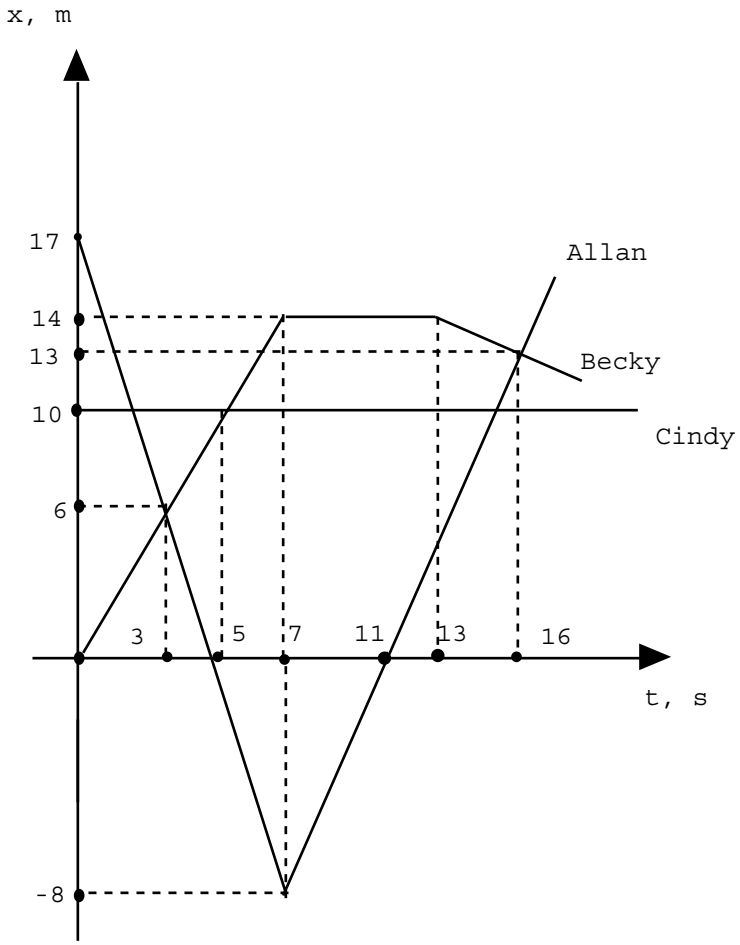
Graphing motion with numbers Problem

The graph below shows the positions of Allan, Becky and Cindy along Main Street. The horizontal axis shows the time in seconds, and the vertical axis gives their position in meters.



In physics texts, the axes are labeled "t, s" and "x, m".

Answer the following questions using the graph. (Some questions may have multiple answers.)

1. Find Allan's position:
   (a) 3 s after the motion began
   (b) 5 s after the motion began
   (c) 7 s after the motion began

2. Find Becky's position:

(a) 3 s after the motion began
(b) 5 s after the motion began
(c) 7 s after the motion began
(d) 10 s after the motion began

3. Find Becky's position at the moments when:
(a) Allan's position is 17 m
(b) Allan's position is -8 m
(c) Allan's position is zero

4. At what time(s) is Becky's position:
(a) 4 m?
(b) 13 m?
(c) 14 m?

5. Find the distance Allan covered:
(a) between 0 s and 3 s
(b) between 0 s and 7 s
(c) between 0 s and 11 s
(d) between 0 s and 16 s

6. Find the distance Becky covered:
(a) between 5 s and 7 s
(b) between 5 s and 11 s
(c) between 5 s and 16 s

7. At what times and locations, if any, do these runners meet?
(a) Allan and Becky.
(b) Allan and Cindy.
(c) Becky and Cindy.

8. (a) Does any student ever stop?
(b) Does any student ever change the direction of motion? Explain.
(c) If your answer to the previous question was "yes" for some of the students, find the moments in time and the coordinates of the points, if any, where the change in direction takes place.

9. (a) Does Allan's speed change between 5 and 9 s? Explain.
(b) Does Becky's speed change between 10 and 14 s? Explain.
(c) Are there any intervals of time when Allan's speed does not change?

10. (a) Who is moving faster: Allan between 7 and 10 s or Becky between 14 and 16 s? Explain clearly.

(b) Calculate Allan's average speed between 5 and 7 s.

(c) Calculate Becky's average speed as she moved from $x = 6$ m to $x = 14$ m.

(d) Calculate Becky's average speed as she moved from $x = 14$ m to $x = 13$ m.

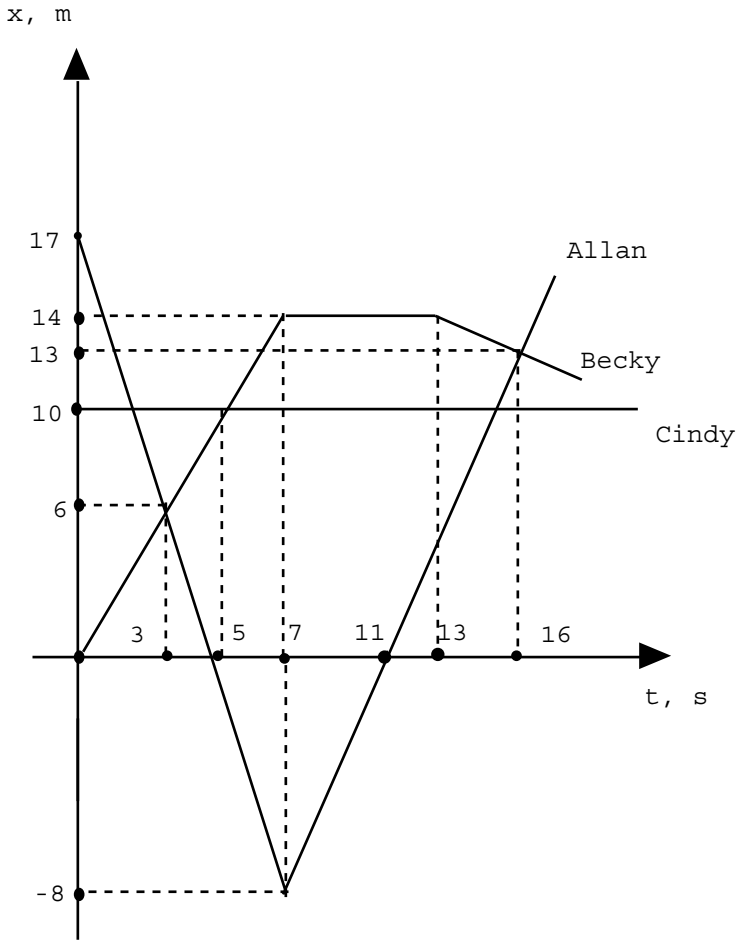
$$v_{av} = \frac{\text{total distance}}{\text{total time}}$$

Hints

There are no hints for this problem sequence.

Answers

The graph below shows the positions of Allan, Becky and Cindy along Main Street. The horizontal axis shows the time in seconds, and the vertical axis gives their position in meters.



1. (a) 6 m
(b) 0 m
(c) -8 m

2. (a) 6 m
(b) 10 m
(c) 14 m
(d) 14 m

3. (a) 0 m
(b) 14 m
(c) 10 m and 14 m (two occasions)

4. (a) 2 s (not marked on the graph)
(b) 6.5 s (not marked on the graph) and 16 s (two occasions)
(c) Between 7 and 13 s (Becky stops)

5. (a) 11 m (from 17 m to 6 m)
(b) 25 m (from 17 m to -8 m)
(c) 33 m (from 17 m to -8 m *and* from -8 m to zero)
(d) 54 m (from 17 m to -8 m *and* from -8 m to 13 m)

6. (a) 4 m (from 10 m to 14 m)
(b) 4 m
(c) 5 m (from 10 m to 14 m *and* from 14 m to 13 m)

7. (a) (3 s; 6 m) and (16 s; 13 m)
(b) (≈2 s; 10 m) and (≈15 s; 10 m)
(c) (5 s; 10 m)

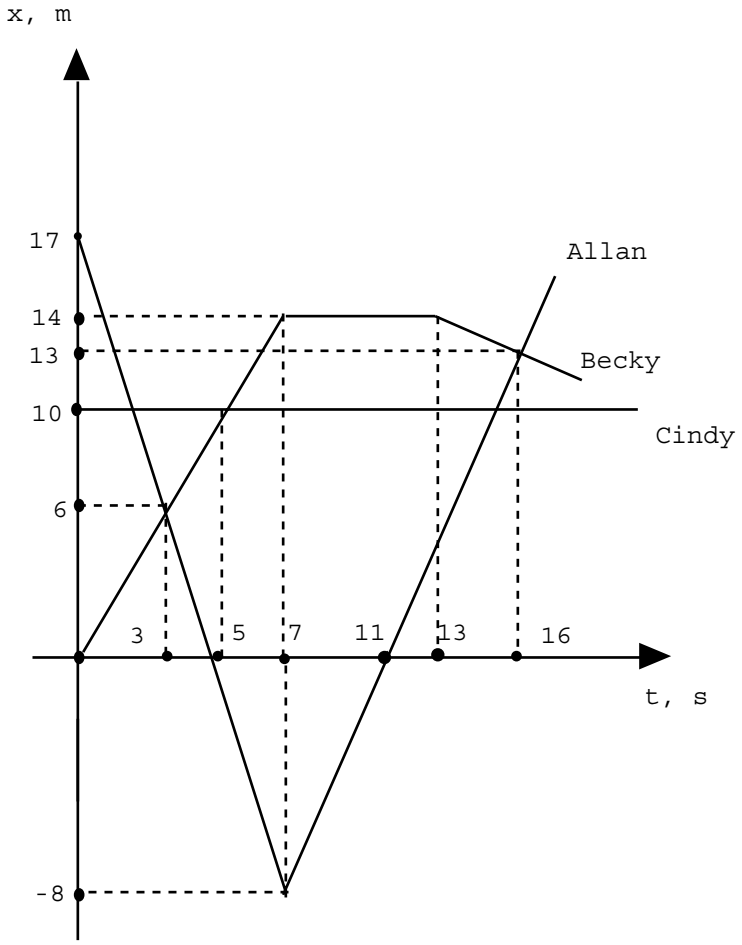
8. (a) Becky stops between 7 s and 13 s; Cindy does not move at all.
(b) Allan changes direction at 7 s. Becky changes direction at 13 s (after the stop).
(c) Allan: (7 s; -8 m); Becky: (13 s; 14 m)

9. (a) Yes, for the explanation, see solution.
(b) Yes, for the explanation, see solution.
(c) Yes, for the explanation, see solution.

10. (a) Allan's speed is greater, for the explanation, see solution.
(b) 4 m/s.
(c) 2 m/s
(d) $\frac{1}{9}m/s = 0.111m/s$

Solutions

The graph below shows the positions of Allan, Becky and Cindy along Main Street. The horizontal axis shows the time in seconds, and the vertical axis gives their position in meters.



1. Find the vertical axis coordinates for the points on Alan's graph that has horizontal coordinates 3s, 5s, and 7s.

(a) 6 m
(b) 0 m
(c) -8 m

2. Find the vertical axis coordinates for the points on Becky's graph that has horizontal coordinates 3s, 5s, 7s, and 10s.

(a) 6 m
(b) 10 m
(c) 14 m

(d) 14 m

3. First, determine the times at which Alan was at each position below by looking at the horizontal coordinates of points on his graph. Then look at the vertical axis' coordinates for the points on Becky's graph at these times.
(a) 0 m
(b) 14 m
(c) 10 m and 14 m (two occasions)

4. Determine the times at which Becky was at each position below by looking at the horizontal coordinates of points on her graph that have vertical coordinates 4m, 13m, and 14m.
(a) 2 s (not marked on the graph)
(b) 6.5 s (not marked on the graph) and 16 s (two occasions)
(c) Between 7 and 13 s (Becky stops)

5. In each case, see where Alan was in the beginning and where he was in the end.
(a) 11 m (from 17 m to 6 m)
(b) 25 m (from 17 m to -8 m)
(c) 33 m (from 17 m to -8 m *and* from -8 m to zero)
(d) 54 m (from 17 m to -8 m *and* from -8 m to 13 m)

6. In each case, see where Becky was in the beginning and where she was in the end.
(a) 4 m (from 10 m to 14 m)
(b) 4 m
(c) 5 m (from 10 m to 14 m *and* from 14 m to 13 m)

7. Runners meet when their graphs intersect. Look for the horizontal (time) and vertical (position) coordinates of the intersection points.
(a) (3 s; 6 m) and (16 s; 13 m)
(b) (≈2 s; 10 m) and (≈15 s; 10 m)
(c) (5 s; 10 m)

8. (a) A horizontal line on the graph indicates that a runner did not change his or her position for a number of seconds, that is the runner stopped.
Becky stops between 7 s and 13 s; Cindy does not move at all.
(b) If a line on the graph changes direction from going down to going up or from going up to going down, it

means that a runner, represented by this graph, has changed a direction of motion.

Allan's position coordinate decreases during the first 7 seconds; then it begins to increase, which indicates change of direction. Similarly, Becky changes direction at 13 s (after the stop).

(c) Allan: (7 s; -8 m); Becky: (13 s; 14 m)

9. A straight graph indicates constant speed, since equal distances are covered in equal times. If a line changes its slope, it indicates a change in speed.

(a) Alan's motion changes at 7 s. It takes Allan 2 s to move from zero to -8 m; it takes him 4 s to go back to zero—so the speed *is* different between 5 and 7 s and between 7 and 9 s.

(b) Yes, she has zero speed between 10 and 13 s and a non-zero one between 13 and 14 s.

(c) Yes: between 0 and 7 s and between 7 and the end of motion ($\approx$ 18 s).

10. The steeper the line, the faster the person is moving.

(a) Allan's speed is 8 m$\div$4 s= 2 m/s; Becky's speed is $(14 - 13)$ m$\div(16 - 13)$ s= $\frac{1}{3}$ = 0.333 m/s (speed is constant!). Allan's speed is greater.

(b) 4 m/s.

(c) 8 m$\div$4 s= 2 m/s

(d) 1 m$\div$9 s= $\frac{1}{9} = 0.111$ m/s

$$v_{av} = \frac{\text{total distance}}{\text{total time}}$$

