Physics 1021

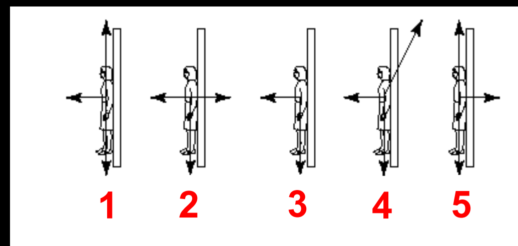
Spring 2012
Chapter 8

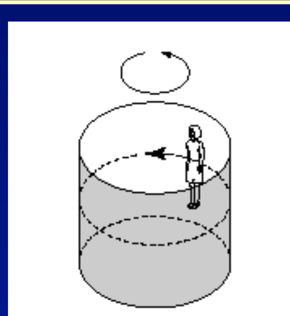
Announcements

- This week's homework …. 2 parts due on Monday
  last one due tonight
- Today's class:
  - Newton's third law
  - Pulleys
  - Tension
- Circular motion
- Quiz on Friday, Ch 5 and 6
- First exam Weds, Feb 22, Chs 1-8, 6 PM to 8 PM, Funger 108
  - Email me if there is a class conflict for you at the exam time

ConcepTest 7.8a Barrel of Fun

A rider in a "barrel of fun" finds herself stuck with her back to the wall. Which diagram correctly shows the forces acting on her?

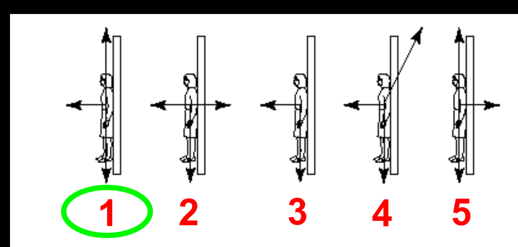




0 of 5

ConcepTest 7.8b Barrel of Fun

A rider in a "barrel of fun" finds herself stuck with her back to the wall. Which diagram correctly shows the forces acting on her?



The normal force of the wall on the rider provides the centripetal force needed to keep her going around in a circle. The downward force of gravity is balanced by the upward frictional force on her, so she does not slip vertically.

Dynamics in Two Dimensions

Suppose the *x*- and *y*-components of acceleration are ***independent*** of each other. That is, a_x does not depend on *y* or v_y, and a_y does not depend on *x* or v_x. Your problem-solving strategy is to

1. **D**raw a pictorial representation and a FBD.
2. Choose the appropriate coordinate system
3. Use Newton's second law in component form.

$$(F_{\text{net}})_x = \sum F_x = ma_x \qquad \text{and} \qquad (F_{\text{net}})_y = \sum F_y = ma_y$$

The force components (including proper signs) are found from the free-body diagram.

Dynamics in Two Dimensions

4. Solve for the acceleration. If the acceleration is constant, use the two-dimensional kinematic equations of Chapter 4 to find velocities and positions.

$$x_f = x_i + v_{ix}\Delta t + \tfrac{1}{2}a_x(\Delta t)^2 \qquad y_f = y_i + v_{iy}\Delta t + \tfrac{1}{2}a_y(\Delta t)^2$$

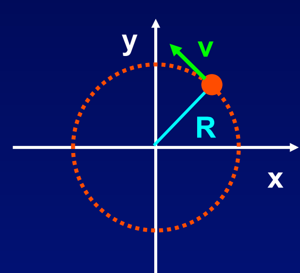
$$v_{fx} = v_{ix} + a_x\Delta t \qquad v_{fy} = v_{iy} + a_y\Delta t$$

Chapter 8:
Circular Motion

New Topic

Uniform Circular Motion

- **Motion in a circle with:**
  - **Constant radius *R***
  - **Constant speed $v = |v|$ (magnitude of velocity)**

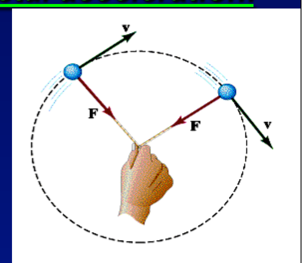


- **Some circular motion terms:**
  - **Recall that 1 revolution = 360° = 2π radians**
    - **frequency (f) = revolutions / second**
    - **period (P) = seconds / revolution**

$$f = 1/P$$

Centripetal (radial) Acceleration

- If you swing a ball in a circle, the ***speed*** is constant but the **velocity** is ***not*** constant, since the direction is changing.
  - must be some acceleration: ***centripetal acceleration!***
  - **Magnitude**: $a = \frac{v^2}{R}$
  - **Direction**: toward center of circle



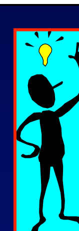
Since there is acceleration, there has to be a force!

➢ ***Centripetal (radial) Force***

- magnitude: $F = ma = \frac{m\,v^2}{R}$
- direction: towards the center of the circle

Phys 1021 Ch 8, p 9

Important Point !!



Note: force is ***always*** provided by another force!

It is *not* a separate force.

Examples:

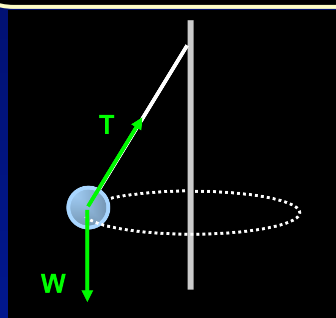
- A car going around a curve ➡ ***friction force***
- A ball on a string ➡ ***tension force***
- The earth going around the sun ➡ ***gravity***

Phys 1021 Ch 8, p 10

ConcepTest 8.1a Tetherball

In the game of tetherball, the struck ball whirls around a pole. In what direction does the net force on the ball point?

1) Towards the top of the pole
2) Towards the ground
3) Along the horizontal component of the tension force
4) Along the vertical component of the tension force
5) Tangential to the circle



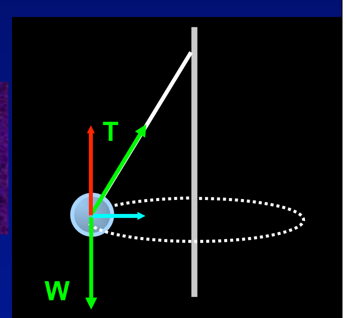
0 of 5

ConcepTest 8.1b Tetherball

In the game of tetherball, the struck ball whirls around a pole. In what direction does the net force on the ball point?

1) Towards the top of the pole
2) Towards the ground
3) Along the horizontal component of the tension force
4) Along the vertical component of the tension force
5) Tangential to the circle

The vertical component of the tension balances the weight. The horizontal component of tension provides the centripetal force which points towards the center of the circle.



ConcepTest 8.2a) Roller Coaster

You're riding on a roller coaster. When the car is at rest, the **normal force *N*** exerted by your seat is equal to your **weight *mg***. How does *N* change when you are in motion and go over the crest of a hill?

1) *N* remains equal to *mg*
2) *N* is smaller than *mg*
3) *N* is larger than *mg*
4) None of the above

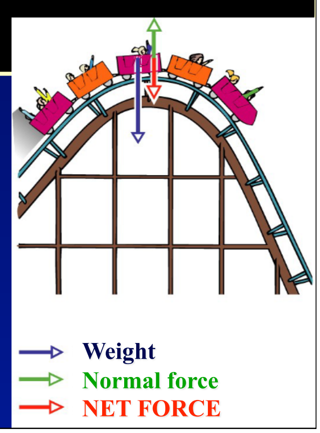
0 of 5

ConcepTest 8.2b Roller Coaster

- You're riding on a roller coaster. When the car is at rest, the **normal force *N*** exerted by your seat is equal to your **weight *mg***. How does *N* change when you are in motion and go over the crest of a hill?

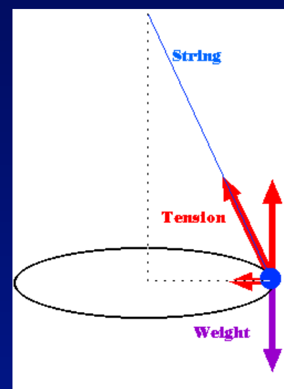
(1) *N* remains equal to *mg*
(2) *N* is smaller than *mg*
(3) *N* is larger than *mg*
(4) None of the above

You are in circular motion, so there has to be a centripetal force pointing ***inward***. At the top, the only two forces are ***mg* (down)** and ***N* (up)**, so ***N* must be smaller than *mg***.



Example: Conical Pendulum

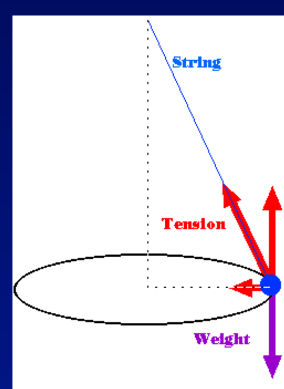
- A conical pendulum is formed by attaching a 600 g ball to a 1.0 m long string, then allowing the mass to move in a horizontal circle. Tension in string equals 8.3 N.
  - What is the angular velocity?
  - What is the angle between the string and the vertical?



Phys 1021 Ch 8, p 15

Ponderable: Conical Pendulum

- A conical pendulum is formed by attaching a 600 g ball to a 1.0 m long string, then allowing the mass to move in a horizontal circle. Tension in string equals 8.3 N.
  - What is the angular velocity?
  - What is the angle between the string and the vertical?



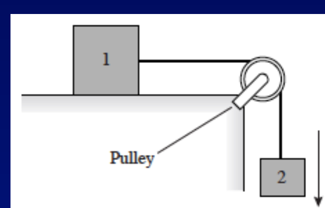
Phys 1021 Ch 8, p 16

Ponderable: Stunt plane

A stunt plane does a series of vertical loop-the-loops. At what point in the circle does the pilot feel the heaviest? Explain. Include a free-body diagram with your explanation.

Tangible: cart on a track
How does the acceleration change the weight?

- In this exercise, you will measure the horizontal force exerted on a weight pulled by another weight that is attached to a pulley. Bring the following items to your table:
  - A track
  - A cart
  - A pulley and photogate
  - A level and a 200 g weight
  - A pair of leveling feet for the track
  - A Spring scale and rubber band



- Do the following:
  - Attach the pulley to the end of the track and put feet on each end
  - Rubber band the scale to the cart and tie a piece of string to the loop on the scale long enough to almost reach the floor when the cart is close to the pulley.
  - Tie a loop for hanging a weight on the free end and hang a 200g weight from the loop
  - Pull the cart back and hold it. What is the measured mass?
- Will the measured mass change if you let go of the cart? Calculate the expected value? (the cart's mass is 500g)
- Let go of the cart. What is the measured mass?