Important Formulas

- **Distance** $S = v_{av} \times t$
- **Average acceleration**

$$Average\ acceleration = \frac{Change\ in\ velocity}{Time\ taken}$$

$$\boldsymbol{a_{av} = \frac{v_f - v_i}{t}}$$

- **First Equation of Motion**

$$v_f = v_i + at$$

- **Second Equation of Motion**

$$S = v_i t + \frac{1}{2}at^2$$

- **Third Equation of Motion**

$$2aS = v_f^2 - v_i^2$$

- To concert ms^{-1} to kmh^{-1} **multiply** speed with $\mathbf{3.6}$
- To concert kmh^{-1} to ms^{-1} **multiply** speed with $\frac{10}{36}$
- **First Equation of Motion Body Moving Under Gravity** $v_f = v_i + gt$
- **Second Equation of Motion Body Moving Under Gravity** $h = v_i t + \frac{1}{2}gt^2$
- **Third Equation of Motion Body Moving Under Gravity** $2gh = v_f^2 - v_i^2$
- For bodies **falling down** freely value of $\boldsymbol{g}$ **is positive** and $v_i = 0$
- For bodies **moving upward** value of $\boldsymbol{g}$ **is negative** and $v_f = 0$

2.1 Draw the representative lines of the following vectors:

(a) A velocity of $400\ ms^{-1}$ making an angle of $60°$ with x-axis.

(b) A force of $50\ N$ making an angle of $120°$ with x-axis.

Solution

(a) A velocity of $400\ ms^{-1}$ making an angle of $60°$ with x-axis.

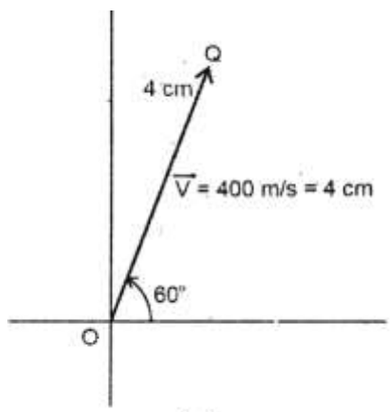
(i) Draw horizontal and vertical lines to represent x-axis and y-axis as shown in figure (a).

(ii) Select a suitable scale

If $100\ ms^{-1} = 1\ cm$

then $400\ ms^{-1} = 4\ cm$

(iii) Draw $4\ cm$ line OQ at angle of $60°$ with positive x-axis. The OQ is vector $\vec{V}$.



(a)

(b) A velocity of $50\ N$ making an angle of $120°$ with x-axis.

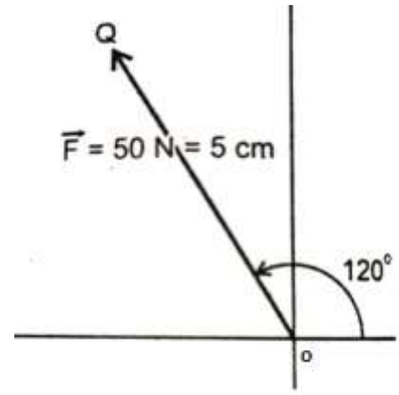
(i) Draw horizontal and vertical lines to represent x-axis and y-axis as shown in figure (b).

(ii) Select a suitable scale

If $10\ N = 1\ cm$

then $50N = 5\ cm$

(iii) Draw $5\ cm$ line OQ at angle of $120°$ with x-axis. The OQ is vector $\vec{F}$.



(b)

2.2 A car is moving with an average speed of $72\ kmh^{-1}$. How much time will it take to cover a distance of $360\ km$?

Given Data

$$Average\ speed\ of\ car = v_{av} = 72\ kmh^{-1}$$
$$Distance = S = 360\ km$$

To Find

$$Time = t = ?$$

Solution

By using formula of distance

$$S = v_{av} \times t$$
$$360 = 72 \times t$$
$$\frac{360}{72} = t$$
$$5 = t$$
$$\boldsymbol{t = 5\ hr}$$

2.3 A truck starts from rest. It reaches a velocity of $90\ kmh^{-1}$ in $50\ seconds$. Find its average acceleration.

Given Data

$$Initial\ velocity\ of\ truck = v_i = 0\ kmh^{-1}$$
$$Final\ velocity = v_f = 90\ kmh^{-1}$$
$$v_f = 90 \times \frac{10}{36}\ ms^{-1}$$
$$v_f = 25\ ms^{-1}$$
$$Time = t = 50\ s$$

To Find

$$Average\ acceleration = a_{av} = ?$$

Solution

By using formula of average acceleration

$$a_{av} = \frac{v_f - v_i}{t}$$
$$a_{av} = \frac{25 - 0}{50}$$
$$a_{av} = \frac{25}{50}$$
$$\boldsymbol{a_{av} = 0.5\ ms^{-2}}$$

2.4 A car passes a green traffic signal while moving with a velocity of $5\ ms^{-1}$. It then accelerates to $1.5\ ms^{-2}$. What is the velocity of car after $5\ seconds$?

Given Data

$$Initial\ velocity\ of\ car = v_i = 5\ ms^{-1}$$
$$Acceleration = a = 1.5\ ms^{-2}$$
$$Time = t = 5\ s$$

To Find

$$Final\ Velocity = v_f = ?$$

Solution

By using first equation of motion

$$v_f = v_i + at$$
$$v_f = 5 + (1.5)(5)$$
$$v_f = 5 + 7.5$$
$$\boldsymbol{v_f = 12.5\ ms^{-1}}$$

2.5 A motorcycle initially travelling at $18\ kmh^{-1}$ accelerates at constant rate of $2\ ms^{-2}$. How far will the motorcycle go in $10\ seconds$?

Given Data

$$Initial\ velocity = v_i = 18\ kmh^{-1}$$
$$v_i = 18 \times \frac{10}{36}\ ms^{-1}$$
$$v_i = 5\ ms^{-1}$$
$$Acceleration = a = 2\ ms^{-2}$$
$$Time = t = 10\ s$$

To Find

$$Distance\ moved = S = ?$$

Solution

By using second equation of motion

$$S = v_i t + \frac{1}{2}at^2$$
$$S = (5)(10) + \frac{1}{2}(2)(10)^2$$
$$S = 50 + \frac{1}{2}(2)(100)$$
$$S = 50 + 100$$
$$\boldsymbol{S = 150\ m}$$

2.6 A wagon is moving on the road with a velocity of $54\ kmh^{-1}$. Brakes are applied suddenly. The wagon covers a distance of $25\ m$ before stopping. Determine the acceleration of the wagon.

Given Data

$$Initial\ velocity\ of\ wagon = v_i = 54\ kmh^{-1}$$
$$v_i = 54 \times \frac{10}{36}\ ms^{-1}$$
$$v_i = 15\ ms^{-1}$$
$$Distance\ covered = S = 25\ m$$
$$Final\ velocity = v_f = 0\ ms^{-1}$$

To Find

$$Acceleration = a = ?$$

Solution

By using third equation of motion

$$2aS = v_f^2 - v_i^2$$
$$2(a)(25) = (0)^2 - (15)^2$$
$$50(a) = 0 - 225$$
$$a = \frac{-225}{50}$$
$$\boldsymbol{a = -4.5\ ms^{-2}}$$

2.7 A stone is dropped from a height of $45\ m$. How long will it take to reach the ground? What will be its velocity just before hitting the ground?

Given Data

$$Height = h = 45\ m$$
$$Initial\ velocity = v_i = 0\ ms^{-1}$$
$$Acceleration\ due\ to\ gravity = g = 10\ ms^{-2}$$
$$Time = t = 5\ s$$

To Find

$$Time\ to reach\ ground = t = ?$$
$$Velocity\ just\ before\ hitting\ ground = v_f = ?$$

Solution

By using second equation of motion body moving under gravity

$$h = v_i t + \frac{1}{2}gt^2$$
$$45 = (0)(t) + \frac{1}{2}(10)(t)^2$$
$$45 = 0 + 5(t)^2$$
$$45 = 5(t)^2$$
$$\frac{45}{5} = t^2$$
$$9 = t^2$$
$$\sqrt{9} = \sqrt{t^2}$$
$$3 = t$$
$$\boldsymbol{t = 3\ s}$$

Now for final velocity by using first equation of motion under gravity

$$v_f = v_i + gt$$
$$v_f = 0 + (10)(3)$$
$$v_f = 0 + 30$$
$$\boldsymbol{v_f = 30\ ms^{-1}}$$

2.8 A car travels $10\ km$ with an average velocity of $20\ ms^{-1}$. Then it travels in the same direction through a diversion at an average velocity of $4\ ms^{-1}$ for the next $0.8\ km$. Determine the average velocity of the car for the total journey.

Given Data

$$Distance\ traveld = S_1 = 10\ km$$
$$S_1 = 10 \times 10^3\ m$$
$$S_1 = 10000\ m$$
$$Average\ velocity = v_1 = 20\ ms^{-1}$$
$$Next\ distance\ traveld = S_2 = 0.8\ km$$
$$S_2 = 0.8 \times 10^3\ m$$
$$S_2 = 800\ m$$
$$Average\ velocity = v_2 = 4\ ms^{-1}$$

To Find

$$Average\ velocity\ for\ total\ journey = v_{av} = ?$$

Solution

For S_1 time taken by using formula $S = vt$

$$t_1 = \frac{S_1}{v_1}$$
$$t_1 = \frac{10000}{20}$$
$$t_1 = 500\ s$$

For S_2 time taken

$$t_2 = \frac{S_2}{v_2}$$
$$t_2 = \frac{800}{4}$$
$$t_2 = 200\ s$$
$$Total\ time = t = t_1 + t_2$$
$$t = 500 + 200$$
$$t = 700\ s$$
$$Total\ distance = S = S_1 + S_2$$
$$S = 10000 + 800$$

$$S = 10800\ m$$

Now by using formula of distance

$$S = v_{av} \times t$$
$$10800 = v_{av} \times 700$$
$$\frac{10800}{700} = v_{av}$$
$$15.4 = v_{av}$$
$$\boldsymbol{v_{av} = 15.4\ ms^{-1}}$$

2.9 A ball is dropped from the top of a tower. The ball reaches the ground in 5 $seconds$. Find the height of the tower and the velocity of the ball with which it strikes the ground.

Given Data

$$Time\ taken = t = 5\ s$$
$$Initial\ velocity = v_i = 0\ ms^{-1}$$
$$Acceleration\ due\ to\ gravity = g = 10\ ms^{-2}$$

To Find

$$Height\ of\ tower = h = ?$$
$$Final\ velocity = v_f = ?$$

Solution

By using second equation of motion body moving under gravity

$$h = v_i t + \frac{1}{2}gt^2$$
$$h = (0)(5) + \frac{1}{2}(10)(5)^2$$
$$h = 0 + (5)(25)$$
$$\boldsymbol{h = 125\ m}$$

Now for final velocity by using first equation of motion under gravity

$$v_f = v_i + gt$$
$$v_f = 0 + (10)(5)$$
$$\boldsymbol{v_f = 50\ ms^{-1}}$$

2.10 A cricket ball is hit so that it travels straight up in the air. An observer notes that it took 3 $seconds$ to reach the highest point. What was the initial velocity of the ball? If the ball was hit 1 m above the ground, how high did it rise from the ground?

Given Data

$$Time\ to\ reach\ the\ highest\ point = t = 3\ s$$
$$Final\ velocity = v_f = 0\ ms^{-1}$$
$$Acceleration\ due\ to\ gravity = g = -10\ ms^{-2}$$

To Find

$$Initial\ velocity = v_i = ?$$
$$Height\ of\ ball\ 1\ m\ above\ the\ ground = h_t = ?$$

Solution

For initial velocity by using first equation of motion under gravity

$$v_f = v_i + gt$$
$$0 = v_i + (-10)(3)$$
$$0 = v_i - 30$$
$$30 = v_i$$
$$\boldsymbol{v_i = 30\ ms^{-1}}$$

Now by using second equation of motion body moving under gravity

$$h = v_i t + \frac{1}{2}gt^2$$
$$h = (30)(3) + \frac{1}{2}(-10)(3)^2$$
$$h = 90 + (-5)(9)$$
$$h = 90 - 45$$
$$h = 45\ m$$

$$Required\ total\ height = h_t = h_{gain} + h_{initial}$$
$$h_t = 45\ m + 1\ m$$
$$\boldsymbol{h_t = 46\ m}$$