

Note on Posted Slides

- These are the slides that I intended to show in class on Wed. Jan. 16, 2013.
- They contain important ideas and questions from your reading.
- Due to time constraints, I was probably not able to show all the slides during class.
- They are all posted here for completeness.

PHY205H1S Physics of Everyday Life Class 4

- Forces and Interactions
- Newton's Third Law of Motion
- Vectors



Chapter 5 Pre-Class Reading Question

- A boxer cannot exert much force on a piece of tissue paper suspended in air because
 - A. the time of the interaction is too brief
 - B. there is little follow-through with the punch
 - C. the tissue lacks enough strength
 - D. the tissue paper has too little mass to exert much force on the boxer's fist

Chapter 5 Pre-Class Reading Question

- In the apple-pulling-the-orange sequence in this chapter, what is the force that accelerates the system across the floor?
 - A. The backward pull by the orange
 - B. Friction between the apple and the floor
 - C. The resistance to motion by the orange
 - D. Internal forces

Forces and Interactions

Interaction

- is between one thing and another.
- requires a pair of forces acting on two objects.

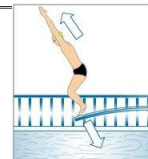
Example: interaction of hand and wall pushing on each other
Force pair—you push on wall; wall pushes on you.



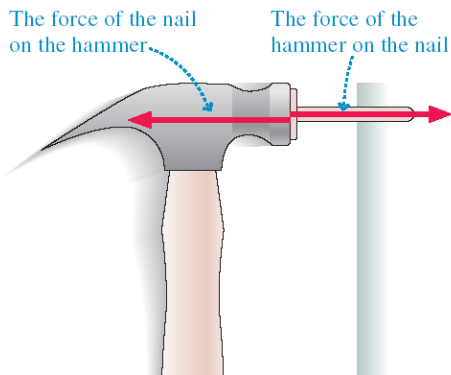
3 Newton's Third Law

If object 1 acts on object 2 with a force, then object 2 acts on object 1 with an equal force in the opposite direction.

$$\vec{F}_{1 \text{ on } 2} = -\vec{F}_{2 \text{ on } 1}$$



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A Mack Truck drives North on the highway, and collides head-on with a mosquito. Which is true?

- A. The Mack Truck exerts a greater force on the mosquito than the mosquito exerts on the Mack Truck.
- B. The mosquito exerts a greater force on the Mack Truck than the Mack Truck exerts on the mosquito.
- C. The Mack Truck exerts the same force on the mosquito as the mosquito exerts on the Mack Truck.
- D. Impossible to determine without knowing the speeds of the truck and mosquito.
- E. Don't know or none of the above

A Mack Truck drives North on the highway, and collides head-on with a mosquito. Which is true?

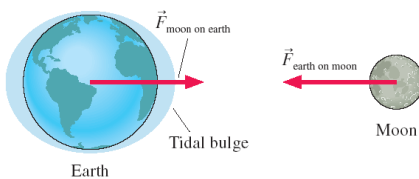
- A. The Mack Truck does more damage to the mosquito than the mosquito does to the Mack Truck.
- B. The mosquito does more damage to the Mack Truck than the Mack Truck does to the mosquito.
- C. The Mack Truck does the same amount of damage to the mosquito as the mosquito does to the Mack Truck.
- D. Impossible to determine without knowing the speeds of the truck and mosquito.
- E. Don't know or none of the above

$$F = ma$$

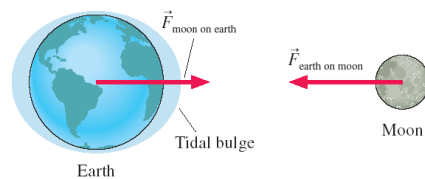
or

$$a = F / m$$

- If the force is equal on the truck and the mosquito, is the acceleration equal?
- Acceleration is *higher* if *m* is *lower* (*F* divided by *m*)
- Mosquito accelerates more, so it receives more damage.



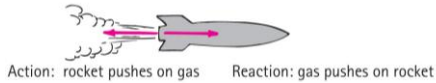
- The entire Earth accelerates toward the Moon, due to this pulling force.
- To find the total acceleration, you use the force as calculated for the centre-to-centre distance.
- Since $F_G = Gm/r^2$, the force on the ocean nearer to the moon will be greater, so it will accelerate more than the rest of the Earth, bulging out.



- Similarly, since $F_G = Gm/r^2$, the force on the ocean further from the moon will be less, so it will accelerate *less* than the rest of the Earth, remaining behind, forming a bulge.
- In general, tidal effects tend to **stretch** objects both toward and away from the object causing the tides.

Simple rule to identify action and reaction

- Identify the interaction—one thing interacts with another
 - Action: Object A exerts a force on object B.
 - Reaction: Object B exerts a force on object A.
- Example: Action—rocket (object A) exerts force on gas (object B).
 Reaction—gas (object B) exerts force on rocket (object A).



Action and reaction forces

- one force is called the action force; the other force is called the reaction force.
- are co-pairs of a single interaction.
- neither force exists without the other.
- are equal in strength and opposite in direction.
- always act on *different* objects.

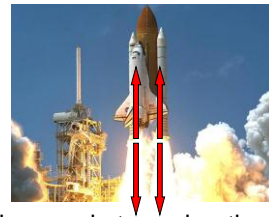


Identifying Action / Reaction Pairs



- Consider an accelerating car.
- **Action:** tire pushes on road.
- **Reaction:** road pushes on tire

Identifying Action / Reaction Pairs



- Consider a rocket accelerating upward.
- **Action:** rocket pushes on gas.
- **Reaction:** gas pushes on rocket

Identifying Action / Reaction Pairs



- **Action force:** man pulls on rope to the left.
- **Reaction force?**

- Feet push on ground to the right.
- Ground pushes on feet to the left.
- Rope pulls on man to the right.
- Gravity of Earth pulls man down.
- Gravity of man pulls Earth up.

Identifying Action / Reaction Pairs



- Consider a stationary man pulling a rope.
- **Action:** man pulls on rope
- **Reaction:** rope pulls on man

Identifying Action / Reaction Pairs



- Consider a basketball in freefall.
- **Action force:** gravity of Earth pulls ball down.
- **Reaction force?**

- A. Feet push ground down.
- B. Ground pushes feet up.
- C. Gravity of Earth pulls man down.
- D. Gravity of ball pulls Earth up.
- E. Air pushes ball up.

Identifying Action / Reaction Pairs



$$a = \frac{F}{m}$$



$$a = \frac{F}{m}$$

- Consider a basketball in freefall.
- **Action:** Earth pulls on ball
- **Reaction:** ball pulls on Earth

Ride the MP Elevator!

- In the corner of every elevator in the tower part of this building, there is a mass hanging on a spring.
- If you look closely at the spring, it has a scale which reads Newtons.
- This is how much upward force is needed to support the hanging mass.
- In your next tutorial you will be going with your team to look more carefully at this scale, and record how it changes as the elevator accelerates!

Example: Chapter 5, Problem 1

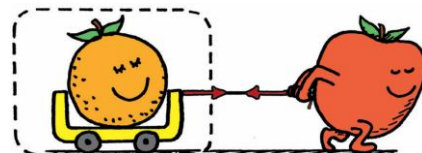
- A boxer punches a piece of kleenex in midair and brings it from rest up to a speed of 25 m/s in 0.05 s.
- (a) What acceleration does the kleenex have while being punched?
- (b) If the mass of the kleenex is 0.003 kg, what force does the boxer exert on it?
- (c) How much force does the paper exert on the boxer?

Defining Your System

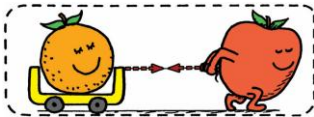
- Consider a single enclosed orange.
 - Applied external force causes the orange to accelerate in accord with Newton's second law.
 - Action and reaction pair of forces is not shown.



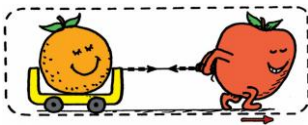
- Consider the orange and the apple pulling on it.
 - Action and reaction do not cancel (because they act on different things).
 - External force by apple accelerates the orange.



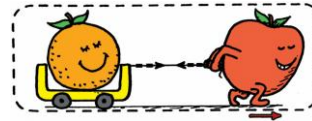
- Consider a system comprised of both the orange and the apple
 - The apple is no longer external to the system.
 - Force pair is internal to system, which doesn't cause acceleration.
 - Action and reaction within the system cancel.
 - With no external forces, there is no acceleration of system.



- One of these acts by the system (apple on the floor) and the other acts on the system (floor on the apple).
- External frictional force of floor pushes on the system, which accelerates.
- Second pair of action and reaction forces do not cancel.



- Consider the same system, but with external force of friction on it.
 - Same internal action and reaction forces (between the orange and apple) cancel.
 - A second pair of action-reaction forces (between the apple's feet and the floor) exists.



Newton's Third Law CHECK YOUR NEIGHBOR

A bird flies by

- flapping its wings.
- pushing air down so that the air pushes it upward.
- hovering in midair.
- inhaling and exhaling air.

Newton's Third Law CHECK YOUR NEIGHBOR

Slightly tilted wings of airplanes deflect

- oncoming air downward to produce lift.
- oncoming air upward to produce lift.
- Both A and B.
- Neither A nor B.

Summary of Newton's Three Laws of Motion

- **Newton's first law** (the law of inertia)
 - An object at rest tends to remain at rest; an object in motion tends to remain in motion at constant speed along a straight-line path.
- **Newton's second law** (the law of acceleration)
 - When a net force acts on an object, the object will accelerate. The acceleration is directly proportional to the net force and inversely proportional to the mass.
- **Newton's third law** (the law of action and reaction)
 - Whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first.

Vectors & Scalars

Vector quantity

- has magnitude and direction.
- is represented by an arrow.

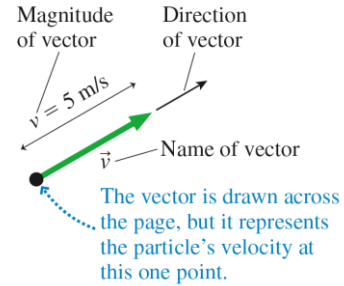
Example: velocity, force, acceleration



Scalar quantity

- has magnitude.

Example: mass, volume, speed

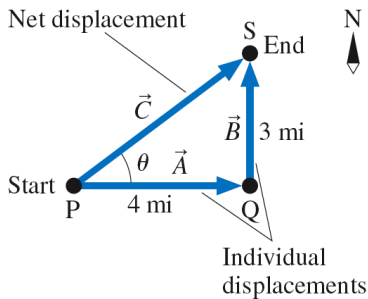
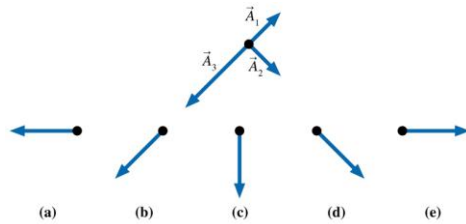


Vector Addition

The sum of two or more vectors

- For vectors in the same direction, add arithmetically.
- For vectors in opposite directions, subtract arithmetically.
- Two vectors that don't act in the same or opposite direction:
 - use parallelogram rule.
- Two vectors at right angles to each other
 - use Pythagorean Theorem: $R^2 = V^2 + H^2$.

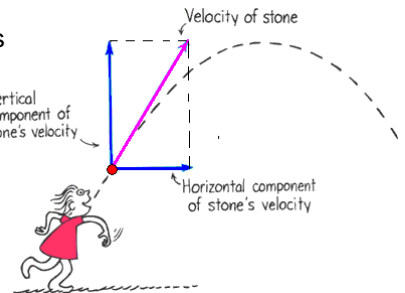
Which figure shows $\vec{A}_1 + \vec{A}_2 + \vec{A}_3$?



$$\vec{C} = \vec{A} + \vec{B}$$

Vector components

- Vertical and horizontal components of a vector are perpendicular to each other
- The components add to give the actual vector



Vectors
CHECK YOUR NEIGHBOR

You run horizontally at 4 m/s in a vertically falling rain that falls at 4 m/s. Relative to you, the raindrops are falling at an angle of

- A. 0° .
- B. 45° .
- C. 53° .
- D. 90° .

Before Class 5 on Monday

- Please read Chapter 6, or at least watch the 10-minute pre-class video for class 5
- Something to think about:

Imagine you are trapped in a canoe in the middle of a still lake with no paddles. There is a large pile of heavy rocks in the canoe. If you start throwing rocks, can you propel the canoe this way? If so, and you want to get to shore, which way should you throw the rocks?



[image downloaded Jan.16 2013 from <http://samples.ebay.com/press.com/2012/01/02/canoe/>]

Example: Chapter 5, Problem 6

- You are paddling a canoe at a speed of 4 km/h directly across a river that flows at 3 km/h, as shown.
- (a) What is your resultant speed relative to the shore
- (b) In approximately what direction should you paddle the canoe so that it reaches a destination directly across the river?

