

Do Now: Find the centripetal force acting on a 65kg person on a Gravitron with a radius of 12m and a period 3.4s.

$$r = 12 \text{ m}$$

$$t = 3.4 \text{ s}$$

$$m = 65 \text{ kg}$$

$$F_c = ? = 2663 \text{ N}$$



Today

- Circular motion and amusement park rides.
- Universal Gravitation and satellite motion.

Centripetal Force and Friction

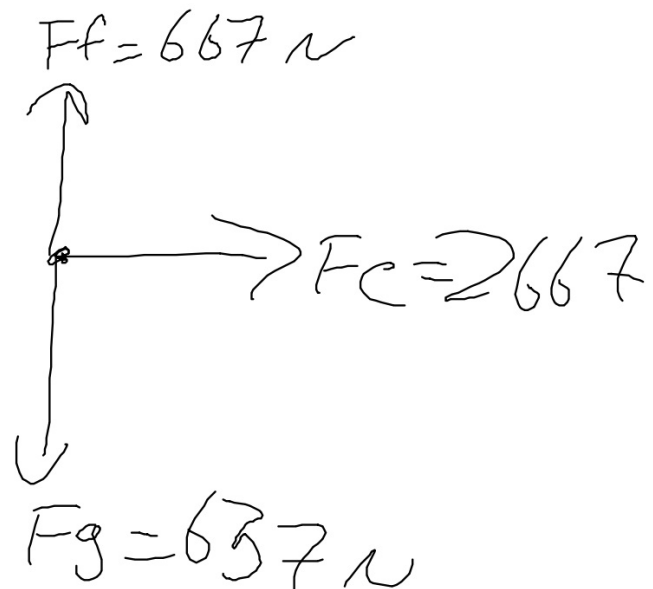
- The centripetal acceleration on an object creates a normal force if it is in contact with the rotating surface.
- If we know the normal force and the coefficient of friction, we can figure out frictional forces.

Gravitron Problem

- We know the normal force acting on the person on the gravitron is 2667N .
- To keep the person from slipping down the side of the gravitron wall, the force of static friction has to be higher than the force of gravity.
- Need coefficient of static friction.

If the coefficient of static friction is 0.25,
does the person slide down the side?

No



Fighting Gravity

- In order not to fall, the forces have to be greater than the force of gravity.
- Centripetal force can create this.



A carnival ride allows riders to board a barrel with a radius of 8m. The barrel spins 20 times a minute and the bottom drops out. What is the minimum coefficient of static friction required to keep the riders from falling out the bottom of the barrel?

Step 1: Solve for the centripetal acceleration.

$$r = 8\text{ m}$$

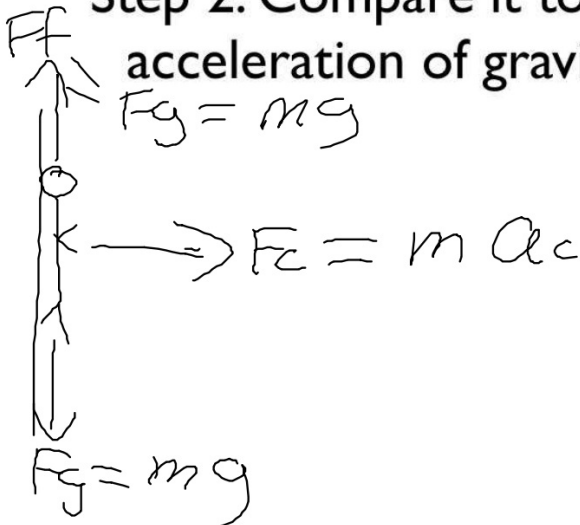
$$t = 3\text{ s}$$

$$a_c = 3\text{ s/m/s}^2$$



A carnival ride allows riders to board a barrel with a radius of 8m. The barrel spins 20 times a minute and the bottom drops out. What is the minimum coefficient of static friction required to keep the riders from falling out the bottom of the barrel?

Step 2: Compare it to the acceleration of gravity.



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The ratio **is** the minimum coefficient of friction needed to keep the riders from sliding.

$$\mu = \frac{9.8 \text{ m/s}^2}{35.1 \text{ m/s}^2} = 0.28$$



A plane flies at 250km/hr. What is the maximum radius of the loop needed to keep a rider in her seat at the top of the loop?



Sum of the Forces

- We now have forces due to centripetal acceleration.
- Solve for the net force at the top and bottom of a loop.
- Top: $F_c - F_g$.
- Bottom: $F_c + F_g$.

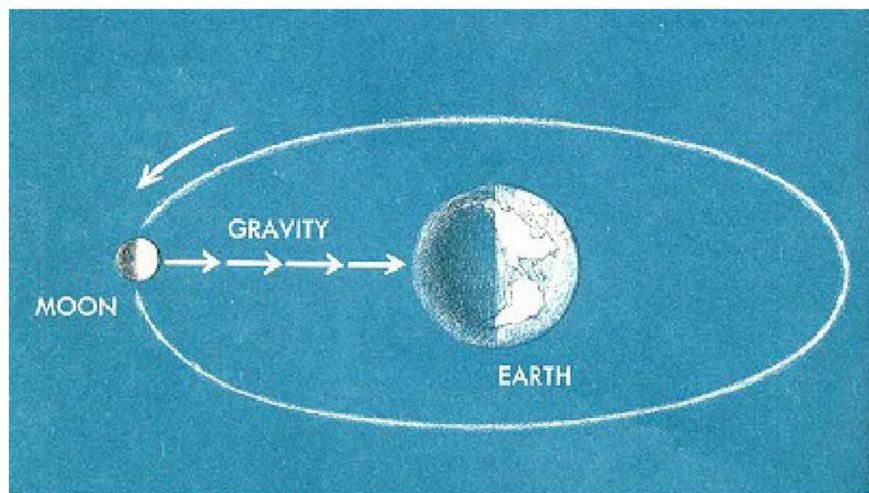
A ninja swings a slingshot with a radius of 1.3m at 70rpm. If the stone has a mass of 0.7kg, what are the sum of the forces at the top and bottom of the circle?



Before Noon?

Quest please?

Yes please!



Universal Gravitation

Force of Gravity

- Gravity affects everything with mass.
- We are attracted to the object with the largest gravitational force relative to proximity.
- The further away you are, the less effect gravity has on you.



How to think about gravity

Write this Down!

- Mass of Earth: $5.97 \times 10^{24} \text{kg}$.
- Radius of Earth: $6.371 \times 10^6 \text{m}$.
- Universal Gravitational Constant:
 $6.67384 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$

G

Force of gravity

- The force drawing any two objects with mass towards one another.
- $F_g = (G m_1 m_2) / (r^2)$
- m_1 and m_2 are objects with a particular mass.
- r is the distance between their centers of mass.

Find the force of gravity between you and the earth if you are on its surface. How does it compare to $F=mg$?

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Satellite Motion

- The centripetal force must be equal to the gravitational force.
- You are falling at the same rate that you are moving to the side.



Free Falling in Outer Space

A 1200kg satellite is 500km from the surface of the Earth. What does its angular velocity need to be in order to stay on a constant orbit? Hint: the centripetal force must be equal to the force of gravity.

Step 1: Solve for the force of gravity.

A 1200kg satellite is 500km from the surface of the Earth. What does its angular velocity need to be in order to stay on a constant orbit? Hint: the centripetal force must be equal to the force of gravity.

Step 2: Solve for the velocity necessary to have the same force as gravity.

At what height above the surface of the Earth will a satellite of 500kg stay stationary over a city on the equator?

