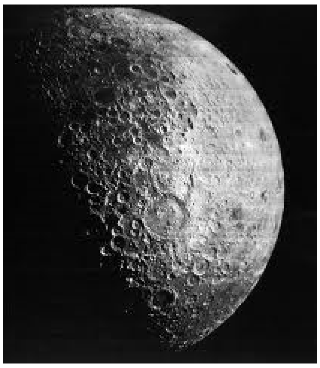
L08 - Centripetal Motion (Horizontal Systems)

Agenda:

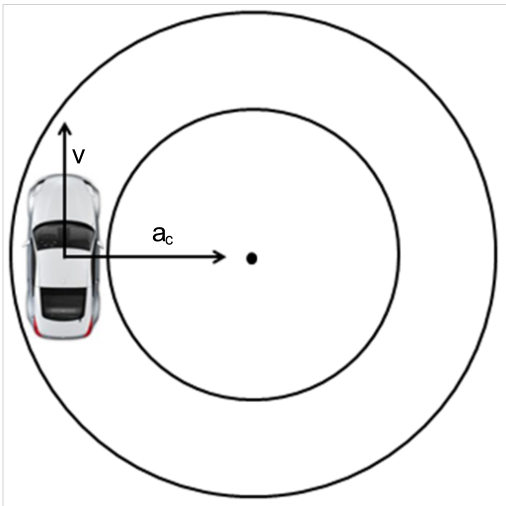
- Introduction to Centripetal Forces
  - Case #1: A car in circular motion.
  - Case #2: A stellar body in circular motion.
  - Case #3: A car on a banked curve.
  - Case #4: An alternate equation.

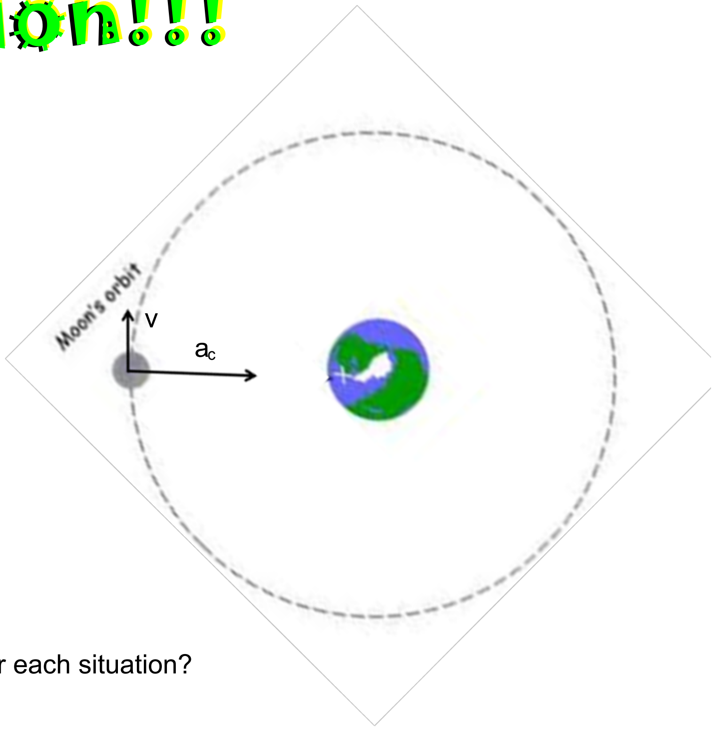
What does a sports car have in common with the Moon?



Answer:

Circular Motion!!!





Q1: What force is acting as the centripetal force for each situation?

center pointing force

Car

$F_c = F_f$

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

Moon

$F_c = F_g$

$\frac{\cancel{m_o} v^2}{\cancel{r}} = \frac{G m_s \cancel{m_o}}{r^{\cancel{2}}}$

$v^2 = \frac{G m_s}{r}$

s = source
o = orbiting object

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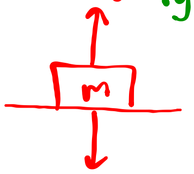
What is the Centripetal Force? ⇨ **What acts as the Centripetal Force?**

$$F_c = F_f$$

$$\frac{mv^2}{r} = \mu_s F_N$$

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

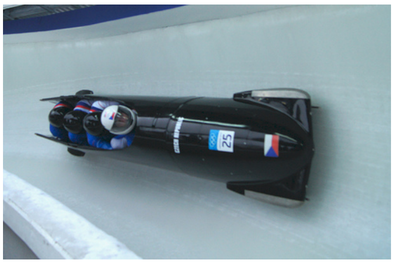
$F_N = F_g = mg$



$F_g = mg$

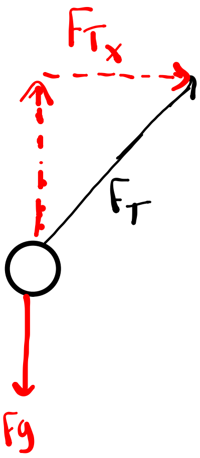
$$F_c = F_g$$

$$\frac{m_o v^2}{r} = \frac{G m_s m_o}{r^2}$$



$$F_c = F_N$$

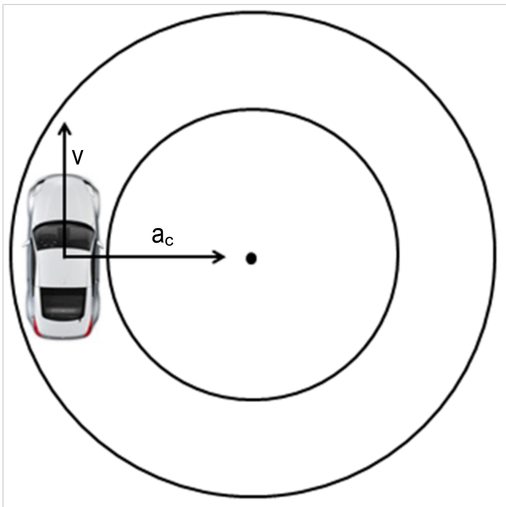
$$\frac{mv^2}{r} = F_N$$



$$F_c = F_{Tx}$$

$$\frac{mv^2}{r} = F_{Tx}$$

Case #1: The Sports Car



What is happening?

The friction of the road is supplying the centripetal force necessary to keep the car in a circular path.

Maximum speed?

1. Determine what we know.
2. Set up our equations (and simplify).
3. Solve.

Practice

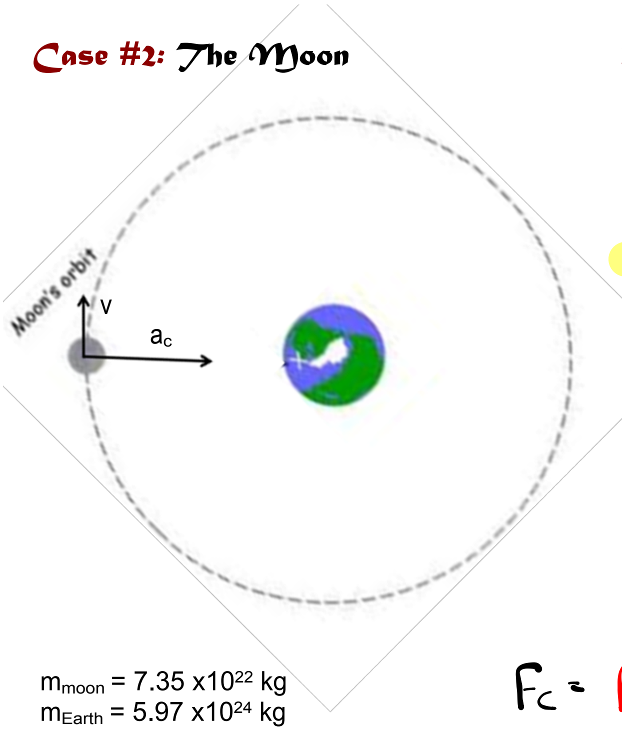
Pg 259 #1-3

m_{350z} = 1446 kg
r = 15 m
μ_s = 0.60
v = ____ m/s ?

$$F_c = F_f$$
$$\frac{mv^2}{r} = \mu_s F_N$$
$$\frac{\cancel{m}v^2}{r} = \mu_s \cancel{m}g$$
$$\frac{v^2}{15} = (0.60)(9.81)$$
$$v^2 = 88.29$$
$$v = 9.396... \text{ m/s}$$

$\boxed{9.40}$

Case #2: The Moon



$m_{moon} = 7.35 \times 10^{22}$ kg
$m_{Earth} = 5.97 \times 10^{24}$ kg
$r = 3.844 \times 10^{8}$ m

What is happening?

The gravitational force is supplying the centripetal force necessary to keep the moon in a circular orbit.

Orbital speed of the Moon?

1. Determine what we know.
2. Set up our equations (and simplify).
3. Solve.

Practice

Pg 279 #1-2

$$F_c = F_g$$

$$\frac{\cancel{m_o} v^2}{r} = \frac{G m_s \cancel{m_o}}{r^{\cancel{2}}}$$

$$v^2 = \frac{G m_s}{r} = \frac{(6.67\times10^{-11})(5.97\times10^{24})}{(3.844\times10^{8})}$$

$$v^2 = 1{,}035{,}897.5026$$

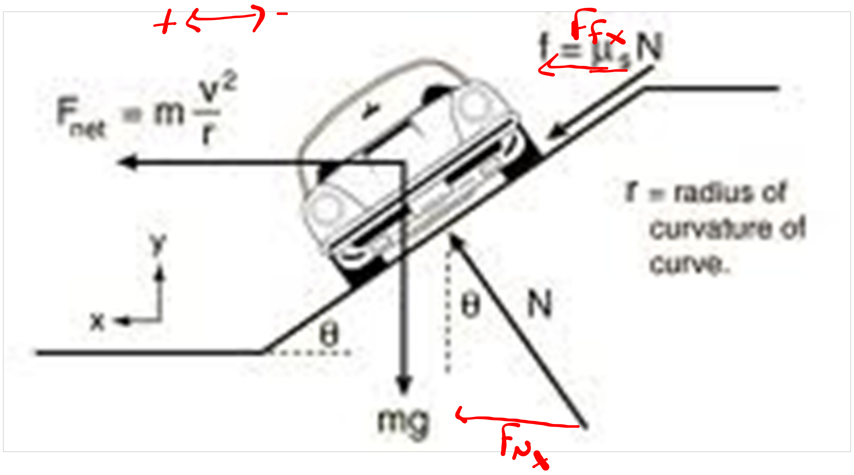
$$v = 1017.79 \text{ m/s}$$

$$v = a.bc\times10^{d} \text{ m/s}$$

$$1.02\times10^{3}$$

$$\boxed{1|0|2|3}$$

Case #3: The Sports Car on a Banked Surface



What is happening?

Both the x-component of the Friction and the x-component of the Normal Force are supplying the necessary centripetal force to keep the car in a circular path!

$$F_c = F_{f_x} + F_{N_x}$$

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Case #4: An Alternate Equation

Given the following equations...

$$a_c = \frac{v^2}{r} \quad where \quad v = \frac{2\pi r}{T}$$

... derive a formula for **centripetal acceleration** that is a function of **radius** and **period**...

$a_c(r,T) =$ $a = \frac{v^2}{r}$

$a = v^2 \cdot \frac{1}{r}$

$a = \left(\frac{2\pi r}{T}\right)^2 \cdot \frac{1}{r}$

$a = \frac{4\pi^2 r^2}{T^2} \cdot \frac{1}{r}$

$\boxed{a = \frac{4\pi^2 r}{T^2}}$

On Sheet

... then derive a formula for **centripetal force** that is a function of **radius**, **mass**, and **period**...

$F_c(m,r,T) =$ $F_c = m a_c$

$= m\left(\frac{4\pi^2 r}{T^2}\right)$

$= \frac{4\pi^2 r m}{T^2}$

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Practice:

Pg 268, Check and Reflect #8

Pg 289, Chapter Review #28, 29, 34