Acceleration & Displacement

Constant velocity: $V = \frac{\Delta d}{\Delta t}$

Constant acceleration: $V_{ave} = \frac{\Delta d}{\Delta t}$ $\left(\text{where } V_{ave} = \frac{V_1 + V_2}{2}\right)$

$a = \frac{\Delta V}{\Delta t}$ $\left(\text{where } \Delta V = V_2 - V_1\right)$

Maybe useful

① $\Delta d = V_1 t + \frac{1}{2} a t^2$

② $\Delta d = V_2 t - \frac{1}{2} a t^2$

③ $V_2^2 = V_1^2 + 2a\Delta d$

MP184

down

$V_1 = -8.3\ m/s$

$\Delta t = 6.9\ s$

$a = -9.81\ m/s^2$

$\Delta d = ??$

acceleration due to gravity

$$\Delta d = V_1 t + \frac{1}{2} a t^2$$

$$\Delta d = (-8.3\ m/s)(6.9\ s) + \frac{1}{2}(-9.81\ m/s^2)(6.9\ s)^2$$

$$\Delta d = -57.27\ m - 233.53\ m$$

$$\Delta d = -290.80\ m$$

290m

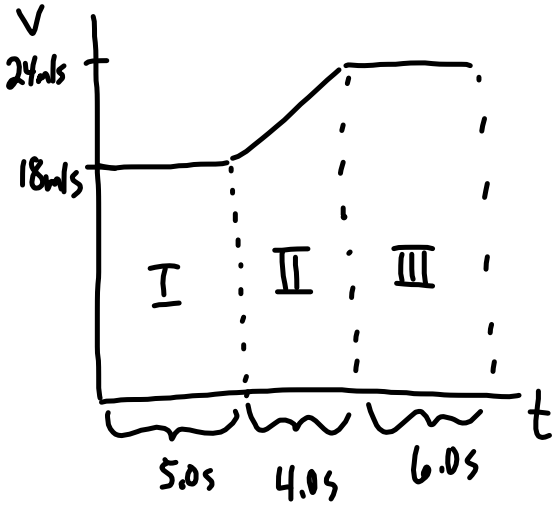
$$\Delta d = -2.9 \times 10^2\ m$$

This is the displacement.

∴ The height of the cliff is: $2.9 \times 10^2\ m$

MP 85

Sketch a velocity-time graph:



$\Delta\vec{d}$ = ? [E]

Section I (constant velocity)

$v = 18\,m/s$
$\Delta t = 5.0\,s$
$\Delta d = ??$

$v = \frac{\Delta d}{\Delta t}$

$\Delta d = v\,\Delta t$

$\Delta d = (18\,m/s)(5.0\,s)$

$\Delta d = 90\,m$

Section II (constant acceleration)

$v_1 = 18\,m/s$
$v_2 = 24\,m/s$
$\Delta t = 4.0$
$\Delta d = ??$

$v_{ave} = \frac{\Delta d}{\Delta t}$

$\Delta d = v_{ave}\,\Delta t$

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

$\Delta d = \left(\frac{18\,m/s + 24\,m/s}{2}\right)(4.0\,s)$

$\Delta d = (21\,m/s)(4.0\,s)$

$\Delta d = 84\,m$

Section III (constant velocity)

$v = 24\,m/s$
$\Delta t = 6.0\,s$
$\Delta d = ?$

$v = \frac{\Delta d}{\Delta t}$

$\Delta d = v\,\Delta t$

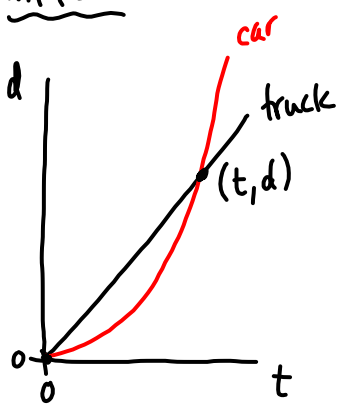
$\Delta d = (24\,m/s)(6.0\,s)$

$\Delta d = 144\,m$

Total Displacement: $90\,m + 84\,m + 144\,m = 318\,m$

$3.2 \times 10^2\,m$ [E]

mp187



Truck (constant velocity)

$v = 22\,m/s$

$\Delta d = ?$

$\Delta t = ?$

$v = \frac{\Delta d}{\Delta t}$

$\Delta d = v\Delta t$

$d - 0 = v(t - 0)$

$d = (22\,m/s)t$

Car (constant acceleration)

$v_1 = 0$

$a = 4.8\,m/s^2$

$\Delta d = ?$

$\Delta t = ?$

$\Delta d = \cancel{v_1 t}^{0} + \frac{1}{2}at^2$

$d = \frac{1}{2}(4.8\,m/s^2)t^2$

$d = (2.4\,m/s^2)t^2$

Solving the system of equations:

$$22t = 2.4t^2$$

$$0 = 2.4t^2 - 22t$$

$$0 = t(2.4t - 22)$$

Set each factor equal to zero:

$t = 0$ and $2.4t - 22 = 0$

$2.4t = 22$

$t = \frac{22\,m/s}{2.4\,m/s^2}$

$t = 9.2\,s$

Sub $t = 9.2\,s$ into

$d = (22\,m/s)t$

$d = (22\,m/s)(9.2\,s)$

$d = 2.0 \times 10^2\,m$

The car will catch up with the truck in 9.2s at $2.0 \times 10^2\,m$ [N] of the traffic light.

Example

An airplane must reach a velocity of 71 m/s for takeoff. If the runway is 1.0 km long, what must the constant acceleration be?

$V_2 = 71 m/s$

$V_1 = 0$

$\Delta d = 1.0 \times 10^3 m$

$a = ??$

$$V_2^2 = V_1^2 + 2a\Delta d$$

$$V_2^2 - V_1^2 = 2a\Delta d$$

$$a = \frac{V_2^2 - V_1^2}{2\Delta d}$$ ($V_1^2 = 0$)

$$a = \frac{(71 m/s)^2}{2(1.0 \times 10^3 m)}$$

$$a \doteq 2.5 m/s^2$$

TO DO

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