

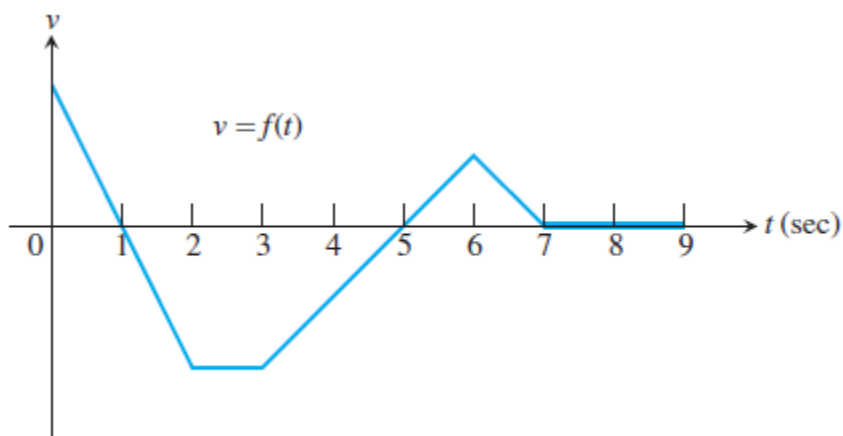
9. **Particle Motion** The accompanying figure shows the velocity $v = f(t)$ of a particle moving on a coordinate line.

(a) When does the particle move forward? move backward? speed up? slow down?

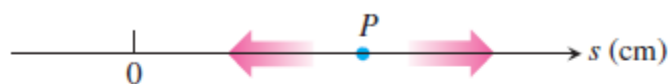
(b) When is the particle's acceleration positive? negative? zero?

(c) When does the particle move at its greatest speed?

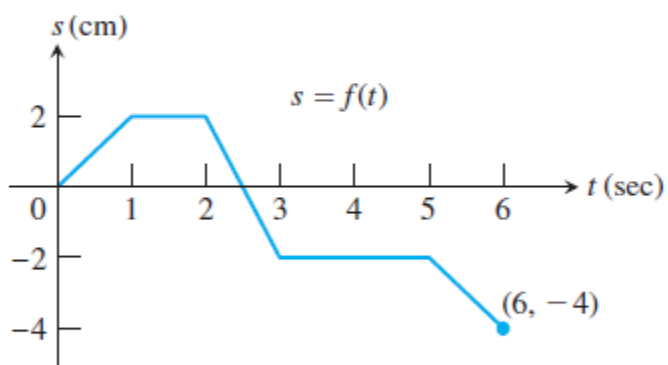
(d) When does the particle stand still for more than an instant?



10. **Particle Motion** A particle P moves on the number line shown in part (a) of the accompanying figure. Part (b) shows the position of P as a function of time t .



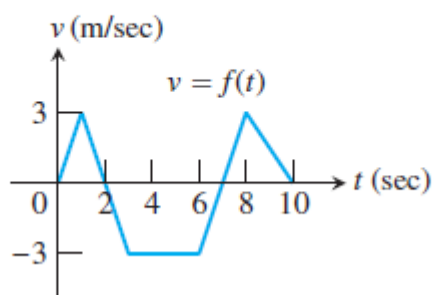
(a)



(b)

- (a) When is P moving to the left? moving to the right? standing still?
- (b) Graph the particle's velocity and speed (where defined).

11. **Particle Motion** The accompanying figure shows the velocity $v = ds/dt = f(t)$ (m/sec) of a body moving along a coordinate line.



- (a) When does the body reverse direction?
- (b) When (approximately) is the body moving at a constant speed?
- (c) Graph the body's speed for $0 \leq t \leq 10$.
- (d) Graph the acceleration, where defined.

12. Thoroughbred Racing A racehorse is running a 10-furlong race. (A furlong is 220 yards, although we will use furlongs and seconds as our units in this exercise.) As the horse passes each furlong marker (F), a steward records the time elapsed (t) since the beginning of the race, as shown in the table below:

F	0	1	2	3	4	5	6	7	8	9	10
t	0	20	33	46	59	73	86	100	112	124	135

- How long does it take the horse to finish the race?
- What is the average speed of the horse over the first 5 furlongs?
- What is the approximate speed of the horse as it passes the 3-furlong marker?
- During which portion of the race is the horse running the fastest?
- During which portion of the race is the horse accelerating the fastest?

19. Particle Motion A particle moves along a line so that its position at any time $t \geq 0$ is given by the function

$$s(t) = t^2 - 3t + 2,$$

where s is measured in meters and t is measured in seconds.

- (a) Find the displacement during the first 5 seconds.
- (b) Find the average velocity during the first 5 seconds.
- (c) Find the instantaneous velocity when $t = 4$.
- (d) Find the acceleration of the particle when $t = 4$.
- (e) At what values of t does the particle change direction?
- (f) Where is the particle when s is a minimum?

20. **Particle Motion** A particle moves along a line so that its position at any time $t \geq 0$ is given by the function $s(t) = -t^3 + 7t^2 - 14t + 8$ where s is measured in meters and t is measured in seconds.

- (a) Find the instantaneous velocity at any time t .
- (b) Find the acceleration of the particle at any time t .
- (c) When is the particle at rest?
- (d) Describe the motion of the particle. At what values of t does the particle change directions?

21. Particle Motion A particle moves along a line so that its position at any time $t \geq 0$ is given by the function $s(t) = (t - 2)^2(t - 4)$ where s is measured in meters and t is measured in seconds.

- (a) Find the instantaneous velocity at any time t .
- (b) Find the acceleration of the particle at any time t .
- (c) When is the particle at rest?
- (d) Describe the motion of the particle. At what values of t does the particle change directions?

- 22. Particle Motion** A particle moves along a line so that its position at any time $t \geq 0$ is given by the function $s(t) = t^3 - 6t^2 + 8t + 2$ where s is measured in meters and t is measured in seconds.
- (a) Find the instantaneous velocity at any time t .
 - (b) Find the acceleration of the particle at any time t .
 - (c) When is the particle at rest?
 - (d) Describe the motion of the particle. At what values of t does the particle change directions?

23. **Particle Motion** The position of a body at time t sec is $s = t^3 - 6t^2 + 9t$ m. Find the body's acceleration each time the velocity is zero.

24. **Finding Speed** A body's velocity at time t sec is $v = 2t^3 - 9t^2 + 12t - 5$ m/sec. Find the body's speed each time the acceleration is zero.