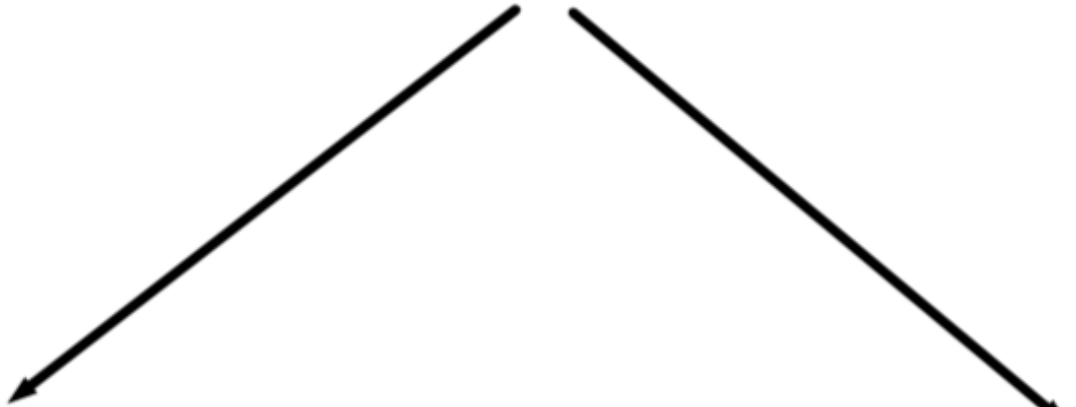
UNIT 1: KINEMATICS

HOW OBJECTS MOVE

Mechanics



Kinematics

Dynamics

The study of *how* objects move.

MOTION

- Motion: Change in position.
- Frame of reference: Something not moving with respect to an observer that can be used to detect motion.

FRAME OF REFERENCE ACTIVITY

- In groups make two roads with the tracks.
- Use two cars, just to pick numbers, one car will travel at 75 km/h and the other at 25 km/h relative to the ground. Arbitrarily choose one direction as east and the other west.
- Have the two cars travel in the same and opposite directions and determine what the velocity of each car is relative to the other.

HOT WHEELS INVESTIGATION

- Construct a loop or jump. Determine the minimum height off the ground for the car to successfully make the loop and a jump through the air of 20 cm.
- Document your trials and observations in your lab notebook.
- Calculate the car's average speed once it makes the loop and lands the jump.

VECTORS AND SCALARS

- it will take you 3 hours to drive to Fredericton.
- My speed is 65 km/h.
- The mass of the car is 125 kg north.
- The movie starts at 2:30 pm west.
- The velocity of the plane is 200 m/s east.
- Gravity pulls me down with 195 lbs of force.
- The flight lasts 7 hours [E25°S].
- Today I drove 50 km.
- Today I drove 50 km south.

SCALARS

- **Scalars** are measurements that are independent of direction.
  - Time
  - Mass
  - Distance
  - Speed

VECTORS

- **Vectors** are measurements that require a direction (it is relative to a coordinate system within a frame of reference). Variables that are vectors are symbolized in bold or with an arrow above them. For example, $\vec{F}$ and $\vec{a}$.
- Position
- Displacement
- Velocity
- Acceleration
- Force

DISTANCE

- Length of the route between two points.

DIRECTION

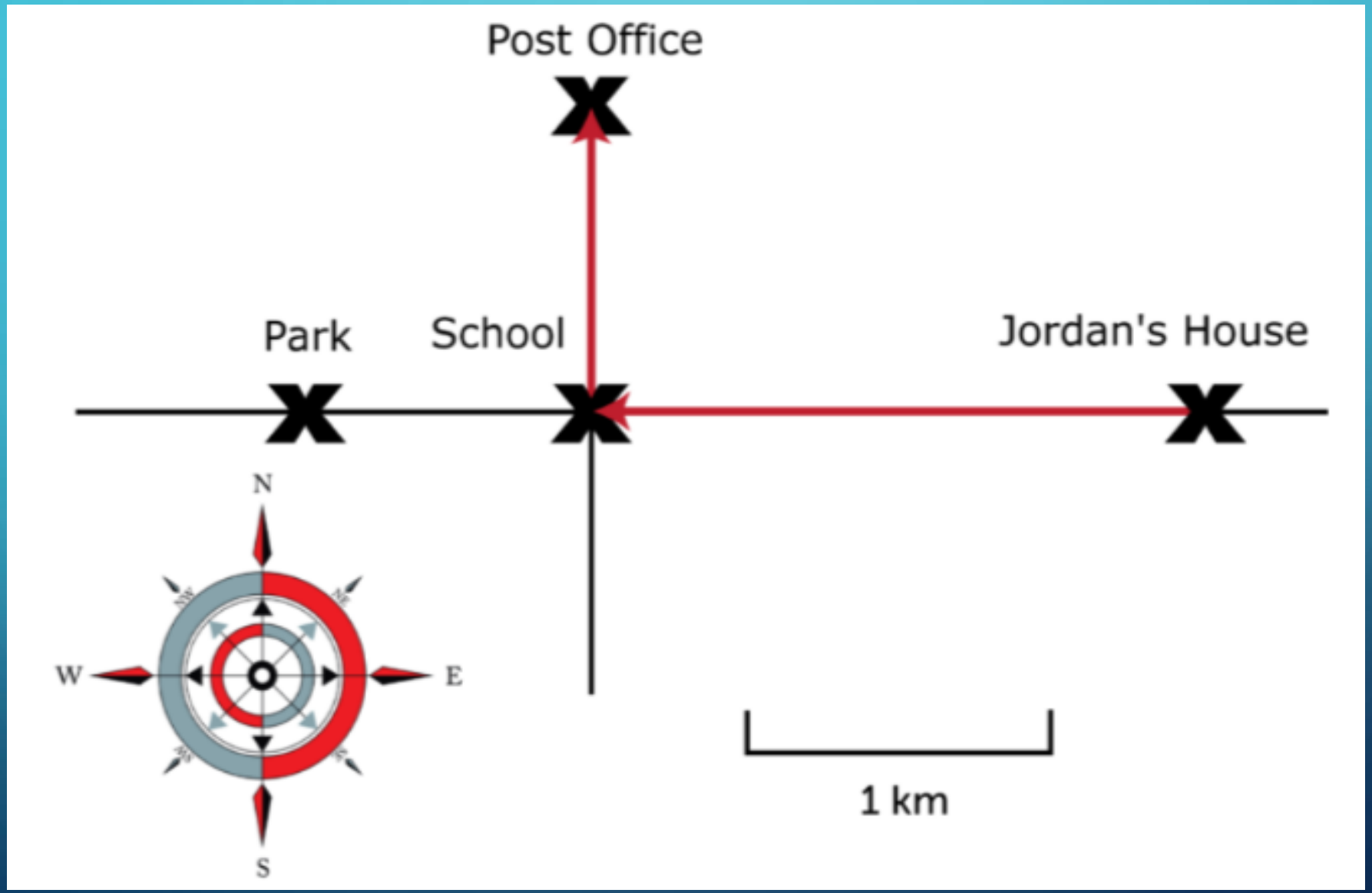
- Described in relative terms: up, down, left, right, forward, etc.
- Cardinal directions: east, west, north and south.
- For calculations it can be positive or negative.

POSITION & DISPLACEMENT

- Position: Distance and direction from a reference point at a given time.
- Displacement: Change in position.

THE MOVING MAN

PRACTICE



POSITION & DISTANCE PROBLEMS

- A person walked the following path:
  - 20 m [W]
  - 10 m [E]
  - 50 m [E]
  - 25 m [W]
  - 60 m [W]
- Calculate this person's distance and final position. Perform the calculations relative to east (east is positive).

YOU TRY:

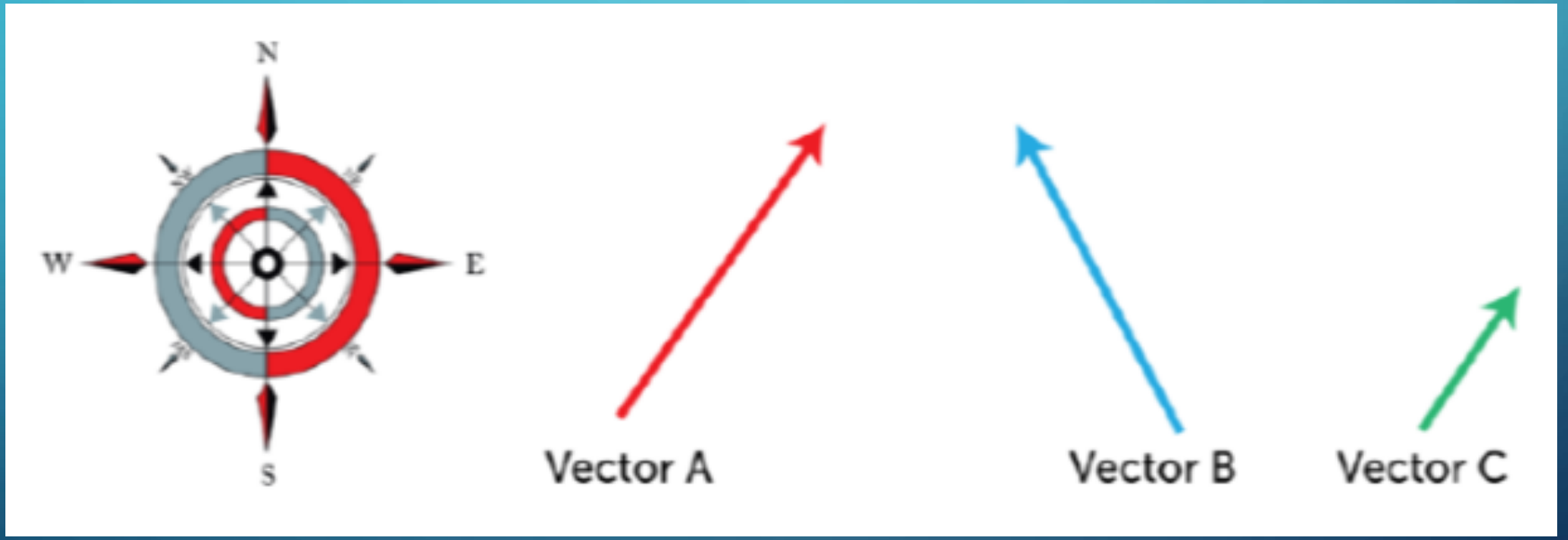
- Calculate this person's distance traveled and final position.
  - 5 m [N]
  - 15 m [N]
  - 40 m [S]
  - 10 m [N]
  - 25 m [S]

SPEED

- Scalar (no direction)
- Average Speed: Distance traveled per unit time.
  - $v_{sp} = \frac{distance}{time}$
- Instantaneous Speed: Speed at an instant in time (speedometer of a car).

VELOCITY

- Vector
- Speed with direction.



AVERAGE VELOCITY

- $\vec{v}_{avg} = \frac{change\ in\ position}{time} = \frac{\vec{d}}{t}$, where $\vec{d} = \vec{d}_f - \vec{d}_o$
- The answer to such a problem communicates how fast and in what direction to travel to reach a destination in a specific amount of time.
- If an object changes its speed or direction, the velocity changes.

EXAMPLE PROBLEM #1

- A person drives the following in 3.5 hours:
  - 25 km [E]
  - 40 km [W]
  - 30 km [W]
  - 60 km [E]

1. Calculate the total distance traveled.
2. Calculate the final position.
3. Calculate the average speed.
4. Calculate the average velocity.

POSITION & VELOCITY PROBLEMS

1. Fred averages 92 km/h [E] and drives for 4.1 hours.

   a) Calculate the final position in that time.

   b) Calculate the length of time necessary for Fred to drive 1375km assuming no change in average velocity.

PRACTICE WITH POSITION-VELOCITY HANDOUT

- Questions 1 – 17 (vectors, mathematical analysis of position and time).

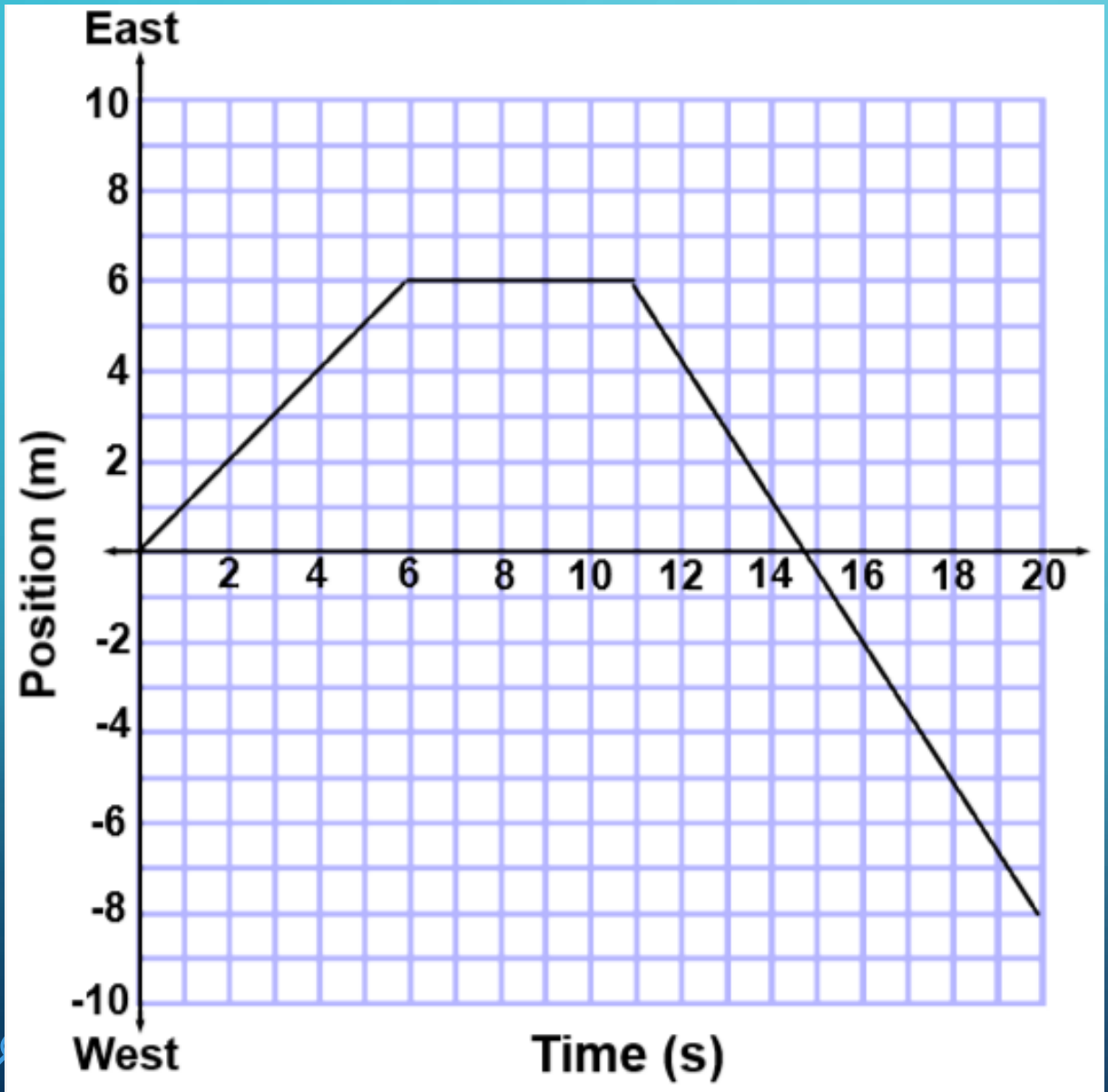
GRAPHICAL ANALYSIS OF POSITION & TIME

- Review Frame of reference and coordinate system.
- Analyze how position can change with time.
- Learn how to find key points on the graph.
- Develop knowledge about how the graph relates to speed and velocity.

POSITION-TIME GRAPHS: KEY CONCEPTS

- Position: Read from the graph.
- Distance: Sum up all the motions.
- Average Speed: Distance/Time
- Instantaneous Speed: Slope of the line at that time; positive value only.
- Average Velocity: Position/Time
- Instantaneous Velocity: Slope of the line at that time; positive or negative.

ANALYZING POSITION-TIME GRAPHS



- What was the object's position at the 4, 10 and 18 s marks?
- Calculate the distance traveled during the first 14 seconds.
- Calculate the average speed during the first 14 seconds.
- Calculate the average velocity during the first 14 seconds.
- Calculate the instantaneous velocity at the 16 s mark.
- Calculate the object's total distance traveled and final position.
- Calculate the object's average speed and velocity for the full 20s.