CH.2 Motion in One Dimension/Discussion

Ed. 9	Motion in one dimension, **Prob. 3, 6, 15, 49, 65**

Prob. 2-3 A person walks first at a constant speed of 5.00 m/s along a straight line from point **A** to point **B** and then back along the line from **B** to **A** at a constant speed of 3.00 m/s. What is: **(a)** her average speed over the entire trip? **(b)** Her average velocity over the entire trip?

(a) Let *d* represent the distance between A and B.
Let t_1 be the time for which the walker speed 5.00 m/s,

$$t_1 = \frac{d}{5.0}.$$

Let t_2 represent the longer time for the **return trip** in 3.00 m/s

$$t_2 = \frac{d}{3.0} \quad \Rightarrow t = t_1 + t_2 = \frac{d}{5} + \frac{d}{3} = \frac{3d + 5d}{15} = \frac{8d}{15}$$

The **average speed** for the entire trip is:

$$\bar{\upsilon} = \frac{\text{Total distance}}{\text{Total Time}} = \frac{d + d}{t_1 + t_2} = 2d/(8d/15) = \frac{2d \times 15.0}{8d} = 3.75 m/s$$

(b) Since she starts and finishes at the same point A.
With total displacement Δ**x = 0**, **the average velocity**

$$\bar{v}_x = \frac{\Delta x}{\Delta t} = 0$$

Prob.2-6 The position of a particle moving along the *x* axis varies in time according to the expression $\boldsymbol{x = 3.00t^2}$, where *x* is in meters and *t* is in seconds. **Evaluate its position** (a) at *t* = 3.00 s and (b) at *3.00 s + Δt.*
(c) Evaluate the limit of Δ*x*/Δ*t* as Δ*t* approaches zero, to find the velocity at *t* = 3.00 s.

(a) $\boldsymbol{x = 3.00\, t^2}$ m. at t_i=3.00 s:

x_i= $3.00 \times (3.00)^2$= 27.0 m

(b) t_f = 3.00+Δt s:

$x_f = 3(3+\Delta t)^2 = 3\,(9+6\Delta t+(\Delta t)^2) = 27 + 18\Delta t + 3(\Delta t)^2$

(c) The instantaneous velocity at t =3.00 s is:

$$v_x = \lim_{\Delta t \to 0} \frac{x_f - x_i}{\Delta t} = 18.0 + 3.00\Delta t = 18.0\ m/s$$

Note also: $v_x(3) = \frac{dx}{dt}|_{t=3} = 6t = 6 \times 3 = 18.0\ m/s$

Prob. 2-15. A velocity–time graph for an object moving along the *x* axis is shown in Figure P2.15.

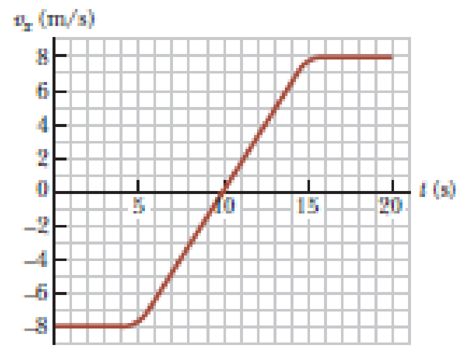


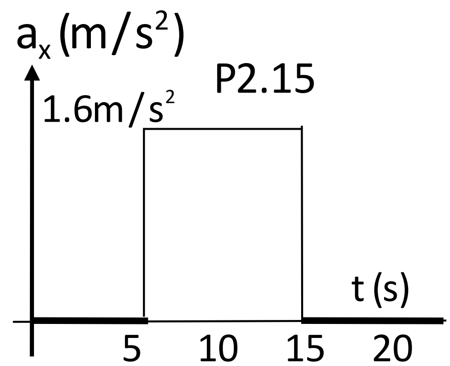
Figure P2.15

(a) Plot a graph of the acceleration versus time.

For $0 \le t \le 5$ and $15 \le t \le 20$ $a_x = 0$

For $5 \le t \le 15$

$$a_x = slope = \frac{\Delta v_x}{\Delta t} = \frac{8-(-8)}{15-5} = 1.6 m/s^2$$



Determine the **average acceleration** of the object

(b) In the time interval *t* = 5.00 s to *t* = 15.0 s .

For **5 < t < 15s**,   avg. acceleration

$$\bar{a}_x = a_{x\,avg} = \frac{v_x(15) - v_x(5)}{15-5} = 1.6\ \ m/s^2$$

(c) in the time interval *t* = 0 to *t* = 20.0 s.

For **5 < t < 20s**, $\bar{a}_x = a_{x\,avg} = \frac{v_x(20) - v_x(0)}{20} = 0.8\ \ m/s^2$

Prob.2-20. An object moves along the *x* axis according to the equation **x = 3.00t ² - 2.00t + 3.00**, where x is in meters and t is in seconds. Determine **(a)** the **average speed** between *t* = 2.00 s and *t* = 3.00 s,
(b) the **instantaneous speed** at *t* = 2.00 s and at *t* = 3.00 s,
(c) the **average acceleration** between *t* = 2.00 s and *t* = 3.00 s,
(d) the instantaneous acceleration at *t* = 2.00 s and *t* = 3.00 s.
(e) At what time is the object at rest?

(a) $v_{avg} = \frac{d}{t} = \frac{d^+ + d^-}{t}$ But

$$v_x = (6t - 2) = 0 \quad \Rightarrow t = \frac{1}{3} sec$$

For t >1/3 the object moves only in one direction d = |Δx|

$$v_{avg} = \frac{|x(3)-x(2)|}{3-2} = \frac{|(27-6+3)-(12-4+3)|}{1} = \frac{13}{1} = 13\text{ m/s}$$

(b) $v_x = \frac{dx}{dt} = (6t-2),$

$$v_x(2) = (6\times2-2) = 10\text{ m/s}, \qquad v(2) = 10\text{ m/s}$$

$$v_x(3) = (6\times3-2) = 16\text{ m/s}, \qquad v(3) = 16\text{ m/s}$$

(c) $a_{x\,avg} = \frac{v_x(3)-v_x(2)}{3-2} = \frac{16-10}{1} = 6m/s^2$

(d) $a_x = \frac{dv_x}{dt} = 6m/s^2 \Rightarrow a_x(2) = a_x(3) = 6m/s^2$

(e) $v_x = (6t-2) = 0 \qquad \Rightarrow t = \frac{1}{3}\text{sec}$

Prob. 2-49 It is possible to shoot an arrow at a speed as high as 100 m/s. (a) If friction can be ignored, how high would an arrow launched at this speed rise if shot straight up? (b) How long would the arrow be in the air?

(a) $v_{yf}^2 = v_{yi}^2 - 2g(y_f - y_i) \quad \Rightarrow 0 = (100)^2 - 2(10)\Delta y$

$$\Rightarrow \Delta y = \frac{10000}{20} = 500m$$

(b) $y_f - y_i = v_{yi}t - \frac{1}{2}gt^2 \Rightarrow$ set $y_f = y_i$ since object comes back to ground finally

$$\left\{ 0 - 0 = 100t - 4.9t^2 \Rightarrow t = \frac{100}{5.00} \quad = 20.0\text{ s} \right.$$

Prob. 2.50 The height of a helicopter above the ground is given by **$h = 3.00\ t^3$**, where h is in meters and t is in seconds. At t = 2.00 s, the helicopter releases a small mailbag.

How long after its release does the mailbag reach the ground?

$$y(t) = 3t^3, \quad \underline{at\ t = 2s} \qquad y_i = y(2)$$

$$y(2) = 3\times 8.0 = 24.0m \quad above\ the\ ground$$

$$v_x(t) = \frac{dy}{dt} = 9.0t^2, \qquad v_{xi} = v_x(2) = 9.0\times 4 = 36.0m/s \quad up(+36m/s)$$

$$y_f - y_i = v_{yi}t - \tfrac{1}{2}gt^2 \Rightarrow 0 - 24 = 36t - 5t^2 \Rightarrow 5t^2 - 36t - 24 = 0$$

$$a = 5, b = -36, c = -24 \quad \Rightarrow t = \frac{-b \mp \sqrt{(b)^2 - 4(a)(c)}}{2a}$$

$$t = \frac{-36 \pm \sqrt{(-36)^2 - 4(5)(-24)}}{2\times 5} = 6.46\ sec.$$

Prob.2-65. A ball starts from **rest and accelerates at 0.500 m/s²** while moving down an inclined plane **9.00 m long**.
When it reaches the bottom, **the ball rolls up another plane**, where it **comes to rest after moving 15.0 m on that plane**.
(a) What is the speed of the ball at the bottom of the first plane?
(b) During what time interval does the ball roll down the first plane? (c) What is the acceleration along the second plane? (d) What is the ball's speed **8.00 m along** the second plane?

(a)
$$\begin{cases} v_f = ? \quad v_i = 0 \quad a_x = 0.5m/s^2 \quad \Delta x = (x_f - x_i) = 9,0m \\ v_f^2 = v_i^2 + 2a_x(x_f - x_i) \quad \Rightarrow v_f^2 = 0 + 2(0.5)(9) \\ \qquad \Rightarrow v_f^2 = 9, \quad v_f = 3.0m/s \end{cases}$$

b) $\{v_f = v_i + a_x t \quad \Rightarrow 3 = 0 + (0.5)t \quad \Rightarrow t = 3/0.5 = 6.0s$

(c) Initial point at bottom of first plane, Final point at the end of the second plane

$$\begin{cases} v_i = 3 \quad v_f = 0 \quad a_x = ? \quad \Delta x = 15.0\text{m} \\ v_f^2 = v_i^2 + 2a_x(x_f - x_i) \Rightarrow 0 = 9 + 2a_x(15) \\ \qquad \Rightarrow a_x = \dfrac{-9}{30} = -0.3\text{m/s} \end{cases}$$

d)

$$\begin{cases} v_f = ? \quad v_i = 3 \quad a_x = -\ 0.3\text{m/s}^2 \quad \Delta x = (x_f - x_i) = 8.0\text{m} \\ v_f^2 = v_i^2 + 2a_x(x_f - x_i) \Rightarrow v_f^2 = 9 - 2(0.3)(8) \\ \qquad \Rightarrow v_f^2 = 4.20, \quad v_f = 2.05\text{m/s}^2 \end{cases}$$

Prob. 2-24 In **Example 2.7**, we investigated **a jet landing** on an aircraft carrier. In a later maneuver, the jet comes in for a landing on solid ground with a **speed of 100** m/s, and its **acceleration** can have a maximum magnitude of **5.00 m/s² as it comes to rest.** **(a)** From the instant, the jet touches the runway, what is the minimum time interval needed before it can come to rest? **(b)** Can this jet land at a small tropical island airport where the runway is **0.800 km long**?
(c) Explain your answer. Note that a = -5 m/s² (تباطؤ)]

(a) **v_i =100 m s , a= – 5.00 m /s² , $v_f = v_i + at$**
so; 0 = 100-5t or t=20.0 s.

(b) We need to find x_f: **x_i = 0, u_i = 100, and a_x = - 5m/s²**

$$v_f^2 = v_i^2 + 2a(x_f - x_i) \Rightarrow 0 = (100)^2 - 2(-5)(x_f - 0)$$
$$\Rightarrow 100^2 = 10x_f \quad or \quad x_f = 1000\ m$$

(c) No. Since 0.800 km = 800 m and at this acceleration the plane would overshoot the runway.