SAFALTA CLASS™

An Initiative by अमर उजाला

Q. A goalkeeper in a game of football pulls his hands backwards after holding the ball shot at the goal. This enables the goalkeeper to:

(a) Exert large force on the ball

(b) Increases the force exerted by the ball on hands

(c) Increase the rate of change of momentum

(d) Decrease the rate of change of momentum

- Q. फ़ुटबॉल के एक खेल में एक गोलकीपर अपने हाथों को पीछे की ओर खींचता है, गोल पर गेंद को मारने के बाद। इससे गोलकीपर सक्षम होता है:

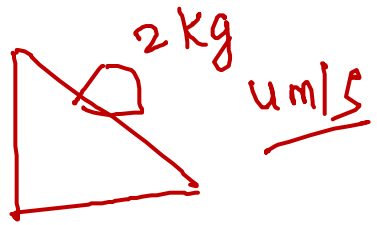
- (ए) गेंद पर बड़ी ताकत लगाओ

- (b) हाथों पर गेंद द्वारा लगाए गए बल को बढ़ाता है

- (c) संवेग के परिवर्तन की दर में वृद्धि

- (d) संवेग के परिवर्तन की दर में कमी

Q. An object of mass 2 kg is sliding with a constant velocity of 4 m/s on a friction less horizontal table. The force required to keep the object moving with the same velocity is:



(a) 32 N

(b) 0 N

(c) 2 N

(d) 8 N

- Q. द्रव्यमान 2 किलोग्राम का एक ऑब्जेक्ट घर्षण कम क्षैतिज तालिका पर 4 m / s के निरंतर वेग के साथ फिसल रहा है। वस्तु को समान वेग से गतिमान रखने के लिए आवश्यक बल है:

- (a) 32 एन

- (b) 0 एन

(c) 2 एन

(d) 8 एन

Q. In a rocket, a large volume of gases produced by the combustion of fuel is allowed to escape through its tail nozzle in the downward direction with the tremendous speed and makes the rocket to move upward.

Which principle is followed in this take off of the rocket?

(a) Moment of inertia

(b) Conservation of momentum

(c) Newton's third law of motion

(d) Newton's law of gravitation

- प्र। एक रॉकेट में, ईंधन के दहन द्वारा उत्पादित गैसों की एक बड़ी मात्रा को जबरदस्त गति के साथ नीचे की दिशा में अपनी पूंछ की नोक के माध्यम से भागने की अनुमति दी जाती है और रॉकेट को ऊपर की ओर बढ़ने के लिए बनाता है।
- रॉकेट के टेक ऑफ में किस सिद्धांत का पालन किया जाता है?

- (ए) जड़ता का क्षण

- (b) संवेग का संरक्षण

- (c) न्यूटन की गति का तीसरा नियम

- (d) न्यूटन के गुरुत्वाकर्षण का नियम

Q, When a balloon held between the hands is pressed, its shape changes. This happens because:

(a) Balanced forces act on the balloon

(b) Unbalanced forces act on the balloon

(c) Frictional forces act on the balloon

(d) Gravitational force acts on the balloon

- क्यू, जब हाथों के बीच रखा एक गुब्बारा दबाया जाता है, तो इसका आकार बदल जाता है। ऐसा इसलिए होता है क्योंकि:

- (a) गुब्बारे पर संतुलित बल कार्य करते हैं

- (b) असंतुलित बल गुब्बारे पर कार्य करते हैं

- (c) घर्षण बल गुब्बारे पर कार्य करते हैं

- (d) गुब्बारे पर गुरुत्वाकर्षण बल कार्य करता है

Q. The speed of a car weighing 1500 kg increases from 36 km/h to 72 km/h uniformly. What will be the change in momentum of the car?

(a) 15000 kg km/h

(b) 15000 kg m/s

(c) 54000 kg m/s

(d) 54000 g m/s

$\vec{a} = 36$ km/h

$= 36 \times \frac{5}{18}$

$\vec{a} = 10$ m/s^2

$\vec{F} = ma$

$= 1500 \times 10$

$= 15000$ kg-m/s^2

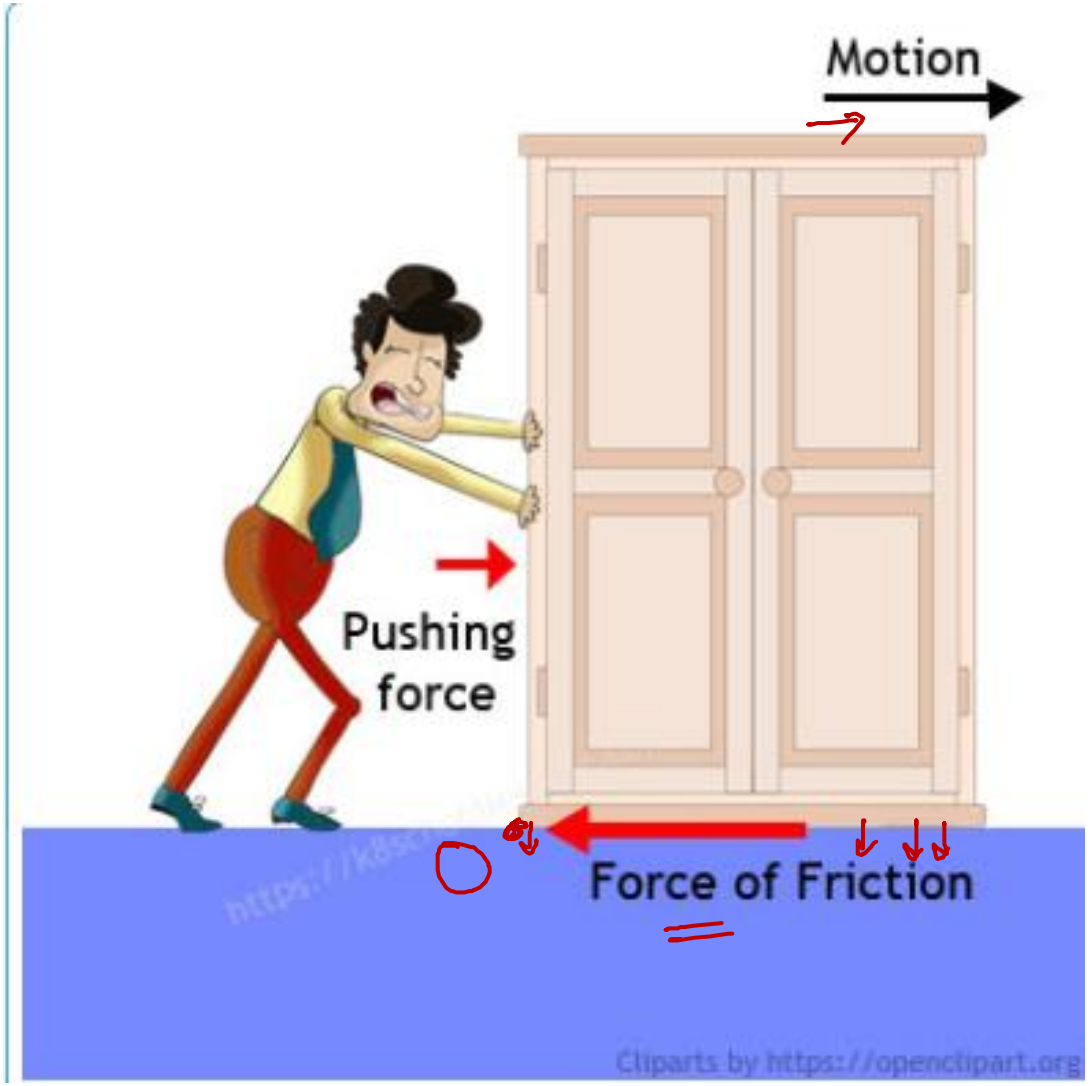
- Q. 1500 किग्रा वजन वाली कार की गति 36 किमी / घंटा से बढ़कर 72 किमी / घंटा तक समान रूप से बढ़ जाती है। कार की गति में क्या बदलाव होगा?

- (a) 15000 किलो किमी / घंटा

- (b) 15000 किग्रा मी / से

- (c) 54000 किग्रा मी / से

- (d) 54000 ग्राम m / s



Friction Force

घर्षण बल

Learning Objectives

- I can explain what causes friction and how it affects the motion of an object.
- I can identify and describe the four types of friction.
- I can give examples of the four types of friction.

- घर्षण क्या होता है और यह किसी वस्तु की गति को कैसे प्रभावित करता है।
- चार प्रकार के घर्षण की पहचान और वर्णन ।
- चार प्रकार के घर्षण का उदाहरण ।

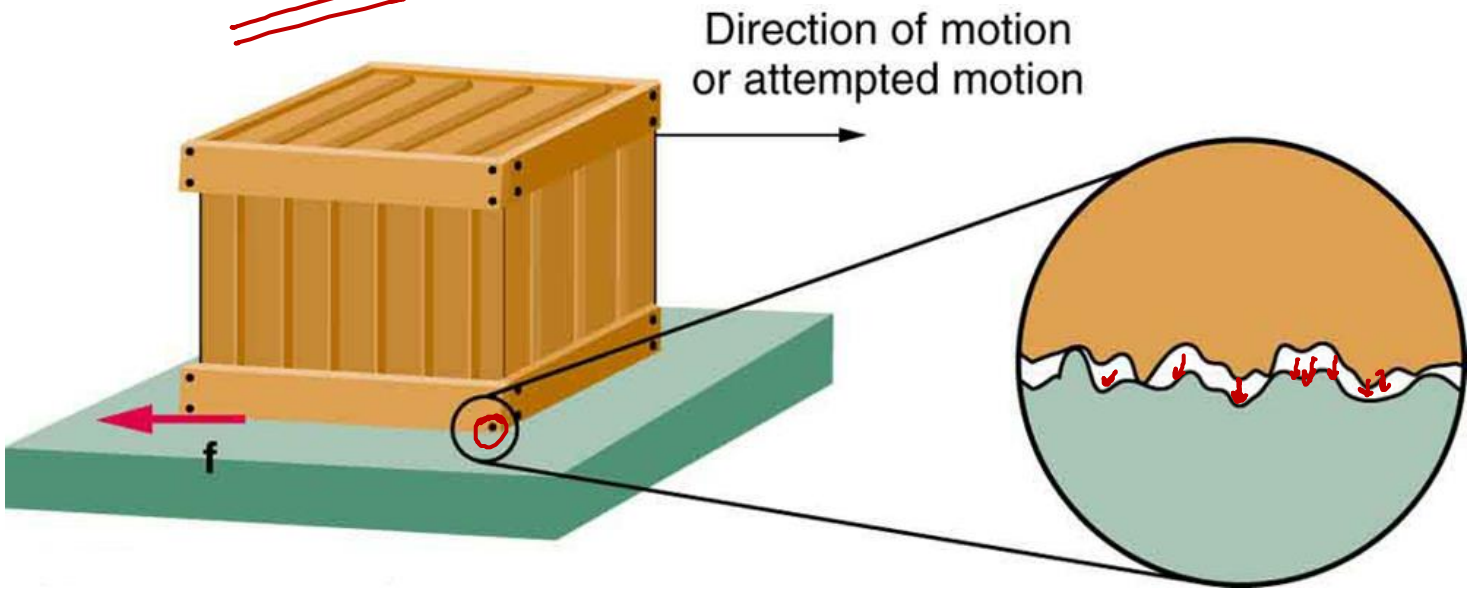
Forces: Friction

Friction is a force that opposes motion between two surfaces.

घर्षण एक बल है जो दो सतहों के बीच गति का विरोध करता है।

Forces: Friction

Friction occurs because the surface of any object is rough. Even surfaces that feel smooth are covered with **microscopic hills** and **valleys**.

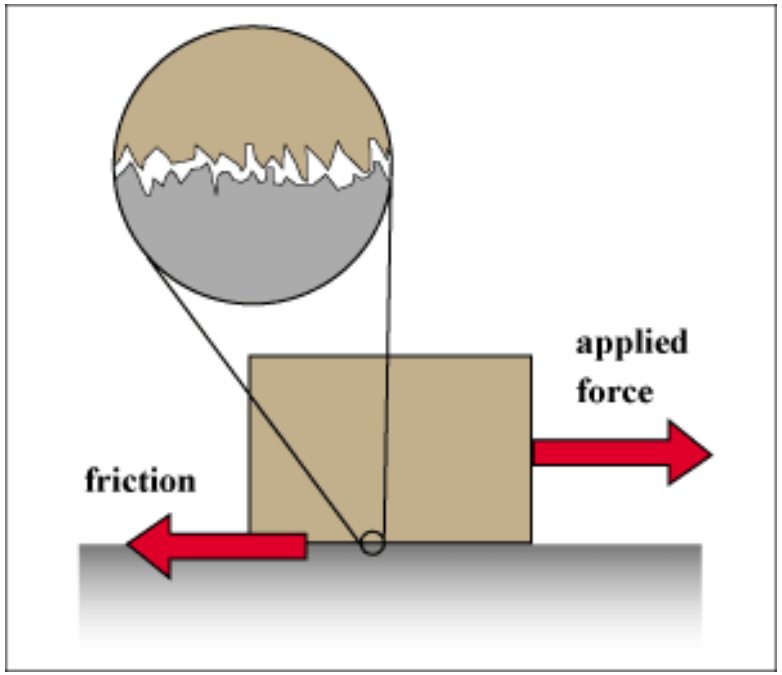


बल: घर्षण

- घर्षण इसलिए होता है क्योंकि किसी भी वस्तु की सतह खुरदरी होती है। यहां तक कि चिकनी महसूस करने वाली सतहों को सूक्ष्म पहाड़ियों और घाटियों के साथ कवर किया गया है।

Forces: Friction

When two surfaces are in contact, the **hills and valleys** of one surface **stick** to the **hills and valleys** of the other surface.



Electrostatic Force
चिपक बहुत बल

बल: घर्षण

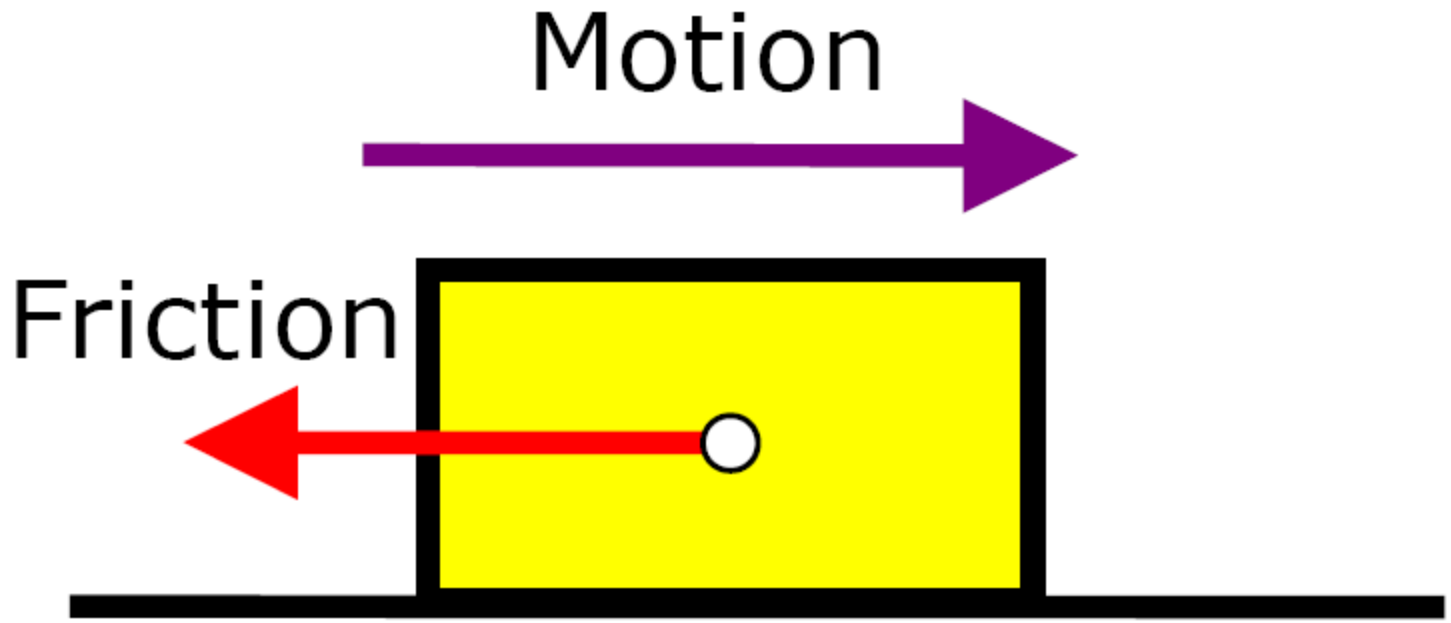
- जब दो सतहें संपर्क में होती हैं, तो एक सतह की पहाड़ियाँ और घाटियाँ दूसरी सतह की पहाड़ियों और घाटियों से चिपक जाती हैं।

Friction Factors

The amount of friction depends on these 2 factors:

1. Roughness of the surfaces

2. The force pushing the surfaces together.

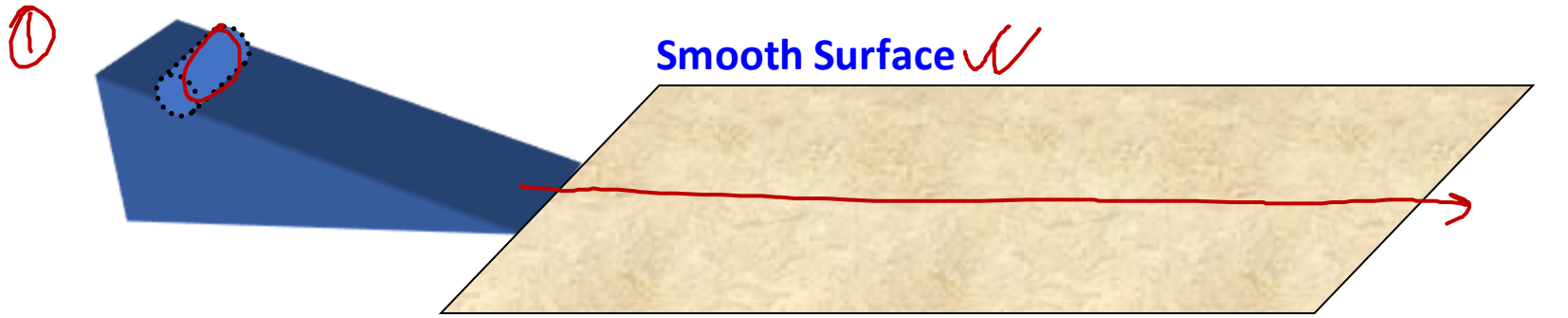


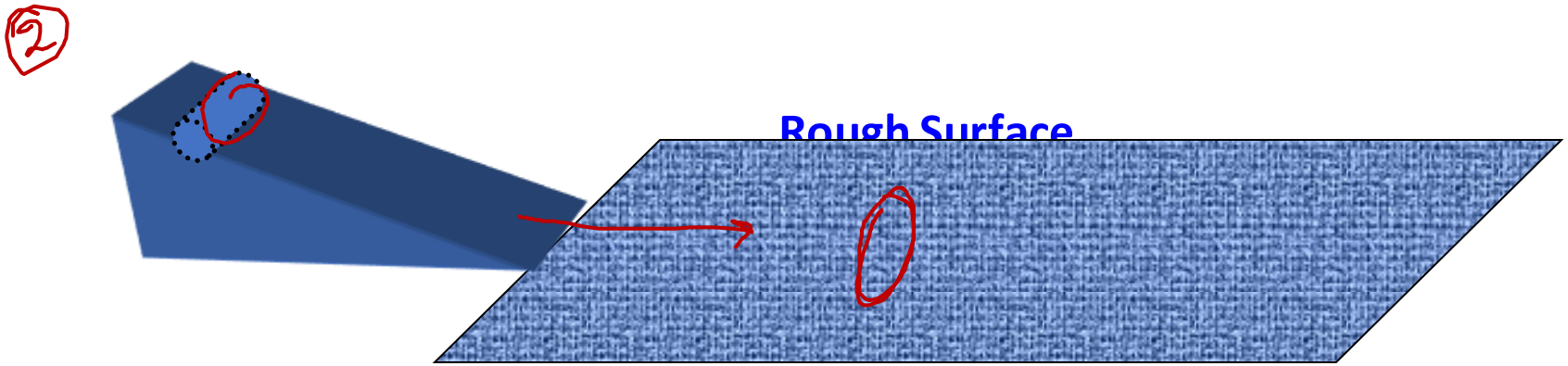
घर्षण कारक

- घर्षण की मात्रा इन 2 कारकों पर निर्भर करती है:
- 1. सतहों की खुरदरापन
- 2. सतहों को एक साथ धकेलने वाला बल।

Will the tube roll less over a smoother surface or a rougher surface? Why?

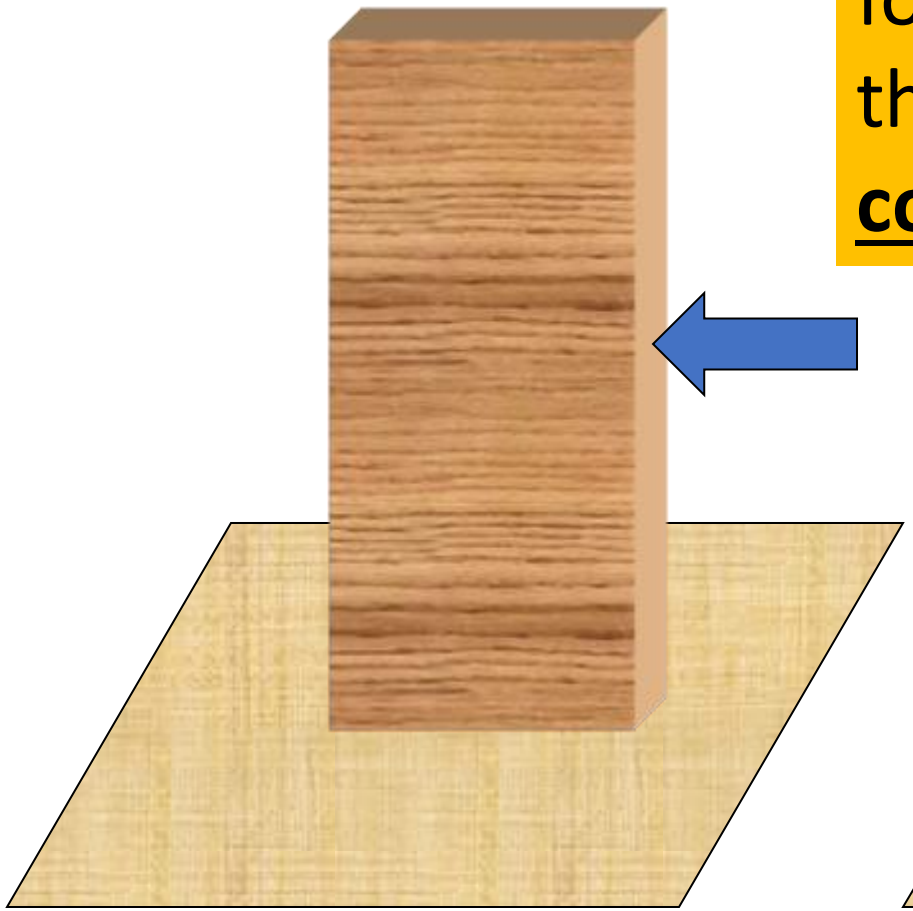
The rougher surface because there are **more hills and valleys** and the **valleys are deeper**.





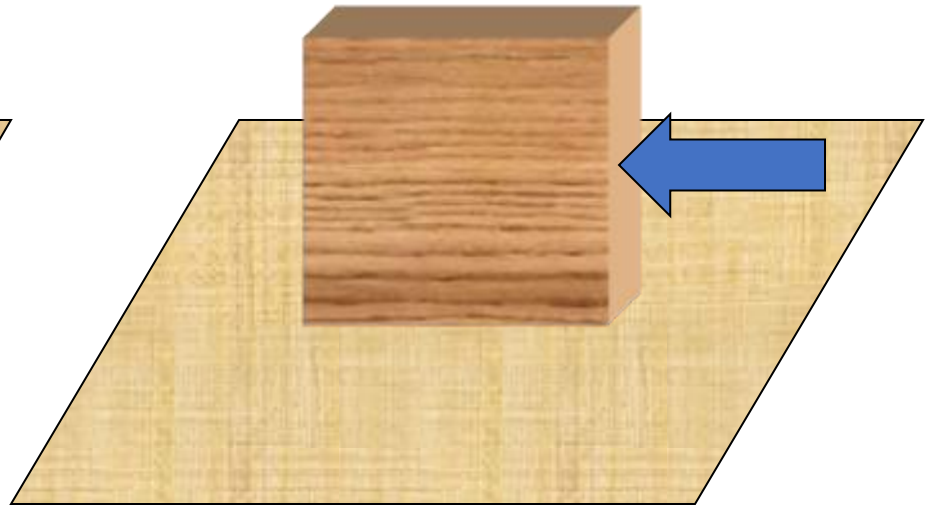
Which has more friction and why?

100 pounds



The 100 pound box because the force pushing together is higher so the **hills and valleys** are in **closer contact.**

40 pounds



Friction Factors Review

1. **Roughness** – The rougher the surface, the more hills and valleys there are and the greater the friction.

2. **Force pushing together/weight** – Force is increased, the hills and valleys will be in closer contact and friction will increase.

Amount of Surface Area in fluids

सतह का क्षेत्रफल

- The amount of surface area affects the friction between objects in liquids and gases. Example: Swimming
- सतह क्षेत्र की मात्रा तरल पदार्थ और गैसों में वस्तुओं के बीच घर्षण को प्रभावित करती है। उदाहरण: तैरना

Surface Area in Fluids

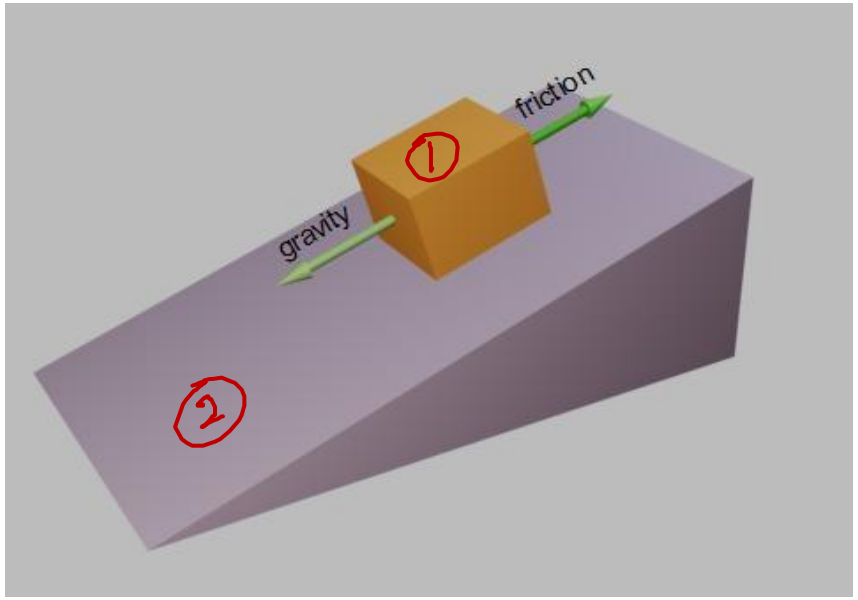
- **The amount of surface area affects the friction on a moving object under the following circumstances:**
  - **air resistance (such as the size of a parachute)**
  - **the resistance of an object as it glides through water (such as a boat).**

- **सतह क्षेत्र की मात्रा निम्नलिखित परिस्थितियों में एक चलती वस्तु पर घर्षण को प्रभावित करती है:**
- **वायु प्रतिरोध (जैसे पैराशूट का आकार)**
- **किसी वस्तु का प्रतिरोध पानी के माध्यम से (जैसे नाव) के रूप में चमकता है।**

Surface area between Solids

- **The amount of surface area in contact usually does not affect friction between two solids.**

- Reason larger surface areas have more contact but the pressure between the 2 is less. The increase in friction area is offset by the reduction in pressure



सॉलिड्स के बीच सतह क्षेत्र

- संपर्क में सतह क्षेत्र की मात्रा आमतौर पर दो ठोस पदार्थों के बीच घर्षण को प्रभावित नहीं करती है।
- - कारण बड़े सतह क्षेत्रों में अधिक संपर्क होता है लेकिन 2 के बीच का दबाव कम होता है। दबाव में कमी से घर्षण क्षेत्र में वृद्धि ऑफसेट है

Frictional Force (घर्षण बल) :

Frictional force refers to the force generated by two surfaces that contacts and slide against each other.

घर्षण बल एक प्रकार का बल होता है जो जो दो तलों के बीच सापेक्षिक स्पर्शी गति का विरोध करता है ।

- 4. If an object is pushed against the surface, then the frictional force will be increased and becomes more than the weight of the object.

यदि किसी वस्तु को सतह के विरुद्ध धकेला जाता है, तो घर्षण बल को बढ़ाया जाएगा और वस्तु के भार से अधिक हो जाएगा।

- **Calculating the Force of Friction :**

$$F_{frict} = \mu \bullet F_{norm}$$

- **<u>घर्षण बल की विशेषताऐं – Features of frictional force</u>**

- दो सतहों के मध्य लगने वाला घर्षण बल उनके सम्पर्क क्षेत्रफल पर निर्भर नहीं करता है यह केवल सतहों की प्रकृति पर निर्भर करता है

- लोटनिक घर्षण बल का मान सबसे कम और स्थैतिक घर्षण बल का मान सबसे अधिक है

- घर्षण बल के कारण ही मनुष्य सीधा खडा रह पाता है तथा चल पाता है

- घर्षण बल न होने पर हम केले के छिल्के तथा बरसान में चिकनी सडक पर फिसल जाते हैं

- **A few factors affecting the frictional force:**

1. These forces are mainly affected by the surface texture and amount of force impelling them together.

ये बल मुख्य रूप से सतह की बनावट और उन्हें एक साथ लगाने वाले बल की मात्रा से प्रभावित होते हैं।

2. The angle and position of the object affect the amount of frictional force.

ऑब्जेक्ट का कोण और स्थिति घर्षण बल की मात्रा को प्रभावित करती है।

3. If an object is placed flat against an object, then the frictional force will be equal to the weight of the object.

यदि किसी वस्तु को किसी वस्तु के खिलाफ सपाट रखा जाता है, तो घर्षण बल होगा वस्तु के भार के बराबर।

Different Types of Frictional Force

- Dry Friction
    - Static Friction
    - Kinetic Friction
    - Rolling Friction
    - Sliding Friction
- Fluid Friction

• घर्षण बल के प्रकार – Types of frictional force

- स्थैतिक घर्षण बल (Static friction force) – जब किसी बस्तु को खिसकाने के लिए बल लगया जाता है बस्तु अपने स्थान न खिसके तो बस्तु और उस सतह के मध्य लगने वाले बल को स्थैतिक घर्षण बल इसका परिमाण लगाए गए बल के बराबर तथा दिशा बल की दिशा के विपरीत होती है

- सर्पी घर्षण बल (Sliding frictional force) – जब कोई बस्तु किसी सतह पर सरकती है तो बस्तु और उस सतह के बीच लगने वाला बल सर्पी घर्षण बल कहलाता है

- लोटनिक घर्षण बल (Rolling frictional force) – जब कोई बस्तु किसी सतह पर लुढकती हैं तो बस्तु और उस सतह के बीच लगने वाला बल लोटिनिक घर्षण बल कहलाता है

- **Examples of Fluid Friction :**

To avoid creaking sounds from doors, we lubricate the door hinges which leads to the smooth functioning of door hinges.

When you drop the ball in a full bucket of water, water splashes out of the bucket and is all because of buoyancy of fluid.

Types of Friction

1. Sliding
2. Fluid
3. Rolling
4. Static

Sliding Friction

- **Sliding friction** is a friction force that opposes the direction of motion of an object that occurs when solid surfaces slide over one another.
- Examples:
  - Writing – pencil point and paper
  - Combing your hair – surface of comb and strands of hair

Fluid Friction

- The force that tries to slow objects down when they move through a liquid or a gas. It's also known as "drag", or "air resistance". हवा का प्रतिरोध
- All gases and liquids are fluids.
- Fluid Friction increases as the speed of the object increases.
- An airplane and a swimmer both experience fluid friction.

Rolling Friction

- **Rolling friction** is friction that occurs between surfaces in motion that are rolling in which one of the surfaces is a wheel, roller, or ball.
- Examples:
  - Riding a bike – tires and ground
  - Bowling – ball and lane

Static Friction स्थिर घर्षण

- Static friction is friction that occurs when the surfaces in contact are at rest (not in motion).

- Examples:
  - A book resting on a desk.
  - A potted plant sitting on a sidewalk.

Ways to Reduce Friction

- Smooth the surface – less hills and valleys and there are not as deep.
- Replace sliding with rolling (Use Wheels)
- Add a lubricant like oil, wax, or grease – Fills in the hills and valleys.
- Less force pushing together – The hills and valleys are not pushed together as hard so they have less contact.

Ways to Increase Friction

- Rough the surface – more hills and valleys and there are not are deeper.
- Replace rolling with sliding
- More force pushing together – The hills and valleys are pushed together harder so the hills and valleys are in closer contact.

Friction Song

- What is friction?
  - Friction Video

Forces: Friction

Friction is both harmful and helpful. Turn to an elbow partner and identify some examples of friction being harmful and friction being helpful.

Forces: Friction

(a) **Prevents us from slipping** when walking or running

Friction between the sole of a shoe and the surface of the ground prevents us from slipping.

(b) **Stops a moving vehicle**

A moving vehicle will stop when the brake is pressed because there is friction between the tyres and the road surface.

(c) **Keeps the position** of an object on a surface

Our furniture does not move because there is friction between the base and the floor surface.

(d) **Produces fire**

Friction between a match and the box can produce fire.

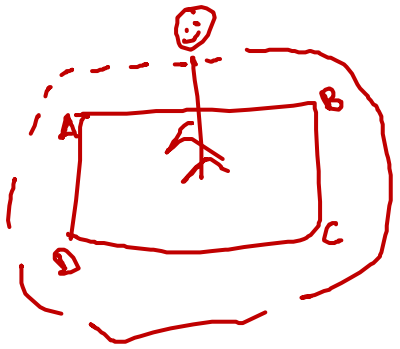
(e) **Holds or grips things**

Friction helps us to hold a glass or grip a pencil and write.

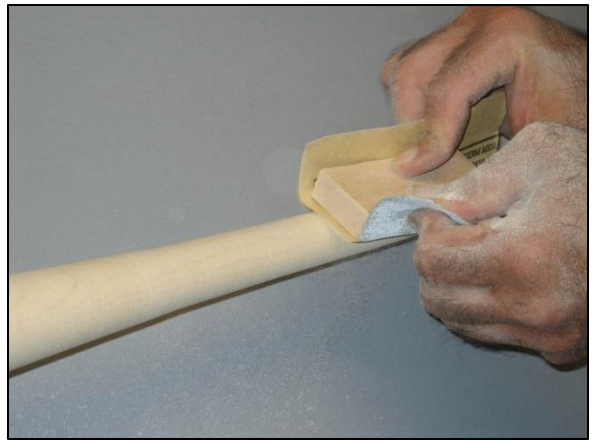
(f) **Sharpens a knife**

Friction causes an object to wear out.This enables us to sharpen a knife or pencil.

Forces: Friction



Is it beneficial to reduce or increase friction? Why or Why Not?



Forces: Friction

Which of the following would NOT help you move a heavy object across a concrete floor?

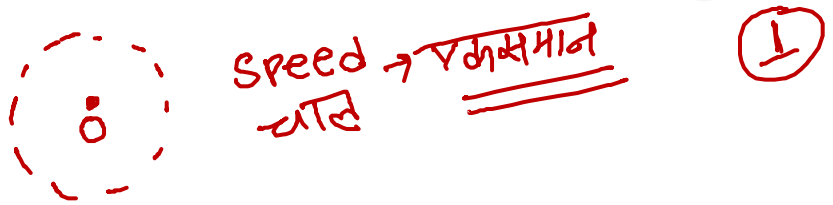
Water, ball bearings, oil, liquid soap, steel rods, foam rubber

Name three common items you might use to increase friction.

UCM (UNIFORM CIRCULAR MOTION)

एकसमान वृत्तीय गति

Uniform Circular Motion (एकसमान वृत्तीय गति):



- The movement of a body following a circular path is called a circular motion.

वृत्ताकार पथ का अनुसरण करने वाले पिंड की गति को वृत्तीय गति कहा जाता है।

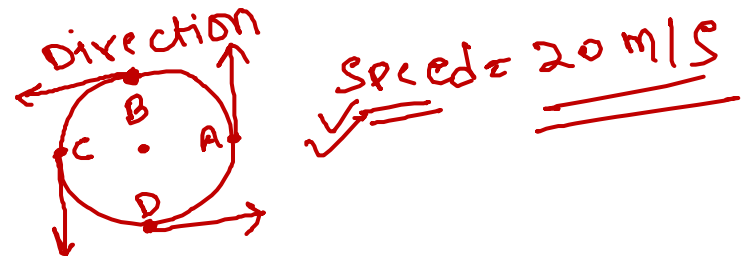
- Now, the motion of a body moving with constant speed along a circular path is called Uniform Circular Motion.

वृत्ताकार पथ के साथ निरंतर गति के साथ गतिमान पिंड की गति को एकसमान वृत्तीय गति कहा जाता है।

- Here, the speed is constant but the velocity changes.

गति स्थिर है लेकिन वेग बदल जाता है।

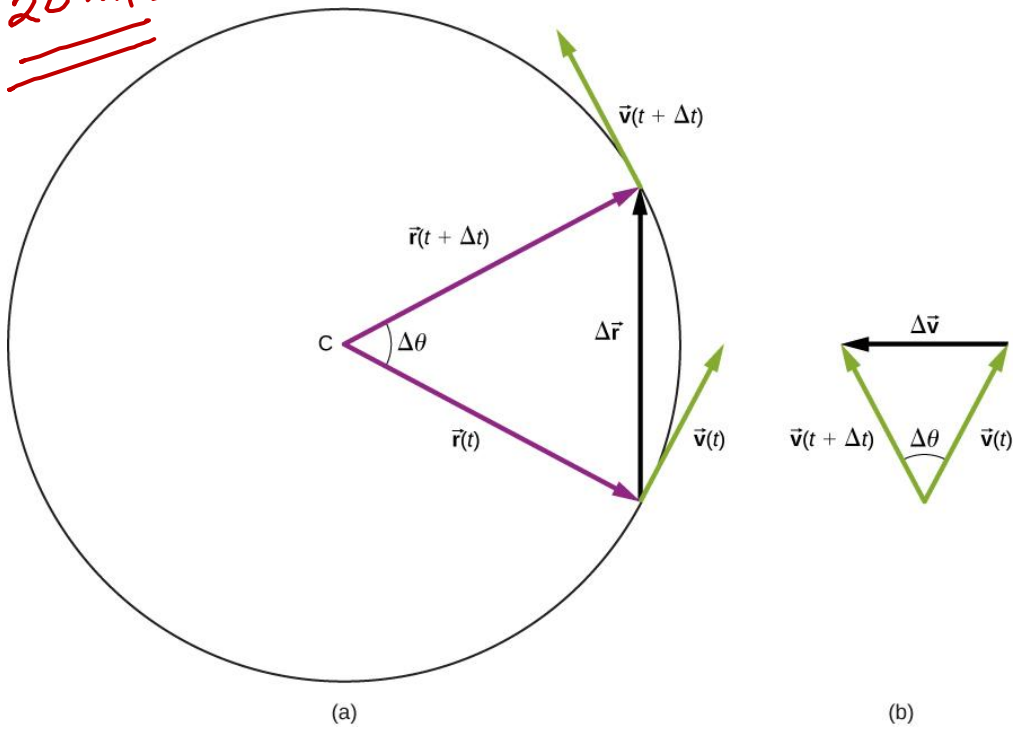
- if a particle is moving in a uniform circular motion:
- 1) Its speed is constant
- 2) Velocity is changing at every instant
- 3) There is no tangential acceleration
- 4) Radial (centripetal) acceleration = ω2r
- 5) v=ωr



constant

Speed = 20 m/s

$\vec{a}$ = 20 m/s2



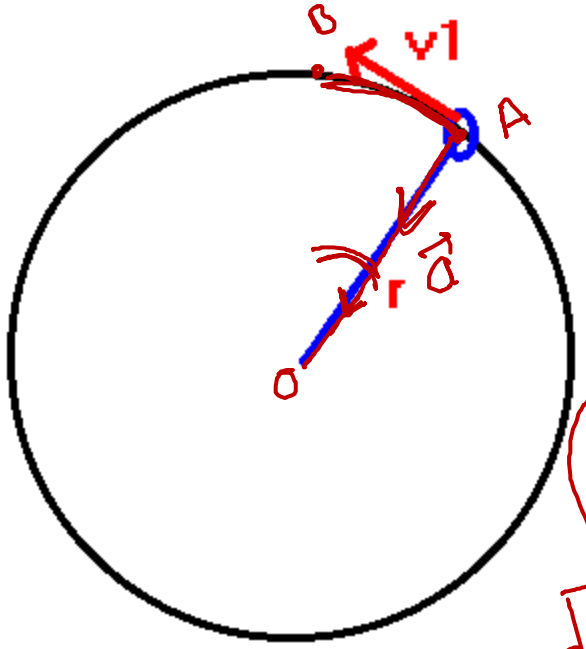
$\vec{a} = |\vec{v}| \cdot \hat{v}$

$\vec{a}$

$S = v \times t$

$v = r\omega$

(1)



$\Delta v =$

$\vec{a} = \frac{\Delta v}{\Delta t}$

$\vec{a} = \frac{dv}{dt}$

$\vec{a} = \frac{v^2}{r}$

$\frac{S}{\Delta t} = r \cdot \frac{\Delta\theta}{\Delta t}$

$v = r\omega$

$\omega = \frac{v}{r}$

$F = m\vec{a} = \frac{mv^2}{r}$ अभिकेन्द्र बल

- **Uniform Circular Motion Examples**

- Motion of artificial satellites around the earth is an example of uniform circular motion. The gravitational force from the earth makes the satellites stay in the circular orbit around the earth.

- The motion of electrons around its nucleus.

- The motion of blades of the windmills.

- The tip of second's hand of a watch with circular dial shows uniform circular motion.

- यूनिफॉर्म सर्कुलर मोशन उदाहरण

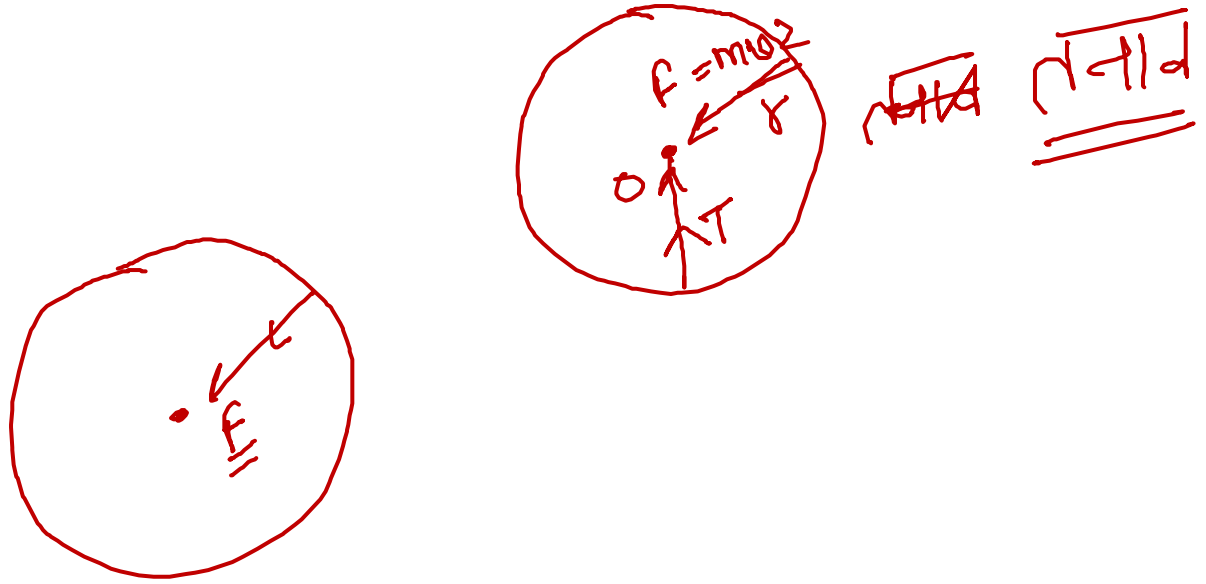
- पृथ्वी के चारों ओर कृत्रिम उपग्रहों का गति एक समान परिपत्र गति का एक उदाहरण है। पृथ्वी से गुरुत्वाकर्षण बल उपग्रहों को पृथ्वी के चारों ओर वृत्ताकार कक्षा में रहने देता है।

- इसके नाभिक के चारों ओर इलेक्ट्रॉनों की गति।

- पवनचक्कियों के ब्लेड की गति।

- परिपत्र डायल के साथ एक घड़ी के दूसरे हाथ की नोक समान परिपत्र गति दिखाती है।

Centripetal Force : **Centripetal force is the component of force acting on an object in curvilinear motion which is directed toward the axis of rotation or center of curvature.**



अभिकेंद्रीय बल एक ऐसा बल है जो किसी भी वस्तु को वृत्तीय पथ (circular path) में घूमने में मदद करता है इसका मुख्य निर्देशित केंद्र में होता है और उसका परिमाण स्थिर रहता है यह किसी भी वस्तु के वजन (weight) व सामूहिक(mass) पर निर्भर करता है इसे ही अभिकेंद्रीय बल (Centripetal force) कहते है

1. गोल घूमते हुए झूले पर बैठे लोग अभिकेंद्रीय बल के कारण बाहर की और चले जाते है

2. जब हम किसी रस्सी से गेंद को बांधकर रस्सी के एक छोर को पकड़कर चारों और घुमाते है तो उस रस्सी में जो तनाव पैदा होता है वह उस गेंद को केंद्र के इर्द गिर्द ही घूमता है यह अभिकेंद्रीय बल कहलाता है

- **Centrifugal Force :** Centrifugal force is a force that arises from the body's inertia and appears to act on a body that is moving in a circular path which is directed away from the centre around which the body is moving.

- Weight of an object at the poles and on the equator

- A bike making a turn.

- Vehicle driving around a curve

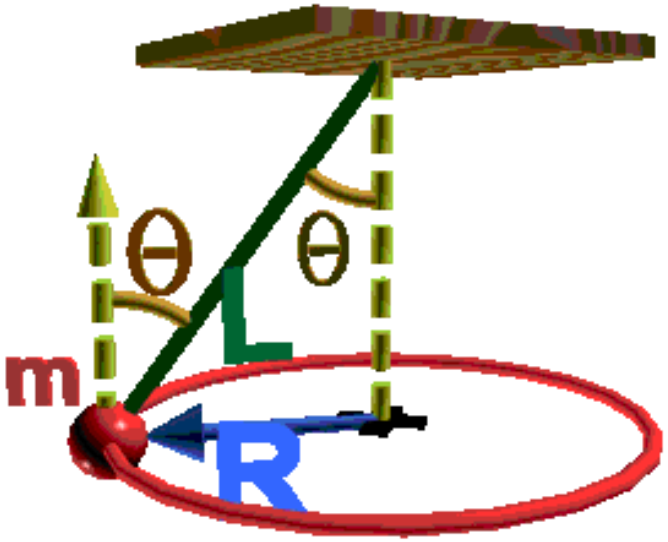
- Equatorial railway

अपकेन्द्रीय बल

- वह बल होता है जिसके कारण किसी गतिशील वस्तु में, केंद्र से दूर भागने की प्रवृत्ति होती है। यह वो आभासी बल होता है जो अभिकेन्द्रीय बल के समान तथा विपरीत दिशा में कार्य करता है।

- क्रीम सेपरेटर तथा सेंट्रीफ्युगल ड्रायर अपकेन्द्रीय बल के सिद्धांत पर कार्य करते हैं।

- न्यूटन यांत्रिकी में **अपकेन्द्री बल** एक जड़त्वीय बल है जो वृत्तीय गति करती हुई वस्तुओं पर गति के पथ के केन्द्र से दूर त्रिज्या की दिशा में लगता हुआ प्रतीत होता है।
- वास्तव में यह एक कल्पित बल (*fictitious force*) है, वास्तविक नहीं।


θ
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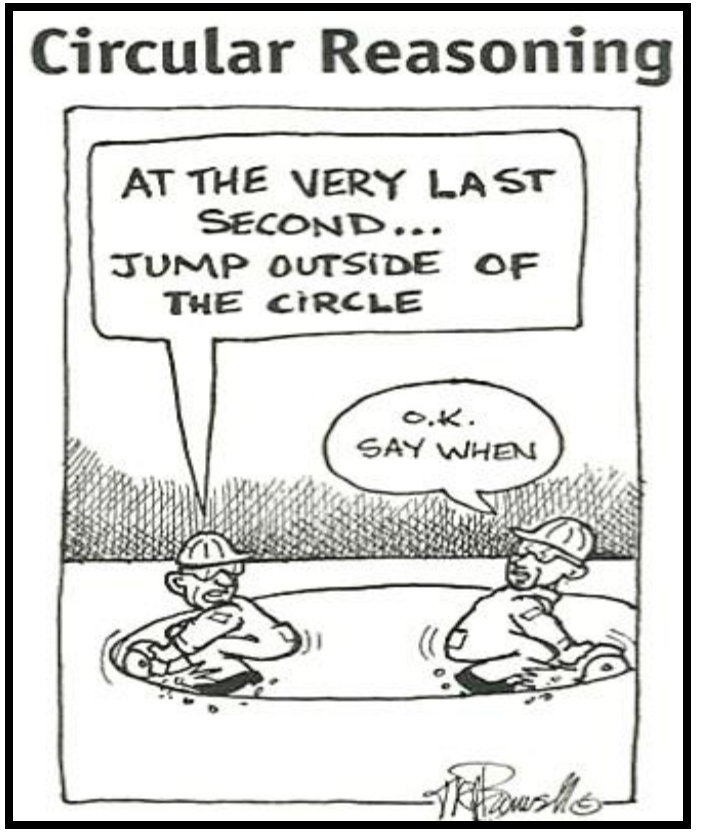
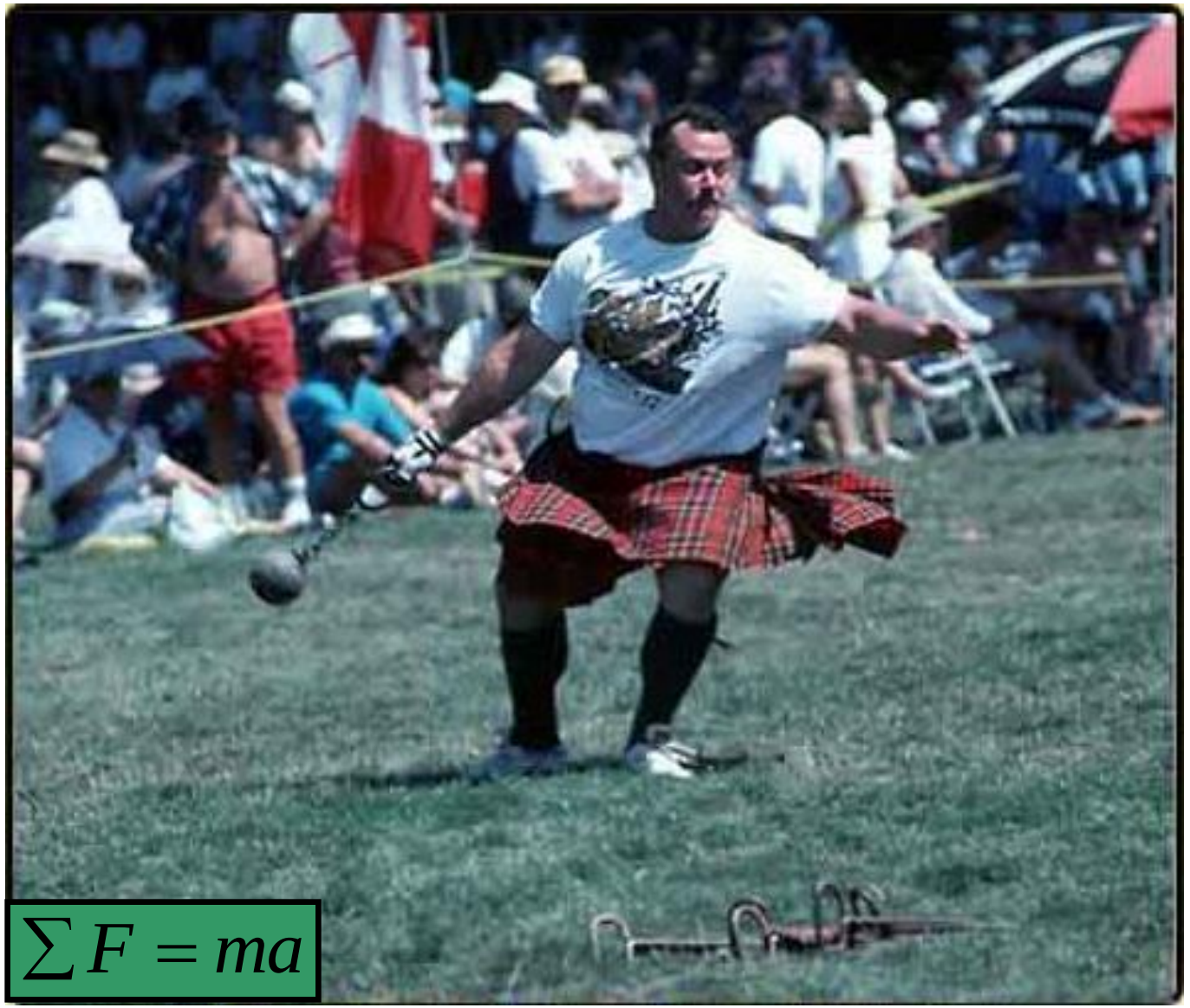
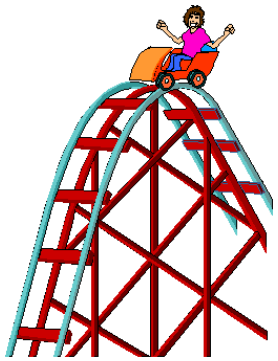
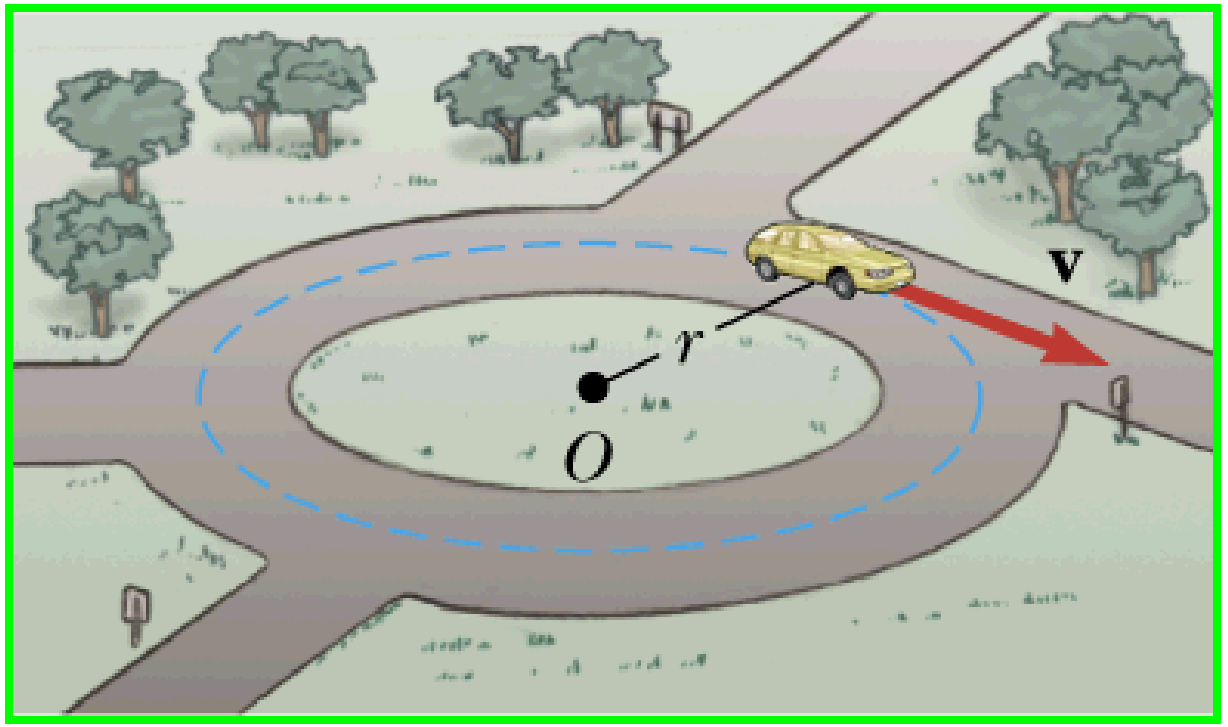

Circular Reasoning
AT THE VERY LAST SECOND... JUMP OUTSIDE OF THE CIRCLE
O.K. SAY WHEN



$$\sum F = ma$$

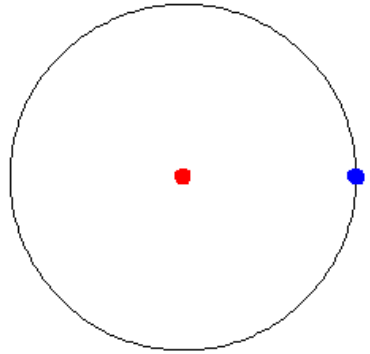
“What is uniform circular motion?”



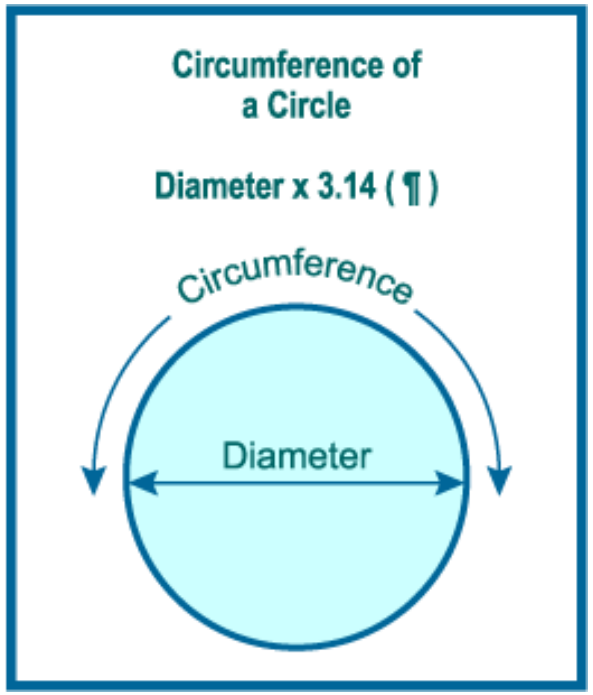


CIRCULAR MOTION

- ***The speed is constant, 'v'***
- ***The velocity is not!***
- ***There is an acceleration***
- ***There is a net force***



Link



$$v\,(speed) = \frac{d}{t} = \frac{2\pi r}{T}$$

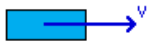
$$a_c = \frac{v^2}{r} = \frac{(\frac{2\pi r}{T})^2}{r} = \frac{4\pi^2 r}{T^2}$$

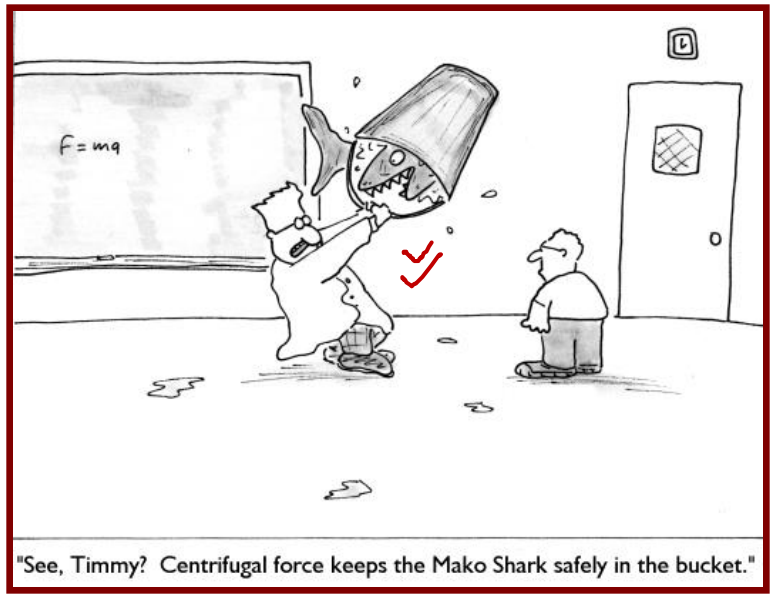
$$T = \frac{1}{f}$$

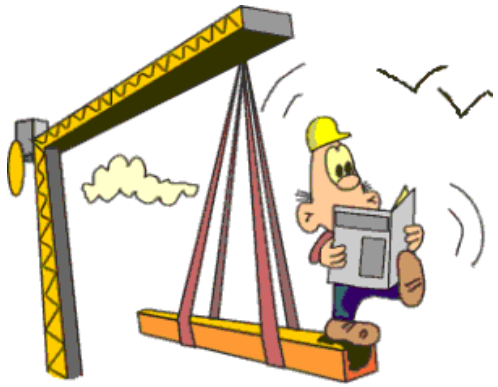
***T* = Period (time per revolution)**
***f* = frequency (revolutions per unit time)**
***v* = speed**
***r* = radius**

To the center ⇒

$$F = \frac{mv^2}{r} = \frac{kg \cdot (m/s)^2}{m} \; kg \cdot m/s^2$$



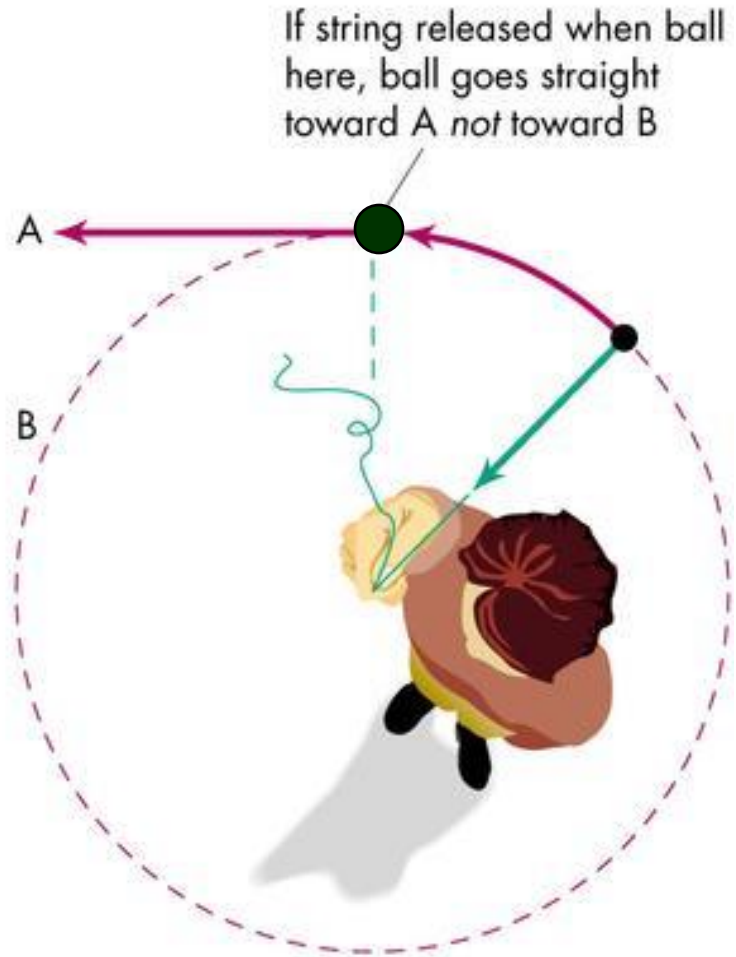




To the center

$$a = \frac{v^2}{r} = \frac{(m/s)^2}{m} = m/s^2$$

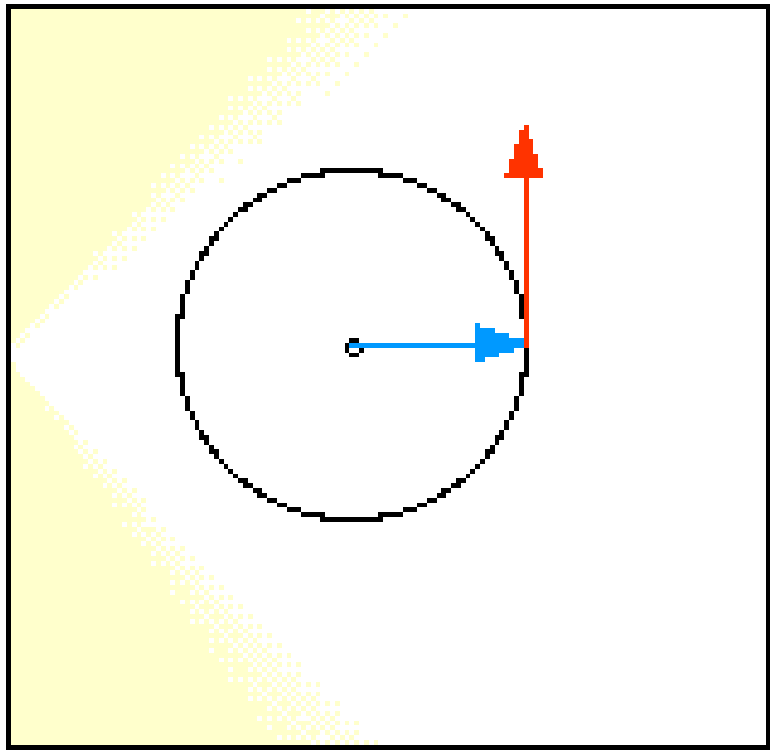
Side view

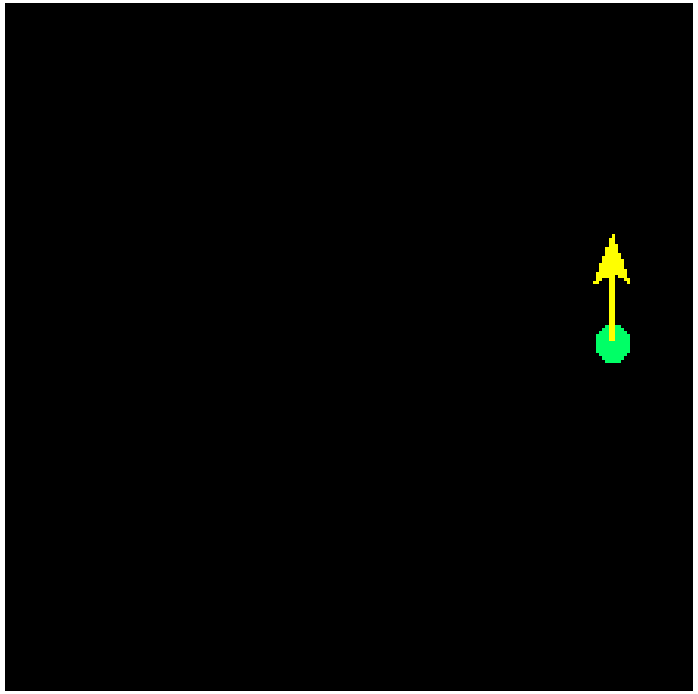


Top view

Constant Speed not Velocity:

The direction of v changes continually!

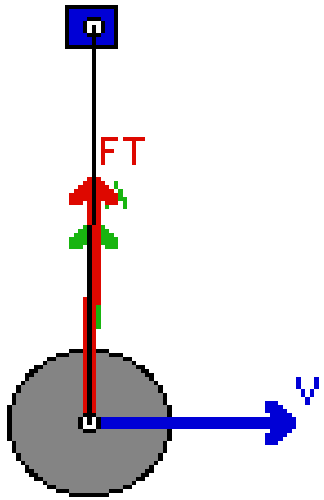




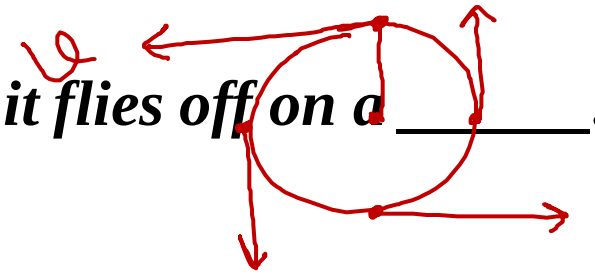
The velocity is always tangent to the path

There must be a force and therefore an acceleration:

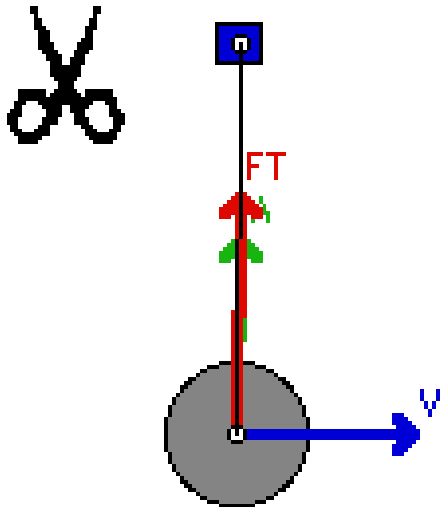
Directed to the center



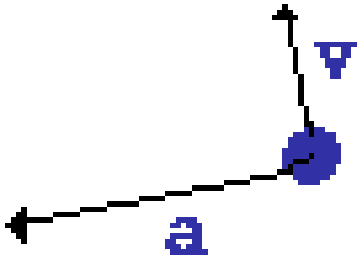
When the string is cut it flies off on a _____.



Tangent



$$F = m\left(\frac{v^2}{r}\right)$$



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

since

$$F_c = ma_c$$

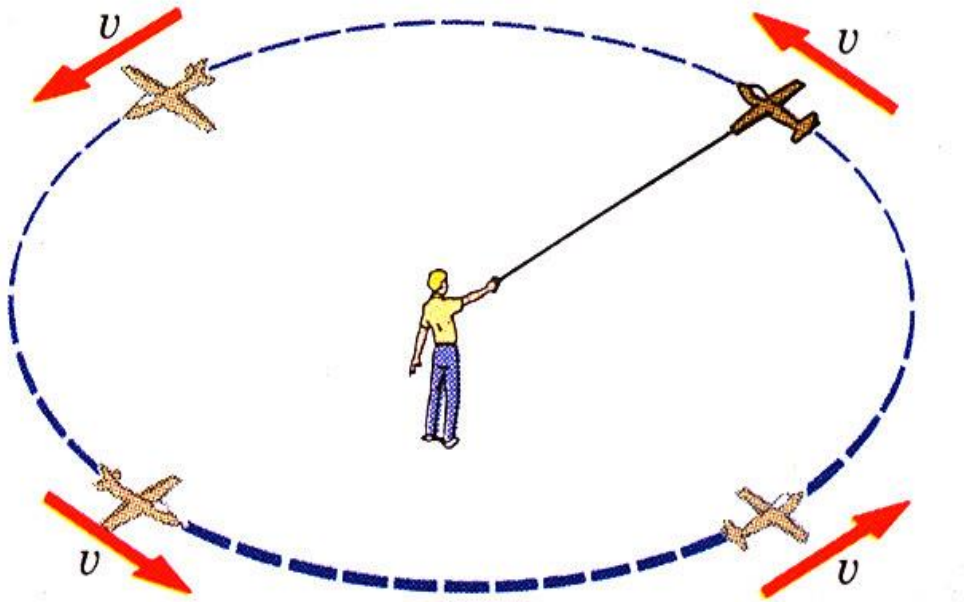
then

$$a_c = \frac{v^2}{r}$$

H.W.

ARJUN flies his model plane, the radius of the orbit is 50 m and the 2 kg plane is flying at 20 m/s.

1. ***What is the tension he feels in his hand?***
2. ***What was the centripetal acceleration of the plane?***
3. ***At the position shown draw in vectors showing the direction of the force, acceleration, and velocity.***



n.w.

A 900-kg car moving at 10 m/s takes a turn around a circle with a radius of 25.0 m. Determine the acceleration and the net force acting upon the car.

1. $a = (v^2)/R$

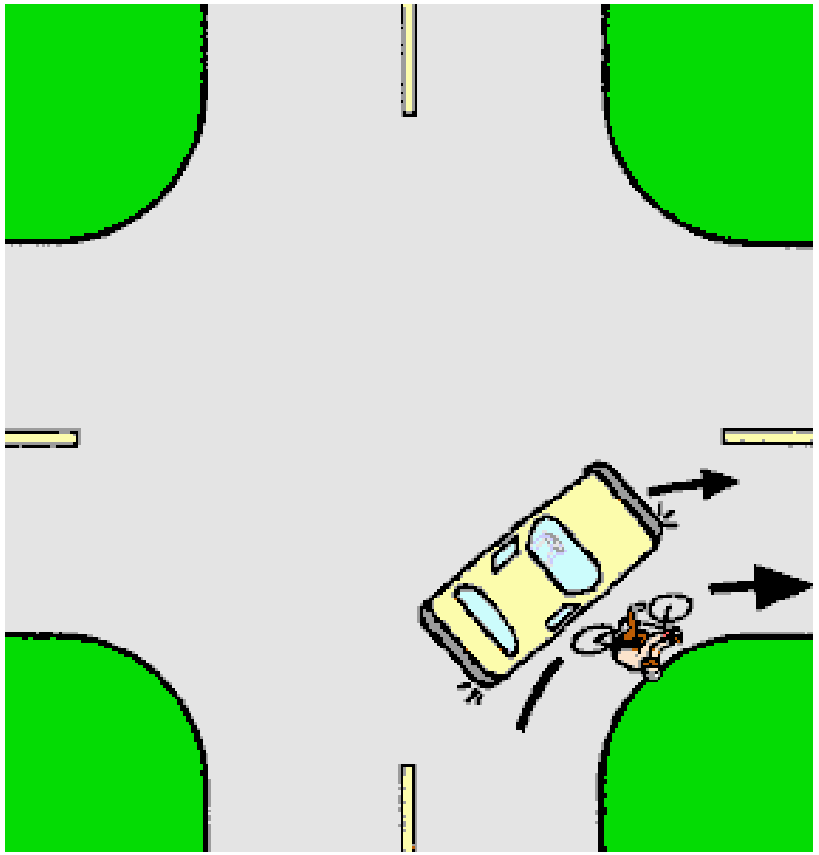
   $a = (10.0\ m/s)^2/(25.0\ m)$

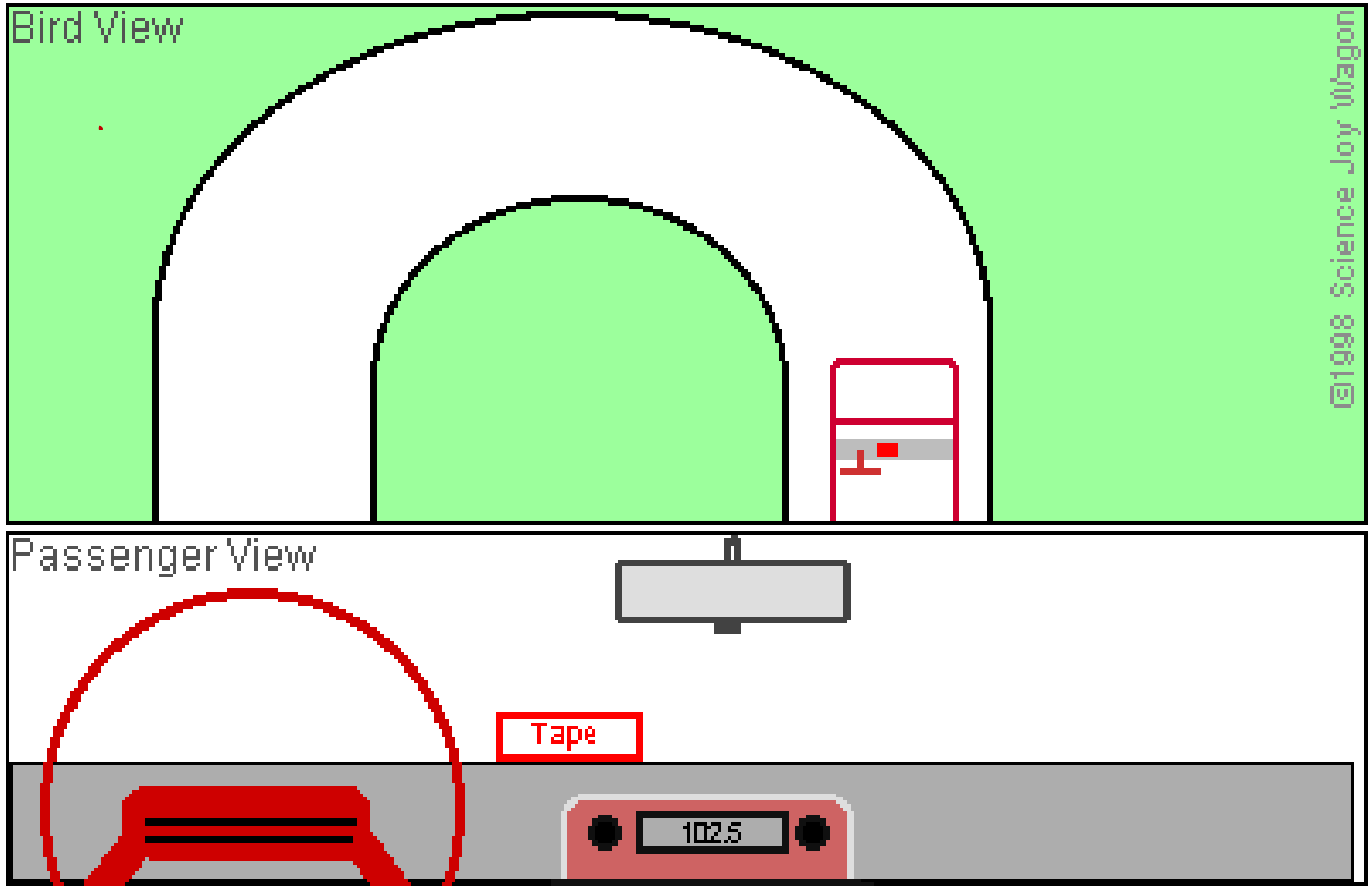
   $a = (100\ m^2/s^2)/(25.0\ m)$

   $a = 4\ m/s^2$

2. $F = ma = (900\ kg) \times (4\ m/s^2)$

   $F = 3600\ N$



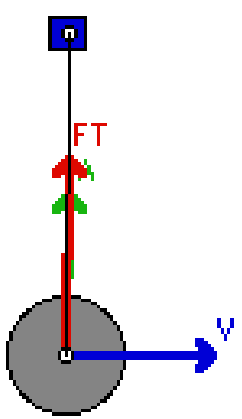


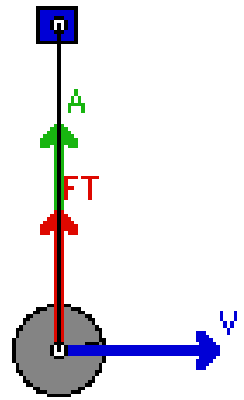
Not enough friction to turn the tape!

Centripetal Force depends on the mass:

Smaller mass → Smaller force

Smaller mass

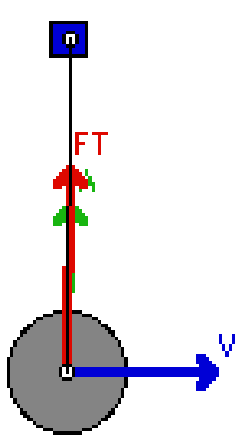


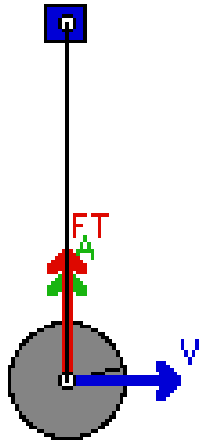


Centripetal Force depends on the velocity

Smaller velocity → Smaller force

Smaller Velocity

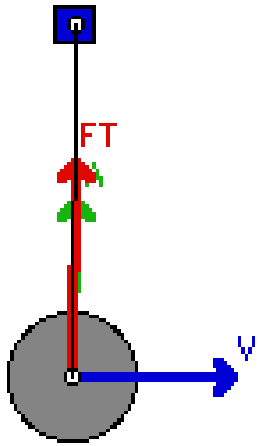


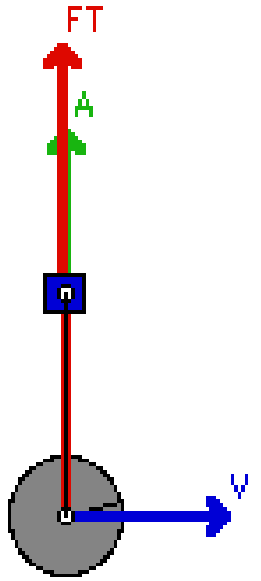


Centripetal Force depends on the radius

Smaller radius → Larger force

Smaller radius





In this animation, the "sticky" or adhesive forces from the tire tread act as the centripetal force. It's large enough to keep the mud in a circular path as the tire spins.

The tire is spinning faster here which means a larger centripetal force is needed to keep the mud in the circular path. The adhesive force is not large enough, it flies off on a tangent and follows Newton's first law!

Hell Hole

The rotor is an amusement park ride where people stand against the inside of a cylinder. Once the cylinder is spinning fast enough, the floor drops out. What force keeps the people from falling out the bottom of the cylinder?

a. Centripetal force

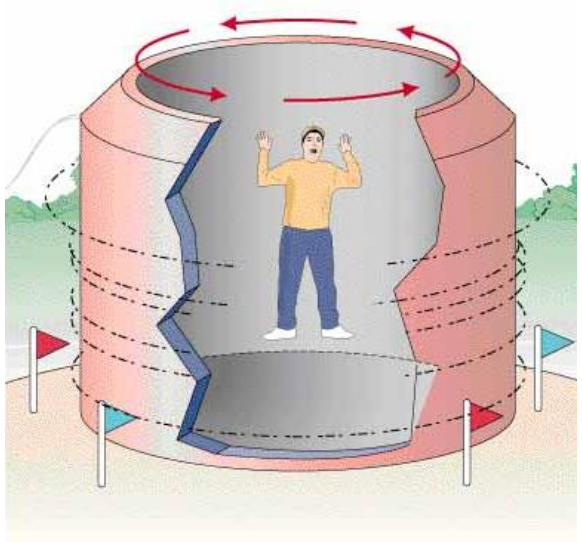
b. Friction ← *correct*

c. Normal force

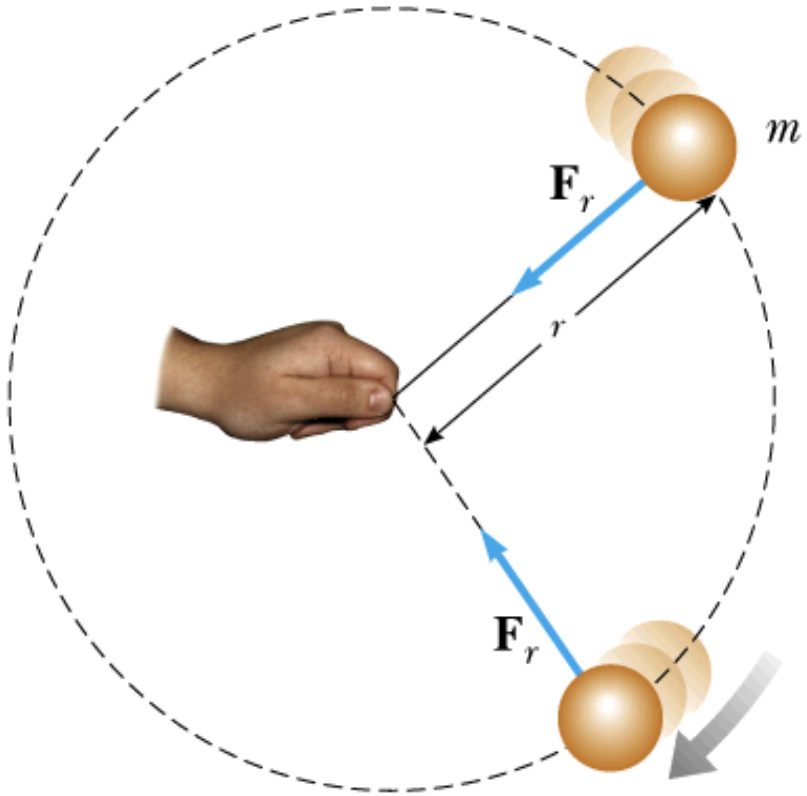
At amusement parks there is a popular ride where the floor of a rotating cylinder room falls away, leaving the backs of the riders "plastered" against the wall. Suppose the radius of the room is 3.3 m and the speed of the wall is 10m/s when the floor falls away.

1. ***How much centripetal force acts on a 55 kg rider?***
2. ***What is the minimum coefficient of static friction that must exist between the rider's back and wall, if the rider is to remain in place when the wall falls away?***

$$F_C = \frac{mv^2}{r} = \frac{(55kg)(10m/s)^2}{3.3m} = 1,667N$$



Newton's Second Law Applied to Circular Motion

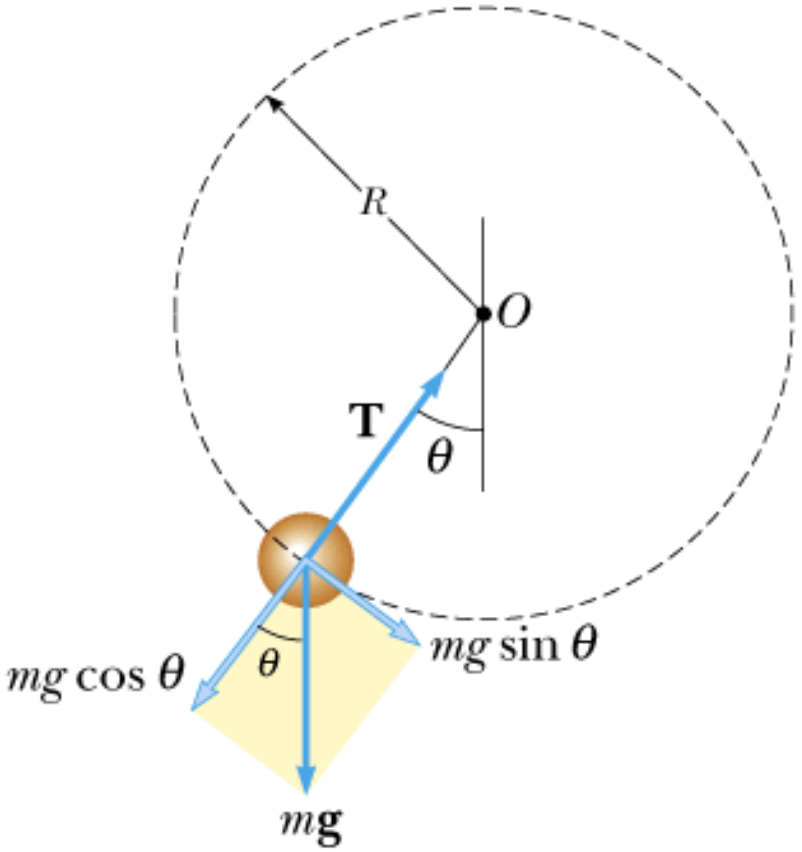


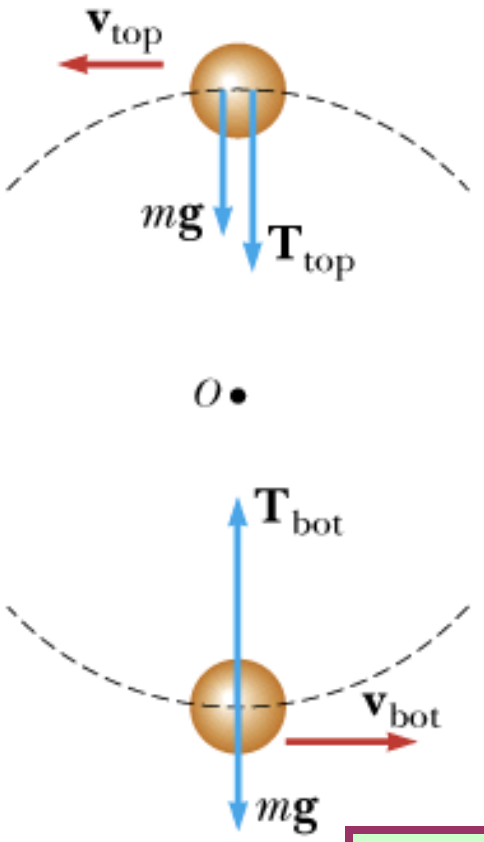
$$\sum F = ma$$

- ***String provides the tension (F_C)***
- ***This force is directed toward the center***

Vertical Circle

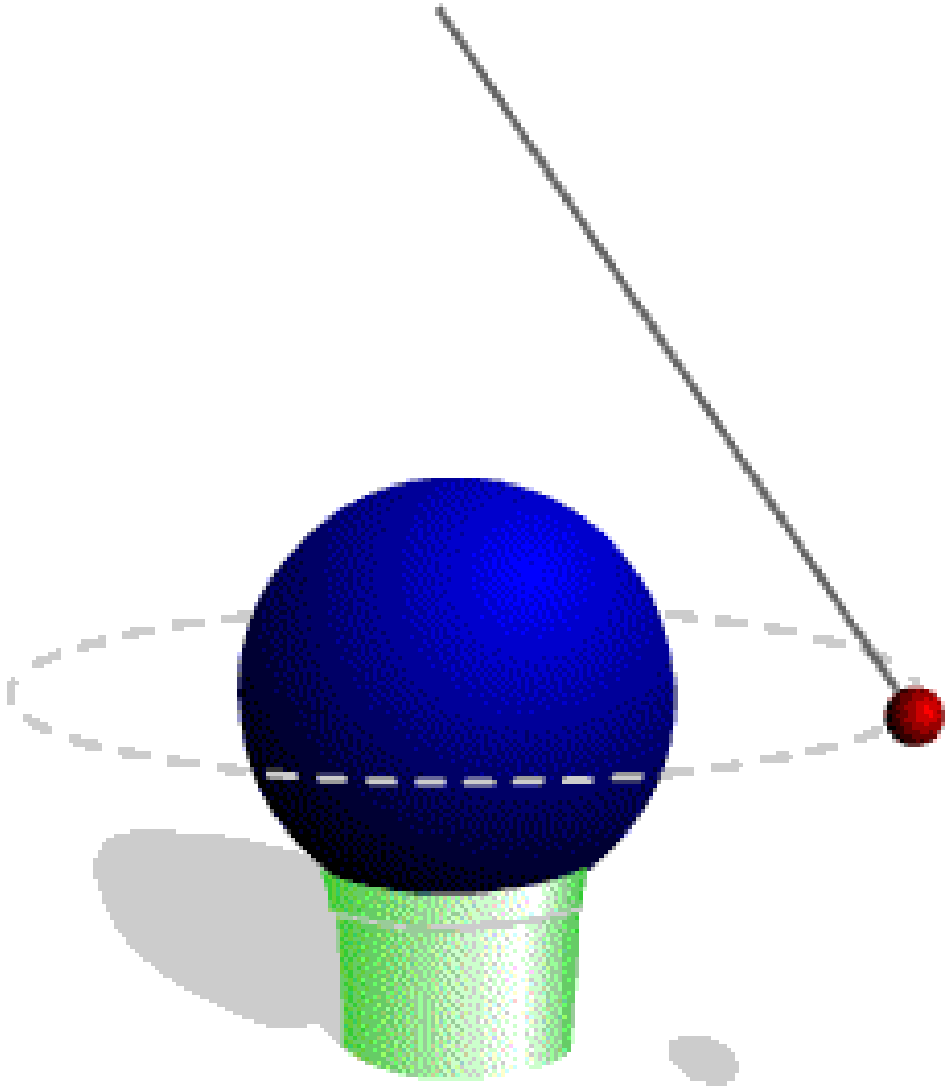
$$\sum F_C = T + mg = \frac{mv^2}{R}$$



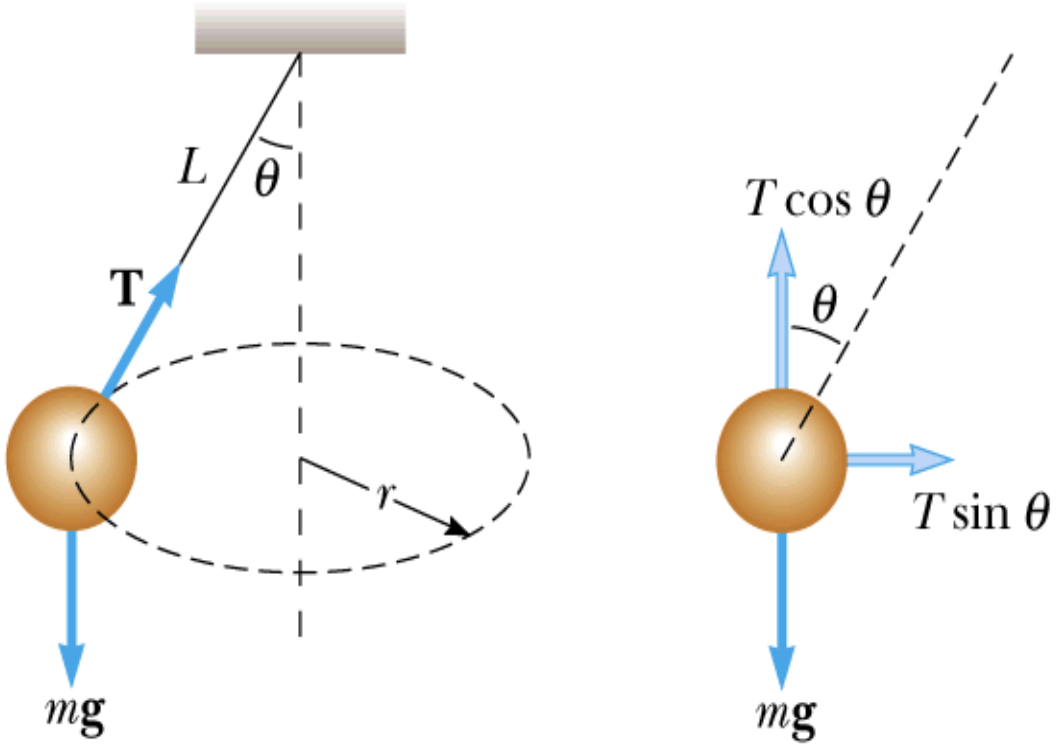


$$\sum F_C = T - mg = \frac{mv^2}{R}$$

Conical Pendulum



Conical Pendulum



A component of the tension provides the centripetal Force

No acceleration in the vertical direction

$$\sum F_Y = T\cos\theta - mg = 0$$

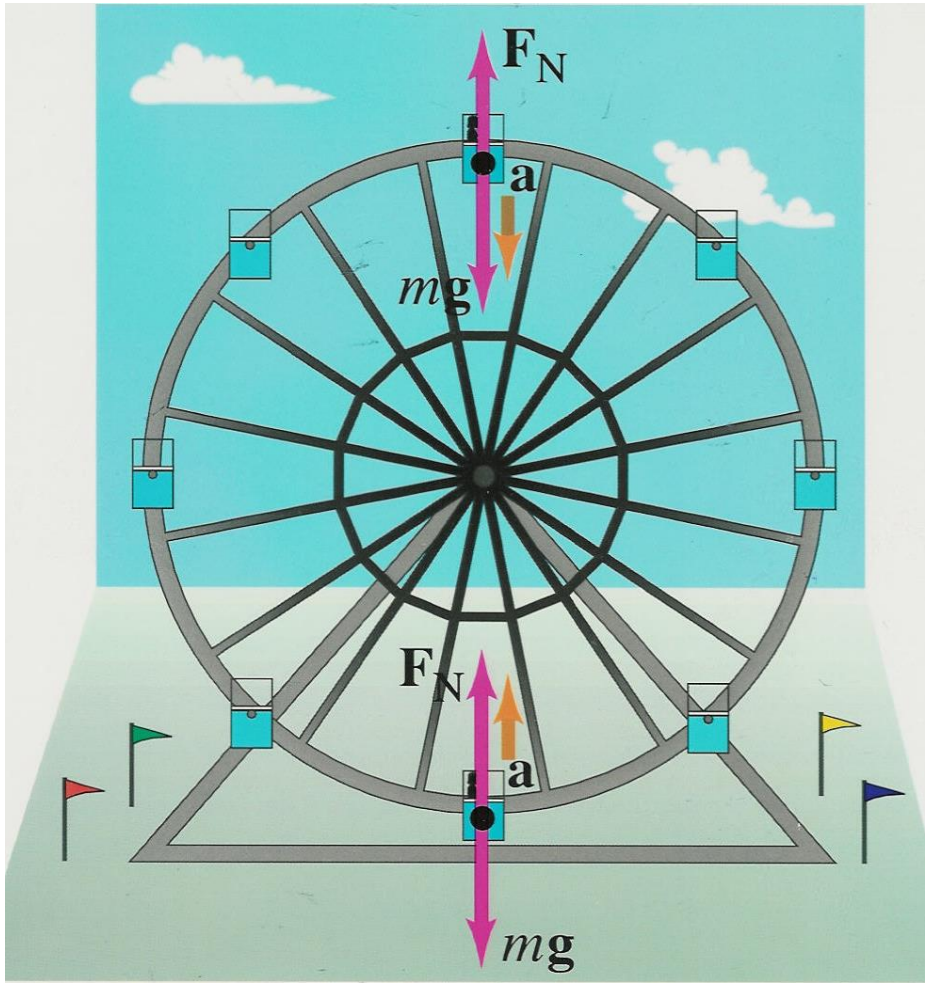
The centripetal force is provided by

$$\sum F_C = T\sin\theta = \frac{mv^2}{R}$$

Ferris Wheel

TOP

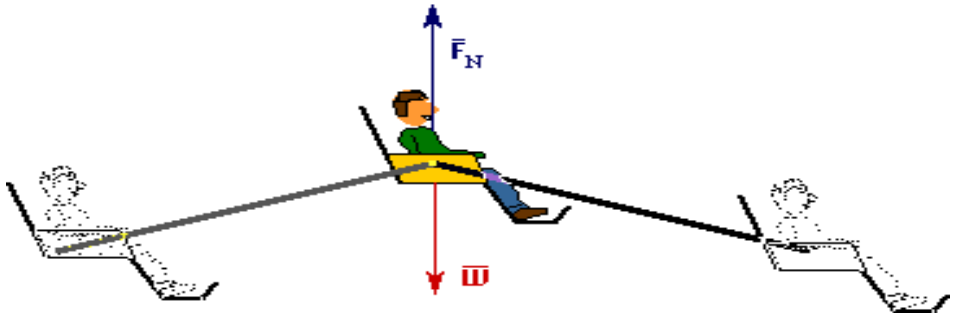
$$\sum F_C = mg - F_N = \frac{mv^2}{R}$$



BOTTOM

$$\sum F_C = F_N - mg = \frac{mv^2}{R}$$

Ferris Wheel



Find an expression for the maximum speed at which the ferris wheel can rotate before turning its passengers into projectiles.

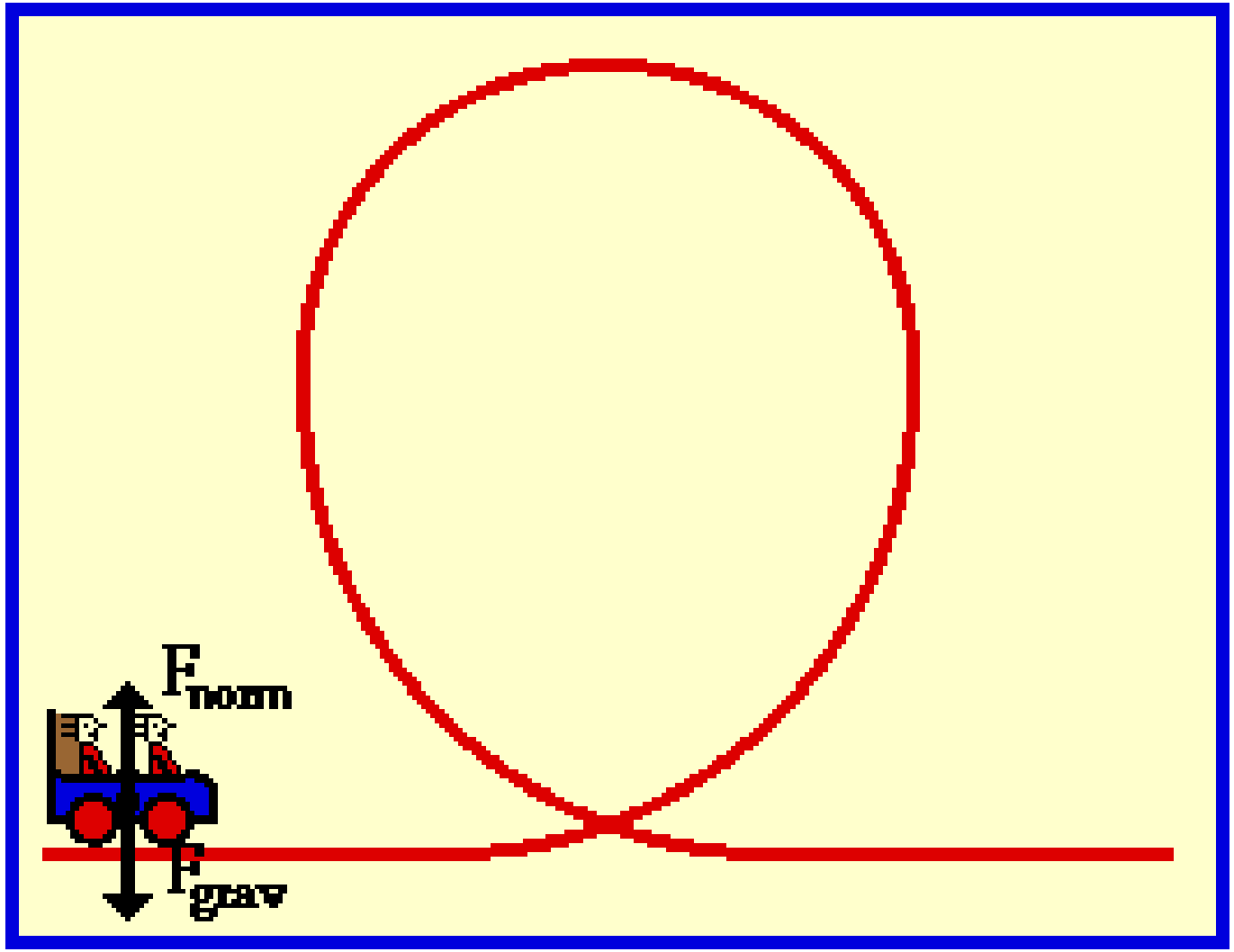
$$\sum F_C = mg - F_N = \frac{mv^2}{R}$$

Making the passengers airborne is the same as saying $F_N = 0$, therefore:

$$mg = \frac{mv^2}{R} \qquad v = \sqrt{Rg}$$

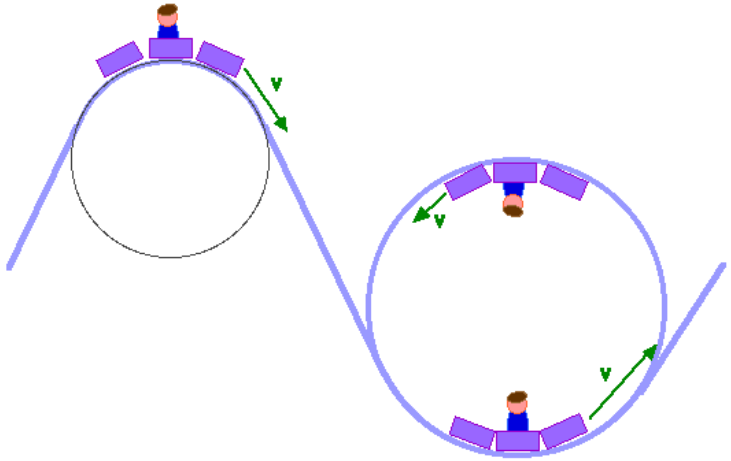
Note: It's independent of the mass of the riders

- ***The normal forces between the roller coaster and tracks***
- ***The normal forces between you and the roller coaster***

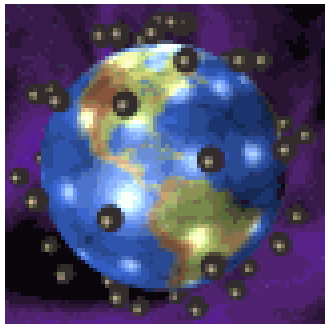

F_{norm}
F_{grav}

Sign Convention:

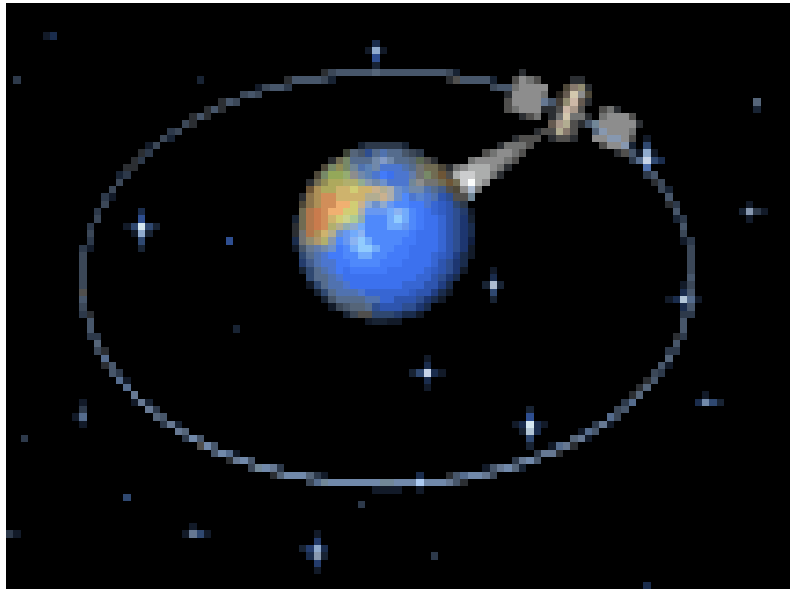
- *To the center is positive*
- *Away from the center is negative*



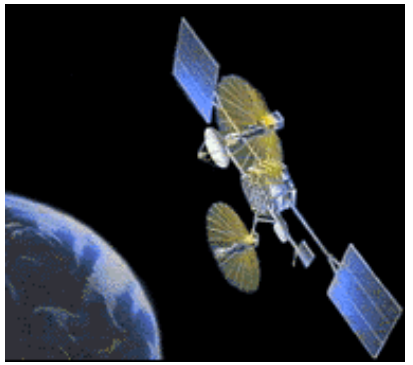
Geosynchronous Satellites



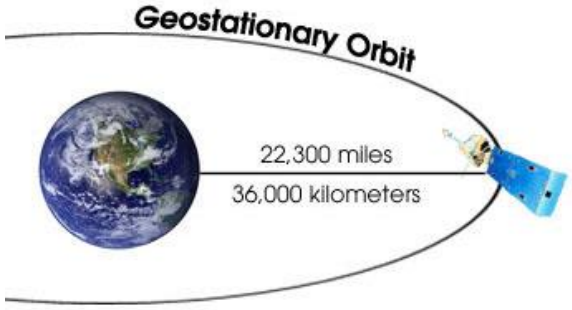
- ***To serve as stationary relay station the satellite must be placed at a certain height above the earth surface***



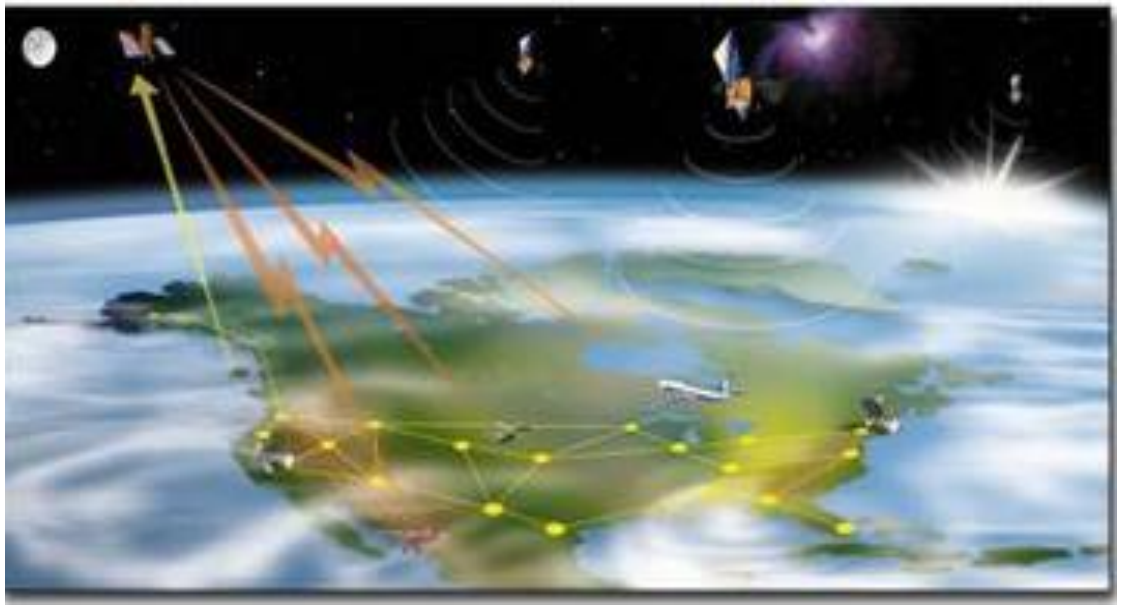
- ***they have an orbital period equal to the rotational period of the earth, 24 hours.***



Military



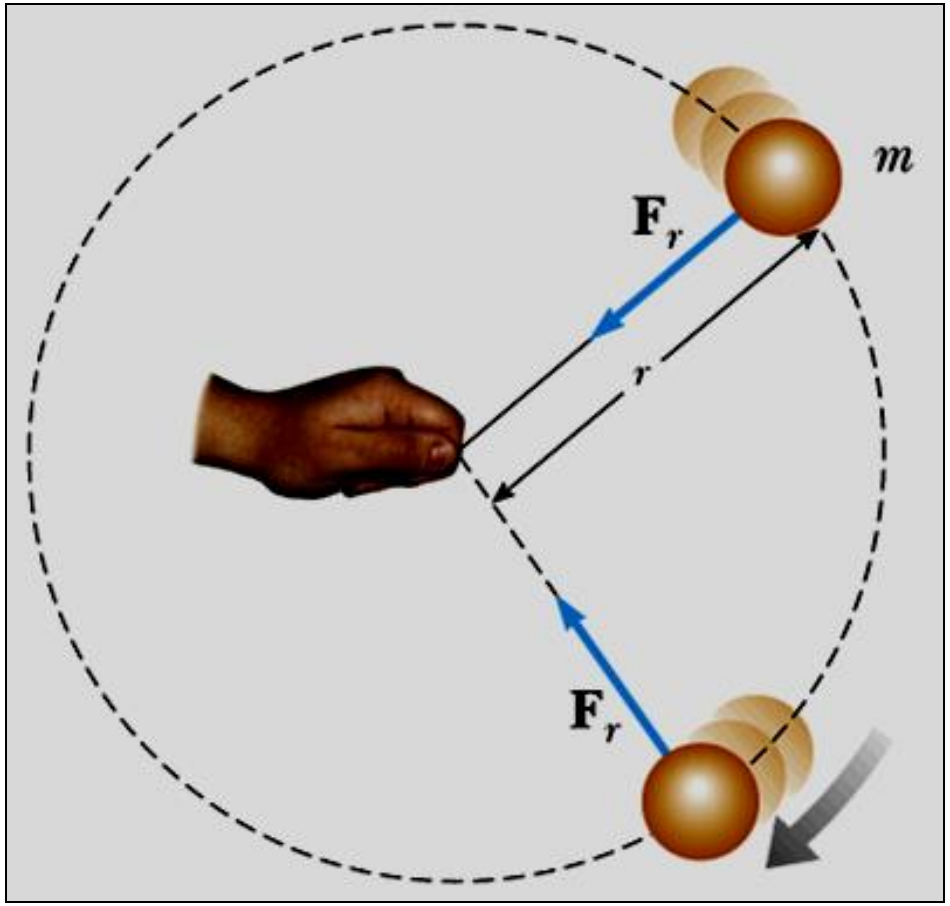
Communications



SUMMARY

Particle moving with uniform speed v in a circular path with radius r has an acceleration a_C:

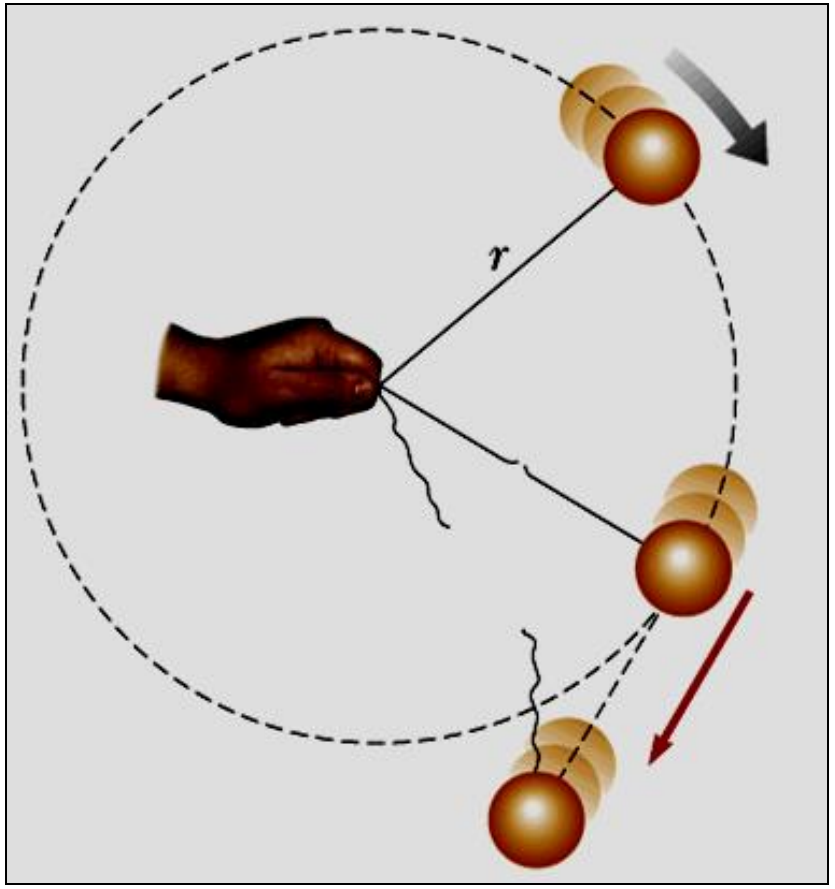
$$a_c = \frac{v^2}{r}$$



- ***The acceleration points to the center of the circle!***
- ***Centripetal acceleration***

- *The velocity of the particle is always _____*
- *The centripetal acceleration is towards the _____*
- *The centripetal force acting on the particle is towards the _____*

- *Centripetal force causes a change in the _____ but no change in _____*

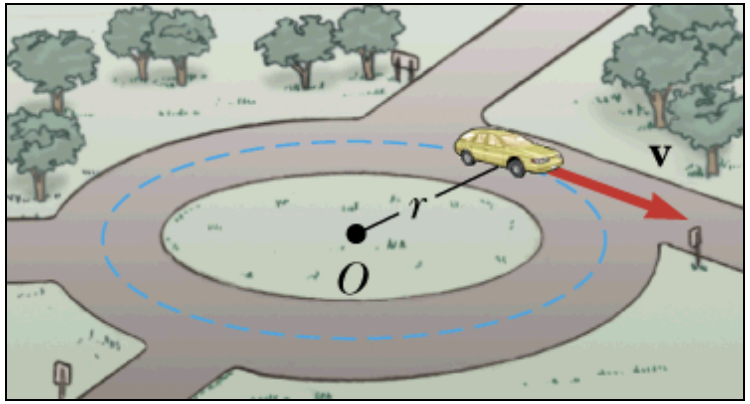


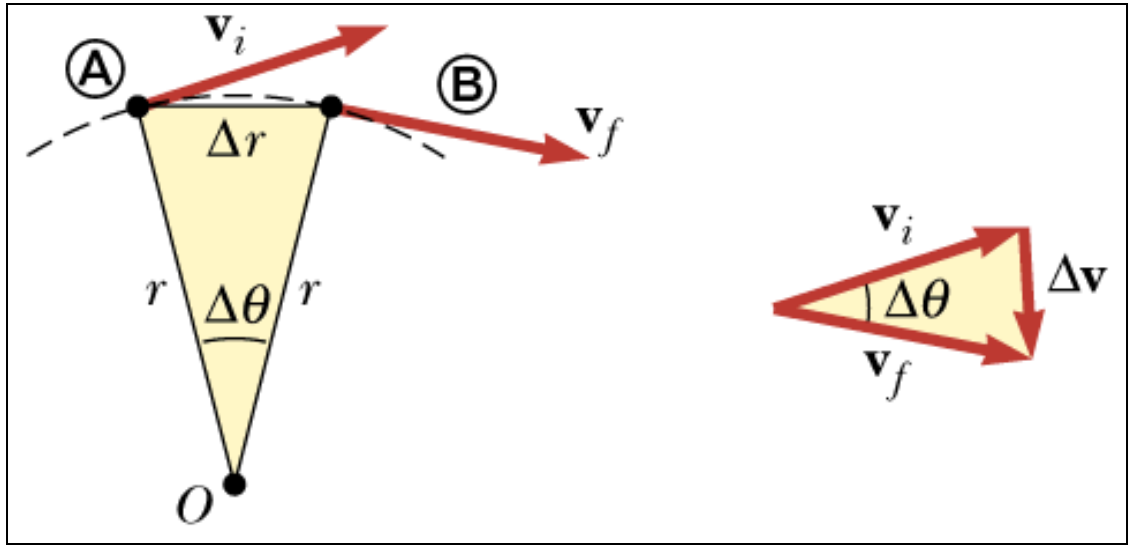
- *The magnitude of the centripetal acceleration is: a = _____*
- *Newton's law: The force on the particle is (centripetal force) F = m·a = _____*

Motion in a circular path at constant speed

- *Velocity is changing, thus there is an acceleration!!*
- *Acceleration is perpendicular to velocity*
- *Centripetal acceleration is towards the center of the circle*
- *Magnitude of acceleration is*
- *The change in velocity is director to the center*

$$a_r = \frac{v^2}{r}$$



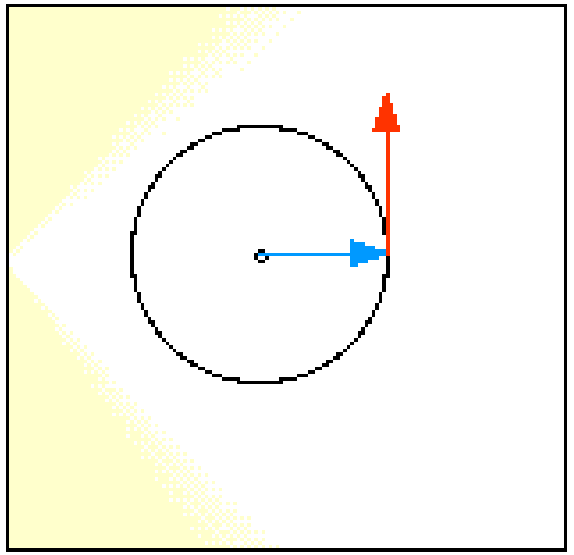


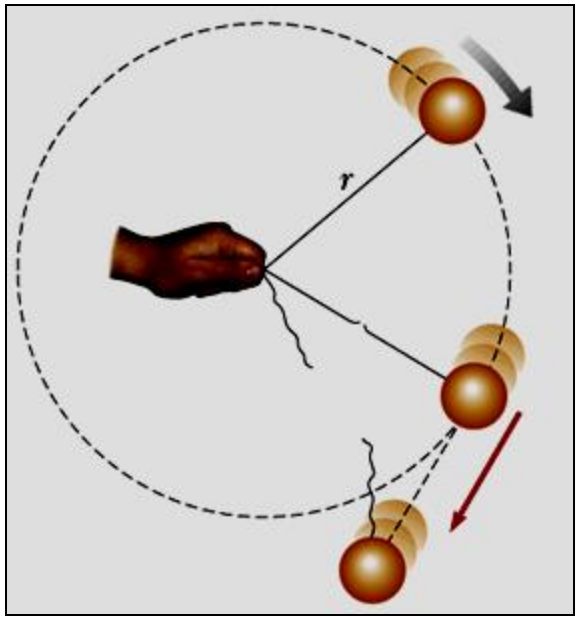
Horizontal Circle

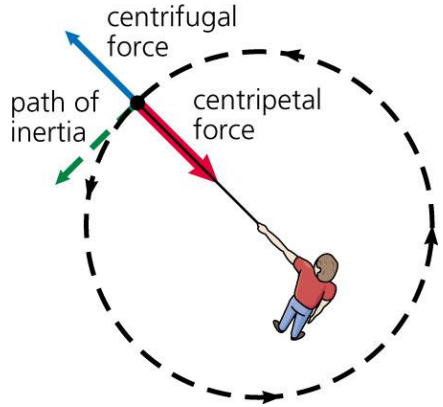
Lauren rotates a stone, m = .50 kg that is attached to the end of a 1.5 m cord above her head in a horizontal circle.

a. If the cord can hold 50 N of tension, at what maximum speed will it rupture.

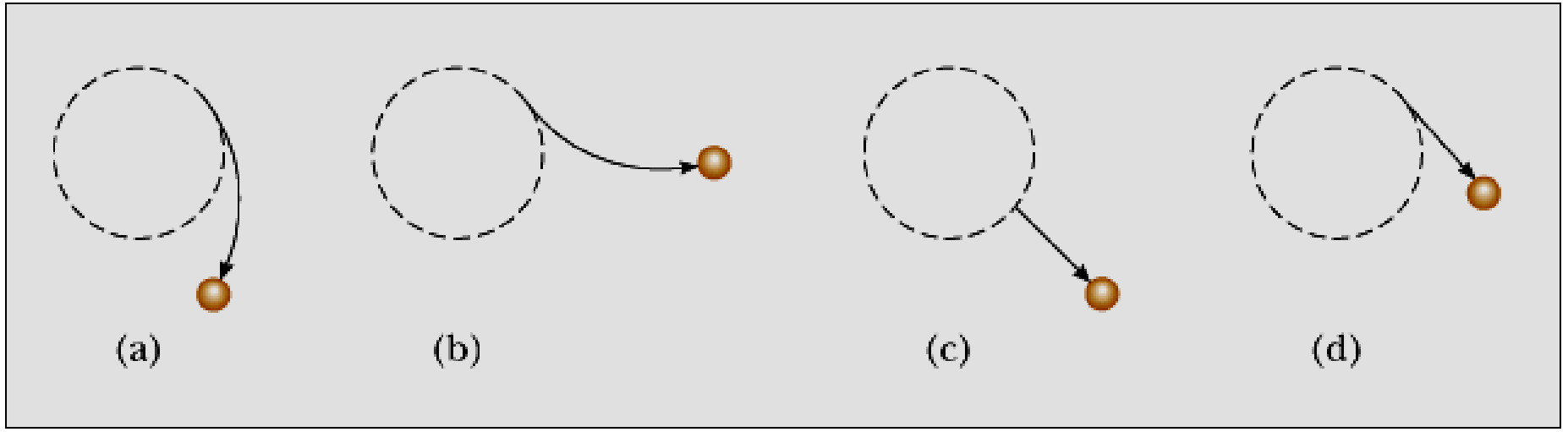
b. Which force "provides" the centripetal force?

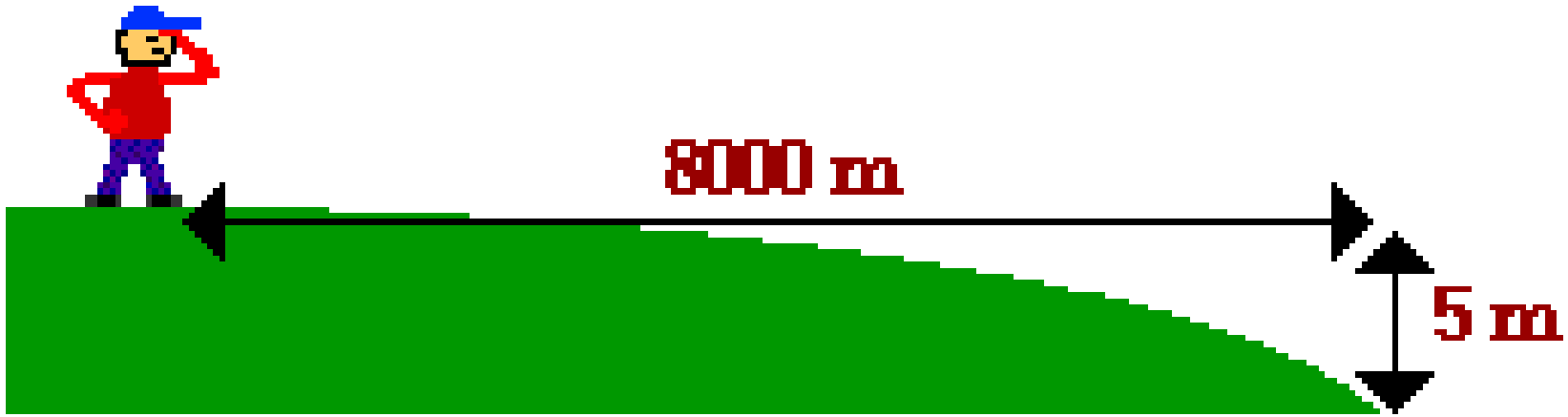






A particle is moving in a circular path. If the force on the particle would suddenly vanish (string cut) in which direction would the ball fly off?





For every 8000 meters along the horizon,
the earth curves downward by 5 meters.


The end !

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