CHRIST CHURCH GRAMMAR SCHOOL

YEAR 12

PHYSICS STAGE 3

MID YEAR EXAMINATION 2013

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1		
2		
3		
Total		/ 180 = %

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
Question/Answer Booklet
Formulae and Data Booklet

To be provided by the candidate
Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, correction fluid/tape, eraser, ruler, highlighters

Special items: non-programmable calculators approved for use in the WACE examinations, drawing templates, drawing compass and a protractor

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 Answers	15	15	50	54	30%
Section Two: Problem-Solving	7	7	90	90	50%
Section Three: Comprehension	1	1	40	36	20%
				Total	100

Instructions to candidates

1. Write your answers in this Question/Answer Booklet

2. When calculating numerical answers, show your working or reasoning clearly. Give final answers to three significant figures and include appropriate units where applicable.

3. 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.

4. The Formulae and Data booklet is **not** handed in with your Question/Answer Booklet.

YEAR 12
PHYSICS STAGE 3
MID YEAR EXAMINATION 2013

Section One: Short Response

This section has **fifteen (15)** questions. Answer **all** questions. Write your answers in the space provided.

Suggested working time for this section is **50 minutes**.

Question 1 **(3 marks)**

A 2.00 m long lever is placed under a 1.00×10^3 N rock. A fulcrum is placed at 0.500 m from the end of the lever (and centre of mass of the rock), placing the lever at 30.0° above the horizontal.

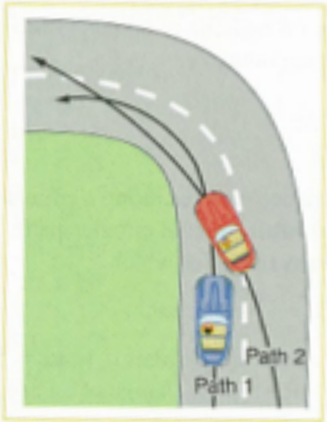
What is the minimum magnitude of force that must be applied to the far end of the lever to lift the rock (assume the force is exerted at one point)?

Question 2 **(3 marks)**

In a cyclotron, protons experience a force of 5.00×10^{-15} N when fired into the device at right angles to the magnetic field. If the protons have a speed of 1.00×10^5 ms^{-1}, what is the magnitude of the magnetic flux density of the field?

Question 3 **(3 marks)**

Race car drivers routinely cut corners, as shown in the diagram below. Explain how this allows the curve to be taken at the greatest speed.



Question 4 **(3 marks)**

A +0.200 C charge is in an electric field. If a force of 1.00×10^2 N is exerted on the charge what is the strength of the electric field?

Question 5 **(5 marks)**

Determine the acceleration due to gravity on the Moon's surface and use this value to calculate the weight of a 70.0 kg astronaut standing on the Moon.

Question 6 **(4 marks)**

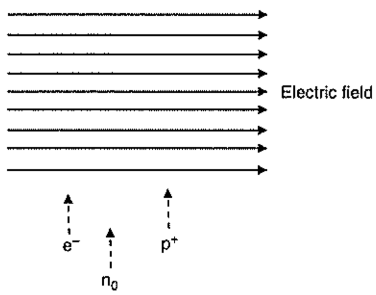
The astronaut from question 5 now floats at a distance of 10.0 m from his 50.0×10^3 kg spacecraft. What is the force between the astronaut and the spacecraft?

Question 7 **(3 marks)**

An archer stands on a castle wall and shoots a flaming arrow towards a group of insurgents on the ground below. The archer is suddenly fearful that he did not take into account the disintegration of the arrow (it can be assumes the arrow breaks into two pieces) as it flies. Should he be concerned that the path of the trajectory of his arrow will change? Explain your reasoning.

Question 8 **(3 marks)**

An electron, proton and neutron are fired at a uniform electric field as shown in the diagram below.



Indicate the direction each of the particles will be deflected using the following key;

L – deflected to the left R – deflected to the right N – not deflected

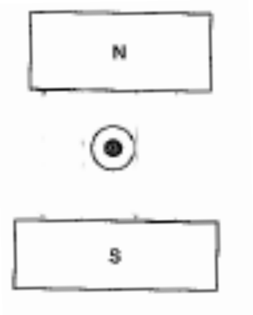
Proton _____

Electron _____

Neutron _____

Question 9 **(4 marks)**

The diagram below shows a piece of wire that is carrying a current passing through a magnetic field. If the current in the wire is 2.00 A and the magnetic flux density is 10.0 μT and the length of the wire in the field is 7.00 cm, what is the force exerted on the wire?



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 **(4 marks)**

Helicopter blades withstand tremendous stresses. In addition to supporting the weight of the helicopter, they are spun at rapid rates and experience large centripetal accelerations, especially at the tip. Determine the centripetal acceleration at the tip of a 4.00 m long helicopter blade, rotating at 440 rev/min.

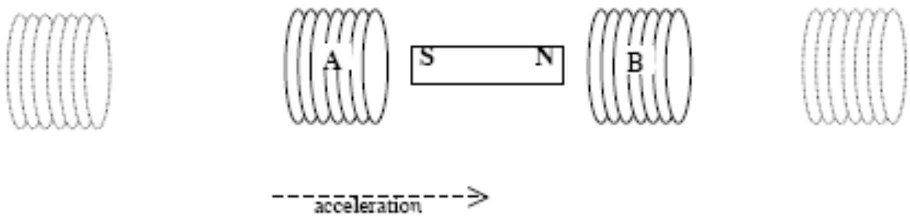
Question 12 **(3 marks)**

Explain, making reference to the domain theory of magnetism, why a permanent magnet can be used to pick up a string of paper-clips, even though the paper-clips are not magnets by themselves.

Question 13 **(3 marks)**

The flux density through a 200 turn coil of area 8.50 x 10^{-4} m^2 changes from 0.030 T to 0.120 T in 15.0 ms. Determine the magnitude of the induced emf in the coil.

Question 14 **(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 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 marks)

(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 marks)

Question 15 **(6 marks)**

A baseball is thrown from the roof of a 22.0 m tall building with an initial velocity of 12.0 ms^{-1} at an angle of 53.1° below the horizontal. Determine the speed of the ball as it strikes the ground, making use of the principle of conservation of energy.

End of Section One

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PHYSICS STAGE 3
MID YEAR EXAMINATION 2013

Section Two: Problem-Solving

This section has **seven (7)** questions. Answer **all** questions. Write your answers in the space provided.

Suggested working time for this section is **90 minutes**.

NAME:____

Question 1 **(17 marks)**

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

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

(3 marks)

(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. At what speed is she travelling? (Hint – draw a free body diagram of the situation).

(5 marks)

Track cycling is a popular spectator sport and one in which Australia has been very successful at the Olympics. Track cycling takes place in an arena called a velodrome, as shown in the diagram 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 kmh^{-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 marks)

(d) Anna Meares, who won gold in the Women's Sprint at the London Olympics, can reach speeds over 65.0 kmh^{-1} on a velodrome track. If then end of the track has a radius of 20.0 m and a cyclist is travelling at 60.0 kmh^{-1}, what is the minimum angle the track would need to be banked at (i.e. so no friction would be required)? (if you have shown the derivation for the required formula in (b), it does not need to be re-derived here).

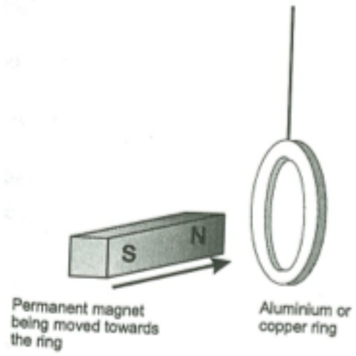
(3 marks)

(e) Why would the velodrome track not need to be banked as sharply as was calculated in part (d)?

(2 marks)

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) Determine the direction of induced current in the ring if you are looking towards the ring from behind the magnet.

(1 mark)

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

(1 mark)

(c) Explain the formation of the current and its direction.

(5 marks)

Question 3 **(11 marks)**

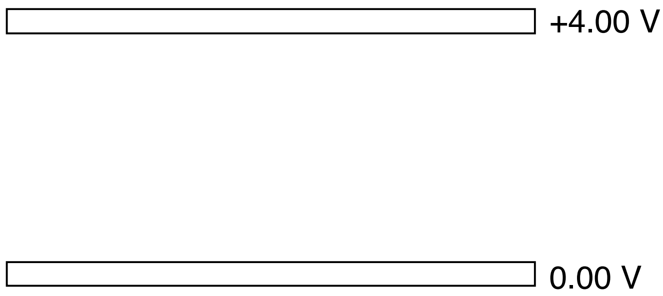
(The word ‘Pikachu’ can be replaced with the word ‘particle’ in this question)

Professor Oak has designed a new training centre for Pokémon.

One of the obstacles is made of two conducting plates, which are placed 1.74 m apart and have a potential difference of +4.00 V.

(a) Draw the electric field associated with the plates on the diagram below.

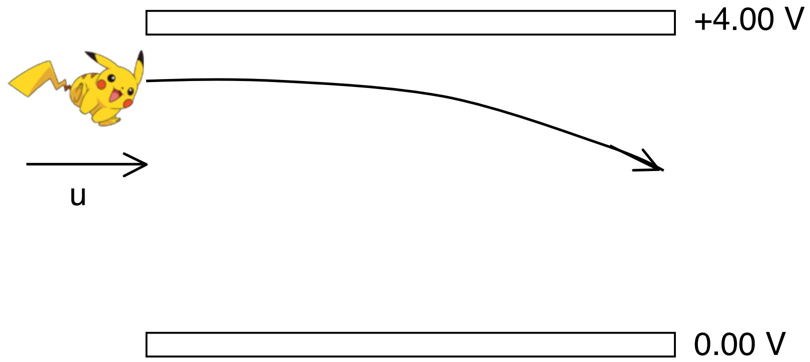
(2 marks)



(b) Determine the electrical field strength between the plates.

(3 marks)

A Pikachu moving at constant speed is sent through the electric field whilst fully charged. As he does this he experiences a force of 3.40 N.
His generalised motion (as seen from above), is shown in the diagram below (NB – this diagram is not meant to be indicative of the actual path taken).



(c) What is the charge of the Pikachu?

(3 marks)

(d) The plates are 2.50 m in length. If the Pikachu enters the field at the positive plate (as shown in the diagram), with a speed of 0.675 ms-1. How long does the Pikachu spend travelling through the plates? Assume a Pikachu has a mass of 6.00 kg and that it does not strike the bottom plate.

(3 marks)

Question 4 **(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) Determine the circumference of the orbit of Phobos.

(2 marks)

(b) Determine the speed of Phobos.

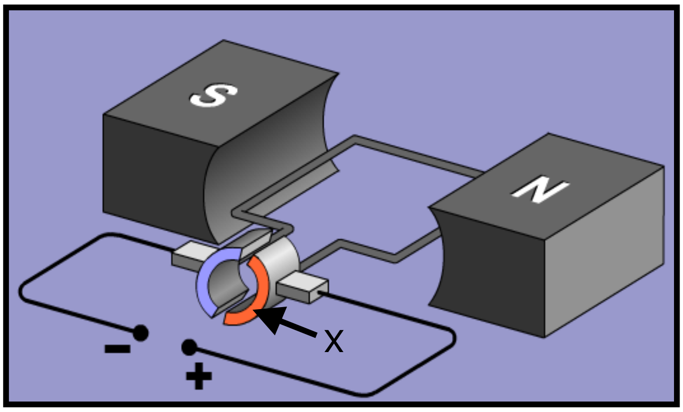
(3 marks)

(c) Use your answer (b) to calculate the mass of Mars.
(If you could not complete (b) use a magnitude of $v_{phobos} = 2.20 \times 10^3$)

(4 marks)

Question 5 **(15 marks)**

A DC motor, consisting of a 100 loop square coil of side 15.0 cm is shown in the diagram below. The two permanent magnets provide a uniform magnetic field of 0.250 T in the region of the coil and the current flowing in the coil is 2.00 A.



(a) State the energy conversion taking place in the motor.

(2 marks)

(b) In what position will the coil experience zero turning effect (torque)? Explain your reasoning with the aid of a diagram.

(3 marks)

(c) Name component 'X' and explain its function.

(3 marks)

(d) Determine the magnitude of the force on one side of the coil.

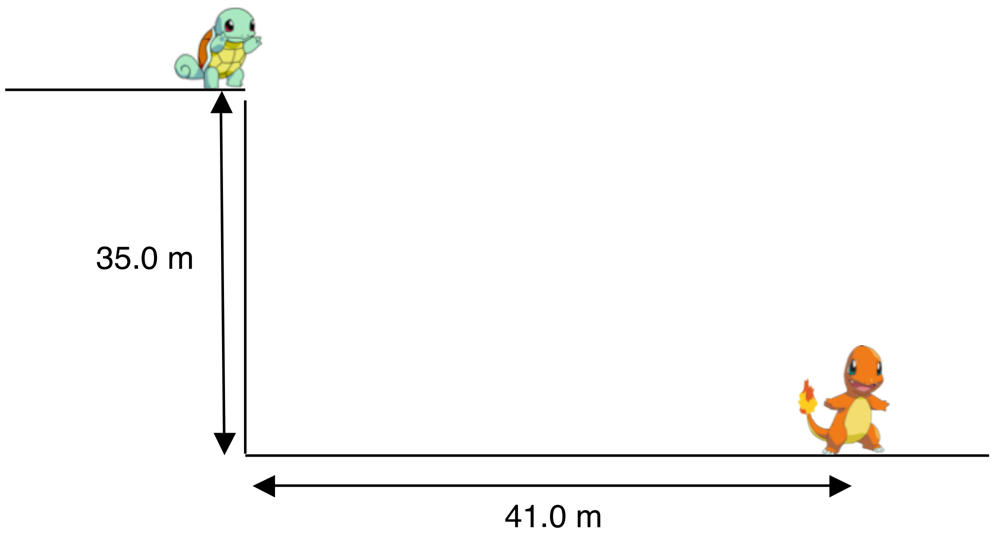
(3 marks)

(e) What is the maximum torque of the motor?

(4 marks)

Question 6 **(17 marks)**

A Squirtle standing on a cliff can see that a Charmander may let a fire get out of control, as shown in the diagram below. He decides to use his water gun to put the fire out.



(a) The Squirtle can only squirt water with a speed of 13.7 ms^{-1} at an angle of 30.0° above the horizontal. How long does it take the water to reach the ground?

(4 marks)

(b) Will the water hit the Charmander? You must justify your answer with an appropriate calculation.

(4 marks)

(c) What is the velocity of the water just before it strikes the ground?

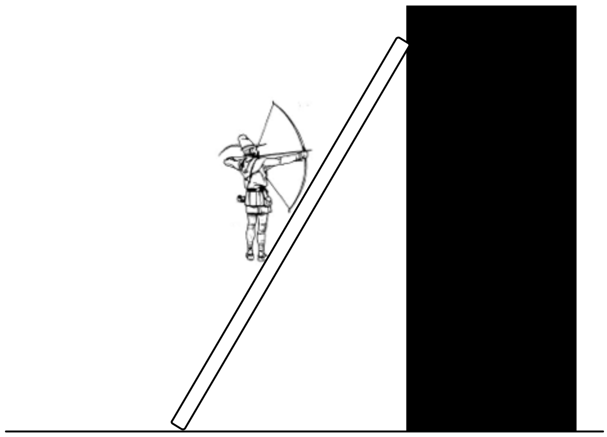
(5 marks)

(d) On the diagram on page 24, sketch the path of the water without air resistance and with air resistance (label your sketches appropriately). Describe how the path of the water would change.

(4 marks)

Question 7 **(14 marks)**

The archer from earlier in the paper has accidentally fallen off the castle wall and needs to get back up to resume his arching duties. To do this he leans a uniform ladder (5.50 m long, weight 200 N) against the side of the castle. The archer has a mass of 70.0 kg and stops two thirds (2/3) of the way up the ladder for a rest. The bottom of the ladder rests on horizontal ground and it can be assumed the castle wall is frictionless. The ladder makes an angle of 40.0° with the horizontal.



(a) Determine the normal force of the wall on the ladder.

(5 marks)

(b) Determine the force acting on the ladder at its base.

(5 marks)

(c) As the archer climbs higher up, is the ladder more or less likely to slip? Explain your reasoning.

(4 marks)

End of Section Two

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Section Three: Comprehension

This section has **one (1)** question. Answer **all** questions. Write your answers in the space provided.

Suggested working time for this section is **40 minutes**.

NAME:____

Question 1 **(36 marks)**

The Cavendish Apparatus

Sir Isaac Newton, in addition to developing the three laws of motion, also studied the motion of heavenly bodies – 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, as shown in Figure 1, 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.

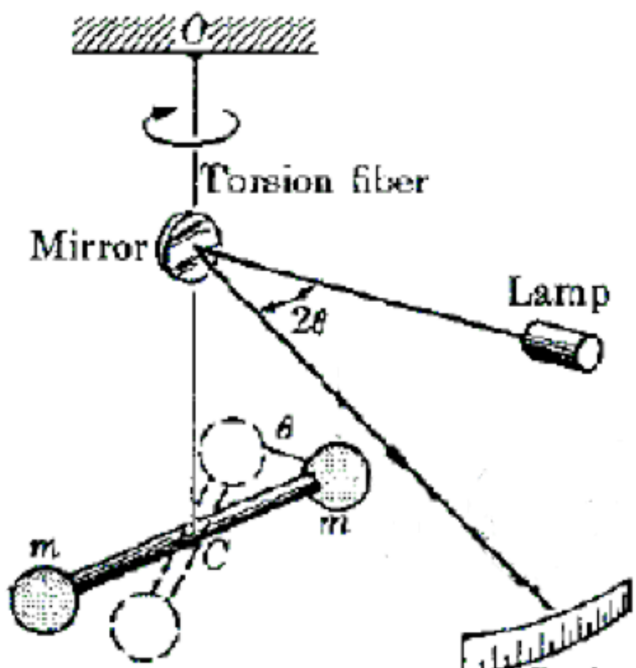

Figure 1 – The Cavendish Apparatus

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). This is shown in Figure 2.

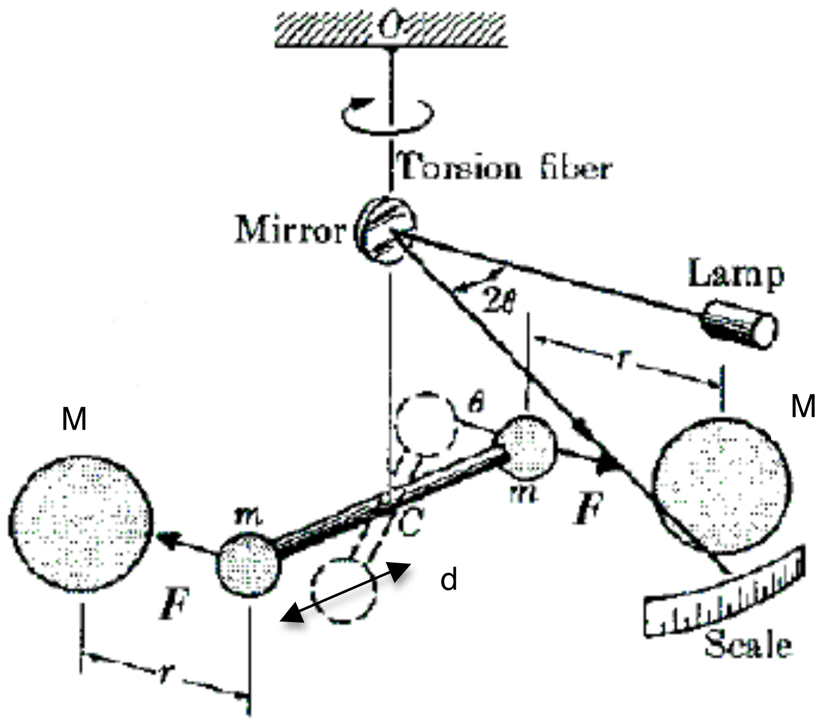

Figure 2 – The Cavendish apparatus used to measure the force of attraction between spheres.

A group of students used a similar setup to Cavendish's experiment, as shown in Figure 2, 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 (hint – look carefully at Figure 2);

$$\tau = 2G\frac{Mm}{r^2}d$$

(3 marks)

(b) In one trial, the beam of light was shone onto the mirror and reflected onto the scale, where the displacement from its starting position, x, could be measured. The screen was 5.50 m from the mirror and the light beam has been deflected through 3.45 mm. Determine the angle of rotation. Include an appropriate diagram as part of your answer.

(3 marks)

The torque is also related to the torsion coefficient (κ) of the wire by;

$$\tau = \kappa\theta$$

(c) What are the units of the torsion coefficient?

(1 mark)

The students' results are given below.

M = 1.50 kg m = 15.0 g Length of rod = 9.00 cm

r (m)	τ (x 10^{-11} Nm)		
0.0500	5.26		
0.0700	2.69		
0.0900	1.63		
0.1100	1.09		
0.1300	0.779		
0.1500	0.350		

(d) The values of 'r' and 'd' were measured with a ruler with 1 mm intervals. Include appropriate error value/s in the first column above.

(1 mark)

(e) Process the students' data (with appropriate errors) so that you are able to plot a graph of

$$\tau \quad vs \quad \frac{1}{r^2}$$

You may use as many columns as you wish.

(6 marks)

(f) Plot a graph (with error bars) of;

(6 marks)

$$\tau \quad vs \quad \frac{1}{r^2}$$

(g) Determine the gradient of your graph (you do not need to take into account the error bars).

(3 marks)

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

(3 marks)

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

(2 marks)

(j) If the torsion coefficient of the wire were increased, how would this affect the value of *G* determined. Explain your reasoning.

(3 marks)

The above derivation and experiment assumes that only the nearest large sphere to each small sphere contributes to the force on the small sphere.

(k) 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 spheres with appropriate calculations (set ‘r’ to a minimum value and treat the masses as point particles).

(5 marks)

End of Section Three

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