Chapter 2

TABLE 1.4 *Prefixes for Powers of Ten*

Power	Prefix	Abbreviation	Power	Prefix	Abbreviation
10^{-24}	yocto	y	10^{3}	kilo	k
10^{-21}	zepto	z	10^{6}	mega	M
10^{-18}	atto	a	10^{9}	giga	G
10^{-15}	femto	f	10^{12}	tera	T
10^{-12}	pico	p	10^{15}	peta	P
10^{-9}	nano	n	10^{18}	exa	E
10^{-6}	micro	μ	10^{21}	zetta	Z
10^{-3}	milli	m	10^{24}	yotta	Y
10^{-2}	centi	c			
10^{-1}	deci	d			

1 mile = 1 609 m = 1.609 km 1 ft = 0.304 8 m = 30.48 cm

1 m = 39.37 in. = 3.281 ft 1 in. = 0.025 4 m = 2.54 cm (exactly)

$$v_x = \frac{d}{t} = \frac{\Delta x}{\Delta_t}$$

$$x_f = x_i + v_x t (for\ constant\ v_x)$$

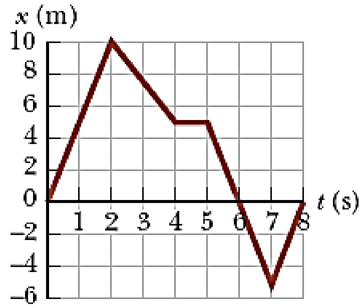
$$a = \frac{\Delta v}{t} = \frac{v_f - v_i}{t_f - t_i}$$

$$a_x = \frac{dv_x}{dt} = \frac{d}{dt}\left(\frac{dx}{dt}\right) = \frac{d^2x}{dt^2}$$

$$x_f - x_i = v_i t + \frac{1}{2} a t^2$$

$$v_f^2 = v_{i+}^2 2a_x (x_f - x_i)$$

1. The position versus time for a certain particle moving along the x axis is shown in Figure P2.1. Find the average velocity in the time intervals (a) 0 to 2 s, (b) 0 to 4 s, (c) 2 s to 4 s, (d) 4 s to 7 s, and (e) 0 to 8 s.



(a) $$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{10\text{ m}}{2\text{ s}} = \boxed{5\text{ m/s}}$$

(b) $$\bar{v} = \frac{5\text{ m}}{4\text{ s}} = \boxed{1.2\text{ m/s}}$$

(c) $$\bar{v} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{5\text{ m} - 10\text{ m}}{4\text{ s} - 2\text{ s}} = \boxed{-2.5\text{ m/s}}$$

(d) $$\bar{v} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{-5\text{ m} - 5\text{ m}}{7\text{ s} - 4\text{ s}} = \boxed{-3.3\text{ m/s}}$$

(e) $$\bar{v} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{0 - 0}{8 - 0} = \boxed{0\text{ m/s}}$$

4. A particle moves according to the equation $x = 10t^2$ where x is in meters and t is in seconds. (a) Find the average velocity for the time interval from 2.00 s to 3.00 s. (b) Find the average velocity for the time interval from 2.00 to 2.10 s.

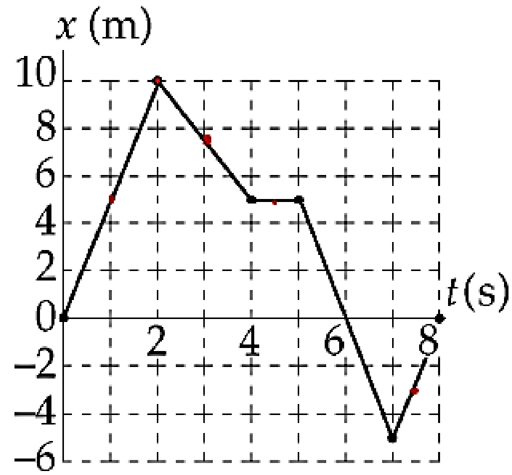
$x = 10t^2$: For

t(s)	=	2.0	2.1	3.0
x(m)	=	40	44.1	90

(a) $$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{50\text{ m}}{1.0\text{ s}} = \boxed{50.0\text{ m/s}}$$

(b) $$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{4.1\text{ m}}{0.1\text{ s}} = \boxed{41.0\text{ m/s}}$$

9. Find the instantaneous velocity of the particle described in Figure P2.3 at the following times: (a) $t = 1.0$ s, (b) $t = 3.0$ s, (c) $t = 4.5$ s, and (d) $t = 7.5$ s.



(a) $$v = \frac{(5-0)\text{ m}}{(1-0)\text{ s}} = \boxed{5\text{ m/s}}$$

(b) $$v = \frac{(5-10)\text{ m}}{(4-2)\text{ s}} = \boxed{-2.5\text{ m/s}}$$

(c) $$v = \frac{(5\text{ m}-5\text{ m})}{(5\text{ s}-4\text{ s})} = \boxed{0}$$

(d) $$v = \frac{0-(-5\text{ m})}{(8\text{ s}-7\text{ s})} = \boxed{+5\text{ m/s}}$$

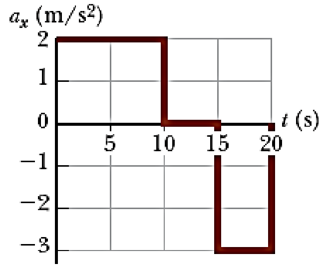
11. A 50.0-g superball traveling at 25.0 m/s bounces off a brick wall and rebounds at 22.0 m/s. A high-speed camera records this event. If the ball is in contact with the wall for 3.50 ms, what is the magnitude of the average acceleration of the ball during this time interval? (*Note:* 1 ms = 10^{-3} s.)

Choose the positive direction to be the outward direction, perpendicular to the wall.

$$v_f = v_i + at: \ a = \frac{\Delta v}{\Delta t} = \frac{22.0\text{ m/s} - (-25.0\text{ m/s})}{3.50 \times 10^{-3}\text{ s}}$$

$$= \boxed{1.34 \times 10^4\text{ m/s}^2}.$$

16. A particle starts from rest and accelerates as shown in Figure P2.16. Determine (a) the particle's speed at $t = 10.0$ s and at $t = 20.0$ s, and (b) the distance traveled in the first 20.0 s.



(a) Acceleration is constant over the first ten seconds, so at the end,

$$v_f = v_i + at = 0 + (2.00\ \text{m/s}^2)(10.0\ \text{s}) = \boxed{20.0\ \text{m/s}}.$$

Then $a = 0$ so v is constant from $t = 10.0$ s to $t = 15.0$ s. And over the last five seconds the velocity changes to

$$v_f = v_i + at = 20.0\ \text{m/s} + (3.00\ \text{m/s}^2)(5.00\ \text{s}) = \boxed{5.00\ \text{m/s}}.$$

(b) In the first ten seconds,

$$x_f = x_i + v_i t + \frac{1}{2}at^2 = 0 + 0 + \frac{1}{2}(2.00\ \text{m/s}^2)(10.0\ \text{s})^2 = 100\ \text{m}.$$

Over the next five seconds the position changes to

$$x_f = x_i + v_i t + \frac{1}{2}at^2 = 100\ \text{m} + (20.0\ \text{m/s})(5.00\ \text{s}) + 0 = 200\ \text{m}.$$

19. Jules Verne in 1865 suggested sending people to the Moon by firing a space capsule from a 220-m-long cannon with a launch speed of 10.97 km/s. What would have been the unrealistically large acceleration experienced by the space travelers during launch? Compare your answer with the free-fall acceleration 9.80 m/s².

From $v_f^2 = v_i^2 + 2ax$, we have $(10.97 \times 10^3\ \text{m/s})^2 = 0 + 2a(220\ \text{m})$,

so that $\boxed{a = 2.74 \times 10^5\ \text{m/s}^2}$ which is $\boxed{a = 2.79 \times 10^4\ \text{times } g}$.

20. A truck covers 40.0 m in 8.50 s while smoothly slowing down to a final speed of 2.80 m/s. (a) Find its original speed. (b) Find its acceleration.

(a) $x_f - x_i = \frac{1}{2}(v_i + v_f)t$ becomes $40\ \text{m} = \frac{1}{2}(v_i + 2.80\ \text{m/s})(8.50\ \text{s})$

which yields $v_i = \boxed{6.61\ \text{m/s}}$.

(b) $$a = \frac{v_f - v_i}{t} = \frac{2.80\ \text{m/s} - 6.61\ \text{m/s}}{8.50\ \text{s}} = \boxed{-0.448\ \text{m/s}^2}$$