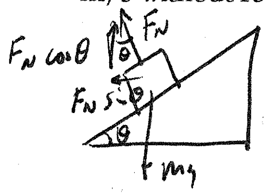
AP Physics

Banked Curves
Practice A

Name: KEY

1. (Cutnell 5.20) At what angle should a curve of radius 150 m be banked, so cars can travel safely at 25 m/s without relying on friction?

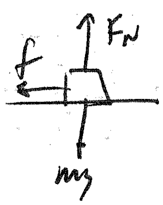


$F_N \sin\theta = mv^2/r$ $\quad$ $F_N \cos\theta = mg$

$\dfrac{\cancel{F_N} \sin\theta}{\cancel{F_N}\cos\theta} = \dfrac{\cancel{m}v^2/r}{\cancel{m}g} \Rightarrow \tan\theta = v^2/rg \rightarrow \boxed{\theta = 22.6^\circ}$

2. (Cutnell 5.22) A car can negotiate an unbanked curve safely at a certain maximum speed when the coefficient of static friction between the tires and the ground is 0.88. At what angle should the same curve be banked for the car to negotiate the curve safely at the same maximum speed without relying on friction?

Use 1st part (unbanked curve) to get v^2/r



$f = \mu F_N = mv^2/r$

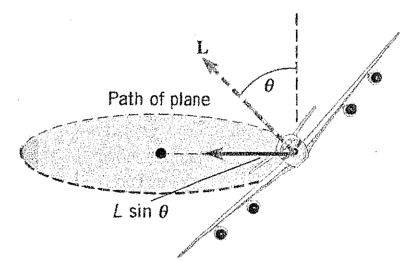
$\mu \cancel{m} g = \cancel{m} v^2/r$ $\leftarrow$ then $\rightarrow$

~~unban~~ no frict.:

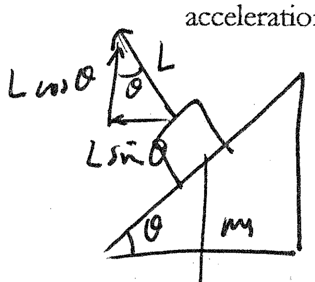
$\tan\theta = v^2/rg = \dfrac{\mu \cancel{g}}{\cancel{g}}$

$\boxed{\theta = 41.3^\circ}$

3. (Cutnell 5.24) There is a similarity between a plane banking into a turn and a car going around a banked curve. The lifting force **L** in the figure to the right plays the same role as the normal force $\mathbf{F_N}$ in the second set of figures to the right.

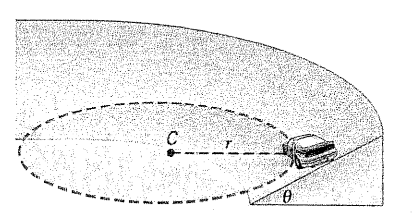


   a. Derive an expression that relates the banking angle to the speed of the plane, the radius of the turn, and the acceleration due to gravity.



$\rightarrow \boxed{\tan\theta = v^2/rg}$

see #1 above and class notes

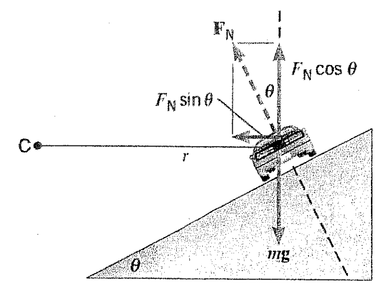


(a)

   b. At what angle with respect to the horizontal should a plane be banked when traveling at 195 m/s around a turn whose radius is 8250 m?

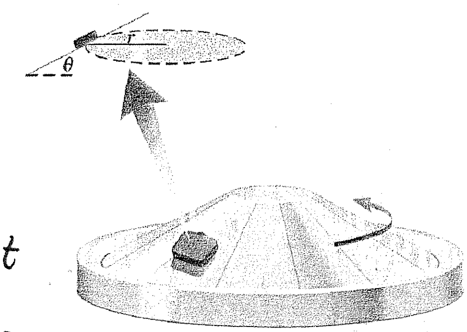
$\theta = \tan^{-1}\left(\dfrac{195^2}{(8250)(10)}\right)$

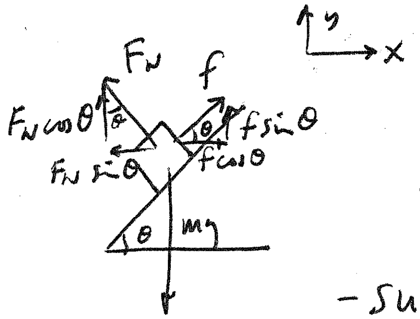
$\boxed{\theta = 24.7^\circ}$



(b)

4. (Cutnell 5.26) The drawing shows a baggage carousel at an airport. Your suitcase has not slid all the way down the slope and is going around at a constant speed on a circle of radius $r = 11.0$ m. The coefficient of static friction between the suitcase and the carousel is 0.76 and the angle θ in the drawing is 36°. How much time is required for your suitcase to go around once? → need v to get t





$\Sigma F_y = ma_y^{\,0} = F_N\cos\theta + f\sin\theta - mg$ ①

$\Sigma F_x = ma_x : f\cos\theta - F_N\sin\theta$

$mv^2/R = f\cos\theta - F_N\sin\theta$ ② $f = \mu F_N$ ③

- substitute ③ into ① and ②

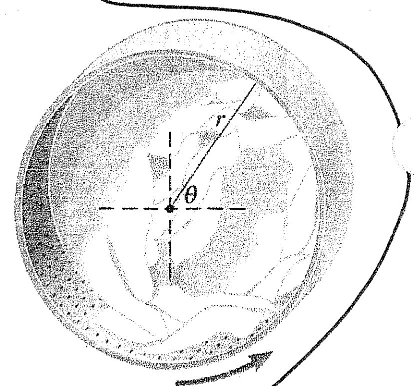
$F_N\cos\theta + \mu F_N\sin\theta = mg$ $\mu F_N\cos\theta - F_N\sin\theta = mv^2/R$

$F_N(\cos\theta + \mu\sin\theta) = mg$ $F_N(\mu\cos\theta - \sin\theta) = mv^2/R$

$\dfrac{\cancel{F_N}(\mu\cos\theta - \sin\theta)}{\cancel{F_N}(\cos\theta + \mu\sin\theta)} = \dfrac{\cancel{m}v^2}{R\cancel{m}g}$ $v = \sqrt{\dfrac{Rg(\mu\cos\theta - \sin\theta)}{(\cos\theta + \mu\sin\theta)}}$

BONUS:

(Cutnell 5.42) In an automatic clothes dryer, a hollow cylinder moves the clothes on a vertical circle of radius $r = 0.32$ m, as shown in the diagram. The appliance is designed so that the clothes tumble gently as they dry. This means that when a piece of clothing reaches an angle of θ above the horizontal, it loses contact with the wall of the cylinder and falls onto the clothes below. How many revolutions per second should the cylinder make in order that the clothes lose contact with the wall when $\theta = 70°$?



$v = \sqrt{\dfrac{(11)(10)(0.76\cos 36° - \sin 36°)}{(\cos 36° + 0.76\sin 36°)}}$

$v = 1.54$ m/s

$T = \dfrac{2\pi R}{v} = \dfrac{2\pi(11)}{1.54} = 44.9$ sec