Phys 111: Lecture 5

"The Lizard & The Blue Rupees"

University of Idaho

September 09, 2019

Today's Announcements

Homework Wk #3 Due Thursday

Exam #1 in 2 Weeks!

See Bblearn for extra Vector reference

Today's Topics

1. Review Examples
2. Relative Velocity
3. Concept of Force & Inertia

C&J 1.AP.71 Let's observe how three vectors are added to form a resultant $\mathbf{R}$.

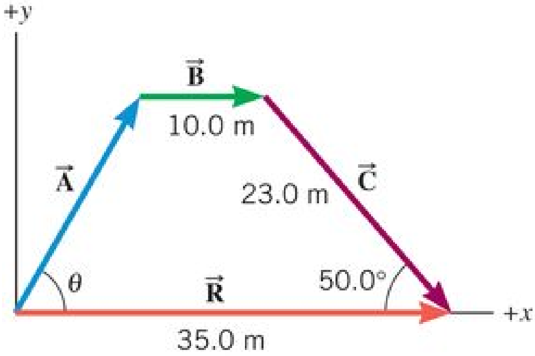

Figure: 5.1 C&J 1.AP.71 Angle Necessary for Resultant

C&J 1.8.50 The magnitudes of the four displacement vectors shown in the drawing are A = 16.0 m, B = 11.0 m, C = 12.0 m, and D = 26.0 m. Determine the magnitude and directional angle for the resultant that occurs when these vectors are added together.

Exercise #1

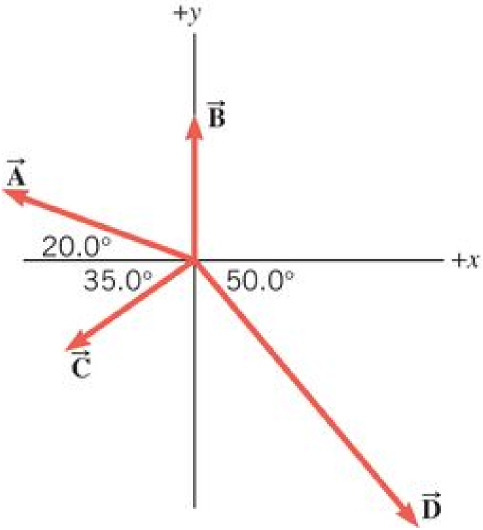

Figure: 5.2 C&J 1.8.50 Determination of a Resultant Vector

Exercise #2

C&J 1.AP.66 Three forces act on an object, as indicated in the drawing. Force $\mathbf{F}_1$ has a magnitude of 21.0 newtons (21.0 N) and is directed 30.0° to the left of the $+$y axis. Force $\mathbf{F}_2$ has a magnitude of 15.0 N and points along the $+$x axis. What must be the magnitude and direction (specified by the angle θ in the drawing) of the third force $\mathbf{F}_3$ such that the vector sum of the three forces is 0 N?

Exercise #2

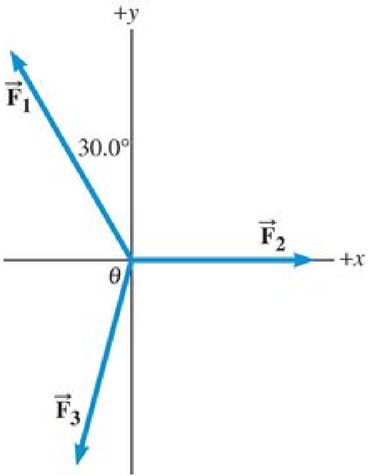

Figure: 5.3 C&J 1.AP.66 Necessary Force for Resultant

C&J 3.3.16 A puck is moving on an air hockey table. Relative to an x, y coordinate system at time t = 0 s, the x components of the puck's initial velocity and acceleration are $v_{0x} = +1.0 m/s$ and $a_x = +2.0\ m/s^2$. The y components of the puck's initial velocity and acceleration are $v_{0y} = +2.0\ m/s$ and $a_y = -2.0\ m/s^2$. Find the magnitude and direction of the puck's velocity at a time of t = 0.50 s. Specify the direction relative to the +x axis.

C&J FOC 3.4.6 Ball 1 is thrown into the air and it follows the trajectory for projectile motion shown in the drawing. At the instant that ball 1 is at the top of its trajectory, ball 2 is dropped from rest from the same height. Which ball reaches the ground first?

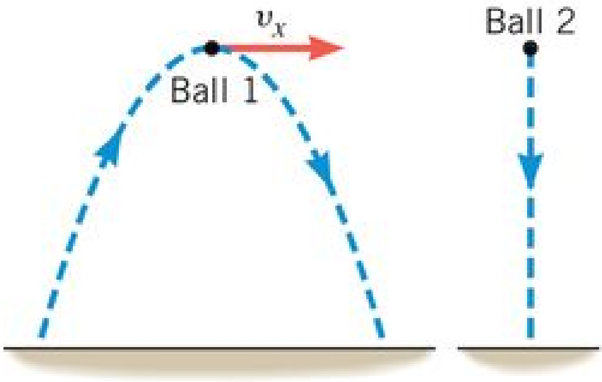

Figure: 5.4 Different paths, same y displacement

Motivation for Relative Velocity

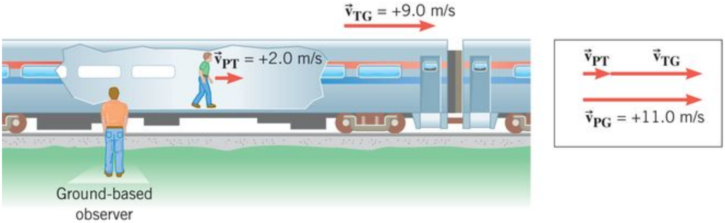

Figure: 5.5 Train Example for Relative Velocities

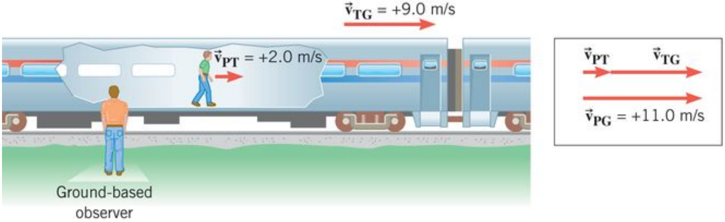

Figure: 5.5 Train Example for Relative Velocities

$$\mathbf{v}_{PG} = \mathbf{v} \text{ of passenger rel. to ground} = +11\ m/s$$
$$\mathbf{v}_{PT} = \mathbf{v} \text{ of passenger rel. to train} = +2.0\ m/s$$
$$\mathbf{v}_{TG} = \mathbf{v} \text{ of train rel. to ground} = +9.0\ m/s$$

Motivation R.V.

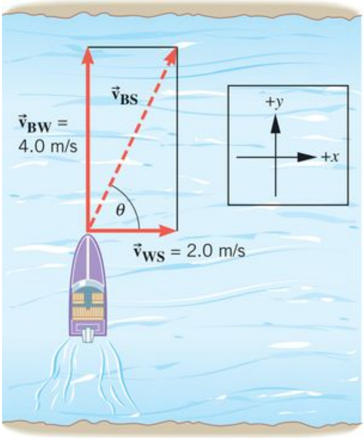

Figure: 5.6 Boat Example for Relative Velocities

Train Example

$$\mathbf{V}_{PG} = \mathbf{V}_{PT} + \mathbf{V}_{TG}.$$

$$\downarrow$$

$$\mathbf{v}_{PT} = \mathbf{v}_{PG} - \mathbf{v}_{TG}.$$

$$\mathbf{v}_{TG} = \mathbf{v}_{PG} - \mathbf{v}_{PT}.$$

Boat Example

$$\mathbf{V}_{BS} = \mathbf{V}_{BW} + \mathbf{V}_{WS}.$$

$$\downarrow$$

$$\mathbf{v}_{BW} = \mathbf{v}_{BS} - \mathbf{v}_{WS}.$$

$$\mathbf{v}_{WS} = \mathbf{v}_{BS} - \mathbf{v}_{BW}.$$

General

$$\mathbf{V}_{AG} = \mathbf{V}_{AB} + \mathbf{V}_{BG}.$$

$$\downarrow$$

$$\mathbf{v}_{AB} = \mathbf{v}_{AG} - \mathbf{v}_{BG}.$$

$$\mathbf{v}_{BG} = \mathbf{v}_{AG} - \mathbf{v}_{AB}.$$

C&J 3.4.53 A swimmer, capable of swimming at a speed of 1.4 m/s in still water (i.e., the swimmer can swim with a speed of 1.4 m/s relative to the water), starts to swim directly across a 2.8 km wide river. However, the current is 0.91 m/s, and it carries the swimmer downstream.

a. How long does it take the swimmer to cross the river?
b. How far downstream will the swimmer be upon reaching the other side of the river?

C&J 3.4.61 A person looking out the window of a stationary train notices that raindrops are falling vertically down at a speed of 5.0 m/s relative to the ground. When the train moves at a constant velocity, the raindrops make an angle of 25° when they move past the window, as the drawing shows. How fast is the train moving?

Figure: 5.5 C&J 3.4.61 Rain Relative Velocities

Summary R.V.

- Relative velocities allow us to compare measurements from different references.
- Technique applies to almost every physical vector quantity.
- Start with the version that makes most sense and rewrite as needed:

$$\mathbf{v}_{AG} = \mathbf{v}_{AB} + \mathbf{v}_{BG}.$$

$$\downarrow$$

$$\mathbf{v}_{AB} = \mathbf{v}_{AG} - \mathbf{v}_{BG}.$$

$$\mathbf{v}_{BG} = \mathbf{v}_{AG} - \mathbf{v}_{AB}.$$

Force: A force is any push or pull acted upon one object by a second object that will cause a change in motion in the second object unless countered by an other force.

- Forces are vector quantities as direction matters.
- Forces are a cause and acceleration is the effect. (or balancing)
- Some forces don't require mechanical contact ("touch").
- SI unit: 1 newton = 1 $N = 1\ kg \cdot m/s^2$

Inertia: Inertia is the natural tendency of an object to resist changes to its current motion. Mass is the quantitative measure of the inertia of an object.

- Mass is a measure of how much matter (stuff) an object is made of.
- Mass is a scalar quantity
- Objects with more mass require more force for the same acceleration.
- SI unit: 1 kilogram = 1 kg

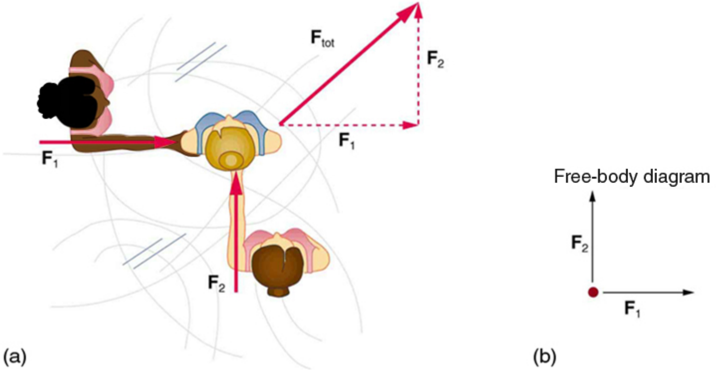

Figure: 5.6 Force Diagrams

Force Concept & Diagrams

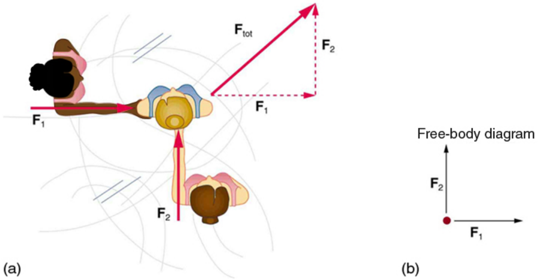

Figure: 5.6 Force Diagrams

- Note how the two forces applied to the third skater are added up as any two vectors would be.
- Note how simplified the free-body diagram is compared to a realistic sketch of the event.

Concept Check

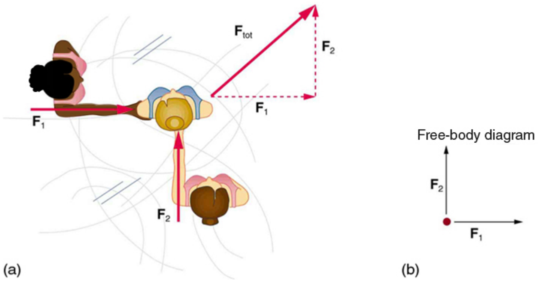

Figure: 5.6 Force Diagrams

Find the net force if

a. the two forces are equal in magnitude.
b. the second force has half the strength of the first.
c. the second force has double the strength of the first.