How fast am I moving?

CHAPTER 12

Motion

Chapter Outline

12.1 Distance and Direction

Lesson Objectives

- Define motion, and relate it to frame of reference.
- Describe how to measure distance.
- Explain how to represent direction.

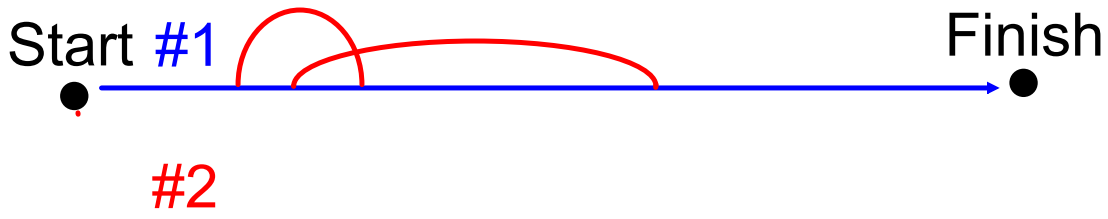
Lesson Vocabulary

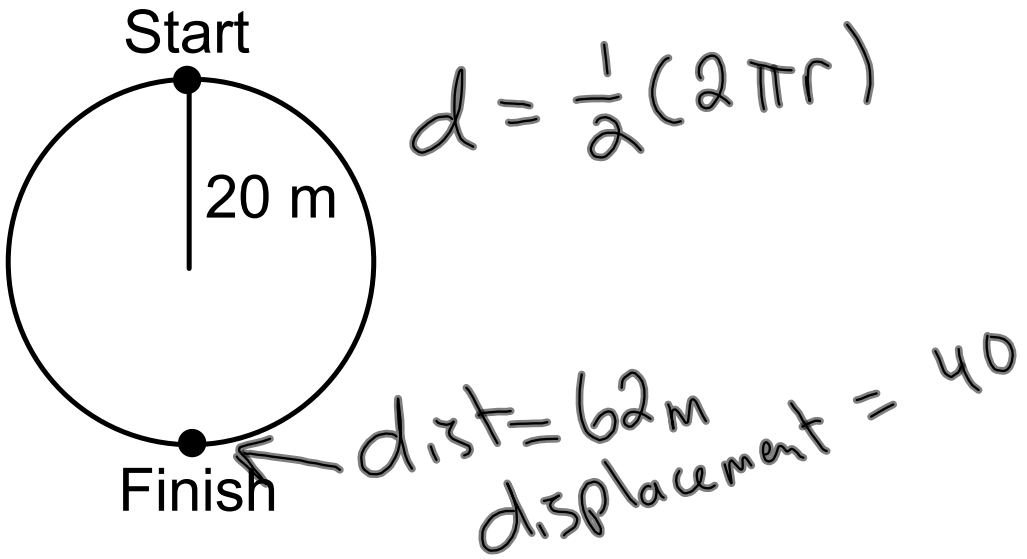
- distance
- frame of reference
- motion
- vector

Frame of Reference

Distance

Did you ever go to a track meet like the one pictured in **Figure** 12.3? Running events in track include 100-meter sprints and 2000-meter races. Races are named for their distance. **Distance** is the length of the route between two points. The length of the route in a race is the distance between the starting and finishing lines. In a 100-meter sprint, for example, the distance is 100 meters.





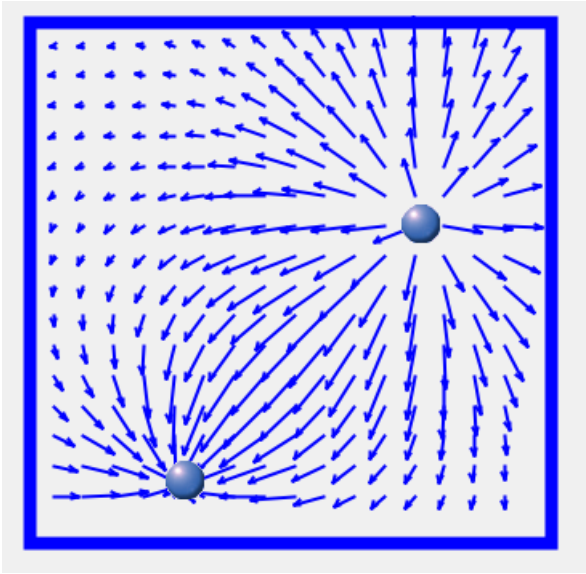
Displacement: Change in position (from start to finish)

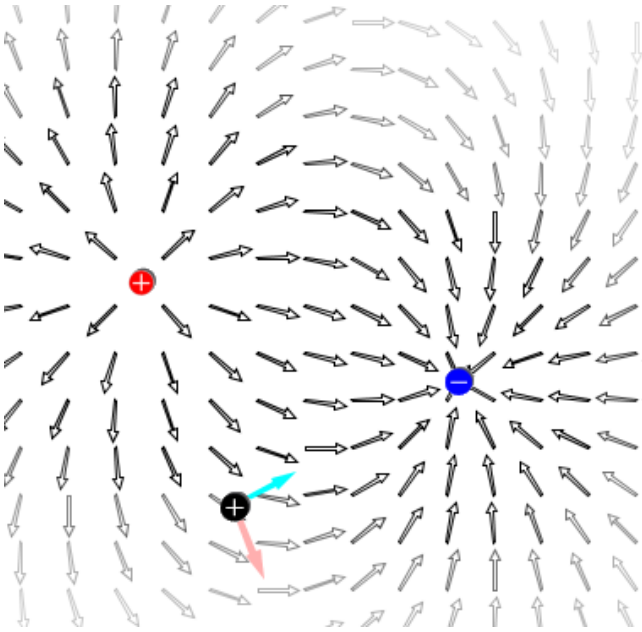
Distance is an example of a *scalar* quantity. In formulas it is represented as *d*.

Displacement is an example of a *vector* quantity. In formulas it is represented as $\vec{d}$.

A scalar only has magnitude or size. Examples include mass, time, distance, and speed.

A vector has both magnitude (size) and a direction. It is represented by an arrow. The arrow tip shows the direction and size of the arrow the magnitude. Examples include displacement, velocity, acceleration, force, electric and magnetic fields.





Example Problems

1. A person walks 25 m [E], then turns around and walks 75 m [W].

a) Calculate the total distance traveled.

$d = 25\,m + 75\,m = \boxed{100\,m}$

W − ⟷ + E

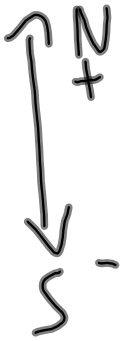
b) Calculate the resulting displacement.

$\vec{d} = +25_m - 75_m = -50_m$ [East]

↑ East ↑ West

or 50 m [West]

2. A cat runs 12 m [N], 8 m [S], 22 m [N], and finally 15 m [S].



a) Calculate the total distance traveled.

$d = 12m + 8m + 22m + 15m$

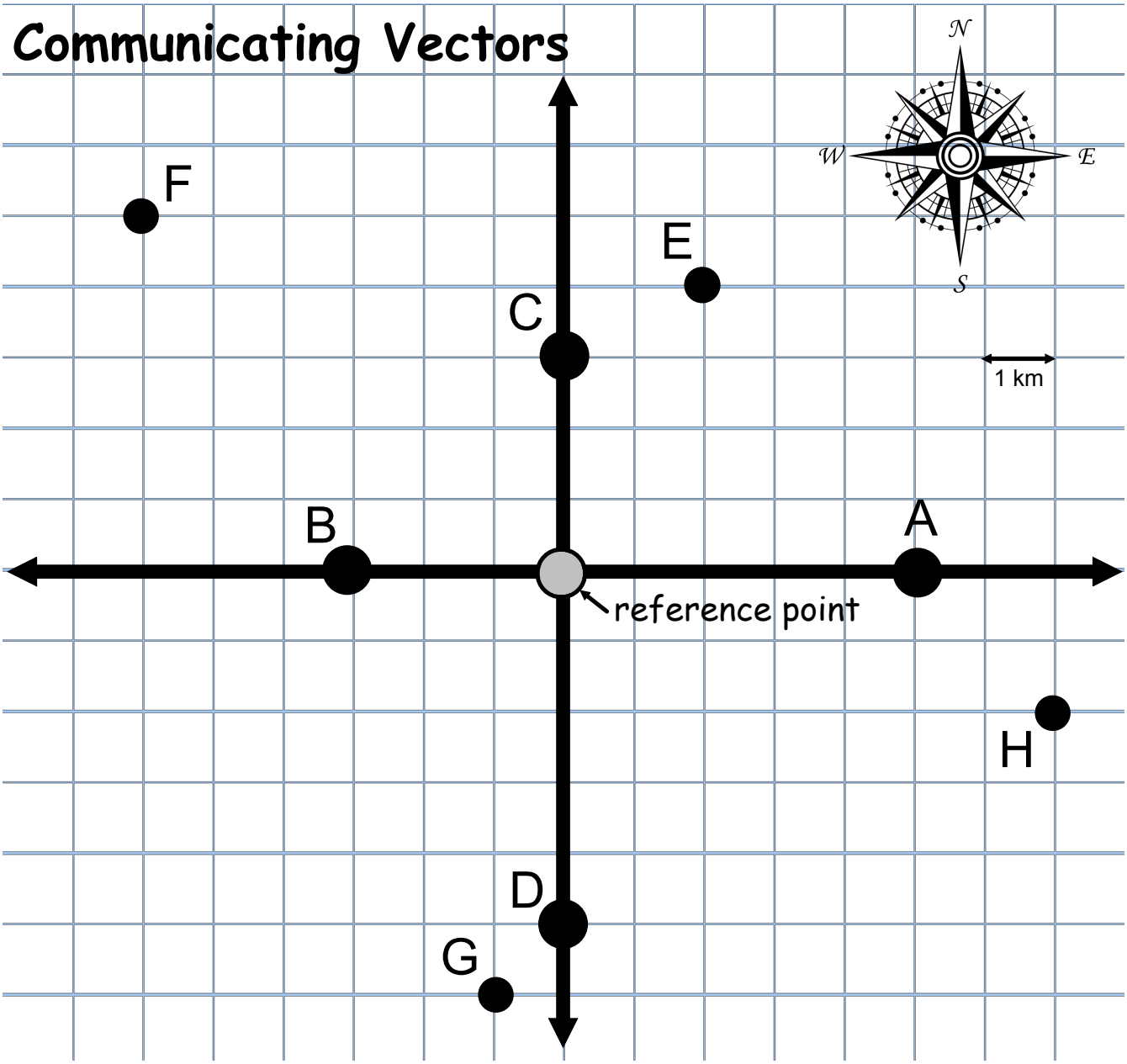
$= \boxed{57m}$

b) Calculate the resulting displacement.

$\vec{d} = +12m - 8m + 22m - 15m$

$= 11m$ North

Communicating Vectors



Communicating Vectors

A: 5 km [E] 0km North

B: -3km [E] 0km [N]

C: 0 km [E] 3km [N]

D: 0 km [E] -5km [N]

E: 2 km [E] 4 Km [N]

F: -6 Km [E] 5 km [N]

G: -1 km [E] -6 km [N]

H: 7 km [E] -2 km [N]

3. Some dude drives 52 km [N], 33 km [E], 49 km [S], 29 km [W].

a) Calculate the total distance traveled.

$d = 52 + 33 + 49 + 29 = \boxed{163\ km}$

b) Calculate the resulting Eastward displacement.

$\vec{d}_{East} = 33km\,[E] + 29km\,[W]$

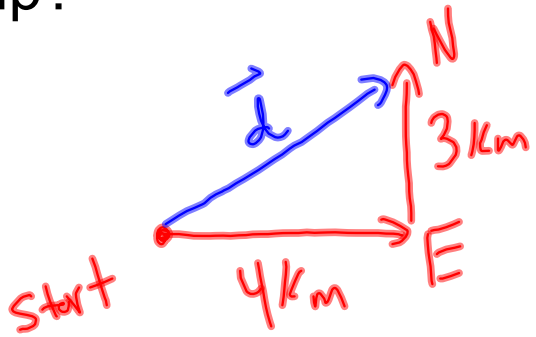
$= 33km\,[E] - 29\,[E] = 4\ km\,[E]$

c) Calculate the resulting Northward displacement.

$\vec{d}_{North} = 52\ km\,[N] + 49\ km\,[S]$

$= 52\ km\,[N] - 49\ km\,[N] = 3\ km\,[N]$

d) How far from his starting position did this dude end up?



12.2 Speed and Velocity

Lesson Objectives

- Outline how to calculate the speed of a moving object.
- Explain how velocity differs from speed.

Speed

Speed is an important aspect of motion. It is a measure of how fast or slow something moves. It depends on how far something travels and how long it takes to travel that far. Speed can be calculated using this general formula:

$$Speed_{avg} = \frac{distance}{time}$$

Instantaneous vs. Average Speed

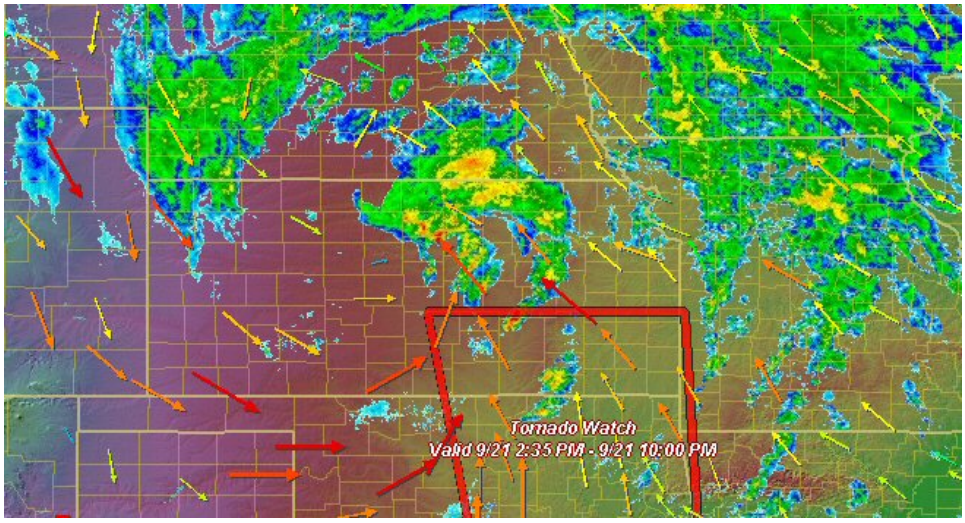
When you travel by car, you usually don't move at a constant speed. Instead you go faster or slower depending on speed limits, traffic, traffic lights, and many other factors. For example, you might travel 65 miles per hour on a highway but only 20 miles per hour on a city street (see **Figure** 12.7). You might come to a complete stop at traffic lights, slow down as you turn corners, and speed up to pass other cars. The speed of a moving car or other object at a given instant is called its instantaneous speed. It may vary from moment to moment, so it is hard to calculate.

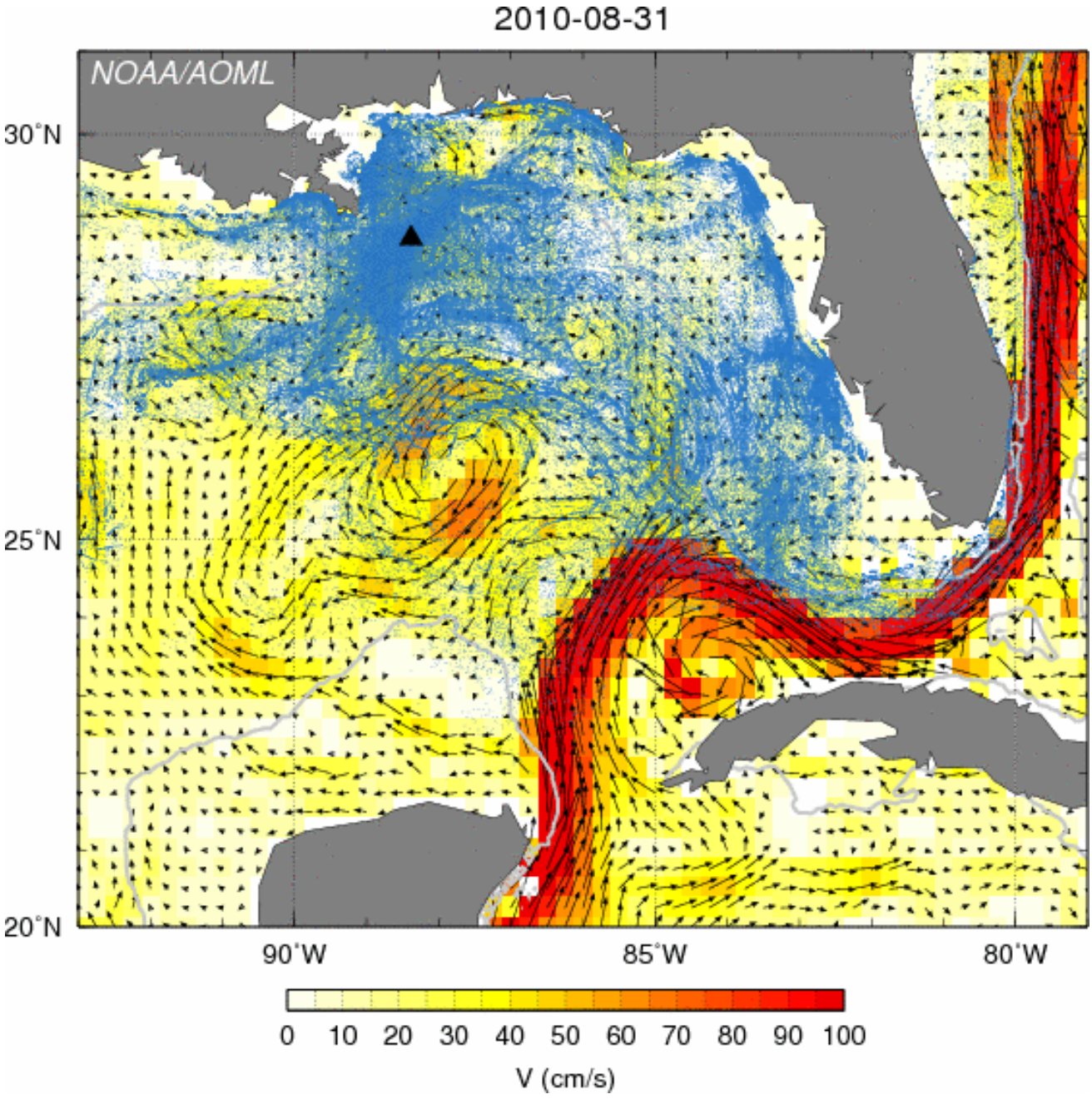
It's easier to calculate the average speed of a moving object than the instantaneous speed. The average speed is the total distance traveled divided by the total time it took to travel that distance. To calculate the average speed, you can use the general formula for speed that was given above. Suppose, for example, that you took a 75-mile car trip with your family. Your instantaneous speed would vary throughout the trip. If the trip took a total of 1.5 hours, your average speed for the trip would be:

Velocity

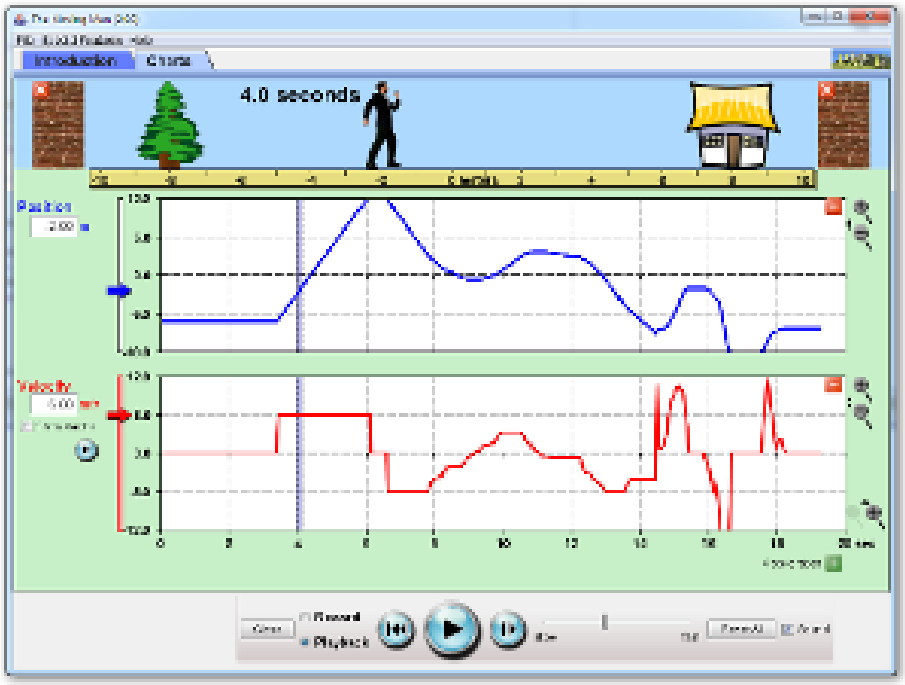
Speed tells you only how fast an object is moving. It doesn't tell you the direction the object is moving. The measure of both speed and direction is called **velocity**. Velocity is a vector that can be represented by an arrow. The length of the arrow represents speed, and the way the arrow points represents direction. The three arrows in **Figure** 12.9 represent the velocities of three different objects. Vectors A and B are the same length but point in different directions. They represent objects moving at the same speed but in different directions. Vector C is shorter than vector A or B but points in the same direction as vector A. It represents an object moving at a slower speed than A or B but in the same direction as A. If you're still not sure of the difference between speed and velocity, watch the cartoon at this URL: http://www.youtube.com/watch?v=mDcaeO0WxBI&feature=related (2:10).

$$\vec{v}_{avg} = \frac{displacement}{time}$$

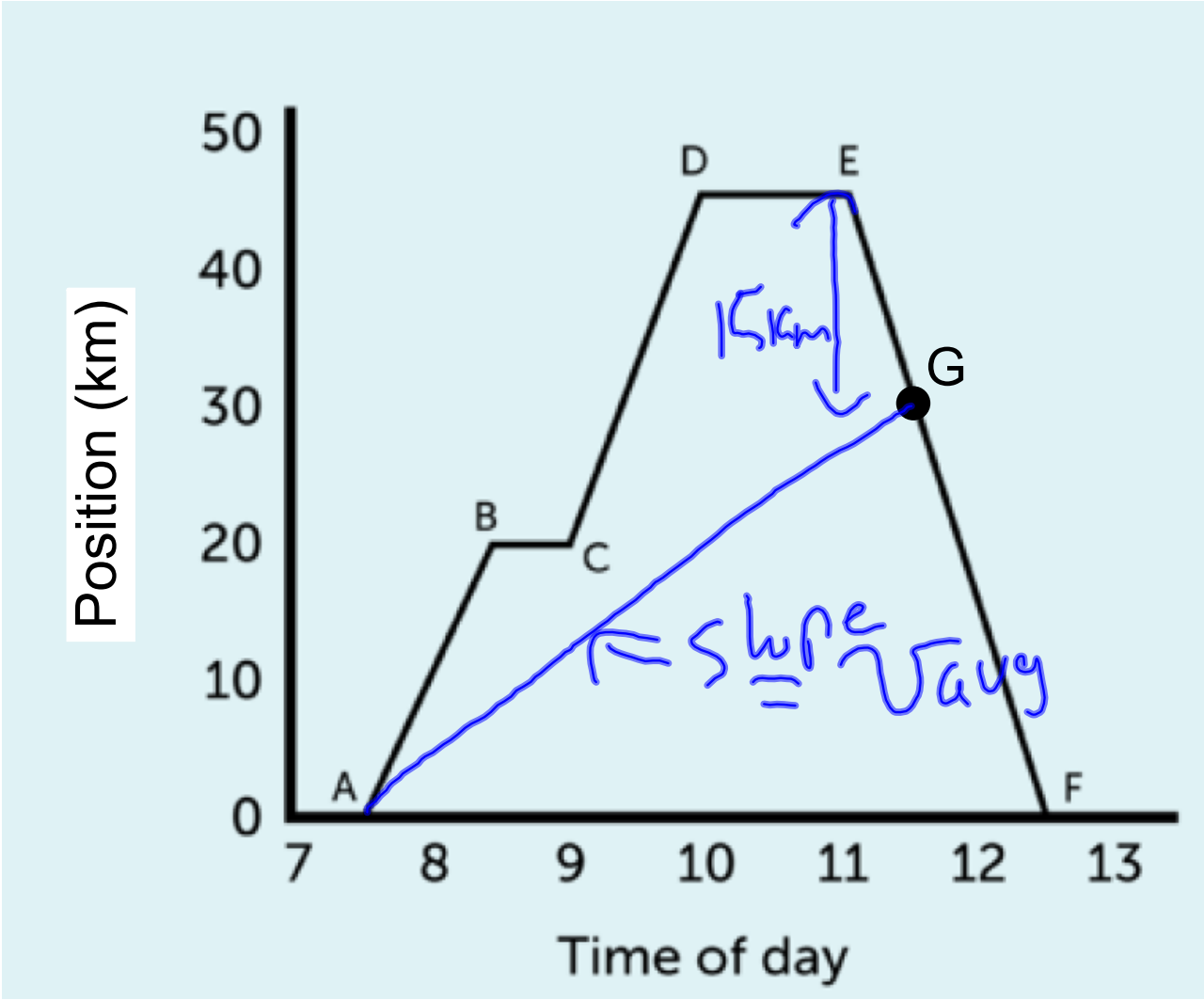



2010-08-31
NOAA/AOML
30°N
25°N
20°N
90°W
85°W
80°W
0 10 20 30 40 50 60 70 80 90 100
V (cm/s)

The Moving Man



Analyzing Position - Time Graphs



Positive Direction ⇒ East

Neg. Direction ⇒ West

A ➡ B

- d = 20 km
- $\vec{d}$ = 20 km East
- Avg Speed = 20 km/h
- v_{avg} = 20 km/h East

A ➡ C

- d = 20 km
- $\vec{d}$ = 20 km East
- Avg Speed = 13.3 km/h
- v_{avg} = 13.3 km/h

$$\text{Speed} = \frac{20\ km}{1.5\ h}$$

C ➡ D

- d = 25 km
- $\vec{d}$ = 25 km East
- Avg Speed = 25 km/h
- v_{avg} = 25 km/h East

A ➡ E

- d = 45 km
- $\vec{d}$ = 45 km East
- Avg Speed = 12.9 km/h
- v_{avg} = 12.9 km/h East

A ➡ G

- d = 60 km
- $\vec{d}$ = 30 km East
- Avg Speed = 15 km/h
- v_{avg} = 7.5 km/h East

$$\text{Speed} = \frac{60\ km}{4\ h} = 15\ km/h$$

$$\text{Vel} = \frac{30\ km}{4} = 7.5$$

E ➡ F

- d = 45 km
- $\vec{d}$ = - 45 km East or 45 km West
- Avg Speed = 45 km/h
- v_{avg} = - 45 km/h East or 45 km/h West

A ➡ F

- d = 90 km
- $\vec{d}$ = 0.0 km East
- Avg Speed = 18 km/h
- v_{avg} = 0.0 km/h East

90km/5h

$$\leftarrow = \frac{0\ km}{5\ h}$$