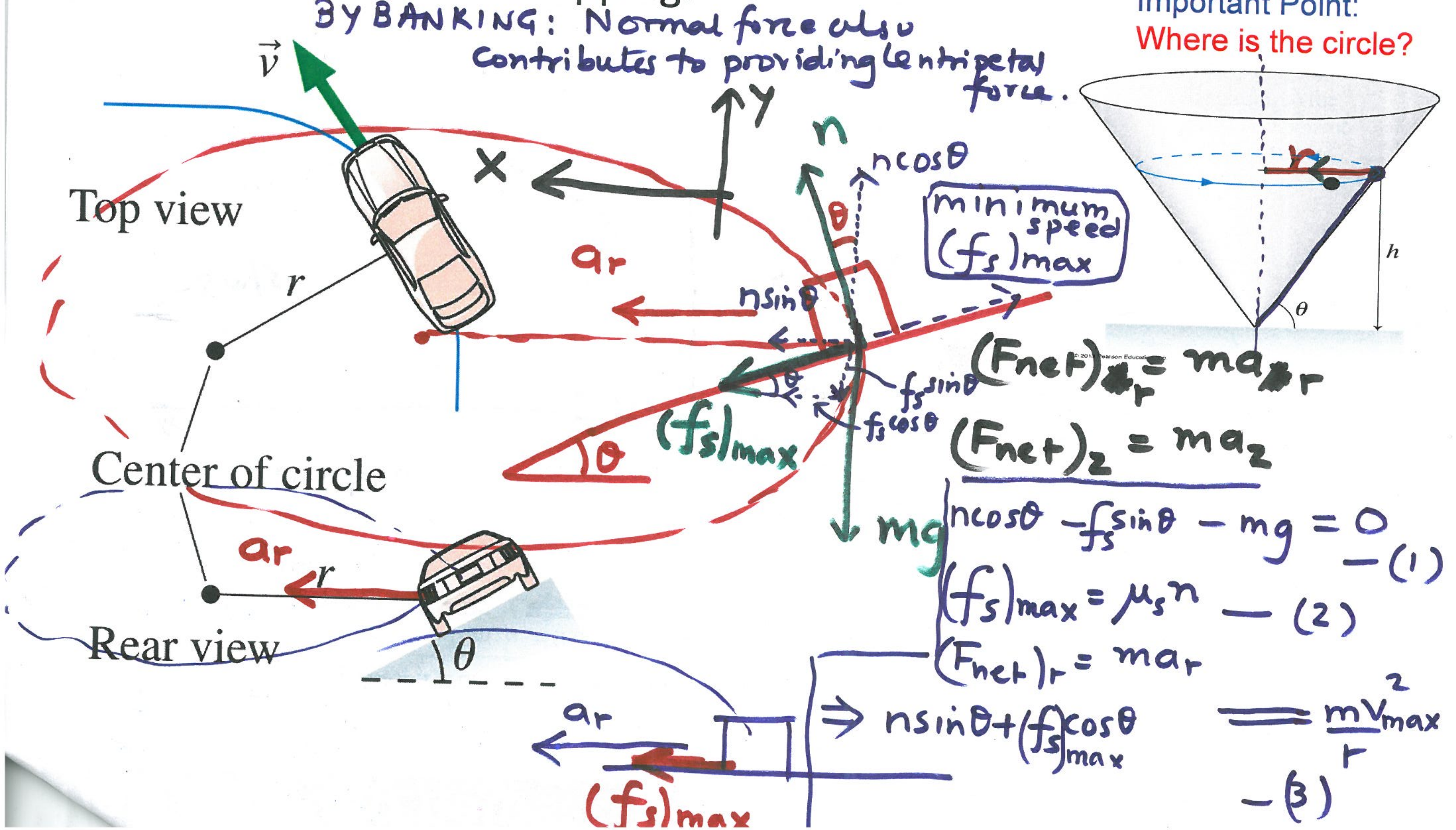
LEVEL ROAD!



$(F_{net})_r = (ma)_r \Rightarrow (f_s)_{max} = \mu_s n = \mu_s mg = \frac{mv_{max}^2}{r}$

Whiteboard Problem 8.5 6: Banked highways

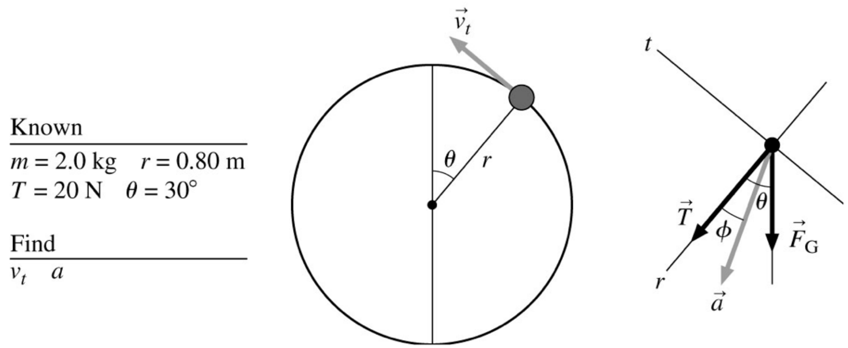
Draw the f. b. d. for a car rounding the curve at the ~~maximum~~ minimum possible speed without slipping.



8.63

8.56. Model: Assume the particle model for a ball in vertical circular motion.
Visualize:

Pictorial representation



Solve: (a) Newton's second law in the r- and t-directions is

$$(F_{net})_r = T + mg\cos\theta = ma_r = \frac{mv_t^2}{r} \quad (F_{net})_t = -mg\sin\theta = ma_t$$

Substituting into the r-component,

$$(20 \text{ N}) + (2.0 \text{ kg})(9.8 \text{ m/s}^2)\cos 30° = (2.0 \text{ kg})\frac{v_t^2}{(0.80 \text{ m})} \Rightarrow v_t = 3.85 \text{ m/s}$$

The tangential velocity is 3.8 m/s.
(b) Substituting into the t-component,

$$-(9.8 \text{ m/s}^2)\sin 30° = a_t \Rightarrow a_t = -4.9 \text{ m/s}^2$$

The radial acceleration is

$$a_r = \frac{v_t^2}{r} = \frac{(3.85 \text{ m/s})^2}{0.80 \text{ m}} = 18.5 \text{ m/s}^2$$

Thus, the magnitude of the acceleration is

$$a = \sqrt{a_r^2 + a_t^2} = \sqrt{(18.5 \text{ m/s}^2)^2 + (-4.9 \text{ m/s}^2)^2} = 19.1 \text{ m/s}^2 \approx 19 \text{ m/s}^2$$

The angle of the acceleration vector from the r-axis is

$$o = \tan^{2\,1}\frac{|a_t|}{a_r} = \tan^{2\,1}\frac{4.9}{18.5} = 14.8° \approx 15°$$

The angle is below the r-axis.