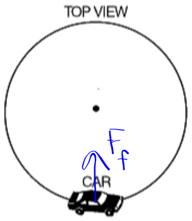
2. A 1.5 kilogram toy car moves on a circular track of 1.3 meter radius at a constant speed of 2.0 meters per second. Determine the following:



a) the time it takes to go around the track once

$$V = \frac{2\pi r}{T} \rightarrow T = \frac{2\pi r}{v} = \frac{2\pi\, 13m}{2m/s}$$

$$T = \boxed{4.1s}$$

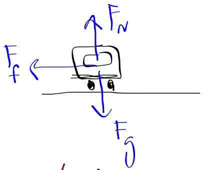
c) the centripetal force acting on the cart

$$\Sigma F_{in} = \frac{mv^2}{r}$$

$$F_f = m(a_{in})$$

$$= 1.5kg \cdot 3.1m/s^2$$

$$= \boxed{4.6N}$$



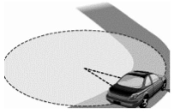
b) the centripetal acceleration of the cart

$$a_{in} = v^2/r = \frac{(2m/s)^2}{1.3m} = \boxed{3.1m/s^2}$$

d) What is causing this force?

$T =$ time/cycle
$V = 2\pi r/T$
$a_{in} = v^2/r$
$\Sigma \vec{F}_{in} = m\frac{v^2}{r}$

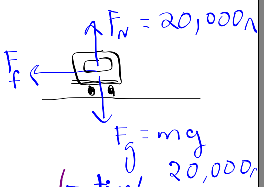
3. A 2000. kg car attempts to turn a corner going at a speed of 25 m/s. The radius of the turn is 15 meters.



a) How much friction is needed to negotiate this turn successfully?

$$\Sigma F = \frac{mv^2}{r}$$

$$F_f = \frac{2000kg\,(25m/s)^2}{15m} = 83\,000N$$

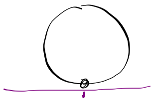


b) If the pavement is dry asphalt, will the car be able to safely turn? Justify your answer.

No!

$$F_{f_s} \leq \mu_s \cdot F_N$$

$$(.8)(20000N) = 16,000N$$



$T =$ time/cycle
$V = 2\pi r/T$
$a_{in} = v^2/r$
$\Sigma \vec{F}_{in} = m\frac{v^2}{r}$

c) Derive an expression for the maximum speed with which a car of mass *m* can safely make a turn around a curve of radius *r*.

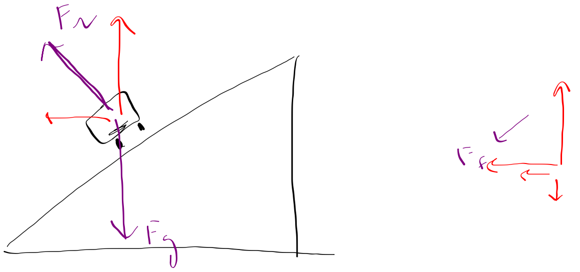
$$F_f = \frac{mv^2}{r}$$

$$\mu_s \cdot F_N = mv^2/r$$

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

$$V_{max} = \sqrt{\mu \cdot r \cdot g}$$

$$\sim\sqrt{0.8 \cdot 15m \cdot 10m/s^2} \approx 11m/s$$



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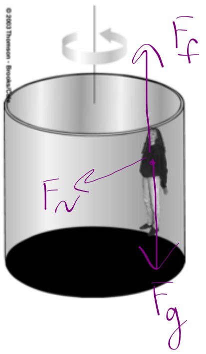
4. At amusement parks, there is a popular ride where the floor of a rotating cylindrical room falls away, leaving the backs of the riders "plastered" against the wall. What is the minimum coefficient of static friction that must exist between a rider's back and the wall, if the rider is to remain in place when the floor drops away?



$$\underline{\Sigma F_{in}} = \frac{mv^2}{r} \qquad F_f = mg$$

$$\underline{\underline{F_N}} = \frac{mv^2}{r} \qquad \mu \underline{\underline{F_N}} = mg$$

$$\frac{\cancel{m}g}{\mu} = \frac{\cancel{m}v^2}{r} \qquad V_{min} = \sqrt{rg/\mu}$$

$$\mu_{min} = rg/v^2$$

Proportional Reasoning

IB 11

1. A student swings a rubber stopper around on a string at a constant speed with a centripetal acceleration of 6.0 m/s^2, as shown. What would happen to the acceleration if:

a) the speed is doubled?

$4\vec{a}_{in} = \frac{(2v)^2}{r}$

b) the speed is halved?

$\frac{1}{4}\vec{a}_{in} = \frac{(\frac{1}{2}v)^2}{r}$

c) the string's length is tripled?

$\frac{1}{3}\vec{a}_{in} = \frac{v^2}{3r}$

d) the speed is doubled and the string's length is halved?

$8\vec{a}_{in} = \frac{(2v)^2}{(\frac{1}{2}r)}$

e) the mass of the stopper is doubled?

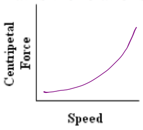
same

f) What would happen to the tension in the string if the mass is doubled and the speed is halved?

$\frac{1}{2}$ $\Sigma F = \frac{2m(\frac{1}{2}v)^2}{r}$

Graphical Relationships

2. What is the relationship between centripetal force and speed?



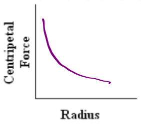
Control: m, r

$\Sigma F_{in} = \frac{m\boxed{v}^2}{r}$

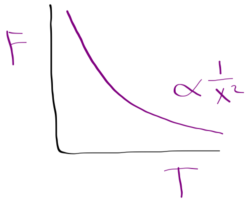
$\boxed{v} = \frac{2\pi r}{T}$

$\Sigma F_{in} = \frac{m4\pi^2 r}{T^2}$

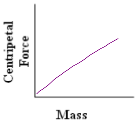
3. What is the relationship between centripetal force and radius?



Control: m, v



4. What is the relationship between centripetal force and mass?



Control: v, r

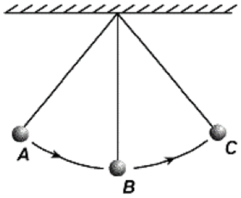
Vertical Circles

IB 11

1. Is a swinging pendulum in equilibrium? Explain.

no, changing direction

2. Is a swinging pendulum in uniform circular motion? Justify your answer.



not uniform (speed changing)

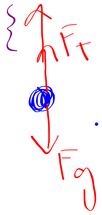
3. Compare the tension in the pendulum's string as it swings.

max at B

4. Compare the tension in a swinging pendulum to one that is hanging motionless. Sketch appropriate diagrams to aid your explanation.

Hanging

Swinging



$$\Sigma F_{in} = \frac{mv^2}{r}$$

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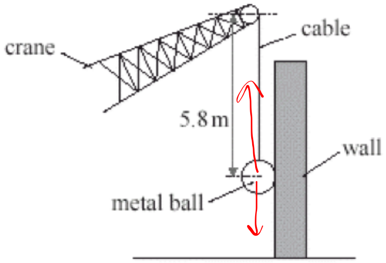
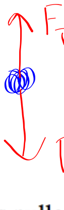
5. A 2100-kg demolition ball is attached to the end of a 5.8-m cable.



a) Determine the tension in the cable as the ball hangs motionless.



$F_T = 21,000\,N$

$F_g = 21,000\,N$

b) The ball is pulled back and released. At the lowest point of the swing, the ball is moving at a speed of 7.6 m/s. Determine the tension in the cable upon impact with the wall.

$$\underbrace{\Sigma F_{in}} = m\left(\frac{v^2}{r}\right)$$

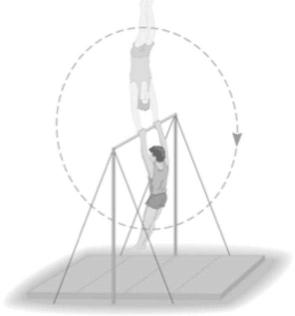
$$F_g + F_T = m\left(\frac{v^2}{r}\right)$$

$$F_T = \overset{(+)}{m\left(\frac{v^2}{r}\right)} - \overset{(-)}{F_g} = 2100\,kg\frac{(7.6\,m/s)^2}{5.8\,m} - (-21000\,N)$$

$$\sim 42,000\,N$$

"in" = +

6. How much force does this 55 kilogram gymnast deed to hold onto the bar as they swing through the bottom of their swing at 3.4 meters per second? Assume their center of mass is approximately 0.80 meter from their outstretched hands.



~1300N

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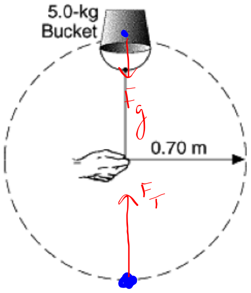
7. a) What is the maximum speed that this bucket can have at the bottom of its swing if the breaking strength of the rope is 100. newtons?



$$\Sigma F_{in} = \frac{mv^2}{r}$$

$$F_T + F_g = \frac{mv^2}{r}$$

+100N -50N

$$V_{max} = \sqrt{\frac{(F_T + F_g)r}{m}}$$

b) What is the minimum speed the bucket must have at the top of its swing to make it around without the water falling out?

$$\Sigma F = \frac{mv^2}{r}$$

$$F_g = mv^2/r$$

$$V_{min} = \sqrt{rg}$$