Physics ATAR 12 /150

Semester One 2017

Question/Answer Booklet

Student name: ______________________________________

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

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.

Student Marks

Section	Percentage of paper	Maximum mark	Student mark	
Section One: Short response	29%	44		
Section Two: Problem-solving	57%	86		
Section Three: Comprehension	14%	20		
		Student Mark	/150	%

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	11	11	45	44	29
Section Two: Problem-solving	5	5	85	86	57
Section Three: Comprehension	1	1	20	20	14
				150	100

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 12 Information Handbook 2017.* 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.

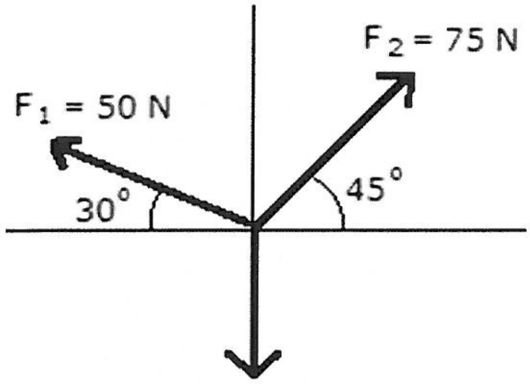
4. Working or reasoning should be clearly shown when calculating or estimating answers. Answers should be given to the appropriate number of significant figures. Answers not given to the appropriate number of significant figures may result in marks being deducted, up to a maximum of 4 marks.

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 that the answer is continued at the "Back of Booklet". Clearly label the number of the question(s) that you are continuing at the back of the booklet.

Section One: 11 Questions for a total of 44 marks.

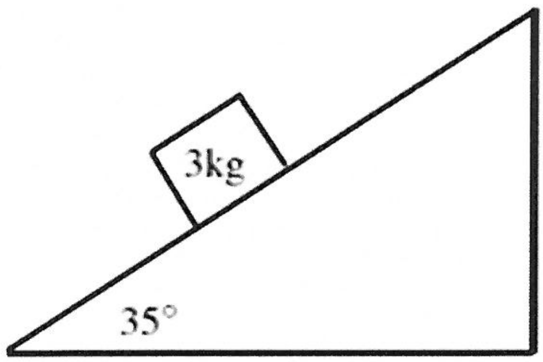
QUESTION ONE **(5 marks)**



The diagram on the left shows three forces in equilibrium about a single point.

Determine the magnitude of the third force.

QUESTION TWO **(5 marks)**

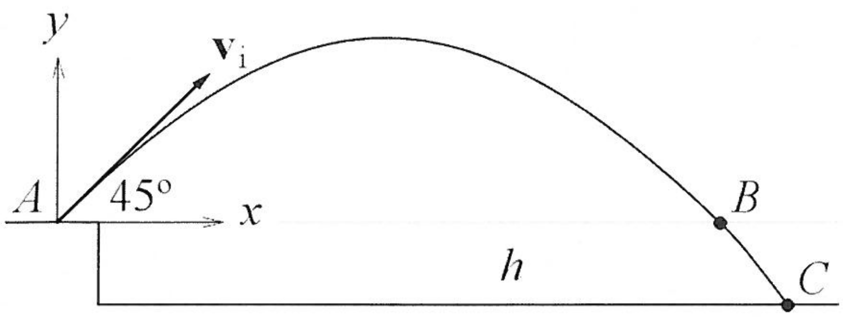


The diagram on the left shows a box of mass 3.00kg sliding down a ramp inclined at 35.0^0 to the horizontal, against a constant 10.0N frictional force.

a) Turn the diagram into a free body diagram. (2)

b) Determine the net acceleration of the box down the slope. (3)

QUESTION THREE **(5 marks)**



A ball of mass 156g is thrown up at 45.0^0 from point A and is caught at point C, 2.40m below vertically below A.

a) On the diagram use vectors to show the real forces acting on the ball at point B. (2)

b) If the ball was thrown at 25.0m/s, determine its total flight time. (3)

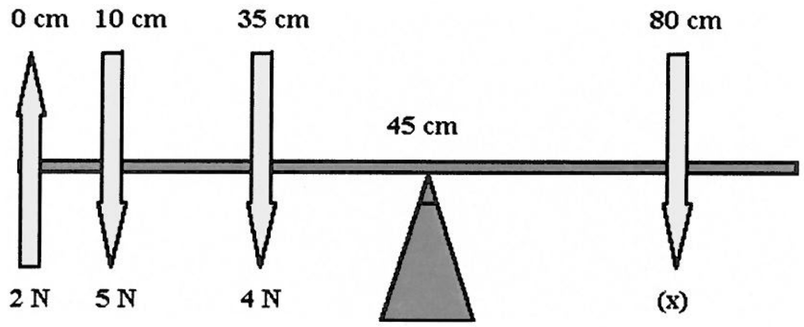
QUESTION FOUR **(4 marks)**

A GPS satellite is in orbit 1450km above the Earth's surface. Determine the **altitude** to which the satellite must be moved in order for the gravitational force it experiences to be **halved**.

QUESTION FIVE **(3 marks)**

There is a lump in the middle of the road on Southport St in West Leederville that allows vehicles to get airborne if they exceed 55.0km/h over the lump. Determine the radius of curvature the road over the lump.

QUESTION SIX **(4 marks)**

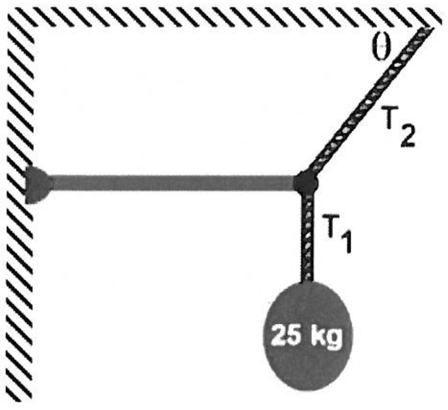


The diagram to the left shows a metre ruler (weight force 1N) at equilibrium.

Determine the weight on the right of the fulcrum required to maintain static equilibrium.

(All distance measurements have been taken from the left hand end)

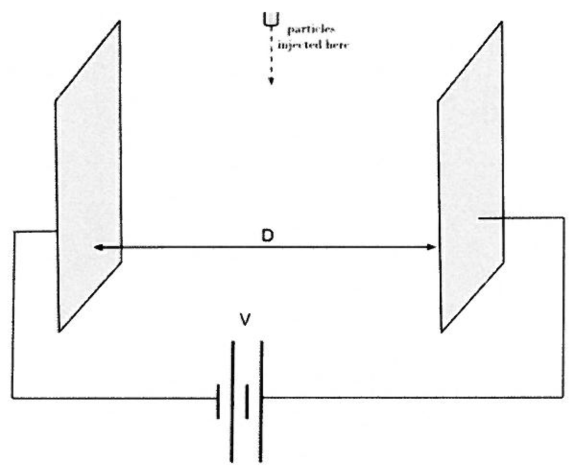
QUESTION SEVEN **(3 marks)**



The diagram on the left shows a heavy chandelier suspended from a wall and ceiling.

If the angle, θ, is 28^0, determine the tension in both T_1 and T_2 (the horizontal supporting rod does not affect the tension in the cables).

QUESTION EIGHT **(5 marks)**



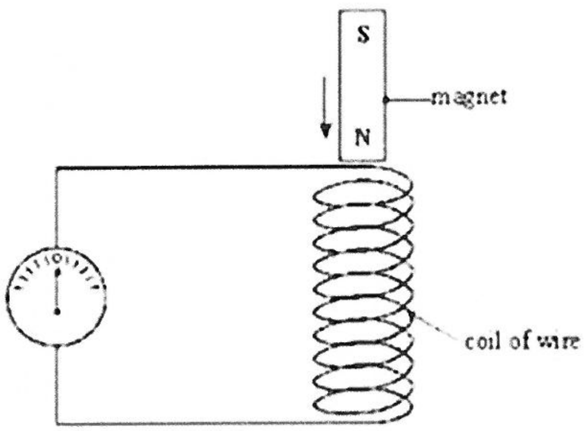
The diagram on the left shows a pair of metal plates separated by a distance, D, which is 14.5cm. The voltage applied across the plates is 245V, and the field established between the plates is uniform.

a) Neatly sketch lines showing the field between the two plates (2)

b) Sketch in the path that a slow moving negative ion, injected from the top of the diagram, would describe. (1)

c) Determine the intensity of the uniform between the plates. (2)

QUESTION NINE **(3 marks)**

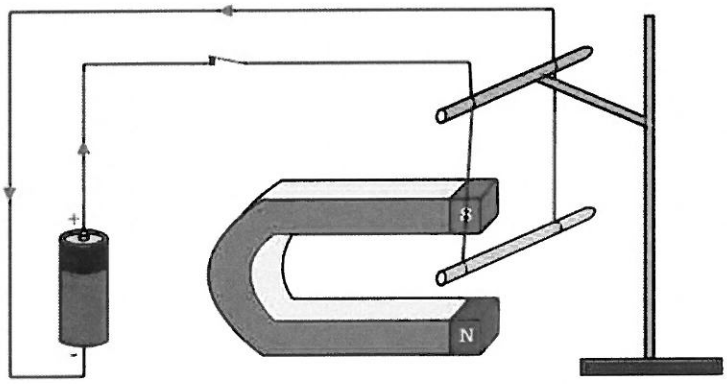


The diagram on the left shows a bar magnet about to fall through a coil of wire.

a) Show on the horizontal wires the direction of current flow as the magnet approaches the coil (as shown). (1)

b) Explain how the needle on the meter on the left on the diagram will behave as the magnet enters the top, moves through and then leaves the coil. (2)

QUESTION TEN **(3 mark)**



The diagram on the left shows a metal rod carrying a current of 0.560A, in a uniform magnetic field of 0.0540T. The uniform field extends along 13.5cm of the metal rod. The wooden retort stand on the right of the diagram has a horizontal wooden bar designed to hold the wires away from the magnet.

a) Use a vector diagram to show the force the metal rod experiences. (1)

b) Determine the magnitude of the electro-magnetic force the metal rod experiences. (2)

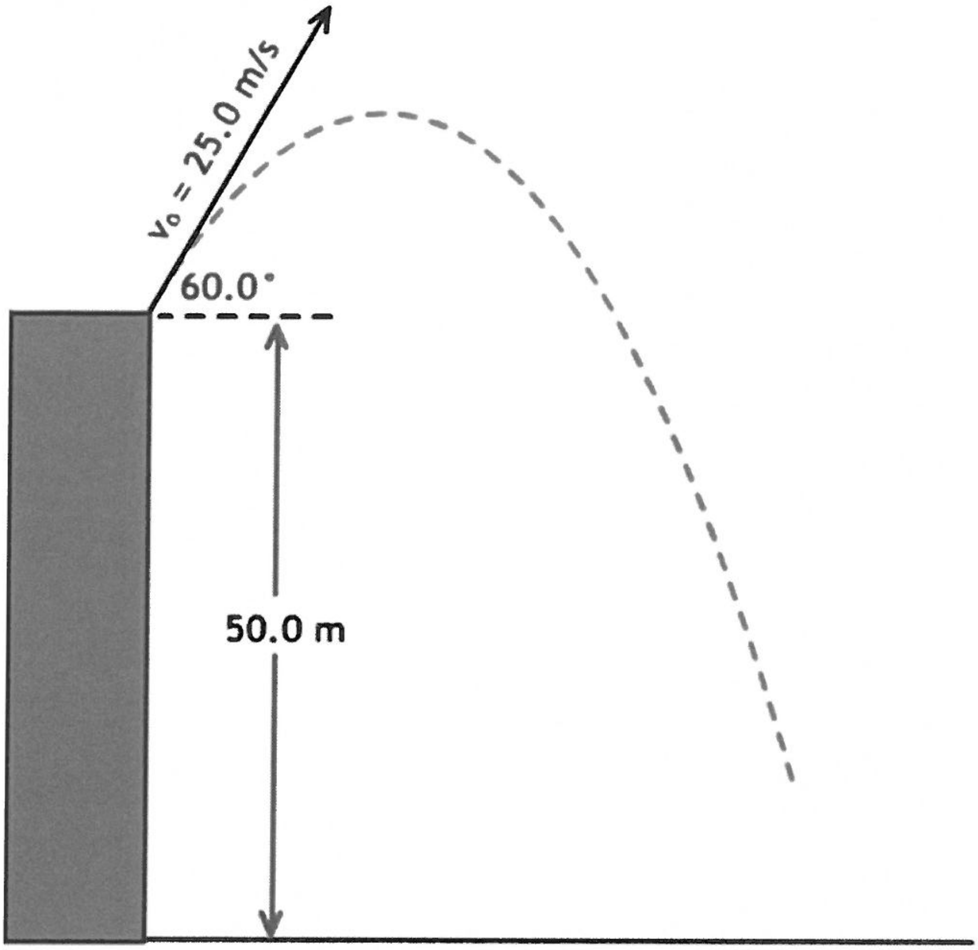
QUESTION ELEVEN **(4 marks)**

An alpha particle approaches to within of 4.55μm of a hydrogen ion.

Determine the magnitude and direction of the force between these two particles.

Section Two: 5 Questions for a total of 86 marks

QUESTION TWELVE **(15 marks)**



Harry has a new bow that he is testing out by firing arrows over a high, steep cliff.

a) Determine the horizontal and vertical components of velocity for this projectile. (2 marks)

b) With the launch angle and velocity shown above, what is the maximum height above the cliff Harry's arrows will go to? (2 marks)

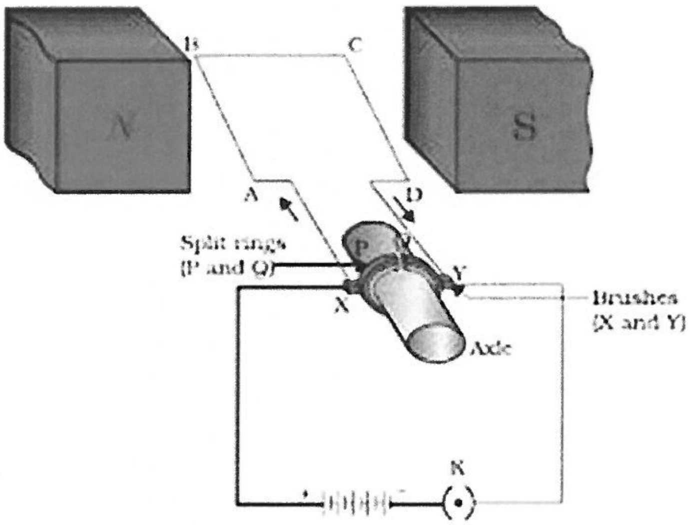
c) What is the total flight time for Harry's arrow. (3 marks)

d) In what position, relative to the top edge of the cliff will Harry's arrow be 3 seconds after launch. (4 marks)

e) Determine the maximum horizontal range (ie from the bottom of the cliff) of Harry's arrow. (1 mark)

f) Explain with the aid of simple diagrams why the real range is much less than the theoretical range. (3 marks)

QUESTION THIRTEEN **(19 marks)**



The diagram on the left represents an electric motor with a rectangular coil containing 425 loops. Each loop has two long sides (AB and CD) which are 9.50cm long, and has a width (BC) of 5.25cm. The current flowing through the circuit is 1.25A and the magnetic field intensity is 0.455T.

a) Will side AB initially move up or down from the position shown? Justify your answer. (2 marks)

b) Determine the maximum force experienced by each **side** of the motor. (2 marks)

c) Determine the maximum total torque of the motor. (2 marks)

d) What is the function of the split rings? How do they achieve this? (3 marks)

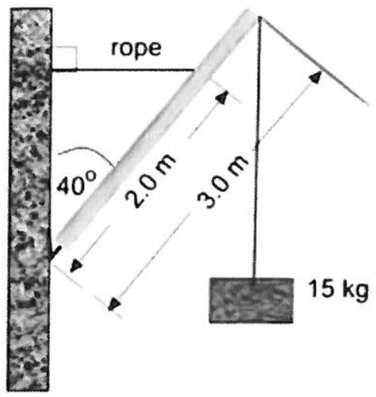
e) **Explain** the main change that would need to be made to the motor's design if it was to be connected to an AC power supply and still run effectively. (2 marks)

f) List three changes that could be made to increase the torque of the motor. (3 marks)

g) Back EMF is always generated in a working electric motor. Explain why it does not **usually** affect the effective operation of the motor. (3 marks)

h) The motor design depicted at the beginning of this question is rarely utilised in practice – most motors have at least two and often three sets of coils, even spaced around the axel. Explain. (2 marks)

QUESTION FOURTEEN **(18 marks)**



The diagram on the left shows a system in static equilibrium. The 3.00m long uniform beam has a mass of 12.5kg and supports a mass of 15.0kg from its end. It is hinged to the wall of a building, making an angle of 40.00 to the vertical. The beam, in turn, is supported by a rope that is joined at a point 2.00m from the hinge, and makes a perfect right angle with the wall.

a) Determine the tensile force present in the rope. (4 marks)

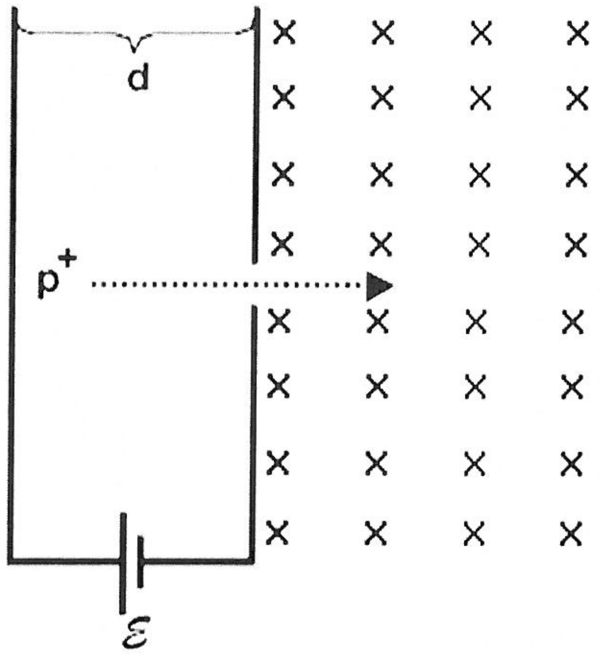
b) Determine the reaction force of the wall on the hinge. (5 marks)

c) If the rope is let out from the wall until the beam becomes horizontal, determine the resulting tension in the rope. (5 marks)

d) **Explain** two simple design changes that could reduce the tension in the rope, while still lifting the same masses. (4 marks)

QUESTION FIFTEEN **(8 marks)**

A **proton** is made to travel through two different fields, as shown in the diagram below, and its motion is investigated at each stage.



If the parallel plates are separated by 5.00cm and have a potential difference of 2450 volts across them, determine:

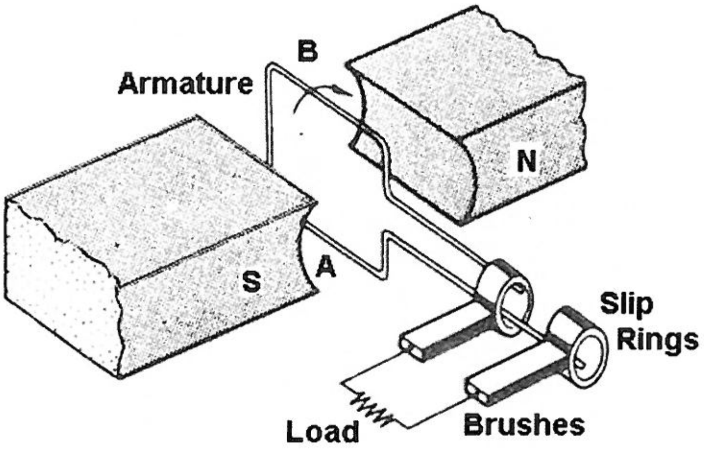
a) the electric field intensity
(1 mark)

b) Determine the exit velocity of the proton from the electric field. (3 marks)

c) Show on the diagram a partition of the trajectory of the proton as it enters the magnetic field. (1 mark)

d) Determine the radius of travel of the proton if the magnetic field intensity is 1.45T. (3 marks)

.**QUESTION SIXTEEN** **(26 marks)**



The diagram on the left represents a simple generator whose coil is being rotated clockwise (as seen from the slip rings). The coil has 156 loops, each formed from a square whose side length is 12.5cm. The magnetic field intensity is 0.324T and the coil / armature is being rotated at 1.20×10^3 rpm. The external load has a resistance of 2.58Ω.

a) Show on the diagram the flow of current in the next quarter turn. (1 mark)

b) Determine the maximum flux through the coil during a full rotation. (2 marks)

c) Determine the average EMF produced by this generator. (3 marks)

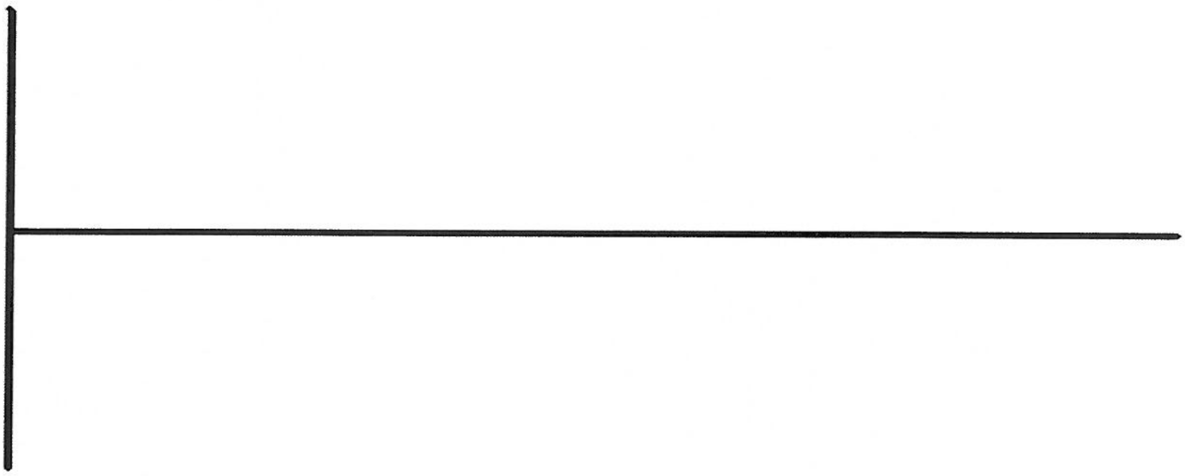
d) Now determine the maximum EMF produced by this generator. (2 marks)

e) On the two sets of axes below, show

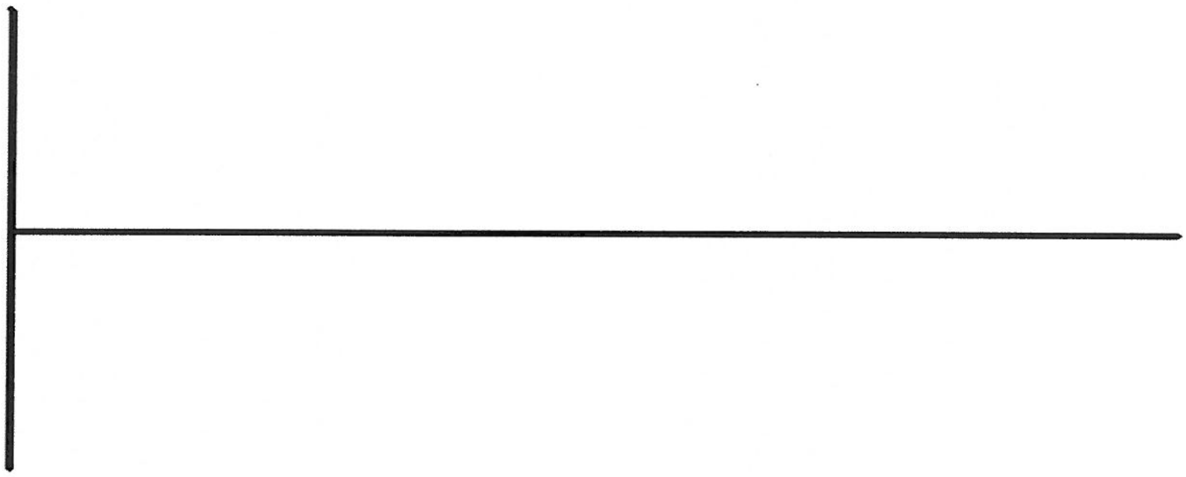
(i) how the flux through the coil varies with time for one full rotation from the position shown in the diagram at the beginning of the question. (3 marks)

(ii) how the EMF generated varies with time for one full rotation from the position shown in the diagram at the beginning of the question. (2 marks)

(i)



(ii)



f) The diagram shows permanent magnets producing the magnetic field, but in reality, electromagnets are often used. Suggest two advantages of using electromagnets over permanent magnets for generators. (2 marks)

g) Industrial generators, such as those at Muja Power Station near Collie in WA have outputs in the order of 200.0MW. They produce an EMF of 16500V – determine the initial current flowing, given these parameters. (2 marks)

h) Prior to transmitting the electricity to Perth, a transformer is employed to step up the voltage to 335 000V. Determine:

i) the turns ratio of the transformer. (2 marks)

ii) The transmission current. (1 mark)

iii) Explain why the voltage is stepped up prior to long distance transmission. (3 marks)

i) Transformers dealing with voltages as high as these are liable to heat up quickly and become inefficient if not designed correctly. Explain how power loss is minimised in the design of transformers. (3 marks)

SECTION THREE - Comprehension and Interpretation

One question worth 20 marks.

QUESTION SEVENTEEN (20 marks)

HOW DESIGN AND ENGINEERING HELP BREAK RECORDS
THE LONDON VELODROME

A cyclist's supreme ability and their high-tech bike will, undeniably, play a large part in deciding the Olympic victor but PDD believes that the track shape, environment and even atmosphere will affect the outcome of London 2012's track cycling events.

Senior Development Engineering, Ian Parker and our Principle of Engineering Design, Julian Swan went along to *Cycling Night: How to break a world track record*; an engineering talk about the London 2012 Olympic velodrome design to find out why.

The last 4 Olympic Velodromes:

Atlanta
An outdoor track made of Timber, laid perpendicular to the racing line. This had a very bumpy surface and was affected by head winds.

Sydney
Purpose built indoor track designed by Australian architect, Ron Webb.

Athens
An out-door track with a roof added on. This still had open sides so was still heavily effected by wind.

Beijing
Purpose built track designed by German architect, Ralph Schuman.

So what is so special about the award winning London 2012 velodrome aside from being a modern, highly sustainable building and why do we expect records broken? (*Hopefully Team GB ones at that*). Designed by Ron Webb with direct input from Team GB - the track shape is rounder and optimised for Pursuit racing; an area in which our cyclists are expected to shine. The geometry is similar to the Manchester velodrome, so not only will it be more suited to events which Team GB are strong at but also will have a familiar feel to the Team GB riders who do all their training at the Manchester velodrome.

As well as the team's influence on the form of the new track, Dave Brailsford, the British Cycling Performance Director, has worked with the athletes analysing their performance on the track to define where the optimum Start-Finish line should be positioned for the riders. Another significant home advantage will be the crowd's support for Team GB riders. Sir Chris Hoy had a key input in the venue's seating layout. Normally velodromes do not have seating at each end of the track, as the banking at 42 degrees exceeds the maximum angle of 32 degrees for stadia seating, and so obscures the view for the spectator.

Furthermore, the home straight normally seats the officials and press, which means that during a race a rider will hear the crowd support on the back straight with 'radio silence' on the ends and the home straight.

The velodrome has a capacity of 6,000, (Manchester only has 3,000) with seating at the ends whilst the officials and press have been relegated from track side to the upper tier. Having been at the velodrome as part of the London Prepares series we have experienced the Mexican Wave of sound following a British cyclist around the track and it definitely makes a positive difference. It gives me goosebumps just thinking about the cheering. Nice one Sir Chris, I hope it drives you on for gold!

Another key element in breaking records is the aerodynamics of the environment. The velodrome is a fully indoor arena in order to remove the effects of head winds, which also makes it possible to control the temperature and humidity inside the track area. Klaus Bode of BDSP, an environmental engineer, explained that there are no restrictions on the temperature or humidity of the track from the UCI (Union Cycliste Internationale) the governing body for international cycling. This is unusual considering the amount of regulations created by them for the bicycle configuration, athletes position & clothing.

Between 70% - 90% of a cyclist's barrier to speed is the air resistance as they cut through the wind. Therefore, when designing a record breaking velodrome, this was one of the biggest areas considered. From a scientific perspective, making the air lighter/ thinner allows the body to cut through it more easily. Lighter Hydrogen molecules in water vapour displace heavier Nitrogen molecules normally in air.

The end result is that the race track area will be maintained at 28 degrees Centigrade with higher humidity content. The environmentalists amongst you should not be overly upset about the energy consumption as the velodrome has been designed using CFD (computation fluid dynamics analysis) to efficiently heat and naturally circulate the air significantly beyond the current building regulations and removes the need for air conditioning. However, if you have seats in the upper tier you should be aware that you will literally be in the Hot Seat as the crowd area can get up to 36 degrees!

All of these aspects amount to a velodrome designed and engineered with impeccable attention to detail and specifically tailored for Team GB's cyclists. Now all that's left to do is for our athletes to pedal like they've never pedalled before...

Reference – Article taken from the April, 2012 edition of PDD – "Perspectives of Design and Development", published in South Kensington, London.

QUESTIONS

a) Describe and explain three factors that should aid athletes in breaking world records in the London Velodrome. (6 marks)

b) Sketch a free body diagram showing all the real forces on a cyclist on the banked track (assume the cyclist is perpendicular to the track on the bank). (3 marks)

c) There are two angles (to the horizontal) of banking mentioned. Each of these banks is on a curve of radius 30.0m. By using the appropriate calculations, determine ratio of the maximum speeds attainable by cyclists on these banks without the aid of friction. (6 marks)

d) British cyclist Jason Kenny had a mass of 72kg and attained a top speed of 74.1km/h on one of the 42^0 banked sections. There was some friction available, in addition to the reaction force provided by the bank. Determine the magnitude of each of these forces. (5 marks)

END OF EXAM

EXTRA WORKING SPACE

EXTRA WORKING SPACE