St Mary's Anglican Girls' School

Semester II Exam

2008 Question/Answer Booklet

PHYSICS 12

(Questions marked with a * are for the pre 2010 course)
(Stars have not been placed in the answer key only in the blank question paper)

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 CANDIDATE
Standard Items
Pens, pencils, eraser or correction fluid, ruler.
Special Items
Physical formulae and constants sheet, drawing implements, templates and calculators satisfying the conditions set by the Curriculum Council.

TO BE PROVIDED BY THE SUPERVISOR
This Question/Answer Booklet.
Physical Formulae and Constants sheet.

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. Please check carefully and if you have any unauthorised material with you hand it in to the supervisor BEFORE reading any further.

NAME: ______________________________

Short Answer	Problem Solving	Comprehension	%
/30	/50	/20	/100

STRUCTURE OF THE PAPER

Section	No of questions	No of marks out of 200	Proportion of exam total
A: Short Answers	15	60	30%
B: Problem Solving	8	100	50%
C: Comprehension & Interpretation	2	40	20%

INSTRUCTIONS TO CANDIDATES

Write your answers in the spaces provided beneath each question in sections A and B
The value of each question in section A is four marks.

Note that (where appropriate) answers should be given numerically and they should be evaluated **and not left in fractional or radical form**. Give all numerical **answers to three significant figures** except in the cases for which estimates are required.

Questions containing specific instructions to **show working** should be answered with a complete, logical, clear sequence of reasoning showing how the final answer was arrived at; **correct answers which do not show working out will not be awarded full marks**.

Questions containing the instruction **estimate** may give insufficient numerical data for their solution. Candidates should provide appropriate figures to enable an approximate solution to be obtained.

Candidates should remember that when descriptive answers are required, they should be used to display understanding of the aims and objectives of the physics 12 course. A descriptive answer, which addresses the context of a question without displaying an understanding of physics principles, will not attract marks.

Despite an incorrect final result, credit may be obtained for method and working, provided these are **clearly and legibly set out**.

SECTION A : Short Answers - 60 Marks (30%)

Attempt ALL 15 questions in this section.
Show all working out. (4 marks each)

1. A swag man is making a pot of billy tea. When the water has boiled the tea leaves are sprinkled over the top of the boiling water. The swag man now wishes to pour the tea into a cup, but when he does so the tea leaves on the top of the water pour into the cup making a cloudy mess. The swag man swings the pot of billy tea in a vertical circle to move the tea leaves to the bottom of the pot. If the centre of the water in the billy is 80.0 cm from the centre of the circle, what is the minimum speed of the water at the top of the circle so that the water does not fall out of the pot?

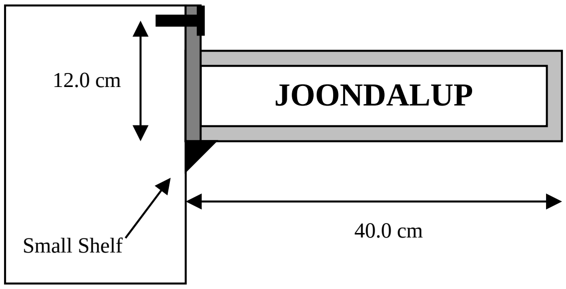
(4 marks)

2. An astronaut is building a physics experiment in space using a 1.00 kg shot put and a 1.00 g pea. She goes for a space walk so that she is sufficiently far from other gravitational fields, taking the shot-put and pea with her. She places an X on the surface of the shotput and sets it spinning at the rate of 1.00 revolution per hour. At what distance from the centre of the shot put should the pea be placed in order to be “geostationary” above the X on the shotput.

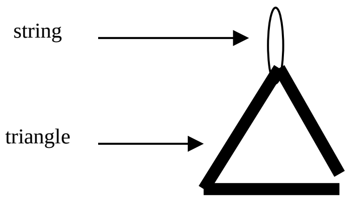
(4 marks)

3. A sign has been mounted onto a pillar in a train station as shown below. What is the tension in the bolt that stops the sign falling off the shelf if the sign has a mass of 400 g?

(4 marks)



4. A triangle is a musical instrument that is played by a percussionist in an orchestra. The triangle is hung off a piece of string as shown in the diagram.



a) What type of equilibrium is the triangle in?

stable unstable neutral (please circle)

(1 mark)

b) Explain why?

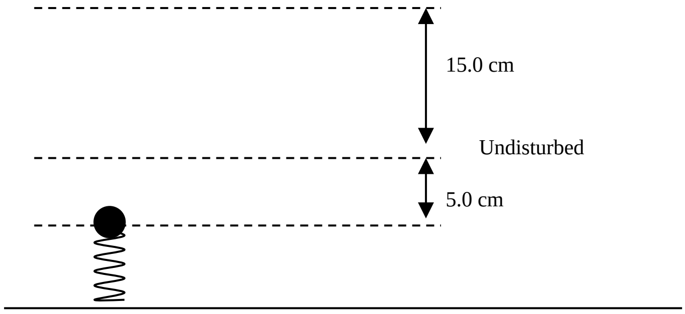
(1 mark)

c) Does the corner to which the string is attached represent a displacement node or a displacement antinode when the triangle is resonating after being struck? Explain.

(2 mark)

***5.** A mass-less spring propels a ball of mass 40.0 g, 15.0 cm into the air. In order to achieve this the spring was compressed by 5.00 cm. Assuming that the spring was operating in its proportional region, what was the Hooke's law constant for the spring?

(4 marks)



***6.** A milk maid is sitting on a three legged stool. Each leg has a circular cross section of radius 1 cm and an original length of 35.0 cm. The milk maid has a mass of 85.0 kg.

a) What is the stress on one leg?

(2 marks)

b) What is the change in length of the leg if the average Young's modulus in this region is 4.00×10^{10} N m^{-2}.

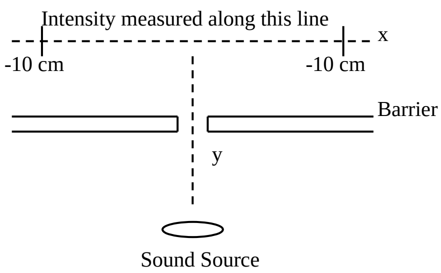
(2 marks)

7. Estimate the fundamental resonant frequency of a test tube when air is blown across the top of its open end.

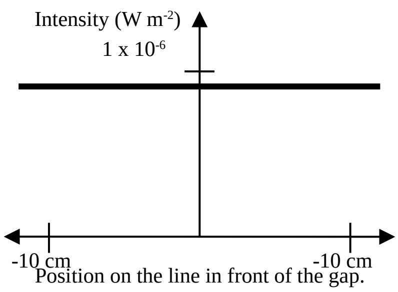
(4 marks)

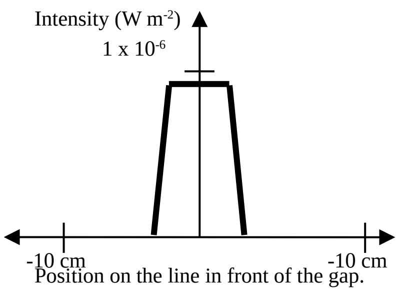
8. Please circle which graph A, B, C or D is the best match for a sound of frequency 100.0 Hz diffracting through a gap of 0.500 cm in air. The intensity of the sound with no barrier or gap at a distance "y" is 1.00×10^{-6} Wm^{-2}.

(4 marks)



A





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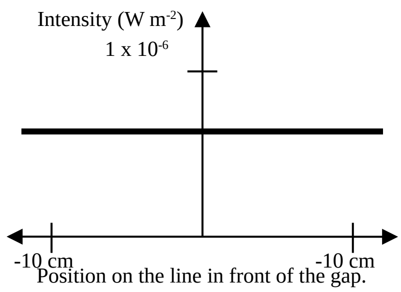
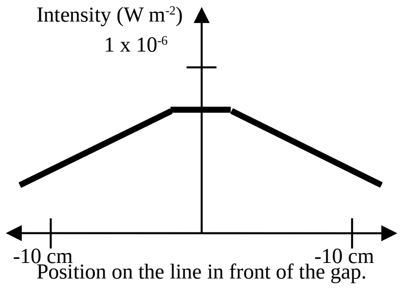
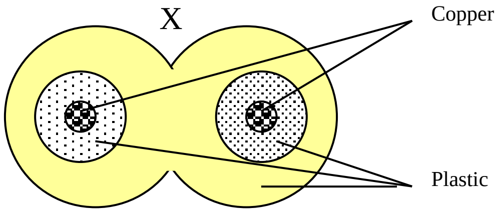


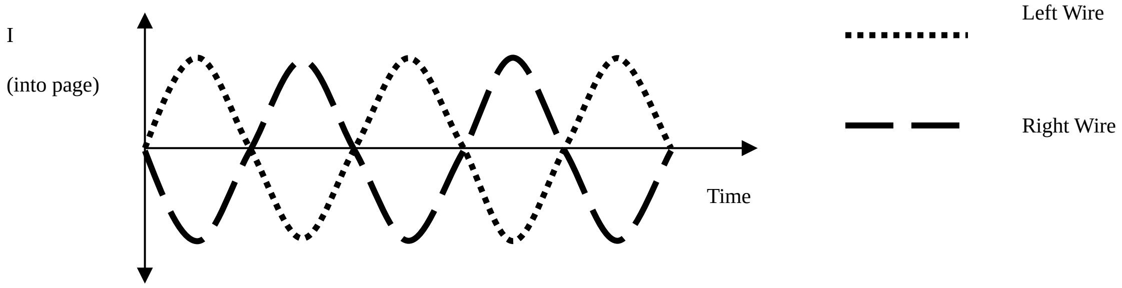
<table><tr><td>C</td><td>D
</td></tr></table>

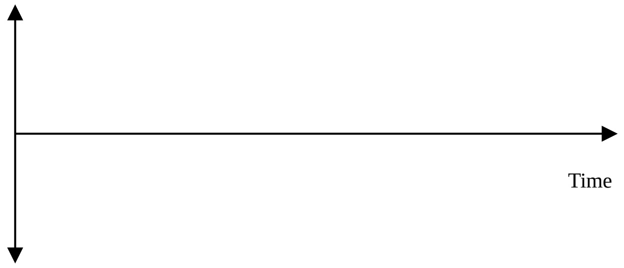
9. An electrical power cord is made from two parallel wires, side by side, encased in two layers of plastic (double insulated). An end view of the two wires is shown in the diagram below. The wire on the left delivers electricity to the appliance situated behind the page (active). The wire on the right returns electricity to the power point (return). The wires (and consequently appliance) are plugged into a typical Australian household power point.

A graph of the current flowing in the left and right wire is shown below. Sketch a graph of the resultant magnetic field produced at the location marked X as a function of time. Make sure you appropriately label and calibrate the axes if you can.

(4 marks)







10. A physics student is asked to make some hypotheses about how altering various characteristics of a tuning fork will affect the wavelength that it produces. Complete the table below by correctly predicting whether the wavelength will **increase, decrease** or **remain the same**.

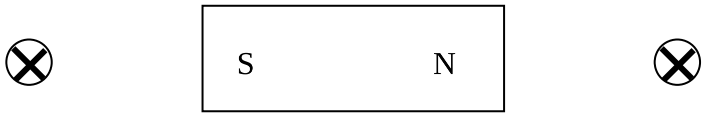
(4 marks)

Change made to original tuning fork.	How wavelength was affected.
The prongs were made thinner without altering their length.	
The thickness of the prongs were maintained but the length was decreased.	
The distance between the prongs was increased but the mass and length were	

unaltered.	
* The tuning fork was manufactured using copper instead of mild steel.	

11.a) Draw the resultant magnetic field around these wires, carrying conventional current into the page, and the magnet.

(2 marks)

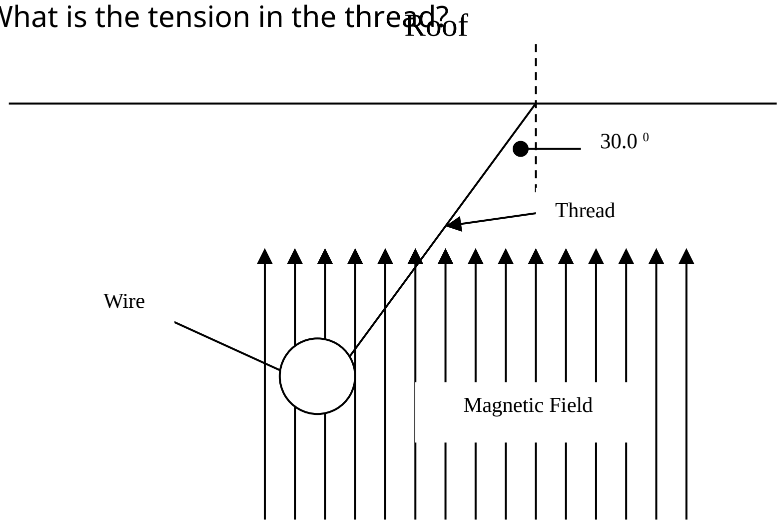


b) If the wires in the above diagram are fixed and the magnet is free to move on a frictionless surface, describe the direction and behavior of the movement of the magnet, if any.

(2 marks)

12 . A piece of thread is hung from the roof and attached to a horizontal wire that is carrying direct electric current. The current carrying wire is then exposed to a constant external magnetic field. The wire moves to a new stationary point with the thread forming an angle of 30.0 ^{0} to the vertical. The wire has a mass of 8.00 g. What is the tension in the thread?

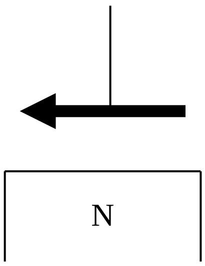
(4 marks)



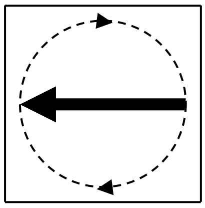
b) In which direction is the current flowing in the wire? Please draw this direction onto the diagram above.

13. A copper sewing needle is hung horizontally from a piece of thread above the north end of a large bar magnet. The needle is then flicked in a clockwise direction as viewed from above so that it spins at the rate of 3.2 revolutions each second. The needle has a length of 4.00 cm.

Side View



Top View



a) Draw the magnetic field lines on the top view diagram of the magnet.

(1 mark)

b) Will the sharp end of the needle be changed positively or negatively?

(1 mark)

c) What is the EMF induced between the ends of the needle? Explain.

(2 marks)

14. Cheryl is installing a low voltage garden lighting system in her garden. The system uses a transformer plugged into a power point in Australia to produce 12 V to run the lights on. The transformer is 90.0 % efficient. The system runs 5 garden lights, each consuming 20 W of energy. How much current is drawn from the power point?

(4 marks)

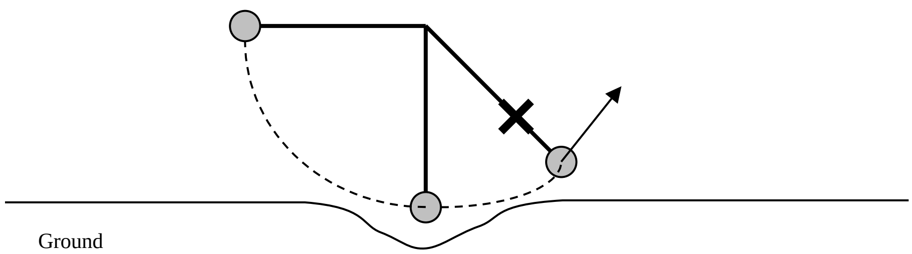
15. Ultraviolet light with a wavelength of 300 nm is shone onto a solar cell. Electrons leave the surface at a speed 5.98 x 10^5 m/s. What is the ionization energy of the metal in joules?

(4 marks)

SECTION B : Problem Solving - 100 Marks (50%)

Attempt ALL 8 questions.

1. A pendulum has a string of length 2.30 m and is dropped from horizontal. When the 0.500 g bob has swung past the bottom and up to the 45.0 ^{0} mark with the horizontal, the string is cut by a razor blade.



a) What is the tension in the string when the bob is at the bottom of the swing?

(4 marks)

b) What is the velocity of the bob as the string is cut?

(4 marks)

c) At what range from the point at which the razor blade cuts the string will the bob land on the ground?

(3 marks)

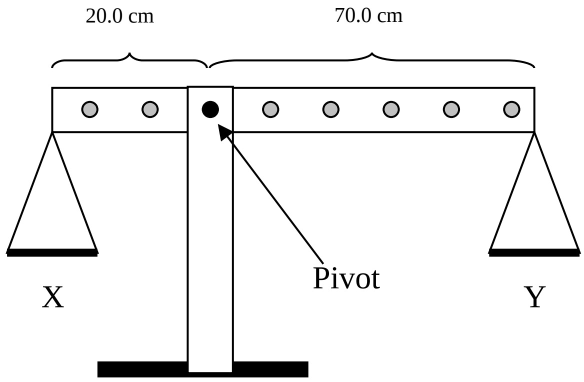
d) The experiment is repeated. The scientist changes the angle at which the string is cut. The scientist is attempting to find an angle that produces a larger range than the original angle of 45.0 ^{0}. Write a hypothesis as to whether the other angles will produce larger ranges in an environment free of air resistance. Explain.

Note - (Assume all launch speeds are identical).

(1 mark)

2. A student is trying to make a set of pan weighing scales. A diagram of the scales is shown below.

Diagram A



The objects to be weighed are placed at Y. Counter balancing masses (of known mass) are added to pan X until the lever arm becomes horizontal. The lever arm itself is to be considered weightless. The lever arm has multiple holes drilled in it so the point at which the lever arm pivots can be altered.

a) What is the load in pan Y when 340 g is placed in pan X and the lever arm is horizontal?

(3 marks)

b) The lever arm is replaced with a new material that is not mass-less. The new arm is identical in shape to the old one and is reattached as shown in Diagram A. The new arm has a mass per unit length of 100×10^{-3} kg/m. Recalculate your answer to part a) using the new lever arm.

(4 marks)

c) Where relative to pan Y should the pivot be placed to negate the mass of the lever arm? Explain.

(2 marks)

d) The weightless lever arm is now **re-installed** and the point at which the arm pivots is shifted to an unspecified location on the lever arm. The beam holds horizontal when the weight in pan Y is 0.4 times the weight in pan X. How far is the pivot horizontally from the point at which pan X attaches?

(4 marks)

***3.** Ronda has just returned from a holiday in Thailand with a lot of washing. Unfortunately the weather is cold and wet in Perth and not suitable for getting clothes dried. Ronda decides to go to a laundro-mat to get her clothes washed and dried more quickly.

The laundro-mat contains 16 top loader washing machines, each individually capable of producing 50 dB of sound when operating. The 8 dryers at the laundro-mat when all operating simultaneously produce 64.0 dB of sound. All sound measurements were taken at a distance of 2.00 m from the machines and all machines (dryers and washing machines) produce an identical frequency (of 346 Hz) in no particular phase with each other. The walls of the laundro-mat have been fitted with sound absorbent material to prevent reflection of sound.

a) What is the loudness of one dryer operating with no washing machines operating?

(3 marks)

b) What is the loudness of the sound in the room when 16 washing machines and 8 dryers are all operating simultaneously?

(3 marks)

c) How many washing machines would produce a loudness of 59.03 dB?

(2 marks)

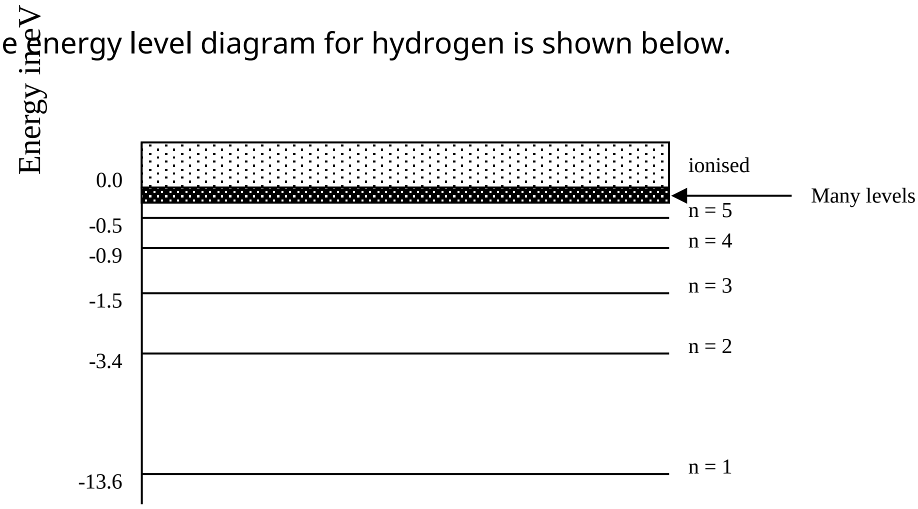
d) Remember that the walls of the laundry mat have been fitted with sound absorbent material to prevent reflection of sound. Ronda goes outside the laundro-mat to get some fresh air and to get away from the noise of **all** the machines operating simultaneously. At a distance of 10 m from all the machines some distance from (but in front of) the open doors, what is the maximum theoretical intensity of the sound?

(3 marks)

e) The sound of the machines has to pass through a door way that is 1.00 m wide. How will this affect the loudness of the sound perceived by Ronda 10.0 m away?

(1 mark)

4. The energy level diagram for hydrogen is shown below.



a) A bombarding electron with a kinetic energy 13.3 eV collides with a hydrogen atom. What is the highest energy level to which an electron originally in the ground state can be elevated? Show working to support your answer.

(2 marks)

b) What is the velocity of the scattered electron?

(2 marks)

c) Show on the above diagram and indicate in the box below, how many different frequencies of light can potentially be produced went the electron falls from its excited state in part a) to the ground state?

(1 mark)

d) To what part of the electromagnetic spectrum does the smallest of these downwards transitions belong? Explain.

(2 marks)

e) A photon of wavelength 110 nm now falls on the atom in the ground state. What effect will this have on the atom? Explain.

(3 marks)

f) To which region of the electromagnetic spectrum does the smallest photon capable of ionizing a hydrogen atom belong? Support your answer with calculations.

(3 marks)

5. A dentist has just unpacked a new X-ray machine to be used in her dental surgery. The X-ray machine is plugged into a 240 V power supply and produces an accelerating potential of 40.0 kV.

a) What is the ratio of windings in the secondary as compared to the primary to achieve this accelerating potential?

(2 marks)

b) The X-ray machine accelerates electrons (cathode rays) emitted by a tungsten filament. What is the velocity of the electrons as a result of passing through this accelerating potential difference? Assume the electrons are initially stationary.

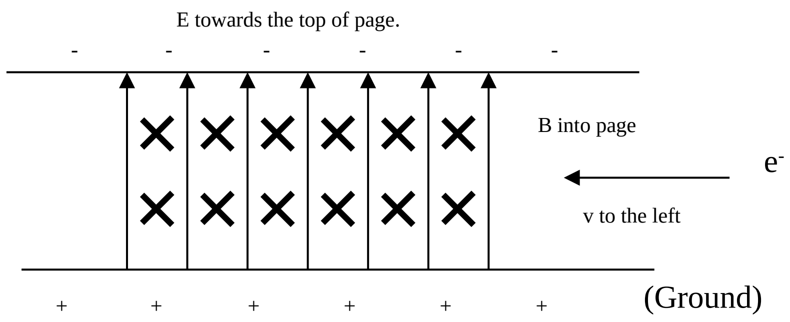
(3 marks)

c) What is the shortest wavelength that the machine is capable of producing?

(2 marks)

d) An X-ray machine is placed at a particular location on the earth where the earth's magnetic field has no effect on it. A particular electron is shot at a speed of 1.00×10^{8} m s^{-1} through a region of space within the machine containing an electric field of 1.31×10^{8} N C^{-1} and a magnetic field of 2.00 T orientated as shown in the diagram below. If the electron is unaffected by gravity, what is the net force on the electron while it is in the fields?

(3 marks)



e) At what approximate location on the surface of the earth and in what direction should the electron gun be pointed so that the earth's magnetic field has no effect? Explain.

(2 marks)

6. (13 marks)

A cattle farmer on a remote cattle station is using a diesel generator to create electricity one evening after a cloudy day in the Northern Territory. The diesel generator is very noisy and is situated 150 m from the house to make its sound quieter. The generator puts out 1000 W of power at a voltage of 240 V. The 2 wires that connect the house to the generator (live and return) each have a resistance of
$0.01\ \Omega\ m^{-1}$.

a) What is the current being put down the transmission line to convey the 1000W of power to the house?

(3 marks)

b) What is the **total** power loss in the transmission line in conveying the current to **and from** the house?

(3 marks)

c) How much useful voltage remains at the house end of the circuit to be used in appliances?

(2 marks)

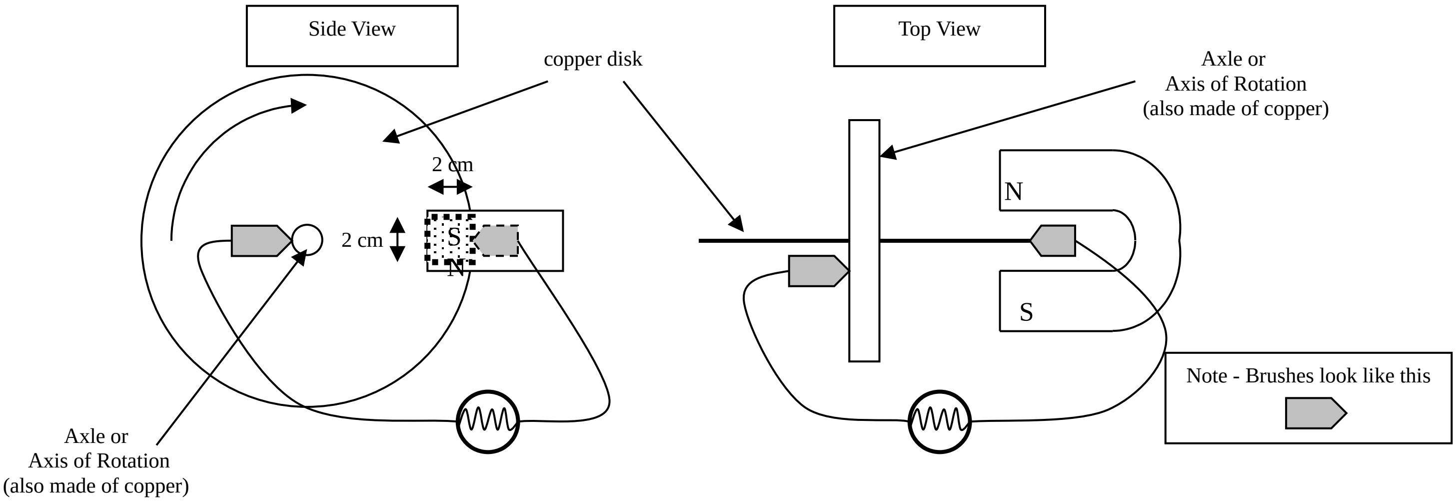
d) If the farmer switches on too many appliances in the house, what effects will this have on the circuit?

(2 marks)

e) What could the farmer do to reduce the power loss in the line? Explain.

(3 marks)

7. One of the first generators ever invented consisted of a circular copper metal disk whose edge was rotated through the magnetic field of a horseshoe magnet. The edge and the centre of the wheel were connected to an external circuit by near frictionless graphite brushes. When the wheel is spun the light bulb glows.



a) In which direction will a positively charged particle experience a force if the metal wheel is rotated in the direction shown in the side view diagram?

(1 mark)

b) What is the polarity of the edge and centre of the wheel?

(1 mark)

Edge = positive / negative (please circle)

Centre of wheel = positive / negative (please circle)

c) The magnetic field passes through a square space of side length 2.00 cm. In one rotation of the disk how much area of the disk is exposed to the magnetic field? Note the disk has a radius of 15.0 cm.

(3 marks)

d) If the wheel is turning at the rate of 420 revolutions per minute, and the magnet has a field strength of 0.8 T, what is the voltage induced in the disk?

(3 marks)

e) Draw onto the wheel in the side view diagram the direction of the eddy currents that are induced in the wheel.

(1 mark)

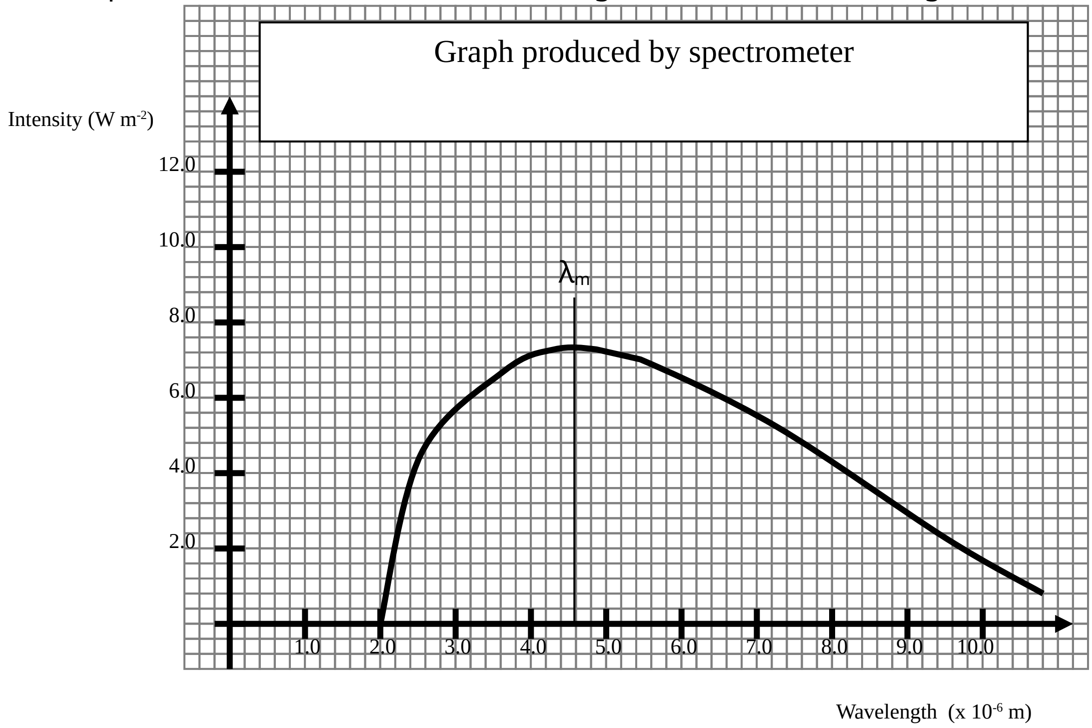
f) The wheel is mounted on frictionless bearings. When the magnet and brushes are removed and the wheel is spun, it appears to spin forever. When the magnet (but not the brushes) are replaced, will the wheel spin forever? Explain why or why not.

(2 marks)

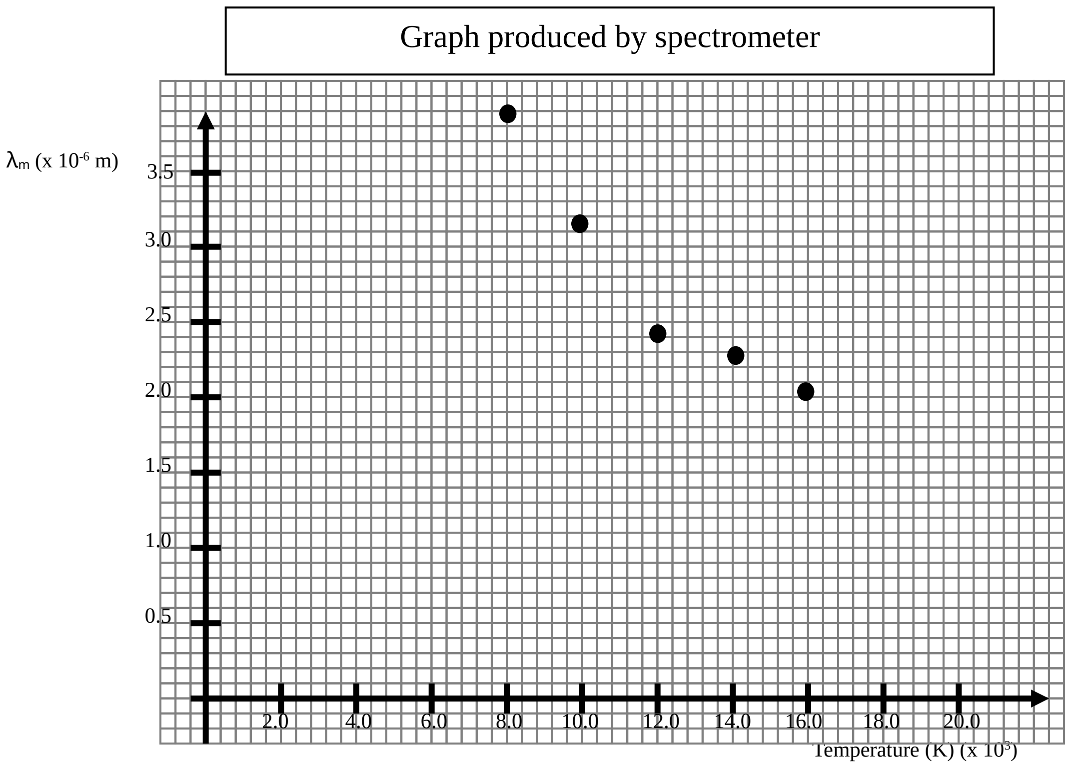
g) The wheel is re-assembled including magnet and brushes. The light bulb is replaced with a 12.0 V battery and current is applied to the wheel. If the outer part of the wheel is connected to the positive terminal of the battery and the centre of the wheel is connected to the negative terminal, how will the wheel respond? Explain

(2 marks)

8. A scientist is trying to find the relationship between the most intense wavelength in a spectrum (λ_m) and the temperature of the object that created the spectrum. Hot objects radiate electromagnetic waves. At any given temperature, the radiated energy covers a wide range of wavelengths. At low temperatures only long wavelengths in the far infra red can be found. As the temperature rises the range extends to smaller wavelengths. The intensity of the waves is not the same at all wavelengths. It is greatest at a certain part of the spectrum and becomes smaller at higher and lower wavelengths.



A scientist heats a small object to various temperatures. At each temperature she uses a spectrometer to determine the wavelength of the radiation with the highest intensity (λ_m). Using the data she has collected she builds the graph below…



a) What are the dependent and independent variables in this experiment?

(1 mark)

Independent ____

Dependent ____

b) The scientist theorizes that the relationship between λ_m and T is …

$$1/\lambda_m = k\,T$$

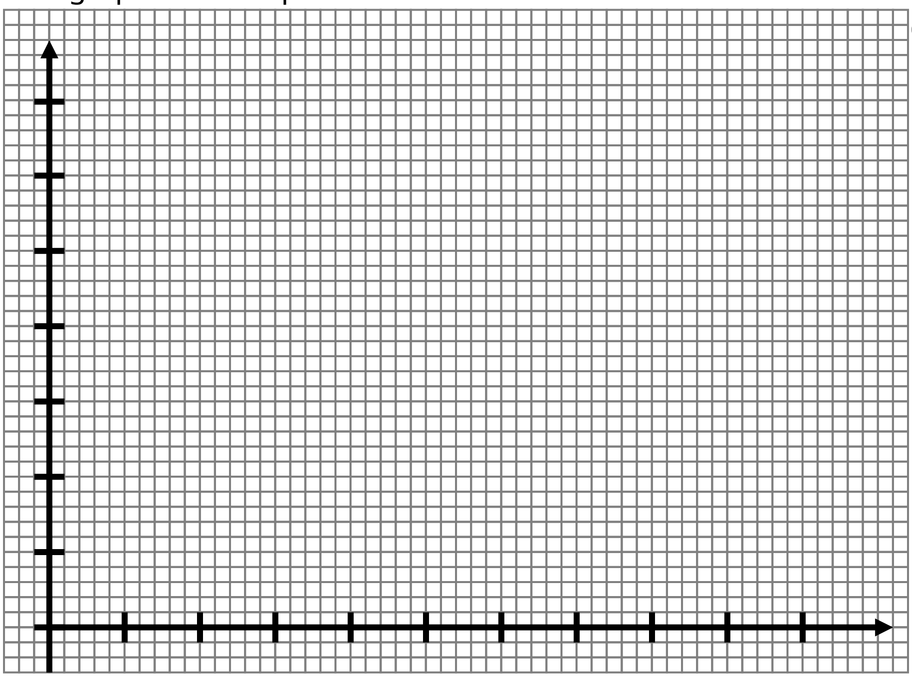
Manipulate her data shown in the table below in preparation for re-graphing. Be sure to state the new units of the manipulated data.

(2 marks)

Data point number	1	2	3	4	5
Temperature (K)	800	1000	1200	1400	1600
Wavelength of the most intense radiation (m) (x 10^{-6})	3.63	2.90	2.22	2.07	1.81

c) Re graph the manipulated data

(4 marks)



d) Is there an outlier(s)? If so which point (s)?

(1 mark)

Yes / No (please circle) ______________________________

e) Calculate the constant of proportionality “k”.

(2 marks)

e) The sun has a λ_m of 5.0 x 10^{-7} m. What is its surface temperature?

(2 marks)

SECTION C : Comprehension and Interpretation - 40 Marks (20%)

Read the passages below carefully and answer all of the questions at the end of the passages. Candidates are reminded of the need for correct English and clear and precise presentation of answers. Diagrams (sketches), equations and/or numerical results should be included as appropriate.

Show all working out for questions requiring numerical answers.

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1. Which Buildings Withstand Earthquakes Best?

[20 marks]

(Paragraph 1)

Earthquakes occur when the plates of solid rock on the outer surface of our planet push against and slide past each other. The boundaries where two different plates come in contact with each other are places where earthquakes occur more frequently. The edges of the Pacific Ocean and the West coast of North and South America are situated on the edge of two or more plates. These plate edges are called fault lines.

(Paragraph 2)

Earthquakes are measured on a mathematical scale called the Richter scale. The Richter scale operates in a similar fashion to the decibel scale used in measuring the loudness of sound.

The formula is …

$$R = 2/3 \text{ Log}_{10} (E / E_o)$$

Where R is the Richter magnitude or local magnitude of the earthquake, E is the energy released by the earthquake in joules and E_o is a reference quantity of energy equal to 6.31×10^4J. Log_{10} is the logarithm function to the base 10, as is used in the decibel equation.

A table of Richter magnitudes and their effects is shown below.

2.5 or less	Detected only by seismographs
2.5 to 5.4	Often felt, but only causes minor damage
5.5 to 6.0	Slight damage to buildings and other structures
6.1 to 6.9	May cause a lot of damage in very populated areas
7.0 to 7.9	Major earthquake, serious damage
8.0 or greater	Great earthquake, can totally destroy communities near the epicenter

Table 1

(Paragraph 3)

The movement of the ground created by an earthquake will vary compared to where you are relative to the hypocenter or source of the quake. If you are above the hypocenter on the earth's surface (called the epicenter) the ground tends to shake more vertically. As you move further and further from the epicenter, the ground will shake increasingly sideways instead of vertically, potentially knocking buildings off their foundations.

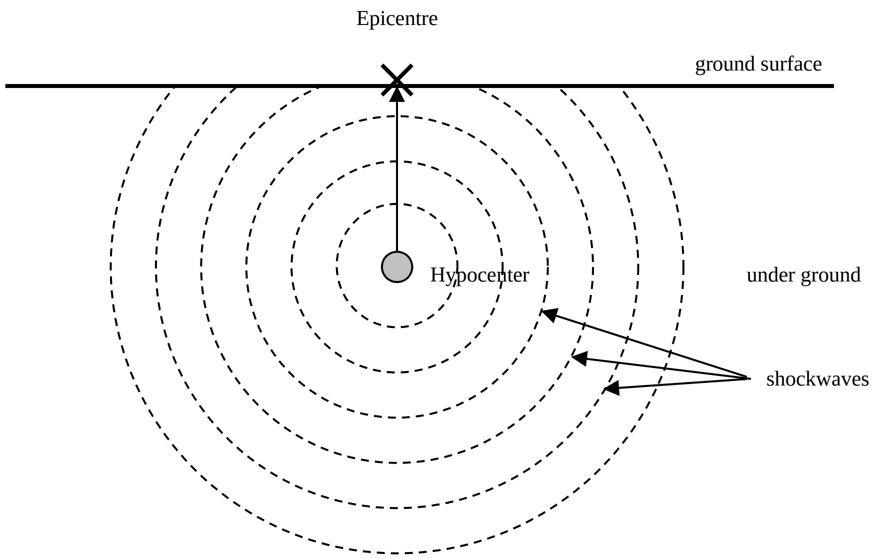


Figure A

(Paragraph 4)

Buildings in earthquake zones need to be built strong, not only to withstand the earthquake but also other side-effects of the earthquake such as aftershocks, tsunamis, land slides, avalanches and floods from burst dams.

(Paragraph 5)

The most common buildings follow one of three methods of construction…

- brick (masonry)
- reinforced concrete
- in filled steel frames

(Paragraph 6)

Brick walls do not stand up well to earthquakes. The sideways motion of the ground causes brick walls to sway. The bricks and cement cannot withstand the tension created resulting in cracking and toppling. The occupants of the building are often injured by the falling bricks.

(Paragraph 7)

Reinforced concrete is a better option than brick because the reinforcing steel within the concrete can withstand tension and so resists cracking. Unfortunately the large mass of the concrete causes the wall to remain stationary as the ground moves suddenly sideways underneath it. This results in large concentrations of force being exerted on the base of the wall where the wall and foundations meet. The steel reinforcing joining the wall to the foundations yields or sheers (snaps) and the wall collapses.

(Paragraph 8)

The best structure in an earthquake zone is a relatively rigid metal frame filled in with a light insulating material.

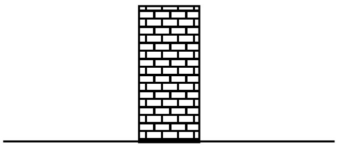
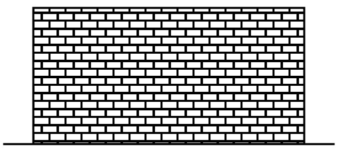
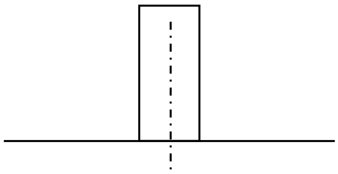
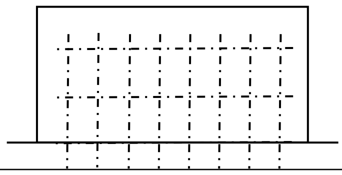
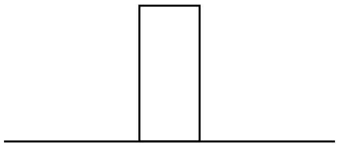
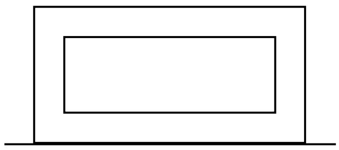
Brick Wall	**Concrete Wall**	**In Filled Metal Frame**
 End View 	 End View 	 End View 
Front View	Front View	Front View

Figure B

(Paragraph 9)

The rigid metal frame filled in with a light insulating material will need to withstand several types of force effects …

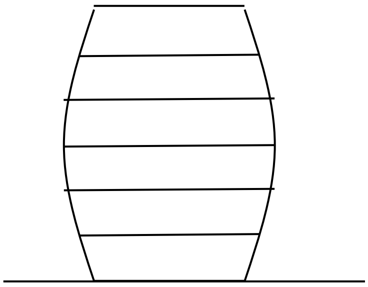
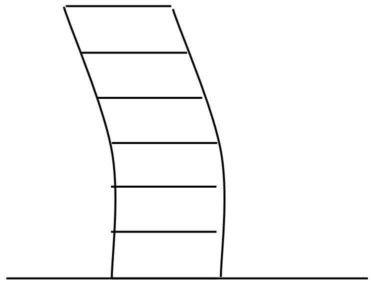
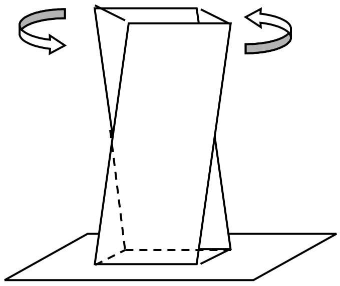
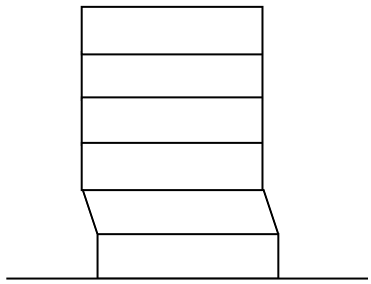
 Vertical compression and tension as the ground bounces up and down.	 Toppling and bending as the ground moves sideways.
 Twisting as different parts of the building accelerate at different speeds.	 Sheer as the bottom of the building moves and the heavy upper parts of the building remain stationary.

Figure C

(Paragraph 10)

With the general style of building now decided, there are some general rules that can be followed to reduce the possibility of metal framed buildings collapsing in an earthquake.

- The building should have a large base and should avoid being overly tall and slender.
- The building should be well anchored to bed rock and not built on sand if possible.
- The building should be simple / symmetrical when viewed from above so that the forces on the building during an earthquake can be easily calculated and evenly distributed through the metal frame of the building.
- Heavy objects (MRI machines in hospitals) and facilities (libraries) inside a building should be placed as close to the ground floor and as centrally in the building as possible.)
- Buildings should not be built too close together.

(Paragraph 11)

The final consideration is the natural frequency of the building. If the average frequency of vibration of earthquakes in the area is known, it is better to design the building so that its natural frequency is not matched to the frequency of vibration of the earthquakes (or for that matter the wind gusts in the area). Generally setting the fundamental natural frequency of the building higher rather than lower is recommended.

Questions

*1. What is the ratio of energy in an earthquake measuring 3.4 on the Richter scale compared to one measuring 2.4 on the Richter scale? (Paragraph 2)

(3 marks)

2. Is the wave produced at the epicenter directly above the hypocenter longitudinal or transverse? Explain. (Figure A)

(2 marks)

3. Will a 15 000 tonne building with a square base of side length 8.00 m topple over if a flood exerts a 350 000 N force on one side of the building at a height of
2.00 m above its base. Assume that the building stays rigidly in one piece and does not collapse.

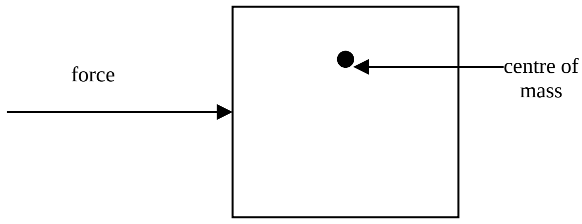
(3 marks)

4. Why do brick (masonry walls) was fail in earthquakes?

(2 mark)

5. If a force is applied to the centre of a floor or level of the building but the centre of mass of that floor is off centre, what effect will this have on the building? Explain why. (Figure C).

(3 marks)



Top View of Building

6. "The building should have a large base and should avoid being overly tall and slender?" Why?

(2 marks)

7. Why should "buildings not be built too close together?"

(2 marks)

8.
Why, if possible, should the fundamental frequency of the building be set above the frequency of earthquake? Explain with the assistance of mathematics. (Paragraph 11)

(3 marks)

2. The Northern and Southern Lights

[20 marks]

(Paragraph 1)

The northern and southern lights are a form of light emitting spectra produced when charged particles from outer space collide with atoms of oxygen and nitrogen in the earth's atmosphere. The unusual thing is that this effect only occurs at a radial distance of approximately 2500 km from the magnetic poles in the northern and southern hemisphere between the months of September - October and March – April.

(Paragraph 2)

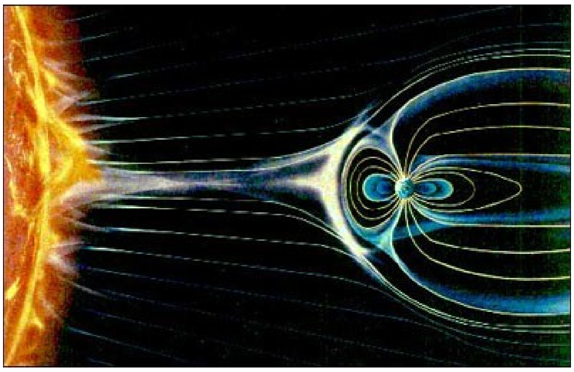
The Northern lights are referred to as the Aurora Borealis and the southern lights are referred to as the Aurora Australis.

(Paragraph 3)

The Sun releases large quantities of charged particles from its surface in the form of electrons and positively charged (ionized) atoms. The immense heat of the sun is capable of providing the energy necessary to ionize the different types of element found in the atmosphere of the sun. The main ionizing effect on the elements in the sun's atmosphere however is created by these elements being stripped of their electrons by the sun's swirling and changing magnetic field. The elemental positive ions and the electrons do not recombine because the particles are travelling at high speed from the surface of the sun outwards in diverging directions, giving them little chance of colliding. This flow of particles outwards from the sun is called the "solar wind". The solar wind is strongest when the sun is going through a sun spot cycle (every 11 to 12 years) which is a violent magnetic event.

(Paragraph 4)

The solar wind collides with the earth's magnetic field. The earth's magnetic field extends a great distance out into space around the planet earth. The interaction of the charged particles with the earth's magnetic field causes the charged particle to change direction, deflecting most of them around the earth before they can come in contact with the earth's atmosphere. Some electrons and positively charged elemental ions are caught by the earth's magnetic field however and directed along the earth's magnetic field lines in a spiral (corkscrew) motion. In following the earth's magnetic field, the charged particles are directed to the icy northern and southern polar regions, where they are drawn close enough to the earth to come in contact with the earth's atmosphere.

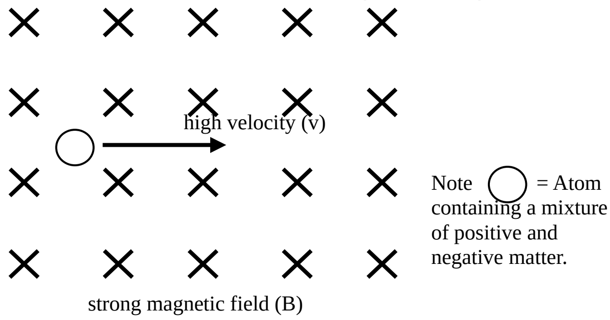


(Paragraph 5)
When the charged particles collide with oxygen and nitrogen (the two most abundant elements in the earth's atmosphere) they transfer their kinetic energy to them resulting in a spectacular light show. The oxygen atoms are responsible for the greens and a few of the reds in the aurora. The nitrogen is responsible of the blues and the rest of the reds.

Questions

1. Explain with the assistance of the diagram below why the electrons of an atom will be stripped from the nucleus when travelling at high speed through a strong magnetic field as occurs in solar wind. (Paragraph 3)

(3 marks)



2. What does the word diverging mean? (Paragraph 3)

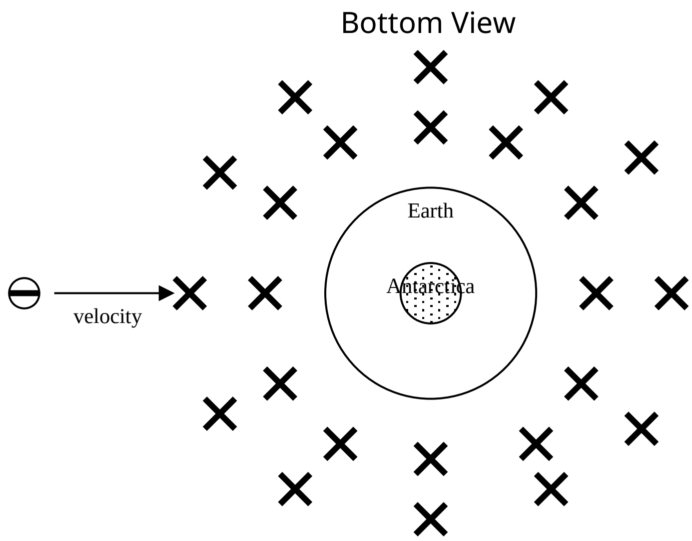
(2 marks)

3. As the charged particles leave the **gravitational** field of sun, what will happen to their speed? Explain.

(3 marks)

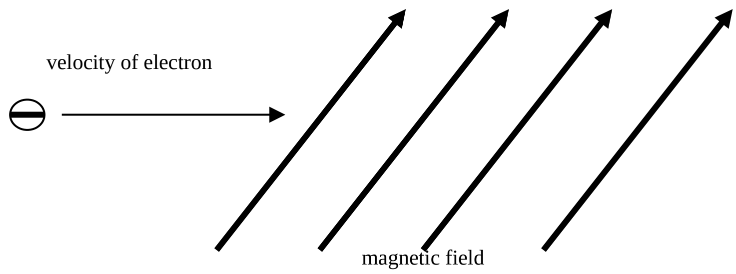
4. When an electron strikes the earths magnetic field at right angles, as shown below, what will the electron do? Explain. (Paragraph 4)

(2 marks)



5. Explain why an electron striking the earth's field, not at right angles, will corkscrew around the earths magnetic field? (Paragraph 4)

(3 marks)



6. Why do oxygen and nitrogen gas give off light when electrons from the sun collide with them? (Paragraph 5)

(2 marks)

7. What is the approximate loss of kinetic energy that a bombarding electron will experience as the result of colliding with nitrogen resulting in a single downward transition producing blue light? State your answer in electron volts.

(3 marks)

8. The earth's magnetic field is created by swirling ferromagnetic materials within the core of the earth. If the sun contains very few ferromagnetic materials, what other effects could give rise to the creation of the sun's magnetic fields? Explain.

(2 marks)

End of Exam

References.

http://en.wikipedia.org/wiki/Aurora_borealis.htm - 28/7/2008

http://www.phy6.org/Education/aurora.htm - 28/7/2008

END OF EXAM

St Mary's Anglican Girls' School

Semester II Exam

2008 Question/Answer Booklet

Answers

PHYSICS 12

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 CANDIDATE
Standard Items
Pens, pencils, eraser or correction fluid, ruler.
Special Items
Physical formulae and constants sheet, drawing implements, templates and calculators satisfying the conditions set by the Curriculum Council.

TO BE PROVIDED BY THE SUPERVISOR
This Question/Answer Booklet.
Physical Formulae and Constants sheet.

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. Please check carefully and if you have any unauthorised material with you hand it in to the supervisor BEFORE reading any further.

NAME: ______________________________

Short Answer	Problem Solving	Comprehension	%
/30	/50	/20	/100

STRUCTURE OF THE PAPER

Section	No of questions	No of marks out of 200	Proportion of exam total
A: Short Answers	15	60	30%
B: Problem Solving	8	100	50%
C: Comprehension & Interpretation	2	40	20%

INSTRUCTIONS TO CANDIDATES

Write your answers in the spaces provided beneath each question in sections A and B
The value of each question in section A is four marks.

Note that (where appropriate) answers should be given numerically and they should be evaluated **and not left in fractional or radical form**. Give all numerical **answers to three significant figures** except in the cases for which estimates are required.

Questions containing specific instructions to **show working** should be answered with a complete, logical, clear sequence of reasoning showing how the final answer was arrived at; **correct answers which do not show working out will not be awarded full marks**.

Questions containing the instruction **estimate** may give insufficient numerical data for their solution. Candidates should provide appropriate figures to enable an approximate solution to be obtained.

Candidates should remember that when descriptive answers are required, they should be used to display understanding of the aims and objectives of the physics 12 course. A descriptive answer, which addresses the context of a question without displaying an understanding of physics principles, will not attract marks.

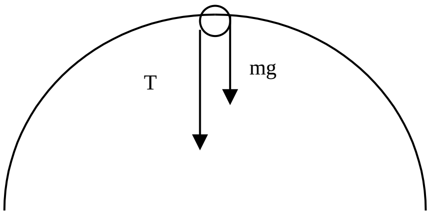
Despite an incorrect final result, credit may be obtained for method and working, provided these are **clearly and legibly set out**.

SECTION A : Short Answers - 60 Marks (30%)

Attempt ALL 15 questions in this section.
Show all working out. (4 marks each)

1. A swag man is making a pot of billy tea. When the water has boiled the tea leaves are sprinkled over the top of the boiling water. The swag man now wishes to pour the tea into a cup, but when he does so the tea leaves on the top of the water pour into the cup making a cloudy mess. The swag man swings the pot of billy tea in a vertical circle to move the tea leaves to the bottom of the pot. If the centre of the water in the billy is 80.0 cm from the centre of the circle, what is the minimum speed of the water at the top of the circle so that the water does not fall out of the pot?

(4 marks)



(1)

Sum of the forces vertically = force centripetal

$-mg + -T = -mv^2 / r$ *(1)*

The minimum speed occurs when $T = 0$

$mg = mv^2 / r$

$g = v^2 / r$

v *= square root of* (gr)

$v = (9.8 \times 0.8)^{½}$ *(1)*

v = 2.80 m/s ***(1)***

2. An astronaut is building a physics experiment in space using a 1.00 kg shot put and a 1.00 g pea. She goes for a space walk so that she is sufficiently far from other gravitational fields, taking the shot-put and pea with her. She places an X on the surface of the shotput and sets it spinning at the rate of 1.00 revolution per hour. At what distance from the centre of the shot put should the pea be placed in order to be "geostationary" above the X on the shotput.

(4 marks)

Use Kepler's law

$r^3 / T^2 = Gm / 4\pi^2$ *(1)*

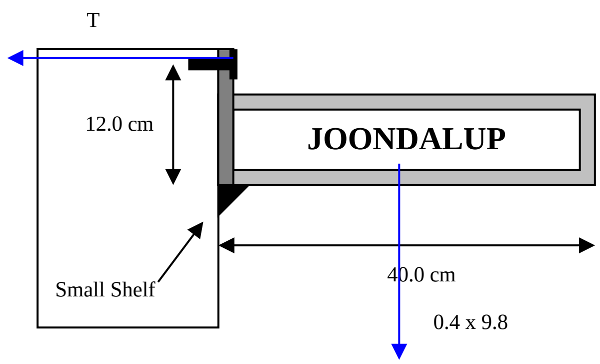
$r^3 = GmT^2 / 4\pi^2$

$r^3 = 6.67 \times 10^{-11} \times 1 \times 3600^2 / 4\pi^2$ *(2)*

$\boldsymbol{r = 2.80 \times 10^{-2}}$ **m** ***(1)***

3. A sign has been mounted onto a pillar in a train station as shown below. What is the tension in the bolt that stops the sign falling off the shelf if the sign has a mass of 400 g?

(4 marks)



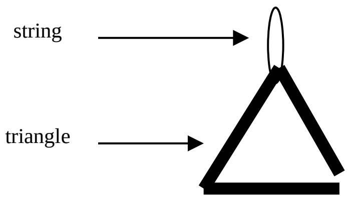
Sum of the moments clock = sum of the moments anti *(1)*

0.2 x 0.4 x 9.8 = 0.12 x T *(2)*

T = 0.2 x 0.4 x 9.8 / 0.12

T = 6.53 N Tension ***(1)***

4. A triangle is a musical instrument that is played by a percussionist in an orchestra. The triangle is hung off a piece of string as shown in the diagram.



a) What type of equilibrium is the triangle in?

stable unstable neutral (please circle)

(1 mark)

b) Explain why?

(1 mark)

When the triangle is pushed it returns to the same position.

c) Does the corner to which the string is attached represent a displacement node or a displacement antinode when the triangle is resonating after being struck? Explain.

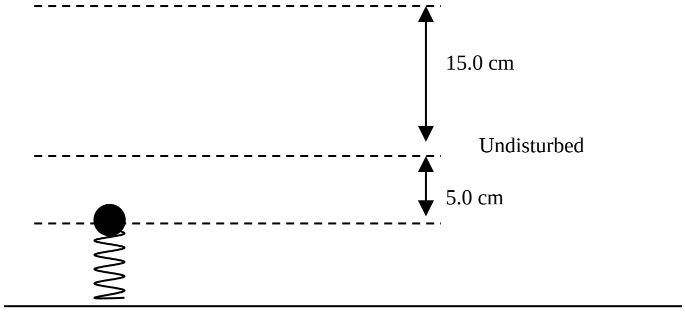
(2 mark)

It represents a displacement node. *(1)*

If it was a displacement anitnode the string would ***damp the vibration*** *of the triangle and stop it resonating after it has been struck.* *(1)*

5. A mass-less spring propels a ball of mass 40.0 g, 15.0 cm into the air. In order to achieve this the spring was compressed by 5.00 cm. Assuming that the spring was operating in its proportional region, what was the Hooke's law constant for the spring?

(4 marks)



$E_p = E_{sprinig}$

$mgh = ½ kx^2$ *(1)*

$0.04 \times 9.8 \times 0.15 = 0.5 \times k \times 0.05^2$ *(2)*

$5.88 \times 10^{-2} = k \times 1.25 \times 10^{-3}$

$k = 4.70 \times 10^1$ J m^{-2} or 4.70×10^1 N m^{-1} ***(1)***

6. A milk maid is sitting on a three legged stool. Each leg has a circular cross section of radius 1 cm and an original length of 35.0 cm. The milk maid has a mass of 85.0 kg.

a) What is the stress on one leg?

(2 marks)

$\sigma = F / A$ *(1)*

$\sigma = 1/3 \times 85 \times 9.8 / \pi \times 0.01^2$

$\sigma = 1/3 \times 85 \times 9.8 / \pi \times 0.01^2$

$\sigma = 8.84 \times 10^5$ N m^{-2} ***(1)***

b) What is the change in length of the leg if the average Young's modulus in this region is 4.00×10^{10} N m^{-2}.

(2 marks)

$Y = \sigma / \varepsilon$ *(1)*

$4 \times 10^{10} = 8.84 \times 10^5 / \varepsilon$

$\varepsilon = 8.84 \times 10^5 / 4 \times 10^{10}$

$\varepsilon = 2.21 \times 10^{-5}$ strain

$\varepsilon = \Delta l / l_0$

$\Delta l = \varepsilon \times l_0$
$\Delta l = 2.21 \times 10^{-5} \times 0.35$
$\Delta l = 7.74 \times 10^{-6}$ m ***(1)***

7. Estimate the fundamental resonant frequency of a test tube when air is blown across the top of its open end.

(4 marks)

Closed pipe

$l = 0.12$ m

$f = nv / 4l$

$f = 1 \times 346 / 4 \times 0.12$

$f = 7.20 \times 10^2$ Hz

8. Please circle which graph A, B, C or D is the best match for a sound of frequency 100.0 Hz diffracting through a gap of 0.500 cm in air. The intensity of the sound with no barrier or gap at a distance "y" is 1.00×10^{-6} Wm^{-2}.

(4 marks)

$\lambda = v / f$

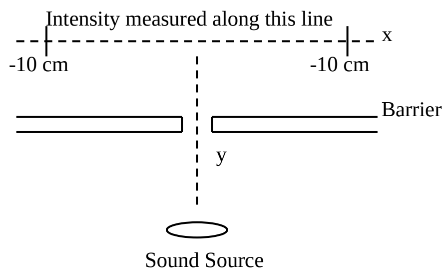
$\lambda = 346 / 100$

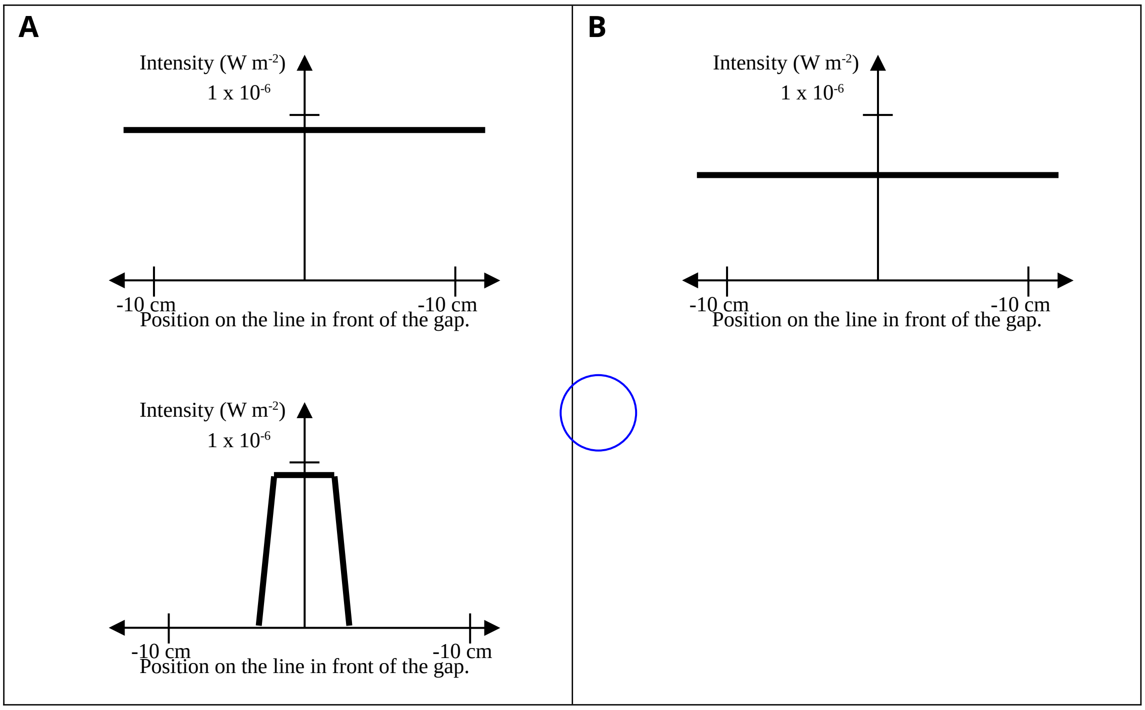
$\lambda = 3.46$

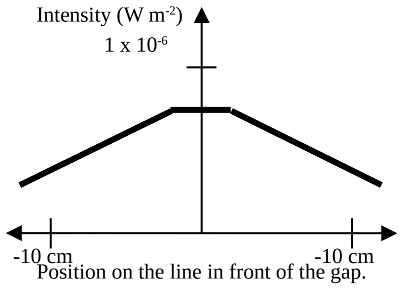
$n^0 = \lambda / gap$

$n^0 = 3.46 / 0.005$

$n^0 = 6.92 \times 10^2$



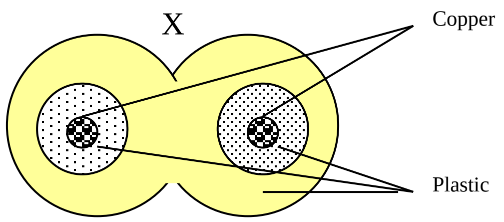


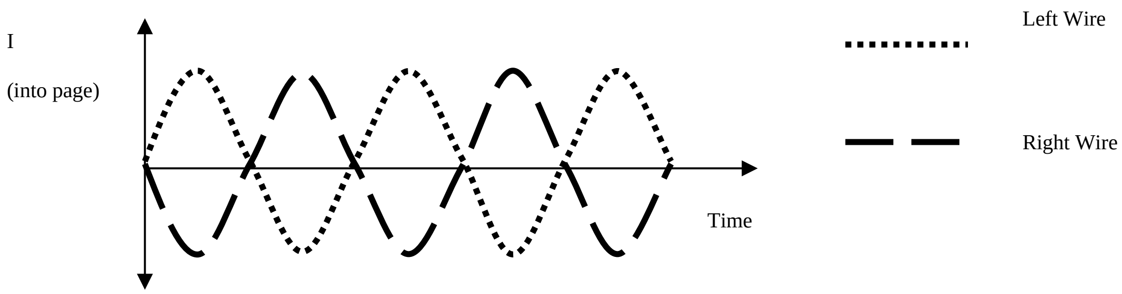
C	D
	Intensity (W m-2) 1 x 10-6 -10 cm -10 cm Position on the line in front of the gap.

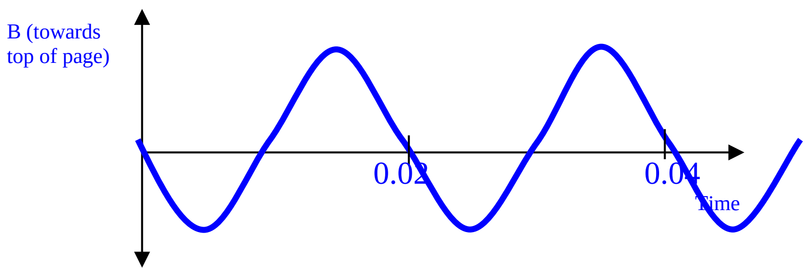
9. An electrical power cord is made from two parallel wires, side by side, encased in two layers of plastic (double insulated). An end view of the two wires is shown in the diagram below. The wire on the left delivers electricity to the appliance situated behind the page (active). The wire on the right returns electricity to the power point (return). The wires (and consequently appliance) are plugged into a typical Australian household power point.

A graph of the current flowing in the left and right wire is shown below. Sketch a graph of the resultant magnetic field produced at the location marked X as a function of time. Make sure you appropriately label and calibrate the axes if you can.

(4 marks)







Shape (1), Y axis labels (1), X axis labels (1), Scale (1).

10. A physics student is asked to make some hypotheses about how altering various characteristics of a tuning fork will affect the wavelength that it produces. Complete the table below by correctly predicting whether the wavelength will **increase, decrease** or **remain the same**.

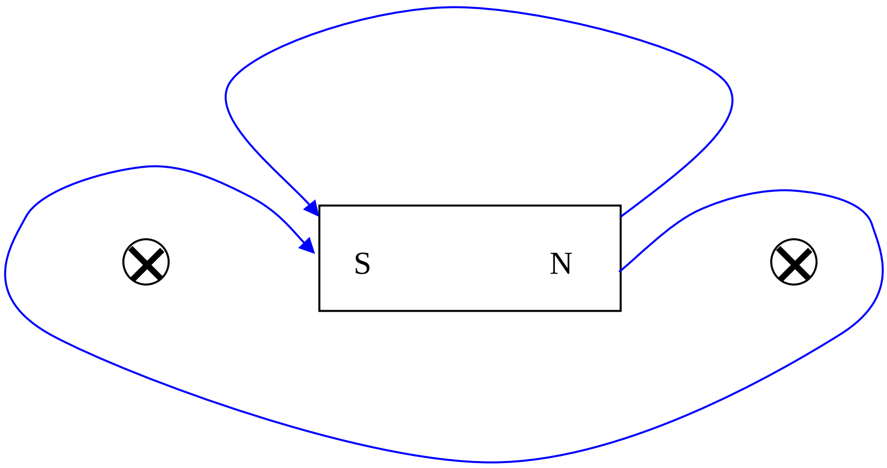
(4 marks)

Change made to original tuning fork.	How wavelength was affected.
The prongs were made thinner without altering their length.	increase
The thickness of the prongs were maintained but the length was decreased.	decrease
The distance between the prongs was increased but the mass and length were	remain the same

unaltered.	
The tuning fork was manufactured using copper instead of mild steel.	increase

11.a) Draw the <u>resultant</u> magnetic field around these wires, carrying conventional current into the page, and the magnet.

(2 marks)



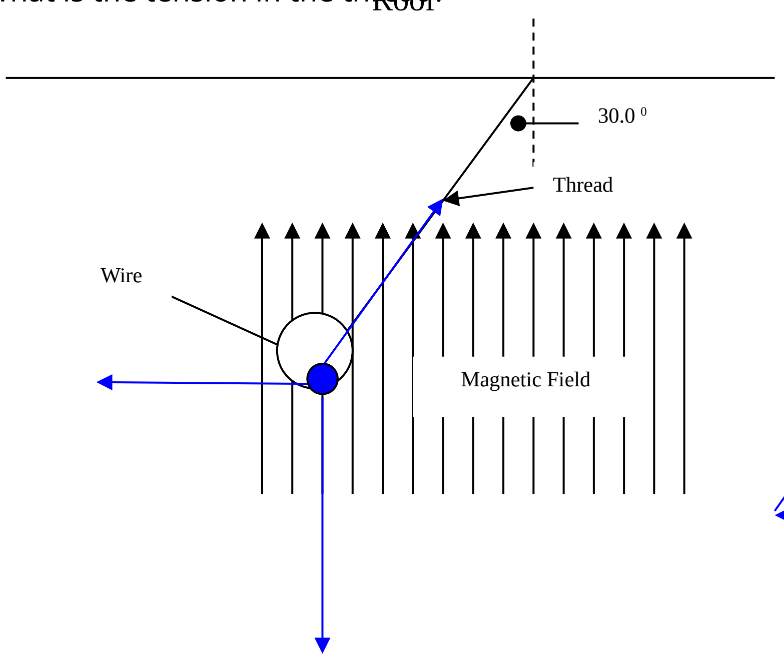
b) If the wires in the above diagram are fixed and the magnet is free to move on a frictionless surface, describe the direction and behavior of the movement of the magnet, if any.

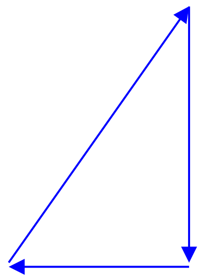
(2 marks)

Magnet will move towards the top of the page. The magnet will not rotate.

12 . A piece of thread is hung from the roof and attached to a horizontal wire that is carrying direct electric current. The current carrying wire is then exposed to a constant external magnetic field. The wire moves to a new stationary point with the thread forming an angle of 30.0 ^{0} to the vertical. The wire has a mass of 8.00 g. What is the tension in the thread?

(4 marks)





Σ F = 0 (1)

Cos 30^0 = mg / T

T = mg / Cos 30

T = 0.008 x 9.8 / Cos 30 *(1)*

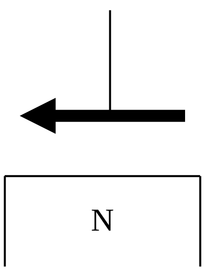
T = 9.05 x 10 $^{-2}$ N ***(1)***

b) In which direction is the current flowing in the wire? Please draw this direction onto the diagram above.

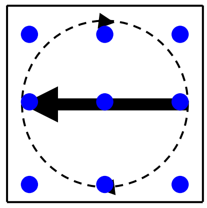
Out of the page. *(1)*

13. A copper sewing needle is hung horizontally from a piece of thread above the north end of a large bar magnet. The needle is then flicked in a clockwise direction as viewed from above so that it spins at the rate of 3.2 revolutions each second. The needle has a length of 4.00 cm.

Side View



Top View



a) Draw the magnetic field lines on the top view diagram of the magnet. (1 mark)

Out of the page *(1)*

b) Will the sharp end of the needle be changed positively or negatively? (1 mark)

Negatively *(1)*

c) What is the EMF induced between the ends of the needle? Explain. (2 marks)

Nil *(1)*

both ends are charged negatively. There is no potential difference. *(1)*

14. Cheryl is installing a low voltage garden lighting system in her garden. The system uses a transformer plugged into a power point in Australia to produce 12 V to run the lights on. The transformer is 90.0 % efficient. The system runs 5 garden lights, each consuming 20 W of energy. How much current is drawn from the power point?

(4 marks)

Power out is 5 x 20 = **100 W** (1)

Power input to power point = 100 / 0.9

P input = **111 W** (1)

P = V x I

111 = 240 x I (1)

I = 0.463 A (1)

15. Ultraviolet light with a wavelength of 300 nm is shone onto a solar cell. Electrons leave the surface at a speed 5.98 x 10^5 m/s. What is the ionization energy of the metal in joules?

(4 marks)

hf = ionization + ½ m v^2 *(1)*

$6.63 \times 10^{-34} \times 3 \times 10^{8} / 300 \times 10^{-9}$ = ionization + $0.5 \times 9.11 \times 10^{-31} \times (5.98 \times 10^{5})^{2}$ *(2)*

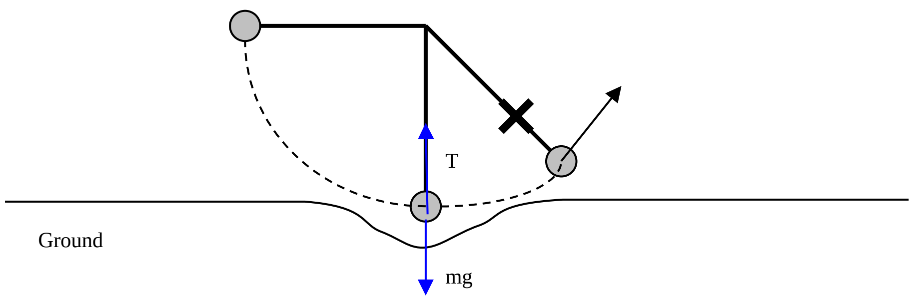
Ionization = $6.63 \times 10^{-19} - 1.629 \times 10^{-19}$

Ionization = 5.00×10^{-19} J ***(1)***

SECTION B : Problem Solving - 100 Marks (50%)

Attempt ALL 8 questions.

1. A pendulum has a string of length 2.30 m and is dropped from horizontal. When the 0.500 g bob has swung past the bottom and up to the 45.0 ^{0} mark with the horizontal, the string is cut by a razor blade.



a) What is the tension in the string when the bob is at the bottom of the swing?

(4 marks)

Sum of the forces = force centripetal

$-mg + T = mv^2 / r$ (1)

$(-0.5 \times 10^{-3} \times 9.8) + T = 0.5 \times 10^{-3} \times v^2 / 2.3$

Energy before = Energy after

$mgh = ½ mv^2$ (1)

$gh = ½ v^2$
$(2gh)^{½} = v$
***$v = 6.71$ m/s** (1)*

$(-0.5 \times 10^{-3} \times 9.8) + T = 0.5 \times 10^{-3} \times 6.71^2 / 2.3$
$T = 1.47 \times 10^{-2}$ N up (1)

b) What is the velocity of the bob as the string is cut?

(4 marks)

$mgh = ½ mv^2 + mgh$ (1)

$gh = ½ v^2 + gh$

$(9.8 \times 2.3) = (0.5 \times v^2) + (9.8 \times h)$ (1)

From diagram

$h = 2.3 - (2.3 \sin 45) = 0.673$ m (1)

$(9.8 \times 2.3) = (0.5 \times v^2) + (9.8 \times 0.673)$

$v = 5.65$ m/s *(1)*

c) At what range from the point at which the razor blade cuts the string will the bob land on the ground?

(3 marks)

Vertical	***Horizontal***
u(v) = 5.65 Sin 45 = 4.00 (1) *$s = ut + ½ at^2$* *$-0.673 = (4.00 \times t) + (0.5 \times -9.8 \times t^2)$* *Solve mode and suggest a positive answer.* *t = 0.959 s (1)*	*s(h) = ?* *u(h) = 5.65 Cos 45 = 4.00 m/s* *s(h) = 4.00 x t* *s(h) = 4.00 x 0.959* ***s = 3.84 m from point of string breaking.*** *(1)*

d) The experiment is repeated. The scientist changes the angle at which the string is cut. The scientist is attempting to find an angle that produces a larger range than the original angle of 45.0 ^{0}. Write a hypothesis as to whether the other angles will produce larger ranges in an environment free of air resistance. Explain.

Note - (Assume all launch speeds are identical).

(1 mark)

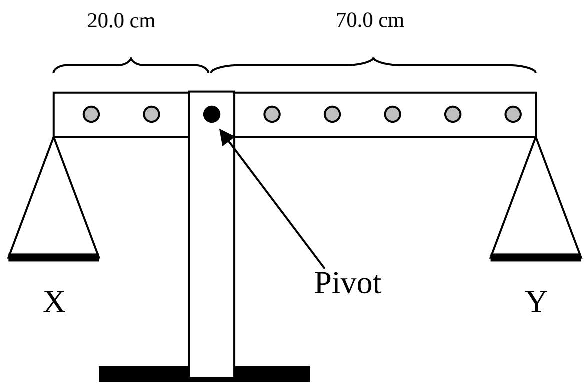
All horizontal displacements will be smaller.

45 degrees is the optimum compromise in allocating the velocity forwards to maximize distance covered and upwards to maximize the time of flight so the ball can continue to cover distance.

(1)

2. A student is trying to make a set of pan weighing scales. A diagram of the scales is shown below.

Diagram A



The objects to be weighed are placed at Y. Counter balancing masses (of known mass) are added to pan X until the lever arm becomes horizontal. The lever arm itself is to be considered weightless. The lever arm has multiple holes drilled in it so the point at which the lever arm pivots can be altered.

a) What is the load in pan Y when 340 g is placed in pan X and the lever arm is horizontal?

(3 marks)

Sum of the moments anti = sum of the moments clock (1)

Take moments about pivot

$0.340 \times 9.8 \times 0.2 = Y \times 9.8 \times 0.7$ (1)

$Y = 9.71 \times 10^{-2}$ kg (Or 0.952 N) (1)

b) The lever arm is replaced with a new material that is not mass-less. The new arm is identical in shape to the old one and is reattached as shown in Diagram A. The new arm has a mass per unit length of 100×10^{-3} kg/m. Recalculate your answer to part a) using the new lever arm.

(4 marks)

Sum of the moments anti = sum of the moments clock

Take moments about pivot – diagram (1)

$0.340 \times 9.8 \times 0.2 = (Y \times 9.8 \times 0.7) + ((0.1 \times 0.9) \times 9.8 \times 0.25)$ (2)

$0.6664 = Y \times 6.86 + 0.2205$

$Y = 6.5 \times 10^{-2}$ kg (1)

c) Where relative to pan Y should the pivot be placed to negate the mass of the lever arm? Explain.

(2 marks)

0.45 m from pan Y (1)

This is the center of mass of the lever arm. By placing the pivot here and taking moments about this point the mass of the lever arm can be ignored in the sum of the moments calculation. (1)

d) The weightless lever arm is now **re-installed** and the point at which the arm pivots is shifted to an unspecified location on the lever arm. The beam holds horizontal when the weight in pan Y is 0.4 times the weight in pan X. How far is the pivot horizontally from the point at which pan X attaches?

(4 marks)

m in Y = 0.4 X (1)

m in X = X

distance from X to pivot is L – solve for this

distance from Y to pivot is 0.9 – L (1)

lever arm is weightless

Sum of the moments anti = sum of the moments clock

Take moments about pivot

X x 9.8 x L = 0.4 X x 9.8 x (0.9 – L) (1)

X x L = 0.4 X x (0.9 – L)

XL =0.4 X 0.9 – 0.4 X L

XL + 0.4 XL = 0.4 X 0.9

1.4 XL = 0.36 X

L = 0.36 / 1.4

L = 0.257 m (1)

3. Ronda has just returned from a holiday in Thailand with a lot of washing. Unfortunately the weather is cold and wet in Perth and not suitable for getting clothes dried. Ronda decides to go to a laundro-mat to get her clothes washed and dried more quickly.

The laundro-mat contains 16 top loader washing machines, each individually capable of producing 50 dB of sound when operating. The 8 dryers at the laundro- mat when all operating simultaneously produce 64.0 dB of sound. All sound measurements were taken at a distance of 2.00 m from the machines and all machines (dryers and washing machines) produce an identical frequency (of 346 Hz) in no particular phase with each other. The walls of the laundro-mat have been fitted with sound absorbent material to prevent reflection of sound.

a) What is the loudness of one dryer operating with no washing machines operating?

(3 marks)

Intensity of all dryers operating = ?

$L = 10 \text{ Log } (I / 1 \times 10^{-12})$
$64 = 10 \text{ Log } (I / 1 \times 10^{-12})$
Solve Mode

$I = 2.51 \times 10^{-6}$ W m^{-2} ***(1)***

1 dryer = $2.51 \times 10^{-6} / 8$
1 dryer = 3.14×10^{-7} ***(1)***

Loudness of 1 dryer = ?

$L = 10 \text{ Log } (I / 1 \times 10^{-12})$
$L = 10 \text{ Log } (3.14 \times 10^{-7} / 1 \times 10^{-12})$
Solve Mode

L = 55.0 dB ***(1)***

b) What is the loudness of the sound in the room when 16 washing machines and 8 dryers are all operating simultaneously?

(3 marks)

Add the intensities

$L = 10 \text{ Log } (I / 1 \times 10^{-12})$

$50 = 10 \text{ Log } (I / 1 \times 10^{-12})$

Solve Mode

$I = 1.00 \times 10^{-7}$ W m^{-2} ***(1)***

*I (total) =($16 \times 1 \times 10^{-7}$) + (**$2.51 \times 10^{-6}$) = 4.11×10^{-6}*** ***(1)***

L = 66.1 dB ***(1)***

c) How many washing machines would produce a loudness of 59.03 dB?

(2 marks)

What is the intensity of the machines?

$L = 10 \text{ Log } (I / 1 \times 10^{-12})$

$59.03 = 10 \text{ Log } (I / 1 \times 10^{-12})$

Solve Mode

$I = 8.00 \times 10^{-7}$ W m^{-2} (1)

Each machine has an intensity of 1×10^{-7}

$n = 8 \times 10^{-7} / 1 \times 10^{-7}$

n = 8 machines (1)

d) Remember that the walls of the laundry mat have been fitted with sound absorbent material to prevent reflection of sound. Ronda goes outside the laundro-mat to get some fresh air and to get away from the noise of **all** the machines operating simultaneously. At a distance of 10 m from all the machines some distance from (but in front of) the open doors, what is the maximum theoretical intensity of the sound?

(3 marks)

2 m from	***10 m from***
$I = P / A$ (1) *$P = I \times A$* *$P = 4.11 \times 10^{-6} \times 4\pi \times 2^2$* *$P = 2.0659 \times 10^{-4}$ W m^{-2} (1)*	*$P = 2.0659 \times 10^{-4}$ W m^{-2}* *$I = P / A$* *$I = 2.0659 \times 10^{-4} / 4\pi \times 10^2$* *$I = 1.62 \times 10^{-6}$ W m^{-2} (1)*

e) The sound of the machines has to pass through a door way that is 1.00 m wide. How will this affect the loudness of the sound perceived by Ronda 10.0 m away?

(1 mark)

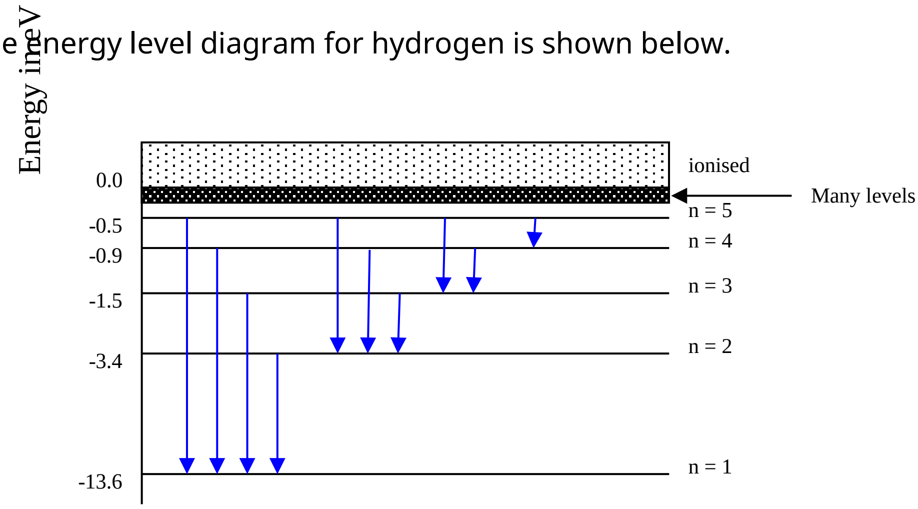
$\lambda = v / f$

$\lambda = 346 / 346$

$\lambda = 1.00$ m

Gap formula indicates some diffraction will occur and so intensity will drop as energy is distributed over a larger area. If intensity drops then loudness will also drop. (1)

4. The energy level diagram for hydrogen is shown below.



a) A bombarding electron with a kinetic energy 13.3 eV collides with a hydrogen atom. What is the highest energy level to which an electron originally in the ground state can be elevated? Show working to support your answer.

(2 marks)

13.6 – 13.3 = 0.3 eV *(1)*

n = 5 *(1)*

b) What is the velocity of the scattered electron?

(2 marks)

0.2 eV x 1.6 x 10^{-19}

3.2 x 10^{-20} J

$E = ½ m v^2$

3.2 x 10^{-20} = 0.5 x 9.11 x 10^{-31} v^2

v = 2.65 x 10^5 m s^{-1}

c) Show on the above diagram and indicate in the box below, how many different frequencies of light can potentially be produced went the electron falls from its excited state in part a) to the ground state?

(1 mark)

10

d) To what part of the electromagnetic spectrum does the smallest of these downwards transitions belong? Explain.

(2 marks)

Energy = -0.4 eV *(1)*

E = hf

$0.4 \times 1.6 \times 10^{-19} = 6.63 \times 10^{-34} \times f$

$f = 9.65 \times 10^{13}$

Frequency is in the infra red range. *(1)*

e) A photon of wavelength 110 nm now falls on the atom in the ground state. What effect will this have on the atom? Explain.

(3 marks)

Energy = hf

$Energy = 6.63 \times 10^{-34} \times 3 \times 10^{8} / 110 \times 10^{-9}$ *(1)*

$Energy = 1.81 \times 10^{-18}$ J

Energy (eV) = 11.3 eV *(1)*

13.6 - 11.3 = 2.3 eV

There is no energy level at 2.3 eV and consequently this photon will have not exciting effect on the atom.

f) To which region of the electromagnetic spectrum does the smallest photon capable of ionizing a hydrogen atom belong? Support your answer with calculations.

(3 marks)

$Energy = 13.6 \times 1.6 \times 10^{-19}$

$Energy = 2.176 \times 10^{-18}$ J

E = h f *(1)*

$2.176 \times 10^{-18}\ J = 6.63 \times 10^{-34} \times f$

$f = 3.28 \times 10^{15}$ Hz

Ultra Violet *(1)*

5. A dentist has just unpacked a new X-ray machine to be used in her dental surgery. The X-ray machine is plugged into a 240 V power supply and produces an accelerating potential of 40.0 kV.

a) What is the ratio of windings in the secondary as compared to the primary to achieve this accelerating potential?

(2 marks)

Vp / Vs = Np / Ns

240 / 40 000 = Np / Ns *(1)*

167 turns in the secondary to 1 turn in the primary. *(1)*

b) The X-ray machine accelerates electrons (cathode rays) emitted by a tungsten filament. What is the velocity of the electrons as a result of passing through this accelerating potential difference? Assume the electrons are initially stationary.

(3 marks)

$qV = \frac{1}{2} mv^2$ *(1)*

$1.6 \times 10^{-19} \times 40\,000 = 0.5 \times 9.11 \times 10^{-31} \times v^2$ *(1)*

$v = 1.18 \times 10^8 \text{ m s}^{-1}$ *(1)*

c) What is the shortest wavelength that the machine is capable of producing?

(2 marks)

$qV = h\, c / \lambda$

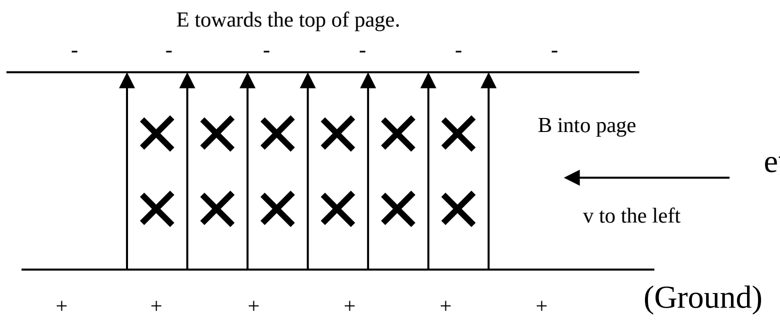
$1.6 \times 10^{-19} \times 40\,000 = 6.63 \times 10^{-34} \times 3 \times 10^8 / \lambda$ *(1)*

$1.6 \times 10^{-19} \times 40\,000 = 6.63 \times 10^{-34} \times 3 \times 10^8 / \lambda$

$\lambda = 3.11 \times 10^{-11} \text{ m}$ *(1)*

d) An X-ray machine is placed at a particular location on the earth where the earth's magnetic field has no effect on it. A particular electron is shot at a speed of 1.00×10^{8} m s^{-1} through a region of space within the machine containing an electric field of 1.31×10^{8} N C^{-1} and a magnetic field of 2.00 T orientated as shown in the diagram below. If the electron is unaffected by gravity, what is the net force on the electron while it is in the fields?

(3 marks)



$F_M + F_E$ = Net Force

$(+qvB) + (-qE)$ = Net Force

$(1.6 \times 10^{-19}\ 1 \times 10^{8} \times 2) +(-1.6 \times 10^{-19} \times 1.31 \times 10^{8})$ = Net Force *(2)*

Net Force = 1.10×10^{-11} N up *(1)*

e) At what approximate location on the surface of the earth and in what direction should the electron gun be pointed so that the earth's magnetic field has no effect? Explain.

(2 marks)

At the equator. *(1)*

With the gun pointing parallel with the earth's magnetic field.

I.e. pointing North or South. *(1)*

6. (13 marks)

A cattle farmer on a remote cattle station is using a diesel generator to create electricity one evening after a cloudy day in the Northern Territory. The diesel generator is very noisy and is situated 150 m from the house to make its sound quieter. The generator puts out 1000 W of power at a voltage of 240 V. The 2 wires that connect the house to the generator (live and return) each have a resistance of
0.01 Ω m^{-1}.

a) What is the current being put down the transmission line to convey the 1000W of power to the house?

(3 marks)

$P = VI$ *(1)*

$1000 = 240 \times I$ *(1)*

$1000 / 240 = I$

$I = 4.17$ A *(1)*

b) What is the **total** power loss in the transmission line in conveying the current to **and from** the house?

(3 marks)

Resistance of line = 300 x 0.01

Resistance of line = 3.00 Ω

$P_{Loss} = I^2 R$ *(1)*
$P_{Loss} = 4.17^2 \times 3$ *(1)*

$P_{Loss} = 52.1$ W ***(1)***

c) How much useful voltage remains at the house end of the circuit to be used in appliances?

(2 marks)

P remaining = 1000 – 52.1

P remaining = 947.9 W ***(1)***

$P = VI$

$947.9 = V \times 4.17$

$V = 227$ V ***(1)***

d) If the farmer switches on too many appliances in the house, what effects will this have on the circuit?

(2 marks)

There will be insufficient power to run all of the appliances and so they will run slower or less brightly or malfunction. *(2)*

e) What could the farmer do to reduce the power loss in the line? Explain.

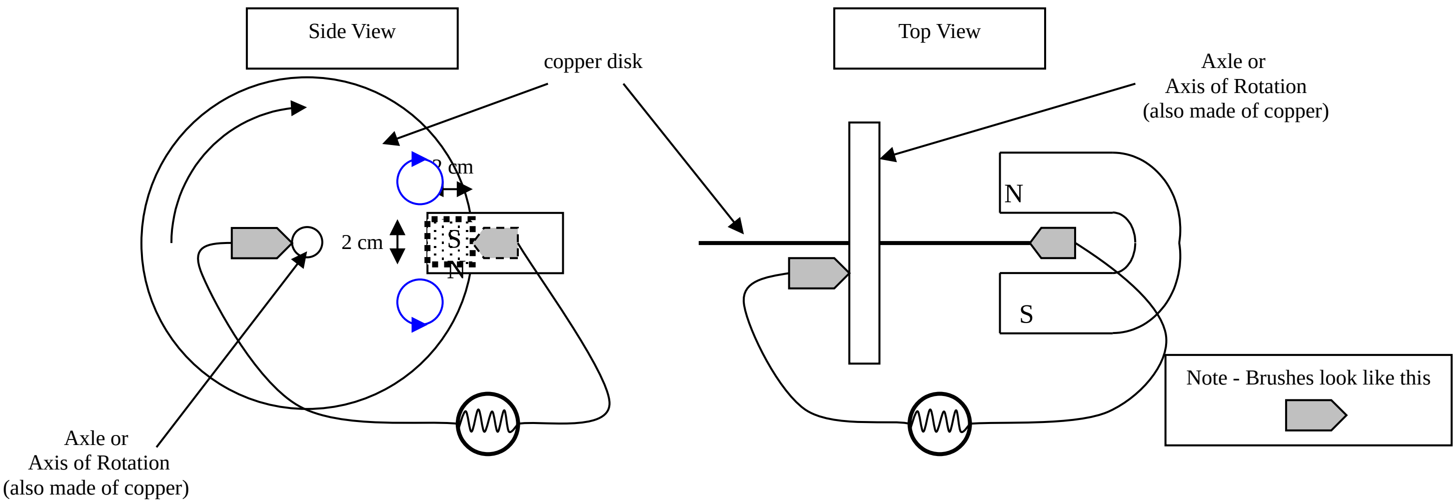
(3 marks)

Use transformers (step up and then step down) and reticulate the power to the house at a higher voltage and so reduce the power loss in the line. *(1)*

shorten the line length *(1)*

use better conducting wire *(1)*

7. One of the first generators ever invented consisted of a circular copper metal disk whose edge was rotated through the magnetic field of a horseshoe magnet. The edge and the centre of the wheel were connected to an external circuit by near frictionless graphite brushes. When the wheel is spun the light bulb glows.



a) In which direction will a positively charged particle experience a force if the metal wheel is rotated in the direction shown in the side view diagram?

(1 mark)

To the left (towards the axle) *(1)*

b) What is the polarity of the edge and centre of the wheel?

(1 mark)

Edge = positive / negative (please circle)

Centre of wheel = positive / negative (please circle)

c) The magnetic field passes through a square space of side length 2.00 cm. In one rotation of the disk how much area of the disk is exposed to the magnetic field? Note the disk has a radius of 15.0 cm.

(3 marks)

area large circle – area small circle (1)

$\pi\ 0.15^2 - \pi\ 0.13^2$ (1)

$1.76 \times 10^{-2}\ m^2$ **(1)**

d) If the wheel is turning at the rate of 420 revolutions per minute, and the magnet has a field strength of 0.8 T, what is the voltage induced in the disk?

(3 marks)

EMF = - n (BA – BA) / t *(1)*

t = ?

420 rpm = 7 Hz = 1.4285 s for 1 revolution

Change in A = ***1.76 x 10^{-2} m^2***

B = 0.8

EMF = - 1 (0.8 x 1.76 x 10^{-2}) / 0.14285 *(1)*

EMF =9.85 x 10^{-2} V *(1)*

e) Draw onto the wheel in the side view diagram the direction of the eddy currents that are induced in the wheel.

(1 mark)

See diagram

f) The wheel is mounted on frictionless bearings. When the magnet and brushes are removed and the wheel is spun, it appears to spin forever. When the magnet (but not the brushes) are replaced, will the wheel spin forever? Explain why or why not.

(2 marks)

No *(1)*

Lenz's law says the current induced in the disk will produce a magnetic field that will oppose the original magnetic field and so slow the disk. *(1)*

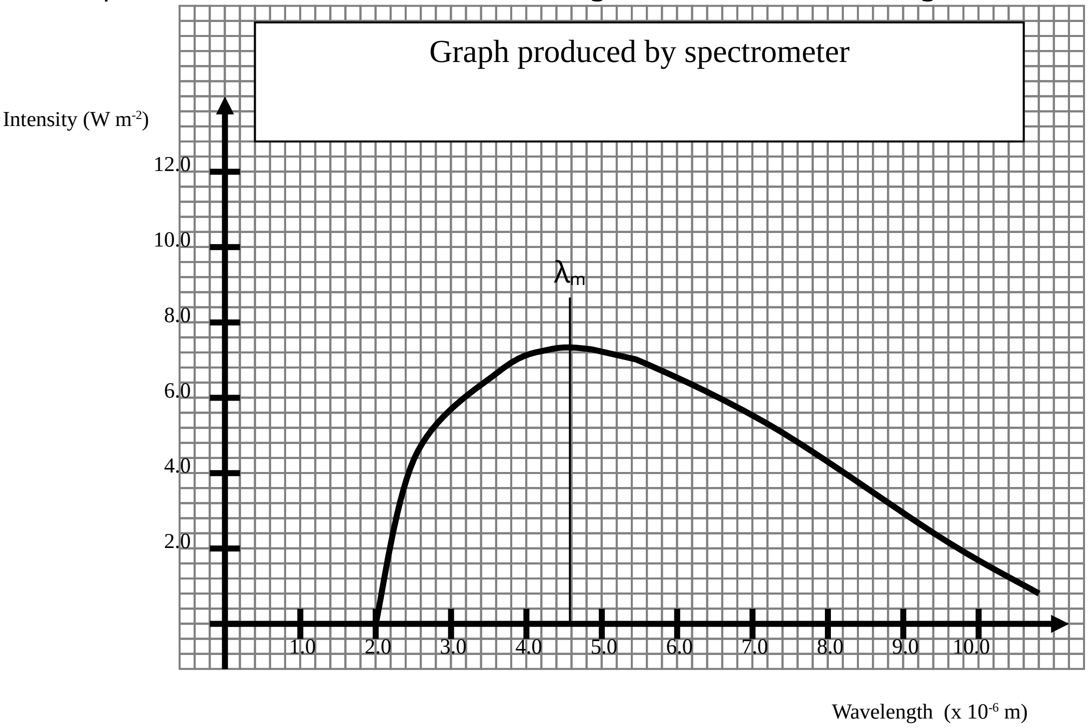
g) The wheel is re-assembled including magnet and brushes. The light bulb is replaced with a 12.0 V battery and current is applied to the wheel. If the outer part of the wheel is connected to the positive terminal of the battery and the centre of the wheel is connected to the negative terminal, how will the wheel respond? Explain

(2 marks)

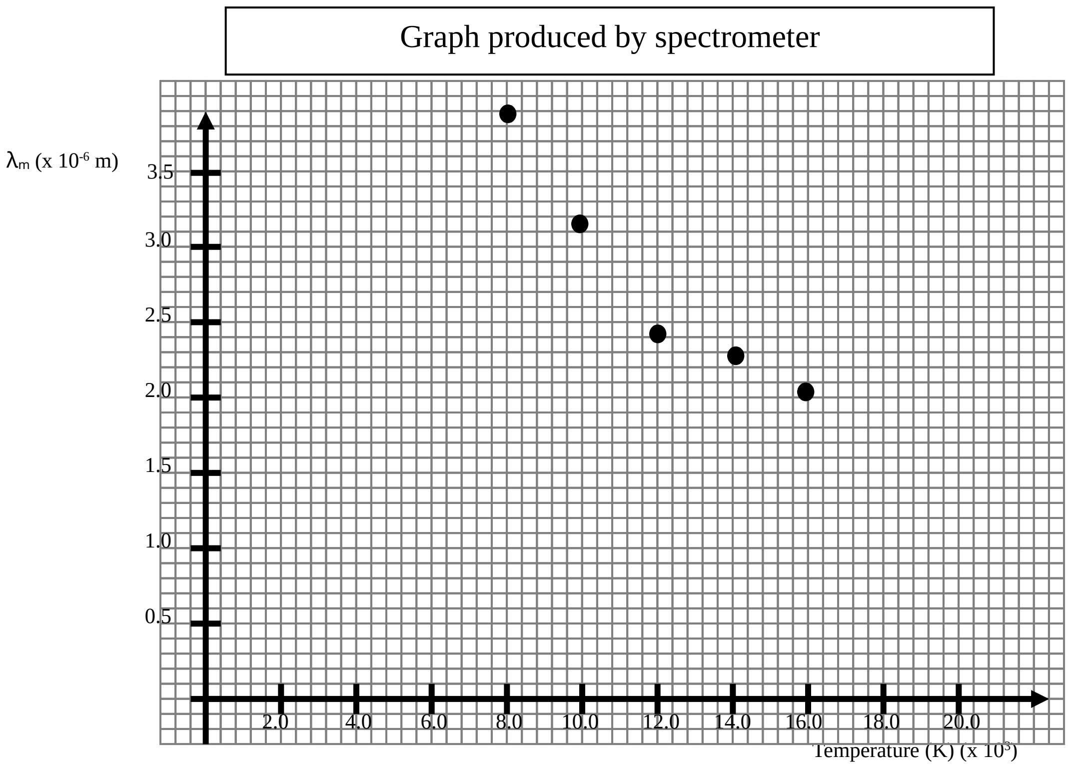
The wheel will turn anticlockwise *(1)*

The generator has been converted into a motor *(1)*

8. A scientist is trying to find the relationship between the most intense wavelength in a spectrum (λ_m) and the temperature of the object that created the spectrum. Hot objects radiate electromagnetic waves. At any given temperature, the radiated energy covers a wide range of wavelengths. At low temperatures only long wavelengths in the far infra red can be found. As the temperature rises the range extends to smaller wavelengths. The intensity of the waves is not the same at all wavelengths. It is greatest at a certain part of the spectrum and becomes smaller at higher and lower wavelengths.



A scientist heats a small object to various temperatures. At each temperature she uses a spectrometer to determine the wavelength of the radiation with the highest intensity (λ_m). Using the data she has collected she builds the graph below…



a) What are the dependent and independent variables in this experiment?

(1 mark)

Independent *Temperature*

Dependent *Wavelength (peek)*

b) The scientist theorizes that the relationship between λ_m and T is ...

$$1/\lambda_m = k\,T$$

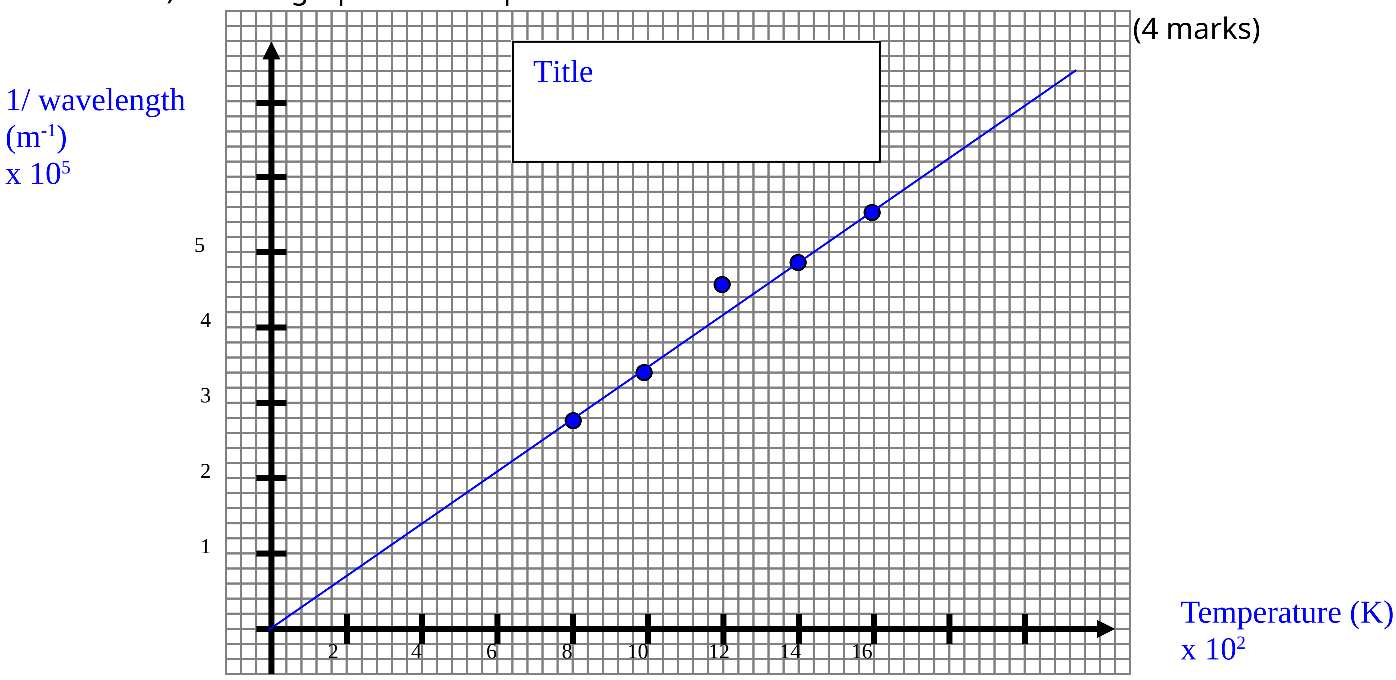
Manipulate her data shown in the table below in preparation for re-graphing. Be sure to state the new units of the manipulated data.

(2 marks)

Data point number	1	2	3	4	5
Temperature (K)	800	1000	1200	1400	1600
Wavelength of the most intense radiation (m) (x 10^{-6})	3.63	2.90	2.22	2.07	1.81
1/ wavelength (m^{-1})	275 482	344 828	450 450	483 092	552 486

c) Re graph the manipulated data

(4 marks)



d) Is there an outlier(s)? If so which point (s)?

(1 mark)

Yes / No (please circle) *Yes – third data point*

e) Calculate the constant of proportionality "k".

(2 marks)

k = slope = rise / run = 3.46 x 10^2 *(1)*

e) The sun has a λ_m of 5.0 x 10^{-7} m. What is its surface temperature?

(2 marks)

$1/\lambda_m = k\,T$

$1/\,5 \times 10^{-7} = 3.46 \times 10^{2}\,T$ *(1)*

$T = 5.77 \times 10^{3}$ K ***(1)***

SECTION C : Comprehension and Interpretation - 40 Marks (20%)

Read the passages below carefully and answer all of the questions at the end of the passages. Candidates are reminded of the need for correct English and clear and precise presentation of answers. Diagrams (sketches), equations and/or numerical results should be included as appropriate.

Show all working out for questions requiring numerical answers.

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1. Which Buildings Withstand Earthquakes Best?

[20 marks]

(Paragraph 1)

Earthquakes occur when the plates of solid rock on the outer surface of our planet push against and slide past each other. The boundaries where two different plates come in contact with each other are places where earthquakes occur more frequently. The edges of the Pacific Ocean and the West coast of North and South America are situated on the edge of two or more plates. These plate edges are called fault lines.

(Paragraph 2)

Earthquakes are measured on a mathematical scale called the Richter scale. The Richter scale operates in a similar fashion to the decibel scale used in measuring the loudness of sound.

The formula is …

$$R = 2/3 \text{ Log}_{10} (E / E_o)$$

Where R is the Richter magnitude or local magnitude of the earthquake, E is the energy released by the earthquake in joules and E_o is a reference quantity of energy equal to 6.31×10^4J. Log_{10} is the logarithm function to the base 10, as is used in the decibel equation.

A table of Richter magnitudes and their effects is shown below.

2.5 or less	Detected only by seismographs
2.5 to 5.4	Often felt, but only causes minor damage
5.5 to 6.0	Slight damage to buildings and other structures
6.1 to 6.9	May cause a lot of damage in very populated areas
7.0 to 7.9	Major earthquake, serious damage
8.0 or greater	Great earthquake, can totally destroy communities near the epicenter

Table 1

(Paragraph 3)

The movement of the ground created by an earthquake will vary compared to where you are relative to the hypocenter or source of the quake. If you are above the hypocenter on the earth's surface (called the epicenter) the ground tends to shake more vertically. As you move further and further from the epicenter, the ground will shake increasingly sideways instead of vertically, potentially knocking buildings off their foundations.

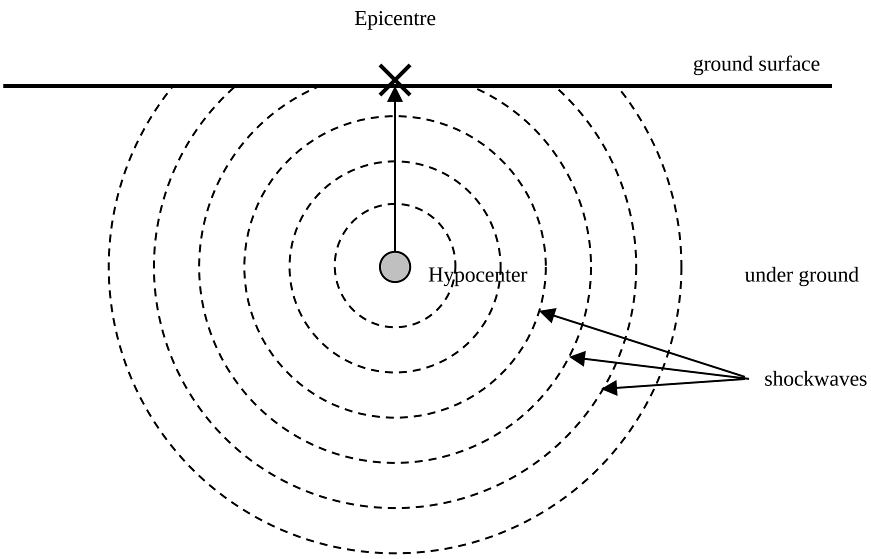


Figure A

(Paragraph 4)

Buildings in earthquake zones need to be built strong, not only to withstand the earthquake but also other side-effects of the earthquake such as aftershocks, tsunamis, land slides, avalanches and floods from burst dams.

(Paragraph 5)

The most common buildings follow one of three methods of construction…

- brick (masonry)
- reinforced concrete
- in filled steel frames

(Paragraph 6)

Brick walls do not stand up well to earthquakes. The sideways motion of the ground causes brick walls to sway. The bricks and cement cannot withstand the tension created resulting in cracking and toppling. The occupants of the building are often injured by the falling bricks.

(Paragraph 7)

Reinforced concrete is a better option than brick because the reinforcing steel within the concrete can withstand tension and so resists cracking. Unfortunately the large mass of the concrete causes the wall to remain stationary as the ground moves suddenly sideways underneath it. This results in large concentrations of force being exerted on the base of the wall where the wall and foundations meet. The steel reinforcing joining the wall to the foundations yields or sheers (snaps) and the wall collapses.

(Paragraph 8)

The best structure in an earthquake zone is a relatively rigid metal frame filled in with a light insulating material.

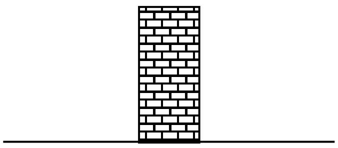
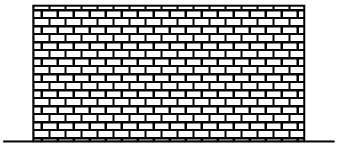
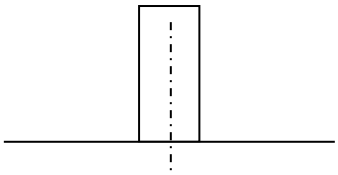
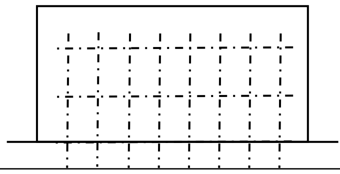
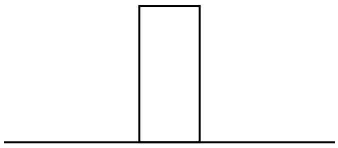
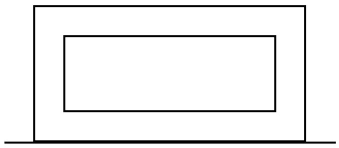
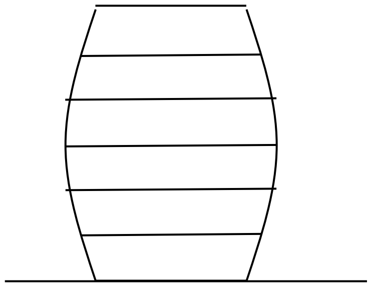
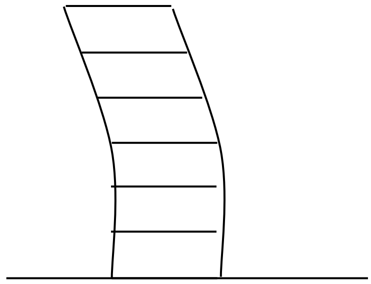
Brick Wall	**Concrete Wall**	**In Filled Metal Frame**
 End View 	 End View 	 End View 
Front View	Front View	Front View

Figure B

(Paragraph 9)

The rigid metal frame filled in with a light insulating material will need to withstand several types of force effects …

 Vertical compression and tension as the ground bounces up and down.	 Toppling and bending as the ground moves sideways.

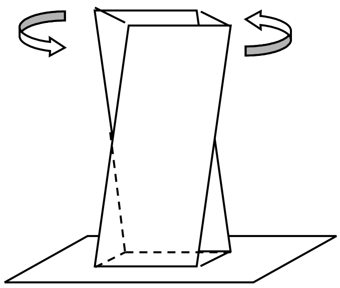
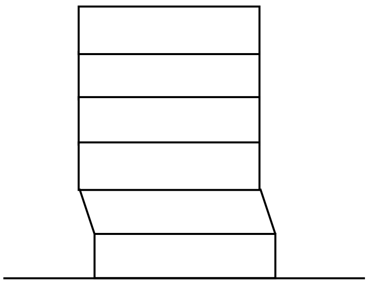
	
Twisting as different parts of the building accelerate at different speeds.	Sheer as the bottom of the building moves and the heavy upper parts of the building remain stationary.

Figure C

(Paragraph 10)

With the general style of building now decided, there are some general rules that can be followed to reduce the possibility of metal framed buildings collapsing in an earthquake.

- The building should have a large base and should avoid being overly tall and slender.
- The building should be well anchored to bed rock and not built on sand if possible.
- The building should be simple / symmetrical when viewed from above so that the forces on the building during an earthquake can be easily calculated and evenly distributed through the metal frame of the building.
- Heavy objects (MRI machines in hospitals) and facilities (libraries) inside a building should be placed as close to the ground floor and as centrally in the building as possible.)
- Buildings should not be built too close together.

(Paragraph 11)

The final consideration is the natural frequency of the building. If the average frequency of vibration of earthquakes in the area is known, it is better to design the building so that its natural frequency is not matched to the frequency of vibration of the earthquakes (or for that matter the wind gusts in the area). Generally setting the fundamental natural frequency of the building higher rather than lower is recommended.

Questions

1. What is the ratio of energy in an earthquake measuring 3.4 on the Richter scale compared to one measuring 2.4 on the Richter scale? (Paragraph 2)

(3 marks)

$R = 2/3 \text{ Log}_{10} (E / E_o)$

$3.4 = 2/3 \log (E / 6.31 \times 10^4)$

$\mathbf{E = 7.94 \times 10^9}$

$2.4 = 2/3 \log (E / 6.31 \times 10^4)$

$\mathbf{E = 2.51 \times 10^8}$

79.4 / 2.51

31.6 :1

2. Is the wave produced at the epicenter directly above the hypocenter longitudinal or transverse? Explain. (Figure A)

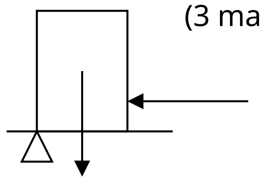
(2 marks)

Longitudinal

The building bounces up and down in line with the source

3. Will a 15 000 tonne building with a square base of side length 8.00 m topple over if a flood exerts a 350 000 N force on one side of the building at a height of
2.00 m above its base. Assume that the building stays rigidly in one piece and does not collapse.

(3 marks)



Sum of torques = 0?

4 x 15 000 000 x 9.8 = 350 000 x 2? (1)

5.88 x 10^8 *verses 7 x 10*^{5} (1)

No it doesn't topple (1)

4. Why do brick (masonry walls) was fail in earthquakes?

(2 mark)

Can not withstand bending – (brittle - crack) diagram – outer surface of wall. Strong in compression weak in tension.

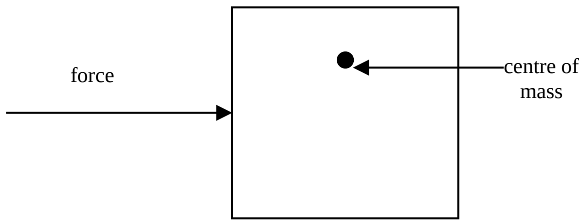
5. If a force is applied to the centre of a floor or level of the building but the centre of mass of that floor is off centre, what effect will this have on the building? Explain why. (Figure C).

(3 marks)

The building will twist.

A torque will be created.

The force is not passing through the center of mass.



Top View of Building

6. "The building should have a large base and should avoid being overly tall and slender?" Why?

(2 marks)

***Stable** objects have large bases and **low centers of mass**.*

7. Why should "buildings not be built too close together?"

(2 marks)

If one building collapses onto another it can cause the second building to collapse.

Or

The 2 buildings have different natural frequencies they can pound against each other and demolish each other.

8.
Why, if possible, should the fundamental frequency of the building be set above the frequency of earthquake? Explain with the assistance of mathematics. (Paragraph 11)

(3 marks)

Resonance

If the buildings natural frequency is set very low then it will have a large number of harmonics above it which the building can resonate to. If the earthquake happens to match one of these harmonics it will increase its chance of failing.

If the fundamental frequency is set high then is will have fewer frequencies above the fundamental that will match the frequency of potential earthquakes and so avoid damaging resonance.

$f = nv / 4L$

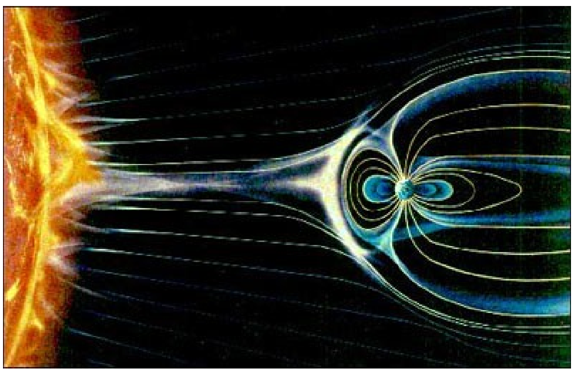
2. The Northern and Southern Lights
[20 marks]

(Paragraph 1)
The northern and southern lights are a form of light emitting spectra produced when charged particles from outer space collide with atoms of oxygen and nitrogen in the earth's atmosphere. The unusual thing is that this effect only occurs at a radial distance of approximately 2500 km from the magnetic poles in the northern and southern hemisphere between the months of September - October and March – April.

(Paragraph 2)
The Northern lights are referred to as the Aurora Borealis and the southern lights are referred to as the Aurora Australis.

(Paragraph 3)
The Sun releases large quantities of charged particles from its surface in the form of electrons and positively charged (ionized) atoms. The immense heat of the sun is capable of providing the energy necessary to ionize the different types of element found in the atmosphere of the sun. The main ionizing effect on the elements in the sun's atmosphere however is created by these elements being stripped of their electrons by the sun's swirling and changing magnetic field. The elemental positive ions and the electrons do not recombine because the particles are travelling at high speed from the surface of the sun outwards in diverging directions, giving them little chance of colliding. This flow of particles outwards from the sun is called the "solar wind". The solar wind is strongest when the sun is going through a sun spot cycle (every 11 to 12 years) which is a violent magnetic event.

(Paragraph 4)
The solar wind collides with the earth's magnetic field. The earth's magnetic field extends a great distance out into space around the planet earth. The interaction of the charged particles with the earth's magnetic field causes the charged particle to change direction, deflecting most of them around the earth before they can come in contact with the earth's atmosphere. Some electrons and positively charged elemental ions are caught by the earth's magnetic field however and directed along the earth's magnetic field lines in a spiral (corkscrew) motion. In following the earth's magnetic field, the charged particles are directed to the icy northern and southern polar regions, where they are drawn close enough to the earth to come in contact with the earth's atmosphere.



(Paragraph 5)
When the charged particles collide with oxygen and nitrogen (the two most abundant elements in the earth's atmosphere) they transfer their kinetic energy to them resulting in a spectacular light show. The oxygen atoms are responsible for the greens and a few of the reds in the aurora. The nitrogen is responsible of the blues and the rest of the reds.

Questions

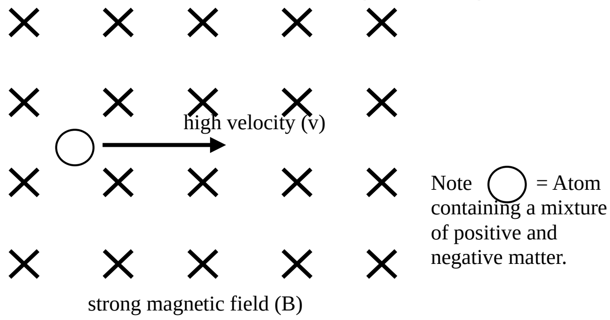
1. Explain with the assistance of the diagram below why the electrons of an atom will be stripped from the nucleus when travelling at high speed through a strong magnetic field as occurs in solar wind. (Paragraph 3)

(3 marks)

Positive matter gets force to top of page.

Negative mater gets force to bottom of page.

$F = qvB$



2. What does the word diverging mean? (Paragraph 3)

(2 marks)

Moving apart / radially outwards form a point

Diagram to support

3. As the charged particles leave the **gravitational** field of sun, what will happen to their speed? Explain.

(3 marks)

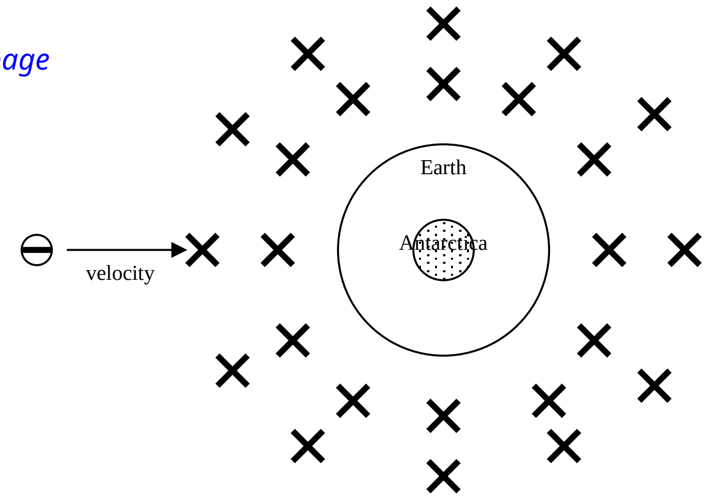
The speed will decrease as their kinetic energy is converted to gravitational potential energy.

$mgh = ½ mv^2$

4. When an electron strikes the earths magnetic field at right angles, as shown below, what will the electron do? Explain. (Paragraph 4)

(2 marks)

Bottom View

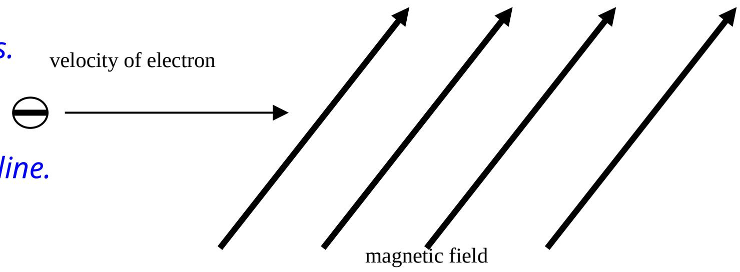


Turn towards the bottom of the page

F = qvB

5. Explain why an electron striking the earth's field, not at right angles, will corkscrew around the earths magnetic field? (Paragraph 4)

(3 marks)



Velocity is broken into 2 components.

Component parallel with field causes particle to move along field line.

Particle at right angles to field cause particle to swirl or turn in a circle.

Hence corkscrews along field lines.

6. Why do oxygen and nitrogen gas give off light when electrons from the sun collide with them? (Paragraph 5)

(2 marks)

Electrons in energy levels are excited by collision

When the electrons move back into the ground state they release photons of light of specific colours.

7. What is the approximate loss of kinetic energy that a bombarding electron will experience as the result of colliding with nitrogen resulting in a single downward transition producing blue light? State your answer in electron volts.

(3 marks)

Blue = f = 6×10^{14} Hz

$E = hf$

$E = 6.63 \times 10^{-34} \times 6 \times 10^{14}$

$E = 3.978 \times 10^{-19}$ J

E (eV) = 2.49 eV

8. The earth's magnetic field is created by swirling ferromagnetic materials within the core of the earth. If the sun contains very few ferromagnetic materials, what other effects could give rise to the creation of the sun's magnetic fields? Explain.

(2 marks)

Swirling charged particles creating currents that generate magnetic fields.

End of Exam

References.

http://en.wikipedia.org/wiki/Aurora_borealis.htm - 28/7/2008

http://www.phy6.org/Education/aurora.htm - 28/7/2008

END OF EXAM