DEVIL PHYSICS
THE BADDEST CLASS ON CAMPUS
AP PHYSICS

2-1: REFERENCE FRAMES AND DISPLACEMENT
2-2: AVERAGE VELOCITY
2-3: INSTANTANEOUS VELOCITY

Big Idea

- Big Idea 3: The interactions of an object with other objects can be described by forces.

Enduring Understanding

- Enduring Understanding 3.A: All forces share certain common characteristics when considered by observers in inertial reference frames.

Essential Knowledge

- Essential Knowledge 3.A.1: An observer in a particular reference frame can describe the motion of an object using such quantities as position, displacement, distance, velocity, speed, and acceleration.

Essential Knowledge

- Displacement, velocity, and acceleration are all vector quantities.
- Displacement is change in position. Velocity is the rate of change of position with time. Acceleration is the rate of change of velocity with time. Changes in each property are expressed by subtracting initial values from final values.
- A choice of reference frame determines the direction and the magnitude of each of these quantities.

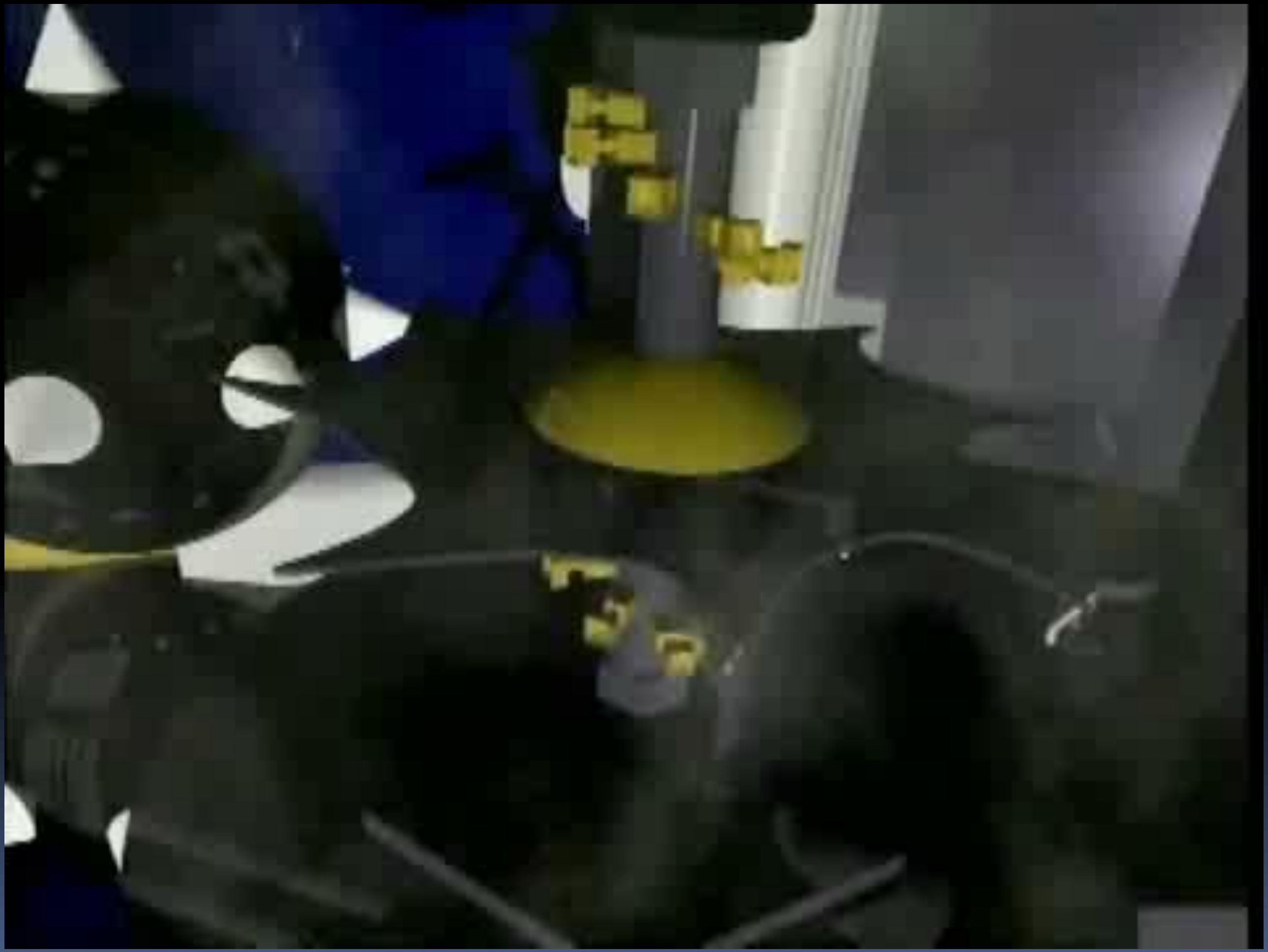
Learning Objectives

- (3.A.1.1): The student is able to express the motion of an object using narrative, mathematical, and graphical representations.
- (3.A.1.2): The student is able to design an experimental investigation of the motion of an object.

Learning Objectives

- (3.A.1.3): The student is able to analyze experimental data describing the motion of an object and is able to express the results of the analysis using narrative, mathematical, and graphical representations.

Introductory Video: Displacement, Velocity and Acceleration



Mechanics

- The study of the motion of objects and the related concepts of force and energy.
- Galileo Galilee (1564-1642)
- Sir Isaac Newton (1642-1727)
- Building blocks of all areas of modern physics

Mechanics

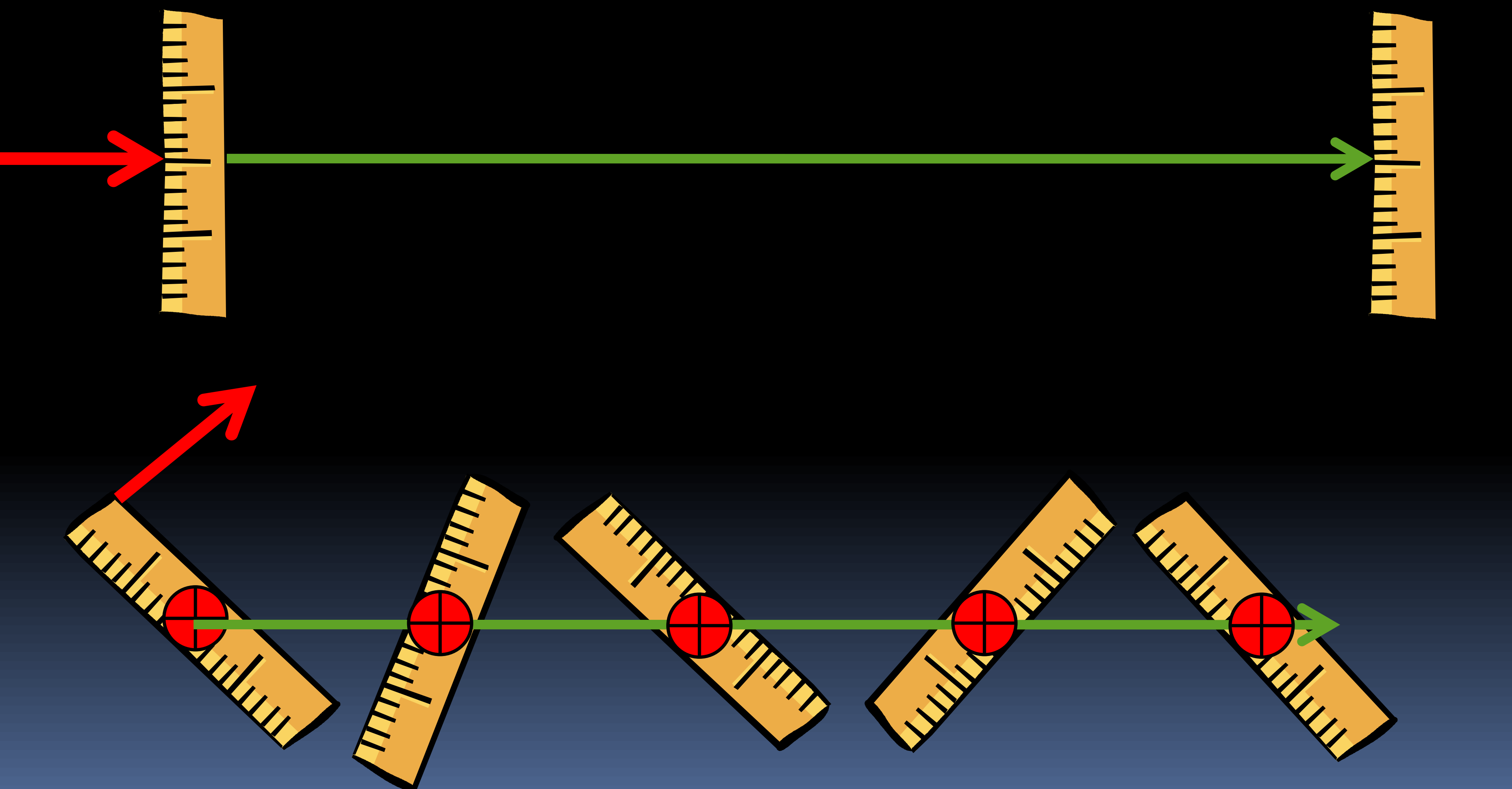
- Two major divisions:
  - Kinematics: description of how things move
  - Dynamics: force and why things move the way they do
- Chapters 2 and 3 deal with kinematics

Translational Motion

- Objects that move without rotating
- Moves along a straight-line path
- One-dimensional motion

Translational Motion

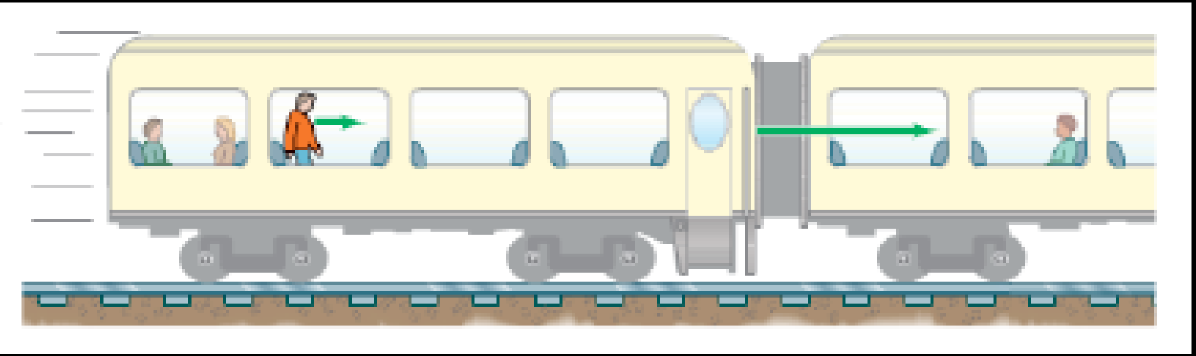
Translational Motion



Frame of Reference

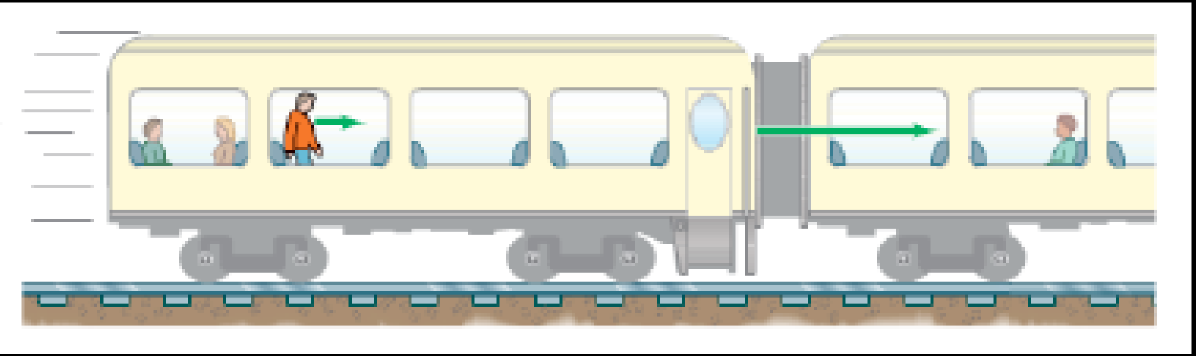
- The point from which you are viewing something
- The point from which you are measuring something
- We normally place a set of ***<u>coordinate axes</u>*** (a coordinate plane) with the origin resting on the reference point

Frame of Reference



- A train is moving from left to right at 20 m/s. A man walks toward the front of the train at 3 m/s.
  - To an observer outside the train, how fast and in what direction is the ***seated woman*** moving?

Frame of Reference



- A train is moving from left to right at 20 m/s. A man walks toward the front of the train at 3 m/s.
  - To an observer outside the train, how fast and in what direction is the ***seated woman*** moving?
    - 20 m/s from left to right

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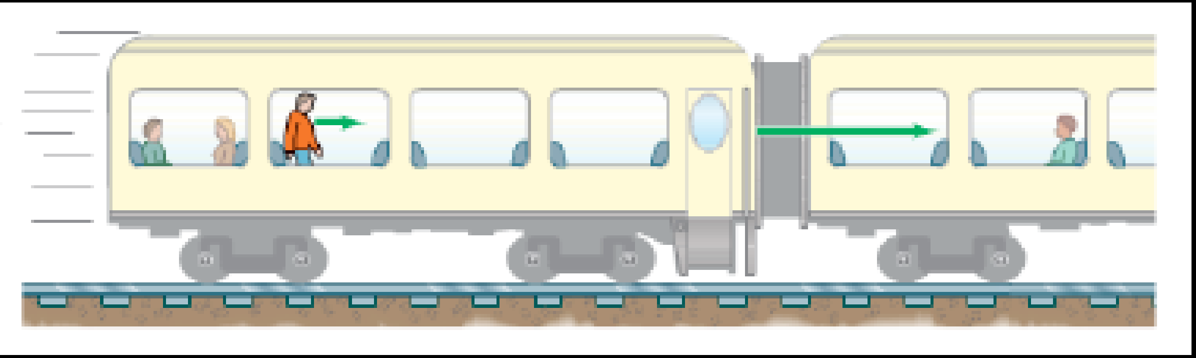
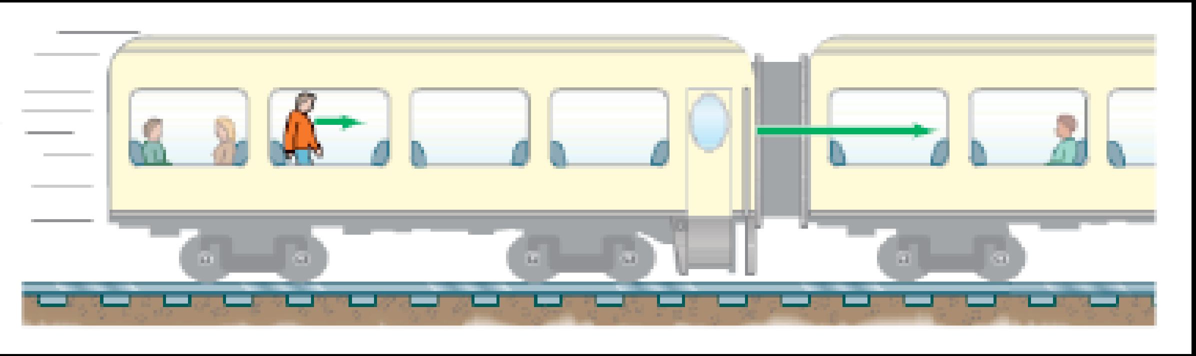


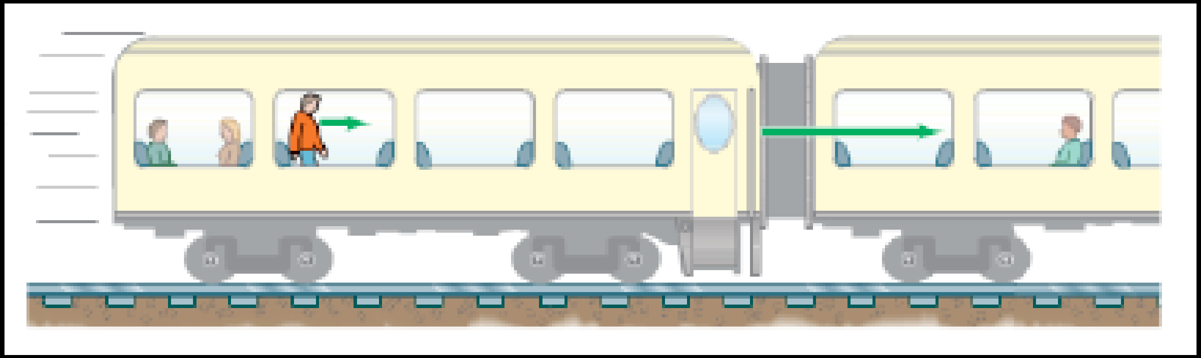
- A train is moving from left to right at 20 m/s. A man walks toward the front of the train at 3 m/s.
  - To an observer outside the train, how fast and in what direction is the *__walking man__* moving?

Frame of Reference



- A train is moving from left to right at 20 m/s. A man walks toward the front of the train at 3 m/s.
  - To an observer outside the train, how fast and in what direction is the walking man moving?
    - 23 m/s from left to right

Frame of Reference



- A train is moving from left to right at 20 m/s. A man walks toward the front of the train at 3 m/s.
  - To the ***seated observer on the right***, how fast and in what direction is the walking man moving?

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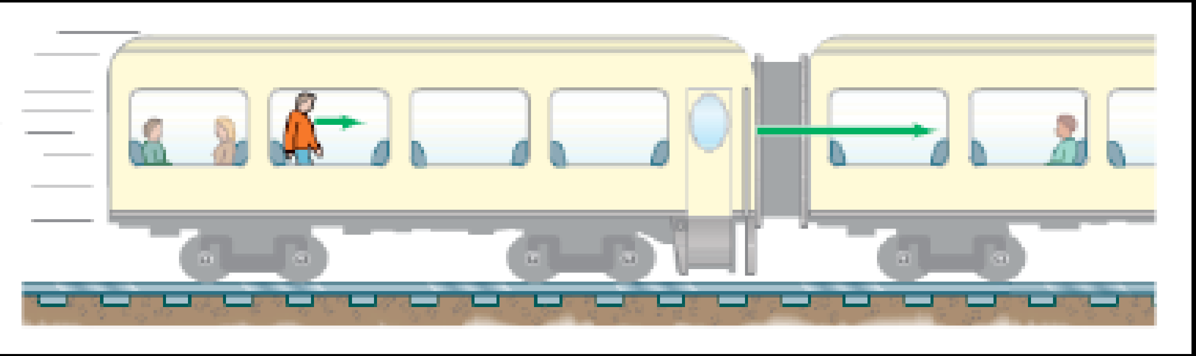
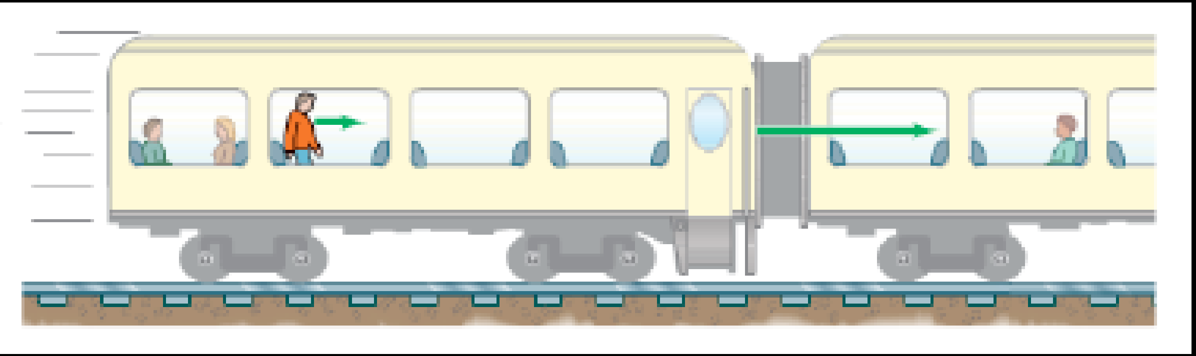


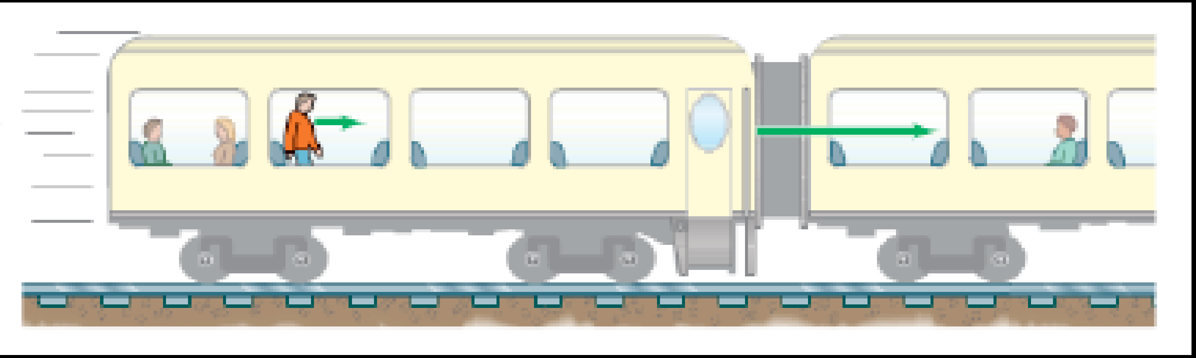
- A train is moving from left to right at 20 m/s. A man walks toward the front of the train at 3 m/s.
  - To the ***seated observer on the right***, how fast and in what direction is the walking man moving?
    - 3 m/s toward him

Frame of Reference



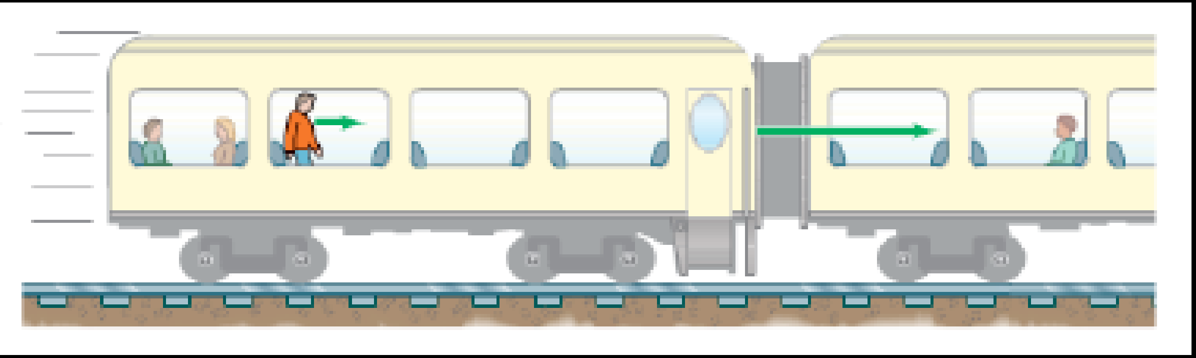
- A train is moving from left to right at 20 m/s. A man walks toward the front of the train at 3 m/s.
  - To the walking man , how fast and in what direction is the seated observer moving?

Frame of Reference



- A train is moving from left to right at 20 m/s. A man walks toward the front of the train at 3 m/s.
  - To the walking man , how fast and in what direction is the seated observer moving?
    - 3 m/s toward him

Frame of Reference



- A train is moving from left to right at 20 m/s. A man walks toward the front of the train at 3 m/s.
  - To the walking man, how fast and in what direction is an observer outside the train moving?

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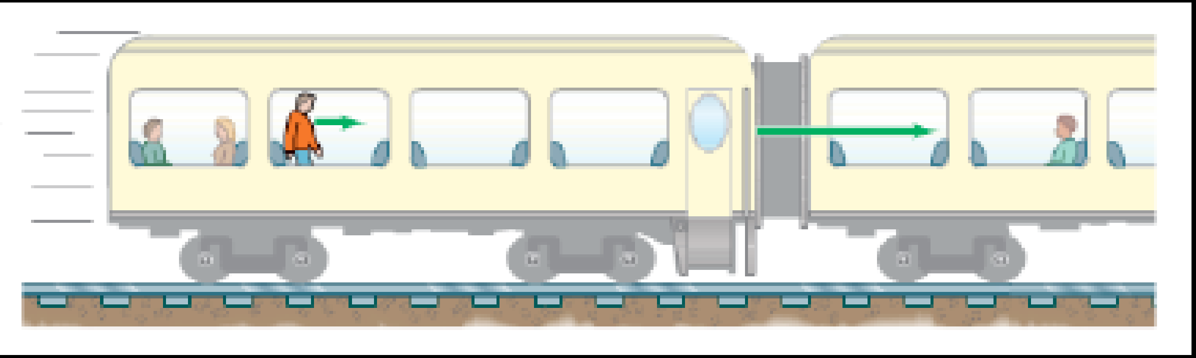


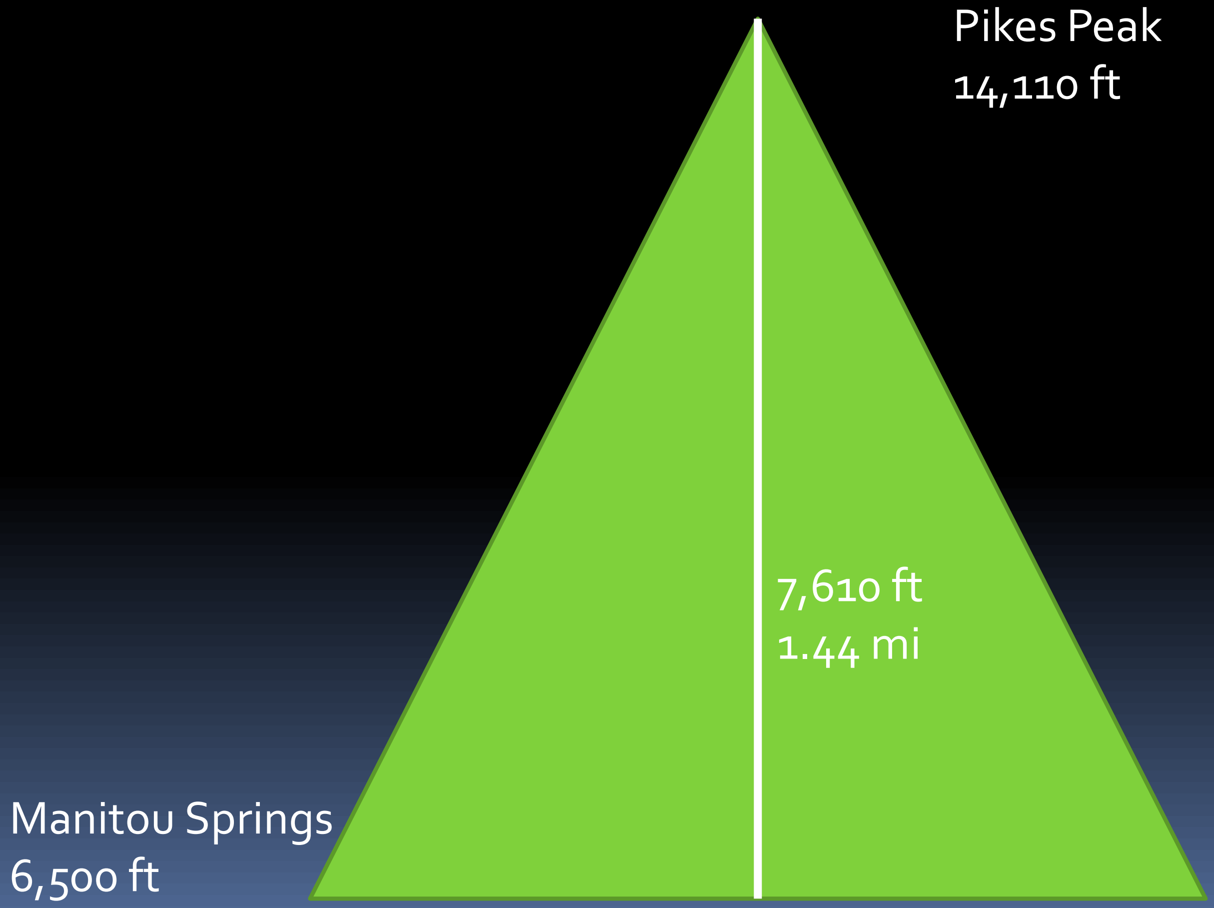
- A train is moving from left to right at 20 m/s. A man walks toward the front of the train at 3 m/s.
  - To the walking man, how fast and in what direction is an observer outside the train moving?
    - 23 m/s from *the walking man's* left to *his* right

Distance vs. Displacement

- Distance: measurement of the entire length travelled without respect to direction
  - Includes magnitude only, a scalar
- Displacement: change in ***position*** of an object, or, how far the object is from its original position and in what direction
  - Includes both magnitude and direction, a vector

Distance vs. Displacement

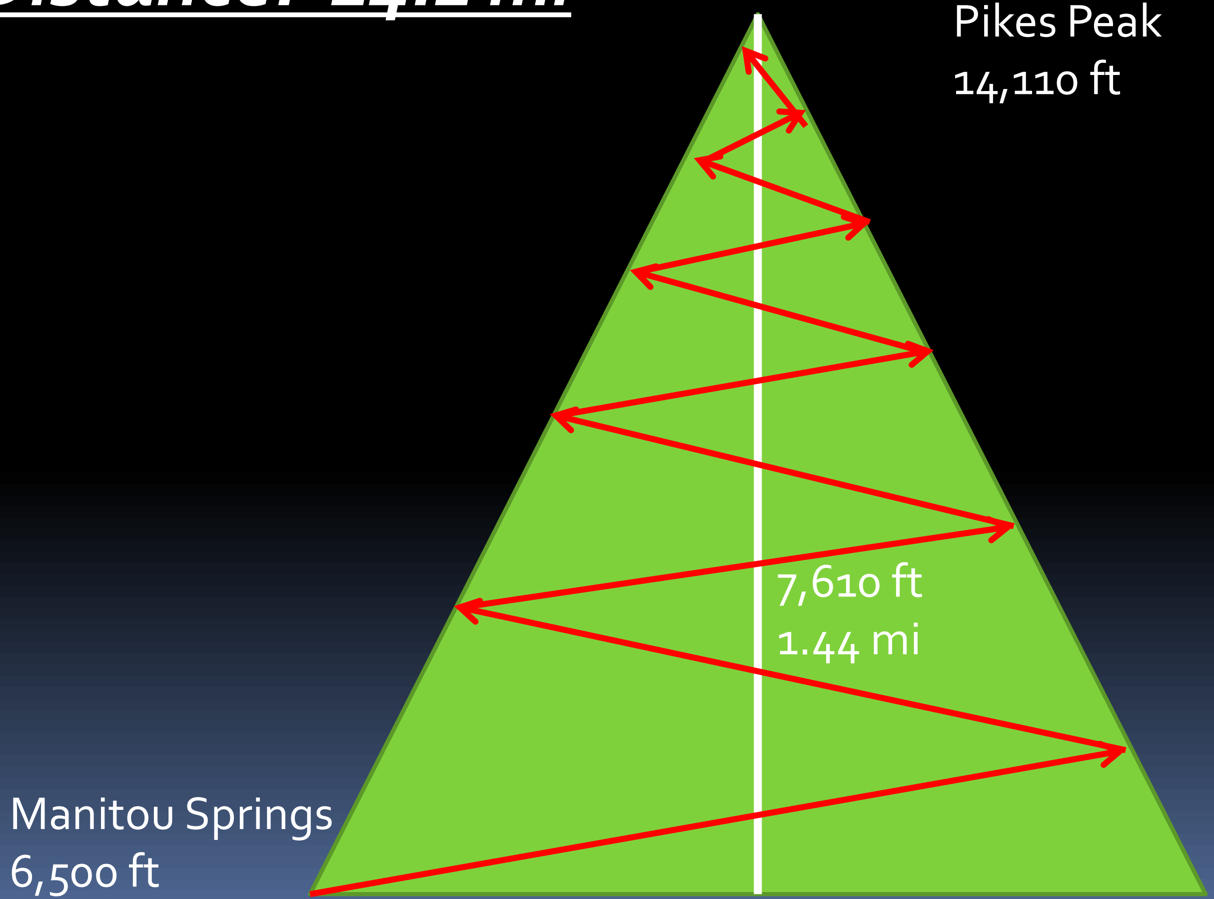
- Pike's Peak Marathon



Distance vs. Displacement

- Pike's Peak Marathon

Distance: 14.1 mi

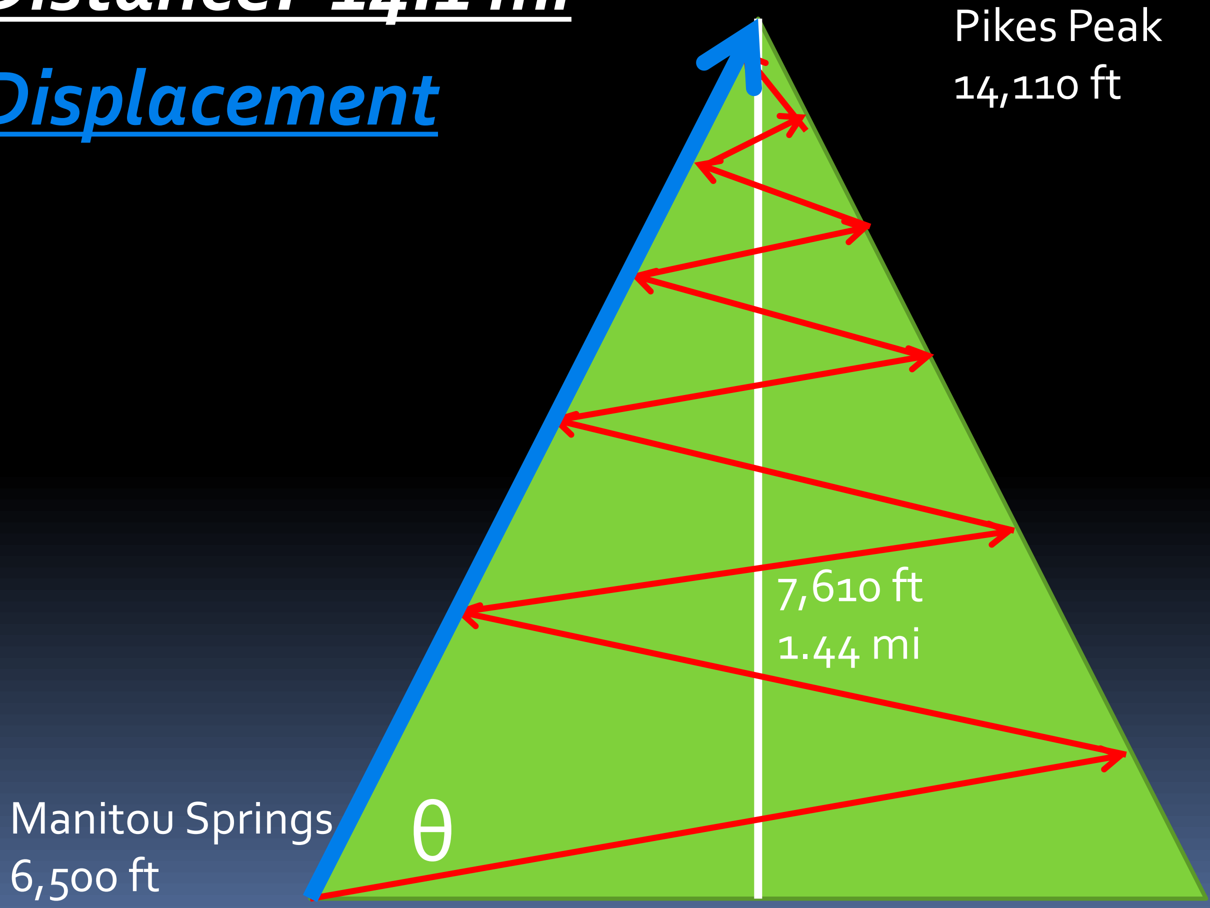


Distance vs. Displacement

- Pike's Peak Marathon

<u>Distance: 14.1 mi</u>

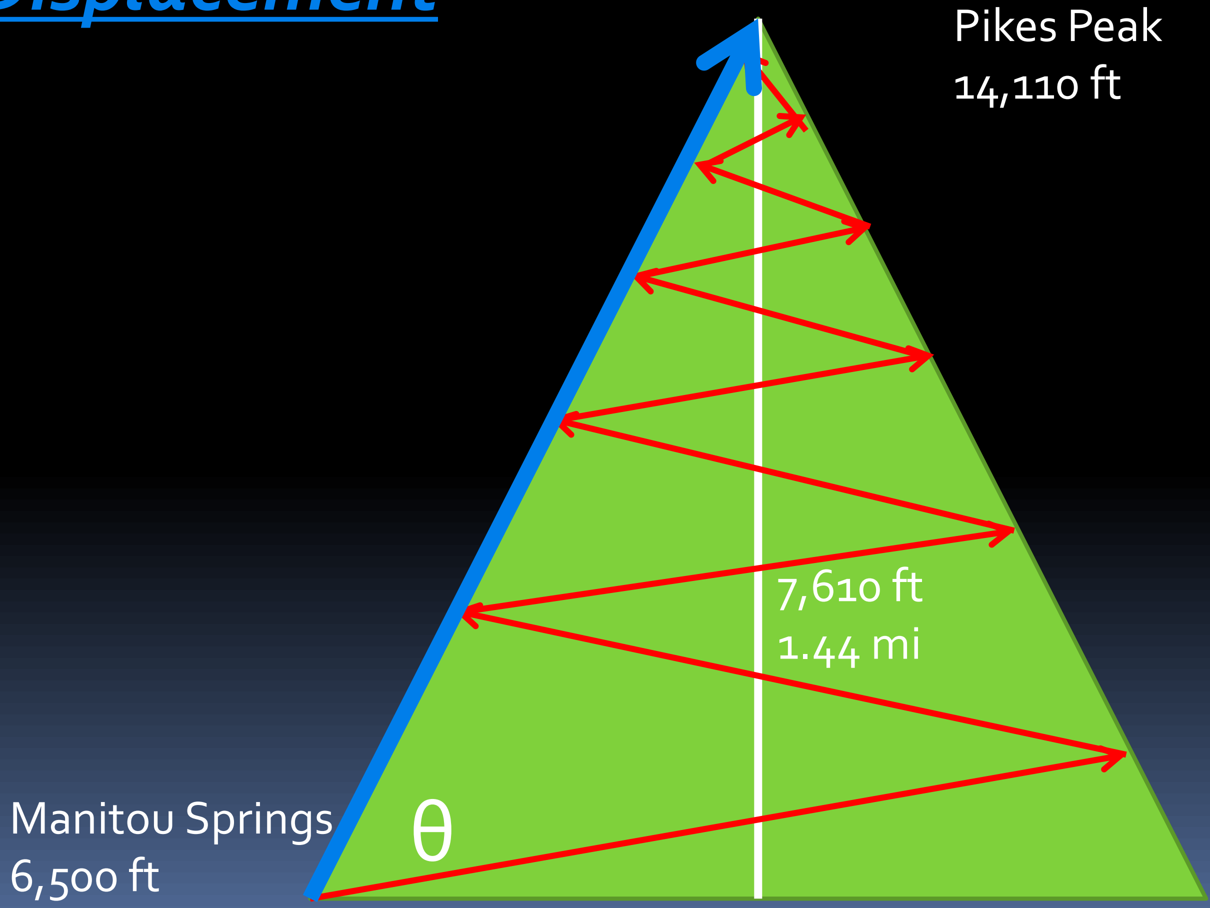
<u>Displacement</u>



Scalar vs. Vector

Distance: 14.1 mi

Displacement



Displacement

$$\Delta x = x_2 - x_1$$

- *"The change in position is equal to the second position minus the first position"*
- Example 1: You are standing on a number line at 23 and suffer a blow to the head. When you wake up, you are laying at -17. What was your displacement?

Displacement

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Displacement

$$\Delta x = x_2 - x_1$$

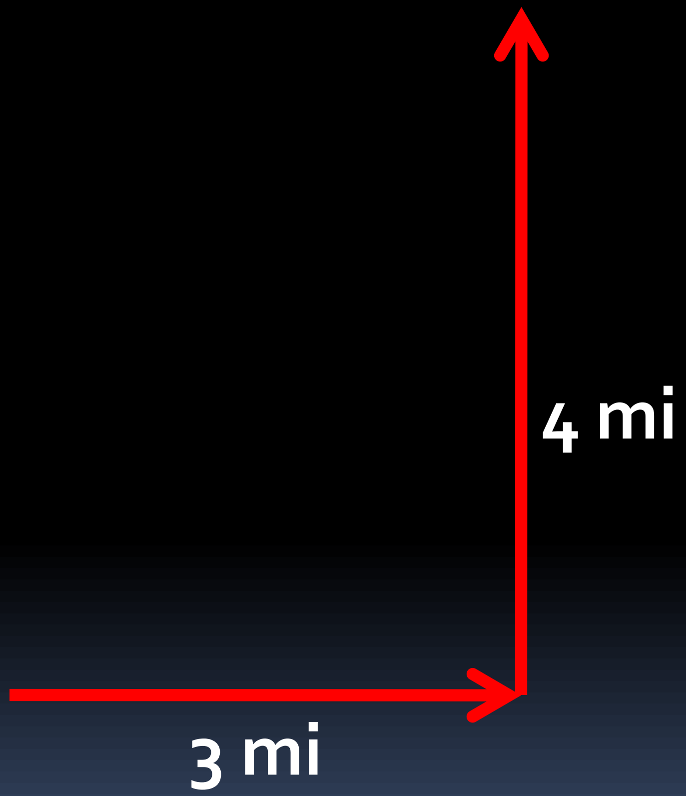
$$\Delta x = -17 - 23 = -40$$

- Example 1: You are standing on a number line at 23 and suffer a blow to the head. When you wake up, you are laying at -17. What was your displacement?
- Your displacement is <u>40 ***to the left***</u>

Displacement

$$\Delta x = x_2 - x_1$$

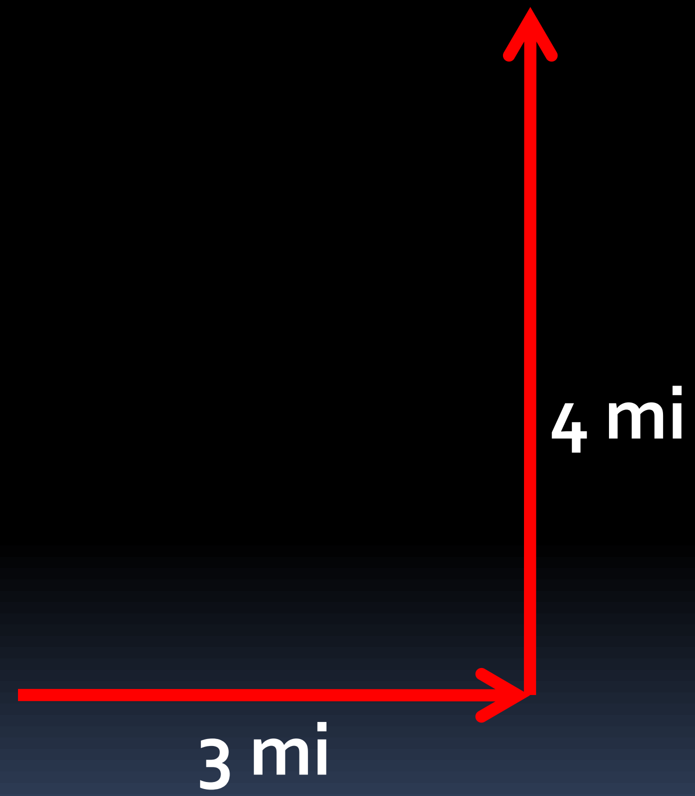
- Example 2: Having nothing better to do, you walk 3 miles east and 4 miles north.
  - What distance did you travel?
  - What was your displacement?
  - Why couldn't you find anything better to do?



Displacement

$$\Delta x = x_2 - x_1$$

- Example 2: Having nothing better to do, you walk 3 miles east and 4 miles north.
  - What distance did you travel?
    - 7 mi
  - What was your displacement?



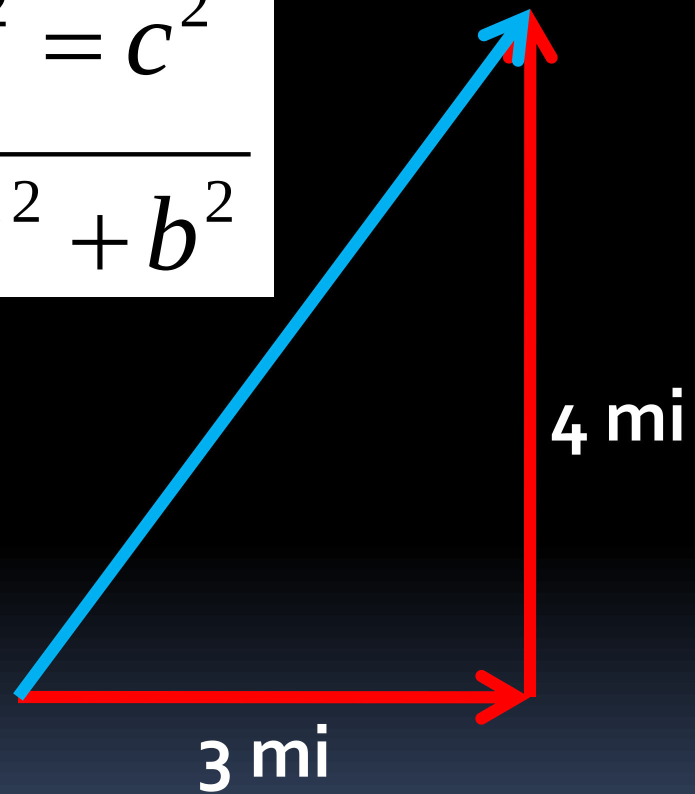
Displacement

- Example 2: Having nothing better to do, you walk 3 miles east and 4 miles north.
  - What was your displacement?
    - Pythagorize 5 mi
  - Why couldn't you find anything better to do?

$$\Delta x = x_2 - x_1$$

$$a^2 + b^2 = c^2$$

$$c = \sqrt{a^2 + b^2}$$



Displacement

$$\Delta x = x_2 - x_1$$

- Example 2: Having nothing better to do, you walk 3 miles east and 4 miles north.
  - Why couldn't you find anything better to do?
    - You had already finished all your physics homework!

$$a^2 + b^2 = c^2$$

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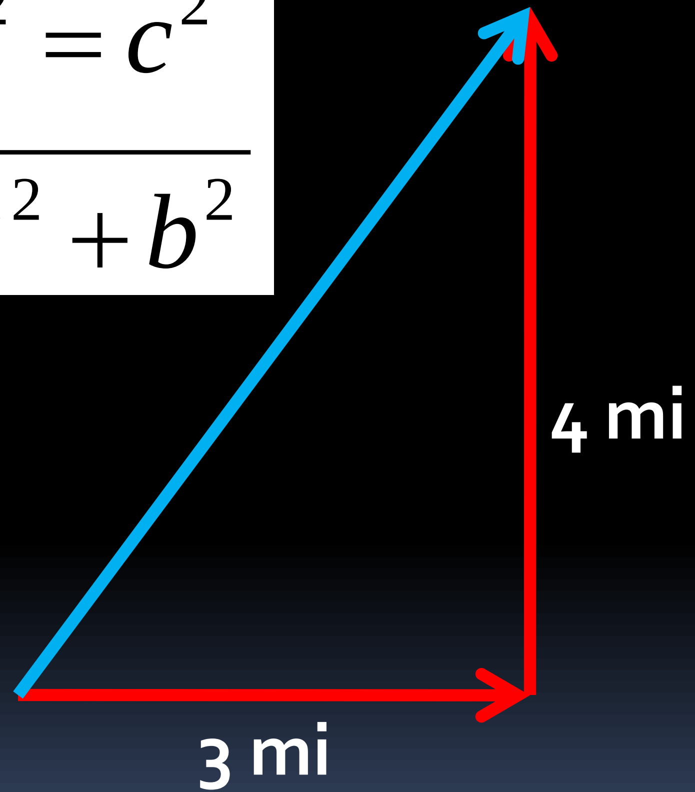


Speed

- ***Distance*** traveled in a given time interval
- ***Distance*** per unit time
- 60 mph, 35 m/s
- Vector or scalar?

Average Speed

- Distance travelled divided by time elapsed
- Avg. speed = distance travelled/time elapsed

Velocity

- ***Displacement*** traveled in a given time interval
- ***Displacement*** per unit time
- 60 mph, 35 m/s
- Vector or scalar?

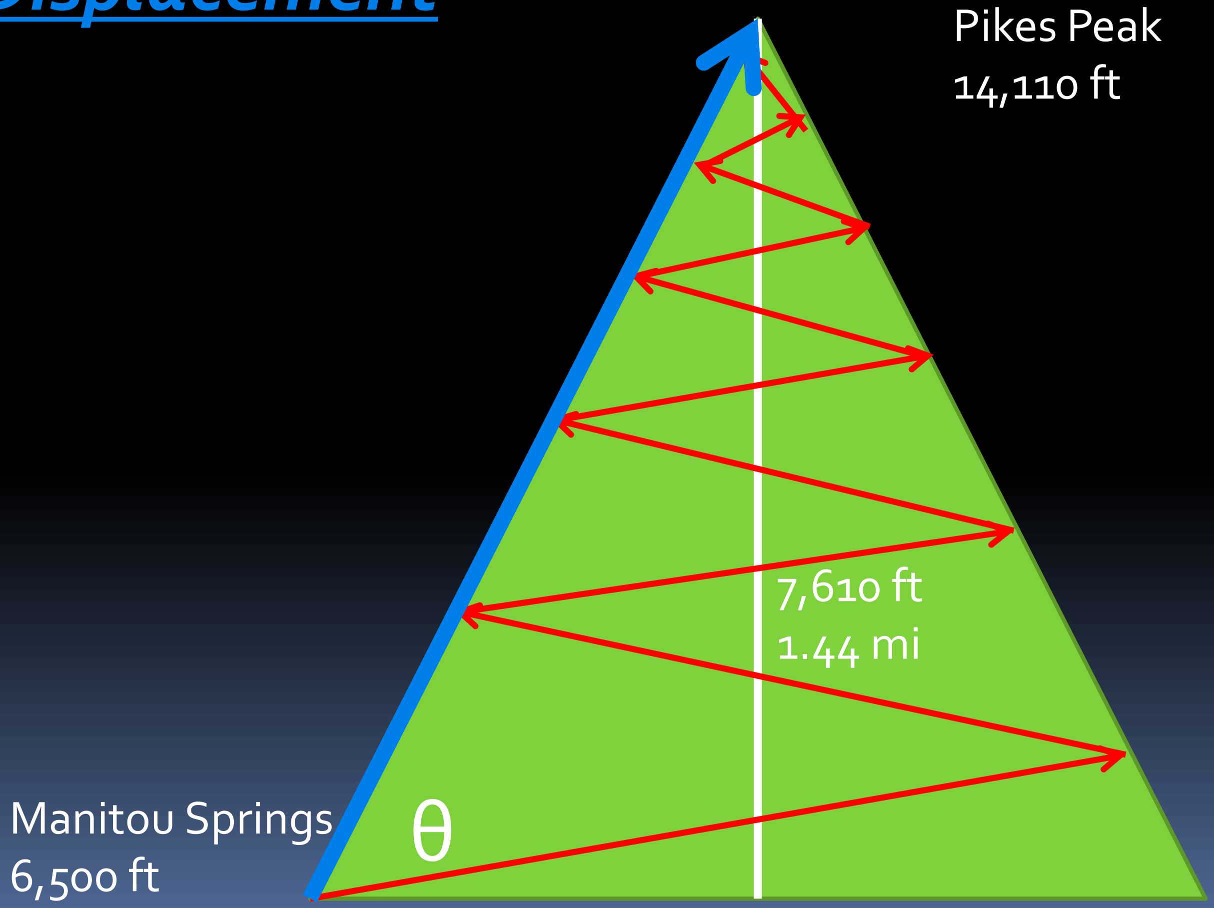
Average Velocity

- ***Displacement*** divided by time elapsed
- Avg. velocity = displacement/time elapsed

Speed vs. Velocity

<u>Distance: 14.1 mi</u>

<u>Displacement</u>



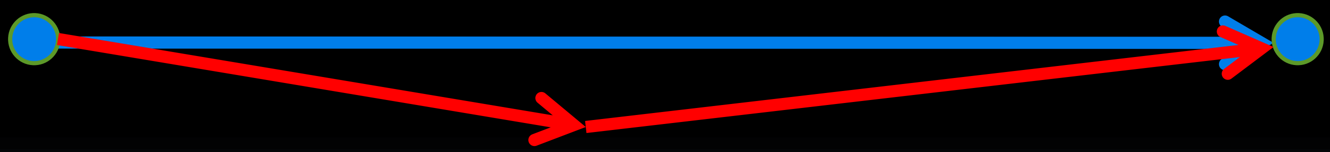
Speed vs. Velocity

- ***Can the magnitude of the velocity ever be more than speed for any given timed movement of a body?***

Speed vs. Velocity

- *Can the magnitude of the velocity ever be more than speed for any given timed movement of a body?*

Distance equals displacement



Distance is greater than or equal to displacement but never less than displacement

Speed vs. Velocity

- ***Can the magnitude of the velocity ever be more than speed for any given timed movement of a body?***
- ***Since distance is always greater than or equal to displacement***
- ***And since speed is distance/time***
- ***And since velocity is displacement/time***
- ***Speed will always be greater than or equal to velocity***

Avg. Velocity: The Equation

$$\bar{v} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t}$$

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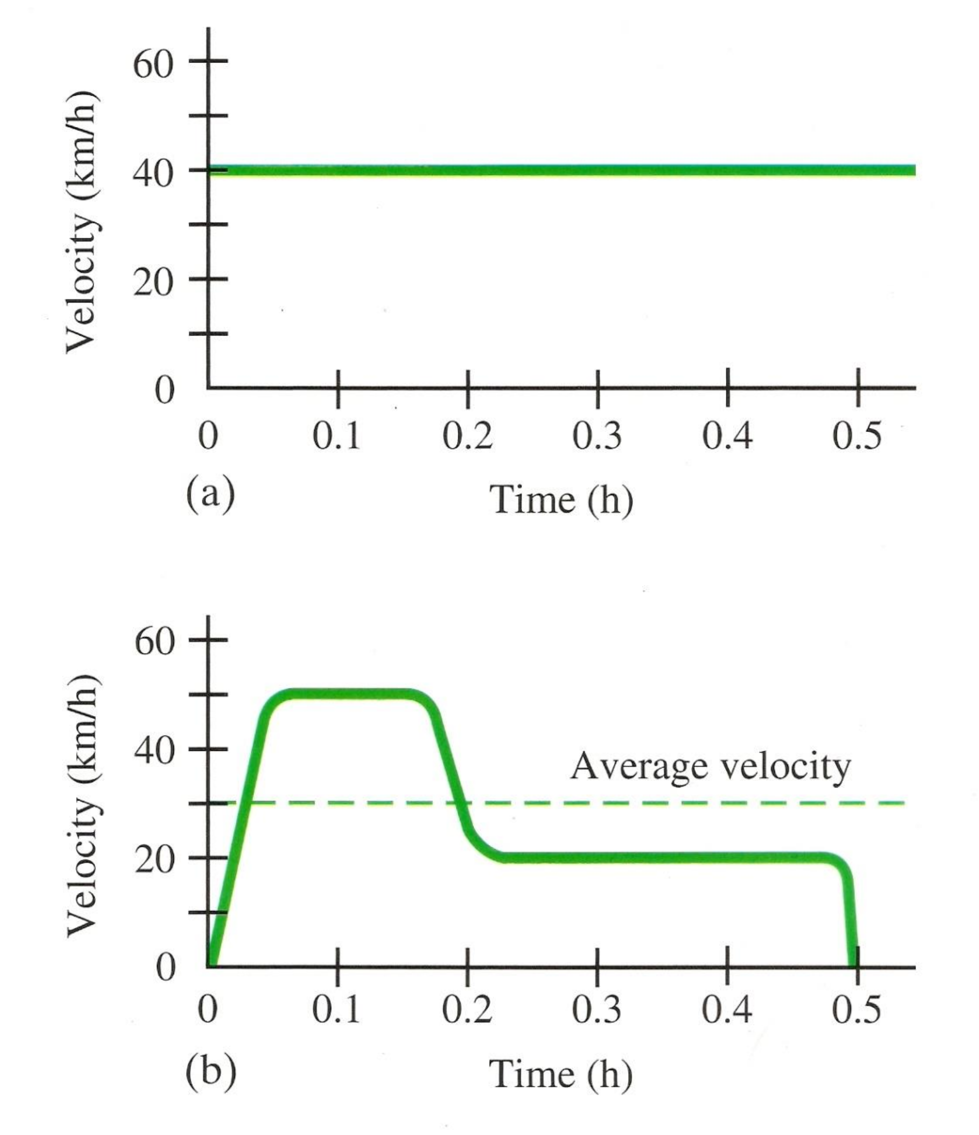
Average Velocity of a Car



Average Velocity – Air Track

Steven Le has my photogates!

Instantaneous Velocity

- Velocity at a split second of time
- ***The average velocity of an infinitesimally short time interval***

Instantaneous Velocity: The Equation

$$\bar{v} = \frac{\Delta x}{\Delta t}$$

$$\bar{v} = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$$

Instantaneous Velocity – Air Track

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Instantaneous Velocity

- **Instantaneous speed will always equal the magnitude of the instantaneous velocity. Why?**

Instantaneous Velocity

- **Instantaneous speed will always equal the magnitude of the instantaneous velocity. Why?**
- ***When distance/displacement become infinitesimally small, their difference also becomes infinitesimally small, approaching zero***

Learning Objectives

- (3.A.1.1): The student is able to express the motion of an object using narrative, mathematical, and graphical representations.
- (3.A.1.2): The student is able to design an experimental investigation of the motion of an object.

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- (3.A.1.3): The student is able to analyze experimental data describing the motion of an object and is able to express the results of the analysis using narrative, mathematical, and graphical representations.

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Enduring Understanding

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Big Idea

- Big Idea 3: The interactions of an object with other objects can be described by forces.

QUESTIONS?

Homework

#1-14