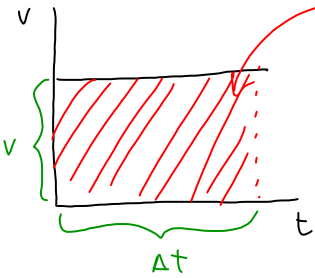
Acceleration and Displacement

Constant Velocity



Area of Rectangle = base x height

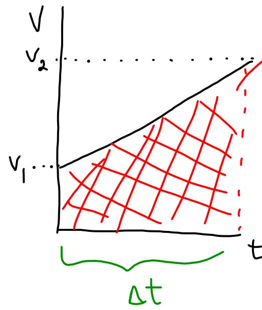
Area = $v\Delta t$

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

$\Delta d = v\Delta t$

$$\boxed{\text{Area (v-t graph)} = \Delta d}$$

Constant Acceleration



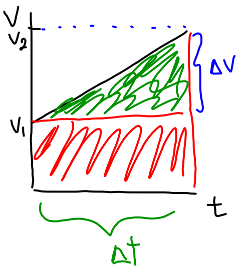
Area of trapezoid $= \frac{1}{2}(h_1 + h_2)\, b$

$\Delta d = \frac{1}{2}(v_1 + v_2)\Delta t$

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

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

* $v_{ave} = \frac{v_1 + v_2}{2}$ ONLY if there is constant acceleration



Area = ▭ + △

$\Delta d = v_1\Delta t + \frac{1}{2}(\Delta v)(\Delta t)$

Recall: $a = \frac{\Delta v}{\Delta t}$

$\Delta v = a\Delta t$

Maybe Useful Equations.

$$\boxed{\Delta d = v_1\Delta t + \frac{1}{2}a(\Delta t)^2}$$

$$\boxed{\Delta d = v_2\Delta t - \frac{1}{2}a(\Delta t)^2}$$

$$\boxed{v_2^2 = v_1^2 + 2a\Delta d}$$

Constant velocity

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

Constant Acceleration

$$V_{ave} = \frac{\Delta d}{\Delta t} \quad \text{where} \quad V_{ave} = \frac{V_1 + V_2}{2}$$

$$a = \frac{\Delta V}{\Delta t} \quad \text{where} \quad \Delta V = V_2 - V_1$$

Maybe Useful Equations.

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

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

③ $V_2^2 = V_1^2 + 2a\Delta d$

MP/84

$V_1 = -8.3\,m/s$ down

$\Delta t = 6.9\,s$

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

$\Delta d = ?$

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

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

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

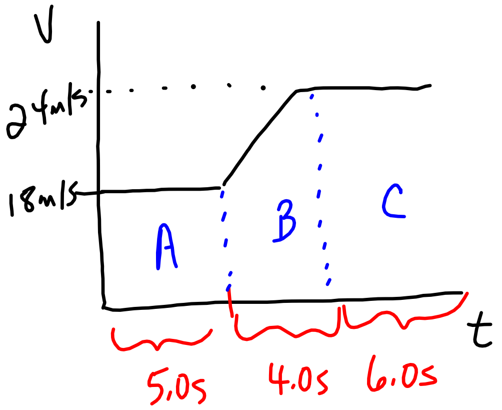
$$\Delta d = -290.80\,m$$

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

$$\vec{\Delta d} = 2.9 \times 10^2\,m\ [down]$$

The height of the cliff is $2.9 \times 10^2\,m$.

MP/85



Section A

constant velocity

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

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

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

$$\Delta d = 90\,m$$

Section B

constant acceleration

$V_1 = 18\,m/s$

$V_2 = 24\,m/s$

$\Delta t = 4.0\,s$

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

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

$$\Delta d = \frac{V_1 + V_2}{2}\,\Delta t$$

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

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

$$\Delta d = 84\,m$$

Section C

constant velocity

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

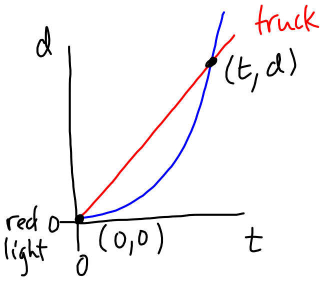
$$\Delta d = 144\,m$$

TOTAL

$$\begin{array}{r} 90\ m \\ 144\ m \\ +\ 84\ m \\ \hline 318\ m \end{array}$$

$$\vec{\Delta d}_{TOTAL} = 3.2 \times 10^2\,m\ [E]$$

mp|87



Truck
constant velocity

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

$\Delta d = v \Delta t$

$d - 0 = (22 m/s)(t - 0)$

$d = 22t$

Car
constant acceleration

$v_1 = 0$
$a = 4.8 m/s^2$
$\Delta d = ?$
$\Delta t = ?$

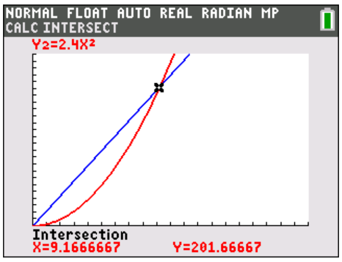
$\Delta d = \cancel{v_1 \Delta t}^{0} + \frac{1}{2} a (\Delta t)^2$

$d - 0 = \frac{1}{2}(4.8 m/s^2)(t - 0)^2$

$d = 2.4t^2$

$d = 22t$
$d = 2.4t^2$

Graph and find intersection



Algebraically

$2.4t^2 = 22t$

$2.4t^2 - 22t = 0$

$t(2.4t - 22) = 0$

$t = 0$ $\quad\quad$ $2.4t - 22 = 0$

$2.4t = 22$

$t = \frac{22}{2.4}$

$t = 9.2s$

Sub $t = 9.2s$ into

$d = 22t$

$d = \underset{m/s}{22}(9.2s)$

$d = 201.7 m$

$d = 2.0 \times 10^2 m$

Example

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

$v_2 = 71 m/s$

$v_1 = 0$

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

$a = ?$

$$v_2^2 = v_1^2 + 2a\Delta d$$

$$v_2^2 - v_1^2 = 2a\Delta d$$

$$a = \frac{v_2^2 - \cancel{v_1^2}}{2\Delta d}$$

0

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

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

units

$$\frac{\cancel{m}^2/s^2}{\cancel{m}} = m/s^2$$