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.

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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

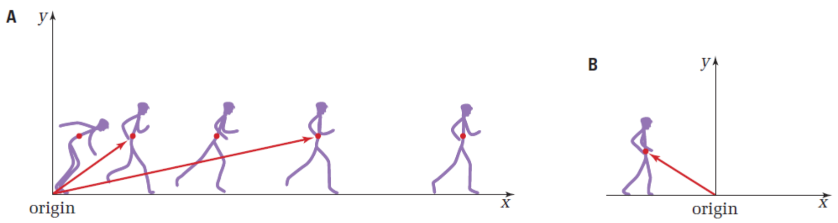

Figure 2.6 **(A)** A coordinate system and position vectors have been added to the stick diagram. **(B)** As the sprinter walks toward the origin, the sprinter's position is negative in this coordinate system.

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.

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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?

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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)

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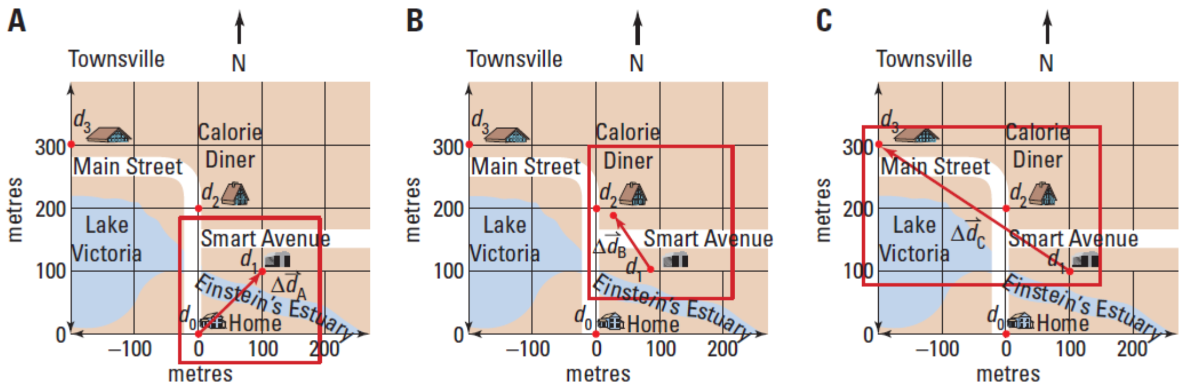
Displacement is ALWAYS a difference between any pair of position vectors



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.

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Time and Time Intervals

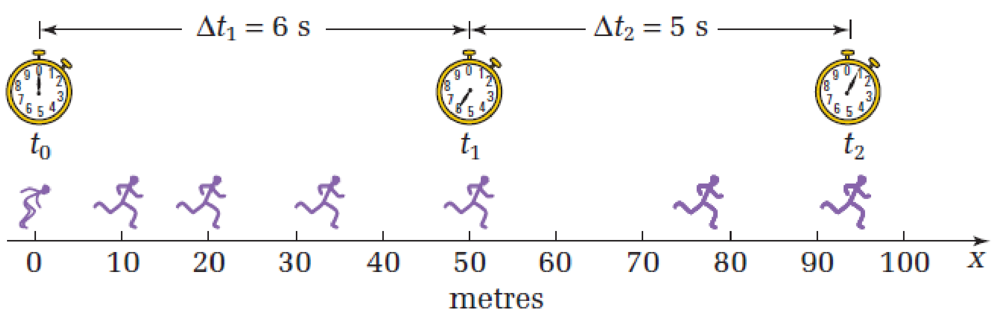

Figure 2.10 A time interval is symbolized as Δt. The symbol t with a subscript indicates an instant in time related to a specific event.

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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)

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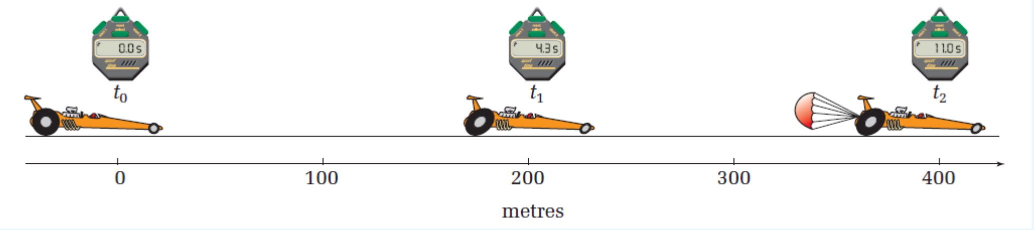
MODEL PROBLEMS

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.



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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.

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2.3 Constant, Average, and Instantaneous Velocity

SECTION OUTCOMES

- Identify the frame of reference for a given motion and distinguish between fixed and moving frames.
- Identify and investigate problems involving motion.
- Analyze word problems, solve algebraically for unknowns, and interpret patterns in data.

KEY TERMS

- uniform motion
- non-uniform motion
- instantaneous velocity

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Constant Velocity

Uniform vs non-Uniform motion

Uniform-velocity remains constant
Non-Uniform-velocity changes

NOTE: A change in direction can mean a change in velocity since velocity is a vector.

27 m/s E

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Time (s)	Position (m[E])
0.0	0.0
1.3	12
2.6	24
3.9	36
5.2	48
6.5	60

Table 2.3 Position versus Time for a Skateboarder

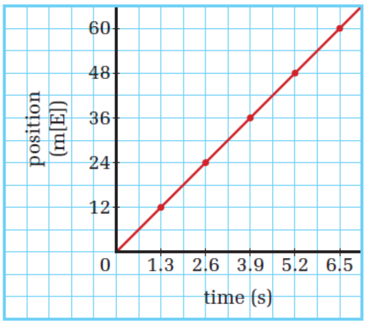

Figure 2.12 Position-time graph for a skateboarder's motion

Question: What is the significance of the straight line in the graph in Fig 2.12?

- Slope is the rise over the run. $\text{slope} = \frac{\text{rise}}{\text{run}}$
- On a typical x-y plot, the slope is written as $\text{slope} = \frac{\Delta y}{\Delta x}$
- However, on a position-time plot, the slope is $\text{slope} = \frac{\Delta \vec{d}}{\Delta t}$
- The definition of velocity is $\vec{v} = \frac{\Delta \vec{d}}{\Delta t}$
- Since the slope and the velocity are equal to the same expression, the slope of the line on a position-time graph must be the velocity of the object. $\vec{v} = \text{slope}$

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SPARK TIMER CONSTANT MOTION LAB

1) Set up the spark timer as shown.

2) Try to pull about 1 metre length of timer tape through the timer at a constant velocity

3) Examine your tape and find a series of 10 dots that look fairly evenly spaced

4) Circle the first dot as your starting point.

5) Measure and record the distance to each successive dot from this first one.

6) Collect your data in a TIME-POSITION data table and draw a TIME-POSITION graph of the data

Answer the following questions

1) Based on the graph and the data you obtained, were you successful in maintaining constant velocity

2) Determine the average velocity of the length of ten dots you used for the data table.

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t	d
0	0
1	3.4
2	6.5
3	10.0
4	13.6
5	16.8
6	19.5
7	22.6
8	26.7

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