Answer on Question #45691 – Physics - Mechanics | Kinematics | Dynamics

An object moves with constant acceleration 4.15 m/s2 and over a time interval reaches a final velocity of 10.4 m/s.
(a) If its original velocity is 5.20 m/s, what is its displacement during the time interval?
m

(b) What is the distance it travels during this interval?

(c) If its initial velocity is
−5.20 m/s,
what is its displacement during this interval?

(d) What is the total distance it travels during the interval in part (c)?

Solution:

(a)

$\mathrm{V_1} = 5.2\frac{\mathrm{m}}{\mathrm{s}} - \text{initial velocity of the object;}$
$\mathrm{V_2} = 10.4\frac{\mathrm{m}}{\mathrm{s}} - \text{final velocity of the object;}$
$\mathrm{a} = 4.15\frac{\mathrm{m}}{\mathrm{s^2}} - \text{acceleration;}$
$\mathrm{T} - \text{time of travelling;}$
$\mathrm{d} - \text{displacement during time T;}$
Rate equation for the object:

$$\mathrm{V_2} = \mathrm{V_1} + \mathrm{aT}$$
$$\mathrm{T} = \frac{\mathrm{V_2} - \mathrm{V_1}}{\mathrm{a}} \quad (1)$$

Equation of motion for the object:

$$\mathrm{d} = \mathrm{V_1 T} + \frac{\mathrm{aT^2}}{2} = \mathrm{T}\left(\mathrm{V_1} + \frac{\mathrm{aT}}{2}\right) = \frac{\mathrm{V_2} - \mathrm{V_1}}{\mathrm{a}}\left(\mathrm{V_1} + \frac{\mathrm{V_2} - \mathrm{V_1}}{2}\right) = \frac{\mathrm{V_2} - \mathrm{V_1}}{\mathrm{a}}\left(\frac{\mathrm{V_1} + \mathrm{V_2}}{2}\right) =$$
$$= \frac{\mathrm{V_2^2} - \mathrm{V_1^2}}{2\mathrm{a}} = \frac{\left(10.4\frac{\mathrm{m}}{\mathrm{s}}\right)^2 - \left(5.2\frac{\mathrm{m}}{\mathrm{s}}\right)^2}{2 \cdot 4.15\frac{\mathrm{m}}{\mathrm{s^2}}} = 9.8\ \mathrm{m}$$

(b)

Here the distance = displacement = $9.8\ \mathrm{m}$ because there wasn't change in moving direction during time T.

(c)

$\mathrm{V_3} = -5.2\frac{\mathrm{m}}{\mathrm{s}} - \text{initial velocity of the object;}$
$\mathrm{V_4} = 10.4\frac{\mathrm{m}}{\mathrm{s}} - \text{final velocity of the object;}$

$t_2 -$ time of travelling;
$d_2 -$ displacement during time t_2;

$$V_4 = V_3 + at_2$$
$$t_2 = \frac{V_4 - V_3}{a} \quad (1)$$

Equation of motion for the object:

$$d = V_3 t_2 + \frac{at_2{}^2}{2} = t_2\left(V_3 + \frac{at_2}{2}\right) = \frac{V_4 - V_3}{a}\left(V_3 + \frac{V_4 - V_3}{2}\right) = \frac{V_4 - V_3}{a}\left(\frac{V_3 + V_4}{2}\right) =$$
$$= \frac{V_4^2 - V_3^2}{2a} = \frac{\left(10.4\frac{m}{s}\right)^2 - \left(-5.2\frac{m}{s}\right)^2}{2 \cdot 4.15\frac{m}{s^2}} = 9.8\ m$$

(d)

$a = 4.15\frac{m}{s^2} -$ acceleration;
$V_1 = -5.2\frac{m}{s} -$ initial velocity of the object;
$t_1 -$ time of first part travelling;
$d_1 - displacement\ during\ time\ t_2$;
$V_2 = 0 - zero\ velocity$;
$t_2 - time\ of\ second\ part\ travelling$;
$V_3 = 10.4\frac{m}{s} - final\ velocity\ of\ the\ object$;

The total distance here will be different , thus we can split the movement of the object into 2 parts :

1) when it starts at $-\ 5.2\frac{m}{s}$ then stops to change direction

Rate equation of the object:

$$V_2 = V_1 + at_1 = 0$$
$$t_1 = \frac{V_1}{a}$$

Equation of motion for the object:

$$d_1 = V_1 t_1 - \frac{at_1^2}{2} = \frac{V_1^2}{a} - \frac{V_1^2}{2a} = \frac{V_1^2}{2a} = \frac{\left(-5.2\frac{m}{s}\right)^2}{2 \cdot 4.15\frac{m}{s^2}} = 3.26\ m$$

2) the distance object passes till its velocity becomes $V_3 = 10.4\frac{m}{s}$

Rate equation of the object:

$$V_3 = V_2 + at_2$$
$$t_2 = \frac{V_3}{a}$$

Equation of motion for the object:

$$d_2 = V_2 t_2 + \frac{a t_2^2}{2} = 0 + \frac{a t_2^2}{2} = \frac{a}{2}\left(\frac{V_3}{a}\right)^2 = \frac{V_3^2}{2a} = \frac{\left(10.4\,\frac{m}{s}\right)^2}{2 \cdot 4.15\,\frac{m}{s^2}} = 13.03\ m$$

Total distance $= \ 3.26\ m + 13.03\ m = 16.3\ m$

Answer: a) $9.8\ m$
b) $9.8\ m$
c) $9.8\ m$
d) $16.3\ m$