Motion in a Straight Line

Numerical

WWW.PHYSICSPOWER.COM

Numerical Explained on the Topics

- Average velocity / Speed Numerical
- Kinematic equations
- Maximum height and Time of flight
- NEET old paper numerical
- **Text book backside problems
- Freely falling body

Numerical Explained on the Topics

- Average velocity / Speed Numerical
- Kinematic equations
- Maximum height and Time of flight
- NEET old paper numerical
- **Text book backside problems
- Freely falling body

Average Velocity / Speed Numerical

WWW.PHYSICSPOWER.COM

If s_1, s_2,s_3,… s_n are the distances travelled by a particle in the time intervals t_1, t_2, t_3,… t_n respectively then,

$$Average\ speed\ = \frac{Total\ distance\ travelled}{Total\ time}$$

$$Average\ Speed\ = \frac{s_1 + s_2 + s_3 + \ldots + s_n}{t_1 + t_2 + t_3 + \ldots + t_n}$$

If s_1 and s_2 are the distances travelled by a particle in the time intervals t_1 and t_2 respectively then,

$$Average\ Speed\ = \frac{s_1 + s_2}{t_1 + t_2}$$

If v_1 and v_2 are the velocities/speeds and t_1 and t_2 are the time intervals respectively then,

$$\text{Average Velocity} = \frac{v_1 t_1 + v_2 t_2}{t_1 + t_2}$$

If s_1 and s_2 are the distances travelled by a particle with velocities/speeds v_1 and v_2 respectively then,

$$Average\ Velocity/Speed\ vavg\ = \frac{s_1 + s_2}{t_1 + t_2}$$

$$v_{avg} = \frac{s_1 + s_2}{\frac{s_1}{v_1} + \frac{s_2}{v_2}}$$

If a cyclist takes one minute to complete half revolution on a circular path 120 m radius. What is the average velocity?

Solution: Given time t = 1 min = 60 sec

$$Average\ velocity = \frac{Total\ displacement}{Total\ time}$$

$$v_{avg} = \frac{2R}{t} = \frac{2 \times 120}{60} = 4\ m/s$$

If a cyclist takes two minutes to complete half revolution on a circular path 120 m radius. What is the average speed?

Solution:

Given time t = 2 min = 2 x 60 = 120 sec

$$Average\ speed = \frac{Total\ distance\ travelled}{Total\ time}$$

$$V_{avg} = \frac{\pi R}{t} = \frac{3.14 \times 120}{120}$$

$$= 3.14 \ m/s$$

A person travels along a straight road for the half time with a velocity v_1 and the next half time with a velocity v_2. Find the mean velocity of the man?

Solution:

$$t_1 = \frac{t}{2} \quad , \quad t_2 = \frac{t}{2}$$

$$v_{avg} = \frac{s_1 + s_2}{t_1 + t_2} = \frac{v_1 t_1 + v_2 t_2}{t_1 + t_2}$$

$$v_1 = \frac{s_1}{t_1}$$

$$\Rightarrow s_1 = v_1 t_1$$

$$\& \; s_2 = v_2 t_2$$

$$v_{avg} = \frac{v_1 t_1 + v_2 t_2}{t_1 + t_2}$$

$$= \frac{v_1\left(\frac{t}{2}\right) + v_2\left(\frac{t}{2}\right)}{\frac{t}{2} + \frac{t}{2}}$$

$$= \frac{\frac{t}{2}\left[v_1 + v_2\right]}{t} = \frac{v_1 + v_2}{2}$$

A person travels along a straight road for the half distance with a velocity v_1 and the next half distance with a velocity v_2. Find the mean velocity of the man?

Solution:

$$s_1 = \frac{s}{2} \quad \& \quad s_2 = \frac{s}{2}$$

$$v_{avg} = \frac{s_1 + s_2}{t_1 + t_2}$$

$$\Rightarrow v_{avg} = \frac{\frac{s}{2} + \frac{s}{2}}{\frac{s_1}{v_1} + \frac{s_2}{v_2}}$$

$$v_1 = \frac{s_1}{t_1}$$

$$\Rightarrow t_1 = \frac{s_1}{v_1}$$

$$\Rightarrow t_2 = \frac{s_2}{v_2}$$

$$\Rightarrow v_{avg} = \frac{\frac{s}{2} + \frac{s}{2}}{\frac{s}{2(v_1)} + \frac{s}{2(v_2)}} = \frac{s}{\frac{s}{2}\left[\frac{1}{v_1} + \frac{1}{v_2}\right]}$$

$$= \frac{2}{\frac{v_2 + v_1}{v_1 v_2}}$$

$$\therefore v_{avg} = \frac{2 v_1 v_2}{v_1 + v_2}$$

**A car travelled the first third of a distance S at a speed of 10 kmph, the second third at a speed of 20 kmph and the last third at a speed of 60 kmph. Calculate the mean speed of the vehicle over the entire distance S.

Solution:

distance travelled, $s_1 = \frac{s}{3}$ velocity, $v_1 = 10$ kmph

distance, $s_2 = \frac{s}{3}$ velocity, $v_2 = 20$ kmph

distance, $s_3 = \frac{s}{3}$ velocity, $v_3 = 60$ kmph

$$\text{Average velocity} = \frac{\text{total distance}}{\text{total time}}$$

$$V_{avg} = \frac{s_1 + s_2 + s_3}{t_1 + t_2 + t_3}$$

$$= \frac{s_1 + s_2 + s_3}{\frac{s_1}{v_1} + \frac{s_2}{v_2} + \frac{s_3}{v_3}}$$

$$= \frac{\frac{s}{3} + \frac{s}{3} + \frac{s}{3}}{\frac{s}{3(10)} + \frac{s}{3(20)} + \frac{s}{3(60)}}$$

$$= \frac{s}{\frac{s}{3}\left[\frac{1}{10} + \frac{1}{20} + \frac{1}{60}\right]} = \frac{3}{\frac{6+3+1}{60}}$$

$$= \frac{3 \times 60}{10}$$

$$= 18 \text{ km/hr}$$

**A man walks on a straight road from his home to a market 2.5 km away with a speed of 5 km/h. Finding the market closed, he instantly turns and walks back home with a speed of 7.5 km/h. What is the (a) magnitude of average velocity and (b) average speed of the man over the time interval o to 50 minutes

Solution:

$$t_1 = \frac{\text{distance}}{\text{speed}} = \frac{2.5}{5} = \frac{1}{2}\ \text{h}$$

$$t_2 = \frac{2.5}{7.5} = \frac{1}{3}\text{h}$$

$$\therefore \text{ Total time taken } = t_1 + t_2 = \frac{1}{2} + \frac{1}{3} = \frac{5}{6}\text{h} = 50 \text{ min.}$$

$$\text{Total distance travelled} = 2.5 + 2.5 = 5 \text{ km}$$

$$\text{a) Average velocity} = \frac{\text{displacement}}{\text{time}} = 0$$

$$\text{b) Average speed} = \frac{\text{distance}}{\text{time}} = \frac{5}{5/6} = 6 \text{ km/h}$$

A car covers the first half of the distance between two places at 40 km/h and other half at 60 km/h. Find the average speed of the car.

Solution:

$$v_{avg} = \frac{2v_1v_2}{v_1 + v_2} = \frac{2 \times 40 \times 60}{40 + 60}$$

$$= 48 \text{ km/h}$$

**A motorist drives north for 30 min at 85 km/h and then stops for 15 min. He continues travelling north and cover 130 km in 2 hours. What is his total displacement and average velocity?

Solution: $S = S_1 + S_2 + S_3$

In first part :

Velocity, $v_1 = 85$ kmph ; Time, $t_1 = 30$ min

Distance travelled, $s_1 = v_1 t_1 = 85 \times \frac{30}{60} = 42.5$ km

In second part :

Distance travelled, $s_2 = 0$; Time, $t_2 = 15.0$ min.

A motorist drives north for 30 min at 85 km/h and then stops for 15 min. He continues travelling north and cover 130 km in 2 hours. What is his total displacement and average velocity?

In third part :

Distance travelled, $s_3 = 130$ km ; Time, $t_3 = 120$ min $= 2$ hours

Total distance of the motorist,

$$= 42.5 + 0 + 130 = 172.5 \text{ km}$$

Total time travelled,

$$t = t_1 + t_2 + t_3 = 30 + 15 + 120 = 165 \text{ minutes}$$

$$= 2 \text{ hrs } 45 \text{ minutes}$$

$$= 2\frac{3}{4} \text{ hrs.} = \frac{11}{4} \text{ hrs.}$$

$$\therefore \quad \text{Average velocity, } v_{avg} = \frac{\text{total displacement}}{\text{total time}}$$

$$= \frac{172.5}{(11/4)}$$

$$= 62.7 \text{ kmph}$$

Numerical on

$$v = u + at$$

$$v^2 - u^2 = 2aS$$

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

$$S_{n^{th}} = u + \frac{a}{2}(2n - 1)$$

The displacement S of a particle at the instant when its velocity v is given by v = √(8S+16). Find its acceleration and initial velocity.

Solution:

Acceleration $a = ?$

Initial velocity $u = ?$

$$v = \sqrt{8s+16}$$

$$v^2 = 8s + 16$$

$$\Rightarrow v^2 = 8s + 4^2$$

$$\Rightarrow v^2 = 2(4)s + 4^2$$

$$\Rightarrow \quad v^2 - 4^2 = 2(4)5$$

$$v^2 - u^2 = 2as$$

$$\therefore \quad u = 4 \text{ m/s}$$

$$\& \quad a = 4 \text{ m/s}^2$$

The displacement s of a particle at the instant when its velocity v is given by v = √(4S+4). Displacement of the particle at time t = 0 is S = 0. Find the displacement of particle at time t = 2 sec.

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

Solution:

Given time $t = 2$ sec

$$v = \sqrt{4S+4} \Rightarrow v^2 = 4S + 2^2$$

$$\Rightarrow v^2 - 2^2 = 2(2)S$$

$\Rightarrow v^2 - 2^2 = 2(2)s$

$v^2 - u^2 = 2as$

$\therefore u = 2\ m/s$

& $a = 2\ m/s^2$

$\therefore s = ut + \frac{1}{2}at^2$

$= (2)(2) + \frac{1}{2}(2)(2)^2$

$= 4 + 4$

$= \underline{\underline{8\ m}}$

**A bullet moving with a speed of 150 m/s strikes a tree and penetrates 3.5 cm before stopping. What is the magnitude of its retardation in the tree and the time taken for it to stop after striking the tree?

Solution:

Velocity of bullet, $u = 150$ m/s

Final velocity, $v = 0$

Distance travelled, $s = 3.5$ cm $= 3.5 \times 10^{-2}$ m

Retardation a = ? **Time taken to stop t = ?**

$$v^2 - u^2 = 2aS$$

Velocity of bullet, u = 150 m/s

Final velocity, v = 0

Distance travelled, s = 3.5 cm = 3.5×10^{-2} m

$$a = \frac{v^2 - u^2}{2s} = \frac{0^2 - 150^2}{2 \times 3.50 \times 10^{-2}} = \frac{22500}{7 \times 10^{-2}}$$

$$= -3.214 \times 10^5 \text{ m / sec}^2$$

$$v = u + at$$

Time taken to stop, $t = \frac{v - u}{a} = \frac{-150}{-3.214 \times 10^5} = 4.67 \times 10^{-4}$ sec.

NEET
Old Paper Bits

WWW.PHYSICSPOWER.COM

A boy standing at the top of a tower of 20 m height drops a stone. Assuming, g = 10 m/s^2, find the velocity with which it hits the ground?

NEET - 2011

Solution: Given, $g = 10\ \text{m/s}^2$

$h = 20\ \text{m}$ **u = 0**

$$v^2 - u^2 = 2aS$$

$$v = \sqrt{2gh}$$

$$v = \sqrt{2gh}$$

$$= \sqrt{2 \times 10 \times 20}$$

$$= \sqrt{400}$$

$$= 20 \text{ m/s}$$

A particle moves in a straight line with a constant acceleration. It changes its velocity from 10 m/s to 20 m/s while passing through a distance 135 m in t sec. What is the value of t? NEET - 2008

Solution:

$$v - u = at$$

$$v^2 - u^2 = 2as$$

$$(20)^2 - (10)^2 = 2 \times a \times 135$$

$$\Rightarrow \frac{300}{270} = a \quad \Rightarrow \quad a = \frac{10}{9} \text{ m/s}$$

$$v - u = at$$

$$20 - 10 = \frac{10}{9} \times t$$

$$\Rightarrow \quad t = 9 \text{ s}$$

Two bodies of A and B of masses 1 kg and 3 kg are dropped from heights of 16 m and 25 m respectively. The ratio of the time taken by them to reach the ground is.

NEET - 2006

Solution:

Given, $h_1 = 16$ m, $h_2 = 25$ m

$$h = ut + \frac{1}{2} gt^2 \qquad u = 0 \text{ (initial velocity)}$$

$$h = 0 + \frac{1}{2} gt^2 \qquad \therefore \qquad \frac{h_1}{h_2} = \left(\frac{t_1}{t_2}\right)^2$$

$$\frac{h_1}{h_2} = \left(\frac{t_1}{t_2}\right)^2 \qquad \therefore \qquad \frac{t_1}{t_2} = \sqrt{\frac{h_1}{h_2}}$$

$$= \sqrt{\frac{16}{25}}$$

$$= \frac{4}{5}$$

$$S_{n^{th}} = u + \frac{a}{2}(2n - 1)$$

The distance travelled by a particle starting from rest and moving with an acceleration 4/3 m/s² in the third second is

NEET - 2008

$$S_{n^{th}} = u + \frac{a}{2}(2n - 1)$$

Solution:

$$\text{Here, } u = 0, \quad a = \frac{4}{3}$$

$$\therefore \quad s_3 = 0 + \frac{1}{2} \times \frac{4}{3} \times (6 - 1)$$

$$= \frac{10}{3} \text{ m}$$

What will be the ratio of the distance moved by a freely falling body from rest in 4^{th} and 5^{th} second of journey?

AIPMT = NEET - 1989

Solution:

$$s_n = u + \frac{1}{2}a(2n-1)$$

Here, $u = 0$, acceleration due to gravity $a = 9.8\ \text{m/s}^2$

For 4^{th} s, $s_4 = \frac{1}{2} \times 9.8 (2 \times 4 - 1)$

and for 5^{th} s, $s_5 = \frac{1}{2} \times 9.8 (2 \times 5 - 1)$

$$\frac{S_4}{S_5} = \frac{\frac{1}{2} \times 9.8 (2 \times 4 - 1)}{\frac{1}{2} \times 9.8 (2 \times 5 - 1)}$$

$$= \frac{7}{9}$$

A ball is dropped from a high rise platform at t = 0 starting from rest. After 6 sec, another ball is thrown downwards from the same platform with a speed v. The two balls meet at t = 18 sec. What is the value of v?

NEET - 2010

Solution: For first ball, $u = 0$

$$s_1 = \frac{1}{2} g t_1^2$$

$$= \frac{1}{2} \times g\,(18)^2$$

For second ball, initial velocity $= v$

$$s_2 = vt_2 + \frac{1}{2}gt_2^2$$

$$t_2 = 18 - 6 = 12 \text{ s}$$

$$s_2 = v \times 12 + \frac{1}{2} g (12)^2$$

$$s_1 = s_2$$

$$\frac{1}{2}g(18)^2 = 12v + \frac{1}{2}g(12)^2$$

$$12v = \frac{g}{2}\left(18^2 - 12^2\right)$$

$$12v = 5(324 - 144)$$

$$12v = 5 \times 180 \quad \Rightarrow \quad v = 74 \text{ ms}^{-1}$$

Maximum Height & Time of Flight

If a body thrown with a velocity 20 m/s vertically upward, find the maximum height travelled by the body.

Solution:

Given initial velocity u = 20 m/s

$$H_{\max} = \frac{u^2}{2g}$$

$$H_{\max} = \frac{20^2}{2 \times 10}$$

$$= \frac{400}{2 \times 10} \qquad = 20\ m$$

If a particle thrown vertically upward with a velocity 10 m/s, what is the time of flight?

Solution:

$$T = \frac{2u}{g}$$

Given, initial velocity u = 10 m/s

$$T = \frac{2(10)}{10}$$

$$= 2 \text{ sec}$$

If a body thrown vertically upward with velocity u, what is the velocity of the particle at half of the maximum height?

Solution:

Given initial velocity = u Acceleration a = - g

$$v^2 - u^2 = 2aS \quad \Rightarrow \quad v^2 = u^2 + 2aS$$

$$v^2 = u^2 + 2(-g)\frac{1}{2}\frac{u^2}{2g}$$

$$v^2 = u^2 - \frac{u^2}{2}$$

$$\Rightarrow \qquad v^2 = \frac{u^2}{2}$$

$$\Rightarrow \quad v = \frac{u}{\sqrt{2}}$$

THANK YOU

WWW.PHYSICSPOWER.COM