SECTION OUTCOMES

- Use vectors to represent position, displacement, and velocity.
- Describe and provide examples of how the position and displacement of an object are vector quantities.
- Analyze word problems and solve algebraically for unknowns.

Scalar quantities		Vector quantities	
Quantity	**Example**	**Quantity**	**Example**
distance	15 km	displacement	15 km[N45°E]
speed	30 m/s	velocity	30 m/s [S]
		acceleration	9.81 m/s^2 [down]
time interval	10 s		
mass	6 kg		

Note: There is no scalar equivalent of acceleration.

Position Vectors

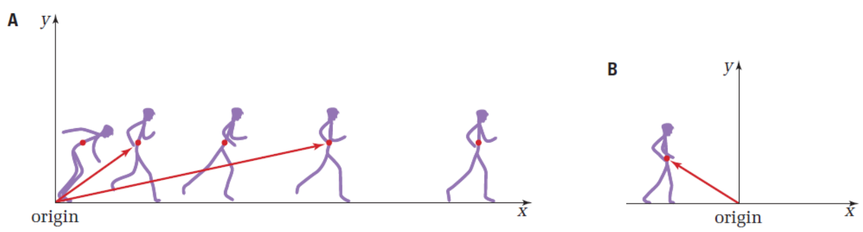


Figure 2.6 (A) A coordinate system and position vectors have been added to the stick diagram. (B) As the sprinter walks toward the origin, the sprinter's position is negative in this coordinate system.

POSITION VECTOR

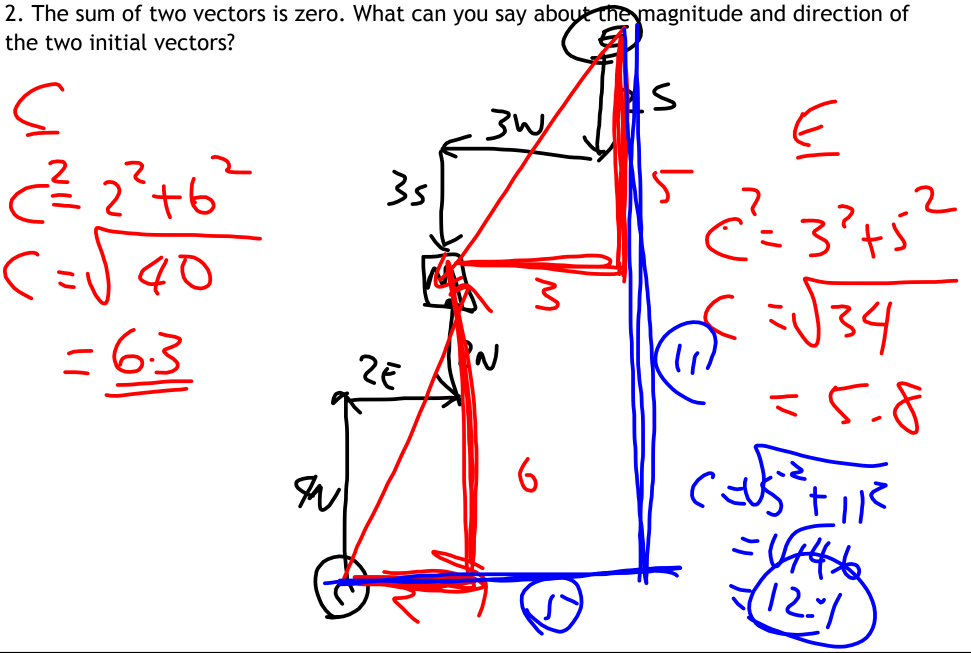
A position vector, $\vec{d}$, points from the origin of a coordinate system to the location of an object at a particular instant in time.

1. Caroline and Erin planned to meet at the shopping mall. Caroline left her home and walked 4 blocks north, 2 blocks east, and 2 more blocks north to reach the mall. Erin left her house and walked 2 blocks south, 3 blocks west, and 3 more blocks south. Draw a careful vector diagram of both motions and answer the following questions:

- What distance did each girl walk?
- Which girl is farthest in a straight line from the mall?
- What is the straight line distance between Caroline's home and Erin's home? *1*

Note: *All distances may be expressed in blocks.*

2. The sum of two vectors is zero. What can you say about the magnitude and direction of the two initial vectors?



Displacement

DISPLACEMENT

Displacement is the vector difference of the final position and the initial position of an object.

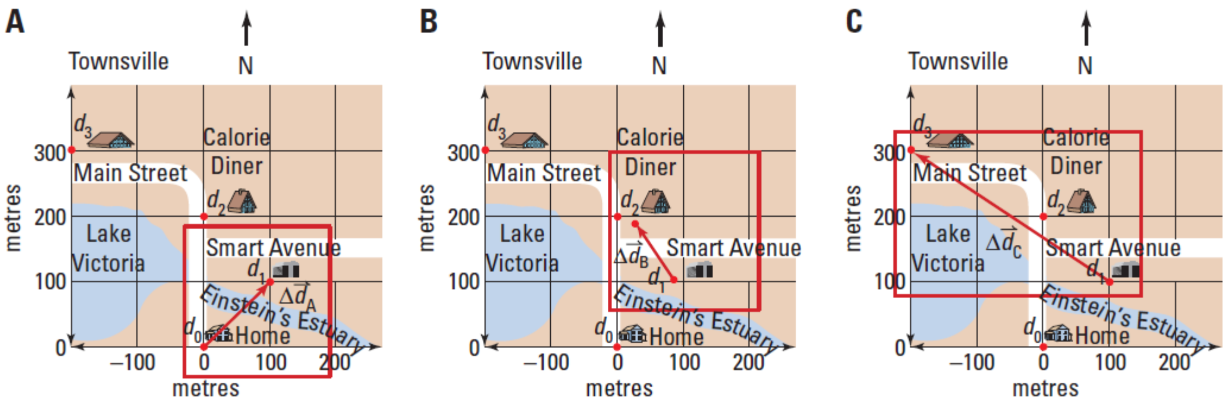
$$\Delta\vec{d} = \vec{d}_2 - \vec{d}_1$$

Quantity	Symbol	SI unit
displacement	$\Delta\vec{d}$	m (metre)
final position	$\vec{d}_2$	m (metre)
initial position	$\vec{d}_1$	m (metre)

$\vec{d}_f$

$\vec{d}_i$

Displacement is ALWAYS a difference between any pair of position vectors p38



A

Home to School

6:30 a.m. to 9:00 a.m.

$\vec{d}_0$ to $\vec{d}_1$

$\Delta\vec{d}_A = \vec{d}_1 - \vec{d}_0$

Since $\vec{d}_0 = 0$, $\Delta\vec{d}_A = \vec{d}_1$

Scale measurement would show that $\Delta\vec{d}_A$ = 140 m and points northeast.

B

School to Lunch

9:00 a.m. to 12:00 noon

$\vec{d}_1$ to $\vec{d}_2$

$\Delta\vec{d}_B = \vec{d}_2 - \vec{d}_1$

Scale measurement would show that $\Delta\vec{d}_B$ = 140 m, but points northwest.

C

School to Sports Complex

9:00 a.m. to 5:00 p.m.

$\vec{d}_1$ to $\vec{d}_3$

$\Delta\vec{d}_C = \vec{d}_3 - \vec{d}_1$

Scale measurement would show that $\Delta\vec{d}_C$ = 360 m, and points a little west of northwest.

Time and Time Intervals

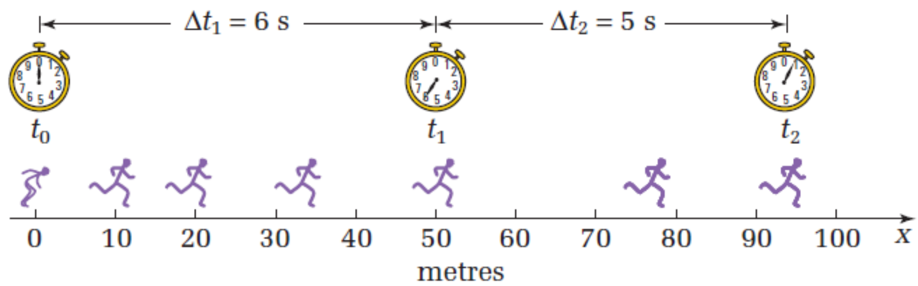


Figure 2.10 A time interval is symbolized as Δt. The symbol t with a subscript indicates an instant in time related to a specific event.

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Velocity

VELOCITY

Velocity is the quotient of displacement and the time interval.

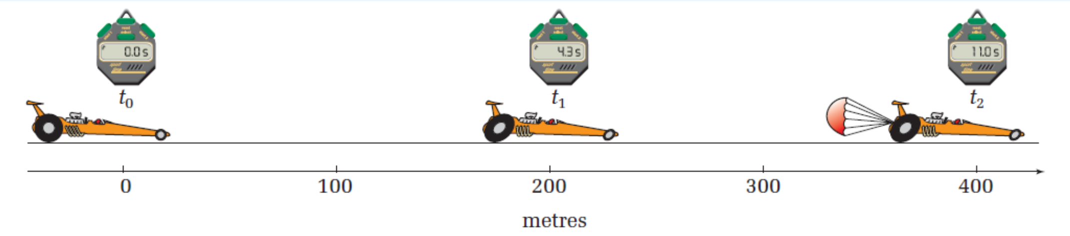
$$\vec{v}_{ave} = \frac{\Delta\vec{d}}{\Delta t} \quad \text{or} \quad \vec{v}_{ave} = \frac{\vec{d}_2 - \vec{d}_1}{t_2 - t_1}$$

Quantity	Symbol	SI unit
average velocity	$\vec{v}_{ave}$	$\frac{m}{s}$ (metres per second)
displacement	$\Delta\vec{d}$	m (metres)
time interval	Δt	s (seconds)

MODEL PROBLEMS

Calculating Average Velocity

1. A dragster in a race is timed at the 200.0 m and 400.0 m points. The times are shown on the stopwatches in the diagram. Calculate the average velocity for (a) the first 200.0 m, (b) the second 200.0 m, and (c) the entire race.



2. A basketball player gains the ball in the face-off at centre court. He then dribbles down to the opponents' basket and scores 6.0 s later. After scoring, he runs back to guard his own team's basket, taking 9.0 s to run down the court. Using centre court as his reference position, calculate his average velocity (a) while he is dribbling up to the opponents' net, and (b) while he is running down from the opponents' net to his own team's net. (A basketball court is 3.0×10^1 m long.)

PRACTICE PROBLEMS

1. Calculate the basketball player's average velocity for the entire time period described in Model Problem 2.

2. Freda usually goes to the sports complex every night after school. The displacement for that walk is 360 m[N57°W]. What is her average velocity if the walk takes her 5.0 min?

3. Imagine that you are in the bleachers watching a swim meet in which your friend is competing in the freestyle event. At the instant the starting gun fires, the lights go out! When the lights come back on, the timer on the scoreboard reads 86 s. You observe that your friend is now about halfway along the length of the pool, swimming in a direction opposite to that in which he started. The pool is 5.0×10^1 m in length.
   - (a) Determine his average velocity during the time the lights were out.
   - (b) What are two possible distances that you might infer your friend swam while the lights were out?
   - (c) Given that the record for the 100 m freestyle race is approximately 50 s, which is the most likely distance that your friend swam while the lights were out? Explain your reasoning.
   - (d) Based on your conclusions in (c), calculate your friend's average speed while the lights were out.