Physics 3A3B

Stage 3 Written Paper Semester One 2011

CHURCHLANDS SENIOR HIGH SCHOOL

Student Name: ____________________

Teacher Name: ______________

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

Special items: non-programmable calculators satisfying the conditions set by the Curriculum Council 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 answer	15	15	54	60	30
Section Two: Extended answer	8	8	90	100	50
Section Three: Comprehension and data analysis	2	2	36	40	20
				Total	100

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year* 12 *Information Handbook 2011.* 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 to follow any instructions that are specific to a particular question.

4. Working or reasoning should be clearly shown when calculating or estimating answers. Answers should be given to the appropriate number of significant figures. Answers not given to the appropriate number of significant figures may result in marks being deducted.

5. Spare pages are included at the end of this booklet. They 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 at the top of the page.

- 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. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Section One: Short response 30% (60 Marks)

This section has 15 questions. Answer **all** questions. Write your answers in the space provided. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.
Suggested working time for this section is 54 minutes.

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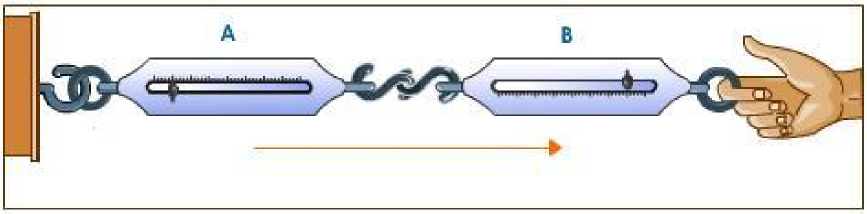
1. (4 marks)



A student is pulling to the right as indicated on the diagram above. The reading on both spring balances is 5.3 N.

(a) What total pull is the student exerting on the wall at the point of attachment of the spring balances? Write your answer in the box provided.

Answer

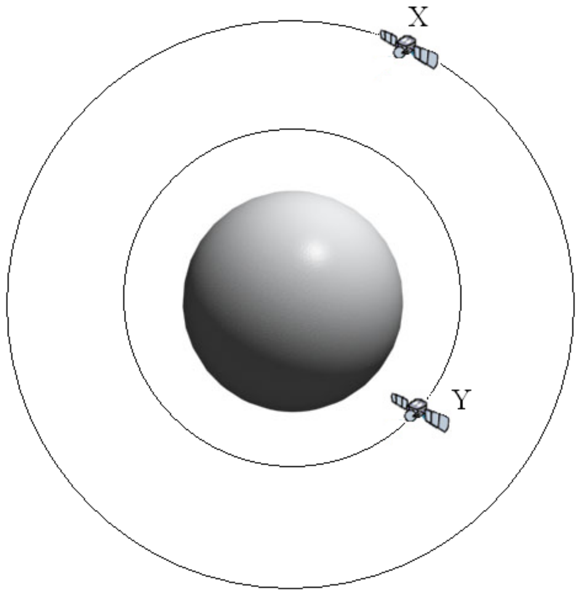
(b) The student then places a third spring balance in line with the other two and pulls with exactly the same force as in part (a) above. What will be the reading on this third spring balance?

Answer

2. The photograph shows a uniform land yacht with a rear wheel base of 1.68 m and a mass of 35.0 kg.

Estimate the torque being produced by the sail that has just begun to tip the yacht as shown. (4 marks)

3. A planet with a uniform density and with radius of 1.65×10^5 m and gravitational field strength on its surface of 0.258 N kg^{-1}, has two satellites, X and Y, in stable orbit around it. (5 marks)



(a) Draw the gravitational field around the planet.
(b) Calculate the gravitational field strength satellite Y experiences if its height above the planet is the same as the planet's radius.

(c) A spare part has to be sent from X to Y. With no motor and no fuel, explain how this could be done.

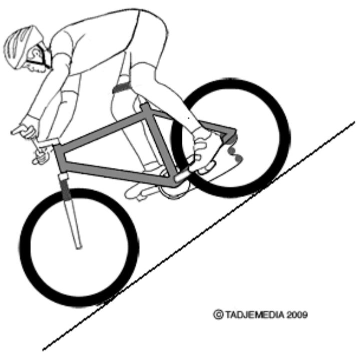
4. A javelin thrower throws the javelin at $50.0\ ^o$ to the horizontal. The initial velocity of the javelin is 25.0 m s^{-1}.
Unfortunately the javelin thrower slipped as he threw and the javelin stuck into a scoreboard at the same height above the ground as she released it. (4 marks)

(a) Calculate how long the javelin was in the air.

(b) On the diagram below, sketch the shape of the path of the javelin without air resistance (label this **without**) and with air resistance (label this **with**).

5. Hannah is riding her bicycle down a long hill which has a 15.0 ° slope. Halfway down she is travelling at a constant velocity of 6.25 m s^{-1} . (5 marks)

(a) Sketch a free body diagram showing and labeling the forces acting on the cyclist.

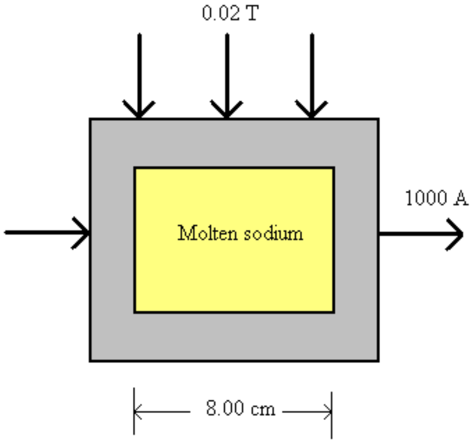


(b) Based on your diagram and your understanding of equilibrium in physics, state if the cyclist is in equilibrium and explain your reasoning.

6. A skater is maintaining a constant speed around a circular track of radius 75.4 m. The mass of the skater is 65.0 kg and the net force on the skater is 144 N. Calculate the speed of the skater. (4 marks)

7. A 3.70 m long uniform ladder of mass 10.5 kg is placed against a frictionless vertical wall. The ladder makes an angle of 37.5 ° to the wall. Hannah decides to climb up the ladder until she is 1.32 m from the top of the ladder. If Hannah has a mass of 55.0 kg, how much horizontal force does the wall experience from the ladder and Hannah? (5 marks)

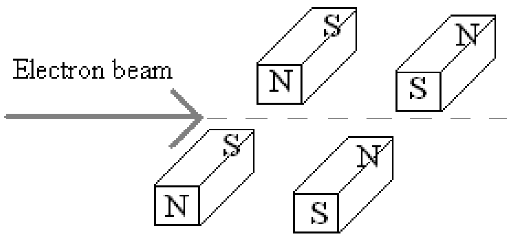
8.



An electromagnetic pump is used in some nuclear power stations to move molten sodium around the cooling system. One such pump consists of a rectangular section of metal pipe as shown. A current of 1.00×10^3 A is passed horizontally in the presence of a vertical magnetic field of 0.0200 T. What is the force on the molten metal shown?

(3 marks)

9. An electron beam is passed through a set of magnets with alternating polarities. Complete the diagram showing the path of the beam as it passes between the magnets and emerges from the other side. (3 marks)



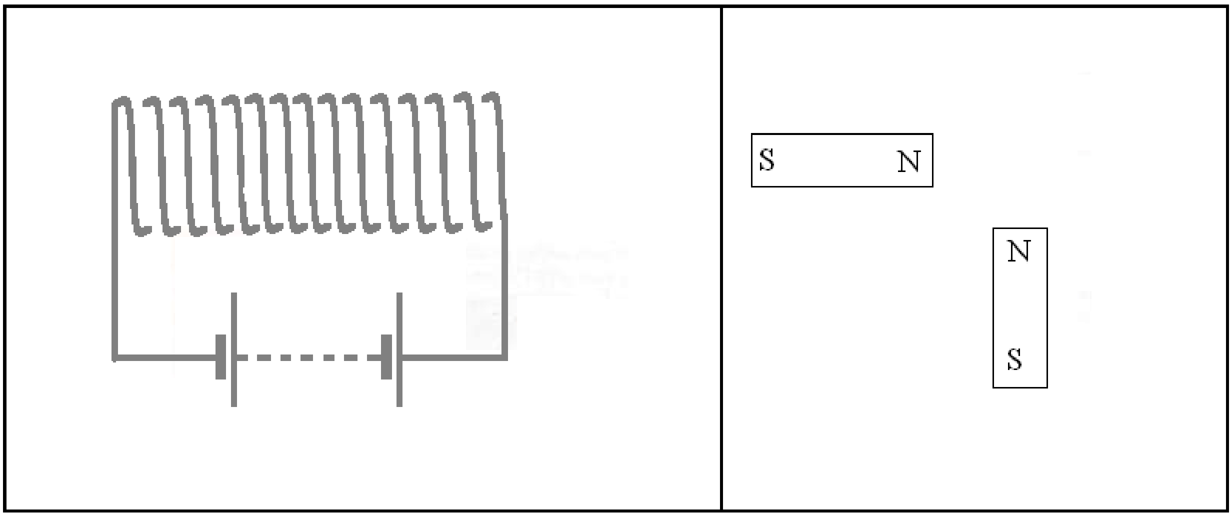
10. A helicopter is moving forward at 65 m s^{-1} and at the same time is rising at 5 m s^{-1}. On the diagram show and label all the forces acting on the helicopter and their relative magnitude. (3 marks)

11. A boat leaves Fremantle to motor to Rottnest Island which is 21.0 km due west. The boat's cruising speed is 15.0 km h^{-1} and there is a strong northerly ocean current running at 4.00 km h^{-1}. (5 marks)

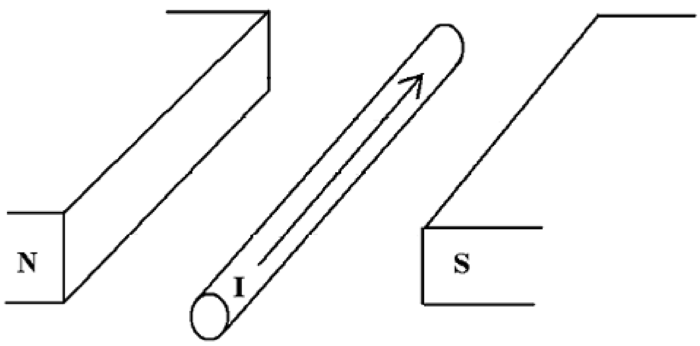
(a) Calculate the direction the boat must head to reach Rottnest Island.

(b) How long does it take to make the journey?

12. On each diagram, show the pattern and direction of the magnetic field. (4 marks)



13. On the diagram below draw in the magnetic field and the direction of the resulting force on the current carrying conductor. (2 marks)



14. An airplane is on approach into Perth airport at an altitude of 1.50×10^3 m and speed of 85.0 m s^{-1}. The tips of the wings of the plane are 30.0 m apart and the flux density of the earth's magnetic field in Perth is 5.80×10^{-6} T and the angle of dip is 66.0 ^{o}.
Using the vertical component of the earth's magnetic field calculate the EMF generated in the plane's wings. (5 marks)

15. A billiard ball rolls off a table with a velocity of 8.95 m s^{-1}. How far from the table will the ball land if the table is 1.65 m high? (4 marks)

End of Section One

Student Name: ____________________

Teacher Name: ________________

Section Two: Problem-solving 50% (100 Marks)

This section has eight (8) questions. You must answer all questions. Write your answers in the space provided.
Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.
Suggested working time for this section is 90 minutes.

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1. Roger Federer hits a tennis ball at an angle of 7.50 ^{o} above the horizontal at a speed of 55.0 m s^{-1}. At the instant he hits the ball it is 0.350 m above the ground. (Total 14 marks)

(a) Sketch the path of the ball from the racquet to the ground ignoring air resistance. On your diagram, clearly draw in the horizontal and vertical velocity vectors approximately to scale. Show your calculations clearly. Make sure you draw in at least 5 pairs of vectors, two before the ball reaches its highest point, one pair at its highest point and 2 pairs as it approaches the ground. (4 marks)

Horizontal velocity calculation	Vertical velocity calculation

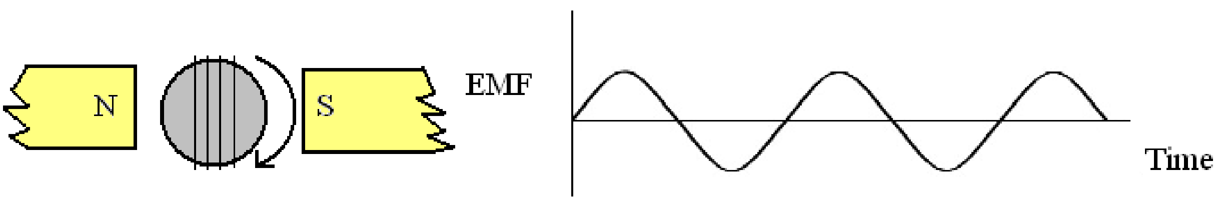
(b) Is there any time at which the ball will have zero acceleration between the time it is hit and the time it reaches the ground? Give a reason for your answer. (2 marks)

(c) The net is 91.5 cm at the point where the ball goes over it and 7.56 m from the point where the ball is hit. By how much does the ball clear the net? (4 marks)

(d) Find the time the ball is in the air from the moment it is hit to the time it reaches the ground. (3 marks)

(e) Find the horizontal distance the ball travelled in this time. If you did not get an answer for (d) use 2.00 s. (1 marks)

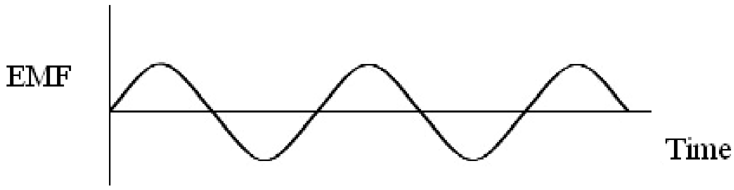
2. A coil is rotated in a magnetic field as shown together with a graph of the EMF (voltage) generated. (Total 12 marks)



(a) Explain why the EMF is generated in the coil and why the graph of output voltage takes the form shown. (2 marks)

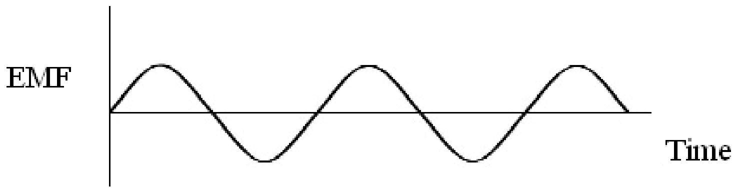
(b) In each of the following cases, sketch (on the graphs provided) the output voltage when the stated changes are made. Give reasons for your answers. The solid black line represents the output voltage before the stated change has been made. (6 marks)

(i) The magnitude of the magnetic field is doubled.



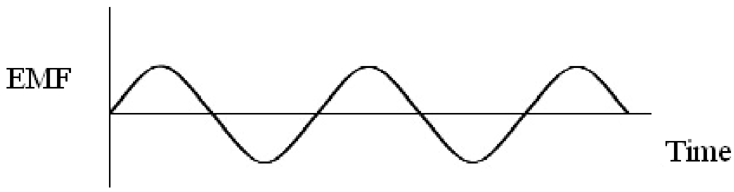
Reasons

(ii) The number of turns in the coil is doubled.



Reasons

(iii) The rate of rotation of the coil is doubled.

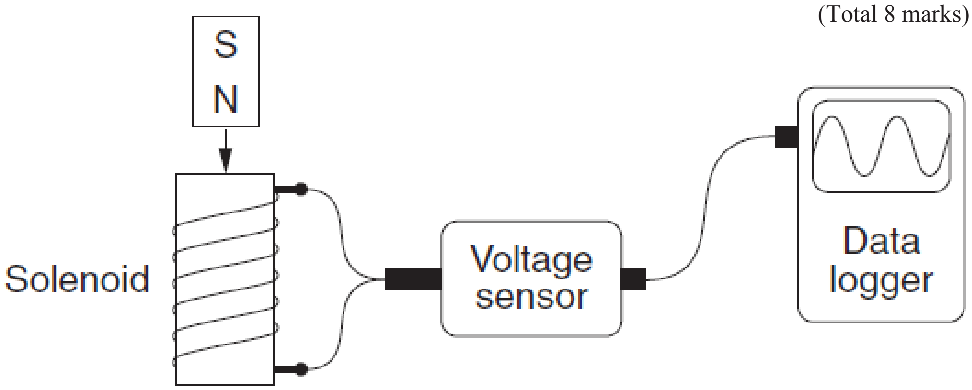


Reasons

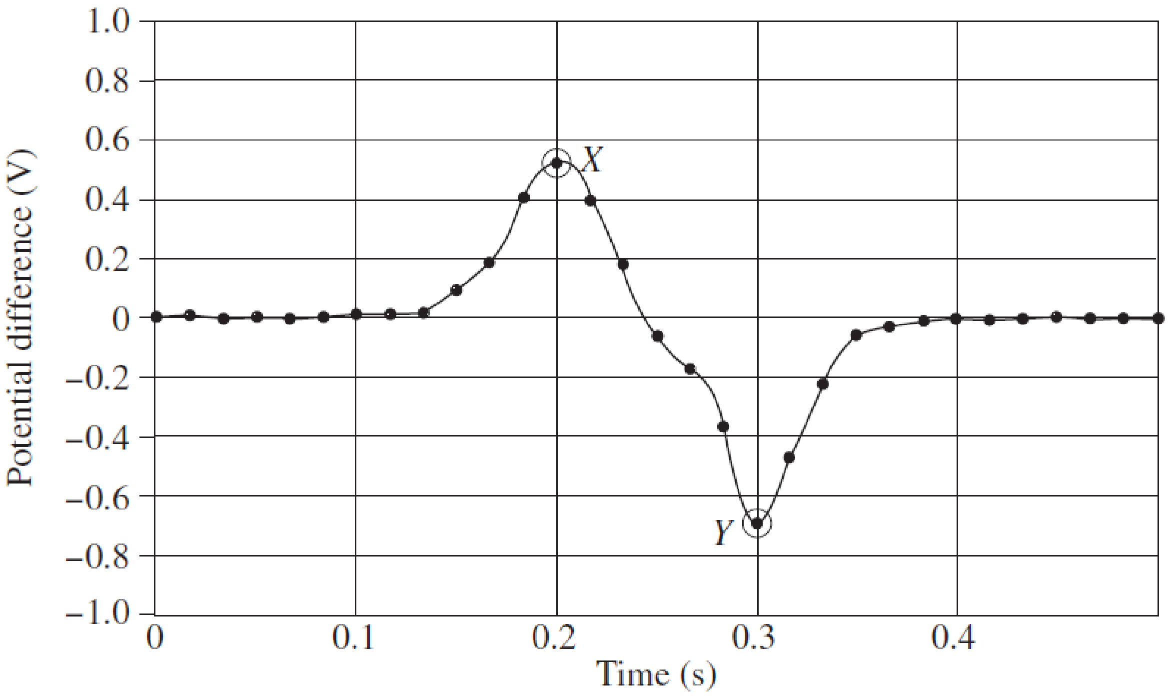
(c) The armature consists of 56.0 coils of radius 8.34 cm. The armature is rotated at a constant rate of 265 rpm (revolutions per minute) in a magnetic field of 9.22×10^{-3} T. Find the EMF produced by this generator. (4 marks)

3. A bar magnet is dropped through the centre of a solenoid connected to a data logger as shown.

(Total 8 marks)



The data are recorded in the graph as shown



(a) Why is the magnitude of the potential difference at Y greater than at X? (2 marks)

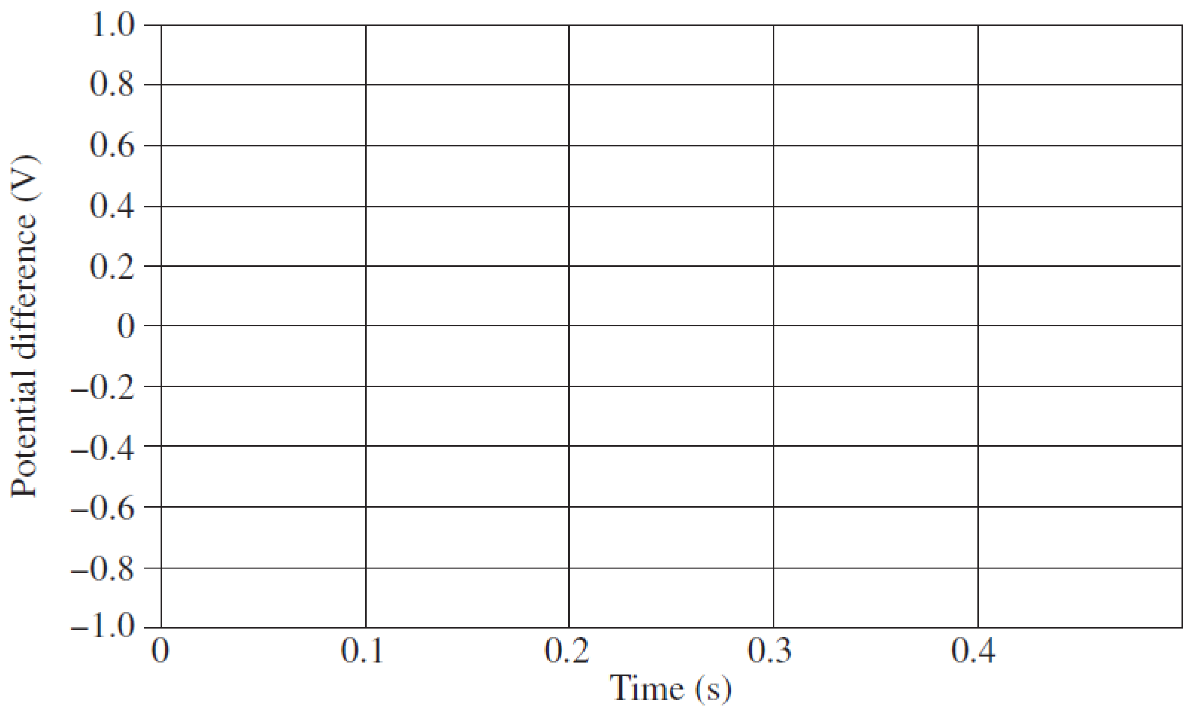
(b) The magnet is dropped again with two changes being made. (4 marks)

It is dropped from a greater height.

and

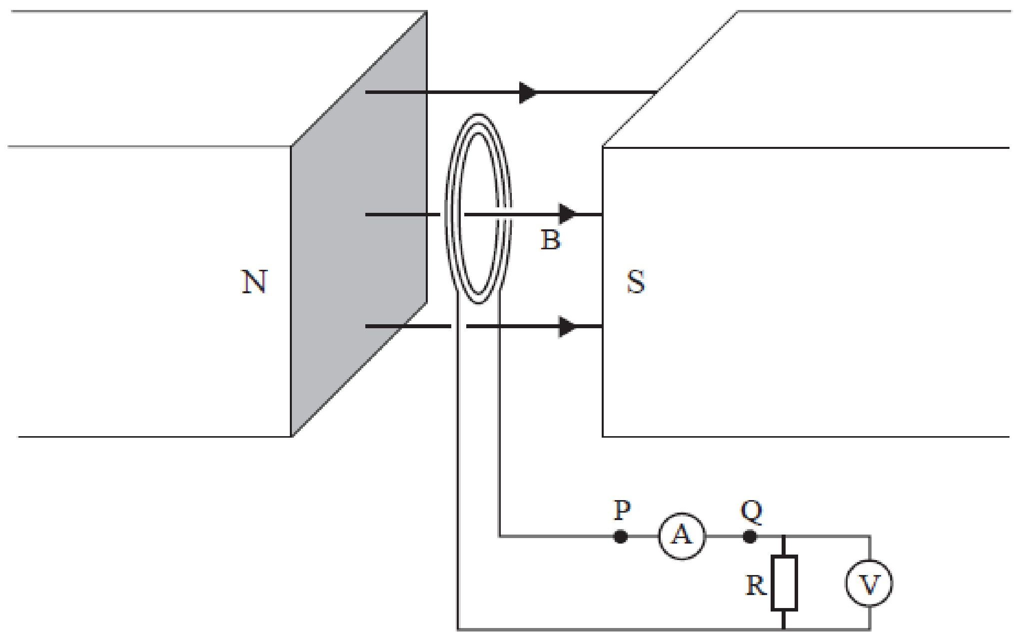
The south pole of the magnet is pointing down.

Sketch and clearly label a graph that represents the most likely outcome of this new experiment and explain the new shape of your graph.

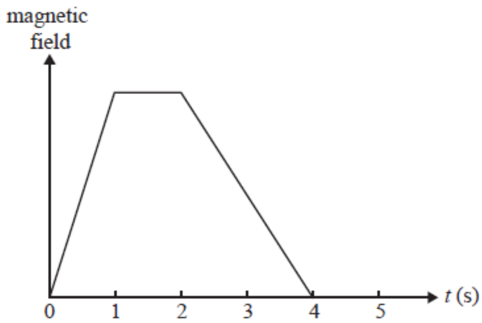


(c) The velocity of the magnet as it just enters the solenoid is 1.40 m s^{-1} and the total length of the wire wound around the solenoid is 40.0 cm. Calculate the approximate strength of the magnetic field of the bar magnet. (2 marks)

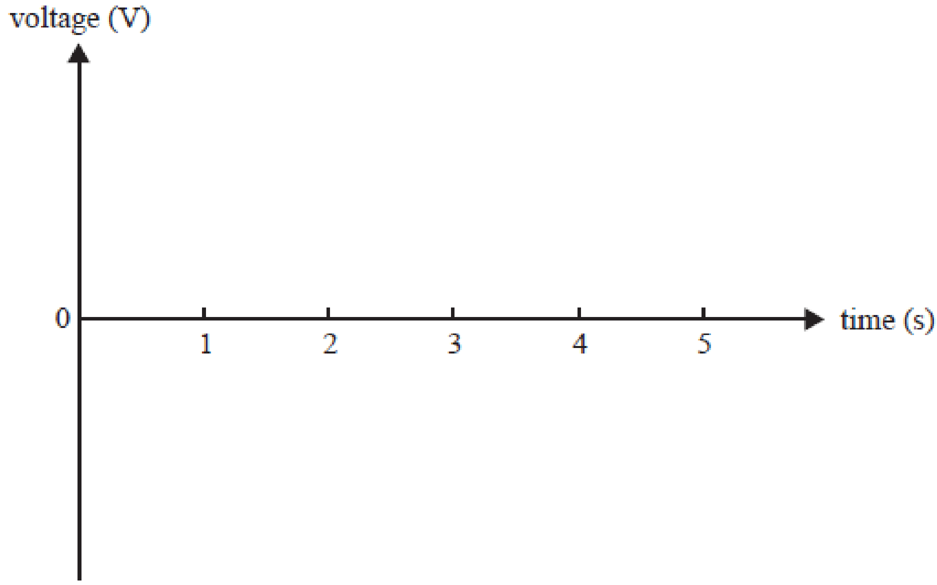
4. The diagram shows an experiment where the voltage induced in a coil by a time-dependent magnetic field is measured.
The voltmeter measures the voltage induced in the coil as a function of time.
The coil has 120 turns. (Total 11 marks)



The magnetic field varies with time as shown in the graph below.



(a) Sketch a graph of voltage against time as measured by the voltmeter. (3 marks)



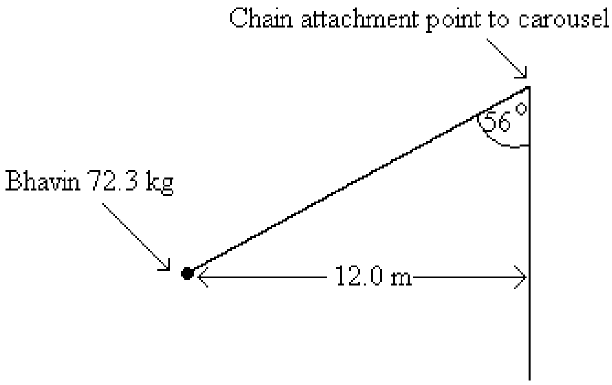
(b) Identify and explain the physical law you used for constructing your graph. (2 marks)

At another time, the magnetic flux through the 120 turns coil is a constant 3.0×10^{-4} Wb.
The magnetic field is now reduced to zero over a period of 0.012 s.

(c) What is the average EMF induced in the coil during that 0.012 s interval? Show your working. (3 marks)

(d) As the field is being reduced, in what direction (P → Q or Q → P) will the current flow through the ammeter in the diagram above? Explain your answer. (3 marks)

5. Bhavin and Aska decide to go to Perth Royal Show because there are two rides they specially want to go on. (Total 13 marks)
The first ride consists of a metal seat attached to four (4) chains which is attached to a rotating carousel which can elevate. At maximum rotational speed, the chains make and angle of 56.0° to the vertical as shown in the photograph and diagram.

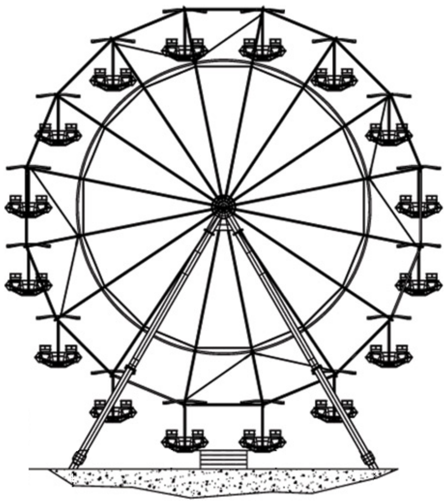


(a) If Bhavin has a mass of 72.3 kg, calculate the tension in each chain attached to his seat at maximum speed. (3 marks)

(b) What is the magnitude of the centripetal force acting on Bhavin? (2 marks)

(c) If Bhavin's radius of rotation is 12.0 m, calculate his maximum speed. (2 marks)

Aska then decides to go on the Ferris Wheel. She first measures the radius of the wheel at 12.0 m and the time for 1 full rotation of the wheel at 18.7 s. Aska's mass is 65.0 kg.

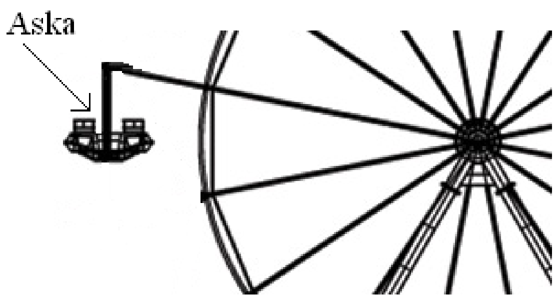


(d) Find Aska's apparent weight at;

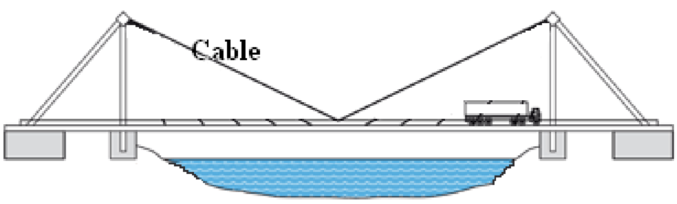
(i) the top of the rotating wheel

(ii) the bottom of the rotating wheel. (4 marks)

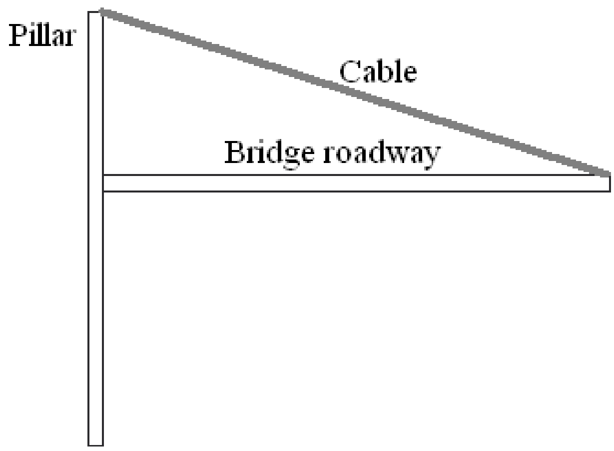
(e) Complete the diagram showing and labeling the forces acting on Aska when she is half way up the left hand side of the rotating wheel.



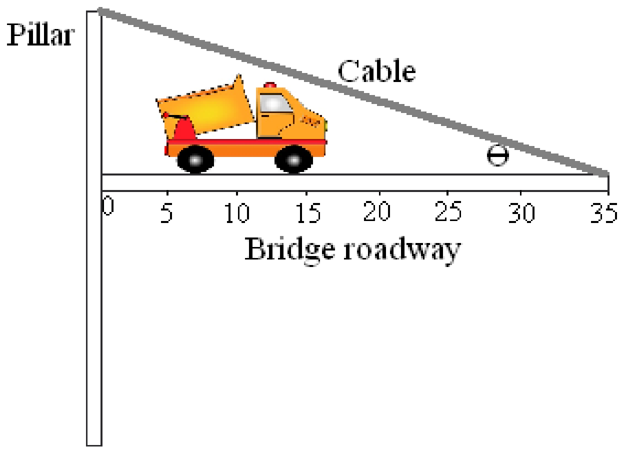
6. A two tower cable stayed bridge is built with reinforced concrete making the roadway and vertical concrete pillars supporting the roadway as shown. (Total 16 marks)



(a) One section of the bridge that is in equilibrium is shown below in a simplified diagram. Draw and label the forces acting on it. (4 marks)



The diagram shows a heavy truck moving along the single bridge roadway during construction. The distances in metres are shown and the centre of mass of the truck is at the 10.0 m mark. The top of the vertical pillar is 17.5 m above the roadway. The bridge roadway shown has a mass of 4.20×10^2 tonnes and the loaded truck a mass of 50.0 tonnes.

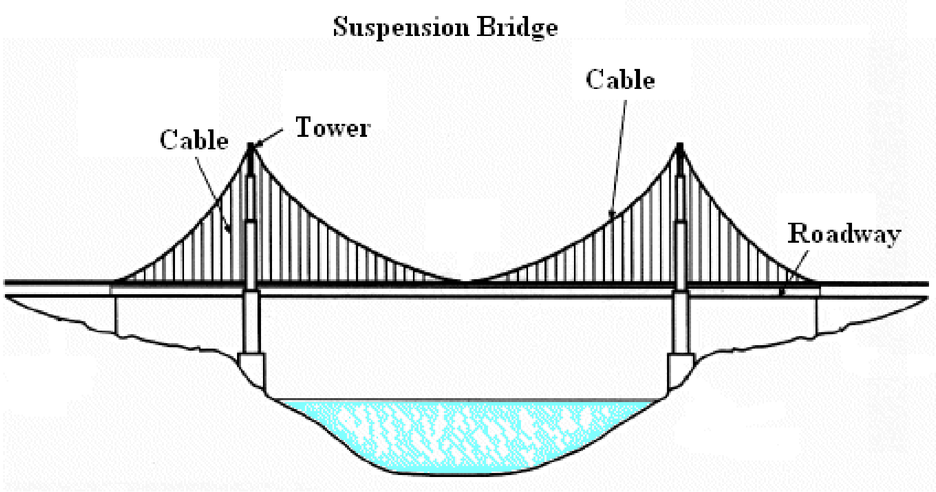


(b) Calculate the angle θ. (2 marks)

(c) Taking moments about an appropriate point, calculate the vertical component of the tension. (4 marks)

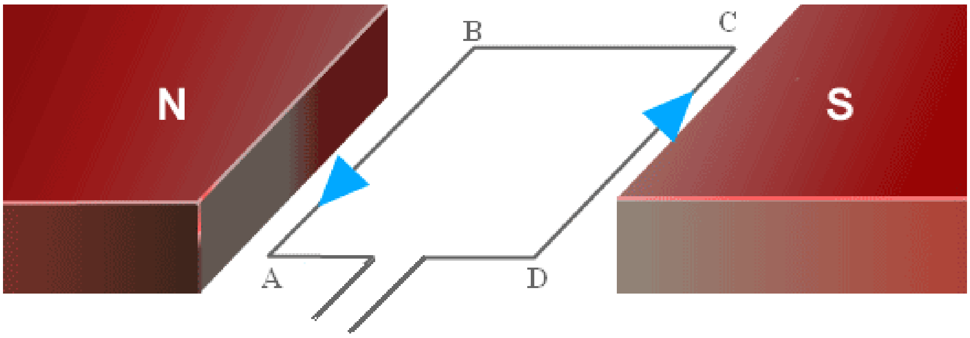
(d) Using the vertical component you just calculated find the tension in the cable. If you did not get an answer for (c), use 4.30 x 10^6 N. (4 marks)

"A suspension bridge is able to span greater horizontal distances than a cable stayed bridge using similar construction materials."



(e) By referring to both diagrams in this question, explain the above statement. (2 marks)

7. A rectangular loop of wire, ABCD, is carrying a current of 2.40 A in a uniform magnetic field of 1.20 T as shown. (Total 14 marks)



AB = CD = 0.150 m
BC = AD = 0.100 m

(a) Determine the force acting on; (2 marks)

(i) AB

(ii) BC

(b) In which direction does CD initially begin to move? (2 marks)

(c) Find the total torque acting on the loop. (4 marks)

(d) Suggest four (4) changes that could be made to increase the torque you calculated in (c). (4 marks)

(e) In practice, such an electric motor is impractical because it produces a very jerky output. How would you redesign the motor so that it turns in a much smoother way. You must include a diagram in your answer. (2 marks)

8. A communication satellite of mass 1.00×10^3 kg is in geostationary (geosynchronous) orbit above earth's equator. (Total 12 marks)

(a) Calculate the height of the satellite above the earth's surface. (4 marks)

(b) Find the velocity of the satellite. (3 marks)

(c) Will a heavier satellite of mass 2.00×10^3 kg, also in geostationary orbit, lie above or below the 1.00×10^3 kg? Explain your answer fully. (3 marks)

(d) There are approximated 300 satellites in geostationary orbits. Why is there no problem in overcrowding with all these satellites? (2 marks)

End of Section Two

Student Name: ____________________

Teacher Name: ______________

Section Three: Comprehension and Data Analysis 20% (40 Marks)

This section has two (2) questions. You must answer all questions. Write your answers in the space provided.
Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.
Suggested working time for this section is 36 minutes.

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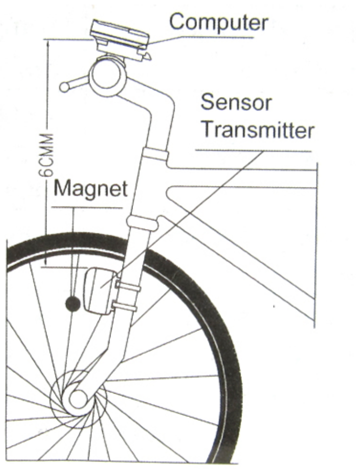
1. Bicycle Tachometer (Total 16 marks)

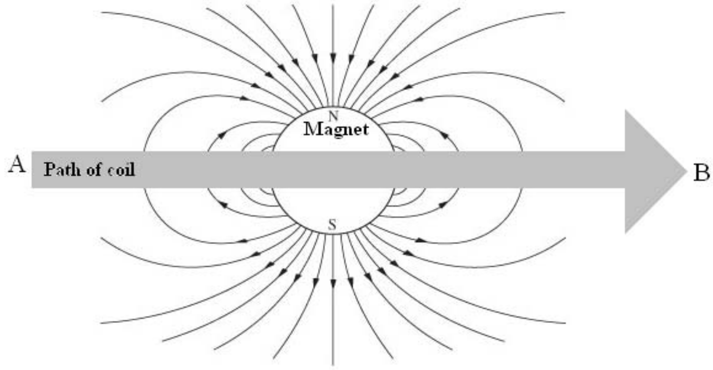
A common method of monitoring the speed of a bicycle is to attach a permanent magnet to the spokes of the wheel and mount a sensing coil/transmitter on the frame so that the magnet passes close by without touching the sensor on each revolution of the wheel when it is rotating.
The magnet and sensing coil mounted on bicycle is shown on the right.

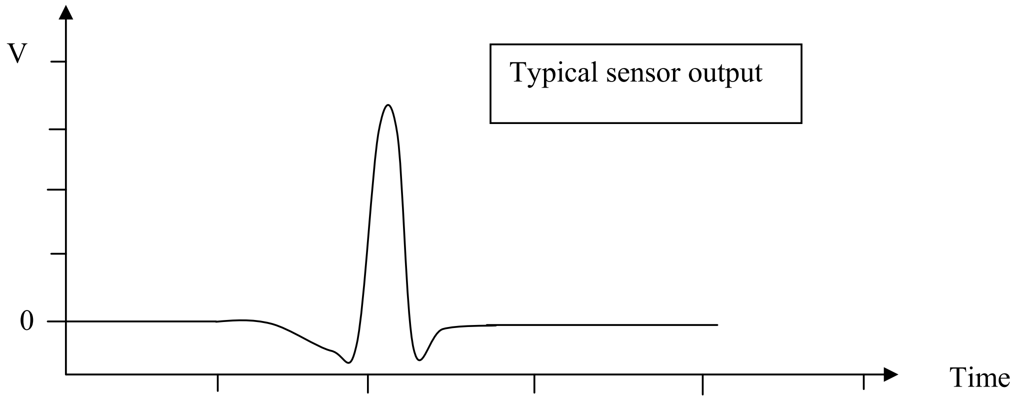


A cylindrical magnet is used where one circular face is a north magnetic pole and the other south. The sensor is a circular coil of ***N*** turns with the same diameter as the magnet.

Consider now the view from a point fixed on the wheel looking toward the magnet as the wheel rotates – the wheel rotates to the left but from the wheel's perspective, the sensor rotates to the right. The sensing coil will appear to follow a path as shown below. The magnetic field lines due to the magnet have been shown.

As the sensing coil passes by the cylindrical magnet from *A* to B in the diagram, the magnetic flux through the coil induces a voltage (emf) across the coil as shown in the graph below.





To estimate the size of the voltage pulse we can approximate the change of magnetic flux through the coil as that due to an average magnetic field of strength B_o acting over a time Δt such that:

$$\text{emf} = -\frac{\Delta \Phi}{\Delta t} = -\frac{N B_0 \pi D^2}{4 \Delta t}$$

where D is the diameter of the magnet and coil and N the number of turns in the coil.

If the wheel has an axle to ground radius of R and the magnet and coil are at a distance R_m from the axle, then during one complete revolution of the wheel the magnet and coil will be aligned for approximately Δt, where:

$$\Delta t = \frac{D}{2\pi R_m} T$$

where *T* is the time it takes the wheel to do a single revolution.
For a bicycle travelling at a constant speed v the period of one revolution is given by:

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

Combining these equations yields the following approximation for the magnitude of the output voltage:

$$\text{emf} = \frac{\pi}{4} N D \left(\frac{R_m}{R}\right) B_0 v$$

(a) If the bicycle is pushed backward, how would this affect the coil output? You may sketch the coil output if you wish. (3 marks)

(b) If the magnet was reversed so that North became South, how would this affect the coil output when the bicycle was moving forward? You may sketch the coil output if you wish. (3 marks)

Consider a particular example for a bicycle with the following values:

wheel radius:	$R = 0.27$ m
magnet position:	$R_m = 0.20$ m
strength:	$B_o = 0.10$ T
magnet diameter:	$D = 0.010$ m

(c) How many voltage pulses would occur if the bicycle travelled 1.0 km? (4 marks)

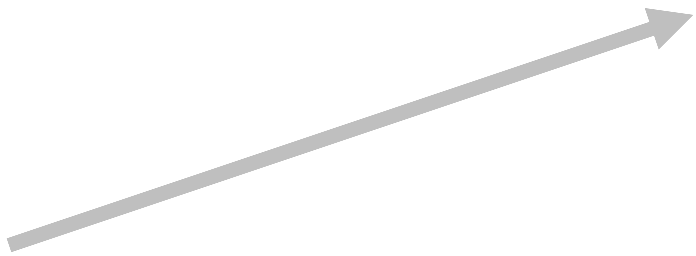
(d) How many turns should the coil have in order to generate1.0 V at a speed of 10 m s^{-1}? (2 marks)

(e) Why is there a slight dip before and after the main peak in the coil response? (4 marks)

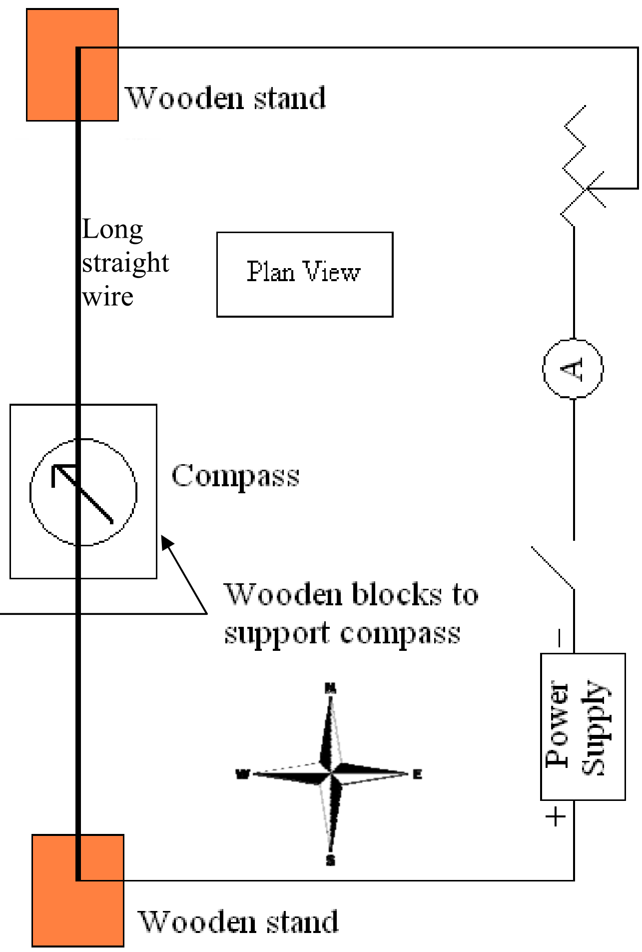
2. Magnetic field associated with a current carrying conductor. (Total 24 marks)

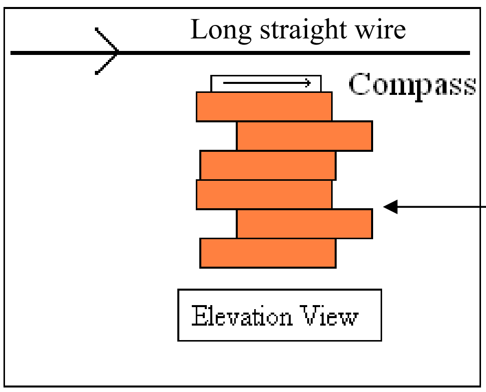
The earth's magnetic field B_e, can be considered to be uniform and constant at any point on the earth's surface. A magnetic compass detects the direction of horizontal component of any magnetic field. If another magnetic field due to the current in a long straight wire is set up perpendicular to earth's component, then the two fields will combine and a compass will point in the direction of the resultant.

(a) Draw in the magnetic field around the current carrying conductor. (2 marks)



An experiment is set up to investigate the field generated by a current carrying conductor. The long straight wire is aligned north-south and set up away from any other magnetic material so that any deflection of the compass is due to the magnetic field generated by the current.





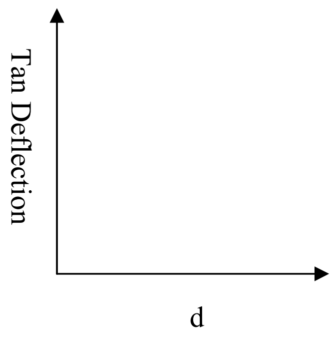
(b) If the horizontal component of the earth's magnetic field is 2.33×10^{-5} T and the compass deflection from the north is 37.0 ^{o}, calculate the magnetic field produced by the current carrying conductor. (2 marks)

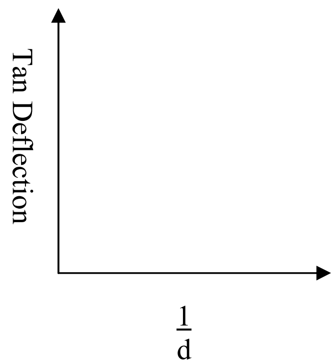
The current in the long straight wire is adjusted to 4.5 A and then a series of compass deflection readings were then taken at different distances, d, from the wire.

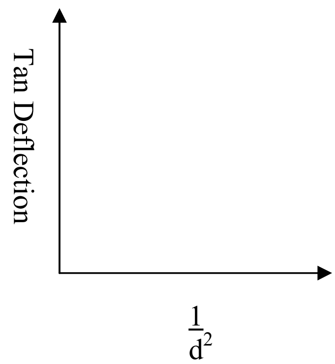
(c) Complete the following table. (4 marks)

Deflection Left (^{o})	Deflection Right (^{o})	Average Deflection (^{o})	Tan Deflection	d (cm)	$\frac{1}{d}$ (cm^{-1})	$\frac{1}{d^2}$ (cm^{-2})
63.8	62.8			0.41		
57.7	60.5			0.48		
54.5	51.7			0.60		
48.3	41.7			0.80		
31.6	36.0			1.19		
17.7	15.7			2.79		

(d) Sketch the following graphs from the data table above. (6 marks)





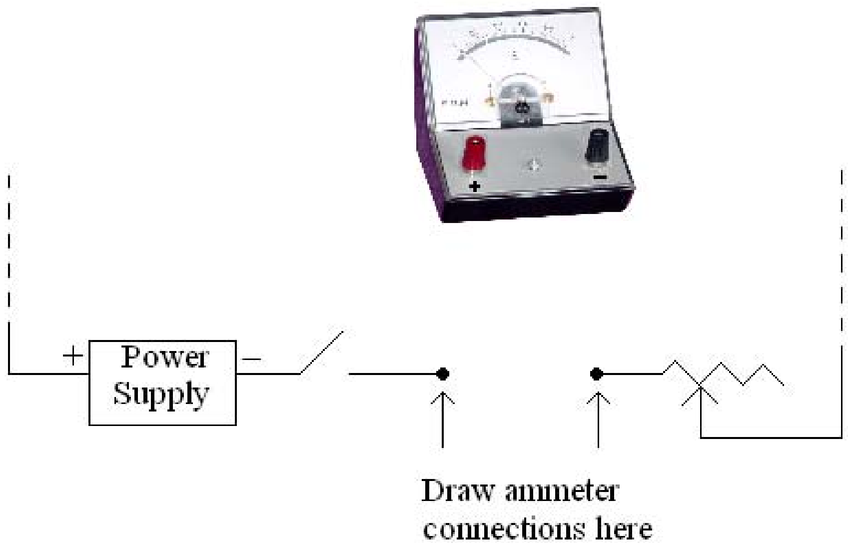


(e) From the shapes of the three graphs above, state the relationship between tan deflection and distance from the wire. (2 marks)

(f) Explain the connection between tan deflection and strength of the magnetic field of the long straight wire. (2 marks)

(g) Suggest at least two (2) reasons why the right and left deflection readings in the table above were different. (2 marks)

(h) Show by drawing in the connections how the ammeter is wired into the circuit. (2 marks)



(i) If an AC power supply was used rather than a DC power supply, how would this have changed the experiment. (2 marks)

End of Examination