Read 5.7–5.9

Pre-Dental club meeting
Thursday 6:30 p.m Dale 103

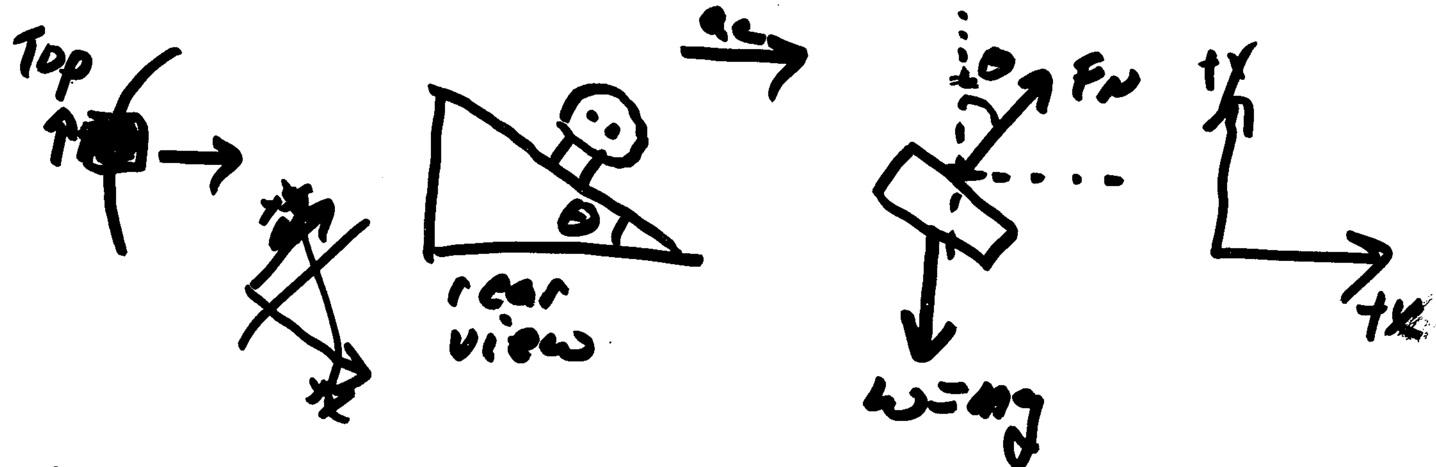
Earlier we solved problem with a car turning on a road with radius 50.0 m

(max speed 21 m/s)

Can we make sharper corner?

Bank road

ex) A car is going around a frictionless banked curve. If the car is traveling at 15 m/s and the radius is 50 m, what angle must the road be banked so car can safely drive without sliding?



$F_{Ny} = F_N \cos\theta$

$F_{Nx} = F_N \sin\theta$

$\Sigma F_y = 0$

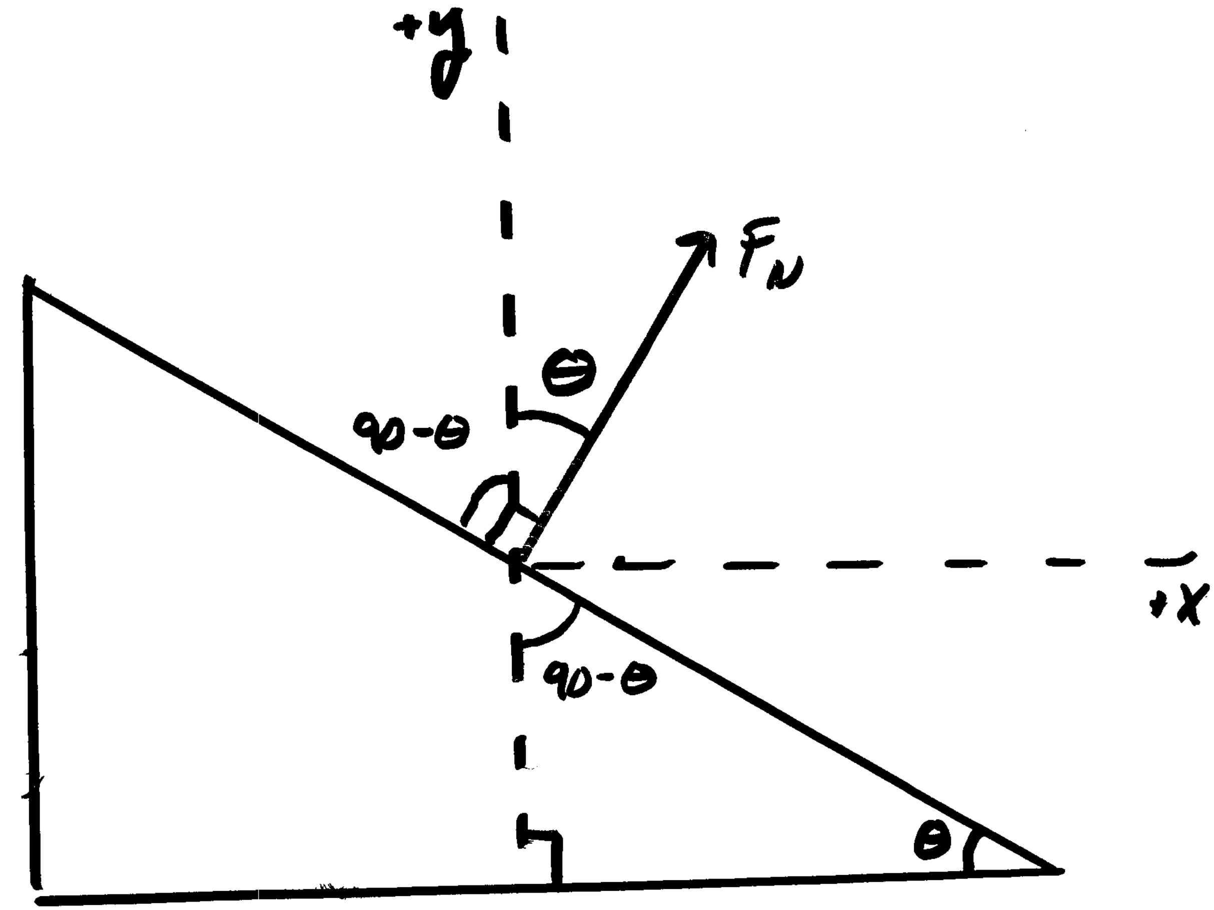
$\Sigma F_x = m a_c$

$y: \; F_N \cos\theta - mg = 0 \Rightarrow F_N = \dfrac{mg}{\cos\theta}$

$x: \; F_N \sin\theta = m a_c = \dfrac{mv^2}{r}$

$$\frac{mg}{\cos\theta} \cdot \sin\theta = \frac{mv^2}{r} \Rightarrow \tan\theta = \frac{v^2}{rg}$$

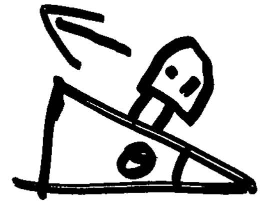
$$\tan\theta = \frac{(15\,m/s)^2}{(50\,m)(9.8\,m/s^2)} = \boxed{25^\circ}$$

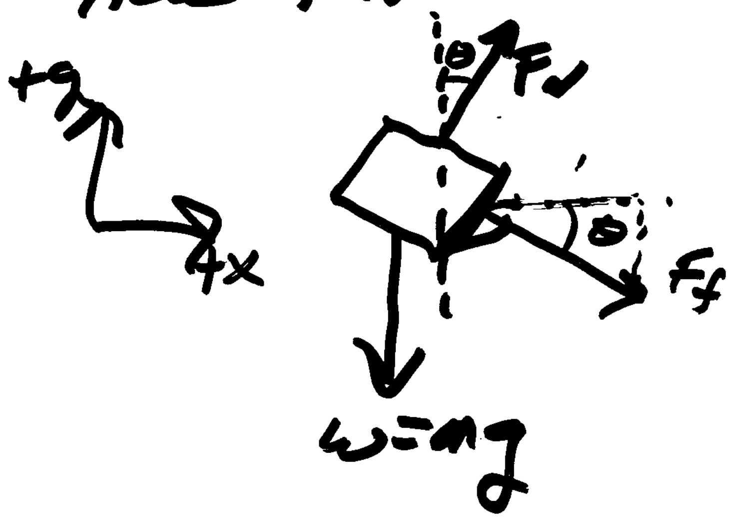

+y
F_N
θ
$90-\theta$
+x
$90-\theta$
θ

Now add friction

$\mu_s = 0.9 \qquad \theta = 15^\circ$

How fast can I drive





$F_{Nx} = F_N \sin\theta$

$F_{Ny} = F_N \cos\theta$

$F_{fx} = F_f \cos\theta$

$F_{fy} = F_f \sin\theta$

y: $\Sigma F_y = 0$

$$F_N\cos\theta - \underbrace{F_f}_{(\mu_s F_N)}\sin\theta - mg = 0 \quad (1)$$

x: $\Sigma F_x = ma_c$

$$F_N\sin\theta + \underbrace{F_f}_{(\mu_s F_N)}\cos\theta = \frac{mv^2}{r} \quad (2)$$

(1) $F_N(\cos\theta - \mu_s\sin\theta) = mg$

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

(1) $$F_N = \frac{mg}{\cos\theta - \mu_s \sin\theta}$$

Put into (2)

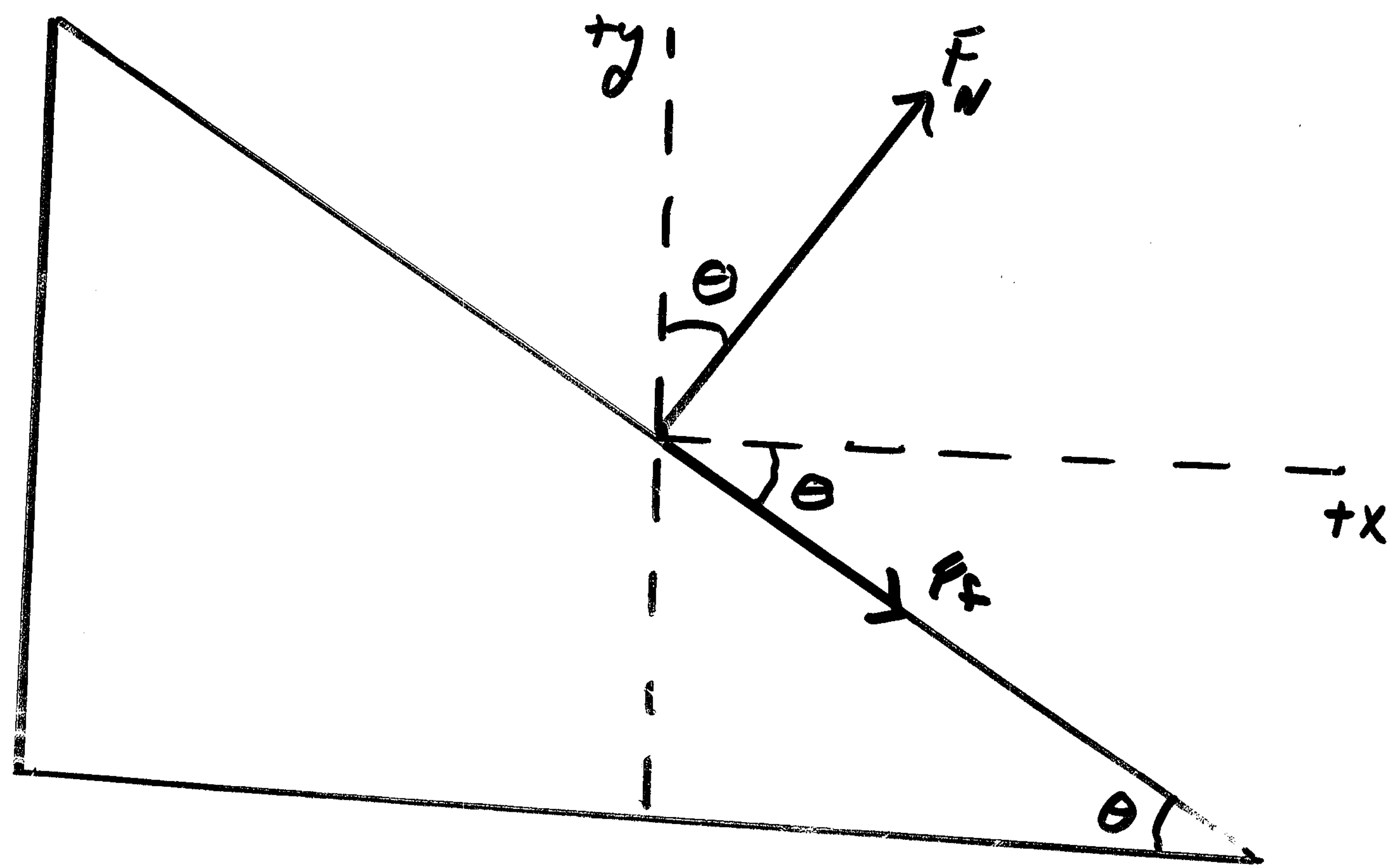
$$\left(\frac{\cancel{m}g}{\cos\theta - \mu_s \sin\theta}\right)\left(\sin\theta + \mu_s \cos\theta\right) = \frac{\cancel{m}v^2}{r}$$

$$v^2 = gr\,\frac{[\sin\theta + \mu_s \cos\theta]}{(\cos\theta - \mu_s \sin\theta)}$$

$$v^2 = (9.8\,m/s^2)(50\,m)\,\frac{[\sin 15^\circ + (0.9)\cos 15^\circ]}{[\cos 15^\circ - (0.9)(\sin 15^\circ)]}$$

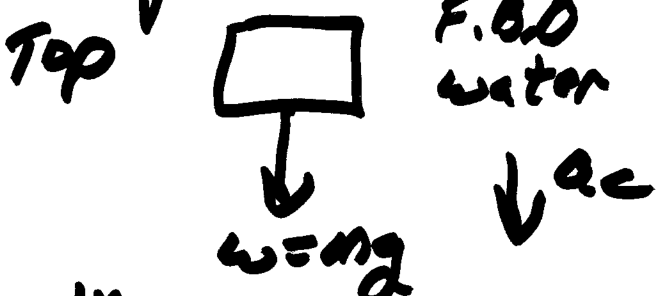
$$v^2 = 756\,m^2/s^2$$

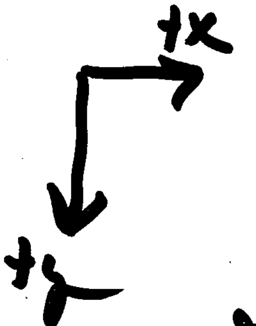
$$\boxed{v = 27\,m/s}$$


+y
$\bar{F}_N$
θ
θ
+x
F_f
θ

what is minimum speed you can spin a can filled with water attached to a 1.0 m long string in a vertical direction without water falling out?

$F_N = 0$ when water just starts to fall out





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

$$\to v = \sqrt{(9.8\,m/s^2)(1\,m)} = 3.13\,m/s$$

$$1\ \text{revolution} = 2\pi r = 6.28\,m$$

$$v = \left(\frac{3.13\,m}{s}\right)\left(\frac{1\,rev}{6.28\,m}\right) = .5\,rev/s$$

or

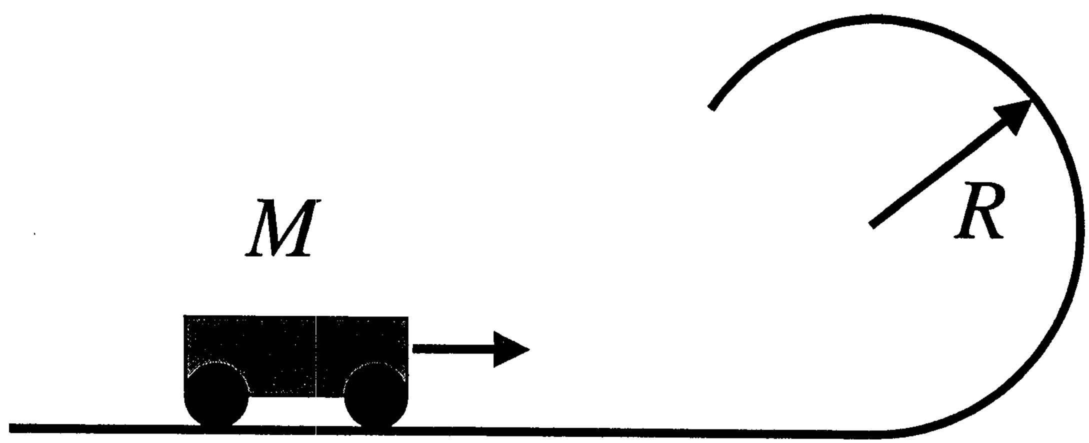
<u>1 revolution in 2 seconds</u>

A car approaches a curve with a radius of 50 m and a banking angle of 25°. If the car is traveling at 15 m/s, the car negotiates the curve. The car is *not* traveling 15 m/s. If there is no friction between the tires and the car, what will happen to the car?

A) It will negotiate the curve just fine
B) It will slide down the bank
C) It will slide up the bank
D) There is not enough information to answer

Interactive Question

A cart of mass M travels along a straight horizontal track. As suggested in the figure, the track then bends into a vertical circle of radius R. Which expression determines the minimum speed that the car must have at the top of the track if it is to remain in contact with the track?



A) $v = MgR$

B) $v^2 = 2gR$

C) $v = gR$

D) $v = 2gR$

E) $v^2 = gR$

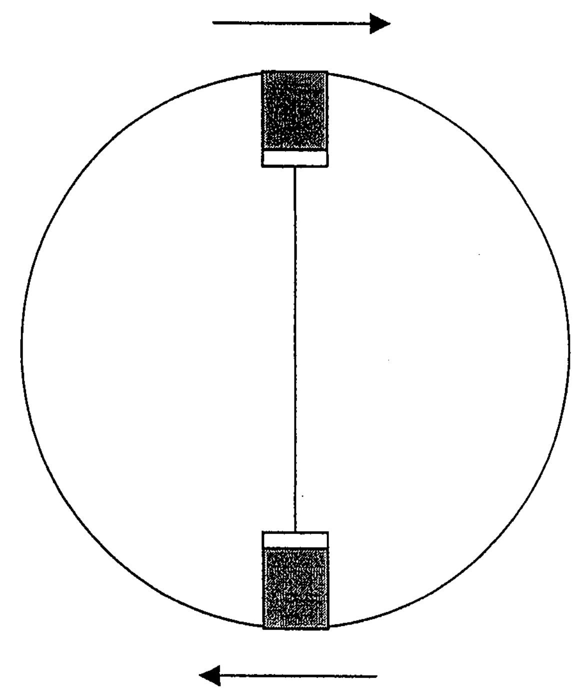
Interactive Question

A can containing water is spun in a vertical circle. The normal force of the can on the water is ______________ at the top than at the bottom.

A) Larger

B) Smaller

C) Same

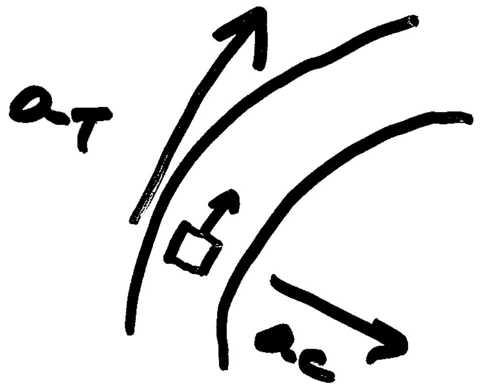


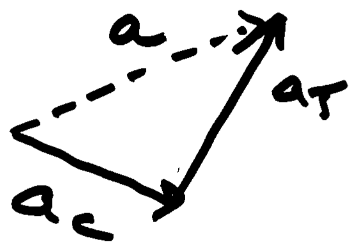
SO FAR we have only looked at
uniform circular motion.
motion in a circle with constant
speed.

NOW look at NON-uniform
circular motion
motion in a circle with varying
speed

For example
Car accelerating by pushing on
gas pedal while going around
a corner

a_T Tangential acceleration





Total acceleration

$$\vec{a} = \vec{a}_c + \vec{a}_T$$

magnitude of a

$$a^2 = a_c^2 + a_T^2$$

$$|a| = \sqrt{a_c^2 + a_T^2}$$