

Motion

For #1 – 5: A particle moves along a line such that its position is $s(t) = 2t^3 - 9t^2 + 12t - 4$, for $t > 0$.

- 1) Find when particle is at rest.
- 2) Find all t for which the velocity is increasing.
- 3) Find all t for which the speed of the particle is increasing.
- 4) Find the speed when $t = 3$
- 5) Find the acceleration at $t = 1$

For #6 – 10: A particle moves along a line such that its position is $s(t) = t^4 - 4t^3$.

- 6) Find velocity in terms of t
- 7) Find all t for which the velocity is increasing.
- 8) Find all t for which the speed of the particle is increasing.
- 9) Find the speed when $t = 3$
- 10) Find the acceleration at $t = 2$.

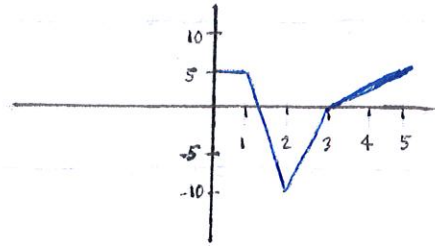
For #11 – 14: The position of a particle moving along a straight line is given by $s = t^3 - 6t^2 + 12t - 8$.

- | | |
|---|---|
| 11) The position of the particle is increasing: | 12) The minimum value of the speed is |
| A) $t < 2$ | A) 1 |
| B) all t except $t = 2$ | B) 2 |
| C) $1 < t < 3$ | C) 3 |
| D) $t < 1$ or $t > 3$ | D) 0 |
| E) $t > 2$ | E) none of these |
| 13) The acceleration is positive for | 14) The speed of the particle is decreasing for |
| A) $t > 2$ | A) $t > 2$ |
| B) all t except $t = 2$ | B) $t < 3$ |
| C) $t < 2$ | C) all t |
| D) $t < 1$ or $t > 2$ | D) $t < 1$ or $t > 2$ |
| E) none of these | E) none of these |

For #15 – 17: A particle moves along a horizontal line, and its position at time t is $s = t^4 - 6t^3 + 12t^2 + 3$.

- | | | |
|--|--|---|
| 15) The particle is at rest when t is equal to | 16) The velocity, v , is increasing when | 17) The speed of the particle is increasing for |
| A) 1 or 2 | A) $t > 1$ | A) $0 < t < 1$ or $t > 2$ |
| B) 0 | B) $1 < t < 2$ | B) $1 < t < 2$ |
| C) $9/4$ | C) $t < 2$ | C) $t < 2$ |
| D) 0, 2, or 3 | D) $t < 1$ or $t > 2$ | D) $t < 0$ or $t > 2$ |
| E) none of these | E) $t > 0$ | E) $t < 0$ |

For #18 – 22, use the graph, which shows the velocity of an object moving along a straight line during the time interval $0 \leq t \leq 5$.



- 18) The object attains its maximum speed when $t = ?$
- 19) For what time interval(s) is the speed of the object increasing?
- 20) The acceleration of the object is positive during what time interval?
- 21) For how many times on the interval $(0, 5)$ is the object's acceleration undefined?
- 22) During the interval $(2, 3)$, what is the object's acceleration (in ft/sec^2)?

For #23 – 30 use the equation (position) of an object moving along a straight line during $t \geq 0$. Find...

$$s(t) = t^3 + t^2 - 8t + 1$$

Show all work below.

23. when particle is at rest
24. when particle is moving in positive direction
25. when particle is moving in negative direction
26. when acceleration is zero
27. when acceleration is $+$
28. when acceleration is $-$
29. when speeding up
30. when slowing down

Motion

For #1 - 5: A particle moves along a line such that its position is $s(t) = 2t^3 - 9t^2 + 12t - 4$, for $t > 0$.

- 1) Find when particle is at rest. $t = 1, 2$
- 2) Find all t for which the velocity is increasing. $(3/2, \infty)$
- 3) Find all t for which the speed of the particle is increasing. $(1, 3/2) \cup (2, \infty)$
- 4) Find the speed when $t = 3$ $|v(3)| = 12$
- 5) Find the acceleration at $t = 1$
 $a(1) = 6$
negative

$$v(t) = 6t^2 - 18t + 12 = 0$$

$$6(t^2 - 3t + 2) = 0$$

$$6(t-2)(t-1) = 0$$

$$t = 1, 2$$

$$a(t) = 12t - 18 = 0$$

$$t = 3/2$$

For #6 - 10: A particle moves along a line such that its position is $s(t) = t^4 - 4t^3$.

- 6) Find velocity in terms of t $v(t) = 4t^3 - 12t^2$
- 7) Find all t for which the velocity is increasing. $(-\infty, 0) \cup (2, \infty)$
- 8) Find all t for which the speed of the particle is increasing. $(0, 2) \cup (3, \infty)$
- 9) Find the speed when $t = 3$ $|v(3)| = 0$
- 10) Find the acceleration at $t = 2$.
 $a(2) = 0$

$$v(t) = 4t^3 - 12t^2 = 0$$

$$4t^2(t-3) = 0$$

$$t = 0, 3$$

$$a(t) = 12t^2 - 24t = 0$$

$$12t(t-2) = 0$$

$$t = 0, 2$$

For #11 - 14: The position of a particle moving along a straight line is given by $s = t^3 - 6t^2 + 12t - 8$.

11) The position of the particle is increasing:

- A) $t < 2$
- B) all t except $t = 2$
- C) $1 < t < 3$
- D) $t < 1$ or $t > 3$
- E) $t > 2$

$$v(t) = 3t^2 - 12t + 12 = 0$$

$$3(t^2 - 4t + 4) = 0$$

$$3(t-2)(t-2) = 0$$

$$t = 2$$

12) The minimum value of the speed is

- A) 1
- B) 2
- C) 3
- D) 0
- E) none of these

13) The acceleration is positive for

- A) $t > 2$
- B) all t except $t = 2$
- C) $t < 2$
- D) $t < 1$ or $t > 2$
- E) none of these

$$a(t) = 6t - 12 = 0$$

$$6(t-2) = 0$$

$$t = 2$$

14) The speed of the particle is decreasing for

- A) $t > 2$
- B) $t < 3$
- C) all t
- D) $t < 1$ or $t > 2$
- E) none of these

When $v(t)$ & $a(t)$ have opposite signs

For #15 - 17: A particle moves along a horizontal line, and its position at time t is $s = t^4 - 6t^3 + 12t^2 + 3$.

15) The particle is at rest when t is equal to

- A) 1 or 2
- B) 0
- C) $9/4$
- D) 0, 2, or 3
- E) none of these

$$v(t) = 4t^3 - 18t^2 + 24t = 0$$

$$2t(2t^2 - 9t + 12) = 0$$

$t = 0$ (marked with a green arrow)

$t = \text{no real roots}$ (marked with a green arrow)

16) The velocity, v , is increasing when

- A) $t > 1$
- B) $1 < t < 2$
- C) $t < 2$
- D) $t < 1$ or $t > 2$
- E) $t > 0$

$$a(t) = 12t^2 - 36t + 24 = 0$$

$$12(t^2 - 3t + 2) = 0$$

$$12(t-2)(t-1) = 0$$

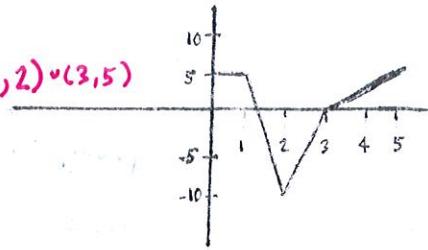
$$t = 1, 2$$

17) The speed of the particle is increasing for

- A) $0 < t < 1$ or $t > 2$
- B) $1 < t < 2$
- C) $t < 2$
- D) $t < 0$ or $t > 2$
- E) $t < 0$

For #18 – 22, use the graph, which shows the velocity of an object moving along a straight line during the time interval $0 \leq t \leq 5$.

- 18) The object attains its maximum speed when $t = ?$ **2**
 19) For what time interval(s) is the speed of the object increasing? **$(1, 2) \cup (3, 5)$**
 20) The acceleration of the object is positive during what time interval? **$(2, 5)$**
 21) For how many times on the interval $(0, 5)$ is the object's acceleration undefined? **3 times** ($t = 1, 2, 3$)
 22) During the interval $(2, 3)$, what is the object's acceleration (in ft/sec^2)? **10 ft/sec^2**



For #23 – 30 use the equation (position) of an object moving along a straight line during $t \geq 0$. Find...

$$s(t) = t^3 + t^2 - 8t + 1$$

Show all work below.

$$v(t) = 3t^2 + 2t - 8 = 0$$

$$(3t - 4)(t + 2) = 0$$

$$t = 4/3, \text{ not in interval}$$



$$a(t) = 6t + 2 = 0$$

$$t = -1/3, \text{ not in interval}$$



23. when particle is at rest
 $t = 4/3$
24. when particle is moving in positive direction
 $(4/3, \infty)$
25. when particle is moving in negative direction
 $(0, 4/3)$
26. when acceleration is zero
never
27. when acceleration is +
 $(0, \infty)$
28. when acceleration is -
never
29. when speeding up
 $(4/3, \infty)$
30. when slowing down
 $(0, 4/3)$