PHYSICS I - MECHANICS

Problem Session-I

1. Physics and Measurement
2. Vectors
3. Motion in One Dimension
4. Two Dimensional Motion

1. Physics and Measurements

1.1 Standards of Length, Mass and Time

The three fundamental physical quantities of mechanics are

Length meters (m)
Mass kilograms (kg)
Time seconds (s)

Temperature (Kelvin), electric current (Amapere), luminous intensity (candela), amount of substance (mole)

Prefixes

Multiples and Submultiples Prefixes Tables

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

1) Express the following quantities using the prefixes.

(a) $3 \text{ X } 10^{-4}$ m = 0.3 mm

(b) $5 \text{ X } 10^{-5}$ s = 50 μs

(c) $72 \text{ X } 10^{2}$ g = 7.2 kg

(d) $2 \text{ x } 10^{9}$ Watt = 2 GW

1. Physics and Measurements

1.3 Density and Atomic Mass

The density ρ (Greek letter rho) of any substance is defined as its *mass per unit volume:*

$$\rho \equiv \frac{m}{V}$$

Atomic mass units (u) 1 u=1.660 538 7 x 10^{-27} kg

2) A small cube of iron is observed under a microscope. The edge of the cube is 5.00 x10-^{6} cm long. Find
(a) the mass of the cube and
(b) the number of iron atoms in the cube. The atomic mass of iron is 55.9 u, and its density is 7.86 g/cm^3.

(a) $$m = \rho L^3 = \left(7.86\ \text{g}/\text{cm}^3\right)\left(5.00 \times 10^{-6}\ \text{cm}\right)^3 = \boxed{9.83 \times 10^{-16}\ \text{g}} = 9.83 \times 10^{-19}\ \text{kg}$$

(b) $$N = \frac{m}{m_0} = \frac{9.83 \times 10^{-19}\ \text{kg}}{55.9\ \text{u}\left(1.66 \times 10^{-27}\ \text{kg}/1\ \text{u}\right)} = \boxed{1.06 \times 10^{7}\ \text{atoms}}$$

3) What mass of a material with density ρ is required to make a hollow spherical shell having inner radius r_1 and outer radius r_2?

$$V = V_o - V_i = \frac{4}{3}\pi\left(r_2^3 - r_1^3\right)$$

$$\rho = \frac{m}{V}, \text{ so } m = \rho V = \rho\left(\frac{4}{3}\pi\right)\left(r_2^3 - r_1^3\right) = \boxed{\frac{4\pi\rho\left(r_2^3 - r_1^3\right)}{3}}.$$

1. Physics and Measurements

1.4 Dimensional Analysis

4) Which of the following equations are dimensionally correct?

$a)\ \ v_f = v_i + ax$

b) y=(2 m) cos (kx), where k=2 m^{-1}

$$\frac{L}{T} = \frac{L}{T} + \frac{L}{T^2}L \Rightarrow \frac{L}{T} + \frac{L^2}{T^2}$$ *This is incorrect*

$$L = L\cos\left(\frac{1}{L}L\right) \Rightarrow L = L$$ *This is correct.*

5) Which of the following equations are dimensionally correct?

$$x = \frac{1}{2}vt^2$$

$$L = \frac{L}{T}T^2 = LT$$ *This is incorrect*

$$x_f = x_i + v_{xi}t + \frac{1}{2}at^2$$

$$L = L + \frac{L}{T}T + \frac{L}{T^2}T^2 \Rightarrow L = L$$ *This is correct*

1. Physics and Measurements

1.5 Conversion of Units

6) A solid piece of lead has a mass of 23.94 g and a volume of 2.10 cm^3. From these data, calculate the density of lead in SI units (kg/m^3).

$$\rho = \frac{23.94\ \text{g}}{2.10\ \text{cm}^3}\left(\frac{1\ \text{kg}}{1\,000\ \text{g}}\right)\left(\frac{100\ \text{cm}}{1\ \text{m}}\right)^3 = \boxed{1.14\times 10^4\ \text{kg/m}^3}$$

7) Suppose your hair grows at the rate 1/32 in. per day. Find the rate at which it grows in nanometers per second.

Apply the following conversion factors:

$$1\ \text{in} = 2.54\ \text{cm},\ 1\ \text{d} = 86\,400\ \text{s},\ 100\ \text{cm} = 1\ \text{m},\ \text{and}\ 10^9\ \text{nm} = 1\ \text{m}$$

$$\left(\frac{1}{32}\ \text{in/day}\right)\frac{(2.54\ \text{cm/in})(10^{-2}\ \text{m/cm})(10^9\ \text{nm/m})}{86\,400\ \text{s/day}} = \boxed{9.19\ \text{nm/s}}$$

1. Physics and Measurements

1.7 Significant Figures

1. **Non-zero digits are always significant.**

    24.7 meters
    0.**743 meter**
    714 meters

2. **Zeros appearing between nonzero digits are significant.**

    7**003 meters**
    4**0.**79 **meters**
    1.5**03 meters**

3. **Trailing zeros follow a non zero digit and are significant only if there is a decimal point.**

0.00**500** 2.3**0** x 10^{-5} 1**00.000**

4.5**00** x 10^{12} 0.03**040** **1**00

0.00000566

1. Physics and Measurements

1.7 Significant Figures

4. When a number ends in zeroes that are not to the right of a decimal point, the zeroes are not necessarily significant:

- 190 miles may be 2 or 3 significant figures:

  $\mathbf{19} \times 10^1$: 2 sig. fig.
  $\mathbf{19.0} \times 10^1$: 3 sig. fig.

- 50,600 calories may be 3, 4, or 5 significant figures.

The potential ambiguity in the last rule can be avoided by the use of standard exponential, or ”scientific,” notation.

For example, depending on whether 3, 4, or 5 significant figures is correct, we could write 50,6000 calories as:

- $\mathbf{5.06} \times 10^4$ calories (3 significant figures)
- $\mathbf{5.060} \times 10^4$ calories (4 significant figures), or
- $\mathbf{5.0600} \times 10^4$ calories (5 significant figures).

1. Physics and Measurements

1.7 Significant Figures

8) Carry out the following arithmetic operations:
(a) the sum of the measured values 756, 37.2, 0.83, and 2.5;
(b) The product 0.003 2 X 356.3;
(c) the product 5.620 X π.

(a)

$$\begin{array}{r} 756.?? \\ 37.2? \\ 0.83 \\ \underline{+\ 2.5?} \\ 796.\cancel{5}\cancel{3} \end{array} = \boxed{797}$$

(b) $0.003\,2(2\text{ s.f.}) \times 356.3(4\text{ s.f.}) = 1.140\,16 = (2\text{ s.f.})\ \boxed{1.1}$

(c) $5.620(4\text{ s.f.}) \times \pi(>4\text{ s.f.}) = 17.656 = (4\text{ s.f.})\ \boxed{17.66}$

9) A carpet is to be installed in a room whose length is measured to be 12.71 m and whose width is measured to be 3.46 m. Find the area of the room.

If you multiply 12.71 m by 3.46 m on your calculator, you will see an answer of 43.976 6 m^2.

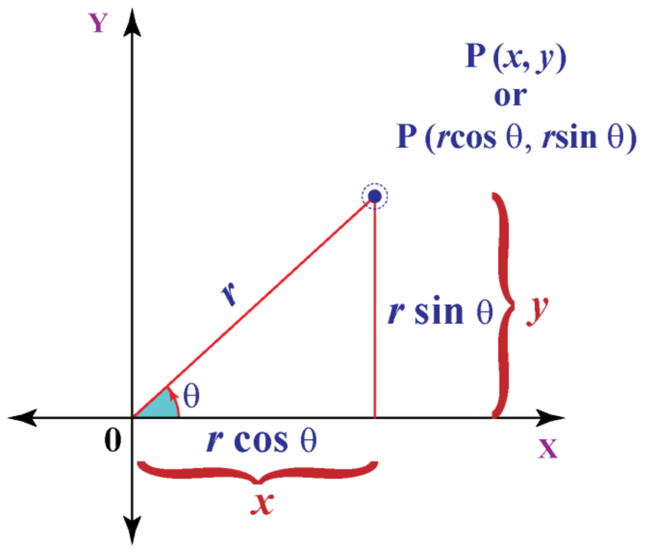
3.46 m, so we should express our final answer as 44.0 m^2.

2. Vectors

2.1 Coordinate Systems

Polar to Cartesian Coordinates

- Based on forming a right triangle from r and θ
- $x = r \cos \theta$
- $y = r \sin \theta$



Cartesian to Polar Coordinates

- r is the hypotenuse and θ an angle

$$\tan\theta = \frac{y}{x}$$

$$r = \sqrt{x^2 + y^2}$$

- θ must be ccw from positive x axis for these equations to be valid

10) If the rectangular coordinates of a point are given by (2, y) and its polar coordinates are (r, 30°), determine y and r.

We have $2.00 = r\cos 30.0°$

$$r = \frac{2.00}{\cos 30.0°} = \boxed{2.31}$$

and $y = r\sin 30.0° = 2.31 \sin 30.0° = \boxed{1.15}$.

2. Vectors

2.4 Components of a Vector and Unit Vectors

11) Vector $\vec{A}$ is in the direction 34⁰ clockwise from the –y axis. The $\overset{y}{x}$-component of $\vec{A}$ is A_x=-16 m. (a) What is the y-component of $\vec{A}$? (b) What is the magnitude of $\vec{A}$?

(a) $\tan 34.0° = \dfrac{|A_x|}{|A_y|}$

$$|A_y| = \frac{|A_x|}{\tan 34.0°} = \frac{16.0 \text{ m}}{\tan 34.0°} = 23.72 \text{ m}$$

$$A_y = -23.7 \text{ m.}$$

(b) $A = \sqrt{A_x^2 + A_y^2} = 28.6 \text{ m.}$

12) Consider the two vectors **A**= 3î – 2ĵ and **B** = –î – 4ĵ.
Calculate (a) **A + B**, (b) **A - B**, (c) |**A + B**|, (d) |**A – B**|, and (e) the directions of **A + B** and **A - B**.

(a) $(\mathbf{A}+\mathbf{B}) = (3\hat{\mathbf{i}} - 2\hat{\mathbf{j}}) + (-\hat{\mathbf{i}} - 4\hat{\mathbf{j}}) = \boxed{2\hat{\mathbf{i}} - 6\hat{\mathbf{j}}}$

(b) $(\mathbf{A}-\mathbf{B}) = (3\hat{\mathbf{i}} - 2\hat{\mathbf{j}}) - (-\hat{\mathbf{i}} - 4\hat{\mathbf{j}}) = \boxed{4\hat{\mathbf{i}} + 2\hat{\mathbf{j}}}$

(c) $|\mathbf{A}+\mathbf{B}| = \sqrt{2^2 + 6^2} = \boxed{6.32}$

(d) $|\mathbf{A}-\mathbf{B}| = \sqrt{4^2 + 2^2} = \boxed{4.47}$

(e) $\theta_{|\mathbf{A}+\mathbf{B}|} = \tan^{-1}\left(-\dfrac{6}{2}\right) = -71.6° = \boxed{288°}$

$\theta_{|\mathbf{A}-\mathbf{B}|} = \tan^{-1}\left(\dfrac{2}{4}\right) = \boxed{26.6°}$

2. Vectors

2.4 Components of a Vector and Unit Vectors

13) A vector is given by **R** = $2\hat{\mathbf{i}} + \hat{\mathbf{j}} + 3\,\hat{\mathbf{k}}$. Find
(a) the magnitudes of the *x*, *y*, and *z* components,
(b) the magnitude of **R**, and
(c) the angles between **R** and the *x*, *y*, and *z* axes.

(a) $R_x = \boxed{2.00},\ R_y = \boxed{1.00},\ R_z = \boxed{3.00}$

(b) $|\mathbf{R}| = \sqrt{R_x^2 + R_y^2 + R_z^2} = \sqrt{4.00 + 1.00 + 9.00} = \sqrt{14.0} = \boxed{3.74}$

(c)

$$\cos\theta_x = \frac{R_x}{|\mathbf{R}|} \Rightarrow \theta_x = \cos^{-1}\left(\frac{R_x}{|\mathbf{R}|}\right) = \boxed{57.7^\circ \text{ from } +x}$$

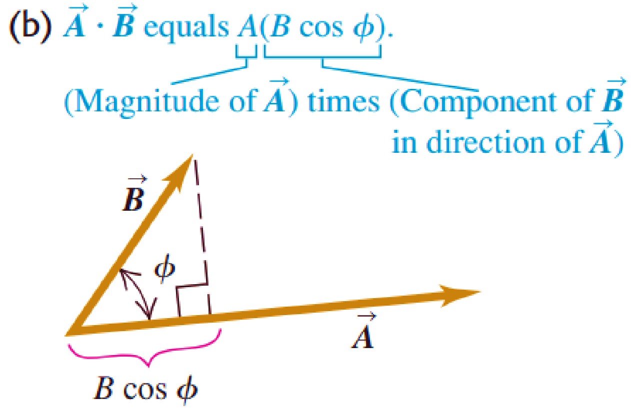
$$\cos\theta_y = \frac{R_y}{|\mathbf{R}|} \Rightarrow \theta_y = \cos^{-1}\left(\frac{R_y}{|\mathbf{R}|}\right) = \boxed{74.5^\circ \text{ from } +y}$$

$$\cos\theta_z = \frac{R_z}{|\mathbf{R}|} \Rightarrow \theta_z = \cos^{-1}\left(\frac{R_z}{|\mathbf{R}|}\right) = \boxed{36.7^\circ \text{ from } +z}$$

2. Vectors

2.5 Products of Vectors

i) Scalar Product



$$\vec{A} \cdot \vec{B} = AB\cos\phi = |\vec{A}||\vec{B}|\cos\phi$$ (definition of the scalar (dot) product)

ii) Vector Product

$$\vec{C} = \vec{A} \, X \, \vec{B} \Rightarrow C = AB\sin\phi$$

$$\vec{A} \, X \, \vec{B} = -\vec{B} \, X \, \vec{A}$$

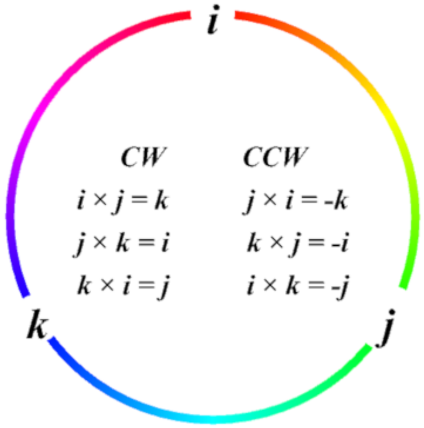
$$\vec{B} \, X \, \vec{A} = -\vec{A} \, X \, \vec{B}$$

$$\hat{\imath} \times \hat{\imath} = \hat{\jmath} \times \hat{\jmath} = \hat{k} \times \hat{k} = 0$$

$$\hat{\imath} \times \hat{\jmath} = -\hat{\jmath} \times \hat{\imath} = \hat{k}$$

$$\hat{\jmath} \times \hat{k} = -\hat{k} \times \hat{\jmath} = \hat{\imath}$$

$$\hat{k} \times \hat{\imath} = -\hat{\imath} \times \hat{k} = \hat{\jmath}$$



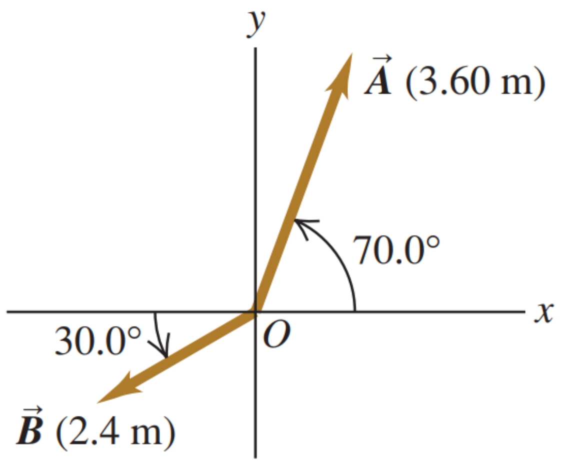
2. Vectors

2.5 Products of Vectors

14) For the two vectors $\vec{A}$ *and* $\vec{B}$ in figure

(a) find the scalar product $\vec{A} \cdot \vec{B}$

(b) find the magnitude and direction of the vector product $\vec{A} \, X \, \vec{B}$



The angle between the vectors is $20° + 90° + 30° = 140°$.

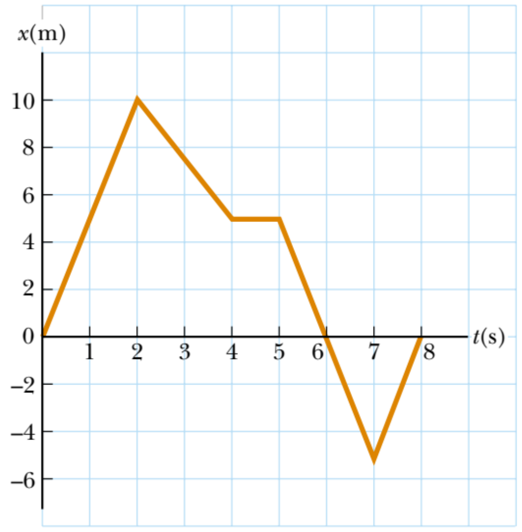
(a) $\vec{A} \cdot \vec{B} = (3.60 \text{ m})(2.40 \text{ m})\cos 140° = -6.62 \text{ m}^2$

(b) $(3.60 \text{ m})(2.40 \text{ m})\sin 140° = 5.55 \text{ m}^2$

direction, from the right-hand rule, is out of the page (the $+z$-direction)

3. Motion in One Dimesion

15) The position versus time for a certain particle moving along the *x* axis is shown in Figure given below. Find the average velocity in the time intervals
(a) 2 s to 4 s, (b) 4 s to 7 s, (c) 0 to 8 s



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

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

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

16) A position-time graph for a particle moving along the *x* axis is shown in Figure given below.
(a) Find the average velocity in the time interval t = 1.50 s to t = 4.00 s.
(b) Determine the instantaneous velocity at t = 2.00 s by measuring the slope of the tangent line shown in the graph.
(c) At what value of t is the velocity zero?

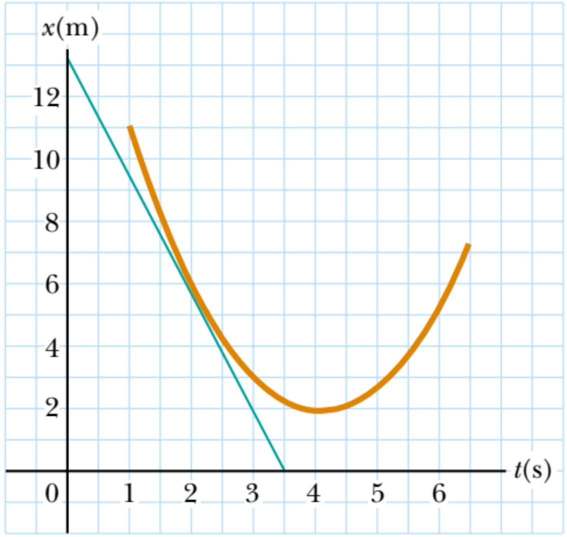
(a) at $t_i = 1.5$ s, $x_i = 8.0$ m (Point A)
at $t_f = 4.0$ s, $x_f = 2.0$ m (Point B)

$$\bar{v} = \frac{x_f - x_i}{t_f - t_i} = \frac{(2.0 - 8.0)\text{ m}}{(4 - 1.5)\text{ s}} = -\frac{6.0\text{ m}}{2.5\text{ s}} = \boxed{-2.4\text{ m/s}}$$

(b) The slope of the tangent line is found from points C and D. ($t_C = 1.0$ s, $x_C = 9.5$ m) and ($t_D = 3.5$ s, $x_D = 0$),

$$v \cong \boxed{-3.8\text{ m/s}}.$$

(c) The velocity is zero when x is a minimum. This is at $t \cong \boxed{4\text{ s}}$

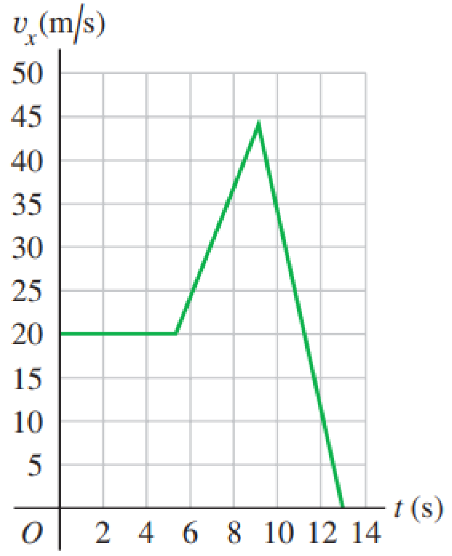


3. Motion in One Dimesion

17) The graph in figure shows the velocity of a car plotted as a function of time.

(a) Find the instantaneous acceleration at t=3 s, at t=7 s and at t= 11s

(b) How far does the car go in the first 5 s? The first 9 s?



(a)

(a) IDENTIFY and SET UP: The acceleration a_x at time t is the slope of the tangent to the v_x versus t curve at time t.

EXECUTE: At $t = 3$ s, the v_x versus t curve is a horizontal straight line, with zero slope. Thus $a_x = 0$.

At $t = 7$ s, the v_x versus t curve is a straight-line segment with slope $\dfrac{45\text{ m/s} - 20\text{ m/s}}{9\text{ s} - 5\text{ s}} = 6.3\text{ m/s}^2$.

Thus $a_x = 6.3\text{ m/s}^2$.

At $t = 11$ s the curve is again a straight-line segment, now with slope $\dfrac{-0 - 45\text{ m/s}}{13\text{ s} - 9\text{ s}} = -11.2\text{ m/s}^2$.

Thus $a_x = -11.2\text{ m/s}^2$.

(b)

$v_{0x} = 20\text{ m/s}$ $a_x = 0$ $t = 5\text{ s}$ $x - x_0 = ?$

$x - x_0 = v_{0x}t$ ($a_x = 0$ so no $\frac{1}{2}a_xt^2$ term)

$x - x_0 = (20\text{ m/s})(5\text{ s}) = 100\text{ m}$; this is the distance the officer travels in the first 5 seconds.

$v_{0x} = 20\text{ m/s}$ $a_x = 6.25\text{ m/s}^2$ $t = 4\text{ s}$ $x_0 = 100\text{ m}$ $x - x_0 = ?$

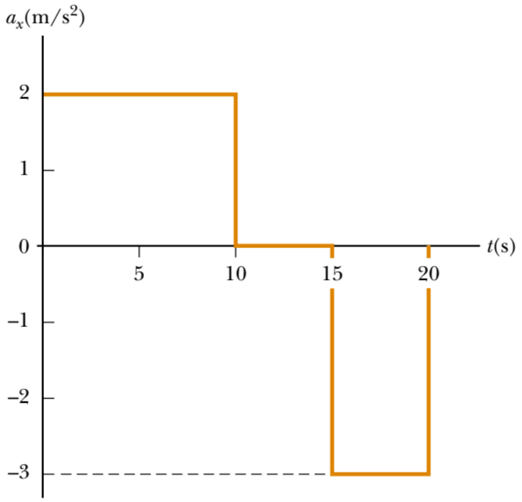
$x - x_0 = v_{0x}t + \frac{1}{2}a_xt^2$

$x - x_0 = (20\text{ m/s})(4\text{ s}) + \frac{1}{2}(6.25\text{ m/s}^2)(4\text{ s})^2 = 80\text{ m} + 50\text{ m} = 130\text{ m}.$

Thus $x - x_0 + 130\text{ m} = 100\text{ m} + 130\text{ m} = 230\text{ m}.$

3. Motion in One Dimesion

18) A particle starts from rest and accelerates as shown in Figure. 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

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

And at $t = 20.0$ s,

$$x_f = x_i + v_i t + \frac{1}{2}at^2 = 200\ \text{m} + (20.0\ \text{m/s})(5.00\ \text{s}) + \frac{1}{2}(-3.00\ \text{m/s}^2)(5.00\ \text{s})^2 = \boxed{262\ \text{m}}.$$

Equation

$$\begin{aligned} v_{xf} &= v_{xi} + a_x t \\ x_f &= x_i + \tfrac{1}{2}(v_{xi} + v_{xf})\,t \\ x_f &= x_i + v_{xi}t + \tfrac{1}{2}a_x t^2 \\ v_{xf}{}^2 &= v_{xi}{}^2 + 2a_x(x_f - x_i) \end{aligned}$$

3. Motion in One Dimesion

19) A particle moves along the x axis according to the equation
$x = 2.00 + 3.00t - 1.00t^2$, where x is in meters and t is in seconds. At $t = 3.00$ s, find
(a) the position of the particle,
(b) its velocity, and
(c) its acceleration.

$$x = 2.00 + 3.00t - t^2,\ v = \frac{dx}{dt} = 3.00 - 2.00t,\ a = \frac{dv}{dt} = -2.00$$

At $t = 3.00$ s:

(a) $x = (2.00 + 9.00 - 9.00)\ \text{m} = \boxed{2.00\ \text{m}}$

(b) $v = (3.00 - 6.00)\ \text{m/s} = \boxed{-3.00\ \text{m/s}}$

(c) $a = \boxed{-2.00\ \text{m/s}^2}$

3. Motion in One Dimesion

20) 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. After 2.00 s, the helicopter releases a box. How long after its release does the box reach the ground?

$y = 3.00t^3$: At $t = 2.00$ s, $y = 3.00(2.00)^3 = 24.0$ m and

$$v_y = \frac{dy}{dt} = 9.00t^2 = 36.0 \text{ m/s} \uparrow.$$

$$y_b = y_{bi} + v_i t - \frac{1}{2}gt^2 = 24.0 + 36.0t - \frac{1}{2}(9.80)t^2.$$

Setting $y_b = 0$,

$$0 = 24.0 + 36.0t - 4.90t^2.$$

Solving for t, (only positive values of t count), $\boxed{t = 7.96 \text{ s}}$.

4. Two Dimensional Motion

21) A particle initially located at the origin has an acceleration of $\mathbf{a} = 3.00\hat{\mathbf{j}}$ m/s^2 and an initial velocity of $\mathbf{v}_i = 500\hat{\mathbf{i}}$ m/s. Find (a) the vector position and velocity at any time *t* and (b) the coordinates and speed of the particle at *t* = 2.00 s.

$$\mathbf{a} = 3.00\hat{\mathbf{j}}\ \text{m/s}^2\,;\ \mathbf{v}_i = 5.00\hat{\mathbf{i}}\ \text{m/s}\,;\ \mathbf{r}_i = 0\hat{\mathbf{i}} + 0\hat{\mathbf{j}}$$

(a)

$$\mathbf{r}_f = \mathbf{r}_i + \mathbf{v}_i t + \frac{1}{2}\mathbf{a}t^2 = \boxed{\left[5.00t\hat{\mathbf{i}} + \frac{1}{2}3.00t^2\hat{\mathbf{j}}\right]\ \text{m}}$$

$$\mathbf{v}_f = \mathbf{v}_i + \mathbf{a}t = \boxed{\left(5.00\hat{\mathbf{i}} + 3.00t\hat{\mathbf{j}}\right)\ \text{m/s}}$$

(b)

$$t = 2.00\ \text{s}\,,\ \mathbf{r}_f = 5.00(2.00)\hat{\mathbf{i}} + \frac{1}{2}(3.00)(2.00)^2\hat{\mathbf{j}} = \left(10.0\hat{\mathbf{i}} + 6.00\hat{\mathbf{j}}\right)\ \text{m}$$

$$\text{so } x_f = \boxed{10.0\ \text{m}}\,,\ y_f = \boxed{6.00\ \text{m}}$$

$$\mathbf{v}_f = 5.00\hat{\mathbf{i}} + 3.00(2.00)\hat{\mathbf{j}} = \left(5.00\hat{\mathbf{i}} + 6.00\hat{\mathbf{j}}\right)\ \text{m/s}$$

$$v_f = \left|\mathbf{v}_f\right| = \sqrt{v_{xf}^2 + v_{yf}^2} = \sqrt{(5.00)^2 + (6.00)^2} = \boxed{7.81\ \text{m/s}}$$

4. Two Dimensional Motion

22) A moderate wind accelerates a pebble over a horizontal *xy* plane with a constant acceleration $\vec{a} = (5.00\, m/s^2)\hat{\imath} + (5.00\, m/s^2)\hat{\jmath}$. At time *t* = 0, the velocity is $(4.00\, m/s)\hat{\imath}$. What are the

(a) magnitude and

(b) angle of its velocity when it has been displaced by 12.0 m parallel to the *x* axis?

We find t by solving $\Delta x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2$:

$$12.0\text{ m} = 0 + (4.00\text{ m/s})t + \frac{1}{2}(5.00\text{ m/s}^2)t^2$$

where we have used $\Delta x = 12.0$ m, $v_x = 4.00$ m/s, and $a_x = 5.00$ m/s^2. We use the quadratic formula and find $t = 1.53$ s. Therefore, its velocity (when $\Delta x = 12.00$ m) is

$$\vec{v} = \vec{v}_0 + \vec{a}t = (4.00\text{ m/s})\hat{\text{i}} + (5.00\text{ m/s}^2)(1.53\text{ s})\hat{\text{i}} + (7.00\text{ m/s}^2)(1.53\text{ s})\hat{\text{j}}$$

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$$= (11.7\text{ m/s})\hat{\text{i}} + (10.7\text{ m/s})\hat{\text{j}}.$$

Thus, the magnitude of $\vec{v}$ is $|\vec{v}| = \sqrt{(11.7\text{ m/s})^2 + (10.7\text{ m/s})^2} = 15.8$ m/s.

(b) The angle of $\vec{v}$, measured from $+x$, is

$$\tan^{-1}\left(\frac{10.7\text{ m/s}}{11.7\text{ m/s}}\right) = 42.6°.$$