Kinematics Review Questions:

1. Define the following: vector, scalar, distance, displacement, speed, velocity, acceleration, uniform motion, uniform acceleration.

2. Sketch the position-time and velocity-time graphs for an object undergoing uniform motion and uniform acceleration.

3. How do you determine average velocity from a position-time graph?

4. How do you determine the instantaneous velocity from a position-time graph for an object undergoing non-uniform motion?

5. How do you determine acceleration from a velocity-time graph?

6. How do you determine displacement from a velocity-time graph for uniform motion and uniform acceleration?

7. Can an object have zero velocity but non-zero acceleration? Give an example.

8. Can an object have negative acceleration but be speeding up? Give an example.

9. Contrast uniform motion and uniform acceleration.

Problems and Graph Analysis:

1. After leaving the huddle, a receiver on a football team runs 8.5 m [E], waiting for the ball to be snapped, then he turns abruptly and runs 12.0 m [S], suddenly changes direction, catches a pass and runs 13.5 m [W] before being tackled. The entire motion takes 7.0 s. Determine the receiver's a) average speed and b) average velocity.

2. A student starts at the westernmost position of a circular track of circumference 200.0 m and runs halfway around the track in 13.0 seconds. Determine the student's a) average speed and b) average velocity.

3. In an acceleration test for a sports car, two markers 0.30 km apart were set up along a road. The car passed the first marker with a velocity of 5.0 m/s [E] and passed the second marker with a velocity of 33.0 m/s [E]. Calculate the car's average acceleration between the markers.

4. A plane travelling at 305.0 km/h [W] lands on a runway and begins accelerating uniformly at 2.7 m/s^2 [E].

    a) What is the plane's velocity after 30.0 s?

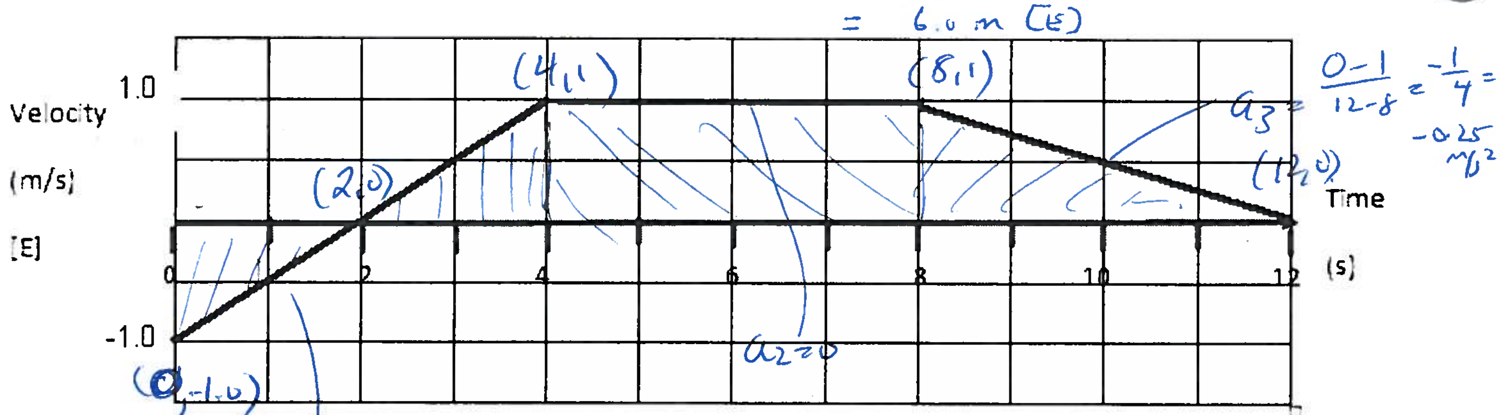
    b) How far has it travelled during this 30.0 second interval?

5. A ball is tossed up into the air with an initial velocity of 3.00 m/s [up]. Find:
    a) the height to which the ball rose. b) its total time of flight (the time to rise up and fall back down)
    c) the final velocity of the ball when it landed back down in the thrower's hand

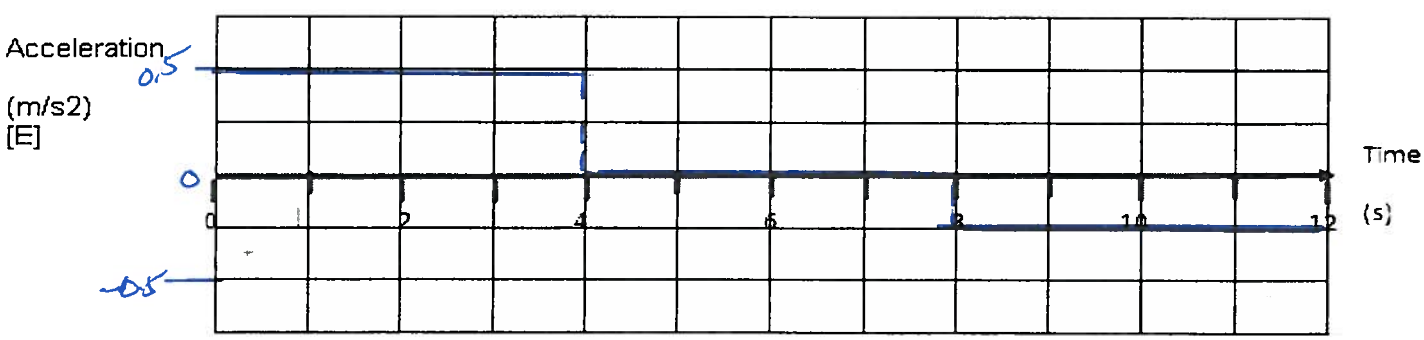
6. For the graph below:

    1) calculate the acceleration over each interval
    2) draw the corresponding acceleration-time graph
    3) find the resultant displacement over the motion

$\Delta\vec{d}_R = \Delta\vec{d}_1 + \Delta\vec{d}_2 + \Delta\vec{d}_3 + \Delta\vec{d}_4$
$= \frac{1}{2}(-1.0)(2) + \frac{1}{2}(2)(1) + (1)(4) + \frac{1}{2}(4)(1)$
$= -1.0 + 1.0 + 4 + 2.0$
$= 6.0$ m [E]

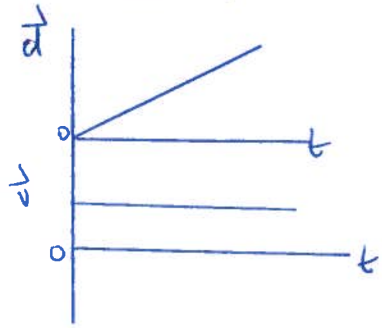


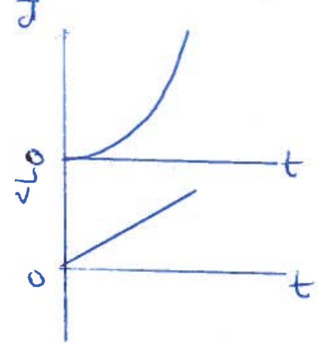
$\vec{a}_1 = \frac{1-(-1)}{4-0} = \frac{1}{2}$ m/s^2 [E]



Kinematics Review Questions

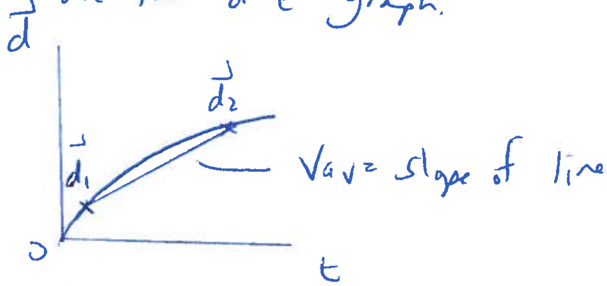
2. uniform motion: uniform acceleration:



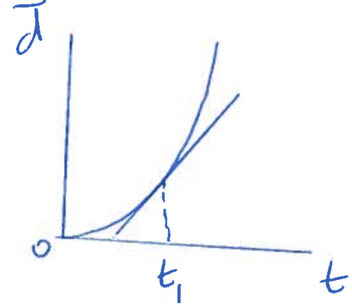


3. Average velocity is the slope of the line joining the first and last positions on the $\vec{d}$-t graph.

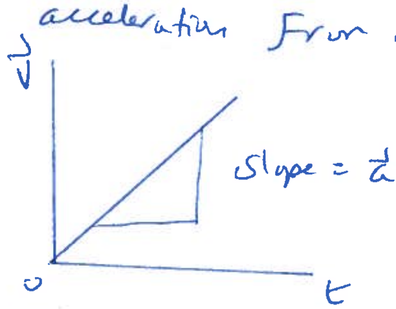
eg.



4. To find instantaneous velocity for a non-uniform $\vec{d}$-t graph find the slope of the tangent at the time point of interest.



5. To find acceleration from a $\vec{v}$-t graph calculate the slope.

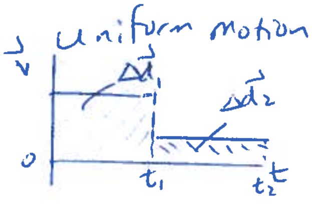


6. To find displacement from a $\vec{v}$-t graph, calculate the area between the graph and the time axis. Add up the displacements to plot a position-time graph.

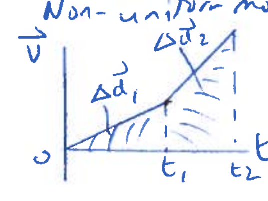
t	$\vec{d}$
0	0
t_1	Δd_1
t_2	$\Delta d_1 + \Delta d_2$

* assume the object starts at the origin

uniform motion



Non-uniform motion



t	$\vec{d}$
0	0
t_1	Δd_1
t_2	$\Delta d_1 + \Delta d_2$

7] Yes - if a ball is thrown up in the air it comes to a stop briefly at the top of its motion but acceleration is still $9.80\ m/s^2$ [↓].

8] Yes - if an object is moving west and accelerating west it will speed up (assuming east is +ve).

9] Uniform motion is <u>constant velocity</u> - constant speed in a constant direction.

Uniform acceleration is motion in a constant direction in which speed is changing uniformly.

Problems:

1. $\Delta\vec{d}_1 = 8.5\ m$ [E] — N, S, E, W — $1\ cm = 1\ m$

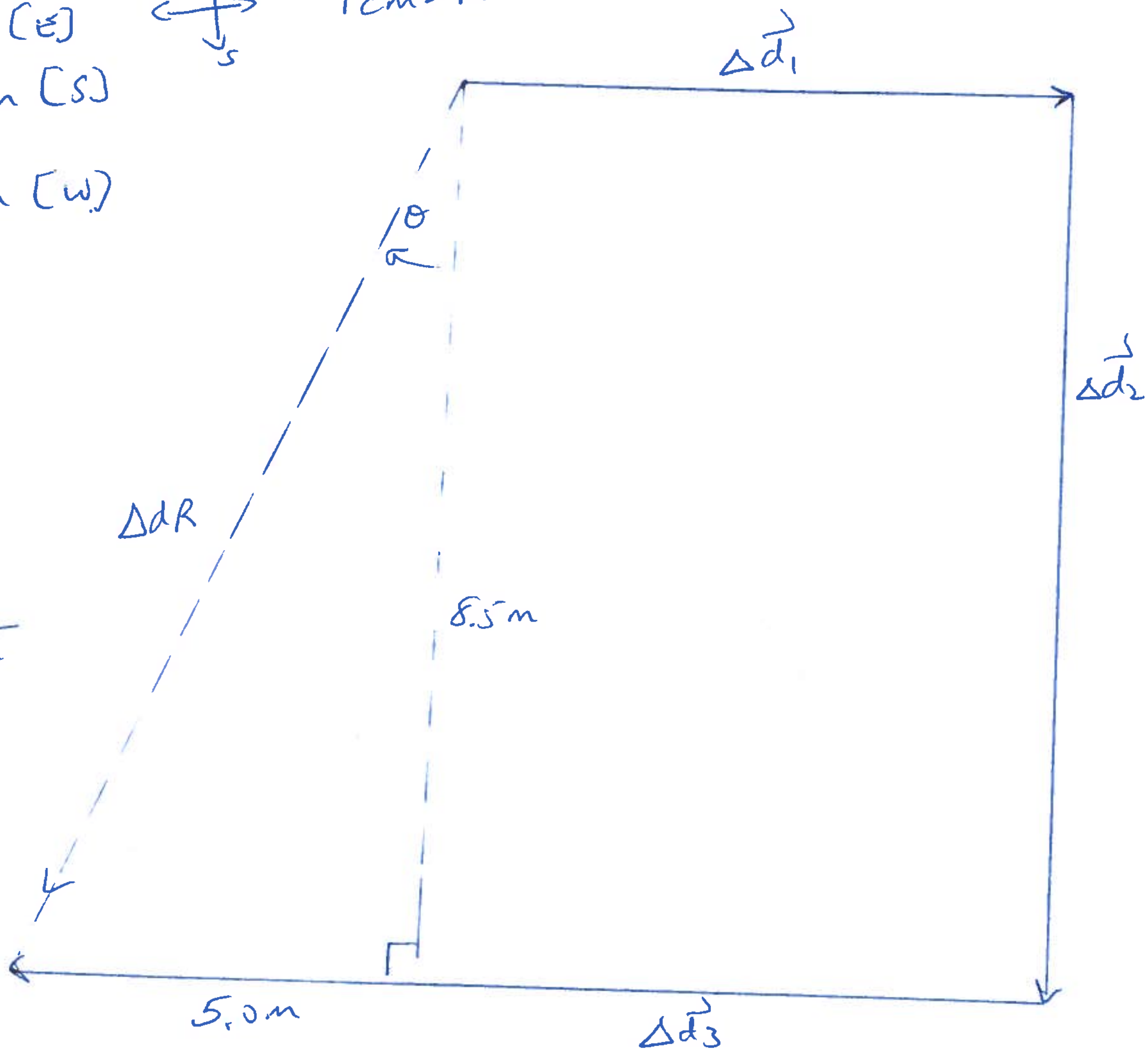
$\Delta\vec{d}_2 = 12.0\ m$ [S]

$\Delta\vec{d}_3 = 13.5\ m$ [W]

$\Delta t = 7.0\ s$

$\Delta d_T = ?$ $v_{av} = ?$

$\Delta\vec{d}_R = ?$ $\vec{v}_{av} = ?$



$\Delta d_R = \sqrt{8.5^2 + 5.0^2}$

$= 9.86\ m$

$\theta = \tan^{-1}\left(\frac{5.0}{8.5}\right)$

$= 30.5°$

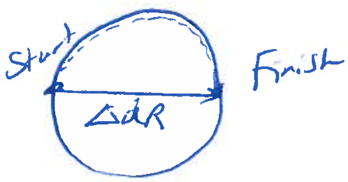
$\therefore \Delta\vec{d}_R = 9.9\ m$ [S 30.5° W]

$$\vec{V}_{av} = \frac{9.86\,m\ [S30.5°W]}{7.0\,s}$$
$$= 1.4\ m/s\ [S30.5°W]$$

$$V_{av} = \frac{\Delta d_T}{\Delta t}$$
$$= \frac{8.5\,m + 12.0\,m + 13.5\,m}{7.0\,s}$$
$$= \frac{34.0\,m}{7.0\,s}$$
$$= 4.9\ m/s$$

3,

2)



$C = 200.0\,m$

$$\Delta d_R = \frac{C}{\pi} = \frac{200.0\,m}{\pi} = 63.66\,m$$

$$V_{av} = \frac{\Delta d_T}{\Delta t} = \frac{200.0\,m}{13.0\,s} = 15.38\ m/s \simeq 15.4\ m/s$$

$$\vec{V}_{av} = \frac{\Delta \vec{d}_R}{\Delta t} = \frac{63.66\,m\ [E]}{13.0\,s} = 4.90\ m/s\ [E]$$

3) $\Delta\vec{d} = 0.300\,km = 300.\,m$

$\vec{V}_1 = 5.0\ m/s\ [E]$

$\vec{V}_2 = 33.0\ m/s\ [E]$

$\vec{a} = ?$

Let $E = +$

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

$$\therefore \vec{a} = \frac{\vec{V}_2^{\,2} - \vec{V}_1^{\,2}}{2\Delta\vec{d}} = \frac{(33.0\,m/s)^2 - (5.0\,m/s)^2}{2\,(300.\,m)}$$
$$= 1.77\ m/s^2\ [E]$$
$$\simeq 1.8\ m/s^2\ [E]$$

4) $\vec{V}_1 = 305.0\,km/h\ [W] = \frac{305.0\,km}{h} \times \frac{1\,h}{3600\,s} \times \frac{1000\,m}{1\,km} = 84.7\,m/s$

$\vec{a} = 2.7\ m/s^2\ [E]$

$\vec{V}_2 = ?$

$\Delta t = 30.0\,s$

$\Delta\vec{d} = ?$

Let $W = +$

$$\vec{V}_2 = \vec{V}_1 + \vec{a}\Delta t$$
$$= 84.72\ m/s + (-2.7\,m/s^2)(30.0\,s)$$
$$= 3.72\ m/s\ [W]$$

$$\Delta\vec{d} = \vec{V}_1\Delta t + \tfrac{1}{2}\vec{a}\Delta t^2$$
$$= (84.7\,m/s)(30.0\,s) + \tfrac{1}{2}(-2.7\,m/s^2)(30.0\,s)^2 = 1326.6\,m$$
$$\approx 1.3\times10^3 \ldots\ [W]$$

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5] $\vec{V}_1 = 3.00 m/s$ [up]

$\vec{a} = \vec{g} = 9.80 m/s^2$ [down]

$\vec{V}_2 = 0.0$

$\Delta\vec{d} = ?$

Let up = +

$$\Delta\vec{d} = \frac{\vec{V}_2^2 - \vec{V}_1^2}{2\vec{a}} = \frac{0 - (3.00 m/s)^2}{2(-9.80 m/s^2)}$$

$= 0.459 m$ [up]

b) Δt to rise?

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

$$\Delta t = \frac{\vec{V}_2 - \vec{V}_1}{\vec{a}} = \frac{0 - (3.00 m/s)}{(-9.80 m/s^2)}$$

$= 0.31 s$

∴ total time to rise + fall is $2 \times 0.31 s = \underline{\underline{0.62 s}}$

c) $\vec{V}_{final} = 3.00 m/s$ [down] (by symmetry)