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Physics DPP

DPP-2 Equation of kinematics

By PRATEEK JAIN SIR

Q) A dog walking to the right with a velocity of 1.5 m/s sees a cat and speeds up with a constant rightward acceleration of magnitude 12 m/s^2 . What is the velocity of the dog after speeding up for 3.0 m ?

(a) 4 m/s

(b) 8.6 m/s

(c) 12.6 m/s

(d) 16.6 m/s

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Ans. b

$$u = 1.5 \text{ m/s}$$

$$a = 12 \text{ m/s}^2$$

$$s = 3 \text{ m}$$

$$v = ?$$

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

$$v^2 - (1.5)^2 = 2 \cdot (12) \cdot (3)$$

$$v^2 = (1.5)^2 + 72$$

$$v^2 = 2.25 + 72$$

$$v^2 = 74.25$$

$$v = 8.61 \text{ m/s}$$

Q) A particle moving in straight line experience constant acceleration for 20 second after starting from rest. If it travel a distance S_1 in the first 10 seconds and distance S_2 in the next 10 seconds then find the relation between S_1 and S_2 :

(a) $S_1 = 3S_2$

(b) $S_1 = \frac{3}{2} S_2$

(c) $S_2 = 3S_1$

(d) $S_2 = \frac{3}{2} S_1$

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Ans. c

Let acceleration = a

$$u = 0$$

for first 10 seconds

$$S_1 = ut + \frac{1}{2}at^2$$

$$S_1 = 0 + \frac{1}{2}a(10)^2 = 5a$$

$$\boxed{S_1 = (50a) \text{ m}}$$

Velocity after $t = 10$ sec

$$V_1 = u + at = 0 + a(10)$$

$$\boxed{V_1 = (10a) \text{ m/s}}$$

Distance covered in next 10 seconds!

$$S_2 = ut + \frac{1}{2}at^2$$

$$\text{Now } u = V_1$$

$$S_2 = (10a)(10) + \frac{1}{2}a(10)^2$$

$$S_2 = 100a + 50a$$

$$\boxed{S_2 = (150a) \text{ m}}$$

$$\frac{S_1}{S_2} = \frac{50a}{150a}$$

$$\frac{S_1}{S_2} = \frac{1}{3}$$

$$\boxed{S_2 = 3S_1}$$

Q) A car travels a distance 100m with a constant acceleration and average velocity of 20 m/s. The final velocity acquired by the car is 25 m/s. Find the initial velocity.

(a) 15 m/s

(b) 30 m/s

(c) 10 m/s

(d) zero

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Ans. a

$$u = ?$$

$$v = 25 \text{ m/s}$$

for constant acceleration

$$v_{\text{avg}} = \frac{v + u}{2}$$

$$20 = \frac{25 + u}{2}$$

$$u = 40 - 25$$

$$u = 15 \text{ m/s}$$

Q) A body starting from rest is travelling on a straight road with constant non-zero acceleration. If the speeds after covering distances S_1 and S_2 be V_1 and V_2 respectively. If $\frac{V_2}{V_1} = 2$, then $\frac{S_2}{S_1} = N$. Find N?

(a) 1

(b) 2

(c) 1/2

(d) 3

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Ans. d

Let acceleration = a

& given; $\frac{v_2}{v_1} = 2$

$$u = 0$$

$$\text{then } v^2 - u^2 = 2as$$

$$\text{for } v = v_1$$

$$\text{given; } s = s_1$$

$$\therefore v_1^2 - (0)^2 = 2as_1$$

$$v_1^2 = 2as_1 \quad \text{--- (1)}$$

$$\text{Now } u = v_1$$

$$\& s = s_2 \quad \& v = v_2$$

$$\text{so; } v^2 - u^2 = 2as$$

$$\Rightarrow v_2^2 - v_1^2 = 2as_2 \quad \text{--- (2)}$$

Put value of v_1^2 in eqⁿ (2)

$$v_2^2 - 2as_1 = 2as_2$$

$$v_2^2 = 2a(s_1 + s_2) \quad \text{--- (3)}$$

$$\frac{(3)}{(1)} \Rightarrow \left(\frac{v_2}{v_1}\right)^2 = \frac{2a(s_1 + s_2)}{2as_1}$$

$$(2)^2 = \frac{s_1 + s_2}{s_1} \Rightarrow 4 = \frac{s_1 + s_2}{s_1}$$

$$4s_1 = s_1 + s_2 \Rightarrow 3s_1 = s_2$$

$$\Rightarrow \left[\frac{s_2}{s_1} = 3\right] \Rightarrow \boxed{N=3}$$

Q) A bike moving along a straight road covers 35 m in the 4th second and 40 m in the 5th second. What is its initial velocity: (if the acceleration is assumed to be uniform)?

(a) 5 m/s

(b) 10 m/s

(c) 17.5 m/s

(d) 15.5 m/s

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Ans. c

distance covered in n^{th} sec.

$$d_n = S_n - S_{n-1}$$

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

when $t = n$ sec.

Now let acceleration = ' a '

\therefore in n^{th} sec.

$$d_4 = S_4 - S_3$$

$$d_4 = \left[u \cdot 4 + \frac{1}{2}a(4)^2 \right] - \left[u \cdot 3 + \frac{1}{2}a(3)^2 \right]$$

$$d_4 = u + \frac{7}{2}a = 35 \text{ m} \quad \text{--- (1)}$$

in 5^{th} sec.

$$d_5 = S_5 - S_4$$
$$= \left[u \cdot 5 + \frac{1}{2}a(5)^2 \right] - \left[u \cdot 4 + \frac{1}{2}a(4)^2 \right]$$

$$= u + \frac{1}{2}a(9)$$

$$d_5 = u + \frac{9}{2}a = 40 \text{ m} \quad \text{--- (2)}$$

from eqⁿ (1) & (2)

$$a = 5 \text{ m/s}^2$$

$$\text{and } \boxed{u = 17.5 \text{ m/s}}$$

Q) A truck moving on a straight road with constant acceleration covers the distance between two points 180 m apart in 6 seconds. Its speed as it passes the second point is 45 m/s. Find its speed when it was at the first point:

(a) 5 m/s

(b) 10 m/s

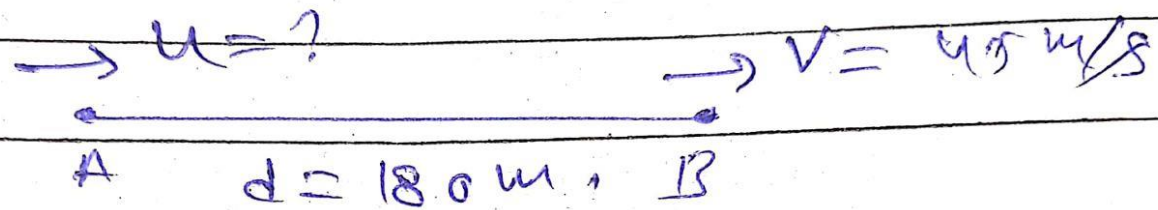
(c) 15 m/s

(d) 20 m/s

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Ans. c



Let acceleration = 'a'

$t = 6 \text{ sec}$ (given)

$$v = u + at$$

$$45 = u + 6a \quad \text{--- (1)}$$

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

$$180 = 6u + \frac{1}{2} a (6)^2$$

$$180 = 6u + 18a \quad \text{--- (2)}$$

eqⁿ (1) \times (2)

$$(u + 6a) \times 3 \quad \text{--- (1)}$$

$$180 = 6u + 18a \quad \text{--- (2)}$$

$$\text{eqⁿ (2)} - (\text{eqⁿ (1)} \times 3) = 45 = 3u$$

$$u = 15 \text{ m/s}$$

Q) A car accelerates uniformly from 18 km/h to 36 km/h in 5 seconds. Calculate the acceleration of truck:

(a) 1 m/s^2

(b) 1 km/h^2

(c) 3 m/s^2

(d) 2.5 m/s^2

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Ans. a

$$u = 18 \text{ km/h} = 18 \times \frac{5}{18} = 5 \text{ m/s}$$

$$v = 36 \text{ km/h} = 10 \text{ m/s}$$

$$a = \frac{v - u}{t} \quad (\because v = u + at)$$

$$t = 5 \text{ sec}$$

$$a = \frac{10 - 5}{5}$$

$$a = 1 \text{ m/s}^2$$

Q) A body starts from rest and travels with a uniform acceleration of 3 m/s^2 and then decelerates at a uniform rate of 2 m/s^2 again to come to rest. Total time of travel is 10 sec. find the maximum velocity during the journey:

(a) 10 m/s

(b) 12 m/s

(c) 15 m/s

(d) 27 m/s

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Ans. b

$$u = 0$$

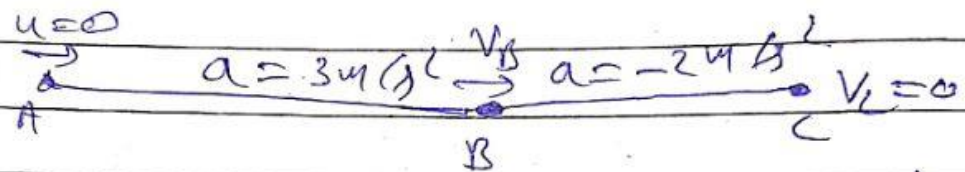
$$a = 3 \text{ m/s}^2$$

$$\text{for } t = t_1$$

$$\text{and } a = 2 \text{ m/s}^2$$

$$\text{for } t = t_1 \text{ to } t = t_2$$

$$t_1 + t_2 = 10 \text{ sec}$$



for $A \rightarrow B$ [max speed will

$$u = 0$$

$$a = 3 \text{ m/s}^2$$

$$t = t_1$$

$\therefore v$ at B

$$v_B = u + at$$

$$= 0 + 3 \times t_1$$

$$v_B = 3t_1$$

in next $t_2 = 10 - t_1$ time

it's final velocity $= 0$

$$v = u + at$$

$$v_c = v_B + (-2)(10 - t_1)$$

$$0 = 3t_1 - 20 + 2t_1$$

$$20 = 5t_1 \Rightarrow t_1 = 4 \text{ sec}$$

$$v_B = 3 \times 4 = 12 \text{ m/s}$$

$$\therefore v_B = \text{max speed} = 12 \text{ m/s}$$

Q) Consider a train which can accelerate with an acceleration of 20 cm/s^2 and slow down with deceleration of 100 cm/s^2 . Find the minimum time for the train to travel between the stations 2.7km apart:

(a) 90 s

(b) 180 s

(c) 160 s

(d) 240 s

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Ans. b

$$\begin{aligned} \text{acceleration} &= 20 \text{ cm/s}^2 \\ &= 20 \times 10^{-2} \text{ m/s}^2 \\ &= 0.2 \text{ m/s}^2 \end{aligned}$$

$$\begin{aligned} \text{deceleration} &= 100 \text{ cm/s}^2 \\ &= 1 \text{ m/s}^2 \end{aligned}$$

let it accelerates for time t_1
and decelerates for time t_2

then; at $t = t_1$

$$v = u + at$$

$$v_f = 0 + (0.2)t_1$$

$$\boxed{v_f = 0.2t_1} \quad \text{--- (1)}$$

deceleration $v = u + at$

$$v = 0; u = v_1$$

$$0 = 0.2t_1 - 1(t_2)$$

$$0.2t_1 = t_2$$

$$t_1 = \frac{t_2}{0.2} = 5t_2$$

$$t_1 = 5t_2 \text{ or } \frac{t_1}{t_2} = \frac{5}{1}$$

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

$$\text{total time} = t_1 + t_2 = t$$

$$t_1 = \frac{5}{6}t \quad \& \quad t_2 = \frac{1}{6}t$$

it accelerates for $t = t_1 = \frac{5}{6}t$
decelerates for $t = t_2 = \frac{1}{6}t$

$$s_1 = 0 + \frac{1}{2}(0.2)t_1^2$$

$$s_1 = (0.1)\left(\frac{5t}{6}\right)^2 = 0.1 \times 25 \left(\frac{t}{6}\right)^2$$

$$s_1 = 2.5\left(\frac{t}{6}\right)^2 \quad \text{--- (1)}$$

$$\text{Now } s_2 = v_1 t_2 + \frac{1}{2}a_c t_2^2$$

$$s_2 = (0.2t_1)t_2 + \frac{1}{2}(-1)t_2^2$$

$$s_2 = (0.2)\left(\frac{5t}{6}\right)\left(\frac{t}{6}\right) - \frac{1}{2}(1)\left(\frac{t}{6}\right)^2$$

$$s_2 = \left(\frac{5t}{6}\right)^2 - \frac{1}{2}\left(\frac{t}{6}\right)^2$$

$$s_2 = \frac{1}{2}\left(\frac{t}{6}\right)^2 \quad \text{--- (2)}$$

$$\text{(1) + (2)} \quad s_1 + s_2 = 2.5\left(\frac{t}{6}\right)^2 + 0.5\left(\frac{t}{6}\right)^2$$

$$2700 = 3\left(\frac{t}{6}\right)^2$$

$$900 = \left(\frac{t}{6}\right)^2$$

$$\frac{t}{6} = 30$$

$$\boxed{t = 180 \text{ sec}}$$

Q) An automobile travelling with the speed of 72 km/h, can be stopped within a distance of 20m, by applying brakes. Determine the distance travelled in the first second:

(a) 10 m

(b) 25 m

(c) 15 m

(d) 35 m

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Ans. c

$$u = 72 \text{ km/h} = 72 \times \frac{5}{18}$$

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

$$d = 20 \text{ m}$$

$$v = 0$$

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

$$0 - (20)^2 = 2a(20)$$

$$\boxed{a = -10 \text{ m/s}^2}$$

∴ distance traveled in
2nd sec is

$$s_1 = ut + \frac{1}{2}at^2$$

$$s_1 = 20(1) - \frac{1}{2}(10)(1)^2$$

$$s_1 = 20 - \frac{1}{2}(10)$$

$$s_1 = 20 - 5$$

$$\boxed{s_1 = 15 \text{ m}}$$

Q) A body starting from rest is moving with a uniform acceleration of 8 m/s^2 . Then the distance travelled by it in 5th second will be:

(a) 40 m

(b) 36 m

(c) 100 m

(d) zero

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Ans. b

distance traveled in 5th sec.

$$d = S_5 - S_4$$

$$= \left[u(5) + \frac{1}{2} (a)(5)^2 \right] - \left[u(4) + \frac{1}{2} a(4)^2 \right]$$

$$d = 4 + \frac{9}{2} a$$

$$d = 0 + \frac{9}{2} (8)$$

$$\boxed{d = 36 \text{ m}}$$

Q) A motor cycle moving with speed of 15m/s is subject to an acceleration of 0.2 m/s^2 in the direction of motion. Calculate the speed of motorcycle after 10 second,

(a) 7 m/s

(b) 10 m/s

(c) 13 m/s

(d) 17 m/s

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Ans. d

$$u = 15 \text{ m/s}$$

$$a = 0.2 \text{ m/s}^2$$

$$t = 10 \text{ sec}$$

$$v = u + at$$

$$v = 15 + (0.2)(10)$$

$$v = 15 + 2$$

$$v = 17 \text{ m/s}$$

Chalo Niklo