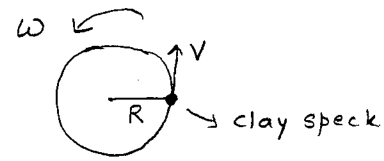
PHYS 2414 - HW 5 Solutions

1. Giancoli6 5.P.006. [352917] **0/1 points** Show Details

What is the magnitude of the acceleration of a speck of clay on the edge of a potter's wheel turning at $\boxed{44}$ rpm (revolutions per minute) if the wheel's diameter is $\boxed{30}$ cm?

[ ] ✖ $\boxed{3.18}$ m/s^2

Sol 1. Acceleration of speck of clay



$$a_R = \frac{V^2}{R} = \frac{(\omega R)^2}{R} = \omega^2 R$$

Given, frequency of Potter's wheel

$$f = \frac{\boxed{44}\ \text{revolution}}{\text{min}} \cdot \frac{1\ \text{min}}{60\ \text{sec}}$$

ω = Angular velocity

V = Linear velocity.

$V = \omega R$

$$f = \frac{\boxed{44}}{60}\ \frac{\text{rev}}{\text{sec}}$$

$$\omega = 2\pi f = 2(3.14)\left(\frac{\boxed{44}}{60}\right)\frac{\text{rad}}{\text{sec}} = \boxed{4.608}\ \frac{\text{rad}}{\text{sec}}$$

$$a_R = \left(\boxed{4.608}\ \frac{\text{rad}}{\text{sec}}\right)^2 \left(\frac{0.30}{2}\ m\right) = \boxed{3.18}\ m/s^2$$

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2. Giancoli6 5.P.009. [354137] **0/2 points** Show Details

What is the maximum speed with which a $\boxed{1150}$ kg car can round a turn of radius $\boxed{75}$ m on a flat road if the coefficient of static friction between tires and road is 0.80?

[ ] ✖ $\boxed{24.2}$ m/s

Is this result independent of the mass of the car?

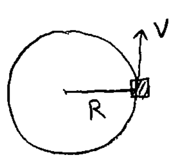
- (o) yes
- ( ) no

✖

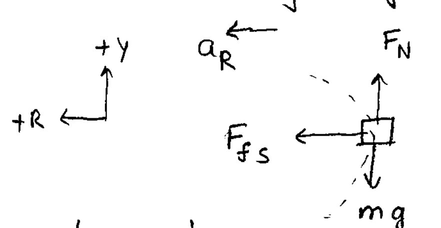
Given: $R = 75$ m (Radius)

$m = 1150$ kg (Mass)

Sol 2: Motion diagram of car



Free body diagram (horizontal view)



a_c = centripetal acceleration.

$$a_R = \frac{V^2}{R}$$

F_{fs} → Force due to static friction trying to stop it from skidding on the curve.

Radial direction $\Sigma F_R = m a_R \Rightarrow F_{fs} = \frac{m V^2}{R} \Rightarrow \mu_s F_N = \frac{m V^2}{R}$ —(1)

transverse direction $\Sigma F_y = m a_y \Rightarrow F_N - mg = 0 \Rightarrow F_N = mg$ —(2)

(2) contd...

2 Contd...

Using eq 2 in 1.

$$\mu_s \cancel{m} g = \cancel{m}\frac{v^2}{R} \Rightarrow v^2 = \mu_s g R \Rightarrow v = \sqrt{\mu_s g R}$$ ← independent of mass

$$v = \sqrt{(0.80)(9.8\ \tfrac{m}{s^2})(\boxed{75}\ m)} = \boxed{24.25}\ m/s^2 = \boxed{24.2}\ m/s^2$$ ✓

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3. Giancoli6 5.P.012. [352962] **0/1 points** Show Details

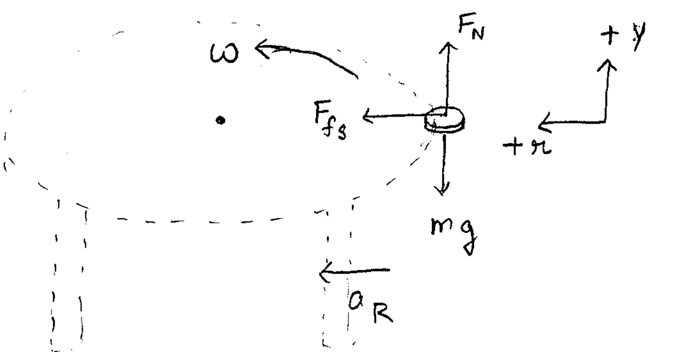
A coin is placed 13.0 cm from the axis of a rotating turntable of variable speed. When the speed of the turntable is slowly increased, the coin remains fixed on the turntable until a rate of 39 rpm is reached, at which point the coin slides off. What is the coefficient of static friction between the coin and the turntable?

Given: $f = 39\ \frac{rev}{min} \left| \frac{1\ min}{60\ sec} \right| = \frac{39}{60}\ \frac{rev}{sec}$

$R = 13\ cm = 0.13\ m$

~~0.221~~

Sol 3: Free body diagram for the coin. (horizontal view)



F_N = Normal force due to (contact) table.

mg = Weight (force) due to gravity.

F_{fs} = static friction force trying to stop coin from sliding off.

a_R = centripetal acceleration experienced by coin. (in circular motion)

ω = angular velocity. $= 2\pi f$ ↑ frequency

Transverse direction (y-dir): $\Sigma F_y = ma_y \Rightarrow F_N - mg = 0$

$\Rightarrow F_N = mg$.

Frictional force $F_{fs} = \mu_s F_N = \mu_s m g$

Radial direction: (Pointing towards center)

$$\Sigma F_R = ma_R \Rightarrow F_{fs} = ma_R = \frac{mv^2}{R}$$

$$\mu_s \cancel{m} g = \cancel{m}\frac{v^2}{R}$$

$$\mu_s = \frac{v^2}{gR} = \frac{\omega^2 R^{\cancel{2}}}{g\cancel{R}} = \frac{(2\pi f)^2 R}{g} = \frac{(2\pi\ rad)^2\left(\frac{\boxed{39}}{60}\ \frac{rev}{sec}\right)^2(\boxed{0.13}\ m)}{9.8\ m/s^2}$$

$$\mu_s = \boxed{0.221}$$ ✓

4. Giancoli6 5.P.022. [354143] **0/3 points** Show Details

A $\boxed{2000}$ kg car rounds a curve of radius 70 m banked at an angle of 12°. If the car is traveling at $\boxed{90}$ km/h, will a friction force be required?

If so, how much force? (Enter zero if there is no friction force.)

✗ $\boxed{13400}$ N

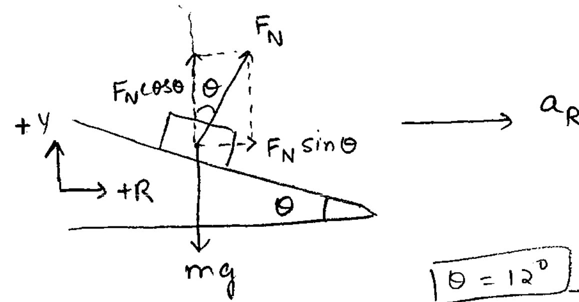
In what direction?

- ( ) up the slope
- (o) down the slope
- ( ) force is zero

Given : $V = \boxed{90}\frac{km}{h}\left|\frac{1000\,m}{1\,km}\right|\frac{1\,h}{60\,min}\left|\frac{1\,min}{60\,sec}\right|$

$V = \frac{\boxed{90000}}{3600}\frac{m}{s} = \boxed{25}\,m/s$

Sol 4: To check if friction force is required in this case we draw free body diagram for car (without friction)



F_N = Normal force due to ground on car (Contact force)

mg = weight due to gravity.

a_R = centripetal acceleration pointing towards center.

$\boxed{\theta = 12^0}$
$\boxed{m = 2000\,kg}$
$\boxed{R = 70\ m}$

$a_R = \frac{v^2}{R}$

In radial direction : $\Sigma F_R = m a_R$

$\Rightarrow F_N \sin\theta = m\frac{v^2}{R}$ (if no other force in horizontal / radial dir is present.

L.H.S = $F_N \sin\theta = mg\sin\theta = (\boxed{2000}\,kg)(9.8\ m/s^2)\sin 12^0 = \boxed{4075.1}$ N

R.H.S = $m\frac{v^2}{R} = \frac{(\boxed{2000}\,kg)\,(\boxed{25}\ m/s)^2}{70\ m} = \boxed{17857.1}$ N

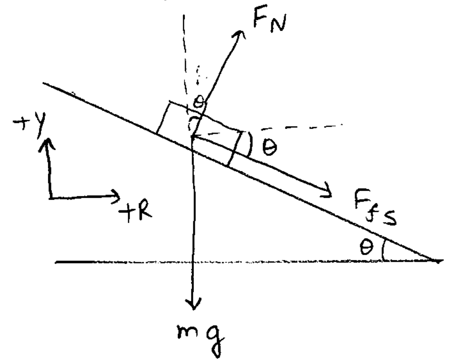
Thus, LHS ≠ RHS.

This implies we need a frictional force to keep this car going in circular arc at this speed. Also ∵ LHS is less than R.H.S, this means Normal force is not enough to cause necessary centripetal acceleration (force). Therefore, the static frictional force has to act down the slope to give an additive component to the inward (toward center) direction.

prob (4) contd...

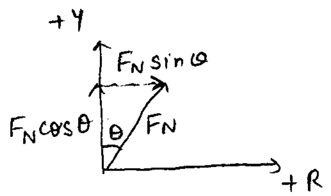
Prob(4) contd..

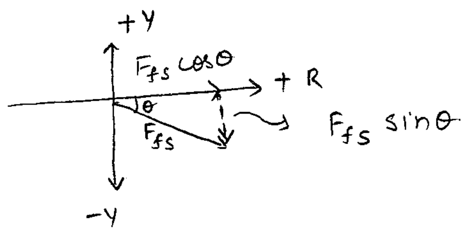
Free body diagram with the static frictional force.



F_{fs} = static frictional force trying to stop car from skidding off.

Resolve F_N and F_{fs} in $+y$ and $+R$ directions.





$\Sigma F_y = ma_y$

$F_N \cos\theta - F_{fs}\sin\theta - mg = 0$

$\Rightarrow F_{fs}\sin\theta = F_N\cos\theta - mg \quad -(1)$

$\Sigma F_R = ma_R$

$F_N \sin\theta + F_{fs}\cos\theta = ma_R$

$\Rightarrow F_{fs}\cos\theta = ma_R - F_N\sin\theta \quad -(2)$

Multiply (1) by $\sin\theta$ and (2) by $\cos\theta$ and add two equations.

$$F_{fs}\sin^2\theta = \cancel{F_N\cos\theta\sin\theta} - mg\sin\theta$$

$$F_{fs}\cos^2\theta = -\cancel{F_N\sin\theta\cos\theta} + ma_R\cos\theta$$

$$F_{fs}\underbrace{(\sin^2\theta + \cos^2\theta)}_{1} = ma_R\cos\theta - mg\sin\theta$$

$$F_{fs} = m\left[\frac{v^2}{R}\cos\theta - g\sin\theta\right]$$

$$F_{fs} = (\boxed{2000}\ \text{kg})\left[\frac{(\boxed{25}\ \frac{m}{s})^2}{70\ m}\cos 12^\circ - (9.8\ m/s^2)\sin 12^\circ\right] = \boxed{13391.9}\ N$$

$F_{fs} = \boxed{13400}$ N down the slope.

5. Giancoli6 5.P.026. [352908] **0/3 points** Show Details

A car at the Indianapolis-500 accelerates uniformly from the pit area, going from rest to $\boxed{310}$ km/h in a semicircular arc with a radius of $\boxed{198}$ m.

Determine the tangential acceleration of the car when it is halfway through the turn, assuming constant tangential acceleration.

✗ ~~5.96~~ m/s^2

Determine the radial acceleration of the car at this time.

✗ ~~18.7~~ m/s^2

If the curve were flat, what would the coefficient of static friction have to be between the tires and the roadbed to provide this acceleration with no slipping or skidding?

✗ ~~2.01~~

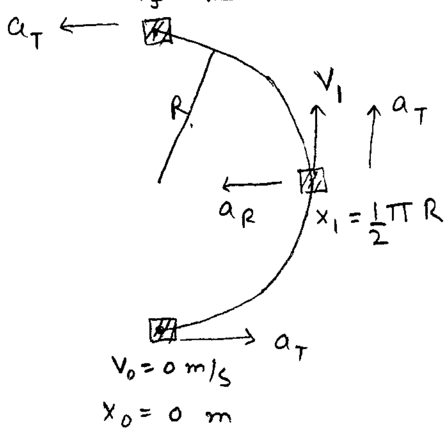
Sol 5: Given, initial velocity $V_0 = 0$ m/s

final velocity $V_f = \boxed{310} \frac{km}{h} \left| \frac{1000\ m}{1\ km} \right| \frac{1\ h}{3600\ sec} \Big|$

$V_f = \boxed{86.11}$ m/s

$x_f = \pi R$ (length of semicircular arc of radius R)

$V_f = \boxed{86.11}$ m/s



Since, car is accelerating uniformly tangential acceleration halfway throught is same as at the end of arc.

$$\Rightarrow \quad V_f^2 = \cancel{V_0^2} + 2a_T(x_f - \cancel{x_0})$$

$$V_f^2 = 2a_T \pi R$$

$$\text{or} \quad a_T = \frac{V_f^2}{2\pi R} = \frac{(\boxed{86.11}\ m/s)^2}{2\pi\ \boxed{198}\ m} = \boxed{5.96}\ m/s^2 \ ✓$$

If car accelerates with a_T uniformly then it's velocity halfway through the turn will be.

$$V_1^2 = \cancel{V_0^2} + 2a_T(x_1 - \cancel{x_0}) = 2(\boxed{5.96}\ m/s^2)(\tfrac{1}{2}\pi\ \boxed{198}\ m) = \boxed{3707.56}\ m^2/s^2$$

$$V_1 = \boxed{60.89}\ m/s$$

Therefore, centripetal acceleration at this point is

$$a_R = \frac{V_1^2}{R} = \frac{(\boxed{60.89}\ m/s)^2}{\boxed{198}\ m} = \boxed{18.73}\ m/s^2 = \boxed{18.7}\ m/s^2 \ ✓$$

5 Contd...

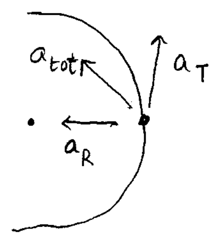
5 Contd ...

Total acceleration experience by car halfway through the semi-circular arc is

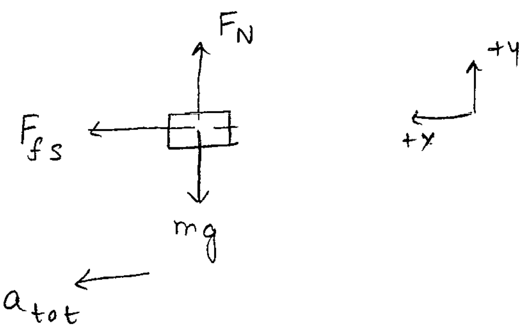
$$a_{tot} = \sqrt{a_T^2 + a_R^2} = \sqrt{\left(\boxed{5.96}\, m/s^2\right)^2 + \left(\boxed{18.73}\, m/s^2\right)^2}$$

$$a_{tot} = \boxed{19.66}\ m/s^2$$

Top view (accelerations)



Free body diagram (horizontal view)



Total Frictional force due to ground on the tyres will be pointing in the direction of total acceleration. (It is the only force to cause a_{tot}).

y-dir $\quad \Sigma F_y = m a_y \Rightarrow F_N - mg = 0$

or $\quad F_N = mg$

Static frictional force $\quad F_{fs} = \mu_s F_N = \mu_s mg$

x-dir $\quad \Sigma F_x = m a_x \Rightarrow F_{fs} = m a_{tot}$

$$\Rightarrow \mu_s \cancel{m} g = \cancel{m}\, a_{tot}$$

$$\mu_s = \frac{a_{tot}}{g} = \frac{\boxed{19.66}\ \cancel{m/s^2}}{9.8\ \cancel{m/s^2}} = \boxed{2.006} = \boxed{2.01}$$

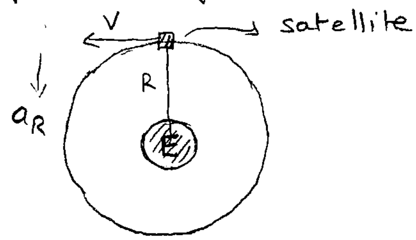
6. Giancoli6 5.P.035. [352946] **0/1 points** Show Details

What is the distance from the Earth's center to a point outside the Earth where the gravitational acceleration due to the Earth is 1/28 of its value at the Earth's surface?

✗ ~~3.39e+07~~ m

Sol 6: Gravitational acceleration on earth's surface is 'g'

Centripetal force is given by the gravitational force between satellite and the Earth.



Let 'R' be the distance at which satellite experiences an acceleration of $\frac{1}{28} g = a_c$

$$\Rightarrow \frac{G m_E \cancel{m_s}}{R^2} = \cancel{m_s}\, a_R$$

$$R^2 = \frac{G m_E}{a_R} = \frac{(6.67 \times 10^{-11}\ N\ m^2/kg^2)(5.98 \times 10^{24}\ kg)}{\frac{1}{\boxed{28}}\ 9.8\ m/s^2}$$

$$R^2 = \boxed{1.13962 \times 10^{15}}\ m^2$$

$$R = \boxed{3.38 \times 10^{7}}\ m$$

7. Giancoli6 5.P.045. [354134] **0/1 points** Show Details

At what rate must the cylindrical spaceship of Fig. 5-32 rotate if occupants are to experience simulated gravity of 0.50g? Assume the spaceship's diameter is 42 m, and give your answer as the time needed for one revolution.

✗ ~~13~~ s

Sol: 7 Occupants of space ship experience a simulated gravity, which is the net centripetal acceleration

Now, $a_R = \frac{V^2}{R}$

$\because V = \omega R$

$$a_R = \frac{\omega^2 R^{\cancel{2}}}{\cancel{R}} = \omega^2 R$$

contd ...

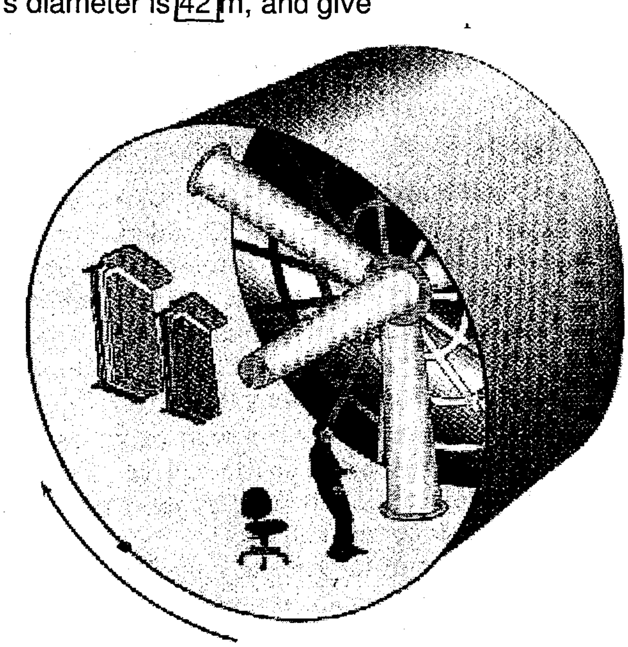


Figure 5-32

7 contd....

where ω = angular velocity.

If 'T' is the time period required for one revolution then

$$\omega = \frac{2\pi}{T}$$

$$\Rightarrow a_R = \left(\frac{2\pi}{T}\right)^2 R = \frac{4\pi^2 R}{T^2}$$

Given $a_c = \boxed{0.5} g$

$R = \frac{\text{diameter}}{2} = \frac{\boxed{42} m}{2}$

$= \boxed{21} m$

$$\Rightarrow T^2 = \frac{4\pi^2 R}{a_R} = \frac{4\pi^2 \boxed{21} \cancel{m}}{(\boxed{0.5})\, 9.8\ \cancel{m}/s^2}$$

$$T^2 = \boxed{169.19}\ s^2 \quad \Rightarrow \quad T = \boxed{13.01}\ sec$$

$$T = \boxed{13}\ s$$

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8. Giancoli6 5.P.053. [772817] **0/5 points** Show Details

What will a spring scale read for the weight of a 54 kg woman in an elevator that moves as follows?

(a) upward with constant speed of 5.0 m/s

✗ 530 N

(b) downward with constant speed of 5.0 m/s

✗ 530 N

(c) upward with acceleration of 0.38 g

✗ 731 N

(d) downward with acceleration 0.38 g

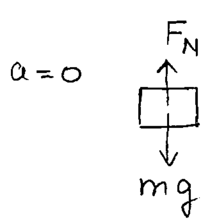
✗ 328 N

(e) in free fall

✗ 0 N

Sol 8: If elevator is moving with constant speed then there is no net acceleration acting on it.

Free body diagram for part (a) and (b)



(a), (b) $\Sigma F_y = m a_y \Rightarrow F_N = mg$

$$F_N = (\boxed{54}\ kg)(9.8\ m/s^2) = \boxed{529.2}\ N$$

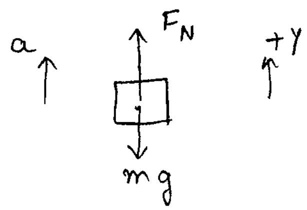
$$F_N = \boxed{530}\ N$$

Note: spring scale reads normal force

Prob 8 contd..

(8) Contd ...

(c) Free body diagram for woman.



Given $a = \boxed{0.38}\, g$

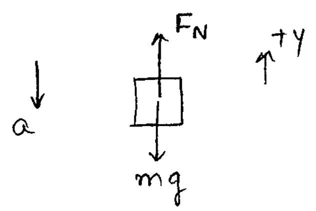
$\Sigma F_y = m a_y \Rightarrow F_N - mg = ma$

$F_N = ma + mg = m(a + g)$

$F_N = (\boxed{54}\ kg)(\boxed{0.38}\, g + g) = (\boxed{54}\ kg)(9.8\ m/s^2)(\boxed{0.38} + 1)$

$F_N = \boxed{730}\ N$

(d) Free body diagram when accelerating downward



Given $a = \boxed{0.38}\, g$

$\Sigma F_y = m a_y \Rightarrow F_N - mg = -ma$

$F_N = mg - ma = m(g - a)$ — (1)

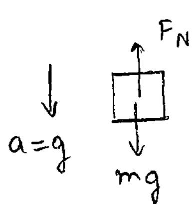
$F_N = (\boxed{54}\ kg)(g - \boxed{0.38}\, g)$

$F_N = (\boxed{54}\ kg)(9.8\ m/s^2)(1 - \boxed{0.38})$

$F_N = \boxed{328}\ N$

(e) Free fall

free body diagram for this is same as above.
i.e woman is accelerating downward with 'g'.



from (1) above.

$F_N = m(g - a) = m(g - g) = 0\ N$

$F_N = 0\ N$

Woman will feel weightless

9. Giancoli6 5.P.066. [352919] **0/1 points** Show Details

Tarzan plans to cross a gorge by swinging in an arc from a hanging vine (Fig. 5-41). If his arms are capable of exerting a force of $\boxed{1100}$ N on the rope, what is the maximum speed he can tolerate at the lowest point of his swing? His mass is $\boxed{80}$ kg and the vine is 4.8 m long.

~~4.35~~ m/s

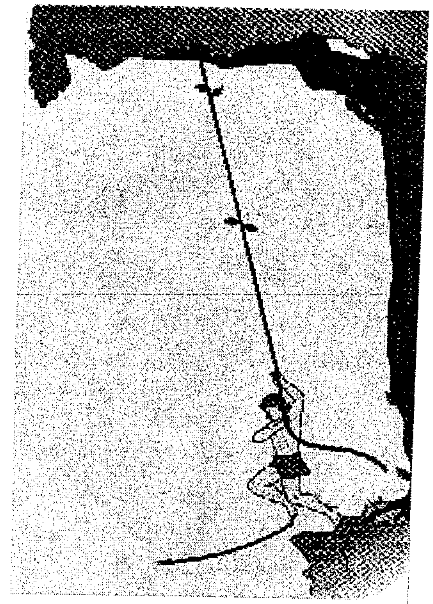
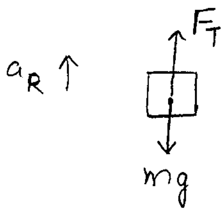
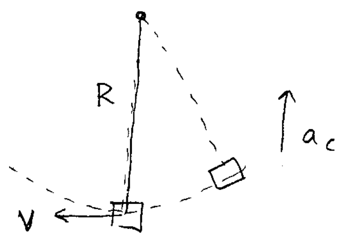


Figure 5-41

Sol^n: Free body diagram for Tarzan at bottom of his swing





Since, Tarzan is going in a circular arc, he experience net centripetal acceleration 'a_R'.

$$\Sigma F = ma \Rightarrow F_T - mg = ma_R = \frac{mv^2}{R}$$

Now F_T = Force due to tension in the vine = $\boxed{1100}$ N

$$F_T - mg = m\frac{v^2}{R} \Rightarrow v^2 = \frac{R(F_T - mg)}{m}$$

$$V = \sqrt{\frac{(4.8\,m)[\boxed{1100}\,N - (\boxed{80}\,kg)(9.8\,m/s^2)]}{\boxed{80}\,kg}} = \sqrt{18.96\ m^2/s^2}$$

$$V = \boxed{4.35}\ m/s$$

10. Giancoli6 5.P.076. [352967] **0/2 points** Show Details

A curve of radius $\boxed{85}$ m is banked for a design speed of $\boxed{80}$ km/h. If the coefficient of static friction is $\boxed{0.30}$ (wet pavement), at what range of speeds can a car safely make the curve?

minimum

____ ✗ ~~51.8~~ km/h

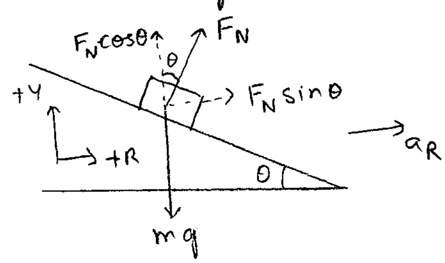
maximum

____ ✗ ~~108~~ km/h

$$V = \boxed{80}\frac{\cancel{km}}{\cancel{hr}}\left|\frac{1000\,m}{1\,\cancel{km}}\right|\frac{1\,\cancel{hr}}{3600\,s}\Big| = \boxed{22.22}\,m/s$$

Sol: 10 Since curve is banked for design speed $V = \boxed{80}$ km/hr

No frictional force is required to keep an automobile from slipping or skidding.



Y dir : $\sum F_y = ma_y$

$$F_N\cos\theta - mg = 0$$

$$F_N = \frac{mg}{\cos\theta}$$

R dir : $\sum F_R = ma_R$

$$F_N\sin\theta = \frac{mV^2}{R}$$

$$\frac{\cancel{m}g}{\cos\theta}\sin\theta = \frac{\cancel{m}V^2}{R}$$

$$g\tan\theta = \frac{V^2}{R} \Rightarrow \tan\theta = \frac{V^2}{gR}$$

$$\theta = \tan^{-1}\frac{V^2}{gR} = \tan^{-1}\left[\frac{(\boxed{22.22}\,m/s)^2}{(9.8\,\frac{m}{s^2})(\boxed{85}\,m)}\right] = \boxed{30.7}^\circ$$

This is the banking angle.

Now an automobile can be going on the curve at a different speed than given ideal speed. In that case an additional frictional force will be required from keeping automobile from slipping or skidding, which will act upword the slope or downward the slope for respective cases.

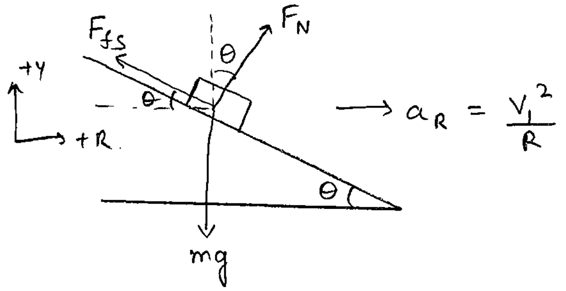
Prob (10) contd...

Prob (10) contd...

Free body diagram

Case 1 : Automobile is moving with a speed lower than ideal speed. therefore frictional force is required to keep it from slipping downward.

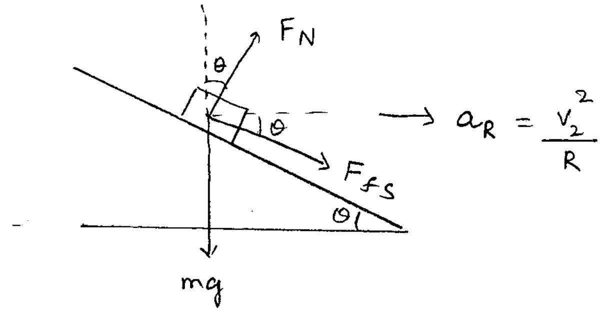
Case 2 : Automobile is moving with a speed higher than ideal speed therefore frictional force is repuired to keet it from skidding away.



Case 1

Y-dir : $F_N \cos\theta + F_{fs}\sin\theta - mg = 0$

R dir : $F_N \sin\theta - F_{fs}\cos\theta = \frac{m v_1^2}{R}$



Case 2

$F_N \cos\theta - F_{fs}\sin\theta - mg = 0$

$F_N \sin\theta + F_{fs}\cos\theta = \frac{m v_2^2}{R}$

Assume maximumum static friction $\boxed{F_{fs} = \mu_s F_N}$.

then v_1 is min speed with which automobile can go on the curve

$\Rightarrow \quad F_N \cos\theta + \mu_s F_N \sin\theta = mg.$

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

and $\quad F_N \sin\theta - \mu_s F_N \cos\theta = \frac{m v_1^2}{R}$

$\Rightarrow \quad F_N (\sin\theta - \mu_s \cos\theta) = \frac{m v_1^2}{R} \quad - (2)$

divide (2) by (1)

$$\frac{\frac{\cancel{m} v_1^2}{R}}{\frac{\cancel{m} g}{1}} = \frac{\cancel{F_N}(\sin\theta - \mu_s \cos\theta)}{\cancel{F_N}(\cos\theta + \mu_s \sin\theta)}$$

$$v_1^2 = gR\left[\frac{\sin\theta - \mu_s \cos\theta}{\cos\theta + \mu_s \sin\theta}\right] \quad - (5)$$

v_2 is maximum speed with which automobile can go on the curve.

$\therefore \quad F_N \cos\theta - \mu_s F_N \sin\theta = mg$

$\Rightarrow \quad F_N (\cos\theta - \mu_s \sin\theta) = mg. \quad - (3)$

and $\quad F_N \sin\theta + \mu_s F_N \cos\theta = \frac{m v_2^2}{R}$

$\Rightarrow \quad F_N (\sin\theta + \mu_s \cos\theta) = \frac{m v_2^2}{R} \quad - (4)$

divide (4) by (3)

$$\frac{\frac{\cancel{m} v_2^2}{R}}{\frac{\cancel{m} g}{1}} = \frac{\cancel{F_N}(\sin\theta + \mu_s \cos\theta)}{\cancel{F_N}(\cos\theta - \mu_s \sin\theta)}$$

$$v_2^2 = gR\left[\frac{\sin\theta + \mu_s \cos\theta}{\cos\theta - \mu_s \sin\theta}\right] \quad - (6)$$

Prob (10) contd..

Prob 10 contd...

Case 1

minimum speed

$$V_1 = \sqrt{gR\left[\frac{\sin\theta - \mu_s\cos\theta}{\cos\theta + \mu_s\sin\theta}\right]}$$

$$V_1 = \sqrt{(9.8\,m/s^2)(\boxed{85}\,m)\left[\frac{\sin(\boxed{30.7}) - (\boxed{0.3})\cos(\boxed{30.7})}{\cos\theta(\boxed{30.7}) + (\boxed{0.3})\sin(\boxed{30.7})}\right]}$$

$$V_1 = \sqrt{\boxed{207.70}\ \frac{m^2}{s^2}}$$

$$V_1 = \boxed{14.41}\ \frac{\cancel{m}}{\cancel{s}}\left|\frac{1\ km}{1000\ \cancel{m}}\right|\frac{3600\ \cancel{s}}{1\ h}$$

$$V_1 = \boxed{51.88}\ \frac{km}{h}$$

minimum

Case 2

maximum speed

$$V_2 = \sqrt{gR\left[\frac{\sin\theta + \mu_s\cos\theta}{\cos\theta - \mu_s\sin\theta}\right]}$$

$$V_2 = \sqrt{(9.8\,\tfrac{m}{s^2})(\boxed{85}\,m)\left[\frac{\sin(\boxed{30.7}) + (\boxed{0.3})\cos\theta(\boxed{30.7})}{\cos(\boxed{30.7}) - (\boxed{0.3})\sin\theta(\boxed{30.7})}\right]}$$

$$V_2 = \sqrt{\boxed{905.86}\ \frac{m^2}{s^2}}$$

$$V_2 = \boxed{30.1}\ \frac{\cancel{m}}{\cancel{s}}\left|\frac{1\ km}{1000\ \cancel{m}}\right|\frac{3600\ \cancel{s}}{1\ h}$$

$$V_2 = \boxed{108.4}\ \frac{km}{h}$$

maximum

11. Giancoli6 5.P.092. [352927] **0/1 points** Show Details

While fishing, you get bored and start to swing a sinker weight around in a circle below you on a $\boxed{0.20}$ m piece of fishing line. The weight makes a complete circle every $\boxed{0.30}$ s. What is the angle that the fishing line makes with the vertical? [Hint: See Figure 5-10.]

✗ 83.6°

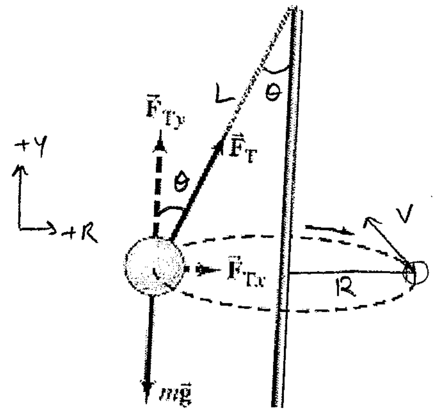


Figure 5-10

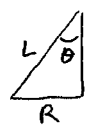
Sol 11: From the figure

$F_{Tx} = F_T \sin\theta$

$F_{Ty} = F_T \cos\theta$

Also length of fishing line

$L = \boxed{0.20}\ m$



then radius 'R' of circle in which sinker weight is going

$R = L\sin\theta$

Time period in which weight completes one circle is

$T = \boxed{0.30}\ s$

We know that uniform tangential velocity (in terms of T) is given by $V = \dfrac{2\pi R}{T}$

Now $\Sigma F_y = ma_y \Rightarrow F_T\cos\theta - mg = 0$

or $F_T = \dfrac{mg}{\cos\theta}$

and $\Sigma F_R = ma_R \Rightarrow F_T \sin\theta = \dfrac{mv^2}{R}$

$\Rightarrow \cancel{m}g\dfrac{\sin\theta}{\cos\theta} = \dfrac{\cancel{m}}{R}\left(\dfrac{2\pi R}{T}\right)^2$

$\Rightarrow g\dfrac{\sin\theta}{\cos\theta} = \dfrac{4\pi^2 R^{\cancel{2}}}{\cancel{R}\,T^2} = \dfrac{4\pi^2 R}{T^2} = \dfrac{4\pi^2 L\sin\theta}{T^2}$

$g\,\cancel{\sin\theta} = \dfrac{4\pi^2 L}{T^2}\cancel{\sin\theta}\cos\theta \Rightarrow \cos\theta = \dfrac{gT^2}{4\pi^2 L}$

$\theta = \cos^{-1}\left(\dfrac{gT^2}{4\pi^2 L}\right) = \cos^{-1}\left(\dfrac{(9.8\ m/s^2)(\boxed{0.30}\ s)^2}{4\pi^2(\boxed{0.20}\ m)}\right) = \boxed{83.6}°$ ✓