



ALL SAINTS'
COLLEGE

WACE PHYSICS Stage 3

Semester 1 Examination, 2014

Question/Answer Booklet

Student Number: In figures

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In words

Time allowed for this paper

Reading time before commencing work: ten minutes

Working time for paper: three 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, mathaid

Special items: non-programmable calculators satisfying the conditions set by the SCSA for this course.

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.

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 response	15	15	50	54	30
Section Two: Problem-solving	9	9	90	90	50
Section Three: Comprehension	1	1	40	36	20
				180	100

Raw exam score: _____

_____%

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 12 Information Handbook 2010*. Sitting this examination implies that you agree to abide by these rules.
2. Write answers in this Question/Answer Booklet.
3. You must be careful to confine your responses to the specific questions asked and follow any instructions that are specific to a particular question.
4. Working or reasoning should be clearly shown when calculating or estimating answers. It is suggested that answers to calculations are given to 3 significant figures.

When you are required to estimate show your working or reasoning clearly. Give final answers to a maximum of 2 significant figures and include appropriate units.

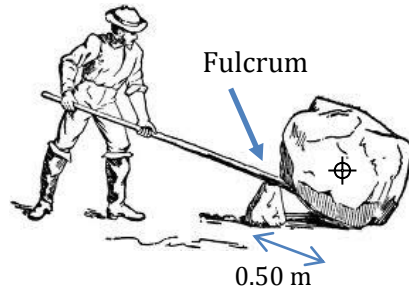
5. A spare page is included at the end of the booklet. It can be used for planning your responses and/or as additional space if required to continue an answer.
 - Planning: If you use the spare pages for planning, indicate this clearly.
 - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Refer to the question(s) where you are continuing your work.

Section One: Short response**30% (54 Marks)**

Answer **all** questions. Write your answers in the space provided. Suggested working time for this section is 50 minutes.

Question 1**(4 marks)**

A rigid lever is placed under a 300 kg rock. A fulcrum is placed at 0.50 m from the end of the lever (and centre of mass of the rock), placing the lever at 30.0° above the horizontal.



Estimate the minimum magnitude of force that must be applied to the end of the lever to lift the rock vertically upward? (Assume the force is exerted at one point).

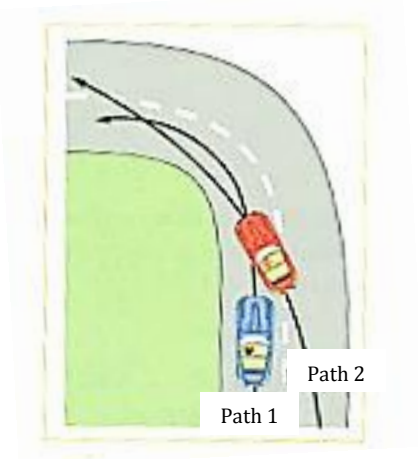
Question 2**(4 marks)**

A golf ball rolls along the ground at 4.00 m s^{-1} West. It then strikes a pole and rebounds at 3.00 m s^{-1} South. Calculate the change in velocity of the golf ball with reference to a vector diagram.

Question 3

(3 marks)

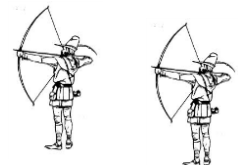
Racing car drivers routinely cut corners, as shown by the racing line (Path 2) in the diagram below. Explain how taking Path 2 allows the curve to be taken at greater speed than Path 1.



Question 4

(3 marks)

Two archers fire identically shaped arrows towards a target. The initial launch speed and angles are equal but one arrow is twice as massive as the other. They are discussing which arrow will have better range. Explain the physics principles for range in terms of 'no air resistance' and 'air resistance'.



Question 5**(5 marks)**

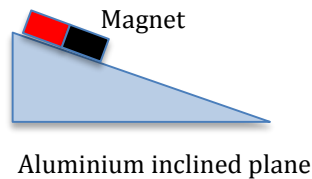
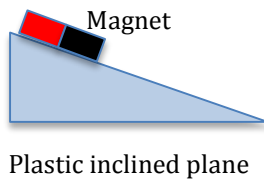
A farmer needs to supply an AC electric pump with high voltage but only has a 240 V domestic supply available. He uses a transformer with 400 turns of wire on the primary stage to step up the voltage to 3.30 kV. Assume that the transformer is 100 % efficient in terms of magnetic flux linkage between the coils but only 89.0 % efficient in terms of power transfer. The transformer has an electrical power output of 4.85 kW.

a) Calculate the number of turns required on the secondary winding. (2)

b) Calculate the current draw on the primary stage of the transformer. (3)

Question 6**(3 marks)**

Two identical bar magnets are placed on frictionless inclined planes that have the same dimensions. One inclined plane is made of plastic, the other is aluminium. The bar magnets are released together and slide down. Explain which magnet will reach the bottom first referring to physics principles.

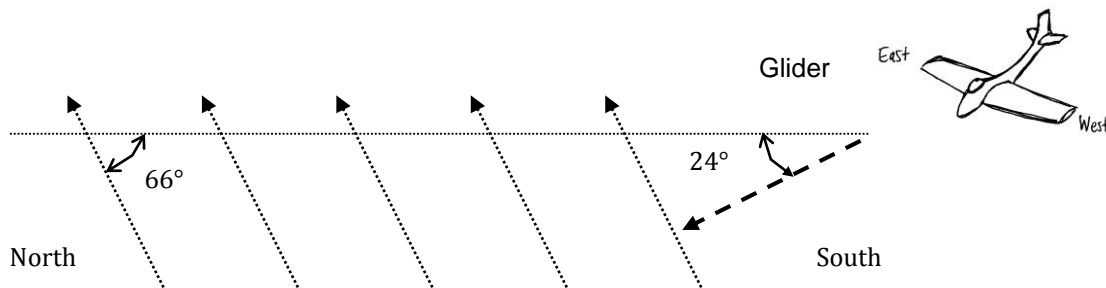


Question 7**(3 marks)**

Explain, making reference to the domain theory of magnetism, why a permanent magnet can pick up a steel paper-clip, even though the paper-clip is not a permanent magnet.

Question 8**(4 marks)**

An aluminium glider with a wingspan of 22.0 m is flying due North over Perth where the Earth's magnetic field has a flux density of $5.50 \times 10^{-5} \text{ T}$ at an angle of dip 66° to the horizontal. The pilot starts her descent with a velocity of 56.0 m s^{-1} at an angle of 24° to the horizontal.

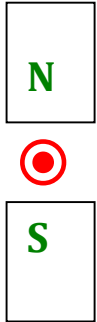


a) Calculate the potential difference between the tips of each wing of the glider. (2)

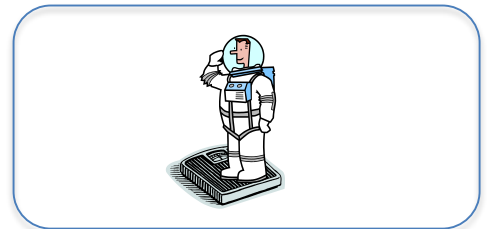
b) On which wing tip (East or West) would there be a build-up of electrons? Explain briefly. (2)

Question 9**(3 marks)**

The diagram below shows a piece of wire that is carrying a current passing through a magnetic field. The current in the wire is 2.00 A, the flux density of the magnet is $10.0 \mu\text{T}$ and the length of the wire in the field is 7.00 cm. Calculate the force exerted on the wire and show its direction on the diagram.

**Question 10****(3 marks)**

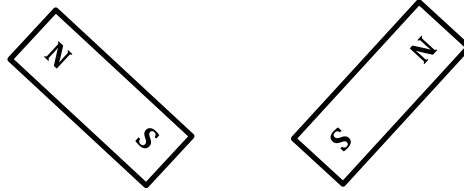
To simulate the apparent weightlessness of space orbit, astronauts are trained in the hold of a cargo aircraft that is accelerating downward at 'g'. Why will the astronauts appear to be weightless, as measured standing on a bathroom scale, in this accelerated frame of reference?



Question 11

(3 marks)

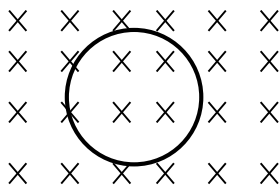
Sketch the magnetic field lines that would be established in the bar magnet configuration below and state whether the magnets are likely to attract, repel or remain stationary if set on a low friction surface.



Question 12

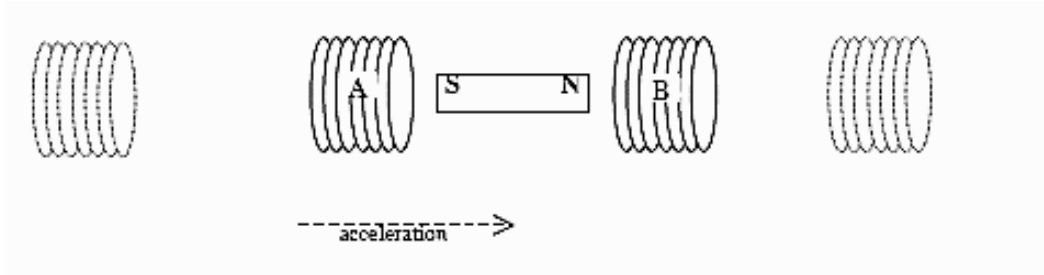
(4 marks)

A circular coil consists of 200 turns of copper wire. It has a radius of 5.00 cm and a uniform magnetic field of flux density 120 mT is threaded through the coil. The magnetic field reduces by 75% in a time of 15.0 ms. Calculate the emf generated in the coil and show the direction of induced current on the diagram.



Question 13

(4 marks)



A coil gun (above) accelerates a magnetic probe through a series of current carrying coils. The direction of the current through each coil is able to be reversed as the magnet travels through it. For the instant shown, current is flowing through coils marked A and B.

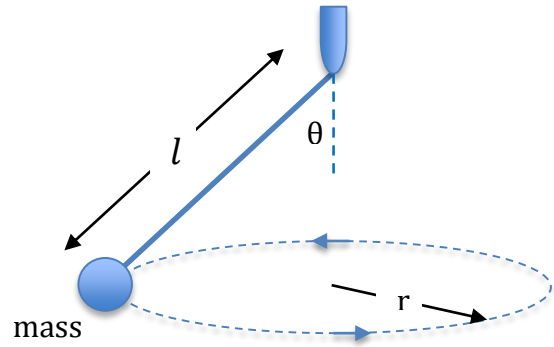
- (a) On the diagram above, draw (for the instant shown), the field lines through the centre of coils A and B which would result in an acceleration of the magnet to the right. (2)

- (b) State the direction of the current flowing in each coil if viewed through the coils from the right hand side of the page. (2)

Question 14**(4 marks)**

Consider a mass moving in uniform horizontal circular motion at the end of a string. It is straightforward to measure the length of the string (l) and the period of rotation (T). Show by algebraic derivation that the horizontal radius (r) is related to the period and the length by the following expression:

$$r = \sqrt{l^2 - \frac{g^2 T^4}{16 \cdot \pi^4}}$$



Question 15

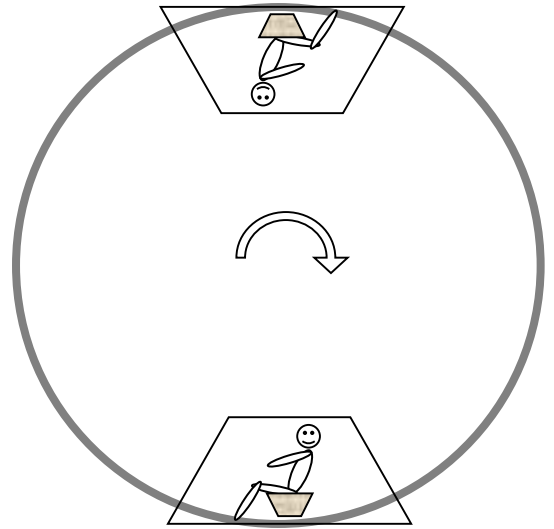
(4 marks)

Pilots are trained to withstand high accelerations by riding in a capsule that can move in vertical circles at a constant speed.

A pilot of mass of 85 kg travels in a vertical circle of diameter 28.0 m

It takes 4.75 s to complete one revolution in a circle.

Calculate the sensation of apparent weight that a pilot experiences at the top of the circle and express this as a percentage of his normal weight on Earth.



End of Section One

Section Two: Problem Solving**50% (90 Marks)**

Answer **all** questions. Write your answers in the space provided. Suggested working time for this section is 90 minutes.

Question 1**(16 marks)**

When riding around a corner (on flat ground), a cyclist will naturally 'lean into' the corner.

(a) Explain with the aid of a vector diagram why this is so.

(3)

(b) A cyclist leans in towards the centre of a 150 m radius bend, so that there is an angle of 12.0° between her body and the vertical. Calculate her speed with reference to a vector diagram.

(4)

Track cycling takes place in an arena called a velodrome, as shown in the picture below. Velodromes have steeply banked curves. Banking in the curves, called superelevation, allows riders to keep their bikes relatively perpendicular to the surface while riding at speed. When travelling through the turns, riders' speeds may exceed 85.0 km h^{-1} .



(c) Explain, with the aid of a diagram, how a banked curve allows track cyclists to travel at higher speeds than they would be able to on a flat track.

(4)

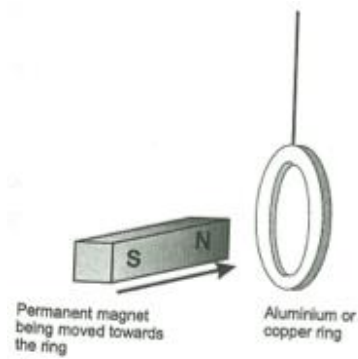
- (d) A velodrome track has a radius of 20.0 m and a cyclist is travelling at 61.2 km h^{-1} on the track. Calculate the angle the track would need to be banked at if centripetal force is derived only from the normal reaction force. (3)

- (e) Explain, by comparing two vector diagrams, why the actual velodrome track would not need to be banked as sharply as calculated in part (d). (2)

Question 2

(7 marks)

The north pole of a magnet is brought towards a circular metal ring that hangs freely from a vertical string, as shown in the diagram below.



- (a) Show the direction of induced current in the ring by drawing an arrow on the diagram and labelling it current. (1)

- (b) What type of magnetic pole (north or south) would be set up on the side of the ring closest to the magnet? (1)

- (c) Explain why current is produced in the ring. (3)

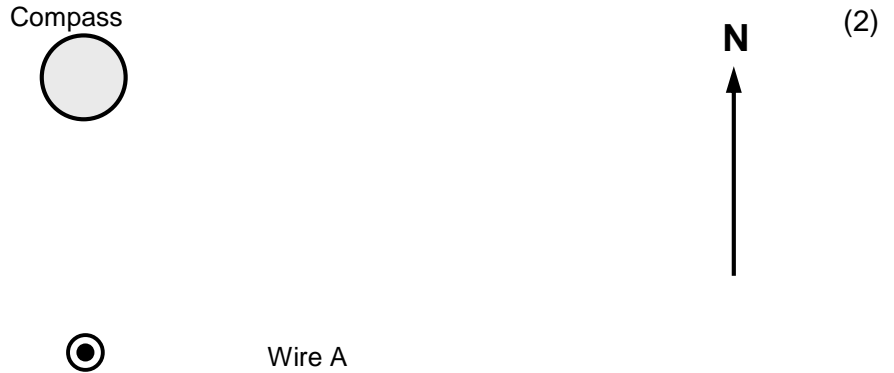
- (d) Describe and explain any motion of the ring as the magnet approaches. (2)

Question 3

(5 marks)

The diagram below represents the current in a wire 'A' looking down from above the wire. This experiment is conducted near the equator where the flux density is $55.5 \mu\text{T}$. The Geographic North Pole of the Earth is towards the top of the page and is aligned with the magnetic pole. A small compass is placed to the North of the wire, as shown.

- a. Draw in four field lines around the wire, to indicate the magnetic flux formed by the current in the wire. (2)



- b. Inside the compass, draw an arrow to show the direction of the resultant field. At this location the strength of the field from the wire is double that of the field from the Earth. (1)

- c. Put the letter 'X' on the diagram to show a location where the resultant flux density is equal to zero. (1)

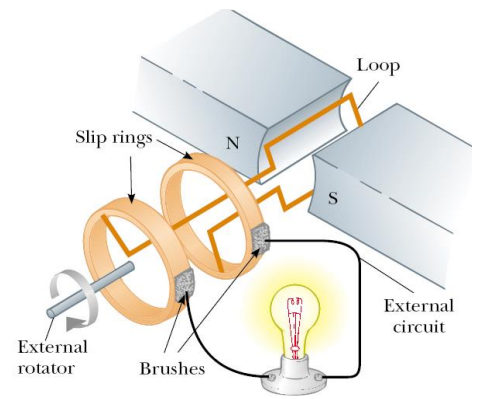
- d. State the direction of force acting on the wire by circling a response below. (1)

North South East West Into page Out of page

Question 4**(5 marks)**

An AC generator is shown in the diagram.

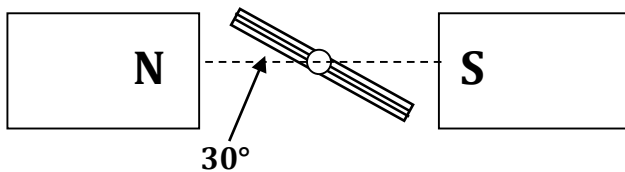
- The loop is a rectangle 15.0 cm long by 8.00 cm wide.
- The loop has 120 turns of copper wire.
- The loop is rotating at a constant rate of 5400 rpm
- The uniform magnetic flux density between the magnetic poles is 834 mT



- a) Calculate the approximate average emf output from this generator by considering a rotation of the coil through $\frac{1}{4}$ of a turn from maximum flux contained in the coil to zero flux contained in the coil.

(3)

At one instant during rotation the plane of coil makes an angle of 30° with the magnetic field lines as shown in the diagram below:



- b) Determine the value of the *instantaneous emf* in this position as a percentage (%) of the *maximum emf* for this generator.

(2)

Question 5**(9 marks)**

Mars has two moons, Phobos and Deimos which move around it in orbits very close to the planet's surface. These satellites of Mars are so tiny that they were not discovered until 1877.

The orbit of Phobos can be assumed to be circular and has a semimajor axis (radius) of 9378 km and a period of 7 hours and 39 minutes. This information can be used to calculate the mass of Mars.

(a) Calculate the circumference of the orbit of Phobos.

(2)

(b) Calculate the speed of Phobos.

(3)

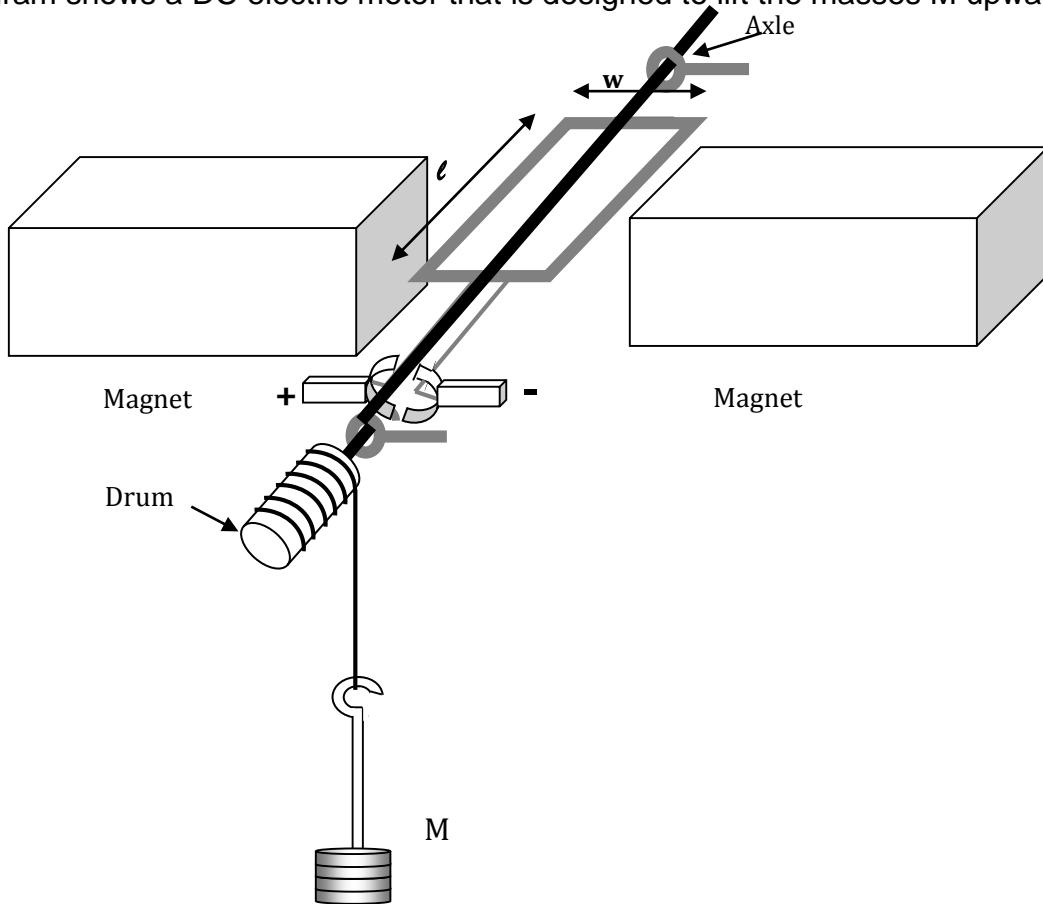
(c) Calculate the mass of Mars from the information provided in the question.

(4)

Question 6

(12 marks)

The diagram shows a DC electric motor that is designed to lift the masses M upwards.



a. Draw in the North and South magnet pole arrangement on the diagram to ensure that the motor turns in the correct direction. (1)

b. Motor specification:

- Length of coil (l) = 12.0 cm
- Width of coil (w) = 5.60 cm
- Number of turns = 150
- Coil resistance = 1.85 Ω

- Voltage of battery connected = 12.0 V
- Flux density of magnets = 1.25×10^{-2} T
- Drum diameter = 4.20 cm

Use these values to calculate the maximum torque available from this motor.

(4)

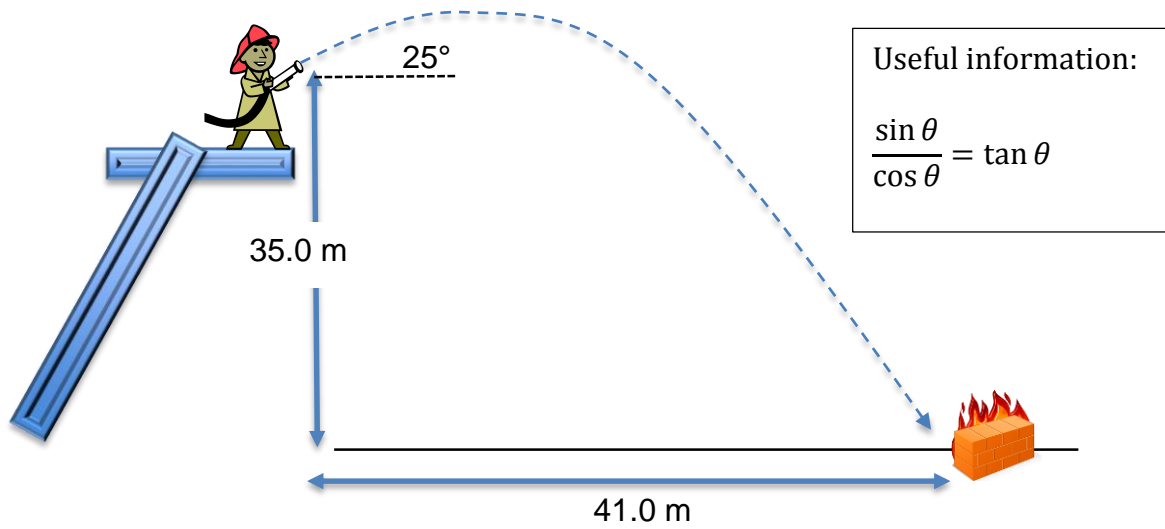
c. The torque available from this simple motor varies over one complete rotation. Explain why. (2)

d. For this question assume that the motor can deliver a constant torque of 8.0×10^{-2} N m. Calculate the maximum mass that it would be capable of lifting. (3)

e. An ammeter is connected to the motor to measure the current in the circuit. It is noticed that without the load attached the current in the circuit is much less than when the motor is used to lift the load. Explain why the current increases when the load is attached. (2)

Question 7**(13 marks)**

The diagram shows a fireperson who directs a hose at a fire from a height of 35.0 m to achieve a range of 41.0 m.



- (a) The fireperson sets the hose at an angle of 25.0° above the horizontal. Calculate the initial speed of the water required to reach the target.

(5)

(b) Calculate the time taken for the water to be at a height of 35.0 m again after leaving the hose. If you could not solve for the initial velocity use a value of 13.6 m s^{-1} at 25.0° above the horizontal.

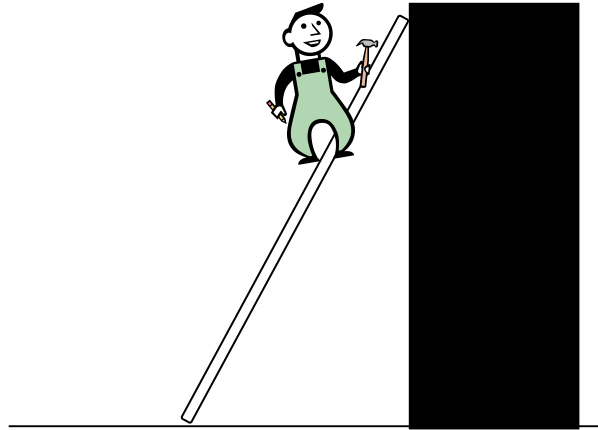
(3)

(c) Calculate the **velocity** of the water just before it strikes the ground. You must make reference to a vector diagram. (If you could not solve for the initial velocity use a value of 13.6 m s^{-1} at 25.0° above the horizontal).

(5)

Question 8**(14 marks)**

A 70.0 kg builder climbs a uniform ladder which is 5.10 m long and has a weight of 200 N. The ladder leans against a vertical wall and the builder is two-thirds ($\frac{2}{3}$) of the way up the ladder. The bottom of the ladder rests on rough horizontal ground. The top of the ladder rests on a frictionless wall so a normal reaction force is applied from the wall to the ladder. The ladder makes an angle of 65.0° with the horizontal.



- (a) Calculate the normal force of the wall acting on the ladder. You must clearly explain the physics principles used in your response.

(5)

(b) Calculate the total force acting on the bottom of the ladder. You must clearly explain the physics principles used in your response.

(5)

(c) Circle the correct response to complete the sentence.

“As the builder climbs higher up the ladder, the ladder is _____ likely to slip?”

less

more

equally

is not

(1)

Explain your reasoning with reference to appropriate equations.

(3)

Question 9

(9 marks)

- a. Explain, with reference to an appropriate formula, why high voltage power lines are used when electrical power is transported over large distances. (3)
- b. When electricity is supplied to households it must typically be stepped down from 66,000 V to 240 V. Explain why transformer will only work with AC and not DC current. (3)
- c. Describe two sources of inefficiency for the energy transformations within a transformer. (2)
- d. Describe a suitable material for the core of a transformer. Explain briefly. (1)

End of Section Two

Spare page for additional working

Answer **all** questions. Write your answers in the space provided. Suggested working time for this section is 40 minutes.

Question 1

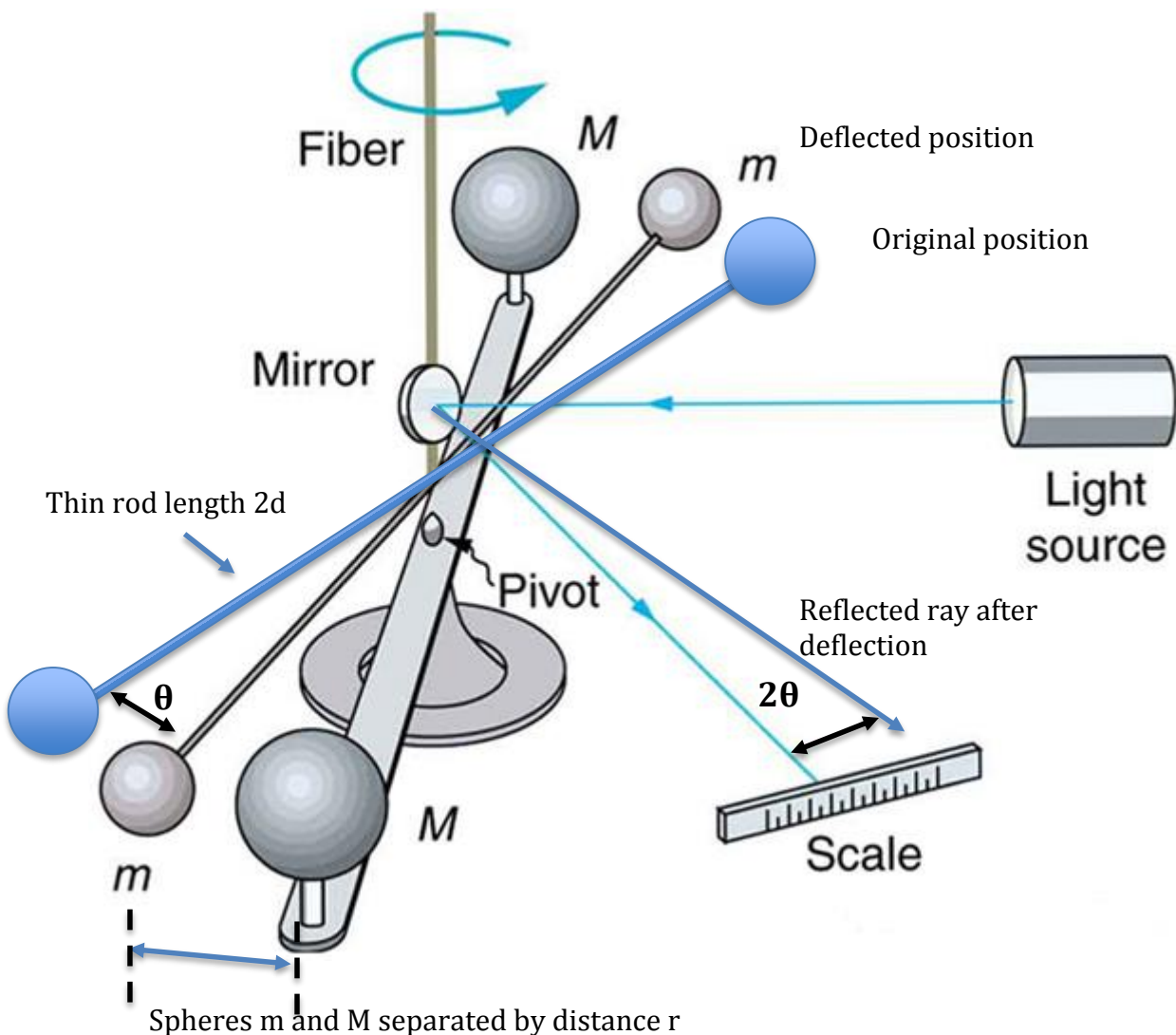
(36 marks)

The Cavendish Apparatus

Sir Isaac Newton studied the motion of heavenly bodies such as the planets and the moon. Through his examination of the orbits of the planets about the Sun and the Moon about the Earth, he developed a law of universal gravitation. In this he proposed a universal constant G (the universal gravitational constant), which would have the same numerical value for all objects.

Henry Cavendish (1731-1810) was the first to measure the universal gravitational constant G experimentally, over 100 years later, in 1798. The Cavendish apparatus consists of two small spheres, each of mass m , fixed to the ends of a light horizontal rod suspended by a thin metal wire (known as the torsion fiber). When the rod turns, the wire (which is fixed in place at the top) becomes twisted - this twisting is known as torsion. The twisted wire exerts a force to try and restore the rod back to its original position. This force is proportional to the angle of rotation of the rod. The greater the twist in the rod, the greater the torsional force exerted will be to return the rod back to its original position. The Cavendish apparatus was calibrated to determine the relationship between the angle of rotation and the amount of torsional force.

Figure 1 – The Cavendish Apparatus



To measure the angle of rotation a light beam and mirror are used. The angle of rotation of the rod is determined by measuring the deflection of the beam of light. Although the rod is only rotated through an angle θ , the beam of light is deflected through 2θ - thus magnifying the effect.

When two large spheres, each of mass M , are placed near the smaller ones, the attractive force between the smaller and larger spheres causes the rod to rotate and the thin metal wire twists until the system is in rotational equilibrium (i.e the torque due to the twisting equals the torque due to gravitational force).

A group of students used a similar setup to Cavendish's experiment to determine the universal gravitational constant using the relationship;

$$F = G \frac{Mm}{r^2}$$

They hung a thin rod (of length $2d$) with small lead spheres (of equal mass) at each end from a fine wire. Two large spheres were placed near the small spheres on the rod. The gravitational force between the large and small spheres twisted the rod. When the rod reached equilibrium, the torque from the wire balanced the torque from the gravitational force.

- (a) Show, including appropriate comments/captions, that the total torque on the rod is

$$t = 2G \frac{Mm}{r^2} d \quad (2)$$

- (b) In one trial, the beam of light was shone onto the mirror and reflected onto the scale, where the beam's deflection from its starting position could be measured. Initially the beam and the screen were perpendicular to each other. The screen was 5.50 m from the mirror. After rotation the light beam was deflected through 3.45 mm on the scale. Calculate the angle of rotation of the rod.

(3)

The students' results are given below.

$M = 1.50 \text{ kg}$

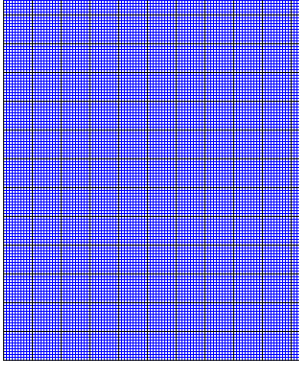
$m = 15.0 \text{ g}$

Length of rod = 90.0 cm

$r \text{ (m)}$	τ ($\times 10^{-10} \text{ N m}$)	$\frac{1}{r^2}$
0.050 ± 0.001	5.26	400 ± 16
0.070 ± 0.001	2.69	
0.090 ± 0.001	1.63	
0.110 ± 0.001	1.09	
0.130 ± 0.001	0.779	
0.150 ± 0.001	0.350	44.4 ± 0.6

The values of 'r' were measured with a ruler with 1 mm intervals. The students were confident that these measurements had an uncertainty range of +/- 1 mm. The uncertainty range for the first column is shown.

- (c) Process the students' data with appropriate uncertainty ranges for $\frac{1}{r^2}$ so that you are able to plot a graph of Torque (vertical axis) versus $\frac{1}{r^2}$ (horizontal axis). Two values have been done for you. (3)
- (d) Place the units for $\frac{1}{r^2}$ in the appropriate position in the table above. (1)
- (e) Plot a fully labelled graph of Torque versus $\frac{1}{r^2}$. You must include error bars and a line of best fit. (4)



(f) Determine the gradient of your line of best fit.

(3)

(g) Use the gradient from your graph to determine the value of the universal gravitational constant, G . (3)

(h) Determine the percentage difference in your result from the accepted value. (2)

(i) If a second trial was conducted and the mass of the larger spheres was increased to 2.00 kg
i. The gradient of the line of best fit would be: (circle a response) (1)
greater the same less impossible to determine

ii. How would this affect the value of G determined? Explain your reasoning. (2)

(j) Referring to the table of results. Consider the value of $\frac{1}{r^2}$ when the torque = 5.26×10^{-10} N m

State the absolute uncertainty of this value: _____ (1)

State the relative uncertainty of this value: _____ (1)

The derivations in this experiment assume that only the large sphere closest to each small sphere contributes to the gravitational force on the small sphere.

(j) Is this a reasonable assumption? Explain your reasoning.

To justify your response:

- Compare the gravitational forces on the small sphere due to each of the two large (1.50 kg) spheres in the scenario that is likely to cause the most error.
- Explain what effect the furthest large sphere will have on the torque values measured.

(6)

(k) Describe two other possible sources of experimental error and explain how their effects could be minimized by careful experimental design.

(4)

Source of experimental error 1:

Effect minimised by:

Source of experimental error 2:

Effect minimised by:

End of Section Three

Spare pages for additional working

Spare pages for additional working