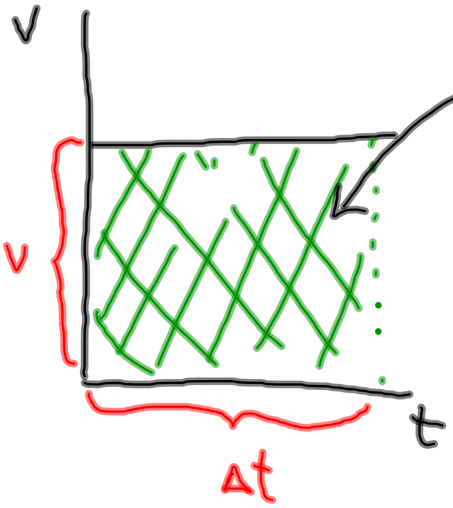
Acceleration & Displacement

Consider the v-t graph for an object with constant velocity:



area of rectangle $= b \times h$

area $= v\Delta t$

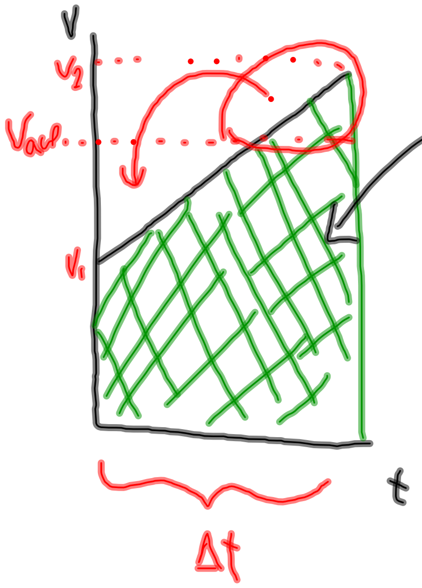
$\boxed{\text{area} = \Delta d}$

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

$\Delta d = v\Delta t$

* Area under a v-t graph gives the displacement.

Consider the v-t graph for an object with constant acceleration:



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

area = displacement

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

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

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

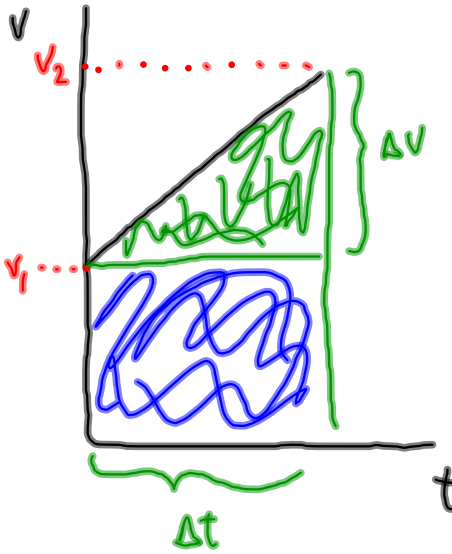
$V_{ave} = \frac{\Delta d}{\Delta t}$

Every kinematics problem involving acceleration has 5 variables: $v_1, v_2, a, \Delta t, \Delta d$. If you know 3 of these, you can find the other two. EVERY kinematics problem can be solved using two BASIC equations:

Constant Velocity: $v = \frac{\Delta d}{\Delta t}$ (1)

Constant Acceleration: $a = \frac{\Delta v}{\Delta t}$ (2)

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



$$\text{Area} = \square + \triangle$$

$$= b\cdot h + \frac{1}{2}bh$$

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

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

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

$\Delta v = a\Delta t$

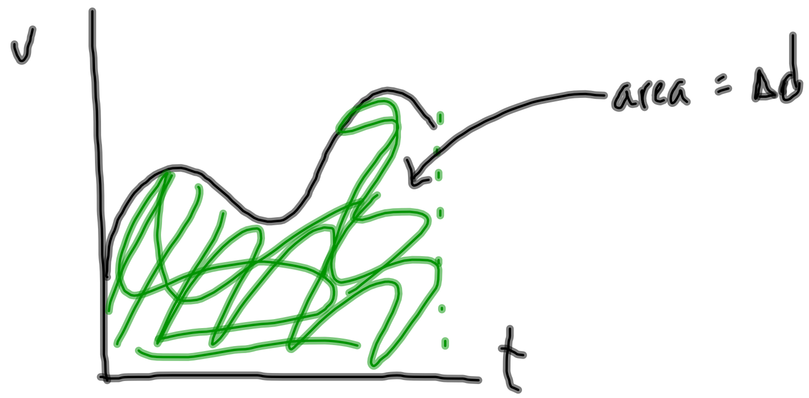
Maybe useful equations

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

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

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

What if:



RECAP:

Constant Velocity: $v = \frac{\Delta d}{\Delta t}$

Constant Acceleration: $a = \frac{\Delta v}{\Delta t}$ and $v_{ave} = \frac{\Delta d}{\Delta t}$

$(\Delta v = v_2 - v_1)$ $\left(v_{ave} = \frac{v_1 + v_2}{2}\right)$

Maybe useful:

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

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

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

MP|84

$\vec{v}_1 = 8.3\, m/s\, [down]$

$\Delta t = 6.9\, s$

$\Delta d = ?$

$\vec{a} = 9.81\, m/s^2\, [down]$

(implied) acceleration due to gravity

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

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

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

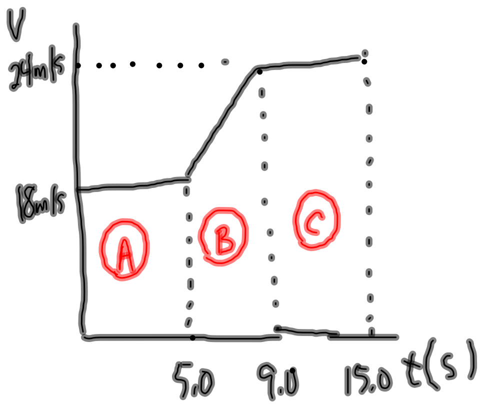
$$\Delta d = -290.80\, m$$

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

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

The height of the cliff is 2.9×10^2 m

MP|85



$\Delta d = ???$

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 acc

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

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

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

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

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

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

Section C - constant velocity

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

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

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

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

TOTAL: $90\,m + 84\,m + 144\,m$

$$\Delta d = 318\,m\,[E]$$

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