

In discussing motion, there are three closely related concepts that you need to keep straight.

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|--|--|
| Initially | |
| Displacement | |
| When is a particle at rest? | |
| When is a particle moving right? | |
| When is a particle moving left? | |
| When does a particle change direction? | |
| Average Velocity | |
| Average Acceleration | |
| Instantaneous Velocity | |
| When is velocity increasing? | |
| When is velocity decreasing? | |
| When is a particle speeding up? | |
| When is a particle slowing down? | |

1. The data in the table below give selected values for the velocity, in meters/minute, of a particle along the x-axis. The velocity, $v(t)$, is a differentiable and continuous function of time.

| | | | | | | |
|------------------------------------|----|---|---|---|---|----|
| Time t (minutes) | 0 | 2 | 5 | 6 | 8 | 12 |
| Velocity $v(t)$ (meters/minute) | -3 | 2 | 3 | 5 | 7 | 5 |

- a. At $t = 0$, is the particle moving to the left or to the right? Explain your answer.
- b. Is there a time during the time interval $[0,12]$ when the particle is at rest? Explain your answer.
- c. Use the from the table to find an approximation for $v'(10)$ and explain the meaning of $v'(10)$ in the context of the problem.
- d. Find the average velocity of the particle from $t = 0$ to $t = 12$.

2. The graph represents the velocity $v(t)$, in meters per second, of a particle moving along the x – axis over the time interval $t = 0$ to $t = 9$ seconds.

a. At $t = 4$ seconds, is the particle moving to the left or right?

b. When is the particle moving to the left?

c. When is the particle moving to the right?

d. When does the particle change direction?

e. At $t = 4$, is the acceleration of the particle positive or negative?

f. What is the acceleration of the particle at $t = 4$?

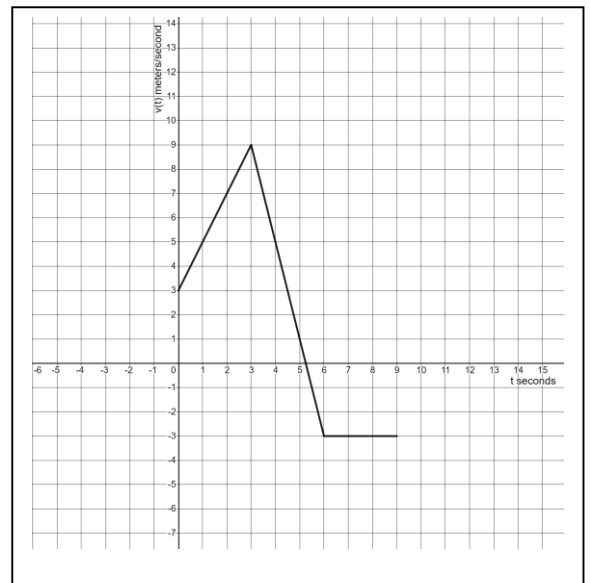
g. When is the acceleration positive?

h. When is the acceleration negative?

i. What is the average acceleration of the particle over the interval $[2,4]$?

j. When is the particle speeding up?

k. When is the particle slowing down?



3. A particle moves along the x -axis so that at time t its position is given by $x(t) = t^3 - 6t^2 + 9t + 11$, where x is measured in meters and t is measured in seconds.
- At $t = 0$, is the particle moving to the left or right?
 - When is the particle moving left?
 - When is the particle moving right?
 - When does the particle change directions?
 - At $t = 1$, is the velocity of the particle increasing or decreasing?
 - When is the velocity of the particle increasing?
 - When is the velocity of the particle decreasing?
 - Find the average velocity of the particle from $t = 0$ to $t = 4$.
 - Find the average acceleration of the particle from $t = 0$ to $t = 4$.
 - Find the instantaneous velocity of the particle at $t = 4$.
 - Find the acceleration of the particle at $t = 4$.
 - At $t = 4$, is the particle speeding up or slowing down?
 - When is the particle speeding up?
 - When is the particle slowing down?