



# Mercedes College

## Semester 1 Examination 2013

### PHYSICS

### Stage 3

Write your name here
Teacher: SG 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 (70 marks = 35%)	Section Two (90 marks = 50%)	Section Three (20 marks = 15%)	Total Mark (180)	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	15	15	55	70	35
Section Two: Extended Answer	7	7	70	90	50
Section Three: Comprehension and Data Analysis	1	1	25	20	10
					100

### Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 12 Information Handbook 2013*. 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

[70 marks or 35% of total]

Write your answers in the spaces provided. Where appropriate show all working.

Question 1

A helicopter is flying at a constant height above the ground. The helicopter is carrying a crate suspended from a cable as shown.



The helicopter flies 20 km south. It then turns and travels south-east for a further 30 km.

- (a) Determine the **magnitude** and **direction** of the resultant displacement of the helicopter.

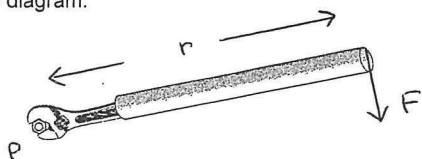
[4 marks]

- (b) The helicopter takes 15 minutes to complete the journey described above. What is the average **velocity** of the helicopter? Give your answer in units of  $\text{ms}^{-1}$ .

[2 marks]

**Question 2**

A student is unable to loosen a nut by using a wrench. The student then attaches a pipe over the end of the wrench as shown in the diagram.



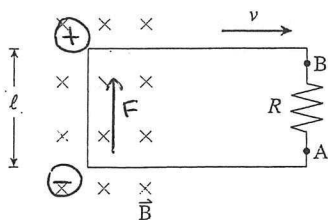
Using the principles of physics, explain why the student is now able to loosen the nut.

[3 marks]

**Question 3**

The single rectangular loop of wire shown below is being pulled out of the 0.50 T magnetic field at a constant speed.

An EMF of 0.60 V is being generated and the length of the side " $l$ " is 0.30 m.



What is the speed of the loop and what is the direction of the induced current through the resistor?

[4 marks]

(g) Use the gradient to calculate an experimental value of "g". Give the final answer to 3 significant figures.

[3 marks]

(h) Comment on the accuracy of the value obtained for "g".

[1 mark]

*End of Section Three*

(d) To obtain a **straight line graph** it is necessary to plot  $P^2$  against  $1/m_2$ .

Complete the following table.

$m_2$ (kg)	$1/m_2$ ( $\text{kg}^{-1}$ )	Average period P (s)	$P^2$ ( $\text{s}^2$ )
0.020			
0.040			
0.060			
0.080			

[3 marks]

(e) Plot a graph to show  $P^2$  versus  $1/m_2$ . Use the graph paper provided.

Show  $P^2$  on the y-axis and  $1/m_2$  on the x-axis. Draw a line of best fit.

[4 marks]

(f) Determine the gradient of the straight line obtained. Include the appropriate units.

[3 marks]

**Question 4**

The polar-orbiting satellite NOAA-N was launched in May 2006.

The satellite is now orbiting in a circular orbit above the Earth's surface at an altitude of 870 km.

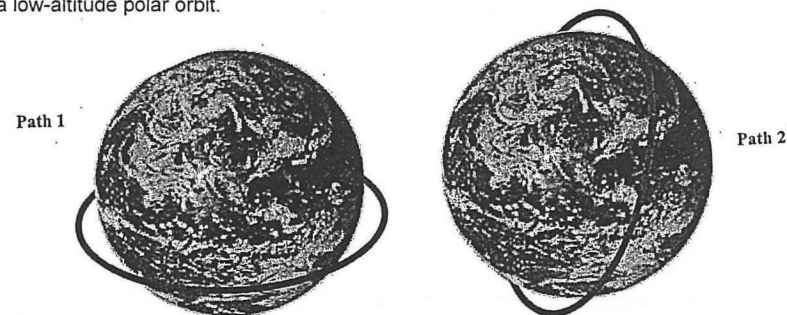
(a) What is the orbital speed of the satellite?

[2 marks]

(b) Calculate the magnitude of the acceleration due to gravity at the satellite's altitude?

[2 marks]

The diagram below shows two circular paths around the Earth. Path 1 is not a possible satellite orbit. Path 2 is a low-altitude polar orbit.

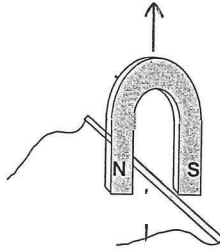


(c) Explain why Path 1 is **not** a possible satellite orbit.

**Question 5**

A strong horseshow magnet of mass 264 g is placed over a metal rod which has a mass of 35.5 g.

Thin wires are connected to the ends of the rod and a current of 225 A is passed through.



The **magnet** just begins to lift upwards.

- (a) Assume that the magnetic field between the poles is 4.00 cm wide. Calculate the strength of the magnetic field.

[3 marks]

- (b) What is the direction of the conventional current flowing in the wire? Show your answer on the diagram.

[1 mark]

	Trial 1	Trial 2	Trial 3	Average
mass $m_2$ (kg)				
0.020	1.40	1.38	1.42	
0.040	1.05	1.06	1.04	
0.060	0.79	0.80	0.79	
0.080	0.73	0.75	0.75	

- (a) Which two important variables were controlled in this investigation?

[2 marks]

1 <sup>st</sup> variable	
2 <sup>nd</sup> variable	

- (b) Is it appropriate to include the values of the period  $P$  from all three trials when finding the average period  $P$ ? Explain your answer.

[2 marks]

- (c) Determine the average period  $P$ . Write the values in the last column of the data table.

[2 marks]

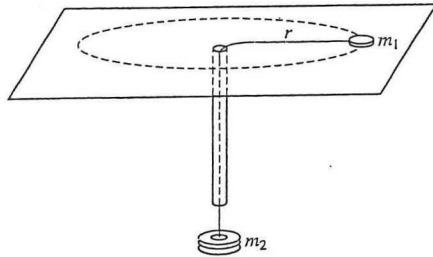
Section Three: Comprehension and Interpretation

[20 marks or 15 % of total]

This section has one (1) question which must be answered in the spaces provided.

Question 23

Read the following information very carefully and then answer the questions which follow.

ESTIMATION of GRAVITATIONAL ACCELERATION

An experiment is performed using the apparatus above. A small disk of mass  $m_1$  on a frictionless table is attached to one end of a string. The string passes through a hole in the table and an attached narrow, vertical plastic tube. An object of mass  $m_2$  is hung at the other end of the string.

A student holding the tube makes the disk rotate in a circle of constant radius  $r$ , while another student measures the period  $P$ .

The relationship between these variables is given below:

$$P^2 = \frac{4\pi^2 m_1 r}{g m_2}$$

(Where  $g$  = acceleration due to gravity)

The procedure is repeated, and the period  $P$  is determined for four different values of  $m_2$ , where  $m_1 = 0.012$  kg and  $r = 0.80$  m.

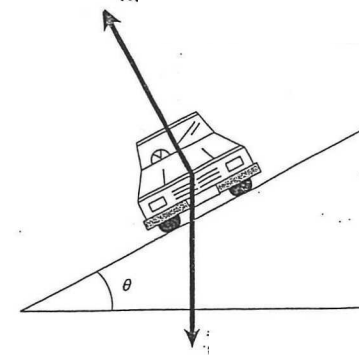
Three trials were performed for each value of  $m_2$  used.

The data obtained is tabulated below.

SEE NEXT PAGE

Question 6

The diagram below shows a car moving around a curved bend in a road. The surface of the road is banked at an angle  $\theta$  to the horizontal.



(a) Label each of the forces represented by the black arrows.

[1 mark]

(b) Explain the advantage in "banking" the surface of the road.

[3 marks]

SEE NEXT PAGE

**Question 7**

Patients are normally asked to remove metallic objects before being MRI scanned.

A patient in a scanner is still wearing a ring of radius 7.5 mm. The magnetic field in the scanner is 0.52 T.

(a) How much magnetic flux passes through the area of the ring when the ring is held perpendicular to the magnetic field direction?

[2 marks]

(b) The magnetic field of the scanner is reduced to zero in 0.085 seconds. Calculate the EMF that can be induced in the ring.

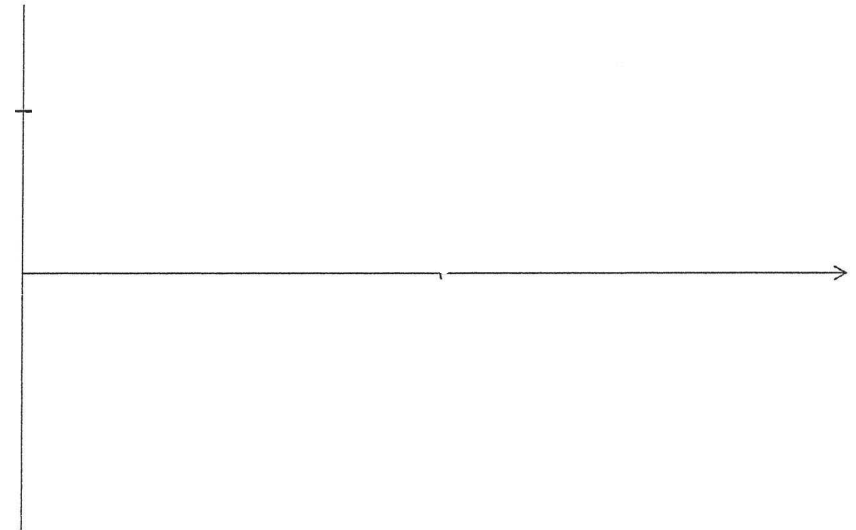
[2 marks]

(c) A ring with a different radius would have a different EMF. State **TWO** other ways in which the EMF in the ring would be halved.

1 <sup>st</sup> way	
2 <sup>nd</sup> way	

[2 marks]

c) If the magnetic field changes at a **uniform** rate, sketch a graph to show how the EMF induced in the coil varies with time during the 0.35 second time interval.



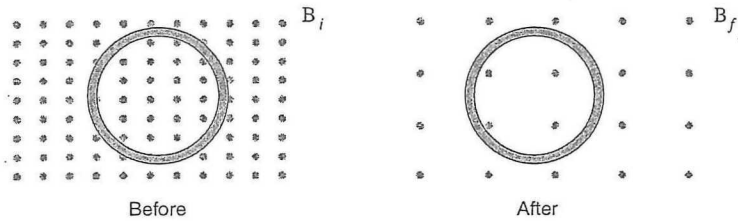
[3 marks]

*End of Section Two*



**Question 22** [Total = 9 marks]

The "Before" diagram shows a coil at one instant in a changing magnetic field. The "After" diagram shows the same coil at a slightly later time.



- a) Has the magnetic field strength increased or decreased during this time? Explain the reason for your answer.

[2 marks]

- b) Use the information in the following table to calculate the EMF induced in the coil.

Coil radius = 0.15 m
Number of turns = 250
Initial field $B_i = 1.50$ T
Final field $B_f = 0.25$ T
Time taken = 0.35 seconds

[4 marks]

**Question 8**

A girl of mass 25.0 kg is hanging on to a rail on a carousel (roundabout) of diameter 5.00 m. The carousel takes exactly 2.00 seconds to spin around once. The girl can hold on to the rail with a maximum force of 255 N.



Will the girl be able to hang on, or will she be forced to let go of the rail? Justify your answer with an appropriate calculation.

[4 marks]

**Question 9**

Susan states that there is no force due to gravity acting on the International Space Station (ISS). She says this must be so as she has seen television footage showing astronauts and equipment floating around in the spacecraft.

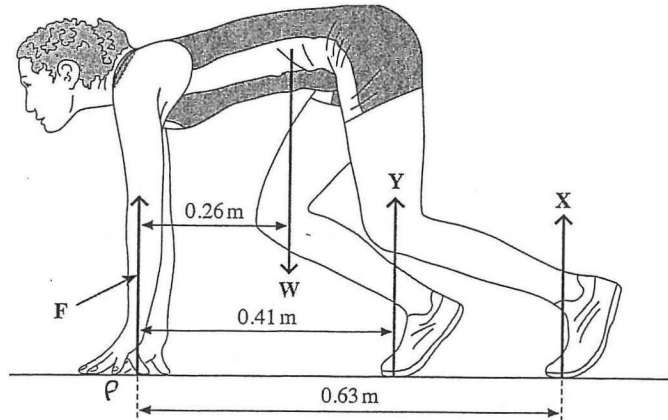
Rose states that this is a common misconception for orbiting spacecraft, such as the ISS.

Using the principles of physics, help Rose convince Susan that there **must** be a force due to gravity acting on the ISS.

[3 marks]

**Question 10**

A sprinter is shown before a race, stationary in the "set" position, as shown in the diagram below. Force  $F$  is the resultant force on the sprinter's finger tips. The reaction force,  $Y$ , on her forward foot is 180 N and her weight,  $W$ , is 520 N.  $X$  is the reaction force on her back foot.



- a) By taking moments about her finger tips, calculate the force on her back foot ( $X$ ).

[3 marks]

- b) Hence, calculate the magnitude of force  $F$ .

[3 marks]

- (c) By taking moments about a suitable point, calculate the tension in the supporting cable.

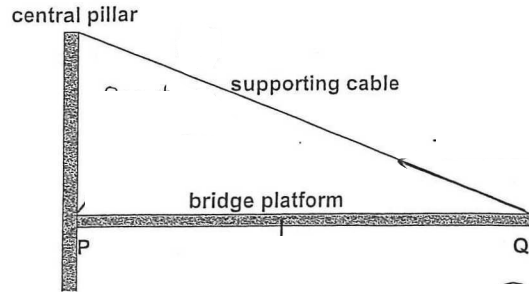
[5 marks]

- (d) What happens to the tension in the cable as the truck moves further to the right along the platform? Explain your answer.

[3 marks]

**Question 21** [Total marks = 13]

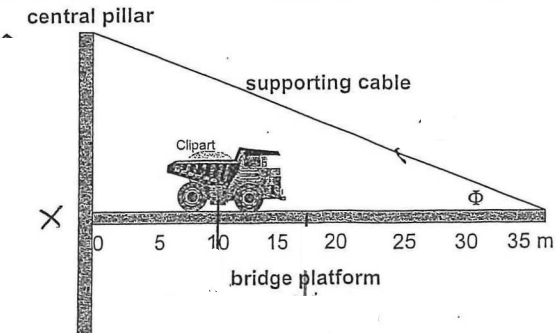
A particular structure consists of a concrete platform PQ attached to a central pillar by means of a very strong cable as shown in the diagram below.



- (a) The structure is in equilibrium even though there are **three** forces acting on it. Draw and label these three forces on the diagram.

[3 marks]

The diagram below shows a heavy truck moving along the platform. The distances (in metres) from the central pillar are shown on the diagram. The centre of mass of the truck is at the 10.0 m and the platform extends 35.0 m from the pillar, the top of which is 17.5 m above the platform. The platform is uniform and has a mass of 440 tonnes and the truck has a mass of 45.0 tonne.

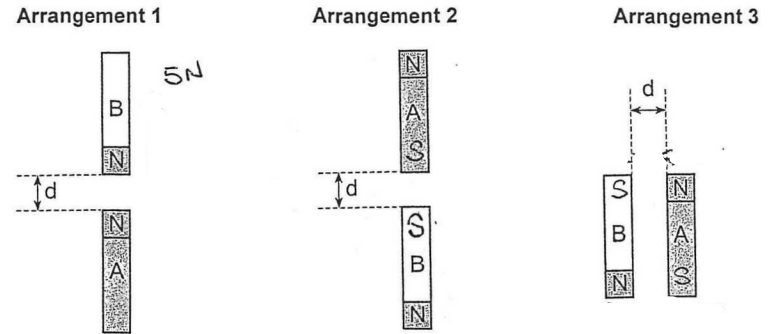


- (b) Calculate the value of the angle  $\phi$ .

[2 marks]

**Question 11**

Two similar bar magnets (A and B) are arranged in a number of different ways as shown in the diagrams below. In each case the distance  $d$  is identical.



In **Arrangement 1**, Magnet B experiences a repulsive force of 5 N upwards.

- (a) In **Arrangement 1**, what is the magnitude and direction of the magnetic force experienced by Magnet A?

[1 mark]

- (b) What is the magnitude and direction of the magnetic force on Magnet B when it is below Magnet A as in **Arrangement 2**?

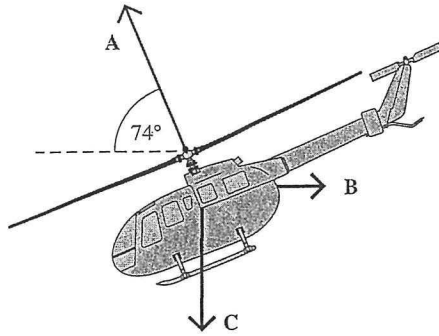
[1 mark]

- (c) When Magnet B is to the left of Magnet A, as in **Arrangement 3**, will the magnetic force be attractive, repulsive or zero? If non-zero, do you expect it to be greater than or less than 5N? Give your reasoning.

[2 marks]

**Question 12**

The helicopter shown in the diagram below is moving horizontally through still air. The lift force from the helicopter's blades is labeled **A**.



- a) Name the two forces **B** and **C** that also act on the helicopter.

<b>B</b>	<b>C</b>
----------	----------

[2 marks]

- b) If the helicopter is moving with a constant velocity, what is the net force acting on it? Why?

[1 mark]

- c) The lift force, **A**, is  $9.5 \times 10^3$  N and acts at an angle of  $74^\circ$  to the horizontal. Calculate the **weight** of the helicopter.

[3 marks]

- b) Determine the **vertical component** of the Earth's magnetic field near Albert Park. Include the direction.

[3 marks]

- c) Calculate the EMF which would be generated between the tips of the wing on the racing car.

[3 marks]

- d) Which end of the wing (as **viewed by the driver**) would be **positive**? Explain how you determined your answer.

[3 marks]

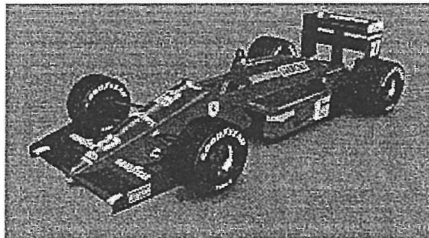
(f) Calculate the period at which the Ferris wheel must rotate if Bonnie experience "weightlessness".

[3 marks]

**Question 20** [Total = 11 marks]

Formula 1 racing cars have a wing above the rear wheels that causes a downwards force to aid traction. The wings are often made of graphite, a form of carbon that is a conductor.

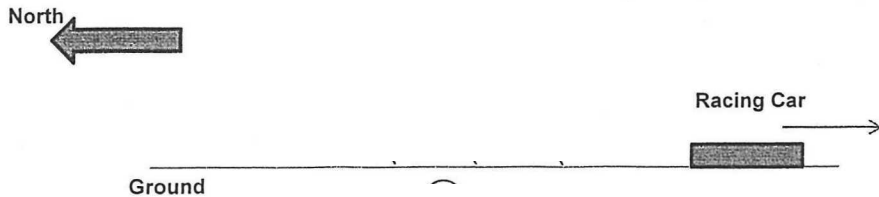
A car with a 2.2 m wing is travelling south at  $228 \text{ kmh}^{-1}$ . Assume that the wing is electrically insulated from the rest of the car.



Albert Park in Melbourne is the site of Australia's F1 race; the Earth's magnetic field here has strength of  $60 \mu\text{T}$  and an angle of dip of  $67^\circ$ .

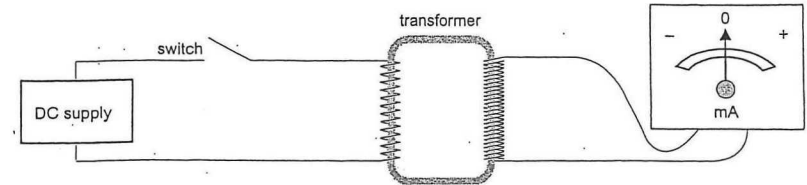
a) On the diagram below, show the flux lines of the Earth's magnetic field in the region of the car.

[2 marks]



**Question 13**

A transformer as shown in the diagram below is being tested. The primary coil is connected to a battery and switch. The switch is initially open and no current is flowing in the primary coil. An ammeter is connected to the secondary coil and initially shows no deflection. When the switch is **first** closed, the ammeter needle is deflected to the right and then returns to its initial position of no deflection.



(a) Explain why the ammeter deflects when the switch is closed and then returns to the un-deflected position.

[3 marks]

(b) The switch, which has been closed for a short time, is now returned to the open position and remains open. Which one of the following **best** describes what happens to the reading of the ammeter?

[1 mark]

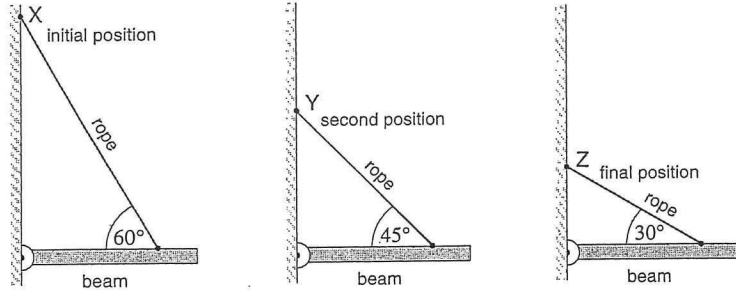
A	It deflects to the left and stays in this position
B	It deflects to the right and stays in this position
C	It deflects to the left and returns to the middle position
D	It deflects to the right and returns to the middle position
E	It does not change



**Question 14**

A horizontal beam is held in position by a rope as shown.

The connection point on the wall is moved from location X to location Y to location Z. Assume the length of the rope is adjusted to keep the beam in a horizontal position in each situation.



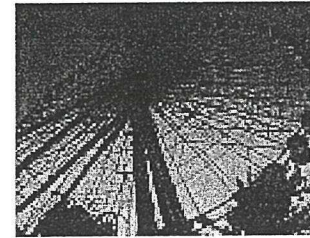
Which of the following best describes what happens to the tension? Write the **letter** corresponding to your answer in the box.

- A: Tension increases
- B: Tension decreases
- C: Tension remains the same
- D: Tension increases then decreases.

Justify your answer.

[4 marks]

Another familiar ride at the amusement park is the Ferris wheel.



The wheel shown in the photograph moves in a **vertical** circle with a radius of 17.5 m and with a constant speed of  $9.05 \text{ ms}^{-1}$ .

(c) How long does it take the wheel to complete one full rotation?

[2 marks]

Bonnie, a passenger on the Ferris wheel has a mass of 57.3 kg.

(d) What reaction force does she experience when she is at the **highest point** of the Ferris wheel's circular path?

[3 marks]

If the Ferris wheel rotates fast enough then Bonnie may experience "**weightlessness**" as she passes through certain parts of the ride.

(e) What is meant by the term "weightlessness" and where on the ride will she experience it? Why?

[3 marks]

Question 19 [Total marks = 16]

The photograph below shows a roller coaster ride at an amusement park. The roller coaster wagons can move along the track safely as long as high velocities are maintained.



The track shown in the photograph is circular in shape and has a **diameter** of 32.6 m.

- (a) What is the **minimum** speed that the roller coaster must have in order to remain on the track at the highest point of the vertical track?

[2 marks]

One of the passengers on the roller coaster, Carla, has a mass of 49.4 kg.

- (b) What reaction force does she experience when the roller coaster is moving at the **lowest point** of the track with a speed of  $18.3 \text{ ms}^{-1}$ ?

[3 marks]

Question 15

A step-up transformer is used to convert a voltage of  $1.50 \times 10^4 \text{ V}$  to a higher voltage of  $3.00 \times 10^5 \text{ V}$ .

The primary coil has 2000 turns. Assume the transformer is 100 % efficient.

- a) How many turns are in the secondary coil?

[2 marks]

- b) The power supplied to the primary coil is 6.5 MW. What is the size of the current in the secondary coil?

[2 marks]

- c) Which coil wires should be **thicker** – the primary, or secondary? Explain why.

[2 marks]



**Section Two: Problem Solving****[90 marks or 50 % of total]**

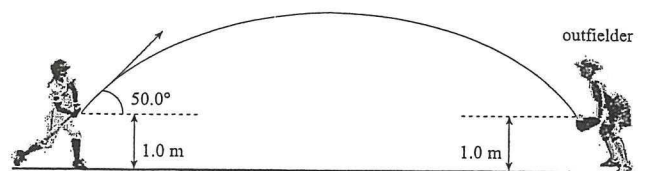
Answer all SEVEN (7) questions in the spaces provided.

**Question 16** (Total marks = 14)

A softball is hit at an angle from a point 1.0 m above the ground. The softball has an initial velocity of  $19.5 \text{ ms}^{-1}$  at an angle of  $50^\circ$  above the horizontal, as shown in the diagram below.

The ball is caught by an outfielder as it returns to a height of 1.0 m above the ground.

Ignore the effects of air resistance.



[This diagram is not drawn to scale.]

(a) Calculate the time the ball takes to reach the outfielder.

**[3 marks]**

(b) How far from the batter is the outfielder when she catches the ball?

**[3 marks]**

The orbit of Jupiter is known to be elliptical rather than circular. At Jupiter's closest point, it is 4.95 AU from the Sun and at its most distant point it is 5.46 AU from the Sun.

(c) Calculate the gravitational force of attraction between Jupiter and the Sun when Jupiter is **most distant** from the Sun.

**[4 marks]**

(d) Calculate the centripetal acceleration experienced by Jupiter in its orbit when it is **most distant** from the Sun.

**[3 marks]**



**Question 18** [Total marks = 13]

The planet Jupiter orbits the Sun with a period of 4333 days. It has a mass 318 times that of the Earth and a diameter 11.2 times larger than the diameter of the Earth.

- (a) Calculate the period of Jupiter's orbit in **seconds**.

[2 marks]

- (b) Assuming Jupiter has a circular orbit with a radius of 5.2 AU (astronomical unit), calculate the speed of Jupiter as it orbits the Sun.

**Note: 1 AU = distance from the Earth to the Sun**

[4 marks]

- (c) Calculate the maximum height **above the ground** reached by the ball as it travels to the outfielder.

[3 marks]

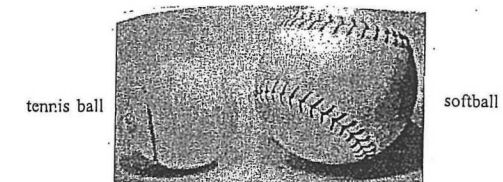
- (d) What is the direction of the **net force** acting on the ball at the highest point of the trajectory?

[1 mark]

- (e) Does the ball have an acceleration of zero at the highest point of the trajectory? Explain.

[2 mark]

- (f) A tennis ball is now hit at the same height and with the same initial velocity as the softball in part (a). The two balls are shown in the photograph below.



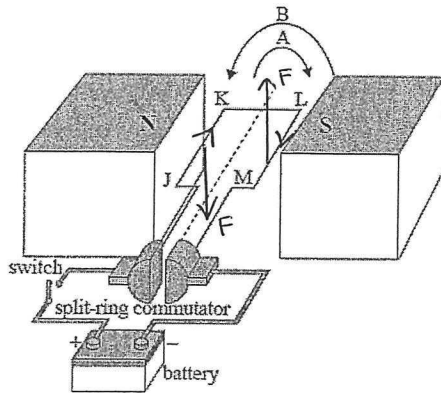
State one difference between the balls and describe how it affects the force of air resistance.

**Question 17** [Total marks = 14]

The diagram below shows a small DC electric motor, powered by a battery through a split-ring commutator.

The rectangular coil has sides **KJ** and **LM** of length 70.0 cm, and sides **KL** and **JM** of length 40.0 cm. The coil contains 4 turns of insulated wire.

With a current of 15.0 A passing through the coil, a maximum torque of 0.600 Nm was achieved.



- a) Does the coil rotate in the direction shown as **A** or in the direction shown as **B** (see diagram)? Explain how you decided.

[2 marks]

- b) Calculate the magnitude and direction of the maximum force acting on side **KJ** of the coil.

[Remember: Torque  $\tau = 2 (F \times r)$ ]

[3 marks]

- c) Hence, calculate the strength of the magnetic field between the poles of the magnet.

[4 marks]

- d) Why is the **split-ring commutator** an essential part of a DC electric motor?

[2 marks]

- e) Sketch a graph showing the magnitude and direction of the torque produced during one complete rotation of the coil. Assume the coil starts perpendicular to the magnetic field.

[3 marks]

