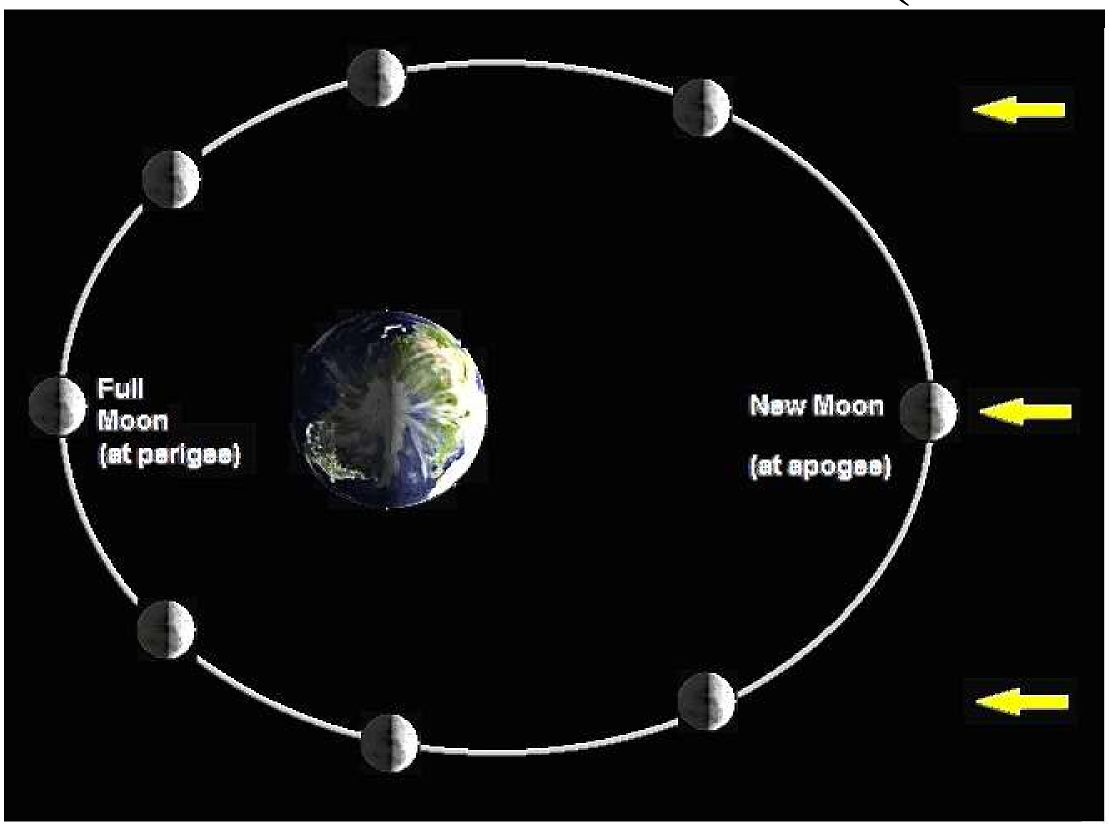
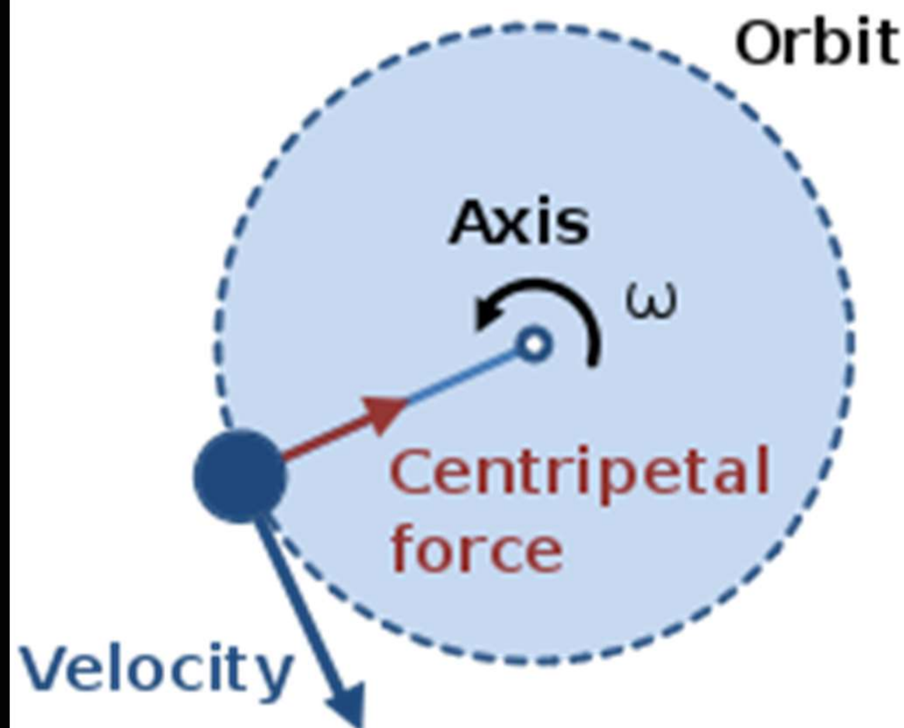
Why does the Moon Orbit the Earth?

The moon's motion about the Earth is ALMOST uniform circular motion. Often approximated as circular. (Actually elliptical)

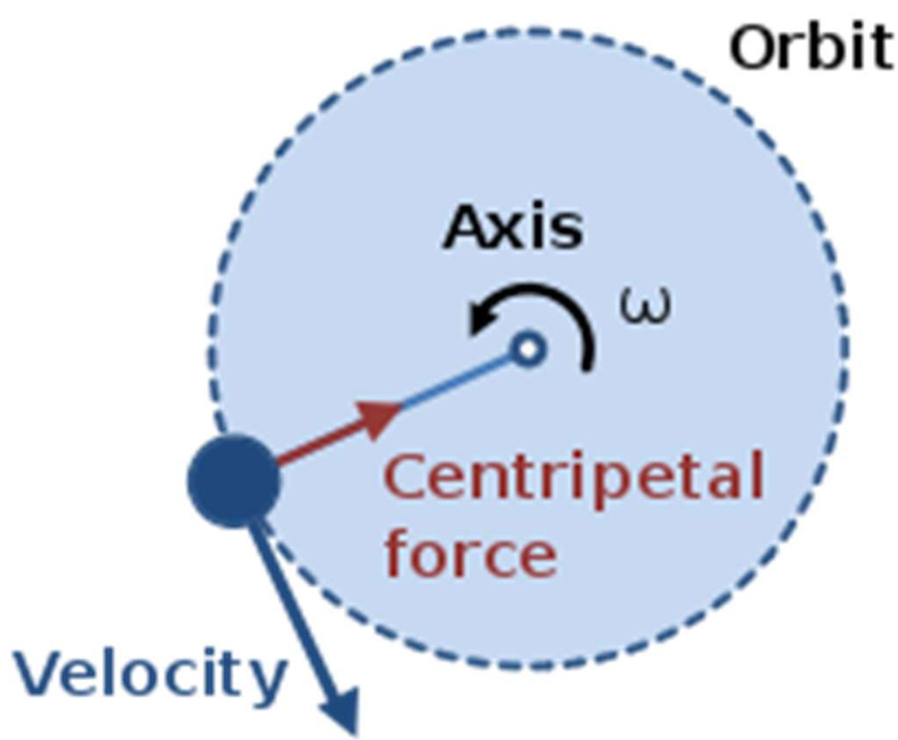




To understand why, read 7.5.4 on Kepler's law which I'm skipping because you probably will never use it.

Important Point!

In order for something to move in a circle there must be a force pointing toward the center of the circle!



Why does the Moon Orbit the Earth?

All objects that have mass attract each other

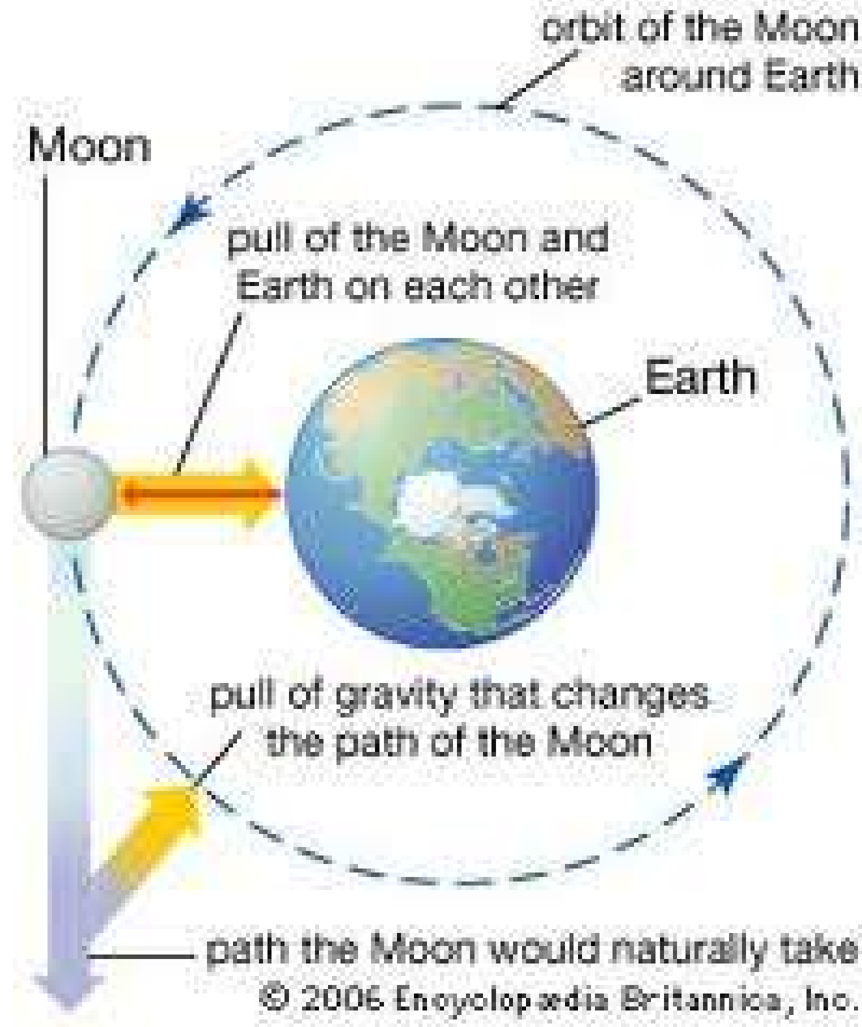
Magnitude of gravitational attractive force between two objects is related to the masses and distance between them.

$$F_G = G\frac{m_1 m_2}{r^2}$$

Near Earth $= m_{you} g$

r = distance between centers of two objects

$G = 6.67 \times 10^{-11}$ N m^2 / kg^2 (Gravitational Constant)



Thus:

- $g = G \quad m_{planet}/r_{planet}^2$
- $G = 6.67 \times 10^{-11}$ N m^2 / kg^2
- Mass of Earth = 6 x 10^{24} kg
- Radius of Earth ~6,400,000 m

6.67×10^{-11} N m^2 / kg^2 *6 x 10^{24} kg/$(6400000m)^2$
= 9.8 m/s^2 = g

Mars is 6.4 x 10^{23} kg (almost 10 x lighter)

Mars' radius is smaller: R=3,379,000 m

Conceptual understanding of gravity

If the moon were twice as far away as it is now, how would that change the force of Earth's gravity on the moon.

a) Same
b) 2 times less
c) 4 times less
d) 2 times more
e) 4 times more

$$F_G = G\frac{m_1 m_2}{r^2}$$

Do you think Spiderman's spider silk could hold up?

of the top of a building 15 m tall.

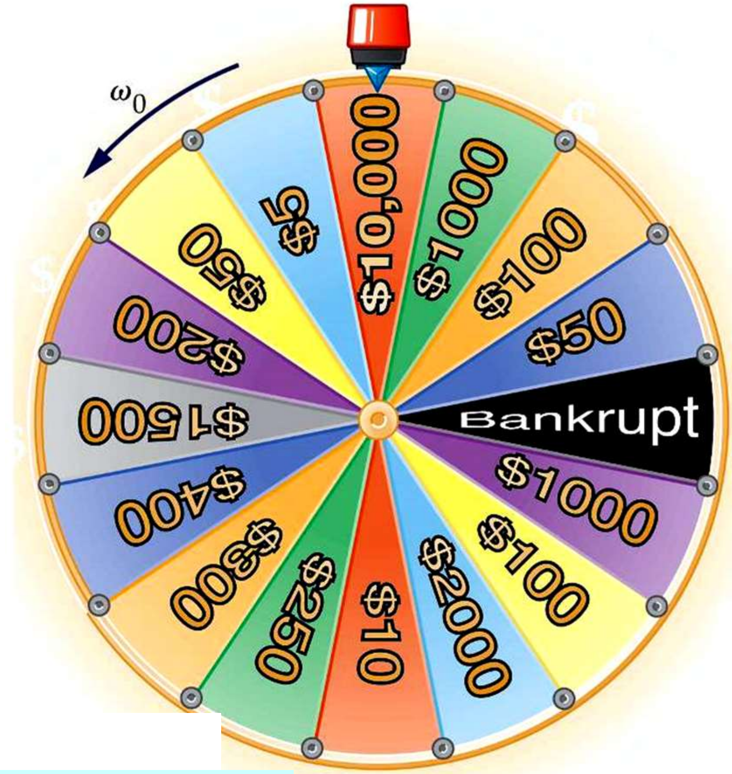
"Spider silk is the strongest of all natural and man-made fibers.... It is even stronger than steel: the dragline of a European garden spider (*Araneus diadematus*), for example, can support a weight of 0.5 g (0.002 oz) without snapping, whereas a steel strand of similar thickness will snap under the strain of just 0.25 g (0.01 oz)."

-Mark Carwardine says in *The Guiness Book of Animal Records* 1995

Would one normal spider strand be enough?

Practice with angular velocity questions

Amy is on the Wheel of Fortune and has to spin the wheel. She gives the wheel an initial angular speed of 3.40 rad/s. It then rotates through 1.25 revolutions and comes to rest on BANKRUPT.



(a) Find the wheel's angular acceleration, assuming it is constant.

(b) How long does it take for the wheel to stop?

$$\omega^2 = \omega_0^2 + 2\alpha\,\Delta\theta$$

$$\alpha = \frac{\omega^2 - \omega_0^2}{2\Delta\theta}$$

$$\omega = \omega_o + \alpha t$$

$$\omega^2 = \omega_o^2 + 2\alpha\,\Delta\theta$$

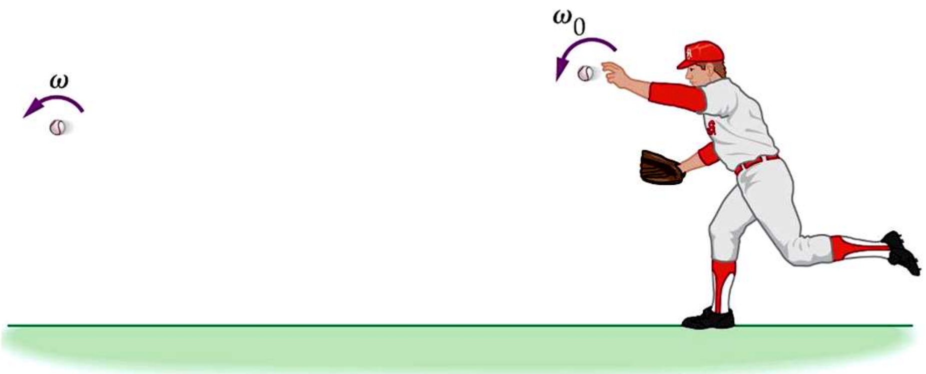
$$\Delta\theta = \omega_o t + \tfrac{1}{2}\alpha t^2$$

$$\omega = \omega_0 + \alpha t$$

$$t = \frac{\omega - \omega_0}{\alpha} = \frac{0 - (3.40\ \text{rad/s})}{(-0.736\ \text{rad/s}^2)} = 4.62\ \text{s}$$

Example: Thrown for a Curve

To throw a curve ball, a pitcher gives the ball an initial angular speed of 36.0 rad/s. When the catcher gloves the ball 0.595 s later, its angular speed has decreased (due to air resistance) to 34.2 rad/s.



Part b: You could also use average angular velocity formula, but have to use average!

$$\overline{\omega} = \frac{\Delta\theta}{\Delta t}$$

(a) What is the ball's angular acceleration, assuming it to be constant?

$$\alpha = \frac{\omega - \omega_0}{t} = \frac{(34.2 \text{ rad/s}) - (36.0 \text{ rad/s})}{(0.595 \text{ s})} = -3.03 \text{ rad/s}^2$$

$$\omega = \omega_o + \alpha t$$

$$\Delta\theta = \omega_o t + \tfrac{1}{2}\alpha t^2$$

(b) How many revolutions does the ball make before being caught?

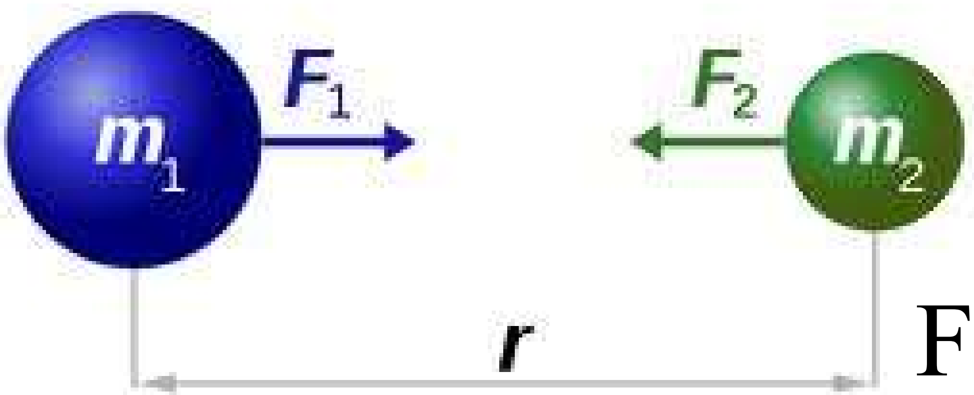
$$\omega^2 = \omega_o^2 + 2\alpha\Delta\theta$$

$$\Delta\theta = \omega_0 t + \tfrac{1}{2}\alpha t^2 = (36.0 \text{ rad/s})(0.595 \text{ s}) + \tfrac{1}{2}(-3.03$$

$$= 20.9 \text{ rad} = 3.33 \text{ rev}$$

We are all attracted to each other.

Hannah and Tommy are sitting side by side. Estimate the force of gravitational attraction between them.



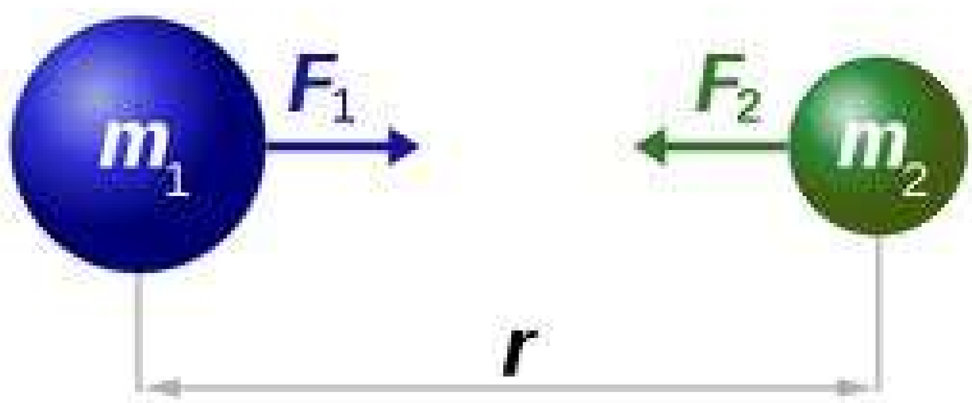
$$F_1 = F_2 = G\frac{m_1 \times m_2}{r^2}$$

r = 0.5 meter

For example, let's say that Hannah weighs 50 kg and Tommy weighs 70 kg.

Tommy and Hannah

Tommy has just come from the gym, so Hannah decides to move a seat away. She has increased her distance from 0.5m to 1m. What is the change in the force?



$$F_1 = F_2 = G\frac{m_1 \times m_2}{r^2}$$

A. 4 times smaller

B. 2 times smaller

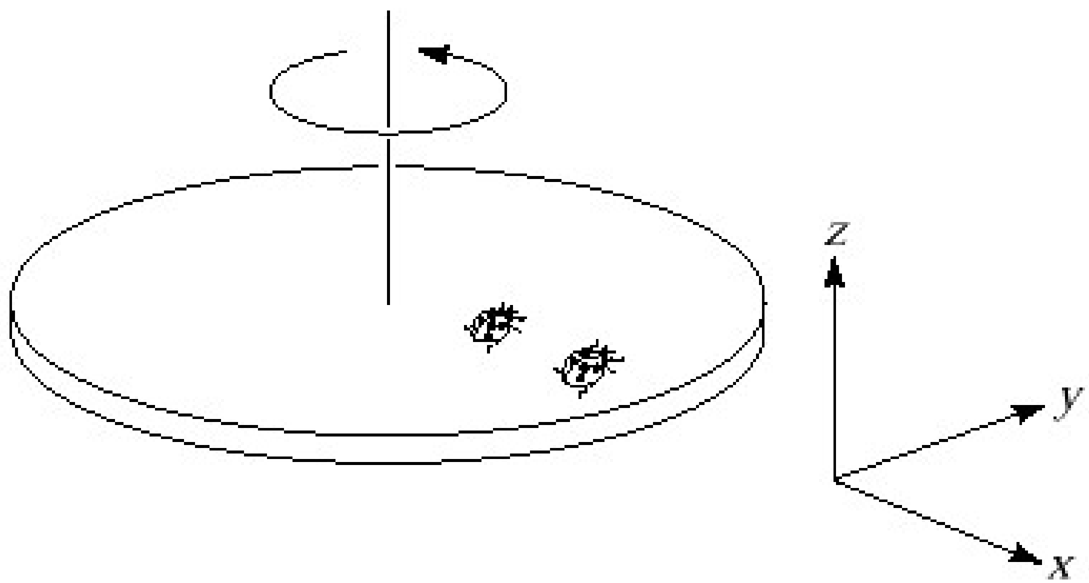
C. The same

D. 2 times larger

E. 4 times larger

Q102

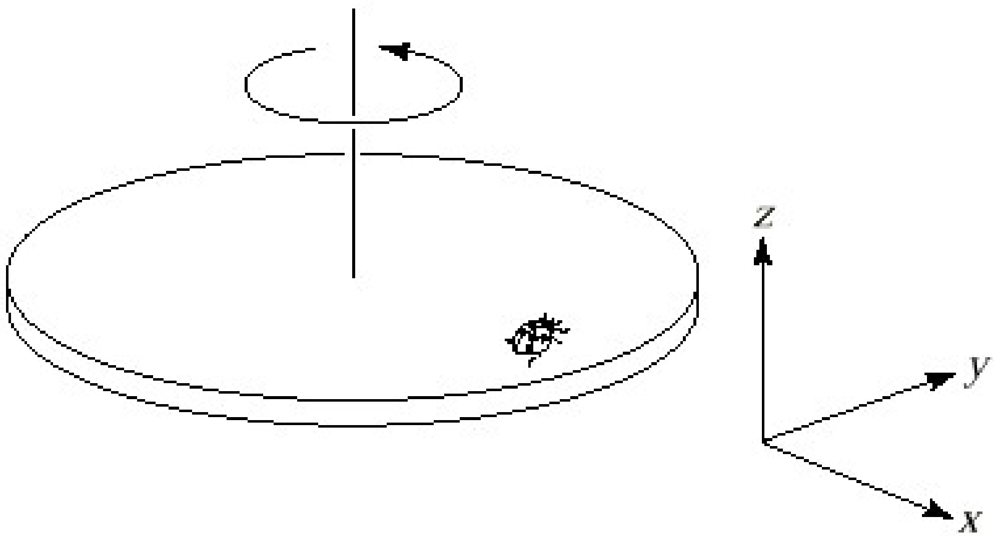
A ladybug sits at the outer edge of a merry-go-round, and a gentleman bug sits halfway between her and the axis of rotation. The merry-go-round makes a complete revolution once each second. The gentleman bug's angular speed is



1. half the ladybug's.
2. the same as the ladybug's.
3. twice the ladybug's.
4. impossible to determine

Q98

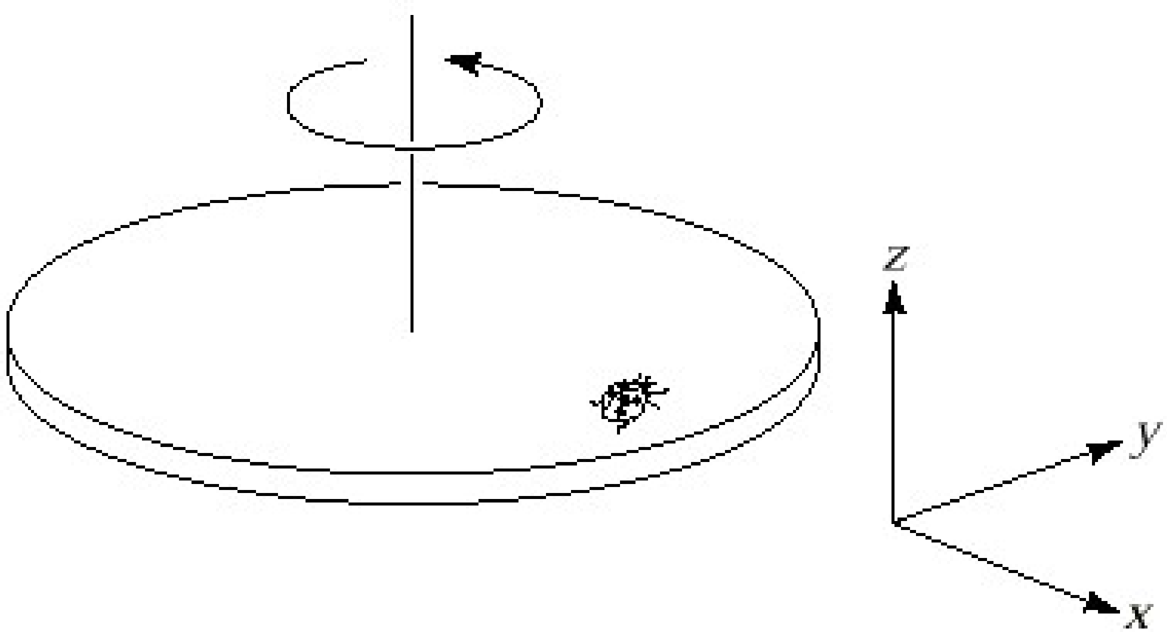
A ladybug sits at the outer edge of a merry-go-round, that is turning and slowing down. At the instant shown in the figure, the radial component of the ladybug's (Cartesian) acceleration is



1. in the $+x$ direction.
2. in the $-x$ direction.
3. in the $+y$ direction.
4. in the $-y$ direction.
5. in the $+z$ direction.
6. in the $-z$ direction.
7. zero.

Q99

A ladybug sits at the outer edge of a merry-go-round that is turning and slowing down. The tangential component of the ladybug's (Cartesian) acceleration is



A. in the $+x$ direction.

B. in the $-x$ direction.

C. in the $+y$ direction.

D. in the $-y$ direction.

E. in the $+z$ direction.

Q100

Why does the Moon Orbit the Earth?

All objects that have mass attract each other

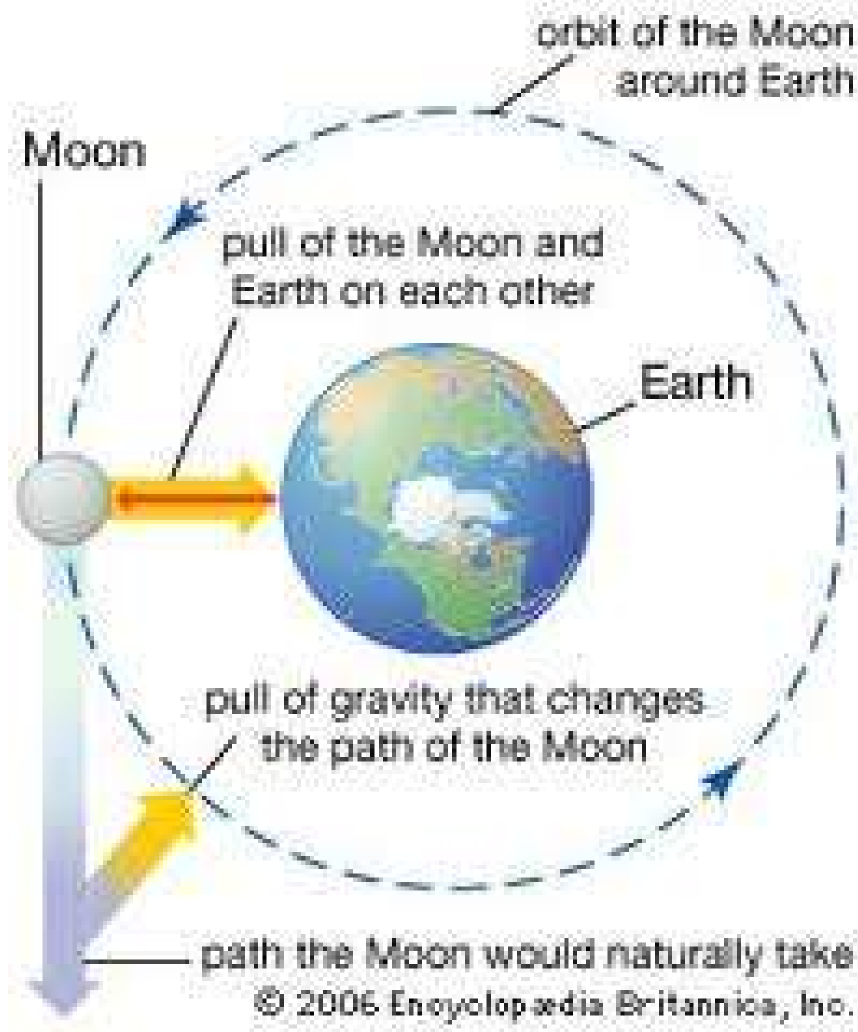
Magnitude of gravitational attractive force between two objects is related to the masses and distance between them.

$$F_G = G\frac{m_1 m_2}{r^2}$$

Different than *mg* when not near surface of Earth
(so is potential energy)

r = distance between centers of two objects

$G = 6.67 \times 10^{-11}$ N m^2 / kg^2 (Gravitational Constant)



Compared to the Earth, Planet X has twice the mass and twice the radius. This means that compared to the Earth's surface gravity, the surface gravity on Planet X is

A. 4 times as much.

B. twice as much.

C. the same.

D. 1/2 as much.

E. 1/4 as much.

$$F_G = G\frac{m_1 m_2}{r^2}$$

Q103

Good Summary

- http://www.youtube.com/watch?v=-G7tjiMNVlc