2A/B PHYSICS
ASSIGNMENT 2: EQUATIONS OF MOTION

NAME: SOLUTIONS DUE DATE: ______________ TOTAL: ~~41~~ 44

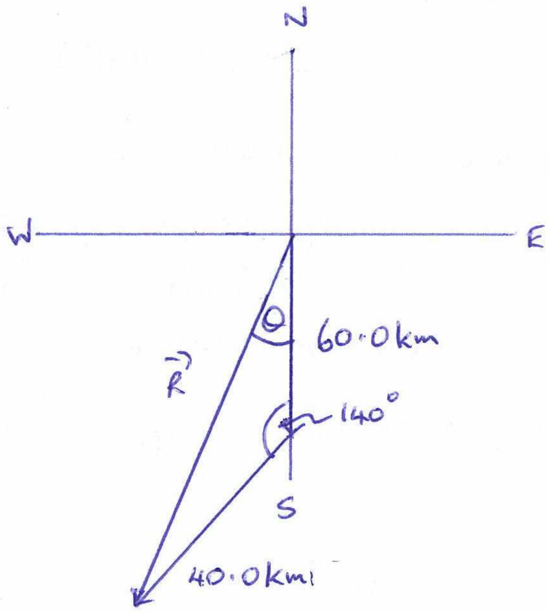
1. During an air race, a competitor leaves the start point and flies at 1.80×10^2 kmh^{-1} due south for 20.0 minutes to reach a small town (A). She then turns to a heading of S 40.0° W and maintains 1.60×10^2 kmh^{-1} for 15.0 minutes to reach town B.

(a) What distance has the competitor covered from the starting point?

$$d = v_1 t_1 + v_2 t_2$$
$$= (1.80 \times 10^2)(0.333) + (1.60 \times 10^2)(0.250) \quad (1)$$
$$= 1.00 \times 10^2 \text{ km}. \quad (1)$$

(2)

(b) What is the displacement of the plane?



$$\vec{R} = \sqrt{(60.0)^2 + (40.0)^2 - 2(60.0)(40.0)\cos 140^\circ}$$
$$= 94.22 \text{ km}. \quad (1)$$

$$\frac{94.22}{\sin 140^\circ} = \frac{40.0}{\sin\theta}$$

$$\Rightarrow \theta = 15.84^\circ. \quad (1)$$

$$\therefore s = 94.2 \text{ km S } 15.8^\circ \text{ W} \quad (1)$$

(3)

(c) Determine the following.

(i) The average speed for the entire journey.

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$
$$= \frac{1.00 \times 10^2}{(0.333 + 0.250)} \quad (1)$$
$$= 1.72 \times 10^2 \text{ kmh}^{-1}. \quad (1)$$

(2)

(ii) The average velocity for the entire journey.

$$V_{ave} = \frac{s}{t}$$

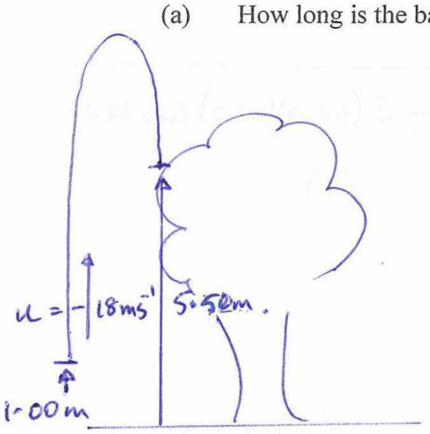
$$= \frac{94.22}{(0.333+0.250)} \quad (1)$$

$$= \underline{1.62\times10^{2}\ \text{kmh}^{-1}\ \text{S}15.8°\text{W}} \quad (1)$$

(2)

2. A boy kicks a football vertically upwards from 1.00 m above the ground at 18.0 ms^{-1}. It rises to its highest point and then falls down, just getting caught on a branch 5.50 m above the ground. (Ignore any sideways movement that has taken place.)

(a) How long is the ball in flight?



↓ +ve

$v = ?$

$u = -18.0\text{ms}^{-1}$

$a = 9.80\text{ms}^{-2}$

$t = ?$

$s = -4.50\text{m}$

$$s = ut + \tfrac{1}{2}at^2$$

$$\Rightarrow -4.50 = -18.0t + \tfrac{1}{2}(9.80t^2) \quad (1)$$

$$\Rightarrow 4.90t^2 - 18.0t + 4.50 = 0.$$

$$\Rightarrow t = \frac{18.0 \pm \sqrt{(-18.0)^2 - 4(4.90)(4.50)}}{2(4.90)} \quad (1)$$

$$= 3.404\text{ s or } 0.2698\text{s}.$$

$$\therefore \underline{t = 3.40\text{s}}. \quad (1)$$

~~(2)~~ (3)

(b) What is the maximum height to which it rises?

Consider to top only.

↓ +ve.

$v = 0.0\text{ms}^{-1}$

$u = -18.0\text{ms}^{-1}$

$a = 9.80\text{ms}^{-2}$

$t = ?$

$s = ?$

$$v^2 = u^2 + 2as \quad (1)$$

$$\Rightarrow 0 = (-18.0)^2 + 2(9.80)s \quad (1)$$

$$\Rightarrow s = -16.53\text{m}.$$

∴ Height = 17.5m above the ground. (1)

~~(2)~~ (3)

(c) What is its velocity as it strikes the branch?

Consider whole motion.

↓ +ve

$v = ?$

$u = -18.0\text{ms}^{-1}$

$a = 9.80\text{ms}^{-2}$

$t = 3.40\text{s}$

$s = ?$

$$v = u + at$$

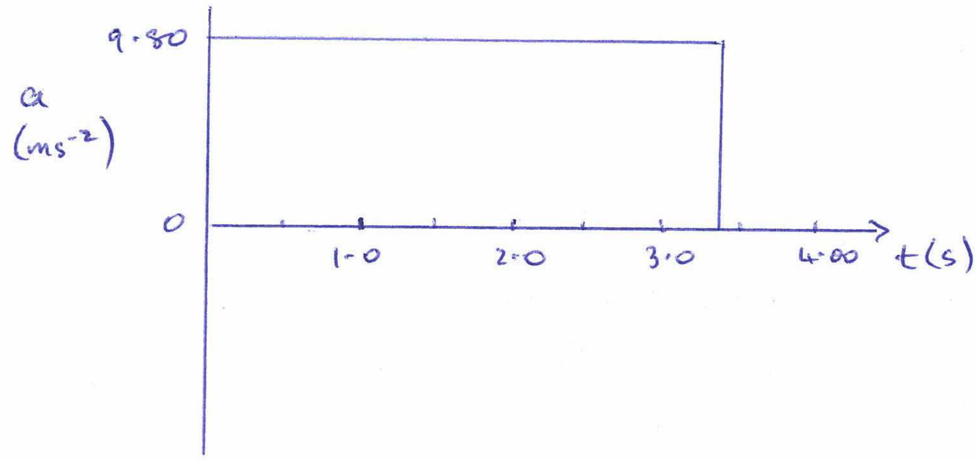
$$= -18.0 + (9.80)(3.40) \quad (1)$$

$$= \underline{15.3\text{ms}^{-1}\ \text{down}}. \quad (1)$$

(2)

(d) Draw the following graphs (with suitable scales) for this motion.

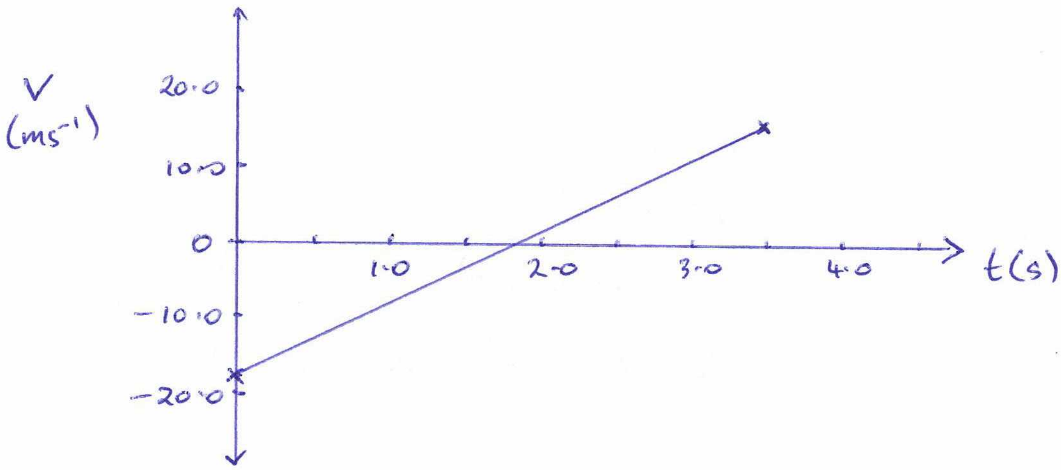
(i) acceleration - time



Accuracy (1)
Scales (1).

(2)

(ii) velocity - time



(2)

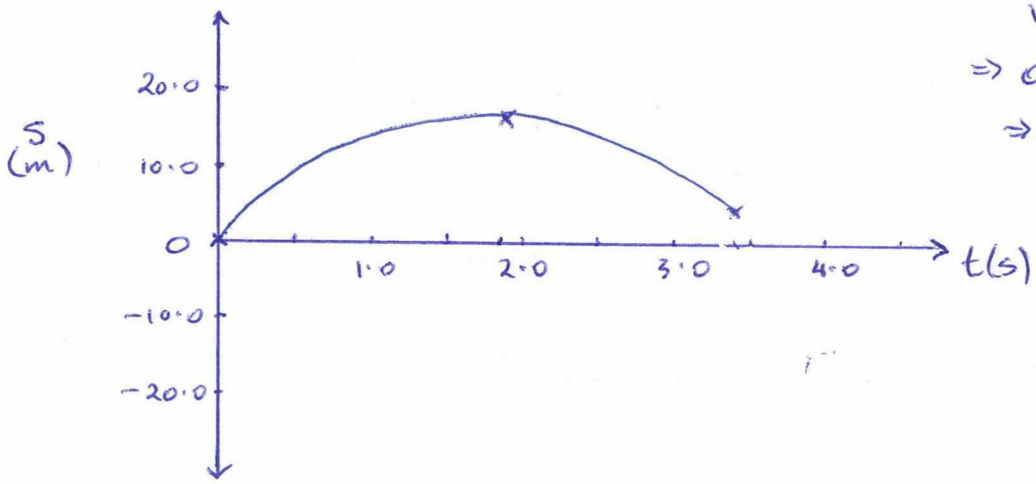
(iii) displacement - time

Calculate time to top.

$v = u + at$

$\Rightarrow 0 = -18{\cdot}0 + 9{\cdot}80t$

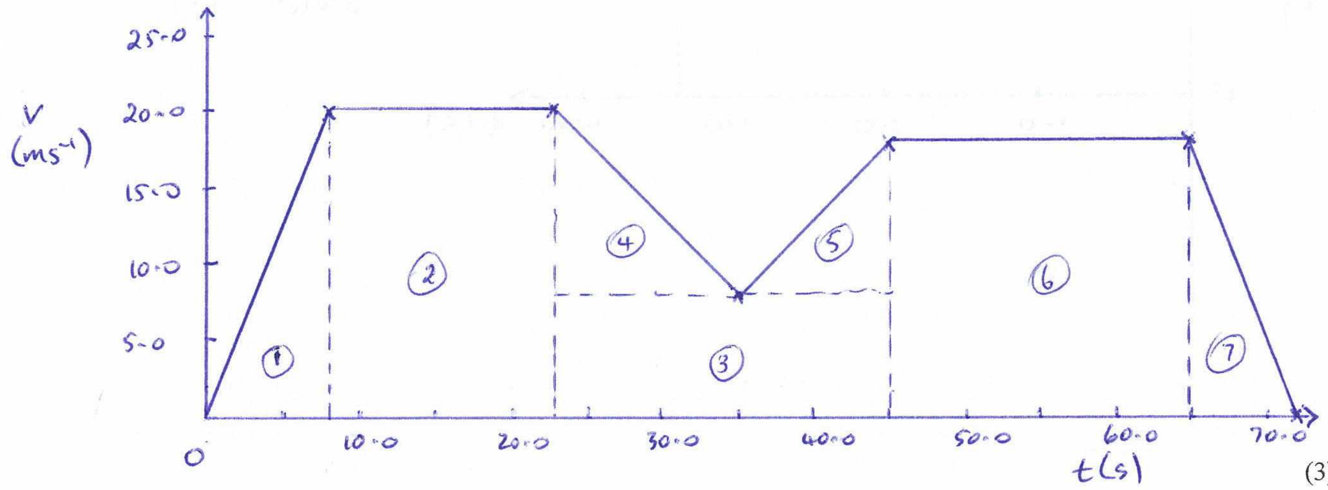
$\Rightarrow t = 1{\cdot}84\,s.$



(2)

3. A car moves off from a standing start with a uniform acceleration. It reaches 20.0 ms^{-1} after 8.00 s before maintaining its speed for another 15.0 s. As it approaches a set of lights, it brakes uniformly to 8.00 ms^{-1} over 12.0 s before accelerating uniformly again (as the light turned green) to 18.0 ms^{-1} in 10.0 s. It maintains this speed for 20.0 s before decelerating uniformly to a stop (at a stop sign) over the next 7.00 s. (Assume the movement has occurred on a straight road.)

(a) Draw a velocity - time graph for the entire motion.



(3)

(b) Calculate:

(i) the acceleration at the start of the motion.

Forwards +ve

$v = 20.0\,ms^{-1}$

$u = 0.0\,ms^{-1}$

$a = ?$

$t = 8.00\,s$

$s = ?$

$v = u + at$

$\Rightarrow 20.0 = 0 + a(8.00)$ (1)

$\Rightarrow a = 2.50\,ms^{-2}$ forwards (1)

(2)

(ii) the deceleration as the car approached the second set of lights.

Forwards +ve

$v = 8.00\,ms^{-1}$

$u = 20.0\,ms^{-1}$

$a = ?$

$t = 12.0\,s.$

$s = ?$

$v = u + at$

$\Rightarrow 8.00 = 20.0 + a(12.0)$ (1)

$\Rightarrow a = -1.00\,ms^{-2}$

$\therefore$ Deceleration $= 1.00\,ms^{-2}$ backwards. (1)

(2)

(c) From the graph, determine the displacement of the car over the entire motion.

$s =$ area under the graph

$= \frac{1}{2}(8{\cdot}00)(20{\cdot}0) + (15{\cdot}0)(20{\cdot}0) + (22{\cdot}0)(8{\cdot}00) + \frac{1}{2}(12{\cdot}0)(12{\cdot}0)$ (3)

$+ \frac{1}{2}(10{\cdot}0)(10{\cdot}0) + (20{\cdot}0)(18{\cdot}0) + \frac{1}{2}(7{\cdot}00)(18{\cdot}0)$

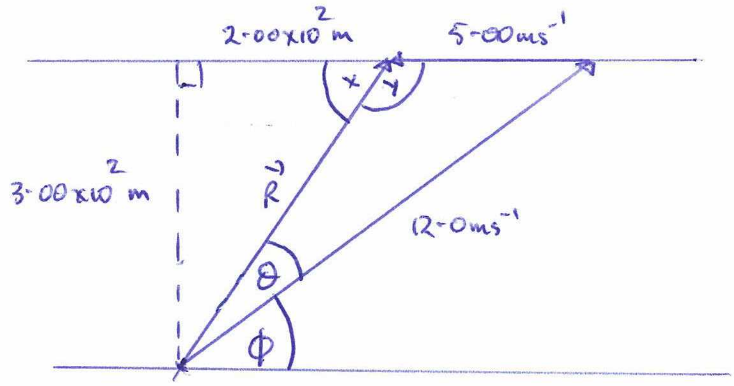
$= 1{\cdot}101 \times 10^{3}$ m.

$\therefore$ $s = 1{\cdot}10 \times 10^{3}$ m forwards. (1)

(4)

4. A river 3.00×10^2 m wide flows at 5.00 ms^{-1}. A person in a boat that can travel at 12.0 ms^{-1} in still water wants to reach a jetty 2.00×10^2 m upstream on the opposite bank.

(a) Draw a vector diagram showing this situation.



(2)

(b) Determine the angle to the bank upstream that the boat must head in order to reach the jetty.

$\tan x = \frac{3{\cdot}00 \times 10^2}{2{\cdot}00 \times 10^2}$

$\Rightarrow x = 56{\cdot}31^\circ$ (1)

$\Rightarrow y = 123{\cdot}7^\circ$. (1)

$\frac{12{\cdot}0}{\sin 123{\cdot}7^\circ} = \frac{5{\cdot}00}{\sin\theta}$

$\Rightarrow \theta = 20{\cdot}28^\circ$. (1)

From the diagram: $\theta + \phi = x$

$\Rightarrow \phi = 56{\cdot}31^\circ - 20{\cdot}28^\circ$

$= 36{\cdot}03^\circ$ (1)

$\therefore$ Must head at $36{\cdot}0^\circ$ to the bank upstream.

(4)

(c) How long does it take for the boat to reach the jetty?

Find the velocity component across the river.

i.e. $V_{across} = 12{\cdot}0 \cos(z+\theta)$

$= 12{\cdot}0 \cos 54{\cdot}0^{\circ}$. ms^{-1}. (1)

$V_{across} = \dfrac{S_{across}}{t}$

$\Rightarrow \quad t = \dfrac{S_{across}}{V_{across}}$ (1)

$= \dfrac{3{\cdot}00 \times 10^{2}}{12{\cdot}0 \cos 54{\cdot}0^{\circ}}$ (1)

$= 42{\cdot}53 \text{ s}$.

~~(3)~~ (4)

$\therefore$ Time taken $= 42{\cdot}5$ s. (1)