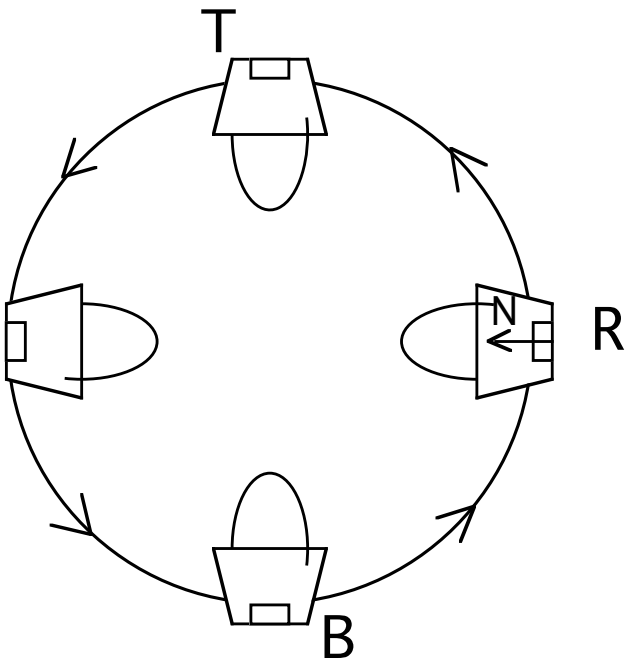
Clicker Question

Room Frequency BA

A bucket containing a brick is swung in a circle at constant speed in a vertical plane as shown. The bucket is swung fast enough that the brick does not fall out.



The **net** force on the brick as it is swung has maximum magnitude at position.

A) Top.

B) Bottom.

C) Right

D) The net force has the same magnitude at all positions.

Clicker Question

Room Frequency BA

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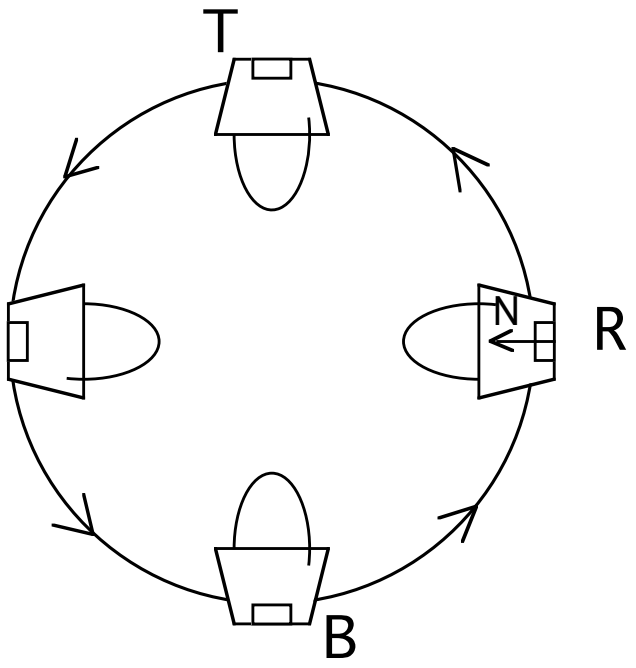

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A) Top.

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C) Right

D) The net force has the same magnitude at all positions.

Answer:

Net force: $F_{net} = m\,a = m\,v^2/R$.

Since the speed v and radius R are constant, the acceleration and hence the net force must also be constant in magnitude.

Spring 2014

PHYS-2010

Lecture 21

Announcements

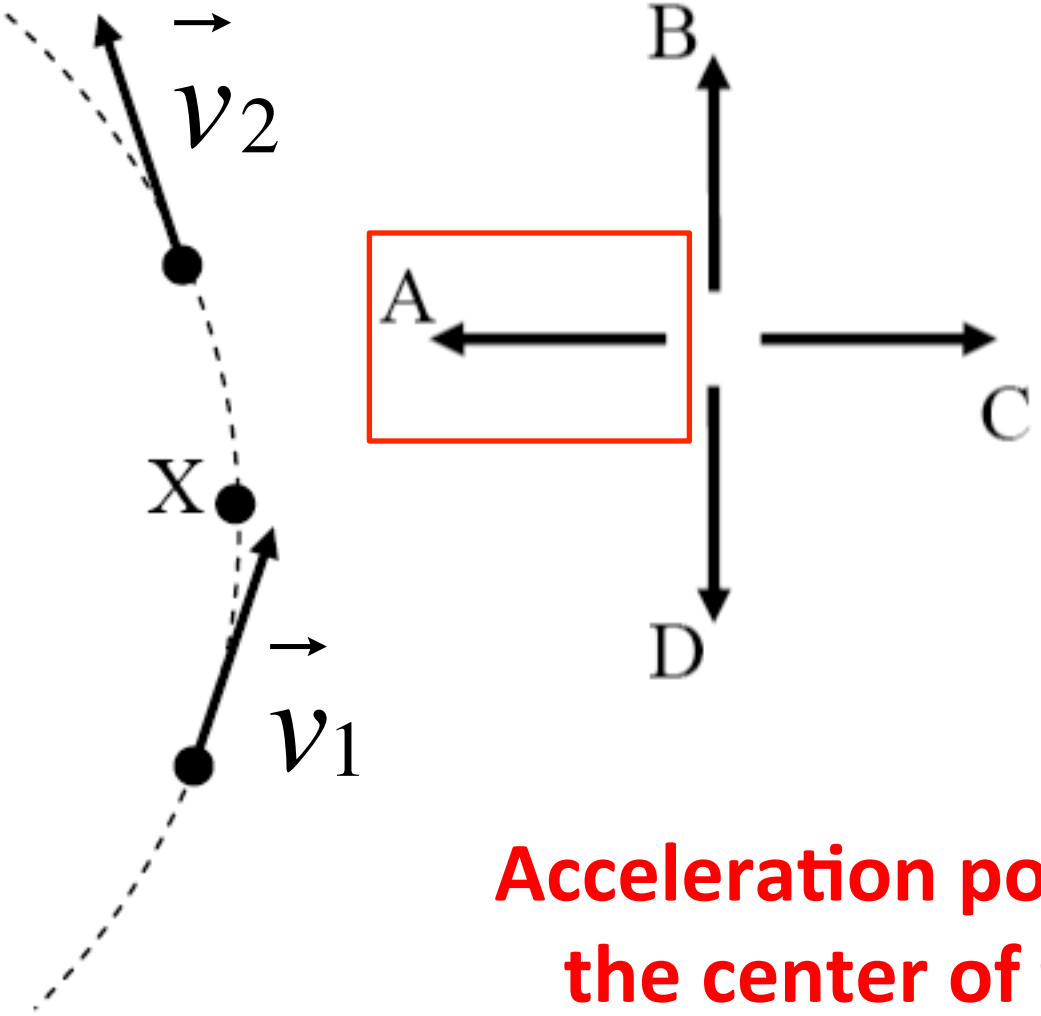
- Read Giancoli Chapter 5.
- **CAPA # 7** due Tuesday at 11 pm.
- **No Written homework** this week!
- This week: **Lab # 4** "Newton's Laws" (no prelab).
- **Midterm II** on Thursday, March 6, at 7:30 pm.
- **Practice exam** is posted on D2L.
- **Review session** tomorrow March 4, 5-6 pm, Duane G125.
- **Exam seating:**
  - if your TA is Rosemary Wulf or Andrew Hess, your exam is here, G1B30.
  - if your TA is Jake Fish or Clarissa Briner, your exam is next door, G1B20.
- More details about the exam are on the course website:

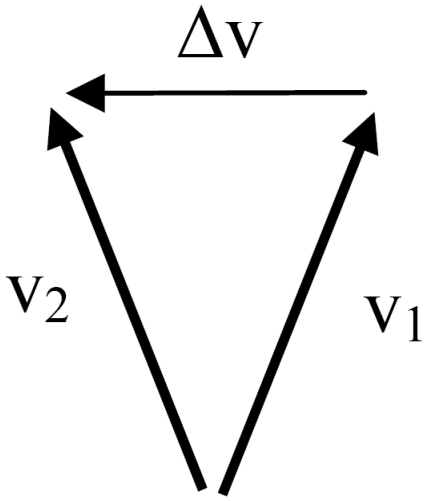
http://www.colorado.edu/physics/phys2010/phys2010_sp14/exams.html

Materials to study for Mid-Term II

- **Giancoli Ch. 3.5 – 5.3** (Vectors, Projectile Motion, Newton's laws, Pulleys, Friction, Circular Motion).
- In-class **Clicker Questions & Lecture Materials**.
- Your **CAPAs** through # 7.
- **Written Homeworks** 3 - 5.
- **Recitation Assignments and Lab**.
- **Giancoli web site**: "Practice Questions", "MCAT Study Guide", "Practice Problems". Link on course web site.
- Old **practice exam** posted on D2L.
- Dr. Michael **Dubson's Chapter Notes** (link on course website).

What is the ***direction*** of the acceleration when particle is at point X?





$$\vec{v}_1 + \Delta\vec{v} = \vec{v}_2$$

$$\Delta\vec{v} = \vec{v}_2 - \vec{v}_1$$

Acceleration points toward the center of the circle.

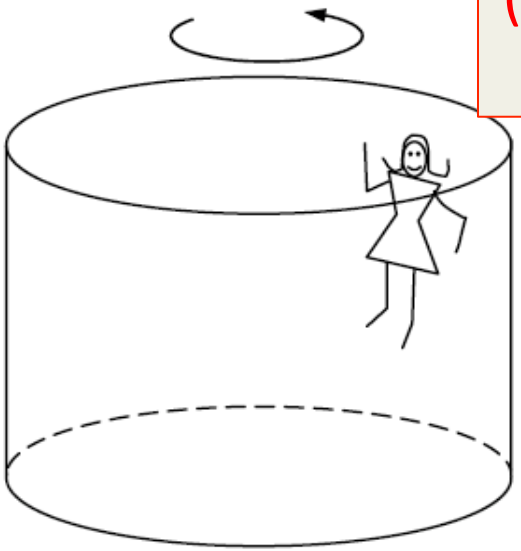
Clicker Question

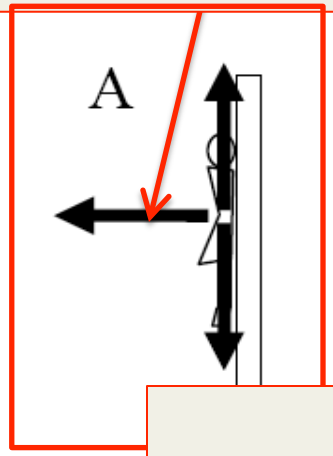
Room Frequency BA

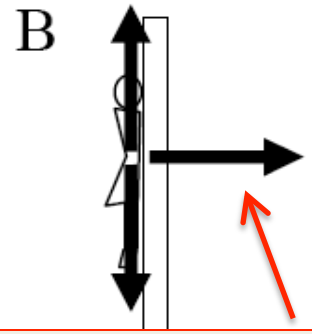
Consider the "Wall-of-Death"

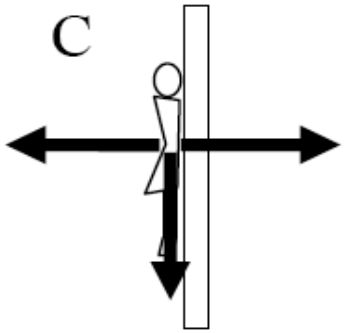
Which diagram correctly shows the real forces on the rider?

(Normal) "Centri**petal** force": a real force.







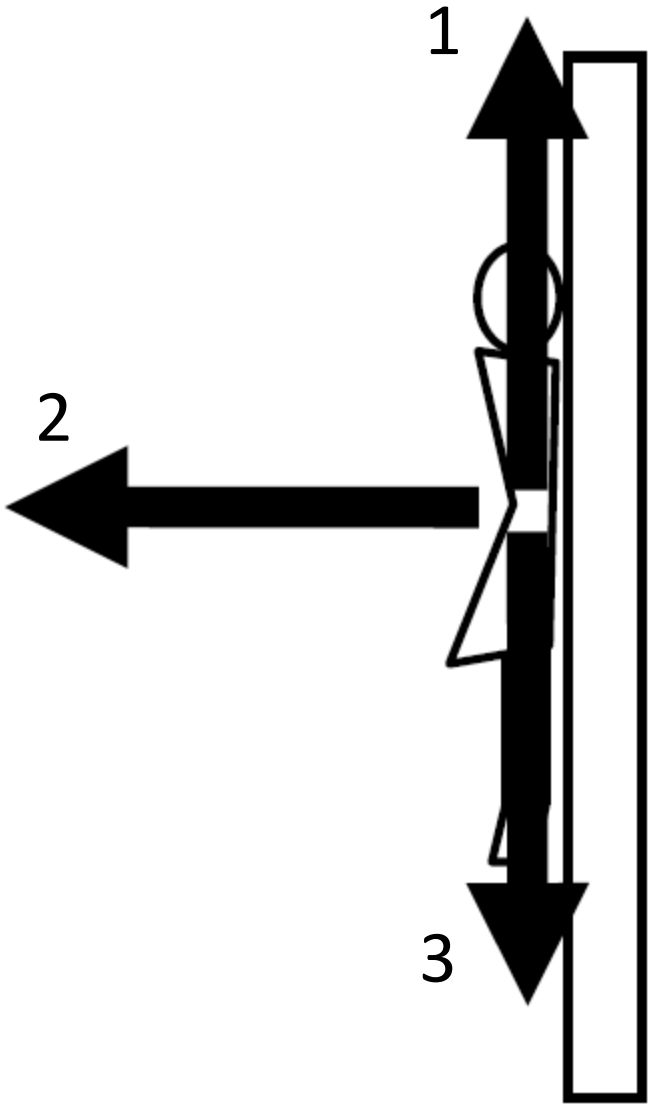


Fictitious force: "centri**fugal** force" – in the rider's frame.

Centrifugal force (from Latin centrum, meaning "center", and fugere, meaning "to flee")

Clicker Question

Room Frequency BA



What are the three forces #1, 2, 3?

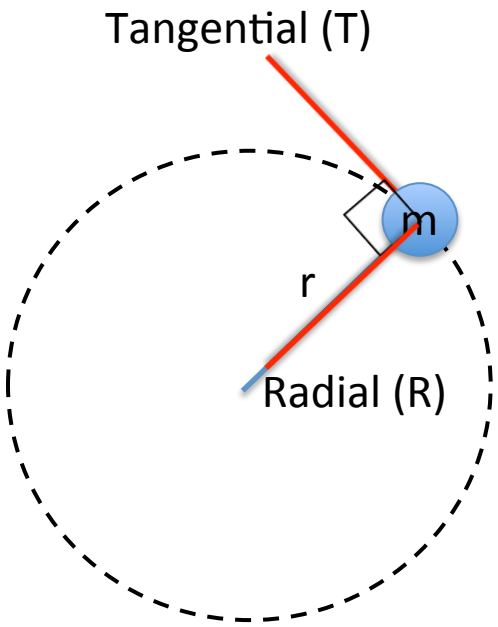
A) 1 - gravity
   2 - centrifugal force
   3 – friction

B) 1 – friction
   2 – normal force of the wall
   3 – gravity

C) 1 - centripetal force
   2 – normal force of the wall
   3 – friction

D) 1 – friction
   2 – centrifugal force
   3 - gravity

Dynamics of Uniform Circular Motion



Choose a coordinate system: Usually radial and tangential.

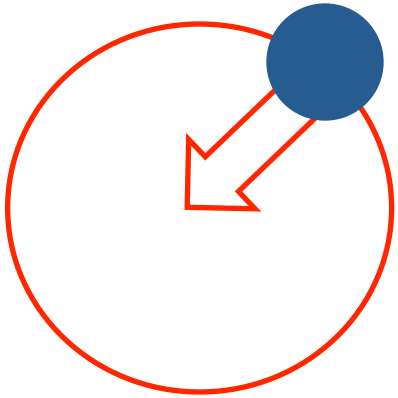
For uniform motion, velocity in the tangential direction is constant, so

$$\Sigma F_T = m a_T = 0$$

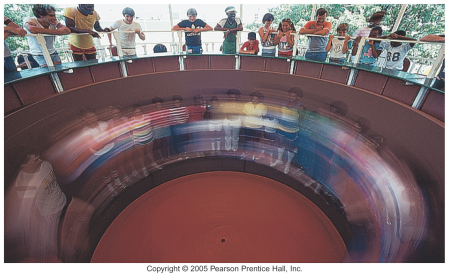
In the radial direction:

$$\Sigma F_R = m a_R = mv^2/r$$

For every case of uniform circular motion, there must be a force directed towards the center.



We say there is a centripetal force. However, there is always a **specific** force that acts as the centripetal force. There is no "circle force". <u>Circular motion does not cause a force</u>.



Wall of Death ride

Centripetal force → Normal Force

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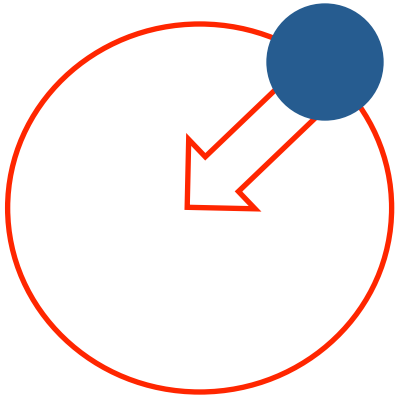

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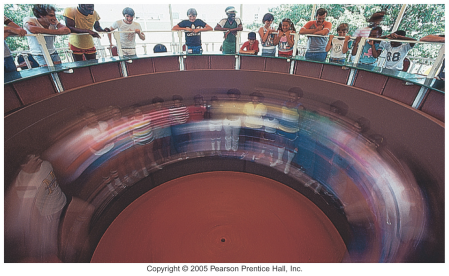

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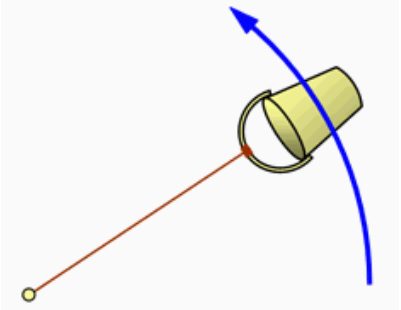


Bucket of water circling around tied to a string.

Centripetal force → Tension Force

Race Car driving in circle

Centripetal force → Friction Force

Corona Arch Swing (Moab, Utah, 03/31/2012)

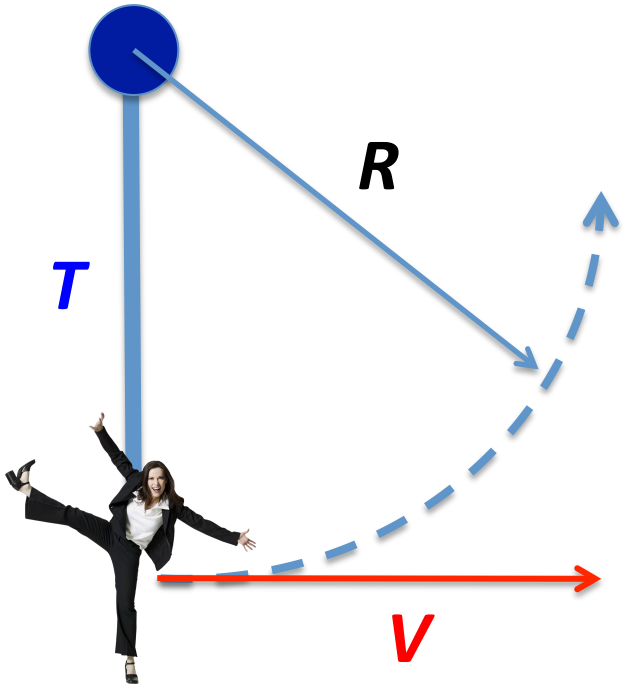
http://www.youtube.com/watch?v=nCjVUaR1tVo

(video cortesy of Sean Kuusinen and CU Alpine Club)

Clicker Question

Room Frequency BA

A student of mass m = 60 kg suspended from the Corona Arch by a rope of length R = 30 m is swinging left to right. When she is at the lowest point of her trajectory, her speed is V = 10 m/s.



How does the tension force in the rope compare with the force of gravity?

A) $T > mg$

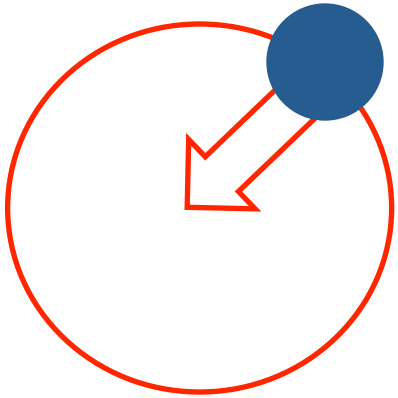
B) $T = mg$

C) $T < mg$

Tension is greater than mg. It has to overcome gravity to provide the upward *net force* necessary to provide the required upward *centripetal acceleration*.

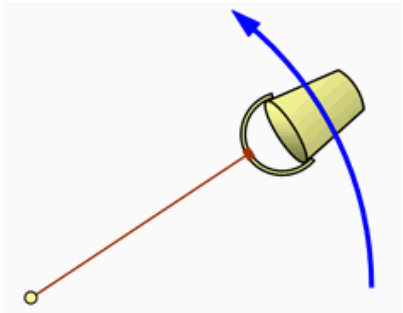
For every case of uniform circular motion, there must be a force directed towards the center.

We say there is a centripetal force. However, there is always a **specific** force that acts as the centripetal force. There is no "circle force".



Wall of Death ride

Centripetal force → Normal Force



Bucket of water circling around tied to a string.

Centripetal force → Tension Force

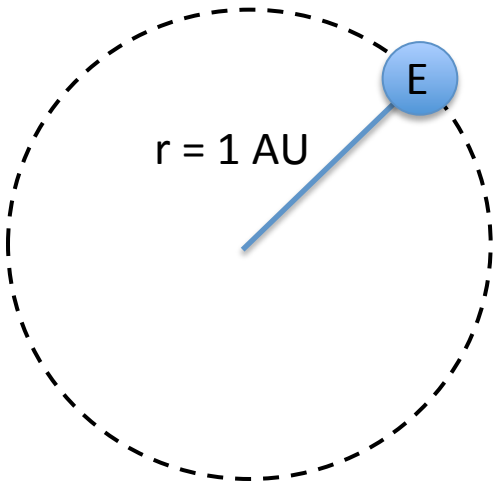
Race Car driving in circle

Centripetal force → Friction Force

Any other examples of circular motion?

The Earth circles the Sun at an average distance of 1 Astronomical Unit (AU) = 1.5 x 10^{11} meters in one year.

What is its orbital centripetal acceleration?



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

$$a_{radial} = \frac{4\pi^2 (1.5\times10^{11} m)}{(3.155\times10^{7} s)^2}$$

$$a_{radial} = 0.006\ m/s^2$$

Sometimes we quote accelerations relative to g (9.81 m/s^2).

$$a_{radial} = 0.006\ m/s^2 \times \frac{1g}{9.81 m/s^2} \approx 0.0006\, g = 0.06\%\ \text{of g}$$

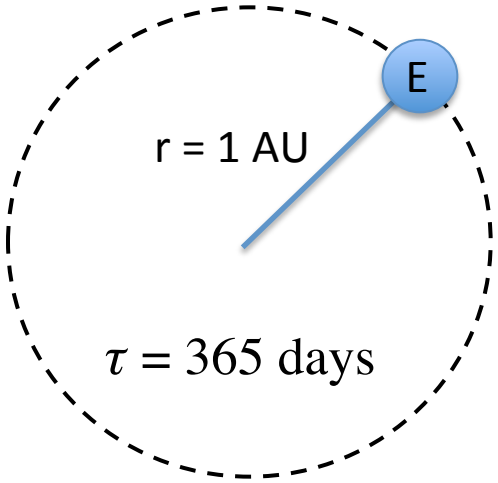
Any other examples of circular motion?

What is the centripetal force in this case?

Clicker Question

Room Frequency BA

The Earth circles the Sun at an average distance of $1\ AU = 1.5 \times 10^{11}$ m in 1 year.



What's causing the centripetal acceleration?

A) The electrostatic force between the Earth and Sun.

B) The tension in the string connecting the Earth to the Sun.

C) The force of gravity between the Earth and the Sun.

D) Depends on the time of day.