Kinematics Equations Practice Problems

1. $\vec{V}_1 = 14.0\,m/s$ [F]

$\Delta t = 5.60\,s$

$\vec{V}_2 = 0.0\,m/s$

$\vec{a} = ?$

$\Delta \vec{d} = ?$

Forward = +

$$\vec{a} = \frac{\vec{V}_2 - \vec{V}_1}{\Delta t}$$

$$= \frac{0.0 - 14.0\,m/s}{5.60\,s}$$

$$= -2.50\,m/s^2$$

$$= 2.50\,m/s^2 \text{ [Backward]}$$

$$\Delta \vec{d} = \frac{1}{2}(\vec{V}_1 + \vec{V}_2)\Delta t$$

$$= \frac{1}{2}(14.0\,m/s + 0)(5.60\,s)$$

$$= 39.2\,m \text{ [Forward]}$$

∴ the cyclist accelerates at a magnitude of $2.50\,m/s^2$ and skids 39.2 m.

2. $\vec{V}_1 = 0.0\,m/s$

$\vec{a} = 1.40\,m/s^2$ [F]

$\Delta t = 8.00\,s$

$\vec{V}_2 = ?$

$\vec{V}_{av} = ?$

$\Delta \vec{d} = ?$

Forward = +

$$\vec{V}_2 = \vec{V}_1 + \vec{a}\Delta t$$

$$= 0.0\,m/s + (1.40\,m/s^2)(8.00\,s)$$

$$= 11.2\,m/s \text{ [F]}$$

$$\vec{V}_{av} = \frac{1}{2}(\vec{V}_1 + \vec{V}_2)$$

$$= \frac{1}{2}(0.0 + 11.2\,m/s)$$

$$= 5.60\,m/s \text{ (F)}$$

$$\Delta \vec{d} = \frac{1}{2}(\vec{V}_1 + \vec{V}_2)\Delta t$$

$$= \frac{1}{2}(0.0\,m/s + 11.2\,m/s)(8.00\,s)$$

$$= 44.8\,m \text{ [F]}$$

∴ the runner's final speed was 11.2 m/s, the average speed was 5.60 m/s and the runner travelled a distance of 44.8 m while accelerating..

3. $\vec{V}_1 = 14.0\,m/s$ [W]

$\vec{a} = 2.30\,m/s^2$ [W]

$\Delta t = 2.70\,s$

$\Delta \vec{d} = ?$

$\vec{V}_2 = ?$

Let [W] = +

$$\Delta \vec{d} = \vec{V}_1 \Delta t + \frac{1}{2}\vec{a}\Delta t^2$$

$$= (14.0\,m/s)(2.70\,s) + \frac{1}{2}(2.30\,m/s^2)(2.70\,s)^2$$

$$= 37.8\,m + 8.3835\,m$$

$$= 46.1835\,m$$

$$\approx 46.2\,m \text{ [W]}$$

$$\vec{V}_2 = \vec{V}_1 + \vec{a}\Delta t$$

$$= 14.0\,m/s + (2.30\,m/s^2)(2.7\,s)$$

$$= 20.21\,m/s$$

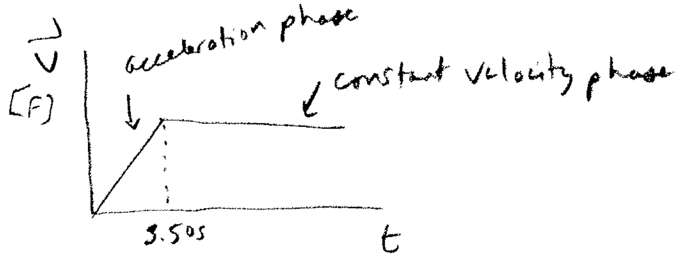
$$= 20.2\,m/s \text{ (W)}$$

or $20.21\frac{m}{s} \times \frac{3600\,s}{h} \times \frac{1.0\,km}{1000\,m}$

$$= 72.8\,km/h \text{ (W)}$$

∴ the car undergoes a displacement of 46.2 m [W] & reaches a final

4. Note: Velocity-time graph



$\vec{v}_1 = 0.0\,m/s$

$\Delta t = 3.50\,s$

$\vec{a} = 2.80\,m/s^2$ [F]

$\Delta\vec{d} = ?$

$\vec{v}_2 = ?$

[F] = +

$$\Delta\vec{d} = \vec{v}_1 \Delta t + \frac{1}{2}\vec{a}\Delta t^2$$
$$= \cancel{(0.0\,m/s)(3.50\,s)}^{\,0} + \frac{1}{2}(2.80\,m/s^2)(3.50\,s)^2$$
$$= 17.15\,m \text{ [F]}$$

$$\vec{v}_2 = \vec{v}_1 + \vec{a}\Delta t$$
$$= 0.0\,m/s + (2.80\,m/s^2)(3.50\,s)$$
$$= 9.80\,m/s \text{ [F]}$$

∴ at the end of the acceleration phase they've run 17.2 m and have reached a speed of 9.80 m/s.

They now have the following distance left to run at a constant speed of 9.80 m/s.

$$\Delta d = 100.0\,m - 17.15\,m$$
$$= 82.85\,m$$

$v = 9.80\,m/s$

$\Delta t = ?$

$$\Delta t = \frac{\Delta d}{v} = \frac{82.85\,m}{9.80\,m/s} = 8.45\,s$$

∴ it takes them 8.45 s to complete the sprint.

5. i) $\vec{v}_1 = 50.0\,\frac{km}{h}$ [F] $\times \frac{1\,h}{3600\,s} \times \frac{1000\,m}{km}$

$= 13.89\,m/s$ [F]

$\vec{a} = 1.60\,m/s^2$ [B]

$\vec{v}_2 = 0.0\,m/s$

$\Delta\vec{d} = ?$

Let [F] = +

$$\Delta d = \frac{\vec{v}_2^{\,2} - \vec{v}_1^{\,2}}{2\vec{a}}$$
$$= \frac{(0.0)^2 - (13.89\,m/s)^2}{2(-1.60\,m/s^2)}$$
$$= 60.28\,m \text{ [F]}$$
$$\sim 60.3\,m \text{ [F]}$$

ii) $\vec{v}_1 = 100.0\,km/h$ [F] $\times \frac{1\,h}{3600\,s} \times \frac{1000\,m}{1\,km}$

$= 27.78\,m/s$ [F]

$$\Delta\vec{d} = \frac{\vec{v}_2^{\,2} - \vec{v}_1^{\,2}}{2\vec{a}}$$
$$= \frac{0.0^2 - (27.78\,m/s)^2}{2(-1.60\,m/s^2)}$$
$$= 241.13\,m \text{ [F]}$$
$$\simeq 241\,m \text{ [F]}$$

b) Given a constant acceleration rate, a lower speed limit greatly reduces the required stopping distance in the event of an accident. A doubling of the initial speed leads to a stopping distance which is four times greater!

6) $\vec{V}_2 = 115 \frac{km}{h} [F] \times \frac{1000m}{km} \times \frac{1h}{3600s} = 31.94 m/s [F]$

$\vec{V}_1 = 0.0 km/h$

$\Delta t = 7.00s$

$\vec{a} = ?$

$\Delta \vec{d} = ?$

$[F] = +$

$\vec{a} = \frac{\vec{V}_2 - \vec{V}_1}{\Delta t}$

$= \frac{31.94 m/s - 0}{7.00s}$

$= 4.56 m/s^2 [F]$

$\Delta \vec{d} = \frac{1}{2}(\vec{V}_1 + \vec{V}_2)\Delta t$

$= \frac{1}{2}(0.0 + 31.94 m/s)(7.00s)$

$= 111.806 m [F]$

$\simeq 112 m [F]$

∴ the coaster's average acceleration is $4.56 m/s^2 [F]$ and it has travelled 112 m [F] in that time.

7) $\vec{a} = 5.60 m/s^2 [W]$

$\vec{V}_1 = 50.0 \frac{km}{h} \times \frac{1h}{3600s} \times \frac{1000m}{km} = 13.89 m/s [E]$

$\vec{V}_2 = 5.00 m/s [E]$

$\Delta \vec{d} = ?$

Let $[E] = +$

$\Delta \vec{d} = \frac{\vec{V}_2^2 - \vec{V}_1^2}{2\vec{a}}$

$= \frac{(5.00 m/s)^2 - (13.89 m/s)^2}{2(-5.60 m/s^2)}$

$= \frac{-167.901 m^2/s^2}{-11.2 m/s^2}$

$= 14.9912 m$

$= 15.0 m [E]$

∴ the car's displacement is 15.0 m [F].

8) $\vec{V}_1 = 5.0 m/s [up]$

$\Delta t = 4.0s$

$\vec{V}_2 = 9.0 m/s [down]$

$\Delta \vec{d} = ?$

Let [up] = +

$\Delta \vec{d} = \frac{1}{2}(\vec{V}_1 + \vec{V}_2)\Delta t$

$= \frac{1}{2}(5.0 m/s - 9.0 m/s)(4.0s)$

$= -8.0 m$

$= 8.0 m$ [down slope]

∴ it's displacement from the release point is 8.0 m [down slope]

9) $\vec{V}_1 = 110.\ \frac{km}{h}\ [F] \times \frac{1h}{3600s} \times \frac{1000m}{km} = 30.56\ m/s\ [F]$

$\vec{V}_2 = 0.0\ m/s$

$\vec{a} = 49.0\ m/s^2\ [B]$

$\Delta\vec{d} = ?$

Let $[F] = +$

$$\Delta\vec{d} = \frac{\vec{V}_2^{\,2} - \vec{V}_1^{\,2}}{2\vec{a}}$$

$$= \frac{(0.0\ m/s)^2 - (30.56\ m/s)^2}{2(-49.0\ m/s^2)}$$

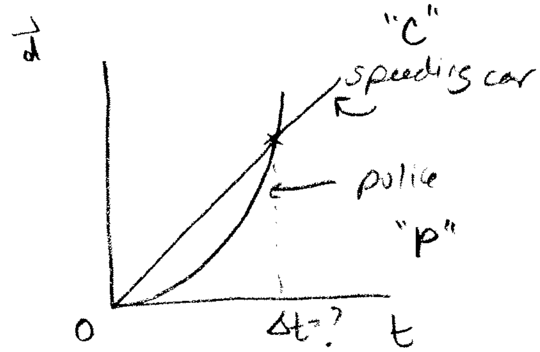
$$= 9.527\ m$$

$$= 9.53\ m\ [F]$$

∴ the minimum distance over which a person should be brought to a stop is 9.53m.

Crumple zones and air bags in a car provide a cushioning effect which increases the time and distance over which a person is brought to a stop. This increased time + distance means that the acceleration rate (and required force to cause this acceleration) is lower.

10) $\vec{D}$-t graph:



$\vec{V}_c = 100.0\ km/h\ [F]$ → $27.78\ m/s\ [F]$

$\vec{V}_{1p} = 0.0\ m/s\ [F]$

$\vec{a}_p = 3.60\ m/s^2\ [F]$

$\Delta t = ?$

$\Delta d_c = \Delta d_p$ ← * when the police car catches up with the speeding car, they will have travelled the same distance.

$\Delta d_p = V_{1p}\Delta t + \frac{1}{2} a_p \Delta t^2 \qquad \Delta d_c = V_c \cdot \Delta t$

but $\Delta d_p = \Delta d_c$

$(0.0\ m/s)(\Delta t) + \frac{1}{2}(3.60\ m/s^2)(\Delta t^2) = (27.78\ m/s)(\Delta t)$

$1.80\ \Delta t^2 = 27.78\ \Delta t$ → divide by Δt

$\Delta t = \frac{27.78}{1.80} = 15.43\ s$

∴ it takes the police car 15.4s ... speeding car.

b) $\Delta d_c = V_c \Delta t$

$= (27.78 \text{ m/s})(15.43 \text{ s})$

$= 428.67 \text{ m}$

$= 429 \text{ m}$

$\therefore$ The police car catches up with the speeding car 429 m from the light.

c) $V_{2p} = ?$ $\quad V_{2p} = V_{1p} + a\Delta t$

$= (0.0 \text{ m/s}) + (3.60 \text{ m/s}^2)(15.43 \text{ s})$

$= 55.56 \text{ m/s}$

OR $55.56 \frac{\text{m}}{\text{s}} \times \frac{3600 \text{ s}}{1 \text{ h}} \times \frac{1 \text{ km}}{1000 \text{ m}} = 200 \text{ km/h}$

The final police car speed is 2.00×10^2 km/h which is very high and is likely unsafe!