KINEMATICS

Q:2.2:

Explain translatory motion and give examples of various types of translatory motion.

Ans:

<u>Translatory motion</u>

<u>Definition:</u>

"In translational motion, a body moves along a line without any rotation. The line may be straight or curved".

<u>Examples:</u>

Following are some examples of translatory motion:

- Motion of a car in a straight line
- The motion of electrons around the nucleus
- The motion of gas molecules

<u>Types of translatory motion</u>

There are three types of translatory motion.

- Linear motion
- Circular motion
- Random motion

Q:2.3:

Differentiate between the following:

(1) rest and motion

(2) circular motion and rotatory motion

(3) distance and displacement

(4) speed and velocity

(5) scalers and vectors

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(1) Difference between rest and motion:

Ans:

Rest

- If a body does not change its position with respect to its surroundings then it is said to be in a state of rest.
- A person standing along the role is not changing his position with respect to his surroundings is in the state of rest.

Motion

- If a body continuously changes its position with respect to its surroundings then it is said to be in a state of motion.
- The motion of the earth about its geographical axis is an example of motion.

(2) circular motion and rotatory motion

Ans:

Circular motion

- The motion of an object in a circular path is known as circular motion.
- In circular motion, the point about which a body goes around is outside the body (its position of axis).
- The motion of the earth around the sun, the motion of individual particles of the spinning top, and the motion of the rider in the Ferris wheel all some example of circular motion are some examples of circular motion.

Rotatory motion

- The spinning motion of a body about its axis is called rotatory motion.
- In rotatory motion, the line around which a body moves about is passing through the body itself (its position of Axis).
- The motion of the earth about its geographical axis, the spinning motion of the top, and the motion of the Ferris wheel are some examples of rotatory motion.

(3) Distance and displacement

Distance

- Length of path between 2 points is called distance between those points.
- Distance is represented by ''S''.
- Distance is a scalar quantity its S.I unit is metre.

Displacement

- This shortest distance between 2 points is called displacement.
- Displacement is denoted by "d".
- Displacement is a vector quantity. its SI unit is metre.

(4) Speed and Velocity

Speed

- The distance covered by an object in unit time is called **speed.**
- Speed is represented by ''v''.
- Speed is a scalar quantity. its S.I unit is metre per second(ms^{-1}).

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- Speed = Distance covered/Total time

$$v = \frac{S}{t}$$

Velocity

- The displacement covered by an object in unit time is called velocity.
- Displacement is denoted by "**v**"
- Speed is a scalar quantity it's SI unit is metre per second (ms^{-1}).
- $$\text{velocity} = \frac{\text{displacement}}{\text{time taken}}$$

(5) Linear motion and random motion

Linear motion

- Translator motion of the body in a straight line is called linear motion.
- The motion of freely falling bodies.
- Motion of a car moving along the straight line.
- MotionOf aeroplane on the state runway.

Random motion

- The disordered or irregular translatory motion of an object is called random motion.
- The flight of an insect and birds.
- Brownian Motion of gas or liquid molecules.
- Motion of dust is no particles in air.

(6) Scalar quantity and vector quantity

Scalar quantities

- Physical Quantities which can be completely described their magnitude only are called scalar quantities or simply scalers.
- Scalar quantities can be added order subtracted by simple arithmetic rules because they have only numeric values with proper units.
- Mass, length, time speed, volume, area, energy etc are examples of scalar quantity.

Vector quantities

- Quantities which can be completely described but their magnitude along with their direction are called vector quantities or simple vectors.
- Vector quantities cannot be added or subtracted by simple arithmetic rules because they have direction along with numeric value and proper unit. They need head to tale rule for this purpose.
- Velocity, force, displacement, momentum, torque etc are the example of vector quantities.

Q:2.4:

Define the term speed, velocity and acceleration.

Ans:

Speed

Definition:

The distance covered by an object in unit time is called speed.

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Symbols:

Speed is represented by ''v''.

Quantity:

Speed is a scalar quantity. its S.I unit is metre per second (ms^{-1}).

Formula:

Speed = displacement/time taken

<u>Velocity</u>

Definition:

'' the displacement covered by an object in unit time is called velocity''

Symbol:

Displacement is denoted by ''**v**''

Quantity:

Speed is a scalar quantity. Its S.I unit is metre per second (ms^{-1}).

Formula:

Velocity = displacement/time

<u>Acceleration</u>

Definition:

''The rate of change of velocity of a body is known as acceleration acceleration.''

Mathematical form:

If a body is moving with initial velocity ''v_i '' and after sometime 't' S velocity become ''v_f '' then change in velocity will be $v_f - v_i$ in time t.

Acceleration = change in velocity/time

Acceleration = final velocity - initial velocity/time
So

$$a = v_f - v_i / t$$

Unit:

SI unit of acceleration is metre per second per second (ms^{-2})

Quantity:

It is a vector quantity.

Q:2.5:

Can a body moving at a constant speed have acceleration?

Ans:

<u>**Constant speed and acceleration**</u>

A body moving with constant speed may or may not have acceleration.

- It will not have acceleration if the body is moving with constant speed in a straight line that will be the case of constant velocity.

That body can have acceleration if its direction of motion changes continuously for example of body moving with constant speed in a circular path has acceleration.

Q:2.6:

How do riders in a Ferris wheel possess translatory motion but not circular motion?

Ans:

<u>**Motion of Rider**</u>

Riders in a Ferris wheel moves in a circle without rotation therefore motion of Rider in Ferris is translatory not rotatory.

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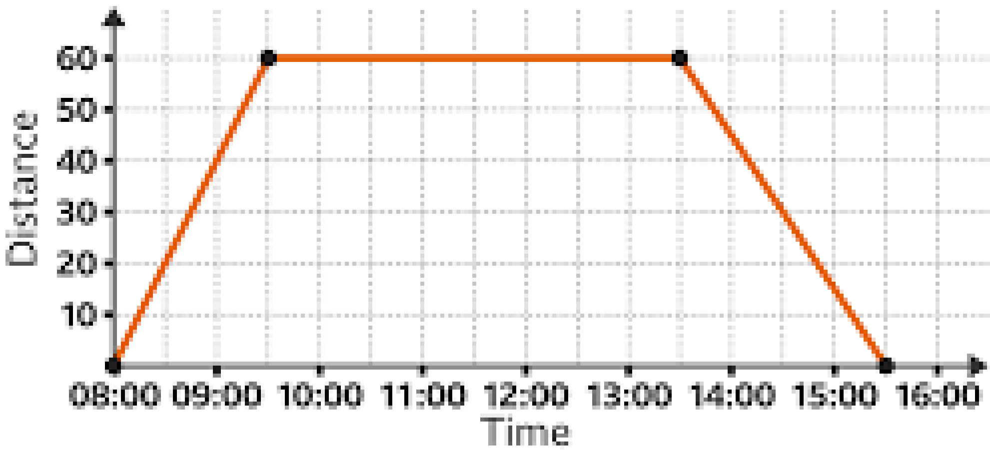
Q:2.7:

Sketch a distance-time graph for a body starting from rest. How will you determine the speed of a body from this graph?

Ans:

The distance-time graph is shown below:



The slope of the graph gives speed with the help of the formula.

Speed(v) of the object = slope of line AB

= distance EF/time CD

=20m/10s

=2 ms^{-1}

Result:

The speed found from the graph is 2 ms^{-1}.

Q:2.8:

What will be the shape of speed-time graph of a body moving with variable speed?

Ans:

Constant speed and acceleration

A body moving with constant speed may or may not have acceleration.

- It will not have acceleration if the body is moving with constant speed in a straight line that will be the case of constant velocity.

That body can have a relation if its direction of motion changes continuously. For example of body moving with constant speed in a circular path has acceleration.

Q:2.9:

Which of the following can be obtained from speed-time graph of a body?

(1) initial speed

(2) final speed

(3) distance covered in time

(4) acceleration of motion

Ans:

Information from speed time graph

All the given quantities can be obtained from the speed-time graph.

Q:2.10:

How can vector quantities be represented graphically?

Ans:

Graphical representation

Graphically a vector can be represented by a line segment with and arrow head. In the figure below line AB with arrow head at B represents a vector ''v''. The length of line AB gives the magnitude of the vector **V** on a selected scale. While the direction of the line from A to B gives the direction of the vector **v**.

Q:2.11:

Quantities cannot be added and subtracted you like scalar quantities?

Ans:

Addition and subtraction

Scalar quantities can be described completely by magnitude only and can be added or subtracted by simple arithmetical rules vector quantities in addition to magnitude also need direction for their description so vectors cannot be added or subtracted by arithmetic rules dual to direction.

Q:2.12:

How are vector quantities important to us in our daily life?

Ans:

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Importance of vector quantities

In order to locate a place from a reference point we will have to describe the direction and direction of that place from the reference point. Description of distance along with direction will make up a vector quantity. hence, by using vector quantities we can describe the position (or location) of bodies.

Q:2.13:

Drive equations of motion for uniformly accelerated rectilinear motion.

Ans:

First equation of motion

The first equation of motion shows the relationship between final velocity, initial velocity, acceleration, and time taken by a body moving in a straight line with uniform acceleration.

Second equation of motion

The second equation of motion shows the relationship between distance covered, initial velocity, time taken, and acceleration of a body moving in a straight line with a uniform acceleration.

Third equation of motion

The third equation of motion shows the relationship between distance covered, initial velocity, time taken, and acceleration of a body moving in a straight line with uniform acceleration

Q:2.14:

Sketch a velocity-time graph for the motion of the body calculate Total distance covered by the body.

Ans:

Distance from velocity time Graph

Solution:

Given data:

Velocity time graph for the calculation of Total distance is given below.

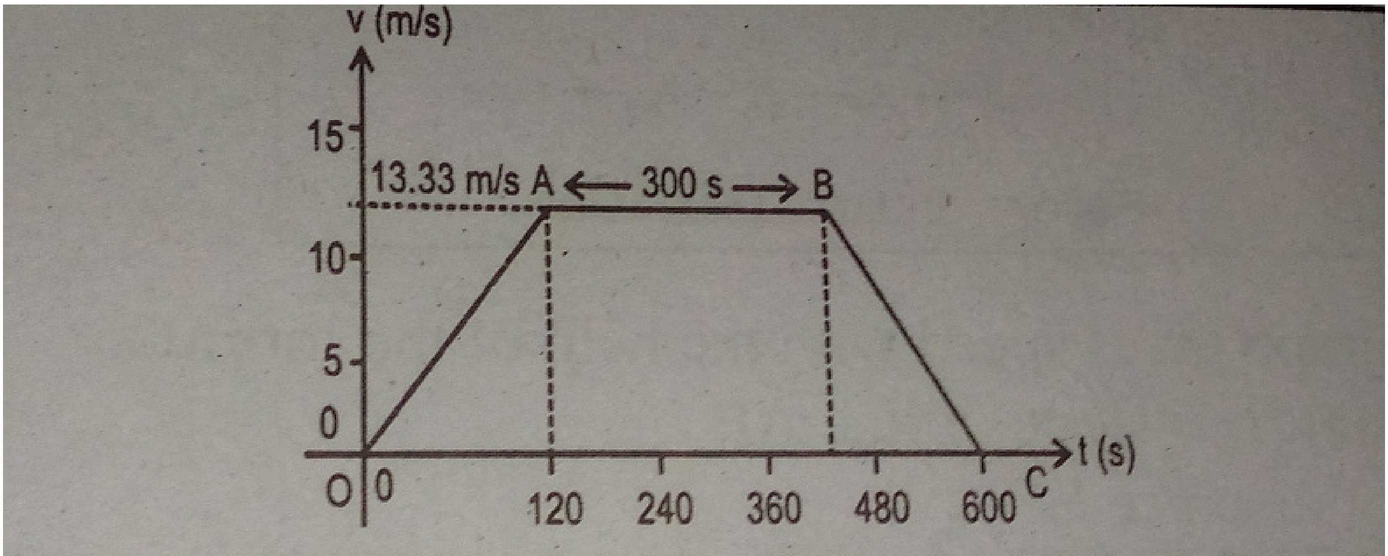

Figure: Speed Time Graph For Finding Total Distance Covered

To find:

Total distance covered = ?

Calculations:

By using the given value a graph shown in the figure.

$$\text{Velocity} = 48\ kmh^{-1}$$

$$\text{Velocity} = 48 \times 1000 / 1000$$

$$\text{Velocity} = 13.33ms^{-1}$$

$$\text{Time taken} = 2\ \text{minutes}$$

$$= 2(60)$$

$$= 120s$$

Again time taken = 5 minutes

= 5(60)

= 300s

Again time taken = 3 minutes

= 3 (60)

= 180s

Vinod area under speed - time graph represents the distance covered by the object

Total distance covered = area of trapezium OABC

S = 1/2(some of parallel sides)(perpendicular distance between parallel sides)

S = 1/2(600+300)(13.33)

S = 1/2(900)(13.33)

S = 6000 m

Result:

Total distance covered by the body has been found by finding total area under speed time graph that is equal to 6000 m.

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NUMERICAL PROBLEMS

Q:2.1:

A train moves with a uniform velocity of 36 kmh^{-1} for 10s. Find the distance traveled by it.

Solution:

Given data:

$$\text{Velocity of train} = V_{av} = 36\ kmh^{-1} = 36 \times 1000/3600 = 10\ ms^{-1}$$

$$\text{Time taken} = t = 10\ s$$

To Find:

Distance travelled by train = S = ?

Calculation:

As we know that

$$S = V_{av} \times t$$

By putting the values, we have

$$S = 10 \times 10$$

$$S = 100\ m$$

Result:

Hence, the distance travelled by train will be 100 m.

Q:2.2:

A train starts from rest. It moves through 1 km in 100 seconds with uniform acceleration. What will be its speed at the end of the 100s?

Solution:

Given data:

Initial velocity of train $= v_i = 0$ ms

Distance covered by train = S = 1km = 1000m

time taken by train = t = 100 s

To Find:

Speed of train after 100 s $= v_f = ?$

Calculation :

First we have to find the acceleration, as we know that

$$S = v_i t + 1/2 at^2$$

By putting the values, we have

$$1000 = 0 \times 100 + a \times (100)^2$$

$$1000 = 1/2 \times a \times 10000$$

$$1000 = a \times 5000$$

So,

$$a = 0.2 \text{ ms}^{-2}$$

Now from first equation of motion, we have

$$v_f = v_i + at$$

by putting the values, we have

$$v_f = 0 + 0.2 \times 100$$

$$v_f = 20 \text{ ms}^{-1}$$

Result :

Hence, the speed of train at the end of 100 s . will be 20 ms^{-1}.

Q:2.3:

A car has a velocity of 10ms^{-1}. It accelerates at 0.2 ms^{-2} for half minute. find the distance travel during this time and the final velocity of the car.

Solution:

Given data:

Velocity of the car = v_i = 10 ms

Acceleration of the car = a = 0.2 ms

Time taken by car = t 0.5min = 0.5 x 60 = 30

To find:

(a) distance travelled by car = S =?

(b) final velocity of the car = v_f = ?

Calculations:

As we know that

$$S = v_i t + 1/2\, at^2$$

by Putting the values, we have

$$S = 10 \times 30 + 1/2 \times 0.2 \times (30)^2$$

$$S = 300 + 0.1 \times 900$$

$$S = 300 + 90$$

$$S = 390 \text{ m}$$

(b) now, by using first equation of motion, we have

$$v_f = v_i + at$$

$$v_f = 10 + (0.2)(30) = 10 + 6$$

$$v_f = 16 ms^{-1}$$

Result:

Hence, the distance travelled and final velocity of the car will be 390 m and 16 ms^{-1} respectively.

Q:2.4:

At tennis Ball is hit vertically upward with a velocity of 30 ms^{-1}. It takes 3 s to reach the highest point. Calculate the maximum height reached by the ball.how long it will takes to return to ground?

Solution:

Given data:

Initial velocity of the tennis ball = $v_i = 30\ ms^{-1}$

Time to reach the maximum height = t = 3s

Gravitational acceleration = g = $-10 ms^{-2}$

Final velocity of the ball = $v_f = 0 ms^{-1}$

To find:

Maximum height released by the ball = h =?

Calculations:

From second equation of motion in vertical motion, we have

$$h = v_i t + 1/2\ gt^2$$

By putting the values, we have

$$h = 30 \times 3 + 1/2 \times (-10)(3)^2$$

$$h = 90 - 5 \times 9$$

$$h = 45\ m$$

As the ball moves with uniform acceleration in vertical motion, so time taken by the ball in both directions will be same.

Total time taken to return the ground = time taken upward + time taken downwards

Total time taken to return the ground = 3 s + 3 s

Total time taken to return the ground = 6s

Result:

Hence the maximum height released by the ball will be 45 m and the total time taken to return the ground will be 6 s.

Q:2.5:

Akaal moves with uniform velocity 40 ms for 6 s . It comes it comes to rest in the next 10 second with uniform deceleration. Find

(1) deceleration

(2) Total distance traveled by the car

Solution:

Given data:

For uniform motion:

Uniform velocity = v_{av} = 40 ms

Time for uniform velocity = t = 5s

When breaks applied

Initial velocity = v_i = 40 ms

Final velocity = v_f = 0

Time for being stop = t = 10s

To find:

(1) the acceleration = - a = ?

(2) distance traveled by the car = S =?

Calculations:

(1) we know

Acceleration = change in velocity/time

Acceleration = final velocity-initial velocity/time

So

$$a = v_f - v_i /t$$

Putting the values,

$$a = 0-40/10$$

$$a = -4 \text{ ms}^{-2}$$

(2) we can find Total distance covered in steps

Step 1 For uniform motion:

As we know that

$$S = v_{av} \times t$$

By putting the values, we have

$$S = 40 \times 5$$

$$S = 200 \text{ m}$$

Step to for the deceleration:

As we know that:

$$S = v_i t + 1/2 \, at^2$$

By putting the values, we have

$$S = (40)(10) + 1/2 (-4)(10)^2$$

$$S = 400 - 200$$

$$S = 200\text{m}$$

Total distance travelled during the journey = 200m + 200m

= 400m

Result:

Hence the deceleration in the car will be 4 ms^{-2} and total distance travelled by the car during the journey will be 400 m.

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Q:2.6:

A train starts from rest with an acceleration of 0.5 MS. Find its speed in kmh^{-1} when it has moved through 100 m.

Solution:

Given data:

$$\text{Acceleration of the train} = a = 0.5\ ms^{-2}$$

$$\text{Initial velocity of the train} = v_i = 0ms^{-1}$$

$$\text{Distance moved by train} = S = 100\ m$$

To find:

Final speed in $kmh^{-1} = v_f = ?$

Calculations:

From third equation of motion, we have

$$2aS = vf^2 - vi^2$$

By puting the values, we have

$$2 \times 0.5 \times 100 = vf^2 - (0)^2$$

$$100 = vf^2$$

By taking square root on both sides, we have

$$\sqrt{100} = vf^2$$

$$\text{So } Vf = 10\ ms^{-1}$$

Speed in kmh^{-1}:

$$Vf = 10 \times 3600 / 1000 = 36kmh^{-1}$$

Result:

Hence, the final speed of the train in kmh^{-1} will be 36 kmh^{-1}.

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Q:2.7:

A train starting from rest accelerates uniformly and attains a velocity 48 kmh^{-1} in 2 minutes. It travels at a speed for 5 minutes. Finally, it moves with uniform retardation and is stopped after 3 minutes. Find the total distance travelled by train.

Solution:

Given data:

$$\text{Velocity} = v = 48\ kmh^{-1}$$

$$\text{Velocity} = v = 48 \times 1000 / 3600 = 13.33ms^{-1}$$

$$\text{Time taken} = t = 2\ \text{minutes} = 2(60) = 300\ s$$

$$\text{Again time taken} = t = 3\ \text{minutes} = 3(60) = 180\ s$$

To find:

Total distance covered = S = ?

Calculation:

By using the given values we can plot a graph shown in the figure:

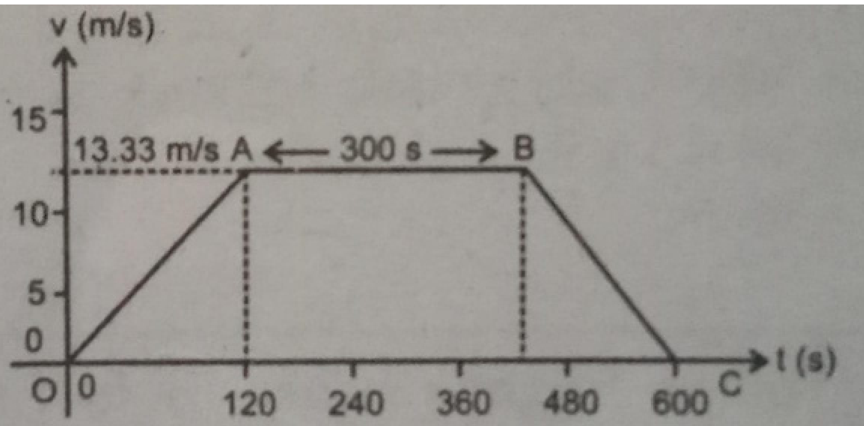

Figure: Speed Time Graph For Finding Total Distance Covered

We know that the area under the speed time graph represents the distance covered by the object.

... Total distance covered = area of trapezium OABC

S = 1/2 (sum of parallel sides) (perpendicular distance between parallel sides)

S = 1/2 (600+300)(13.33)

S = 6000 m

Result:

Hence, the Total distance covered by the train has been found by finding the total area under the graph line in the speed time graph and that will be equal to 6000 m.

Q:2.8:

A cricket ball is hit vertically upwards and returns to the ground 6s later. Calculate (1, the maximum height reached by the ball. (2) initial velocity of the ball.

Solution:

Given data:

Final velocity of the ball = $V_f = 0\ ms^{-1}$

Gravitational acceleration = g = $10\ ms^{-2}$

Time in which ball return to ground = t = 6 s

To find:

Maximum height reached by ball = h = ?

Initial velocity of the ball = v_i = ?

Calculation:

We know that for ball thrown vertically upward in air

Time taken by ball to reach maximum height = time taken by the ball to reach Ground from maximum height

... Time taken by the ball to reach maximum height = t = 3 s

From first equation of motion, we have

$$v_f = v_i + gt$$

By putting the values, we have

$$0 = v_i + (-10) \times 3$$

$$0 = v_i - 30$$

$$v_i = 30\ ms^{-1}$$

Now from second equation of motion, we have

$$S = v_i t + 1/2\ gt^2$$

, by putting the values, we have

$$S = 30 \times 3 + 1/2 \times (-10) \times (3)^2$$

$$S = 90 - 5 \times 9$$

$$S = 45\ m$$

Result:

Hence, the maximum height reached by the ball will be 45 m and the initial velocity of the ball will be 30 ms^{-1}.

Q:2.9:

When breaks are applied, the speed of a train decreases from 96 kmh^{-1} to 48 kmh^{-1} in 800 m. How much further will the train move before coming to rest? (assuming the retardation to be constant)

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Solution:

Given data:

Initial velocity of train = v_i = 96 kmh^{-1} = 96 x 1000 /3600 = 26.67 ms^{-1}

Final velocity of train = v_f = 48 kmh^{-1} = 48 x 1000 / 3600 = 13.33 ms^{-1}

Distance covered by train = 800 m

To find:

Distance covered by the train before coming to rest = S =?

Calculation:

First, we have to find

Retardation of the train = -a =?

From third equation of motion, we have

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

By putting the values, we have

$$2a\,(800) = (13.33)^2 - (26.67)^2$$

$$1600\ a = 177.69 - 711.29$$

$$1600\ a = -533.6$$

$$a = -533.6 / 1600$$

$$a = -0.33\ ms^{-2}$$

Again for over all motion till train stop

Initial velocity of train = v_i = 48 kmh^{-1} = 40/3 ms^{-1} = 13.33 ms^{-1}

Final velocity of train = v_f = 0 ms^{-1}

Retardation of train = a = -0.333 ms^{-2}

From third equation of motion, we have

$$2as = v_f^2 - v_i^2$$

Bhai putting the values, we have

$$2\,(-0.333)\,S = (0)^2 - (13.33)^2$$
$$-0.66\,6S = -\,(177.69)$$
$$S = 177.69/0.66$$
$$S = 266.8\text{m}$$

Result:

hence, the distance moved by the train before coming to rest will be 266.8 m.

Q:2.10:

In the above problem, find the time taken by the train to stop after the application of the brakes.

Solution:

Given data:

Initial velocity of train = v_i = 96 kmh^{-1} = 96 x 1000/3600 = 80/3 ms^{-1}

=26.67 ms^{-1}

Final velocity of train = v_f = 0 ms^{-1}

Acceleration = a = -0.333 ms^{-2}

To find:

Time taken by the train = t = ?

Calculation:

From first equation of motion,we have

$$v_f = v_i + at$$

By putting the values, we have

$$0 = 26.67 + (-0.333)\,t$$
$$-26.67 = -(0.333)t$$
$$t = 26.67/0.333$$

$$t = 80s$$

Result:

Hence, the time taken by the train to stop after the application of the brakes will be 80s.