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Physics worksheet solutions – Straight line motion under constant acceleration

Ignore air resistance in the following questions

Q1 A car starts from rest at 50 m to the west of a road sign. It travels to the east reaching 20 ms^{-1} after 15 s. Determine the position relative to the road sign at $t = 15$ s.

Displacement $s = \frac{1}{2}(u+v)t = \frac{1}{2}(0+20)15 = {}^{+}150$ m

Position $r + s = {}^{-}50 + {}^{+}150 = {}^{+}100$, i.e. 100 m east of road sign

Q2 A car starts from rest at 50 m west of a road sign. It has a velocity of 20 ms^{-1} east when it is 50 m east of the road sign. Determine the acceleration of the car.

$s = {}^{+}50 - {}^{-}50 = {}^{+}100$ m

$v^2 = u^2 + 2as$, $20^2 = 0^2 + 2a({}^{+}100)$, $a = 2\ ms^{-2}$

Q3 During a 10-second period a car has an average velocity of 25 ms^{-1} and an acceleration of 2 ms^{-2}. Determine the initial and final velocities of the car in the 10-second period.

$v_{av} = \frac{1}{2}(u+v)$, $25 = \frac{1}{2}(u+v)$, $\therefore u + v = 50$ .....(1)

$v = u + at$, $v - u = 2 \times 10$, $v - u = 20$ .....(2)

Solve (1) and (2), $u = 15\ ms^{-1}$, $v = 35\ ms^{-1}$

Q4 A racing car increases its speed to 30 ms^{-1} after a displacement of 80 m in 4 seconds. Calculate its acceleration and the change in its velocity during the 4-s period.

$s = vt - \frac{1}{2}at^2$, $80 = 30 \times 4 - \frac{1}{2} \times a \times 4^2$, $a = 5\ ms^{-2}$

$\Delta v = v - u = at = 5 \times 4 = 20\ ms^{-1}$

Q5 A stone is projected vertically upwards. It takes 3.2 s for it to return to the point of projection. Find the total distance covered.

It takes $\frac{1}{2} \times 3.2 = 1.6$ s to reach the highest point.

$s = vt - \frac{1}{2}at^2 = 0 - \frac{1}{2} \times {}^{-}9.8 \times 1.6^2 = {}^{+}12.544$ m

Total distance $= 2 \times 12.544 \approx 25$ m

Q6 A stone is projected vertically upwards from a height of 5 m above the ground. It takes 3.2 s for it to hit the ground. Find the total distance covered.

$s = {}^{-}5$ after 3.2 s

$s = ut + \frac{1}{2}at^2$, ${}^{-}5 = 3.2u + \frac{1}{2} \times {}^{-}9.8 \times 3.2^2$, $u = {}^{+}14.1175\ ms^{-1}$

When it reaches the highest point: $v^2 = u^2 + 2as$

$0^2 = 14.1175^2 + 2 \times {}^{-}9.8 \times s$, $s \approx {}^{+}10.17$ m

Total distance $\approx 10.17 + 10.17 + 5 \approx 25$ m

Q7 A stone is projected vertically upwards from a height of 5 m above the ground. It takes 3.2 s for it to hit the ground. Calculate the average speed and average velocity of the stone.

Average speed $= \frac{dist}{time} \approx \frac{25}{3.2} \approx 7.9\ ms^{-1}$

Average velocity $= \frac{s}{\Delta t} = \frac{{}^{-}5}{3.2} \approx {}^{-}1.6\ ms^{-1}$

Q8 A marble is dropped from a height of 15 m above the ground, and at the same time a stone is projected vertically upwards from a height of 5 m above the ground. They pass each other after 1.0 s. Find the speed of projection of the stone.

Initially the marble is 10 m above the stone.

In 1.0 s the marble has fallen $\frac{1}{2}at^2 = \frac{1}{2} \times 9.8 \times 1.0^2 = 4.9$ m

$\therefore$ the stone has risen $10 - 4.9 = 5.1$ m, $s = ut + \frac{1}{2}at^2$,

${}^{+}5.1 = u \times 1.0 + \frac{1}{2} \times {}^{-}9.8 \times 1.0^2$, $u = {}^{+}10$, speed = 10 ms^{-1}

Q9 A car travels in a straight road under constant acceleration. In the 5th second the car travels 15 m, and in the 6th second it travels 12 m. Find the speed of the car at $t = 0$.

5th second is from $t = 4$ to $t = 5$ s

Let d metres be the total distance travelled at $t = 4$ s

$\therefore d + 15$ at $t = 5$ and $d + 27$ at $t = 6$ s

Let u ms^{-1} be the velocity at $t = 0$, and a ms^{-2} the constant acc.

$s = ut + \frac{1}{2}at^2$ $\therefore$ $d = 4u + \frac{1}{2}a \times 4^2$, $d + 15 = 5u + \frac{1}{2}a \times 5^2$ and

$d + 27 = 6u + \frac{1}{2}a \times 6^2$

Solve the 3 equations simultaneously, $u = {}^{+}28.5$,

$\therefore$ speed $= 28.5\ ms^{-1}$

Q10 A car travels in a straight road under constant acceleration. In the first 20 s the distance covered is 125 m and the displacement is 100 m east. Find the acceleration and initial velocity of the car.

Let u ms^{-1} be the velocity at $t = 0$, and a ms^{-2} the constant acc.

$s = ut + \frac{1}{2}at^2$ $\therefore$ ${}^{+}100 = 20u + \frac{1}{2}a \times 20^2$ $\therefore$ $5 = u + 10a$ ..... (1)

When the car is furthest to the east, $v = 0$, $v^2 = u^2 + 2as$,

$0 = u^2 + 2as$, $s = -\frac{u^2}{2a}$.

$\therefore 2\left(-\frac{u^2}{2a}\right) - 100 = 125$ $\therefore$ $-\frac{u^2}{225} = a$ .....(2)

Solve the 2 equations simultaneously, $u = {}^{+}15\ ms^{-1}$, $a = {}^{-}1\ ms^{-2}$, i.e. $u = 15\ ms^{-1}$ east, and $a = 1\ ms^{-2}$ west.