UNIT #1 KINEMATICS

The Big 5

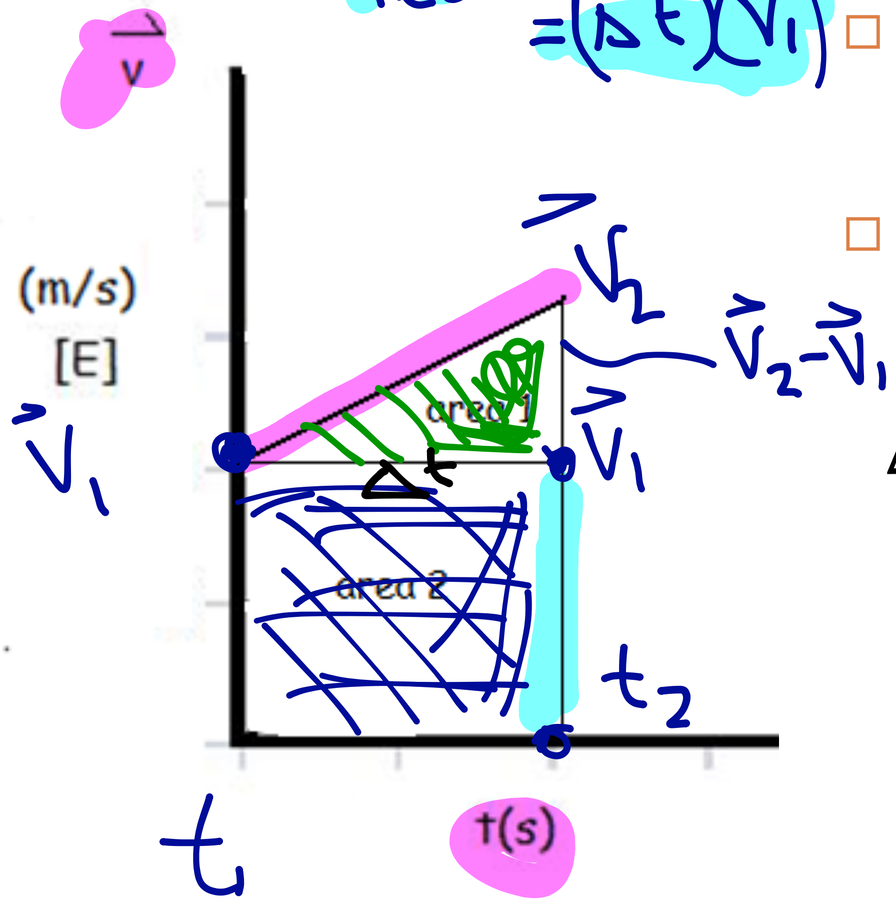
Uniform Acceleration

- acceleration is constant
- 5 Kinematic equations...much easier than graphical analysis!

Equation #1

$$A_{Triangle} = \frac{bh}{2} = \frac{\Delta t(\vec{v}_2 - \vec{v}_1)}{2}$$

$$A_{Rect} = bh = (\Delta t)(\vec{v}_1)$$



- ☐ v-t graph, straight line (uniform acceleration)
- ☐ Δd = area under graph

$$\Delta d = A_{triangle} + A_{rectangle}$$

$$\boxed{\overrightarrow{\Delta d} = \left(\frac{\vec{v}_2 + \vec{v}_1}{2}\right)\Delta t}$$

$$A_{Total} = A_{Triangle} + A_{rectangle}$$

$$= \frac{\Delta t(\vec{v}_2 - \vec{v}_1)}{2} + \Delta t(\vec{v}_1)$$

$$= \frac{\Delta t(\vec{v}_2 - \vec{v}_1)}{2} + \frac{2\Delta t(\vec{v}_1)}{2}$$

$$= \frac{\Delta t(\vec{v}_2 - \vec{v}_1) + 2\Delta t\vec{v}_1}{2}$$

$$= \frac{\Delta t(\vec{v}_2 - \vec{v}_1 + 2\vec{v}_1)}{2}$$

$$= \frac{\Delta t(\vec{v}_2 + \vec{v}_1)}{2}$$

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

Equation #2

- we know that $\vec{a} = \frac{\vec{v}}{\Delta t}$
- we can say, $\vec{a} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t}$
- rearranging, we get

$$\overrightarrow{v_2} = \overrightarrow{v_1} + \vec{a}\Delta t$$

Equation #3

- we can use equations (1) and (2) to derive equation (3)

$$\overrightarrow{\Delta d} = \left(\frac{\vec{v}_2 + \vec{v}_1}{2}\right)\Delta t \quad \textbf{(1)}$$

$$\overrightarrow{v_2} = \boxed{\overrightarrow{v_1} + \vec{a}\Delta t} \quad \textbf{(2)}$$

substitution

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

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

The Big Five

	Equation	Missing Variable
(1)	$\overrightarrow{\Delta d} = \left(\frac{\vec{v}_2 + \vec{v}_1}{2}\right)\Delta t$	$\vec{a}$
(2)	$\overrightarrow{v_2} = \overrightarrow{v_1} + \vec{a}\Delta t$	Δd
(3)	$\overrightarrow{\Delta d} = \vec{v}_1\Delta t + \frac{1}{2}\vec{a}\Delta t^2$	$\vec{v}_2$
(4)	$\vec{v}_2^2 = \vec{v}_1^2 + 2\vec{a}\Delta d$	Δt
(5)	$\overrightarrow{\Delta d} = \vec{v}_2\Delta t - \frac{1}{2}\vec{a}\Delta t^2$	$\vec{v}_1$

Examples

$v_1 = 0$

1. A car accelerates at $3 m/s^2$ from rest for 10s. How far does it travel?
2. A car is moving at 100km/h. It stops in 5.0s. What is the car's acceleration?

Given: $v_1 = 0$

$a = 3 m/s^2$

$\Delta t = 10s$

Required: d = distance

Analysis:

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

$$d = \underset{\overset{\uparrow}{0\,m/s}}{\cancel{v_i t}} + \frac{1}{2}at^2$$

$$d = \frac{1}{2}at^2$$

$$d = \frac{1}{2}\left(3\frac{m}{s^2}\right)(10\,s)^2$$

$$d = \frac{1}{2}\left(3\frac{m}{\cancel{s^2}}\right)100\,\cancel{s^2}$$

$$d = \frac{1}{2}(300\,m)$$

$$d = 150\,m$$

#2

Given:

$v_1 = 100\ km/h$

$\Delta t = 5.0s$

$v_2 = 0\ m/s$ (stopped)

Required $\vec{a}$ = acceleration.

Analysis: $v_2 = v_1 + a\Delta t$

Steps: $100\frac{\cancel{km}}{\cancel{h}} \times \frac{1000\,m}{1\,\cancel{km}} \times \frac{1\,\cancel{h}}{60\,\cancel{min}} \times \frac{1\,\cancel{min}}{60\,s}$

$v_1 = 27.8\,m/s$

$v_2 = v_1 + at$ (subtract v_1 from both sides)

$v_2 - v_1 = at$

(divide both sides by t)

$$\frac{v_2 - v_1}{t} = a$$

$$\frac{0\,m/s - 27.8\,m/s}{5.0s} = a$$

$$\frac{-27.8\,m/s}{5.0s} = a$$

$\therefore a = -5.6\,\frac{m}{s^2}$

Homework

- Read 1.5
- p.39#1-6

GRASS

- Redo | Retest
- Missed quizzes (2 No marks
  - If you write all quizzes 2 lowest get removed)

Extra Help
Tues & Thur @ lunch.

Pg 39 #4

A	B
$d = 1.0\,km$	$d = 1.0\,km$
$= 1000\,m$	$= 1000$
$v = 20.0\,m/s$	$v_1 = 0\,m/s$
$a = 0\,m/s^2$	$a = 0.333\,m/s^2$
$v = \frac{d}{t}$	
$t = ?$	$t = ?$

2 sig digs

2 sig digs

Given

Required:

Analysis:

Ⓐ

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

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

$$= \frac{1000\,m}{20\,m/s}$$

$$t = 50s$$

$$t = 50.0s$$

Ⓑ

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

$v_1 = 0\,m/s$

$$d = \frac{1}{2}at^2$$

multiply ×2

$$2d = at^2$$

divide by a

$$\frac{2d}{a} = t^2$$

$$t = \sqrt{\frac{2d}{a}}$$

$$t = \sqrt{\frac{2d}{a}}$$

$$t = \sqrt{\frac{2(1000\,m)}{0.333\,m/s^2}}$$

$$t = \sqrt{6000\,s^2}$$

$$\boxed{t = 77\,s}$$

$\therefore$ CART A wins by 27 seconds.

#5.

Given: $v_1 = 5.0\,m/s$

$V_2 = 7.5\,m/s$

$d = 50.0\,m$

Required: a = acceleration

Analysis: $V_2^2 = V_1^2 + 2ad$

Steps: $$a = \frac{V_2^2 - V_1^2}{2d}$$

$$a = \frac{\left(7.5\,\frac{m}{s}\right)^2 - \left(5\,\frac{m}{s}\right)^2}{2(50\,m)}$$

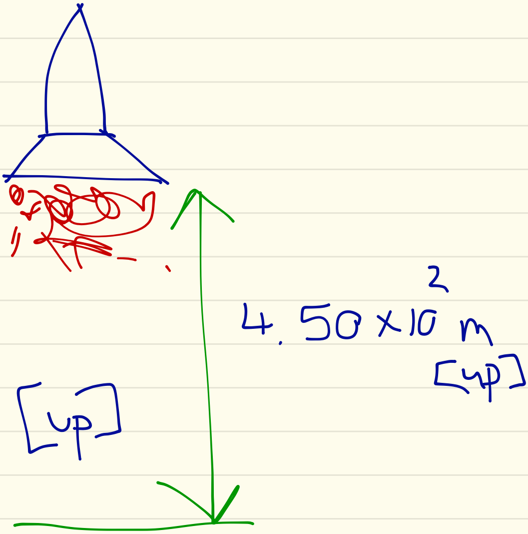
$$a = \frac{56.25\,\frac{m^2}{s^2} - 25\,\frac{m^2}{s^2}}{100\,m}$$

$$a = \frac{31.25\,\frac{m^{\cancel{2}}}{s^2}}{100\,\cancel{m}}$$

$$a = 0.3125\,m/s^2$$

$$\boxed{\therefore\ a = 0.31\,m/s^2}$$

Pg. 39 #6



Given:

$\Delta t = 4.0 s$

$\vec{v}_1 = 0 m/s$

$\vec{\Delta d} = 4.50 \times 10^2 m [up]$

Required: $\vec{a}$ = acceleration

Analysis: $\vec{\Delta d} = \cancelto{0}{\vec{v}_1 \Delta t} + \frac{1}{2}\vec{a}\Delta t^2$

$$= 4.5 \times 10^2 m [up] = \frac{1}{2}\vec{a}(4.0 s)^2$$

$$= 4.5 \times 10^2 m [up] = (8 s^2)\vec{a}$$

$$= \frac{4.5 \times 10^2 m [up]}{8 s^2} = \vec{a}$$

$$\vec{a} = 56 m/s^2 [up]$$

b) $\vec{v}_2 = \cancelto{0}{\vec{v}_1} + \vec{a}\Delta t$

$\vec{v}_2 = \vec{a}\Delta t$

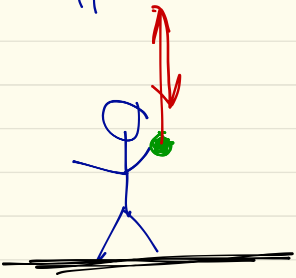
$= 56\frac{m}{s^{\cancel{2}}}[up] \times 4.0\cancel{s}$

$\vec{v}_2 = 224\ m/s\ [up]$

$\vec{v}_2 = 220\ m/s\ [up]$

↑ 2 sig digs

Pg. 42 #1



Given: $\vec{v}_1 = 8.3\,\frac{m}{s}$ [up]

$\vec{a} = 9.8\,\frac{m}{s^2}$ [down]

Required: max height $= \vec{\Delta d}$ max

Analysis: at max height $v_2 = 0\,m/s$

$\vec{v}_2^{\,2} = v_1^2 + 2\vec{a}\Delta d$ $\qquad \uparrow +$ [up]

$$\left(0\frac{m}{s}\right)^2 = \left(8.3\frac{m}{s}\right)^2 + 2\left(-9.8\frac{m}{s^2}\right)\Delta d$$

$$0\frac{m^2}{s^2} = 68.89\frac{m^2}{s^2} - 19.6\frac{m}{s^2}\Delta d$$

$$0\frac{m^2}{s^2} - 68.89\frac{m^2}{s^2} = -19.6\frac{m}{s^2}\Delta d$$

$$-68.89\frac{m^2}{s^2} = -19.6\frac{m}{s^2}\Delta d$$

$$\vec{\Delta d} = \frac{-68.89\,\frac{m^{\cancel{2}}}{\cancel{s^2}}}{-19.6\,\frac{\cancel{m}}{\cancel{s^2}}}$$

$$\vec{\Delta d} = 3.51\,m$$

$$\therefore \vec{\Delta d} = 3.5\,m\,[up]$$

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

$$0\,\frac{m}{s} = 8.3\,\frac{m}{s} + \left(-9.8\,\frac{m}{s^2}\right)\Delta t$$

$$0\,\frac{m}{s} - 8.3\,\frac{m}{s} = -9.8\,\frac{m}{s^2}\,\Delta t$$

$$\frac{-8.3\,\frac{\cancel{m}}{\cancel{s}}}{-9.8\,\cancel{m}/s^{\cancel{2}}} = \Delta t$$

$$0.85\,s = \Delta t$$

Read 1.6 (pg 40-43)

#2 pg. 42.