Mercedes College

Semester One Examination 2012

PHYSICS
Stage 3

Write your name here

ANSWERS — PM

Time allowed for this paper

Reading time before commencing work: ten minutes
Working time for paper: two and a half hours

Materials required/recommended for this paper

To be provided by the supervisor
This Question/Answer Booklet
Formulae and Constants Sheet

To be provided by the candidate
Standard items: pens, pencils, eraser, correction fluid, ruler, highlighters

Special items: non-programmable calculators satisfying the conditions set by the Curriculum Council for this course. Graphics calculators may **not** be used.

Important note to candidates

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

MARKS SUMMARY

Section One (60 marks = 37.5%)	Section Two (90 marks= 50%)	Section Three (25 marks= 12.5%)	Total Mark (175)	Final %

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Short answers	16	16	60	60	37.5
Section Two: Extended Answer	6	6	65	90	50
Section Three: Comprehension and Data Analysis	1	1	25	25	12.5
					100

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 12 Information Handbook 2012.* Sitting this examination implies that you agree to abide by these rules.

2. Write your answers in this Question/Answer Booklet.

3. Working or reasoning should be clearly shown when calculating or estimating answers.

4. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

5. The "Formula and Constants Sheet" may be used as required.

6. All final numerical answers should be expressed to **three** (3) significant figures and include the appropriate **units**.

Section One (Short Answer) **60 marks = 37.5% of total**

Answer all 16 questions in this section. Write your answers in the space provided.

Question 1

a) What is the speed of a satellite in a stable orbit 390 km above the surface of the earth? **[3 marks]**

$R = R_e + h = 6.37 \times 10^6 + 390 \times 10^3$

$= 6.76 \times 10^6$ m (1)

$v^2 = \frac{GM_e}{r} = \frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24}}{6.76 \times 10^6}$ (1)

So $v^2 = 5.90 \times 10^7$

$\therefore v = 7.68 \times 10^3$ ms^{-1} (1)

b) "The acceleration due to the Earth's gravity at the height of the orbit is only slightly less than at the surface of the earth".

Do you agree or disagree with this statement? Justify your answer. **[2 marks]**

Agree

(1) $g = \frac{GM_e}{R^2} = \frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24}}{(6.76 \times 10^6)^2}$

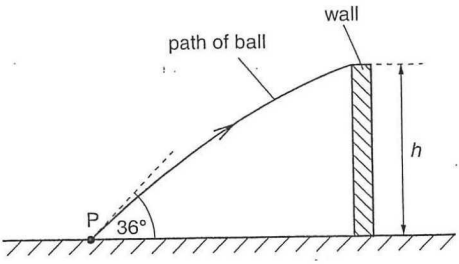
$= 8.73$ ms^{-2}

on surface $g_e = 9.80$ ms^{-2} (1)

ie only slightly less

Question 2

A ball is thrown from a point **P**, which is at ground level, as illustrated in the diagram below.



The initial velocity of the ball is 12.4 ms^{-1} at an angle of 36° to the horizontal. The ball just passes over a wall of height ***h***. The ball reaches the wall 0.17 seconds after it has been thrown.

Assume air resistance is negligible.

a) Calculate the horizontal distance of point **P** from the wall.

$v_H = v\cos\theta = 12.4 \cdot \cos 36 = 10.03\ ms^{-1}$ **[2 marks]**

$R = v_H \cdot t$ (1)

$= 10.03 \times 0.17$

distance $= 1.71$ m (1)

b) What is the height ***h*** of the wall?

vertical displacement at $t = 0.17s$

$u = 12.4 \sin 36 = 7.29\ ms^{-1}$ (1) **[3 marks]**

$a = -9.8$

$t = 0.17$

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

$= (7.29 \times 0.17) - 4.9 \times 0.17^2$ (1)

ie height of wall $= 1.10$ m (1)

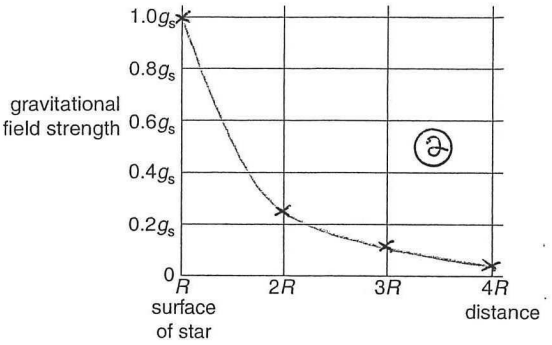
Question 3

An isolated star has a radius **R**. The mass of the star may be considered to be a point mass at the centre of the star.

The gravitational field strength at the surface of the star is $\mathbf{g_S}$.

On the grid below, sketch a graph to show the variation of the gravitational field strength of the star with distance from its centre. You should consider distances in the range **R** to **4R**.

[3 marks]



$g \propto \frac{1}{R^2}$

R	1.0
2R	0.25
3R	0.11
4R	0.063

Question 4

A young child of mass 20 kg stands at the centre of a uniform horizontal platform which rotates at a constant speed of 4.3 ms^{-1}. The child begins to walk radially outwards the edge of the platform. The maximum frictional force between the child and the platform is 200 N.

What is the maximum distance from the centre of the platform to which the child could walk without the risk of slipping? **[3 marks]**

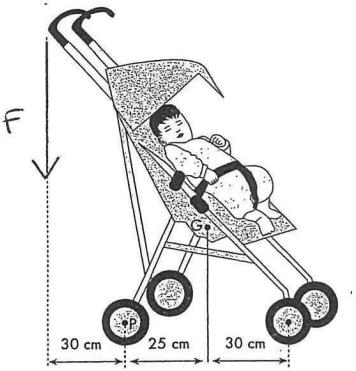
$F_c = \frac{mv^2}{r} =$ friction (1)

ie $200 = \frac{20 \times 4.3^2}{r}$

$r = \frac{20 \times 4.3^2}{200} (1) = \frac{1.85 \text{ m}}{(1)}$

Question 5

A pram and baby together weigh 135 N. The diagram below shows the position of the centre of gravity (**G**) of the baby and pram.



In order to lift the front wheels up and over a kerb on a footpath whilst moving forwards, the person pushing the pram must exert a downward force (**F**) on the handle. Calculate the minimum value of **F**. **[3 marks]**

Taking moments about P

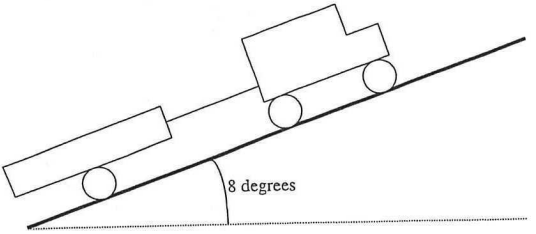
$\Sigma CW = \Sigma ACW$ (1)

$135 \times 0.25 = F \times 0.30$ (1)

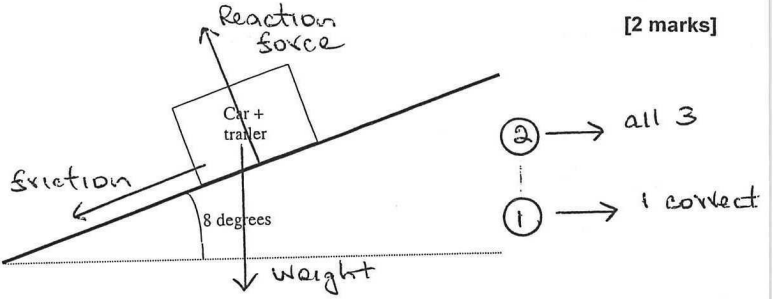
$\therefore F = \frac{135 \times 0.25}{0.30} = \frac{113 \text{ N}}{(1)}$

Question 6

The diagram shows a car towing a boat on a trailer up a ramp. The total mass of the car, boat and trailer is 3000 kg.



a) On the following simplified diagram, show all **three** forces acting on the car and trailer together. **[2 marks]**



b) If the car is moving at a constant velocity, what is the **resultant** of these three forces? **[1 mark]**

resultant force = 0 (1)

c) Show that the frictional force between the wheels of the car and the ramp has a value of about 4000 N. **[3 marks]**

component of weight W acting down slope = $W \sin\theta$ (1)

$= 3000 \times 9.8 \times \sin 8^\circ$

$= 4.09 \times 10^3$ N (1)

Since net force = 0

friction = 4.09×10^3 N (1)

(ie approximately 4000 N)

Question 7

A velodrome is an oval-shaped cycle track, parts of which are steeply banked. The riders in the picture are travelling at 14.8 ms^{-1} and the radius of curvature of the banked track is 32 m.

a) Why is the track banked on a steep angle? **[2 marks]**

By having the track at an angle the reaction force exerted by the tracks on the bike will have a horizontal component acting towards the centre (1)

⇒ this will provide the centripetal force needed for the cyclist to move around the curve at high speed

ie less dependence on friction to provide F_c (1)

b) If the bikes shown in the diagram have no tendency to slide up or down the slope, calculate the value of the banking angle θ. **[2 marks]**

$$\tan\theta = \frac{v^2}{gr}$$

$$= \frac{14.8^2}{9.8 \times 32} \quad (1) = 0.6984$$

$$\therefore \theta = 34.9^0 \quad (1)$$

Question 8

A mass is suspended by a 90 cm long rope attached to a spring balance that initially reads 14.0 N as shown in **diagram 1**.

The mass is pulled to one side and then released as shown in **diagram 2**.

Diagram 1

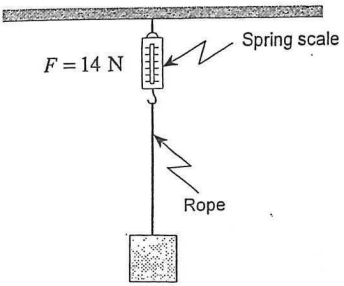
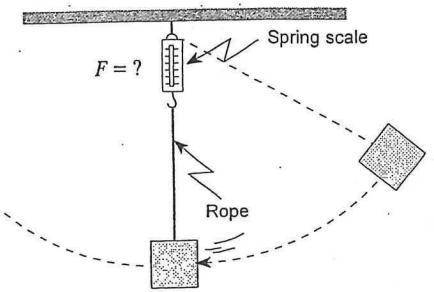


Diagram 2



As the mass passes through the vertical point it has a velocity of 2.45 ms^{-1}.

What is the reading on the spring balance at this instant?

4
~~[3~~ marks]

$W = mg$

$\therefore m = \frac{14}{9.8} = 1.43\ kg$ (1)

$F_c = R - W$

so $R = F_c + W$

$= \frac{mv^2}{r} + mg$ (1)

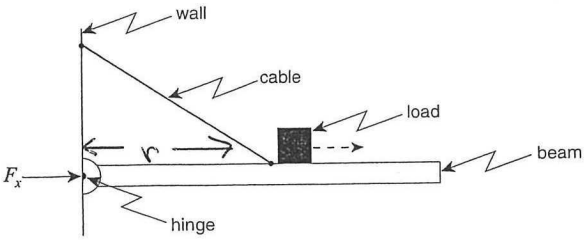
$= \frac{1.43 \times 2.45^2}{0.90} + 14.0$ (1)

$= 9.54 + 14.0$

ie reading $= \underline{23.5\ N}$ (1)

Question 9

A load is supported on a uniform beam as shown in the diagram below.



The load is now moved to the **right**.

a) Which of one of the following best describes what happens to the tension force in the cable and the horizontal force exerted by the hinge on the beam?
Write the letter of your answer in the box at the right.

② D

[2 marks]

	TENSION FORCE F_T	HORIZONTAL FORCE F_x
A.	Decrease	Decrease
B.	Decrease	Increase
C.	Increase	Decrease
D.	Increase	Increase

b) Briefly explain your choice.

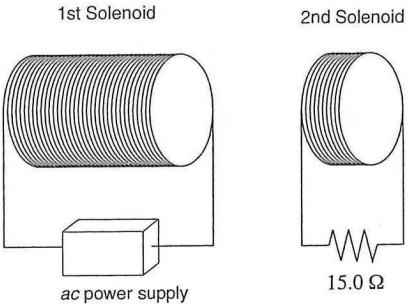
[2 marks]

Moving the load to the right will increase the CW torque. To remain in equilibrium, the ACW torque ($= T\sin\theta . r$) must increase. Since the distance r is fixed the tension in the cable must increase. ①

This means that the horizontal component of T (acting to the left) must also increase ie F_x must also increase ①

Question 10

Two solenoids, placed side by side as shown, are functioning as an ideal transformer. The first solenoid has 230 turns and the second has 46 turns. An AC power supply provides the first solenoid with a current of 0.35 A.



What current flows in the second solenoid? **[3 marks]**

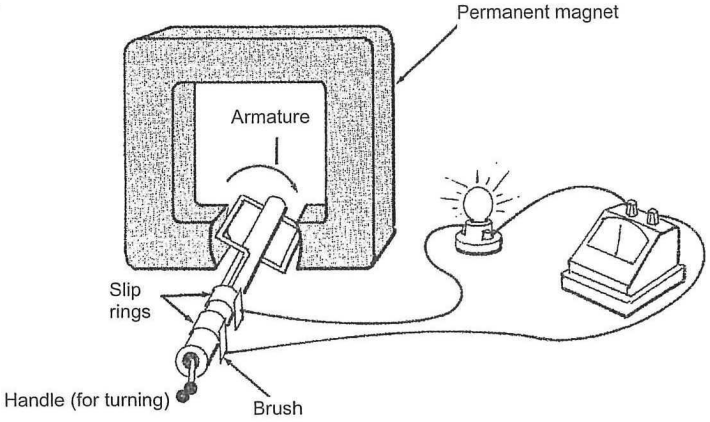
$$\frac{N_S}{N_P} = \frac{V_S}{V_P} = \frac{I_P}{I_S} \quad (1)$$

$$\frac{46}{230} = \frac{0.35}{I_S} \quad (1)$$

ie $$I_S = \frac{0.35 \times 230}{46} = 1.75\ A \quad (1)$$

Question 11

The diagram below shows a simple generator. The coil is rotated in the magnetic field and an induced EMF is produced.



a) Does the diagram show an **AC** generator or a **DC** generator? Justify your answer.

[2 marks]

(1) AC — only has slip rings (1)

There is no split ring commutator to reverse the current.

b) Which of the following changes will produce a **larger voltage** output from the generator? **Tick** your answers.

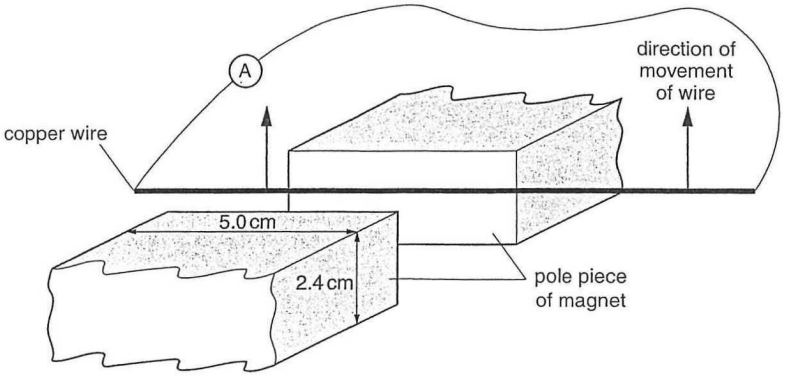
Increase the number of turns of wire on the armature of the generator	✓
Reduce the strength of the magnetic field	
Rotate the armature at a slower rate	
Increase the cross-sectional area of the armature	✓

(2)

[2 marks]

Question 12

A stiff copper wire is connected to a sensitive ammeter as shown in the diagram below. A student moves the wire at a constant speed of 1.80 ms^{-1} between the poles of a horseshoe magnet in a direction parallel to the faces of the poles.



The magnetic field in the region between the poles is uniform and has strength of 89 mT.

a) Calculate the magnitude of the EMF induced in the wire as it is moved between the poles of the magnet. **[2 marks]**

induced EMF $= vlB$ (1)

$= 1.80 \times 0.05 \times 89 \times 10^{-3}$

$= 8.01 \times 10^{-3}$ V (1)

b) To determine the **direction** in which the current induced in the copper wire flows, what piece of **additional** information is needed? **[1 mark]**

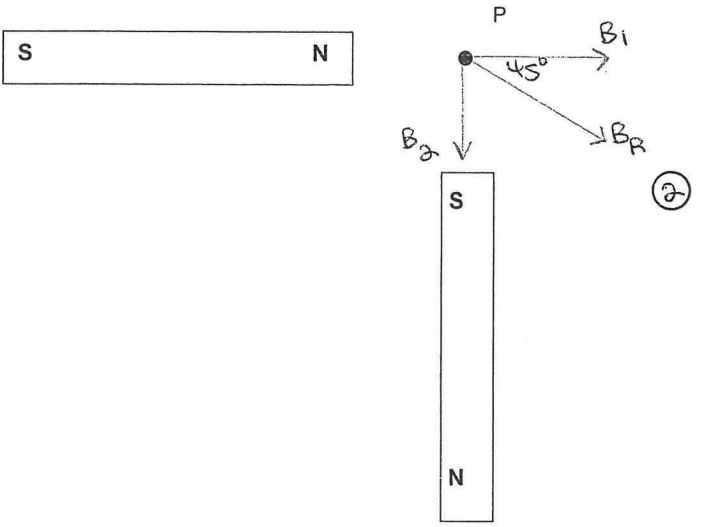
direction of the magnetic field

ie which pole is N & which is S. (1)

Question 13

Two identical bar magnets of the same strength are arranged at right angles and are an equal distance from point **P**, as shown in diagram 1.

Diagram 1



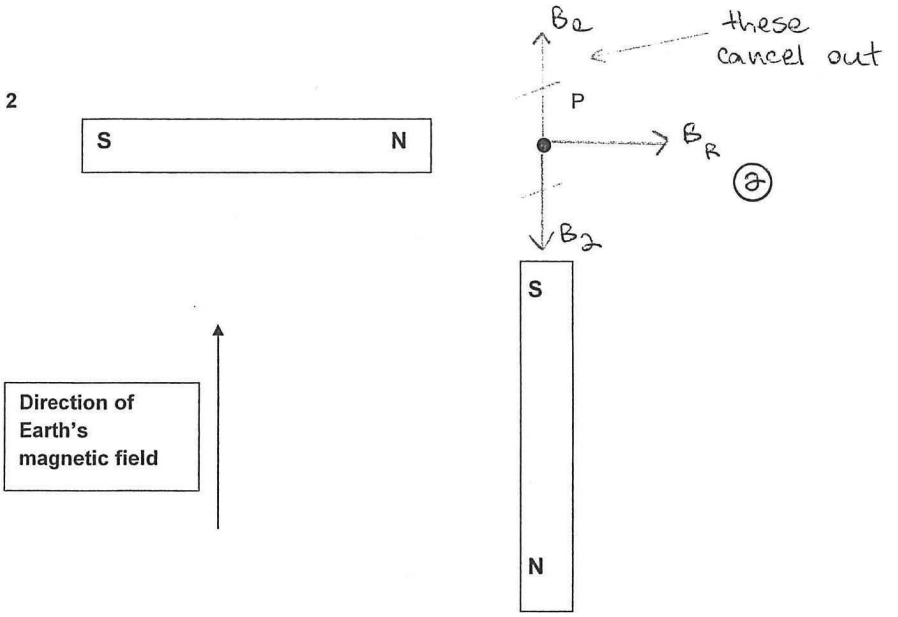
a) At point **P** on the diagram, draw an arrow indicating the direction of the combined magnetic field of the bar magnets. Ignore the effects of the Earth's magnetic field.

[2 marks]

The bar magnets are replaced by two much weaker magnets. The two new magnets are still identical to each other. They are arranged in the same way as before; with point **P** still an equal distance from each magnet.

The magnitude of the magnetic field of a **single** bar magnet at point **P** is the same as the magnitude of the magnetic field of the Earth at point **P**. The direction of the Earth's magnetic field is shown in diagram 2.

Diagram 2



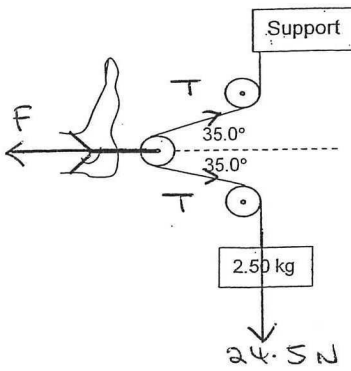
b) At point P on diagram 2, draw an arrow indicating the direction of the combined magnetic field of the bar magnets and Earth.

[2 marks]

Question 14

In a hospital, a traction device is used to apply a horizontal force to a patient's foot. A single cord goes around three fixed pulleys. One end of the cord is attached to a 2.50 kg load and the other end is tied to a rigid support. The middle pulley is attached to the patient's ankle and pulls it as shown.

Calculate the magnitude of the force exerted on the patient's ankle. Assume the pulleys are frictionless.



$F_{left} = F_{right}$ ①

$F = T\cos 35 + T\cos 35$

$= 2T\cos 35$

$= 2 \times 24.5 \times \cos 35$ ①

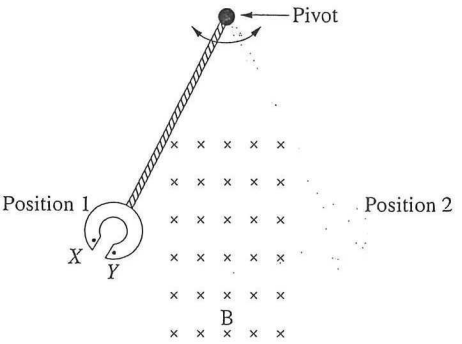
force F = 40.1 N

①

[3 marks]

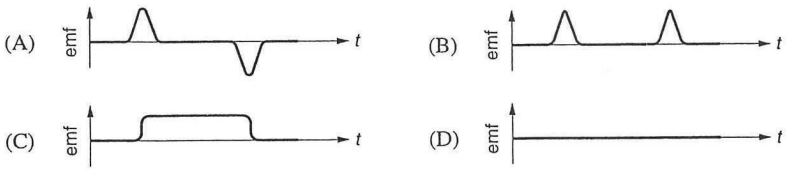
Question 15

A heavy copper split ring is attached by a light insulating rod to a pivot to form a pendulum. A region of uniform magnetic field B is present as shown. As the pendulum swings from Position 1 to Position 2, the induced EMF in the ring is measured between points X and Y.



a) Which graph best represents the measured EMF during the time that the pendulum swings from Position 1 to Position 2? Write the letter of your answer in the box provided.

A



[2 marks]

b) Give a brief explanation for your answer.

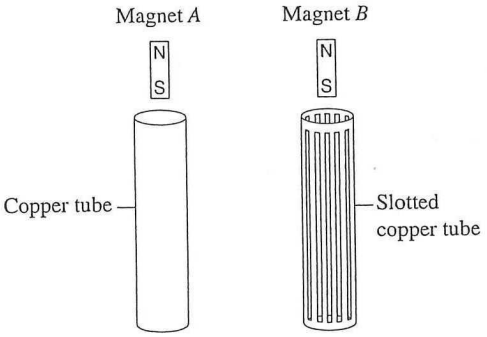
The direction of the induced EMF must reverse as the copper ring leaves the field

ie increase in flux on entry
decrease in flux on exit

[1 mark]

Question 16

Identical magnets **A** and **B** are suspended above vertical copper tubes as shown in the diagram.



The magnets are dropped at the same time. Each magnet falls straight through its tube without touching the tube walls.

Which magnet leaves its tube first and why?

[3 marks]

Maguet B will fall faster (1)

Both maguets will induced a current in the coppex tube as it falls ($\Delta\phi$ occurs)

The induced current will produce a maguetic field which will oppose the motion of the maguet ie slow it down (1)

The slotted coppex tube will have a higher electrical resistance & so the induced current will be smallex ⟶ smallex maguetic field will be created. (1)

End of Section One

Section Two: Extended Answer **90 marks = 50 %**

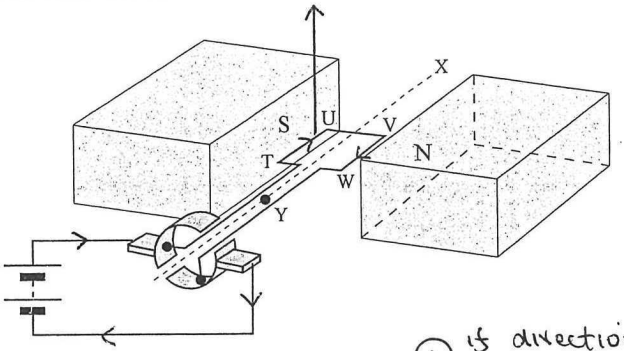
This section has six (6) questions. You must answer all questions. Write your answers in the spaces provided.

Question 17

The diagram below represents a simple DC electric motor. The square loop **TUVW** consists of 140 turns and has a side of length 0.09 m and is free to rotate about the axis **XY**.

Current is supplied from a battery via the split-ring commutator. Two permanent magnets provide a uniform magnetic field of 0.25 T in the region of the coil.

The current flowing in the coil is 1.65 A.



(1) if direction of current is reversed

a) What is the direction of the force acting on side **TU** of the coil?

upwards (2)

[2 marks]

b) What is the magnitude of the total magnetic force acting on side **TU** of the coil?

$F = N(ILB)$ (1)

$= 140 \times 1.65 \times 0.09 \times 0.25$ (2)

$= 5.20\ N$ (1)

[4 marks]

c) What is the magnitude and direction of the maximum torque exerted on the coil?

[3 marks]

maximum torque $\tau = 2(F \times r)$ (1)

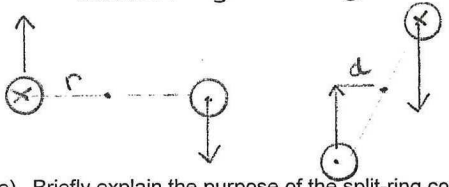
$= 2 \times 5.20 \times \frac{0.09}{2}$ (1)

$= 0.468$ Nm cw (1)

d) The coil of wire does **not** rotate at a constant rate. Why not?

[3 marks]

(1) The torque varies as the armature rotates — the distance from the line of action of the force to the axis decreases (1)



$d < r$

so τ will be smaller (1)

e) Briefly explain the purpose of the split-ring commutator.

[3 marks]

Commutator reverses the direction of current flow in the armature every (1) ½ - rotation

⇒ torque will always act in the same direction (1)

ie the armature will rotate continuously in the same direction (1)

f) Which of the following alterations to the simple motor will make the coil turn **faster**? Tick your answers.

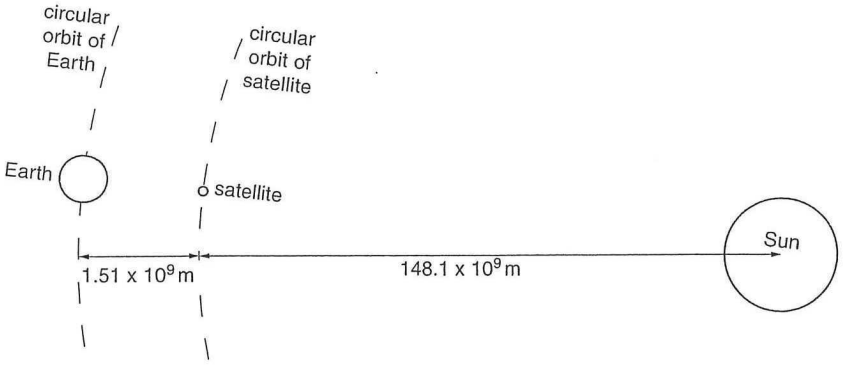
Replace the original coil with a new coil of 60 turns	
Increase the current to 2.25 A	✓
Use rare earth magnets which increases the strength of the magnetic field	✓
Reduce the friction in the pivots	✓

(3)

[3 marks]

Question 18

A satellite of mass 200 kg is placed between the Earth and the Sun. The satellite is at a distance of 1.51×10^9 m from the centre of the Earth and a distance of 148.1×10^9 m from the centre of the Sun, as shown in the diagram below.



The speed of the satellite is adjusted so that it orbits the Sun with a period of 1 year (= 3.1526×10^7 s). The rocket motor is then switched off. The satellite then orbits round the Sun in a circle, keeping constant the distances between the satellite, the Earth and the Sun.

a) What is the centripetal acceleration of the satellite as it orbits the Sun? [4 marks]

$$v = \frac{2\pi r}{T} = \frac{2\pi \times 148.1 \times 10^9}{3.1526 \times 10^7} = 2.95 \times 10^4 \text{ ms}^{-1}$$ (1)

$$a_c = \frac{v^2}{r} = \frac{(2.95 \times 10^4)^2}{148.1 \times 10^9}$$ (1)

$$= 5.88 \times 10^{-3} \text{ ms}^{-2}$$ (1)

use $g = \frac{GM_S}{R^2}$ $\longrightarrow$ 6.05×10^{-3} ms^{-2}

b) Calculate the magnitude of the gravitational force exerted on the satellite by the Earth. **[2 marks]**

$$F = \frac{Gm_1m_2}{r^2}$$

$$= \frac{6.67 \times 10^{-11} \times 200 \times 5.98 \times 10^{24}}{(1.51 \times 10^{9})^2} \quad (1)$$

$$= 3.50 \times 10^{-2} \text{ N} \quad (1)$$

c) Calculate the magnitude of the gravitational force exerted on the satellite by the Sun. **[2 marks]**

$$F = \frac{Gm_1m_2}{r^2}$$

$$= \frac{6.67 \times 10^{-11} \times 200 \times 1.99 \times 10^{30}}{(148.1 \times 10^{9})^2} \quad (1)$$

$$= 1.21 \text{ N} \quad (1)$$

d) Hence, determine the **magnitude** and **direction** of the resultant force exerted on the satellite. **[3 marks]**

net force $= 1.21 - 3.50 \times 10^{-2}$ (1)

$= 1.18$ N towards the Sun (1) (1)

The radius of orbit of Venus around the Sun is 1.08×10^{11} m.

e) Calculate the time (in Earth days) for Venus to complete a single orbit around the Sun. **[5 marks]**

$$v^2 = \frac{GM_S}{R}$$

$$\left(\frac{2\pi R}{T}\right)^2 = \frac{GM_S}{R}$$

ie $$R^3 = \frac{GM_S}{4\pi^2} \cdot T^2$$

$$T^2 = \frac{4\pi^2 R^3}{GM_S} \quad (2)$$

$$= \frac{4\pi^2 \times (1.08 \times 10^{11})^3}{6.67 \times 10^{-11} \times 1.99 \times 10^{30}} \quad (2)$$

$$= 3.75 \times 10^{14}$$

$$\therefore \quad T = 1.94 \times 10^{7} \text{ sec} = \underline{224 \text{ days}} \quad (1)$$

$$v^2 = \frac{GM_S}{R} \quad (1) \longrightarrow v = 3.506 \times 10^{4} \text{ ms}^{-1} \quad (2)$$

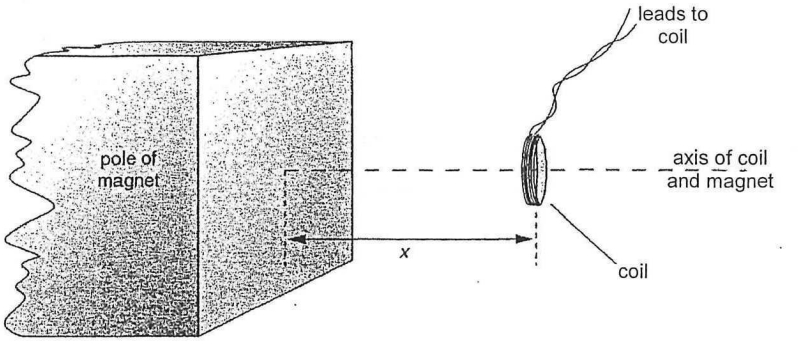
$$v = \frac{2\pi r}{T}$$

$$T = \frac{2\pi r}{v} \quad (1) = \frac{2\pi \times 1.08 \times 10^{11}}{3.506 \times 10^{4}}$$

ie $$T = \underline{1.94 \times 10^{7} \text{ sec}} \quad (1)$$

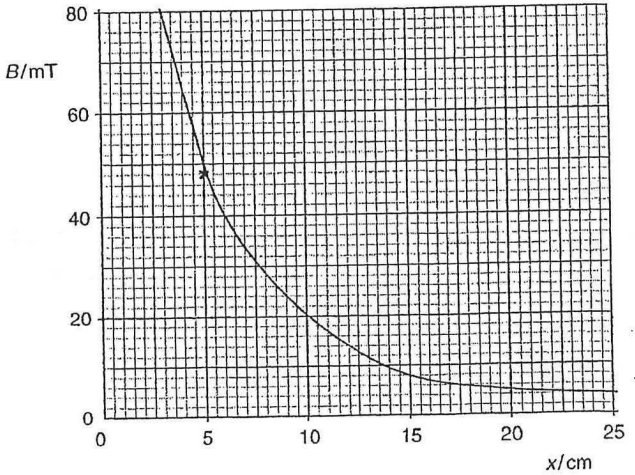
Question 19

A small coil is positioned so that its axis lies along the axis of a large bar magnet, as shown in the diagram below.



The coil has a cross-sectional area of 0.40 cm^2 and contains 150 turns of wire.

The strength of the magnetic field **B** (measured in mT) varies with the distance **x** (measured in cm) between the face of the magnet and the plane of the coil, as shown in the graph below.



a) The coil is 5.0 cm from the face of the magnet. Use the graph to determine the strength of the magnetic field at the position of the coil.

48 mT ②

[2 marks]

b) The coil is moved along the axis of the magnet so that the distance **x** changes from **x** = 5.0 cm to **x** = 15.0 cm in a time of 0.25 seconds.

Use Faraday's Law to calculate the (average) EMF induced in the coil during this time.

[6 marks]

For $x = 5$ $\quad \phi_1 = BA = 48\times10^{-3} \times 0.40\times10^{-4}$ (1)

$= 1.92\times10^{-6}$ Wb

For $x = 15$ $\quad \phi_2 = BA = 8\times10^{-3} \times 0.40\times10^{-4}$

$(B = 8\text{ mT})$ $\quad = 3.20\times10^{-7}$ Wb (1)

$\Delta\phi = \phi_2 - \phi_1 = 3.2\times10^{-7} - 1.92\times10^{-6}$

$= -1.60\times10^{-6}$ Wb (1)

induced EMF $= -\dfrac{N\Delta\phi}{\Delta t}$ (1)

$= -\dfrac{150\times(-1.60\times10^{-6})}{0.25}$ (1)

$= +9.60\times10^{-4}$ V (1)

c) The induced EMF is observed to remain **constant** during the 0.25 second period of time.

Which of the following statements correctly describes the **speed** of the coil during this time?

Write the letter corresponding to your answer in the box.

A. The coil moves with an increasing speed

B. The coil moves with a constant speed

C. The coil moves with a decreasing speed

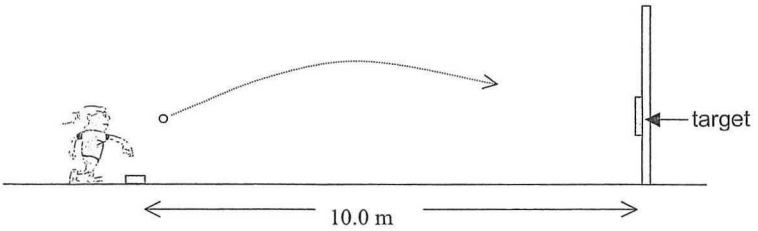
B

(1)

[1 mark]

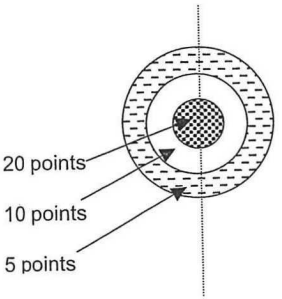
Question 20

A girl throws a golf ball at a target marked on a wall 10.0 m in front of the throwing line. As she releases the ball, her hand is level with the centre of the target.



The ball leaves her hand with a velocity of 11.9 ms^{-1} at an angle of 20.0 degrees above the horizontal.

The target, as shown here, consists of concentric circles with diameters of 20 cm, 40 cm and 60 cm. The arrows show the scoring.



a) Calculate the time taken for the golf ball to strike the target. **[3 marks]**

$v_H = v\cos\theta = 11.9 \times \cos 20$

$= 11.18\ ms^{-1}$ (1)

$R = v_H \cdot t$

$\therefore t = \frac{R}{v_H} = \frac{10.0}{11.18} = 0.894\ sec$

(1) (1)

b) Calculate how many points the girl should score. Assume the golf ball lands on the vertical dotted line. **[Hint: find the vertical displacement of the ball]**

[6 marks]

Find the vertical displacement

$u = 11.9 \times \sin 20 = 4.07 \text{ ms}^{-1}$ (1)

$a = -9.8$

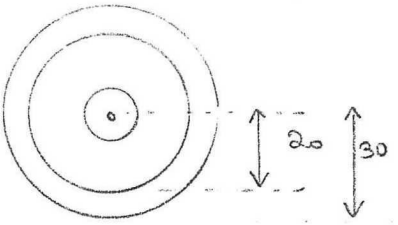
$t = 0.894$ sec

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

$$= (4.07 \times 0.894) - 4.9 \times 0.894^2$$

$$= -0.278 \text{ m}$$ (3)

ie approx 28 cm below centre of target



Since the displacement is > 20cm but less than 30cm

she will score 5 points (2)

c) A second throw lands just below the target. State and explain one change that she could make so that her next throw will get a better score.

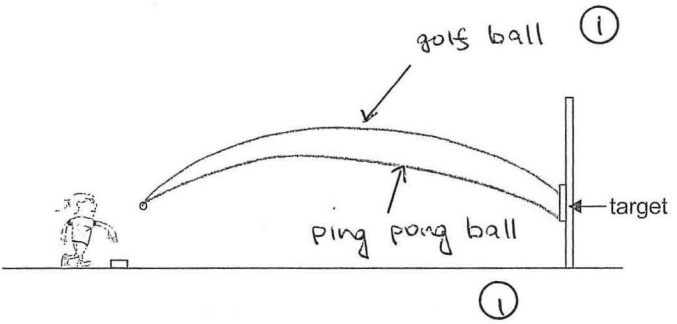
(1) Change: throw at a greater angle to the horizontal

Explanation: vertical component will ↑ so ball will be in air longer → will not have dropped as much in covering 10 m distance (1)

[2 marks]

d) The girl is then given a table tennis (ping-pong) ball to throw from the same position, and she manages to hit the target. However, it follows a different path from the golf balls.

On the diagram below, sketch and label the approximate trajectories of the golf ball and the table tennis ball.



(1) (1)

Briefly explain why the table tennis ball follows a different path.

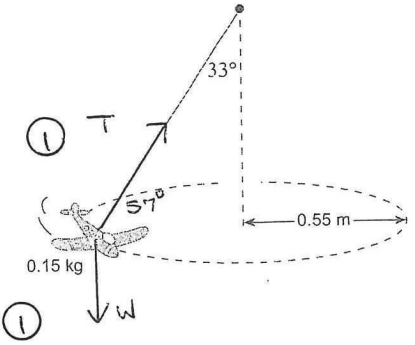
Ping pong ball is much lighter than the golf ball → will be more affected by air resistance (1)

ie smaller maximum height, shorter range (1)

[4 marks]

Question 21

A 0.15 kg toy airplane is suspended as shown. It travels in a horizontal circle at a constant speed.



(1) (1)

-1 for any additional forces shown

a) Show the direction of the forces acting on the airplane as it moves in the horizontal circle. Make sure you label each force clearly.

[2 marks]

b) Calculate the **tension** in the string which supports the toy airplane.

[3 marks]

$F_{up} = F_{down}$

$T\sin 57 = W$ (1)

ie $T = \frac{mg}{\sin 57} = \frac{0.15 \times 9.8}{\sin 57}$ (1)

ie tension $T = 1.75\ N$ (1)

c) Determine the **speed** of the airplane as it moves in the horizontal circle.

[Hint: remember that the horizontal component of the tension in the string is equal to the centripetal force acting on the airplane]

[4 marks]

$F_H = T\cos\theta = 1.75 \times \cos 57$

$= 0.955\ N$ (1)

Since $F_H = F_C = \frac{mv^2}{r}$

$v^2 = \frac{F_c \cdot r}{m} = \frac{0.955 \times 0.55}{0.15}$ (2)

$v^2 = 3.50$

so $v = 1.87\ ms^{-1}$ (1)

d) Hence, calculate the **period** of the motion of this airplane. **[3 marks]**

$$v = \frac{2\pi r}{T} \quad (1)$$

$$T = \frac{2\pi r}{v}$$

$$= \frac{2\pi \times 0.55}{1.87} \quad (1)$$

$$\text{Period} = 1.85 \text{ sec} \quad (1)$$

e) As the speed of the airplane increases will the angle between the string and the vertical (shown as 33° in the diagram) increase, stay the same or decrease? Explain your answer. **[3 marks]**

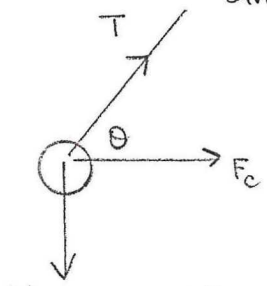
increasing $v \longrightarrow F_c$ will increase

ie T_H will increase (1)

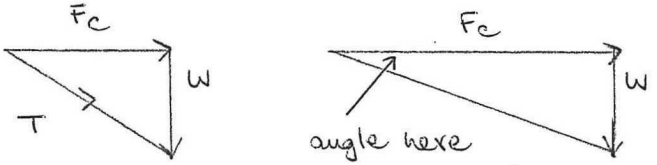
Since $T_H = T\cos\theta$

$\cos\theta$ must increase $\longrightarrow$ (1) θ is smaller

ie angle to the vertical must increase (1)



OR



ie further from the vertical

Question 22

The Muja power station (near Collie) generates at a total of 1040 MW from its 8 generators. There are four 60 MW generators and four 200 MW generators.

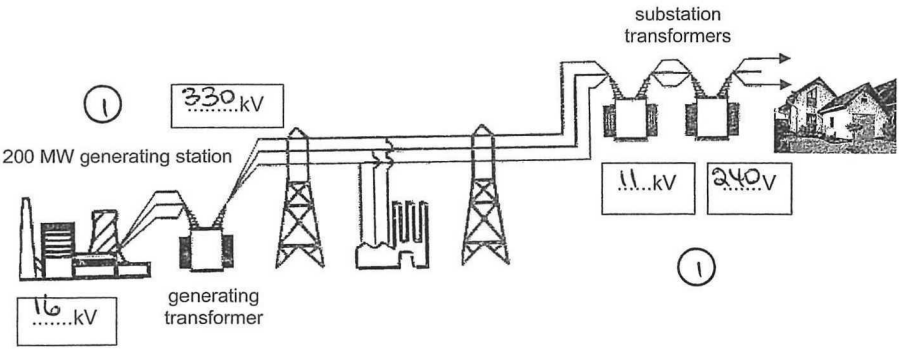
The 60 MW generators produce power at 11.6 kV and the 200 MW generators produce power at 16 kV.

Generators feed the electricity produced into transformers where the voltage can be increased or decreased.

Before the electricity is distributed, transformers step up the voltage to 330 kV. On the outskirts of Perth there is a sub-station that reduces the voltage to 11 kV and in the local park there is a further small transformer that reduces the voltage to 240 V.

a) On the diagram below show the voltages at the different stages of transmission. **Write the values in the appropriate boxes.**

[2 marks]



b) Explain why the generator is designed to produce alternating current and not direct current.

[2 marks]

alternating current (AC) allows transformers to be used to either increase or decrease the voltage during the transmission ②

c) Calculate the current generated in **one** of the 200 MW generators. **[2 marks]**

$P = VI$

$200 \times 10^6 = 16 \times 10^3 \cdot I$ (1)

$I = \frac{200 \times 10^6}{16 \times 10^3} = 1.25 \times 10^4$ A (1)

d) Explain why the voltage is increased to 330 kV before it is distributed to users. **[3 marks]**

By increasing the voltage to 330 kV the current flowing in the transmission lines is reduced (1)

Since the power loss during transmission

$P_{loss} = I^2R$ (1)

a smaller current will result in less energy being wasted as heat during transmiss (1)

ie more efficient

e) Calculate the turns ratio (N_S:N_P) of a transformer used to increase the voltage from a 60 MW generator to 330 kV. **[3 marks]**

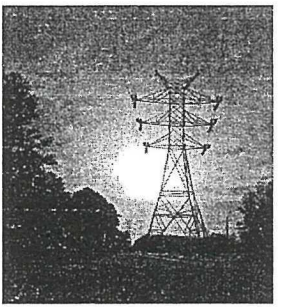
$\frac{N_S}{N_P} = \frac{V_S}{V_P} = \frac{330 \times 10^3}{11.6 \times 10^3}$ (1)

(1)

$= 28.4$ to 1

(1)

f) The power lines shown in the diagram below are carrying the **total power** output from the Muja power station through 330 kV high voltage lines.



What is the size of the current flowing through these high voltage cables? **[3 marks]**

$P = VI$

$1040 \times 10^6 = 330 \times 10^3 \cdot I$ (1)

$I = \frac{1040 \times 10^6}{330 \times 10^3}$ (1)

$= 3.15 \times 10^3$ A (1)

g) The transformers used to change the voltage are usually less than 100 % efficient. Give **two** reasons for the loss of energy in the operation of a transformer.

1st reason	heat loss due to resistance of wire in primary & secondary coil (1)
2nd reason	heat loss due to Eddy currents induced in the core (1)

* sound produced due to vibrations **[2 marks]**

End of Section Two

Section Three: Comprehension and Data Analysis **25 marks = 12.5 %**

This section contains one (1) question. You must answer all parts of the question. Write your answers in the spaces provided.

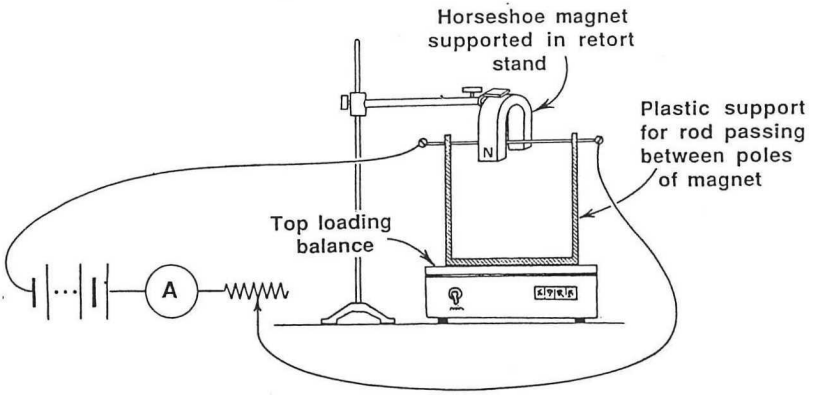
Question 23

Magnetic Forces

An investigation was conducted to examine the relationship between the magnetic force experienced by a conductor and the current flowing in it.

The experiment is set up as shown in the diagram below.

A rigid copper rod carrying an electric current is suspended between the poles of a magnet, and the force exerted on the rod is measured by a sensitive electronic balance.



When the trial is ready to begin the "Tare" button on the electronic balance is pressed. This zeros the reading on the balance. The current was varied by adjusting the variable resistor (rheostat). Three trials were conducted for each value of the current used.

The following results were obtained:

	Trial 1	Trial 2	Trial 3		
Current (A)	**Balance reading (kg)**	**Balance reading (kg)**	**Balance reading (kg)**	**Average balance reading (kg)**	**Average force exerted (N)**
2.0	**0.013**	**0.014**	**0.012**	0.013	1.27
3.0	**0.019**	**0.018**	**0.018**	0.018	0.176
4.0	**0.024**	~~0.019~~	**0.023**	0.024	0.235
5.0	**0.030**	**0.032**	**0.029**	0.030	0.294
6.0	**0.035**	**0.035**	**0.034**	0.035	0.343
7.0	**0.041**	**0.040**	~~0.050~~	0.041	0.402
8.0	**0.047**	**0.046**	**0.048**	0.047	0.461

(2)

 (2)

a) What was the independent variable in this experiment?

current in the copper wire (1)

[1 mark]

b) Why did the students carry out three trials for each current used?

improve reliability of results (1)

determine average, get more consistency (1)

[2 mark]

c) What are three (3) important variables which should have been controlled in this experiment?

1st variable	same magnet	(1)
2nd variable	same copper rod	(1)
3rd variable	same balance / ammeter	(1)

[3 marks]

d) Determine a **reliable** value for the "average balance reading" for each current used and show this in the 5th column of the table.

see table ✓

[2 marks]

e) Calculate the value of the **average force** for each current used. Remember that F = mg where g = 9.80 ms^{-2}. Show this value in the 6th column of the table. Express the values to 3 significant figures.

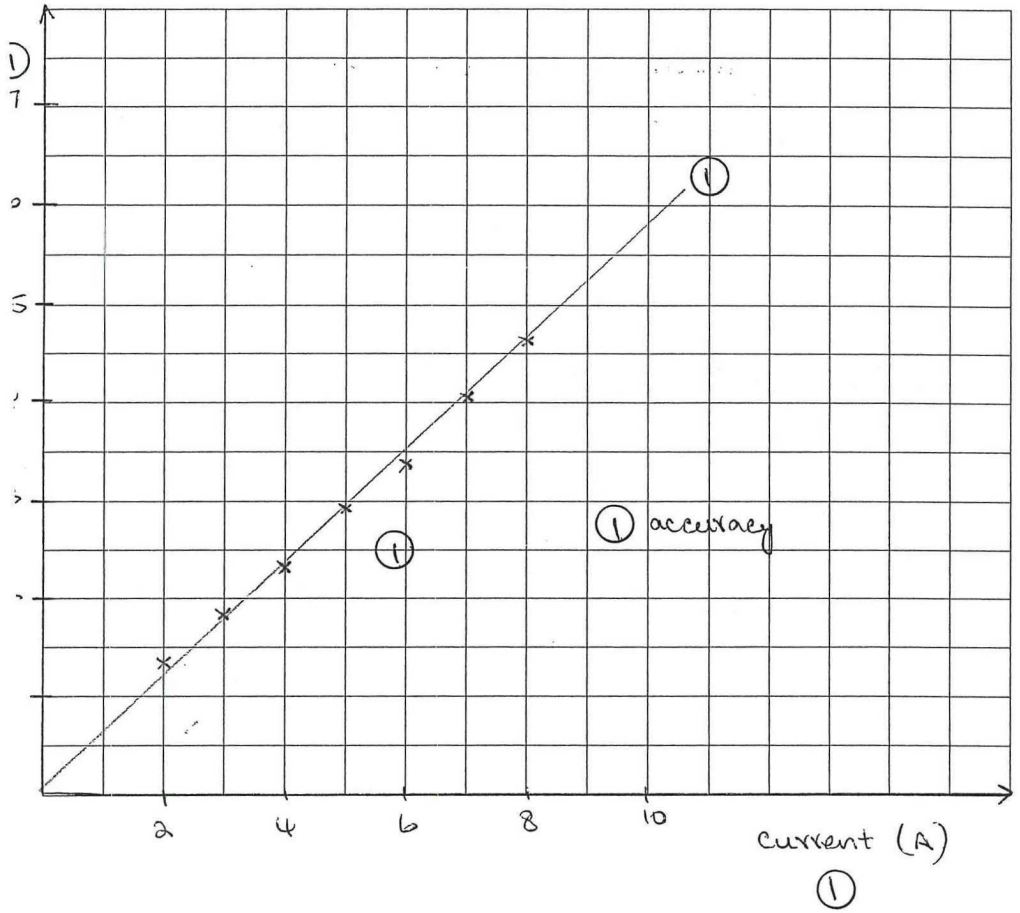
see table ✓

[2 marks]

f) Plot this data on the graph grid provided. Show the current on the horizontal axis.

Draw a line of best fit.

[5 marks]



g) Determine the gradient of the linear graph. Include the appropriate units. Give the value to 3 significant figures.

[4 marks]

$$\text{gradient} = \frac{\text{Rise}}{\text{Run}}$$

$$= \frac{0.461}{8} \quad (1)$$

$$= 5.75 \times 10^{-2} \ \text{NA}^{-1} \quad (1)$$

(2)

h) Using the **gradient** of the graph determine the strength of the magnetic field of the horseshoe magnet used in this experiment. The length of wire in the field is 36.5 mm.

Express the value for the field strength to 3 significant figures.

[4 marks]

$F = ILB = (LB)I$

gradient $= LB$ (1)

$B = \frac{\text{gradient}}{L} = \frac{5.75 \times 10^{-2}}{36.5 \times 10^{-3}}$ (2)

$= 1.58\ T$ (1)

(range $1.55 \longrightarrow 1.61\ T$)

i) Sometimes when this experiment is carried out, the reading obtained on the electronic balance is **negative**. What is one modification which could be made to the equipment used to overcome this problem?

[2 marks]

reverse direction of current (2)

reverse direction of magnetic field

End of Section Three