Semester Two Examination, 2010

Question/Answer Booklet

3AB PHYSICS

Please place your student identification label in this box

Time allowed for this paper

Reading time before commencing work: Ten minutes
Working time for paper: Three hours

Materials required/recommended for this paper

To be provided by the supervisor

This Question/Answer Booklet
Formulae and Constants Sheet

To be provided by the candidate

Standard items: pens, pencils, eraser, correction fluid, ruler, highlighters

Special items: non-programmable calculators satisfying the conditions set by the Curriculum Council for this course

Important note to candidates

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

	A	B	C	Total
Score				
Out of	54	90	36	180
%				

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	15	15	50	54	30
Section Two: Problem-solving	8	8	90	90	50
Section Three: Comprehension	2	2	40	36	20
					100

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 12 Information Handbook 2010.* 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.

5. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Section One: Short response 30% (54 Marks)

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

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

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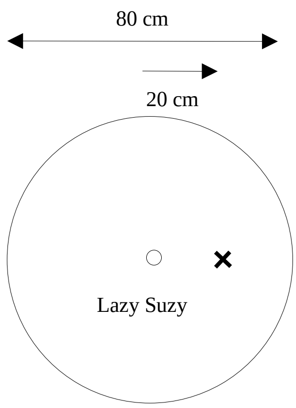
Suggested working time for this section is 50 minutes.

Question 1

(3 marks)

A child is having a meal at a Chinese restaurant. In the middle of the table there is a rotating circular piece of wood called a Lazy Suzy (table not shown)

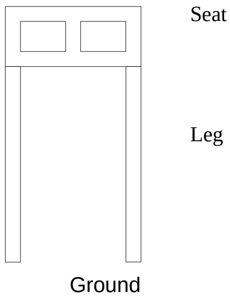
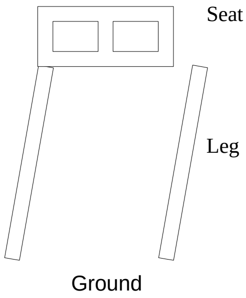
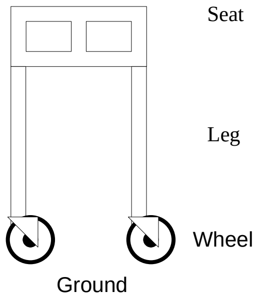
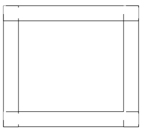
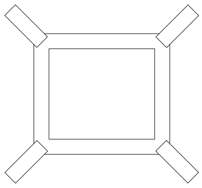
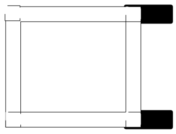


A 50.0 g glass salt shaker is placed half way from the centre to the edge (marked X on the diagram). The maximum value of static friction between the salt shaker and the Lazy Suzy is half the weight of the salt shaker. A child begins to spin the Lazy Suzy. At what speed will the **outer edge** or the Lazy Suzy be moving when the salt shaker starts to slip?

Question 2

(3 marks)

Below are three designs of high chairs for children.

Design	Chair A	Chair B	Chair C
Front View			
Top View			

All of the chairs have the same height and the same centre of mass positioned 2/3 rds of the height from the ground up.

a) Rank the above chairs from <u>most</u> stable to <u>least</u> stable

(1 mark)

__________________ __________________ __________________

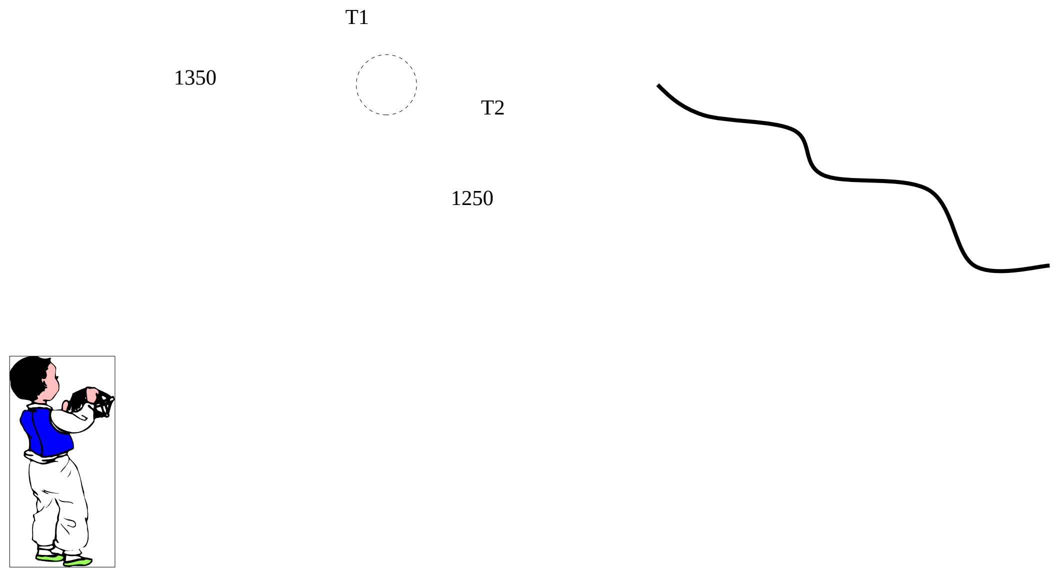
b) Explain the reasoning behind your ranking.

(2 marks)

Question 3

(3 marks)

A stationary child is flying a kite at the park. The string (------) is attached to the kite in a “V” shape.



The child maintains a constant pulling force on the string with a force of 100 N. The kite’s position remains constant. Calculate the magnitude of the tension forces T_1 and T_2.

Question 4

(4 marks)

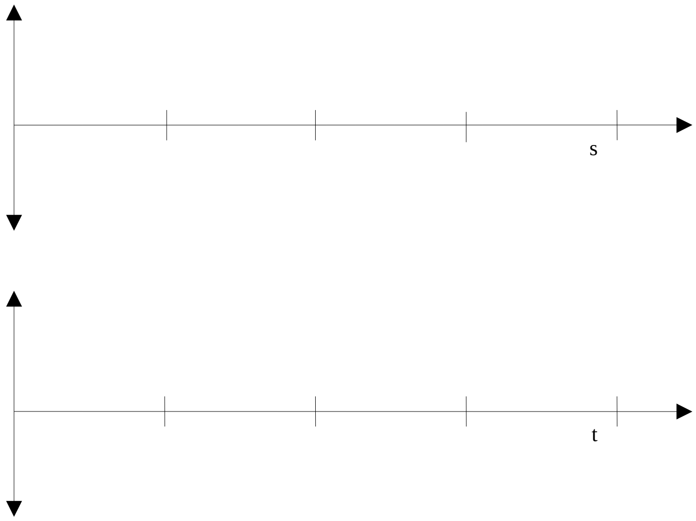
A flag is waving in the breeze. The tail of the flag takes 0.600 s to complete one cycle. When a photograph is taken of the 1.2 m long flag, it contains1.5 ripples along its length.

a) What is the frequency of the flags oscillation?

(1 mark)

b) Sketch a displacement distance graph and a displacement time graph of the flag.

(2 marks)



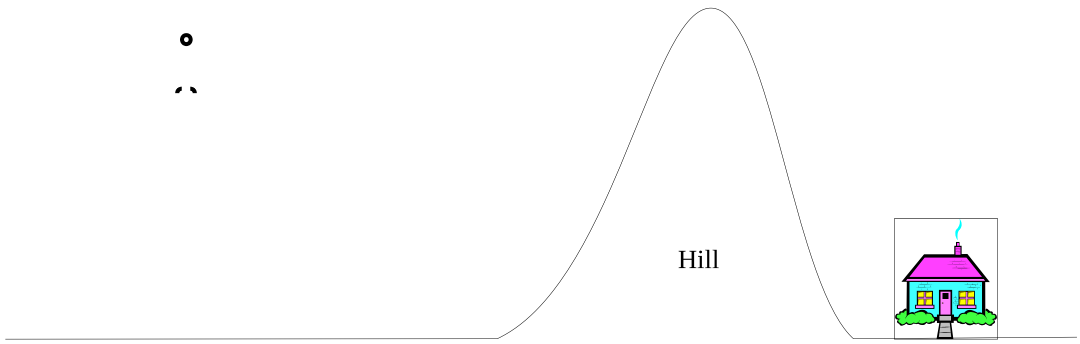
c) What is the velocity of the wave in the flag?

(1 mark)

Question 5

(3 marks)

A radio and television signal is being broadcast from a large transmission aerial to the houses in the surrounding areas. Some of the houses are situated behind a 20 m high hill. A diagram of the situation is shown below.



The radio station frequency is 30 MHz and the television station frequency is 3000 MHz. Which signal (radio or television) will be received most clearly by the house on the far side of the hill? Explain why.

Question 6

(4 marks)

A frequency of 900 Hz is directed into a closed pipe of length 67.3 cm causing it to resonate. If the speed of sound in air that day is 346 m s^{-1}, draw with the assistance of calculations the standing wave pattern created.

Question 7

(3 marks)

The sun sends out electromagnetic radiation in all directions. At the outer edge of the earth's atmosphere at a distance of 1 AU the intensity of the sun's radiation is 1.366×10^3 W m^{-2}. What is the intensity of the radiation measured at the surface of the sun?

Question 8

(4 marks)

Draw a flow chart classifying the different types of matter according to the standard model. The chart must contain sufficient information to explain the differences between the various types of matter and the forces between them.

Question 9

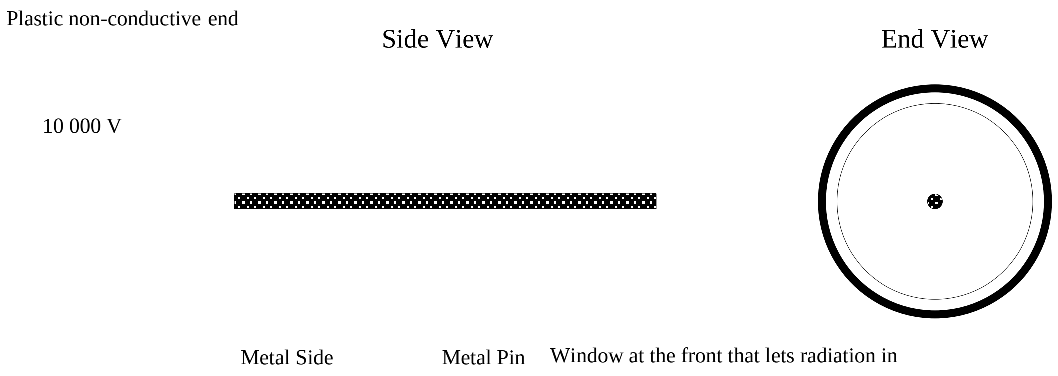
(3 marks)

A stupendously strong Olympic javelin thrower throws a 2.4 m long 9.00×10^2 g javelin at a velocity of 3.00×10^7 m s^{-1}. Considering relativity, comment on how the density of the javelin will appear to a person moving with the javelin as compared to a person watching the javelin move away from them. The formula for density is mass / volume. No numerical calculations are necessary in your explanation.

Question 10

(5 marks)

A Geiger - Muller tube consists of a metal tube with a metal pin running down its centre.



In this particular model the central pin is positive and the metal tube is neutral. The potential difference between the tube and the pin is 500 V. The space between the side and the pin is filled with neon gas at 1 / 10th atmospheric pressure.

a) Draw the electric field existing inside the tube onto the end view diagram.

(1 mark)

b) Is the field uniform or non uniform?

(1 mark)

Uniform Non Uniform (Circle one only)

c) Explain your answer to b)

(1 mark)

d) When radiation enters the tube one of the Neon gas particles becomes ionised resulting in an electrical discharge. What type of spectrum will be produced by the neon gas as a result of the discharge? Explain your answer.

(2 marks)

Question 11

(4 marks)

a) State two possible medical reasons for deliberately exposing a patient to X rays.

(2 marks)

b) The spectra from two different X ray tubes is compared. Both tubes use the same size voltage to accelerate the bombarding electrons. One of the tubes uses Molybdenum as a target and the other uses Tungsten. Explain one similarity between the two spectra and one difference. Use diagrams to assist your explanation.

(2 marks)

Similarity

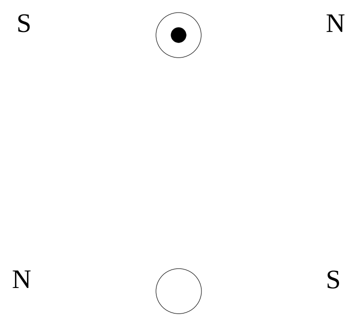
Difference

Question 12

(3 marks)

a) Draw the resultant magnetic field associated with the magnets and the wires onto the diagram below.

(2 marks)



b) If the wires are able to move in which direction will they move?

(1 mark)

Question 13

(4 marks)

a) The peak voltage produced by a generator is 10 V. Calculate the root mean squared voltage.

(2 marks)

b) If the generator now turns at twice the speed and has a resistance of 10.0 Ω connected to it, calculate the peak power produced.

(2 marks)

Question 14

(4 marks)

A car is travelling around a corner at 40 km h^{-1} ± 1 km h^{-1}. The car has a mass of 9.6×10^2 kg ± 2×10^1 kg and is turning through a radius of 15 m ± 1 m.

a) What is the velocity of the car and error in the velocity of the car in m s^{-1}?

(1 mark)

b) Convert the absolute errors in the numbers above into relative errors.

(1 mark)

Symbol	Number (SI units)	Absolute Error (SI units)	Relative Error (%)
v			
m	960 kg	20 kg	
r	15.0	1 m	

c) What is the relative error in the centripetal force?

(2 marks)

Question 15

(4 marks)

What is the difference between reliability and validity? Support your answer with examples.

Reliability

Validity

End of Section One

Section Two: Problem-solving 50% (90 Marks)

This section has **eight (8)** questions. You must answer **all** questions. Write your answers in the space provided.

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Suggested working time for this section is 90 minutes.

Question 16

(11 marks)

In order to attract younger members to the golf club the old members have invented a new game using golf balls. A 50.0 g golf ball is put in a slingshot / catapult. The player stands at the start and fires the golf ball from the catapult towards the hole in the ground.

a) If the ball is projected with an initial velocity of 18.0 m s^{-1} at 20.0^{o} above the horizontal from a height of 0.700 m above the ground what will be the maximum height of the golf ball above the ground?

(3 marks)

b) What will be the kinetic energy of the golf ball as it hits the ground?

(2 marks)

c) What is the final speed of the golf ball as it hits the ground?

(1 mark)

d) If the boy is standing 83.0 m for the hole, will the golf ball land directly in the hole?

(3 marks)

e) If a wind now begins to blow towards the boy at 9.00 m s^{-1} before the ball is shot, draw the shape of the trajectory taken by the ball, as compared to the trajectory when no wind is present.

(1 mark)

f) Explain how the boy should change what he is doing with the sling shot to compensate for the wind and maximise range.

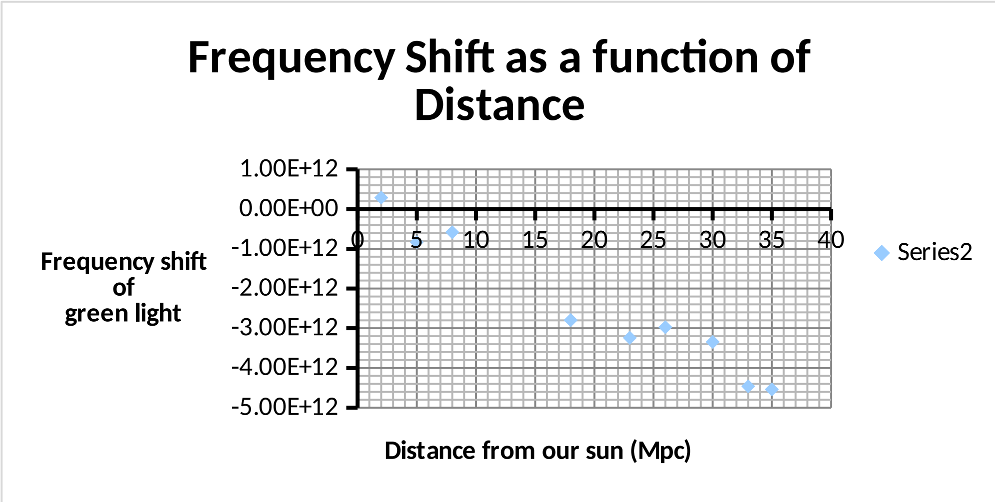
(1 mark)

Question 17

(12 marks)

Below is a graph of the amount of frequency shift experienced by originally green light of frequency 5.50 x 10^{14} Hz emitted from a range of stars at different distances from earth.

Distance from our sun (Mpc)	2	5	8	18	23	26	30	33	35
Shift in Frequency (Hz)	2.90E+11	-8.34E+11	-5.83E+11	-2.79E+12	-3.24E+12	-2.97E+12	-3.34E+12	-4.46E+12	-4.54E+12



a) Are the majority of the points on the graph showing red shift or blue shift? Explain citing evidence from the graph.

(2 marks)

b) How does this graph support Edwin Hubble's theory that the universe is expanding? Explain.

(1 mark)

c) One point on the graph does not support Hubble's theory of an expanding universe. Please circle it on the graph.

(1 mark)

d) Is the point circled in part c) an outlier? Explain why or why not.

(1 mark)

e) Calculate the slope of the line from the graph using a line of best fit.

(1 mark)

f) Using the slope of the line you have calculated in part e) calculate the frequency shift for a celestial object that is 28 Mpc from us?

(2 marks)

g) What is the theoretical cause of the universe expanding? Explain.

(2 marks)

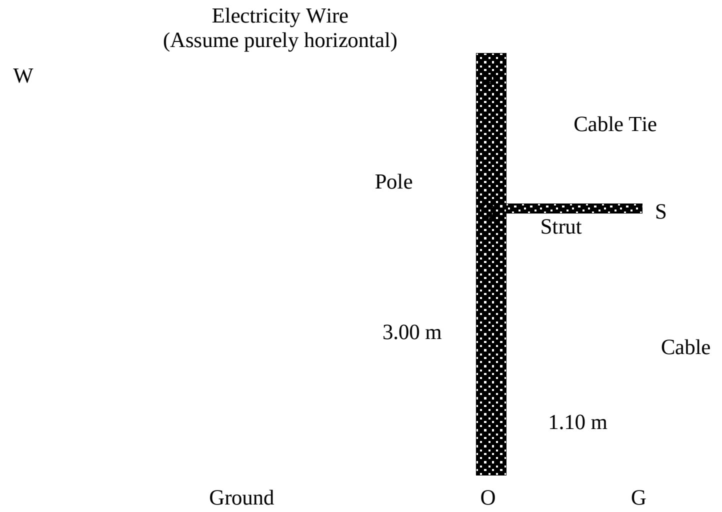
h) State 2 other pieces of evidence supporting the theoretical cause of the expanding universe as stated in part g) above.

(2 marks)

Question 18

(12 marks)

The diagram below is of an electricity wire attached to a pole. The pole has been reinforced by a cable tie, strut and cable.

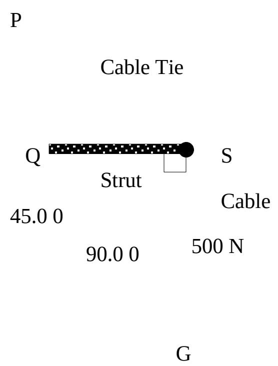


a) An electrical wire (WP) is under tension and is exerting a force on the electrical power pole (PO) and is attempting to topple it. To stop the pole from toppling the electrical power pole has been tied back to the ground using a cable (SG). If the tension measured in cable (SG) is 500 N what is the tension in the electrical wire (WP)? (Note - the strut is weightless)

(4 marks)

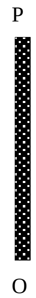
b) What are the forces in the cable tie and the strut given that cable (SG) has a tension of 500 N? A close up of the relevant section is provided below. (Assume the strut is weightless)

(3 marks)



c) In the table below state whether the following components are under tension, compression or both and draw the forces on each component.

(3 marks)

Component	Tension, Compression or Both	Draw forces on object
Cable tie (SP)		P S
Strut (SQ)		
Pole (OP)		

d) If the tension in the electrical cable is kept constant and the length of the strut is increased. What will happen to the size of the tension required in the cable (SG) to keep the situation in equilibrium? Explain.

(2 marks)

Question 19

(9 marks)

Electromagnetic radiation (EMR) of frequency 2×10^{15} Hz is shone onto the surface of a sheet of potassium metal in outer space.

a) Which region of the electromagnetic spectrum does this EMR belong to?

(1 mark)

____

b) This frequency of radiation causes electrons to be emitted from the surface of the metal with a velocity of 1.18×10^{6} m s^{-1}. What is the ionisation energy of potassium in electron volts?

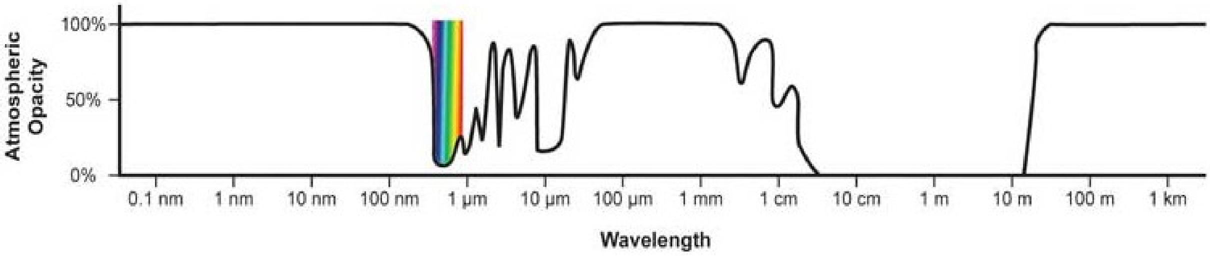
(3 marks)

c) What is longest wavelength of light that will just ionise potassium?

(2 marks)

d) The sheet of potassium is now placed on the surface of the earth in a glass container filled with a noble gas. Assume that the glass of the container and the noble gas do not restrict the type of radiation that enters the glass. With the assistance of the diagram below, explain what range of wavelengths of EMR will be able to penetrate the earth's atmosphere and cause ionisation in the potassium?

(2 marks)



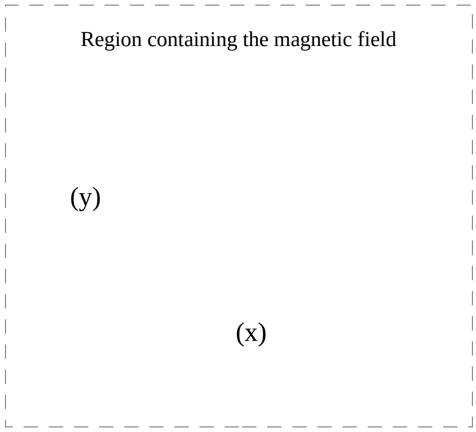
e) Why are metals with large work functions not used to manufacture photoelectric cells?

(1 mark)

Question 20

(12 marks)

Two electrons x and y, both with speed 5.00×10^6 m s^{-1} are shot into a uniform magnetic field. The first (x) is shot from the origin out along the x axis. It bends out of the page with a radius of curvature equalling 8.00 cm. The second (y) is shot along the y axis. It travels in a straight line un-deviated.



a) Draw onto the diagram the direction of the magnetic field.

(1 mark)

b) Calculate the strength of the magnetic field.

(3 marks)

c) Through what potential difference would the electrons have to be accelerated to achieve the above stated velocity?

(2 marks)

d) In what direction would you direct a uniform **electric field** to stop the electron from bending in the magnetic field?

(1 mark)

e) Calculate what electric field strength is required to stop electron x bending?

(3 marks)

f) The electric field is now switched off leaving only the magnetic field switched on. Considering relativity, if electron x is now shot faster at a speed of 3.00 x 10^7 m s^{-1} will the radius of curvature predicted by the equation you used in part b) still be perfectly obeyed? Explain.

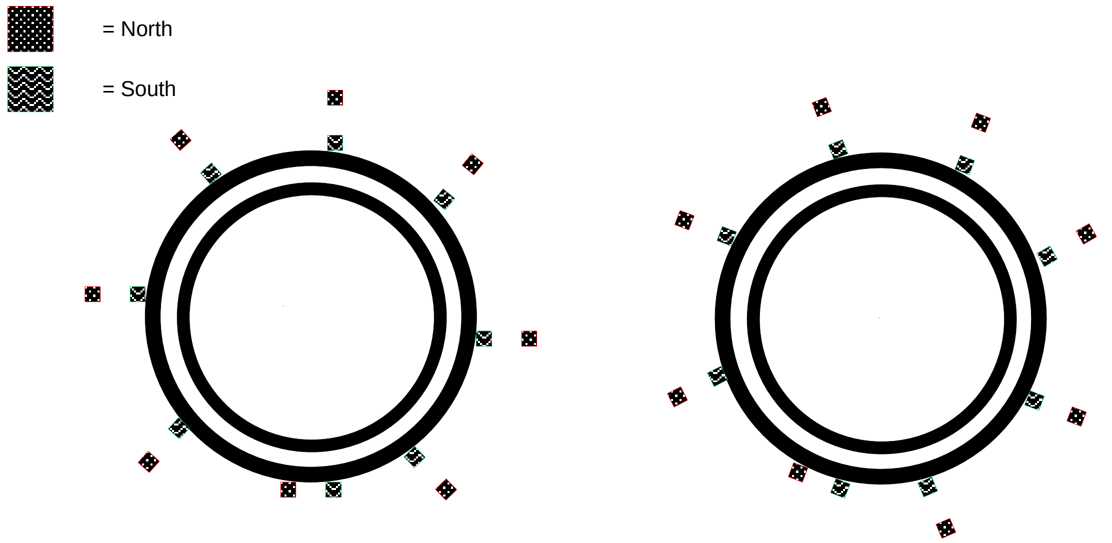
(2 marks)

Question 21

(11 marks)

Below is a diagram a brushless alternator. The alternator consists of two rings of plastic, one inside the other. Horse shoe magnets are attached to the outer plastic ring. Soft iron U shapes are attached to the inner plastic ring. The inner plastic ring is held stationary. The outer ring is turned causing the magnetic field in the soft iron U shapes to periodically reverse direction.

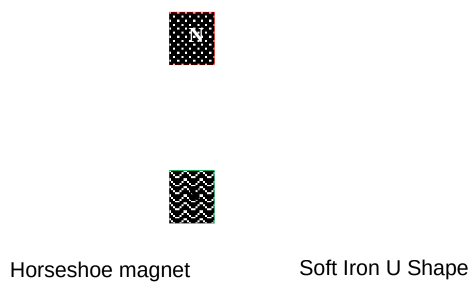
Diagram 1



a) Below is an enlarged diagram of a stationary horse shoe magnet in front of a stationary soft iron U shape. Draw the direction of the magnetic field created around the horse shoe magnet and the soft iron U shape.

(1 mark)

Diagram 2



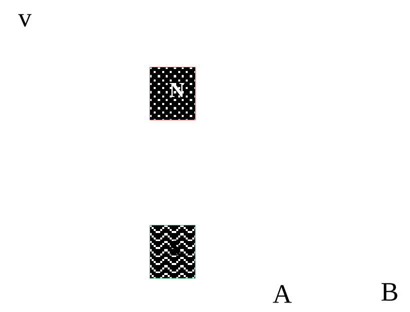
b) The magnetic field strength emitted by the horse shoe magnet in part a) is 0.04 T. If the soft iron U shape has a cross sectional area of 2.00 cm by 2.00 cm, what is the magnetic flux in the soft iron U shape?

(2 marks)

c) If each of the soft iron U shapes is wrapped with a solenoid as shown in Diagram 3, what type of current will be produced by the solenoids. Explain using relevant physics theories.

(3 marks)

Diagram 3



d) If the outer wheel in diagram 1 makes 4 complete revolutions in one second, calculate the time it takes for the magnetic field to reverse in each soft iron U shape.

(2 marks)

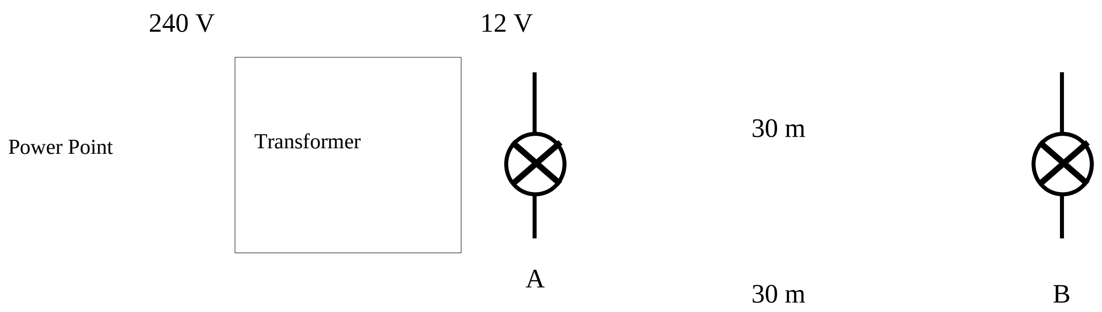
e) Calculate the magnitude of voltage output from each solenoid if each solenoid has 50 turns.

(3 marks)

Question 22

(12 marks)

A home handy man has connected together a 12.0 Volt garden lighting system in his backyard at home. The system consists of a transformer that plugs into a 240 V power point and changes the voltage to 12.0 V. The 12.0 V is then connected to two light bulbs in parallel as shown in the diagram below. Each light bulb has a resistance of 10Ω. The 30 m wires do add additional resistance to the circuit.



a) If the current supplied to the transformer is 7.619×10^{-2} A. What is the power input to the transformer by the power point?

(2 marks)

b) If the transformer is 90% efficient, what is the power output of the transformer?

(2 marks)

c) What is the current output of the transformer?

(2 marks)

d) What is the power consumed by light bulb A?

(2 marks)

e) What is the combined resistance of the two 30.0 m long wires?

(2 marks)

f) Which light bulb, A or B will be brighter? Explain why.

(2 marks)

Question 23

(11 marks)

A scientist is creating a formula to predict the intensity of a star based on a star's colour. The scientist finds a data table that converts star colour to temperature.

Temperature (K)	**Star Colour**
30 000	Blue
22 500	Blue – White
12 500	White
8 500	White - Yellow
6 000	Yellow
4 500	Orange
3 500	Red

He also finds a formula that converts star temperature to intensity which is …

$$I = \sigma T^4$$

a) Convert the colour provided in the table below to temperatures

(1 mark)

Variable	Units	1	2	3	4	5
Colour		White	White - yellow	Yellow	Orange	Red
Temperature	K					
Intensity	W/m^2	1.38×10^9	2.96×10^8	7.35×10^7	2.33×10^7	8.51×10^6

b) Manipulate one of the above variables in preparation for producing a straight line graph. Be sure to complete the variable and units column.

(2 marks)

c) Graph the straightened data on the graph paper below.

(4 marks)

d) Calculate from the graph the value of the constant σ? Show all working leaving evidence on the graph.

(3 marks)

e) Use the formula of the line to calculate the intensity of a blue star.

(1 mark)

End of Section Two

Section Three: Comprehension 20% (36 Marks)

Question 24

(18 marks)

Gravitational Red Shift

Paragraph 1
Red shift is often explained as being similar to the Doppler Effect. An example of the Doppler Effect is the alteration in sound that occurs when a car passes. As the car approaches the observer the sound of the engine is higher than after the car has passed.

Paragraph 2
Cosmological Red shift and Blue shift occurs in a similar way. Instead of sound being emitted by a car moving towards or away from you however, it is light being emitted by a star as it moves towards or away from the earth. If the star is moving towards the earth all of the frequencies emitted will be slightly increased. This is called Blue shift. Conversely if the star is moving away from the earth all of the frequencies emitted will be slightly lowered. This is called Red shift.

The formula for cosmological red-shift is

$$f_L = \left(\sqrt{\frac{c-v}{c+v}} \right) f_S$$

Where

Symbol	Definition	Units
f_L	Frequency observed by the person on earth.	Hz
f_S	Frequency of the source	Hz
c	Speed of light in a vacuum (3×10^8 m s^{-1})	m s^{-1}
v	Speed of the object producing the electromagnetic radiation (light) v = away from earth → v = positive. v = towards the earth → v = negative.	m s^{-1}

Paragraph 3
Instead of considering blue and red shift purely as a frequency effect, a better understanding can be found by consider the energy of the situation. When photons are blue shifted they have a higher frequency. This means they have more energy. Red shift reduces the energy that a photon has. This can be considered analogous to kinetic energy.

Paragraph 4
Let's do 3 thought experiments …

i) A stationary person throws a 100g ball forwards at 10 m s^{-1}.
ii) A person riding a bike forwards at 5 m s^{-1} throws a 100g ball forwards at 10 m s^{-1}.
iii) A person riding a bike backwards at 5 m s^{-1} throws a 100g ball forwards at 10 m s^{-1}.

The velocities of the each ball are 10 m s^{-1}, 15 m s^{-1} and 5 m s^{-1} respectively.
The kinetic energies of each ball are 5 J, 11.25J and 1.25J respectively.

Paragraph 5
In the above thought experiment we see that the velocity of the bike effected the kinetic energy of the ball. When the movement of the bike was in the same direction as the ball the kinetic energy increased and when they were in opposite directions it decreased.

Paragraph 6
Light from a star is actually a stream of photons being thrown from the star out into space. Photons have different properties to a ball however and so the formula for calculating the energy of a photon will be different from the energy of a ball. Both of these energies (ball or photon) can be regarded as kinetic energies.

Paragraph 7
So to summarise the story so far we see that the kinetic energies of particles can be modified by the speed of the object that throws them.

Paragraph 8
Kinetic energies of objects can also be modified by gravity. When a ball is thrown up into the air, the kinetic energy of the ball drops as its speed decreases. The potential energy of the ball increases as the distance of separation between the centre of the earth and the centre of the ball increases.

Paragraph 9
It is not surprising to discover therefore that gravity can also alter the energy of a photon. Gravity cannot alter the speed at which light / photons travel. This speed is constant regardless of the situation. If we cannot alter speed we will have to alter another variable that is related to photon energy. We will alter frequency.

Paragraph 10
When photons are emitted by stars they have to escape the gravitational field of the star. This means that as the photon travels outwards it will lose "kinetic" energy and its frequency will be progressively red shifted. The stronger the gravitational field of the star, the more red shifted the photons produced by the star. This is called Gravitational Red Shift.

The formula for gravitational red shift is

$$f_L = f_S \left(1 - \frac{GM}{Rc^2}\right)$$

Where

Symbol	Definition	Units
f_L	Frequency of the photon observed by the person outside stars gravitational field.	Hz
f_S	Frequency of the photon observed in the stars gravitational field	Hz
c	Speed of light in a vacuum (3×10^8 m s^{-1})	m s^{-1}
G	The gravitational constant 6.67×10^{-11}	N m^2 kg^{-2}
M	Mass of the star.	kg
R	Distance from the centre of the star.	m

Paragraph 11
Let's suppose the "kinetic" energy required to escape a particular star's gravitational field is larger than the energy of the most energetic photon. Based on this logic the photon will not escape. In this situation the star will be called a black hole.

a) State two similarities and 2 differences between the gravitational red shift of a photon and the ionisation energy of an electron and atom.

(4 marks)

	Grav. Red Shift	**Ionisation Energy**
Similarities		
Differences		

b) Based on cosmological red shift what will be the frequency of an originally blue photon of wavelength 5000 Å that that has been emitted from an electric torch moving away from an astronaut in empty space at a speed of 20 000 km s^{-1}?

(3 marks)

c) To which part of the electromagnetic spectrum does the photon received by the astronaut belong?

(1 mark)

d) The astronaut returns to earth and is looking through a telescope at the torch which is still flying away one hour later. Explain **two** ways in which the photons from the torch will now look different from your answer to part b).

(2 marks)

e) Using the gravitational red shift formula, state the new frequency of a 9.00 x 10^{15} Hz photon originating at the surface of our sun. The new frequency is received / measured in empty space outside the sun's gravitational field.

(4 marks)

f) Would Edwin Hubble need to take gravitational red shift into account in formulating his theory of an expanding universe? Explain why or why not.

(2 marks)

g) A satellite orbiting the earth is set to receive signals at a frequency of 3.00 x 10^{6} Hz. Should the signal be sent from the transmitter at the surface of the earth at a frequency above, equal to or below 3 x 10^{6} Hz taking into account gravitational red shift? Do not calculate your answer.

(2 marks)

Question 25

(18 marks)

Electricity from the Ocean

Paragraph 1

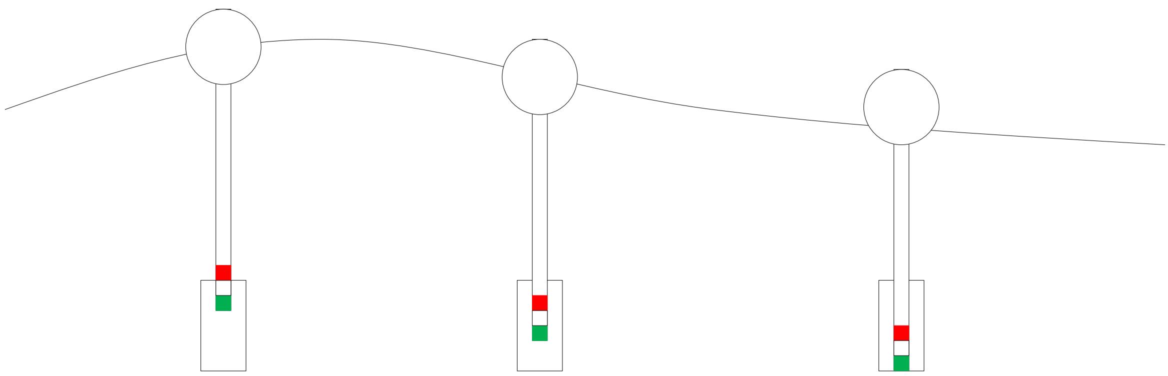
With the demand for electrical energy always on the increase, scientists are on the lookout for new ways of generating electricity.

Paragraph 2

The latest invention is a "wave rider electricity generator". The device consists of a permanent magnet attached to a rigid plastic pole with a large white foam float on top. As the waves pass under the float it rises lifting the magnet from the sea floor. The magnet is contained in a plastic pipe around which a coil of copper wire has been wrapped. The magnet moving past the wire generates electricity in the coil.

Diagram 1

3 wave rider electricity generators. Motion of the float is shown by the arrows.



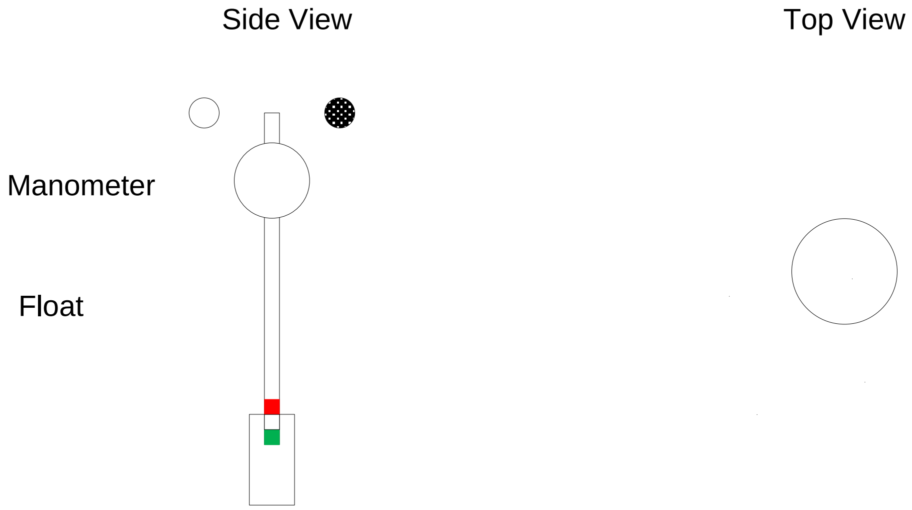
Paragraph 3

It was expected when the riders were first put into the ocean for testing that the buoys would ride lightly on the surface. Instead however it was observed that the motion of the buoys showed a delay in movement. For example …

- when a wave rose the float was substantially more submerged than normal.
- when a wave fell the float came clear of the water and descended slowly.

Consequently the amplitude executed by the wave rider was somewhat less than that of the ocean swell.

Paragraph 4
In the next prototype the scientists are going to attach a manometer (wind turbine) to the top of the floats in an attempt to get the float, pipe and vertical magnet to spin.



Physicists are predicting that will produce little additional electrical energy.

Questions

a) How does the rise and fall of the waves generate electricity?

(2 marks)

b) Why does the buoy at the top of the wave rider refuse to follow identically the rise and fall of the waves?

(3 marks)

c) What will scientists discover about the motion of the wave riders if they try to wire together 2 or more of these devices in series? Why?

(2 marks)

d) If 3 waves past in 22 seconds on average and the amplitude of the rise and fall of the wave rider is 1 m, what will be the average voltage induced in a coil of 200 turns and area 30 cm^2. Assume that the magnet has a field of 0.65 T and one upward movement of the buoy changes the flux from zero to maximum to zero. State any assumptions.

(4 marks)

e) Draw the voltage output of one wave rider buoy under the conditions mentioned in part d)

(3 marks)

f) Explain one advantage and one disadvantage to the environment of using wave rider electricity generators.

(2 marks)

g) Why is the spinning of the magnet unlikely to produce any voltage? Explain.

(2 marks)

End of Exam

Additional working space

Additional working space

Additional working space

Semester Two Examination, 2010

Question/Answer Booklet

3AB PHYSICS

Answers

Time allowed for this paper

Reading time before commencing work: Ten minutes
Working time for paper: Three hours

Materials required/recommended for this paper

To be provided by the supervisor

This Question/Answer Booklet
Formulae and Constants Sheet

To be provided by the candidate

Standard items: pens, pencils, eraser, correction fluid, ruler, highlighters

Special items: non-programmable calculators satisfying the conditions set by the Curriculum Council for this course

Important note to candidates

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

	A	B	C	Total
Score				
Out of	54	90	36	180
%				

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	15	15	50	54	30
Section Two: Problem-solving	8	8	90	90	50
Section Three: Comprehension	2	2	40	36	20
					100

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 12 Information Handbook 2010.* 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.

5. Working or reasoning should be clearly shown when calculating or estimating answers.

5. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Section One: Short response 30% (54 Marks)

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

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

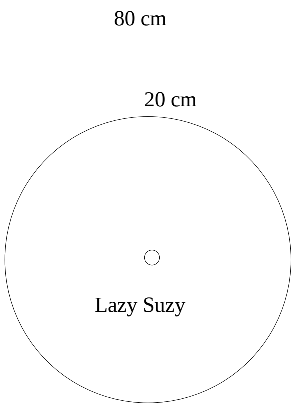
- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time for this section is 50 minutes.

Question 1

(3 marks)

A child is having a meal at a Chinese restaurant. In the middle of the table there is a rotating circular piece of wood called a Lazy Suzy (table not shown)



A 50.0 g glass salt shaker is placed half way from the centre to the edge (marked X on the diagram). The maximum value of static friction between the salt shaker and the Lazy Suzy is half the weight of the salt shaker. A child begins to spin the Lazy Suzy. At what speed will the **outer edge** or the Lazy Suzy be moving when the salt shaker starts to slip?

$F_F = ½ mg$

$F_F = 0.5 \times 0.05 \times 9.8$

$F_F = 0.245$ N

$F = \dfrac{mv^2}{r}$

$0.245 = \dfrac{0.05 x v^2}{0.2}$

$\sqrt{\dfrac{0.245 x 0.2}{0.05}}$

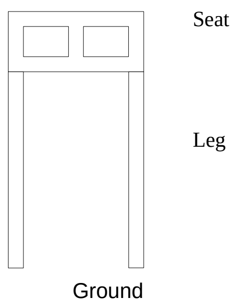
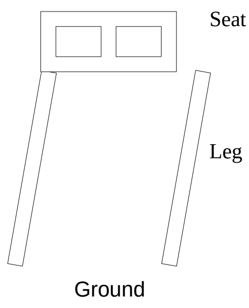
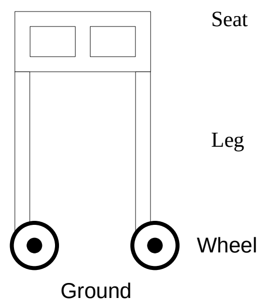
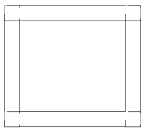
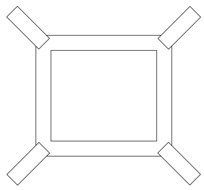
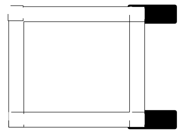
r = 0.99m/s at 20cm

v = 1.98m/s at 40cm

Question 2

(3 marks)

Below are three designs of high chairs for children.

Design	Chair A	Chair B	Chair C
Front View			
Top View			

All of the chairs have the same height and the same centre of mass positioned 2/3 rds of the height from the ground up.

a) Rank the above chairs from <u>most</u> stable to <u>least</u> stable

(1 mark)

Chair B Chair A Chair C

b) Explain the reasoning behind your ranking.

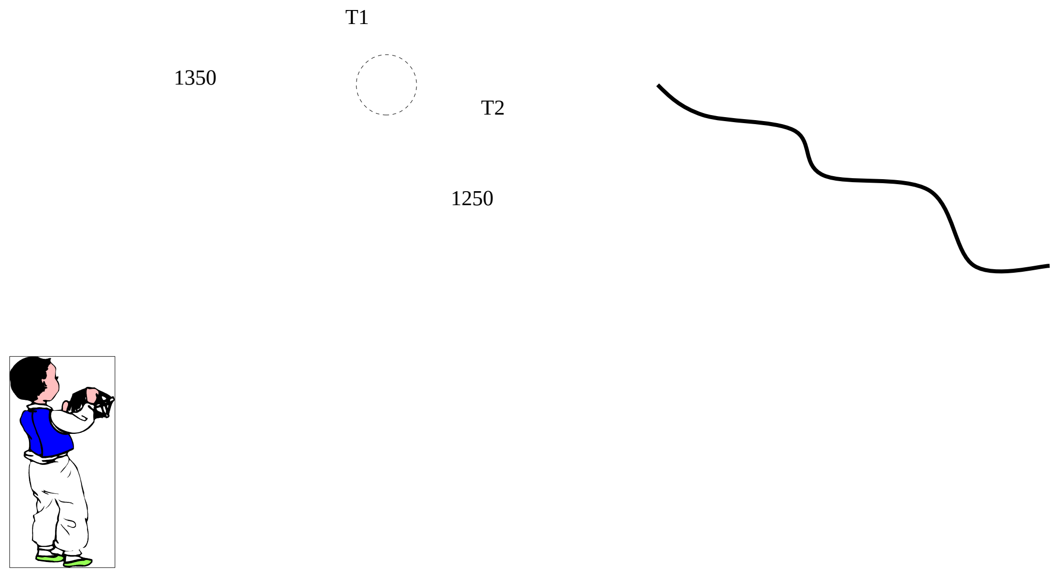
(2 marks)

- Chair B has the widest base of the 2
- There is more friction under Chair A than under C
  (A rotates about the ground)
  (C rotates about the centre of mass of the system)

Question 3

(3 marks)

A stationary child is flying a kite at the park. The string (------) is attached to the kite in a "V" shape.



The child maintains a constant pulling force on the string with a force of 100 N. The kite's position remains constant. Calculate the magnitude of the tension forces T_1 and T_2.

$$\frac{100}{\sin 100°} = \frac{T_1}{\sin 125°}$$

$$T_1 = \frac{100\, x \sin 125°}{\sin 100°}$$

T_1 = 83.2 N

$$\frac{100}{\sin 100°} = \frac{T_2}{\sin 135°}$$

$$T_2 = \frac{100\, x \sin 135°}{\sin 100°}$$

T_2 = 71.8 N

Question 4

(4 marks)

A flag is waving in the breeze. The tail of the flag takes 0.600 s to complete one cycle. When a photograph is taken of the 1.2 m long flag, it contains1.5 ripples along its length.

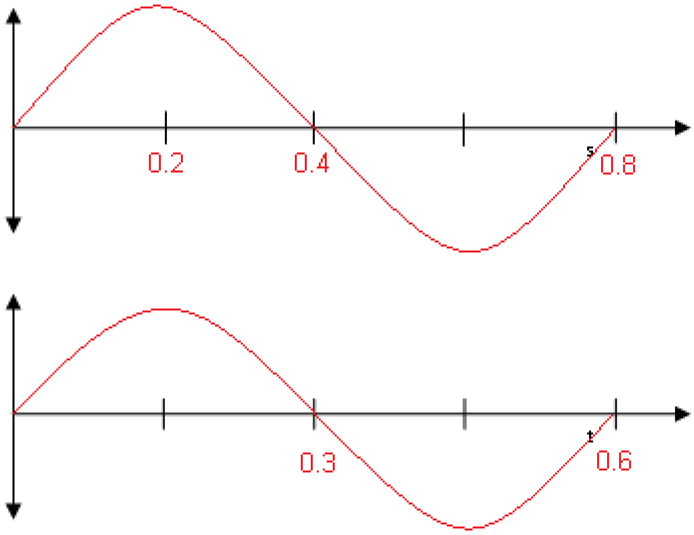
a) What is the frequency of the flags oscillation?

(1 mark)

f = $\frac{1}{T}$ = $\frac{1}{0.6}$ = 1.$\overline{6}$ Hz = $\frac{1.2}{1.5}$ = 0.8m

b) Sketch a displacement distance graph and a displacement time graph of the flag.

(2 marks)



c) What is the velocity of the wave in the flag?

(1 mark)

v = f x λ

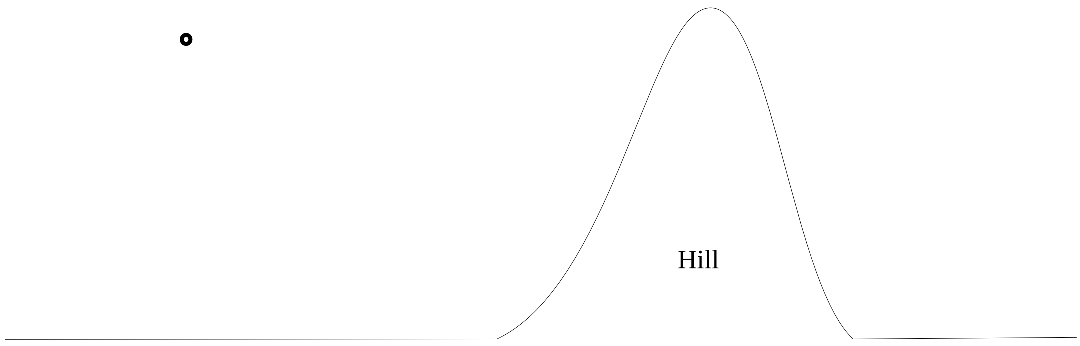
v =1.$\overline{6}$ x 0.8

v = 1.33 m/s

Question 5

(3 marks)

A radio and television signal is being broadcast from a large transmission aerial to the houses in the surrounding areas. Some of the houses are situated behind a 20 m high hill. A diagram of the situation is shown below:



The radio station frequency is 30 MHz and the television station frequency is 3000 MHz. Which signal (radio or television) will be received most clearly by the house on the far side of the hill? Explain why.

- The signal with the longest wavelength (radio wave) will be received most clearly.

- The longer the wavelength the better the wave diffracts around obstacles.

- $c = \lambda \times f$

$\frac{c}{f} = \lambda$

$f = 30 \times 10^6$ Hz

$\lambda = \frac{3 x 10^8}{30 x 10^6}$

$\lambda = 10$ m

$f = 3000 \times 10^6$ Hz

$\lambda = \frac{3 x 10^8}{30 x 10^9}$

$\lambda = 0.1$ m

Radio waves will be clearest

Question 6

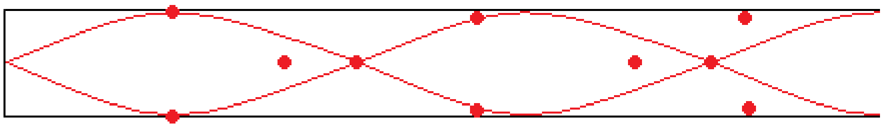
(4 marks)

A frequency of 900 Hz is directed into a closed pipe of length 67.3 cm causing it to resonate. If the speed of sound in air that day is 346 m s^{-1}, draw with the assistance of calculations the standing wave pattern created.

$f = \frac{nv}{4l}$

$900 = f = \frac{n\,x\,346}{4\,x\,0.673}$ $\qquad$ $\frac{900\,x\,4\,x\,0.673}{346} = n$

n = $\qquad$ n = 7



Question 7

(3 marks)

The sun sends out electromagnetic radiation in all directions. At the outer edge of the earth's atmosphere at a distance of 1 AU the intensity of the sun's radiation is 1.366 x 10^3 W m^{-2}. What is the intensity of the radiation measured at the surface of the sun?

r = 1AU

I = 1.366 x 103 Wm^{-2}

P = ?

I = $\frac{P}{A}$

P = I x A

P = 1.366 x 10^3 x 4π x (1.5 x 10^{11})^2

P = 1.366 x 10^3 x 1.885 x 10^{12}

P = 3.863 x 10^{26} W

P = I x A

I = $\frac{P}{A}$

I = $\frac{3.863 x 10^{26}}{4\pi ¿¿}$

I = 6.346 x 10^7 Wm^{-2}

Question 8

(4 marks)

Draw a flow chart classifying the different types of matter according to the standard model. The chart must contain sufficient information to explain the differences between the various types of matter and the forces between them.

ALL MATTER

MATTER with mass

BOSONS FORCE EXCHANGE

QUARKS

LEPTONS

HADRONS

BARYONS

MESONS

Question 9

(3 marks)

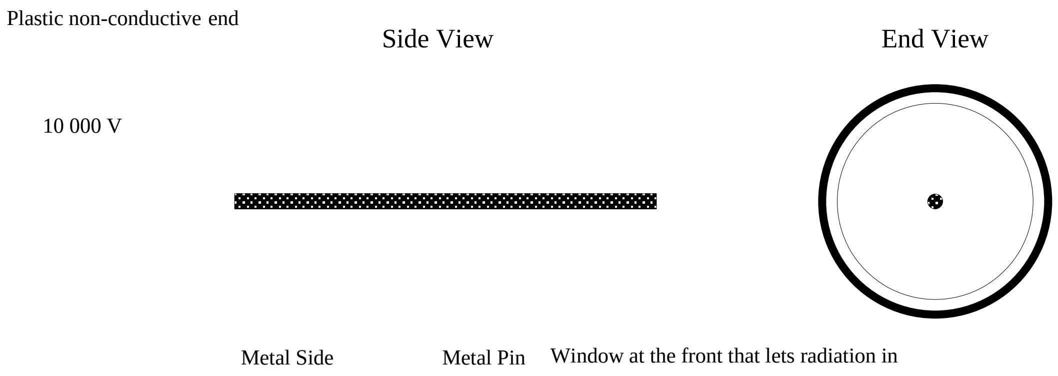
A stupendously strong Olympic javelin thrower throws a 2.4 m long 9.00 x 10^2 g javelin at a velocity of 3.00 x 10^7 m s^{-1}. Considering relativity, comment on how the density of the javelin will appear to a person moving with the javelin as compared to a person watching the javelin move away from them. The formula for density is mass / volume. No numerical calculations are necessary in your explanation.

Moving with	Watching leave
No change in mass volume or density.	Mass increases Length contracts therefore volume decreases. Density increases (more mass less vol) $\rho\uparrow = \dfrac{m\uparrow}{Vol\downarrow}$

Question 10

(5 marks)

A Geiger - Muller tube consists of a metal tube with a metal pin running down its centre.



In this particular model the central pin is positive and the metal tube is neutral. The potential difference between the tube and the pin is 500 V. The space between the side and the pin is filled with neon gas at 1 / 10th atmospheric pressure.

a) Draw the electric field existing inside the tube onto the end view diagram.

(1 mark)

b) Is the field uniform or non uniform?

(1 mark)

Uniform Non Uniform (Circle one only)

c) Explain your answer to b)

(1 mark)

Field lines are not parallel

d) When radiation enters the tube one of the Neon gas particles becomes ionised resulting in an electrical discharge. What type of spectrum will be produced by the neon gas as a result of the discharge? Explain your answer.

(2 marks)

Electrons removed from neon collide with other neon atoms resulting in excitation. When the electrons de excite (fall) photons are released. This produces a line emission spectrum.

Question 11

(4 marks)

a) State two possible medical reasons for deliberately exposing a patient to X rays.

(2 marks)

- To see factures / broken bones
- To treat cancer

b) The spectra from two different X ray tubes is compared. Both tubes use the same size voltage to accelerate the bombarding electrons. One of the tubes uses Molybdenum as a target and the other uses Tungsten. Explain one similarity between the two spectra and one difference. Use diagrams to assist your explanation.

(2 marks)

Similarity

Same shape to the Bremsstrahlung. Same minimum wavelength.

Difference

Different metals have different energy spacing between inner orbits.

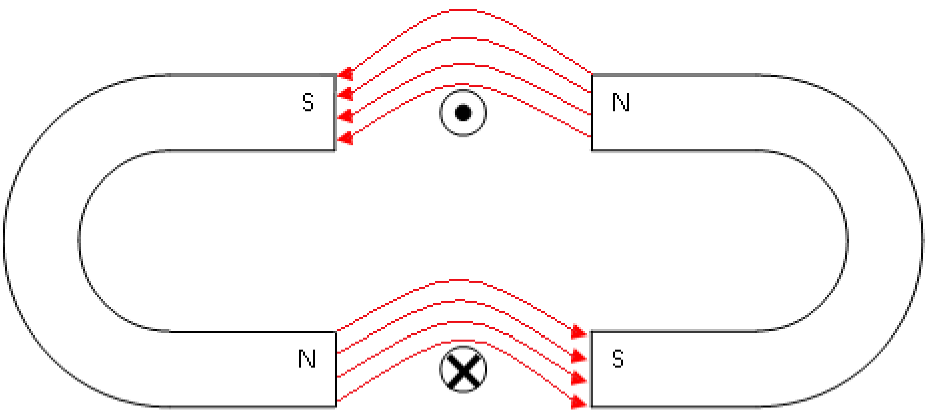
This results in peaks at different locations in the graph.

Question 12

(3 marks)

a) Draw the resultant magnetic field associated with the magnets and the wires onto the diagram below.

(2 marks)



b) If the wires are able to move in which direction will they move?

(1 mark)

Towards the bottom of the page

Question 13

(4 marks)

a) The peak voltage produced by a generator is 10 V. Calculate the root mean squared voltage.

(2 marks)

$V_{RMS} = \frac{10}{\sqrt{2}}$

$V_{RMS} = 7.07$ V

b) If the generator now turns at twice the speed and has a resistance of 10.0 Ω connected to it, calculate the peak power produced.

(2 marks)

$V_{peak} = 20$ V

$R = 10\ \Omega$

$I = ?$

$V = IR$

$20 = I_{peak} \times 10$

$I_{peak} = 2$A

$P_{peak} = V_{peak} \times I_{peak}$

$P_{peak} = 20 \times 2$

$P_{peak} = 40$ W

Question 14

(4 marks)

A car is travelling around a corner at 40 km h^{-1} ± 1 km h^{-1}. The car has a mass of 9.6×10^2 kg ± 2×10^1 kg and is turning through a radius of 15 m ± 1 m.

a) What is the velocity of the car and error in the velocity of the car in m s^{-1}?

(1 mark)

$$V = \frac{40}{3.6} \pm \frac{1}{36}$$

$$= 11.\bar{1} \pm 0.2\bar{7} \text{ m/s}$$

b) Convert the absolute errors in the numbers above into relative errors.

(1 mark)

Symbol	Number (SI units)	Absolute Error (SI units)	Relative Error (%)
v	11.1 m/s	0.27 m/s	2.5%
m	960 kg	20 kg	2.08%
r	15.0	1 m	6.67%

all or none

c) What is the relative error in the centripetal force?

(2 marks)

$$F_C = \frac{m v^2}{r}$$

F_C = (2.08%) + [(2.5) x 2] + 6.67%

F_C = 13.75%

Question 15

(4 marks)

What is the difference between reliability and validity? Support your answer with examples.

Reliability – of the data

Reliability is an aim to assess the repeatability of the results (data).
E.g. - If this experiment were conducted again would you expect to get a similar set of results?

This is regardless of whether the results have a clear pattern or not

This is regardless of whether the results are useful or not.

All that is required to satisfy the reliability requirement is that the experiment produces similar results ever time it is conducted. This means that there is at least a consistent amount of randomness (be it large or small) in the results. Thus, assuming the experiment is carried out the same way each time …

The correlation coefficient for each experiment should be consistent

and

The error bars for each averaged data point should be relatively consistent. (By repeated taking the same piece of data and forming an average the size of the error bars becomes more consistent)

Comparison of correlation coefficients and error bars between the experiments is a measure of reliability.

Validity – of the experiment / procedure

Was the experiment conducted in a sufficiently **controlled** way (control all of the other variables except the independent and dependant) so that the data and any pattern in the data is a **fair** representation of the relationship between the independent and dependant variables only. This is the concept of a fair test.

Other related concepts (not assessed in this question but just for your information).

If the experiment is conducted in a fair way (Valid) and the data is consistent from experiment to experiment (Reliable) then we can move to the third and final stage (Is your hypothesis supported or not?).

If reliability and validity conditions have not been met then there is no point comparing your hypothetical / theoretical mathematical pattern (hypothesis) with the pattern in the data because the data is not measuring the real pattern (validity - control issues) or not consistent enough (Reliability - inconsistent repeats) to make the comparison.

End of Section One

Section Two: Problem-solving 50% (90 Marks)

This section has **eight (8)** questions. You must answer **all** questions. Write your answers in the space provided.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
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Suggested working time for this section is 90 minutes.

Question 16

(11 marks)

In order to attract younger members to the golf club the old members have invented a new game using golf balls. A 50.0 g golf ball is put in a slingshot / catapult. The player stands at the start and fires the golf ball from the catapult towards the hole in the ground.

a) If the ball is projected with an initial velocity of 18.0 m s^{-1} at 20.0^{o} above the horizontal from a height of 0.700 m above the ground what will be the maximum height of the golf ball above the ground?

(3 marks)

v = u + at
$v^2 = u^2 + 2as$
s = ut + ½at^2

$v^2 = u^2 + 2as$
$0 = (18\text{Sin}20°)^2 + 2 \times -9.8 \times 5$

$$\frac{-(188 \sin 20°)^2}{2 x 9.8} = s$$

s = 1.93m
h = 1.93 + 0.7 = 2.63 m

b) What will be the kinetic energy of the golf ball as it hits the ground?

(2 marks)

½mu^2 + mgh = ½mv^2

½ x 0.05 x 18^2 + 0.05 x 9.8 x 0.7 = Ek

8.1 + 0.343 = Ek

Ek = 8.443 J

c) What is the final speed of the golf ball as it hits the ground?

(1 mark)

$8.443 = \frac{1}{2} \times 0.05 \times v^2$

$v = 18.4$ m/s

d) If the boy is standing 83.0 m for the hole, will the golf ball land directly in the hole?

(3 marks)

$v^2 = u^2 + 2as$
$v = u + at$
$s = ut + \frac{1}{2}at^2$
$v^2 = (18\sin 20°)^2 + 2 \times (-9.8) \times -0.7$
$v^2 = 51.62$
$v = -7.185$ m/s
$v = u + at$
$-7.185 = 18\sin 20 - 9.8\,t$
$\frac{-7.185 - 6.156}{-9.8} = t$
$t = 1.36$ s

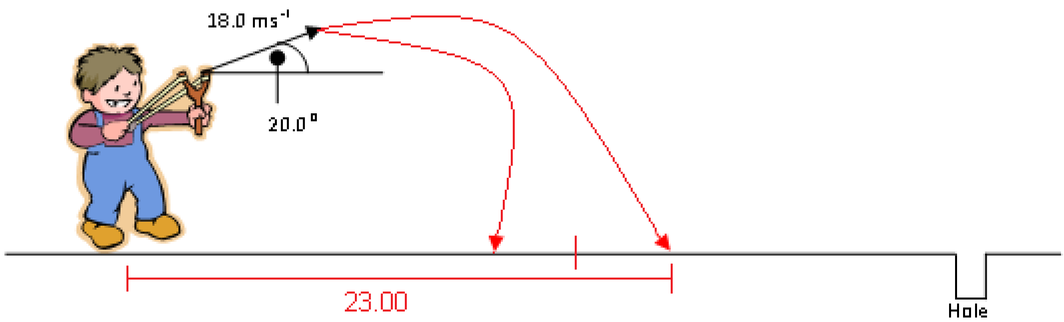
$n = \frac{s}{t}$

$18\cos 20 = \frac{s}{1.36}$

$16.9 \times 1.36 = s$
$s = 23.00$ m

e) If a wind now begins to blow towards the boy at 9.00 m s^{-1} before the ball is shot, draw the shape of the trajectory taken by the ball, as compared to the trajectory when no wind is present.

(1 mark)



f) Explain how the boy should change what he is doing with the sling shot to compensate for the wind and maximise range.

(1 mark)

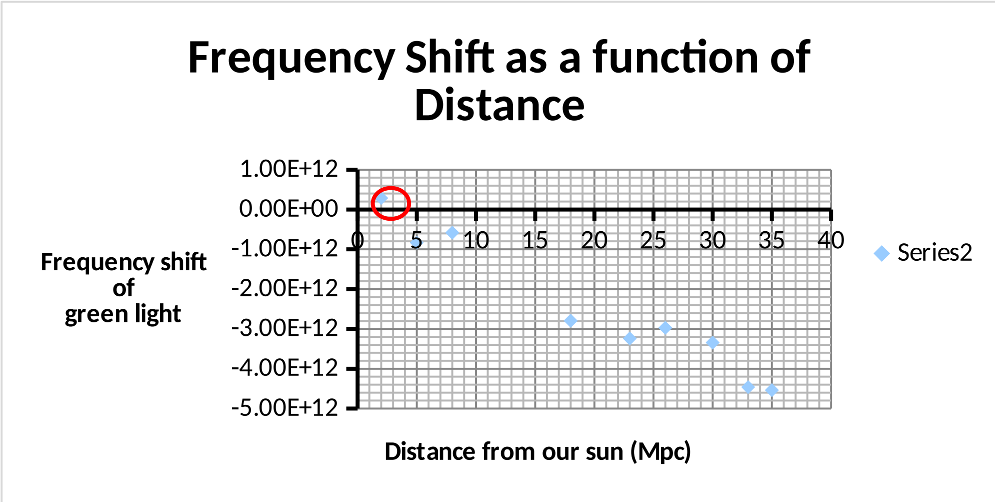
Increase initial velocity (pull the sing shot back more)
Lower angle to increase horizontal component
Shoot from up wind so you are with the wind (if this sis allowed)

Question 17

(12 marks)

Below is a graph of the amount of frequency shift experienced by originally green light of frequency 5.50 x 10^{14} Hz emitted from a range of stars at different distances from earth.

Distance from our sun (Mpc)	2	5	8	18	23	26	30	33	35
Shift in Frequency (Hz)	2.90E+11	-8.34E+11	-5.83E+11	-2.79E+12	-3.24E+12	-2.97E+12	-3.34E+12	-4.46E+12	-4.54E+12



a) Are the majority of the points on the graph showing red shift or blue shift? Explain citing evidence from the graph.

(2 marks)

Red shift
Frequency is generally lowered

b) How does this graph support Edwin Hubble's theory that the universe is expanding? Explain.

(1 mark)

When objects move away from you the light emitted by those objects is red shifted.
∴ moving away means expansion

c) One point on the graph does not support Hubble's theory of an expanding universe. Please circle it on the graph.

(1 mark)

d) Is the point circled in part c) an outlier? Explain why or why not.

(1 mark)

No, this is a point caused by an object moving towards earth, perhaps because of its orbit.

e) Calculate the slope of the line from the graph using a line of best fit.

(1 mark)

Slope = $\frac{-4\,x\,10^{Hz}}{+32}$

Slope = -1.25 x 10^{11} Hz/Mpc

f) Using the slope of the line you have calculated in part e) calculate the frequency shift for a celestial object that is 28 Mpc from us?

(2 marks)

f = -1.25 x 10^{11} s

f = -1.25 x 10^{11} x 28

f = -3.5 x 10^{12} Hz

g) What is the theoretical cause of the universe expanding? Explain.

(2 marks)

Big bang

As a result of the explosion the matter from which the universe is made was thrown outwards causing the explosion.

h) State 2 other pieces of evidence supporting the theoretical cause of the expanding universe as stated in part g) above.

(2 marks)

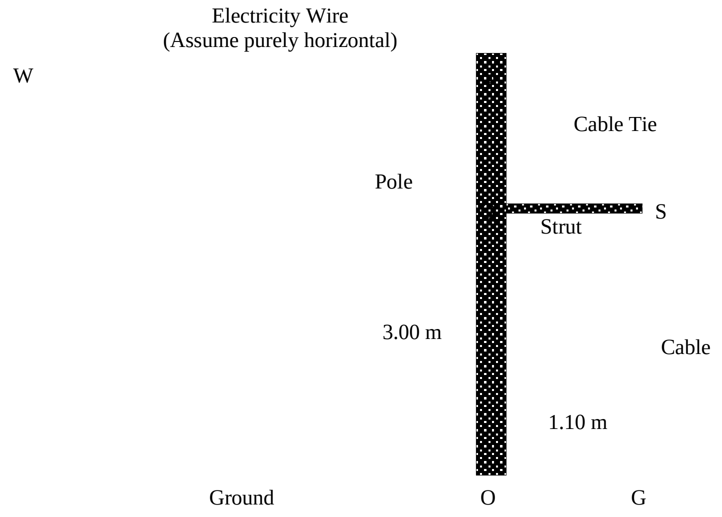
- Abundance of He in the universe is too large given the age of the universe (13.7 billion years)

- All pervasive microwave background radiation

Question 18

(12 marks)

The diagram below is of an electricity wire attached to a pole. The pole has been reinforced by a cable tie, strut and cable.



a) An electrical wire (WP) is under tension and is exerting a force on the electrical power pole (PO) and is attempting to topple it. To stop the pole from toppling the electrical power pole has been tied back to the ground using a cable (SG). If the tension measured in cable (SG) is 500 N what is the tension in the electrical wire (WP)? (Note - the strut is weightless)

(4 marks)

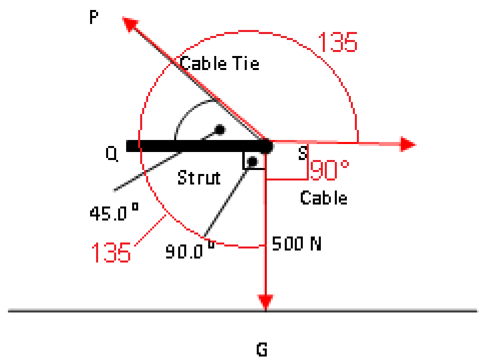
$$\sum M_C = \sum M_A$$

$1.10 \times 500 = 3.00 \times T_{WP}$

$$\frac{1.10 x\, 500}{3} = T_{WP} = 183.\bar{3}\ \text{N}$$

b) What are the forces in the cable tie and the strut given that cable (SG) has a tension of 500 N? A close up of the relevant section is provided below. (Assume the strut is weightless)

(3 marks)



$$\frac{F_{PS}}{\sin 90°} = \frac{500}{\sin 135°}$$

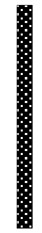
$F_{PS} = 707$ N

$$\frac{F_{QS}}{\sin 135°} = \frac{500}{\sin 135°}$$

$F_{QS} = 500$ N

c) In the table below state whether the following components are under tension, compression or both and draw the forces on each component.

(3 marks)

Component	Tension, Compression or Both	Draw forces on object
Cable tie (SP)	Tension	P S
Strut (SQ)	Compression	Q S
Pole (OP)	Both	P  O

d) If the tension in the electrical cable is kept constant and the length of the strut is increased. What will happen to the size of the tension required in the cable (SG) to keep the situation in equilibrium? Explain.

(2 marks)

The tension required is reduced

$M_A = M_C$

↑

Constant = r F

↓

Question 19

(9 marks)

Electromagnetic radiation (EMR) of frequency 2 x 10^{15} Hz is shone onto the surface of a sheet of potassium metal in outer space.

a) Which region of the electromagnetic spectrum does this EMR belong to?

(1 mark)

Ultra violet

b) This frequency of radiation causes electrons to be emitted from the surface of the metal with a velocity of 1.18 x 10^6 m s^{-1}. What is the ionisation energy of potassium in electron volts?

(3 marks)

$hf = I + \frac{1}{2} mv^2$

$6.63 \times 10^{-34} \times 2 \times 10^{15} = I + \frac{1}{2} \times 9.11 \times 10^{-31} \times (1.18 \times 10^6)^2$

$1.326 \times 10^{-18} = I + 6.34 \times 10^{-19}$

$I = 6.92 \times 10^{-19}$ J = 4.325 eV

c) What is longest wavelength of light that will just ionise potassium?

(2 marks)

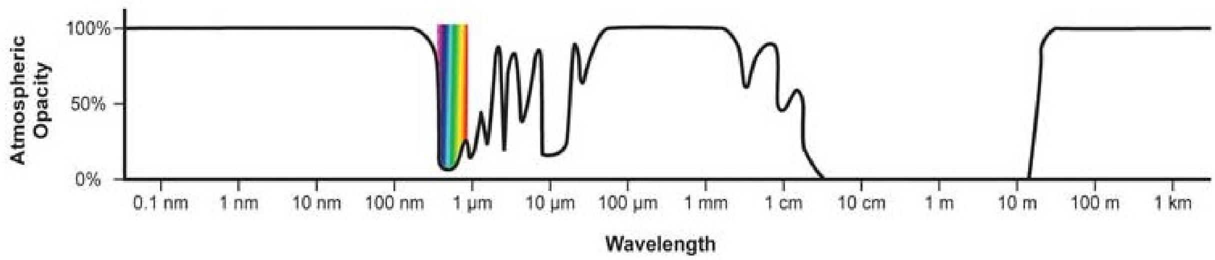
$hf = I + 0$

$6.63 \times 10^{-34} \times 3 \times 10^8 / \lambda = 6.92 \times 10^{-19}$

$\lambda = 2.88 \times 10^{-7}$ m (288 nm or 0.288 μm)

d) The sheet of potassium is now placed on the surface of the earth in a glass container filled with a noble gas. Assume that the glass of the container and the noble gas do not restrict the type of radiation that enters the glass. With the assistance of the diagram below, explain what range of wavelengths of EMR will be able to penetrate the earth's atmosphere and cause ionisation in the potassium?

(2 marks)



$\lambda = 2.88 \times 10^{-7}$ m (288 nm or 0.288 μm)

None

The atmosphere absorbs all of the light with sufficient energy to cause ionisation.

e) Why are metals with large work functions not used to manufacture photoelectric cells?

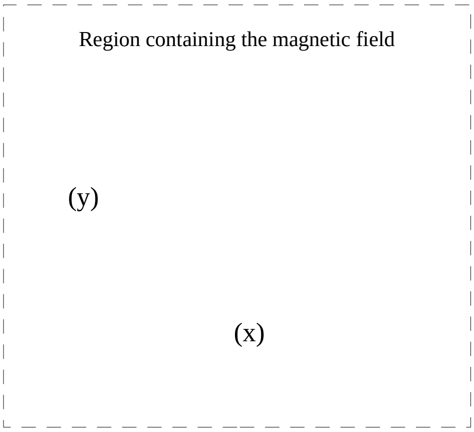
(1 mark)

There is insufficient energy in the light/atmospheric photons that fall on the surface of the metal to cause ionisation.

Question 20

(12 marks)

Two electrons x and y, both with speed 5.00 x 10^6 m s^{-1} are shot into a uniform magnetic field. The first (x) is shot from the origin out along the x axis. It bends out of the page with a radius of curvature equalling 8.00 cm. The second (y) is shot along the y axis. It travels in a straight line un-deviated.



a) Draw onto the diagram the direction of the magnetic field.

(1 mark)

b) Calculate the strength of the magnetic field.

(3 marks)

r = $\frac{mv}{qB}$

B = $\frac{mv}{qr}$

B = $\frac{9.11 x 10^{-31} x 5 x 10^{6}}{1.6 x 10^{-19} x 0.08}$

B = 3.56 x 10^{-4} T

c) Through what potential difference would the electrons have to be accelerated to achieve the above stated velocity?

(2 marks)

9V = ½ mv^2

V = ½ $x 9.11 x 10^{-31} x$ ¿¿

V = 71.2 V

d) In what direction would you direct a uniform **electric field** to stop the electron from bending in the magnetic field?

(1 mark)

Out of the page

e) Calculate what electric field strength is required to stop electron x bending?

(3 marks)

$9vB = 9E$

$5 \times 10^{6} \times 3.56 \times 10^{-4} = E$

$E = 1.78 \times 10^{3}\ NC^{-1}$

f) The electric field is now switched off leaving only the magnetic field switched on. Considering relativity, if electron x is now shot faster at a speed of 3.00×10^{7} m s^{-1} will the radius of curvature predicted by the equation you used in part b) still be perfectly obeyed? Explain.

(2 marks)

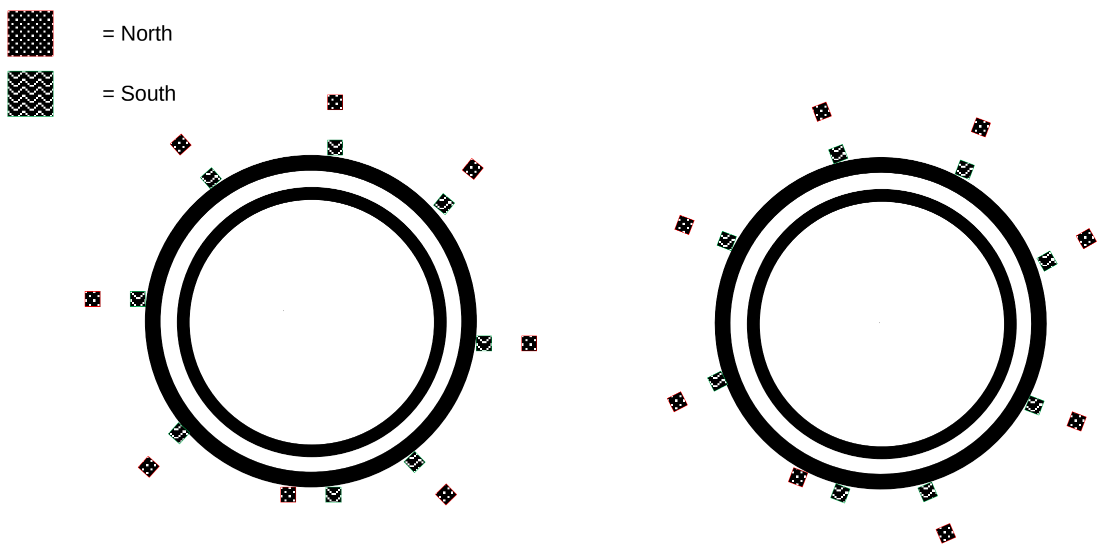
- No
- At higher speeds the mass of the electron increases due to relativistic effects, causing the radius of curvature to increase.

Question 21

(11 marks)

Below is a diagram a brushless alternator. The alternator consists of two rings of plastic, one inside the other. Horse shoe magnets are attached to the outer plastic ring. Soft iron U shapes are attached to the inner plastic ring. The inner plastic ring is held stationary. The outer ring is turned causing the magnetic field in the soft iron U shapes to periodically reverse direction.

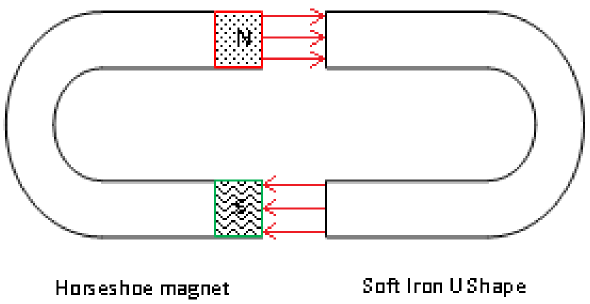
Diagram 1



a) Below is an enlarged diagram of a stationary horse shoe magnet in front of a stationary soft iron U shape. Draw the direction of the magnetic field created around the horse shoe magnet and the soft iron U shape.

(1 mark)

Diagram 2



b) The magnetic field strength emitted by the horse shoe magnet in part a) is 0.04 T. If the soft iron U shape has a cross sectional area of 2.00 cm by 2.00 cm, what is the magnetic flux in the soft iron U shape?

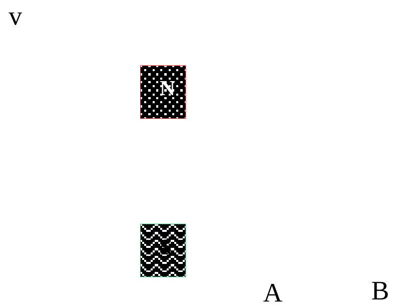
(2 marks)

Φ = BA
Φ = 0.04 x 0.02 x 0.02
Φ = 1.6 x 10^{-5} Wb

c) If each of the soft iron U shapes is wrapped with a solenoid as shown in Diagram 3, what type of current will be produced by the solenoids. Explain using relevant physics theories.

(3 marks)

Diagram 3



- AC
- Magnetic field changes direction periodically
- Faraday's Law – current induced as ΔB.
or
- Lenz's Law current induced in opposition to change in field

d) If the outer wheel in diagram 1 makes 4 complete revolutions in one second, calculate the time it takes for the magnetic field to reverse in each soft iron U shape.

(2 marks)

1 revolution = **0.25 s**

Time for field to reverse = $\frac{0.25}{8 x 2}$ = **0.015625 s**

e) Calculate the magnitude of voltage output from each solenoid if each solenoid has 50 turns.

(3 marks)

EMF = $\frac{nA(\Delta\Phi)}{\Delta t}$

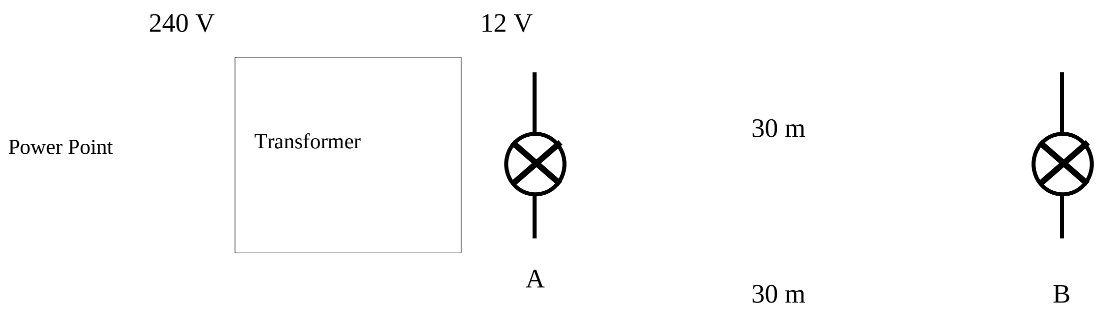
$$\text{EMF} = \frac{50\,x\,0.02\,x\,0.02\,x\left(-0.04-0.04\right)}{0.015625}$$

EMF = 0.1024 V

Question 22

(12 marks)

A home handy man has connected together a 12.0 Volt garden lighting system in his backyard at home. The system consists of a transformer that plugs into a 240 V power point and changes the voltage to 12.0 V. The 12.0 V is then connected to two light bulbs in parallel as shown in the diagram below. Each light bulb has a resistance of 10Ω. The 30 m wires do add additional resistance to the circuit.



a) If the current supplied to the transformer is 7.619×10^{-2} A. What is the power input to the transformer by the power point?

(2 marks)

P = VI
$P = 240 \times 7.619 \times 10^{-2}$
P = 18.3 W

b) If the transformer is 90% efficient, what is the power output of the transformer?

(2 marks)

$P_{out} = P_{in} \times 0.9$

$P_{out} = 18.2856 \times 0.9$

$P_{out} = 16.5$ W

c) What is the current output of the transformer?

(2 marks)

P = VI

16.45704 = 12 x I

I = 1.37 A

d) What is the power consumed by light bulb A?

(2 marks)

Method 1	Method 2
P = $\frac{V^2}{R}$ P = $\frac{12^2}{10}$ P = 14.4 W	$V_A = I_A R$ $12 = I_A \times 10$ $I_A = 1.2A$ P = VI $P_A = 12 \times 1.2$ $P_A =$ **14.4W**

e) What is the combined resistance of the two 30.0 m long wires?

(2 marks)

Power left for Bulb B and wires is 16.5 - 14.4 = 2.1 W

P = $\frac{V^2}{R}$

R = $\frac{V^2}{P}$

R = $\frac{12^2}{2.05704}$

$R_{\text{wires and bulb (series)}}$ = 70 Ω

$R_{\text{wires}} = R_{\text{wires and bulb}} - R_{\text{bulb}}$
$R_{\text{wires}} = 70 - 10$
R_{wires} = 60Ω

f) Which light bulb, A or B will be brighter? Explain why.

(2 marks)

A is brighter.

Resistance of wires to Bulb B reduces current and voltage applied to Bulb B and so reduced power supplied to Bulb B. Brightness is a function of power supplied.

Question 23

(11 marks)

A scientist is creating a formula to predict the intensity of a star based on a star's colour. The scientist finds a data table that converts star colour to temperature.

Temperature (K)	**Star Colour**
30 000	Blue
22 500	Blue – White
12 500	White
8 500	White - Yellow
6 000	Yellow
4 500	Orange
3 500	Red

He also finds a formula that converts star temperature to intensity which is …

$$I = \sigma T^4$$

a) Convert the colour provided in the table below to temperatures

(1 mark)

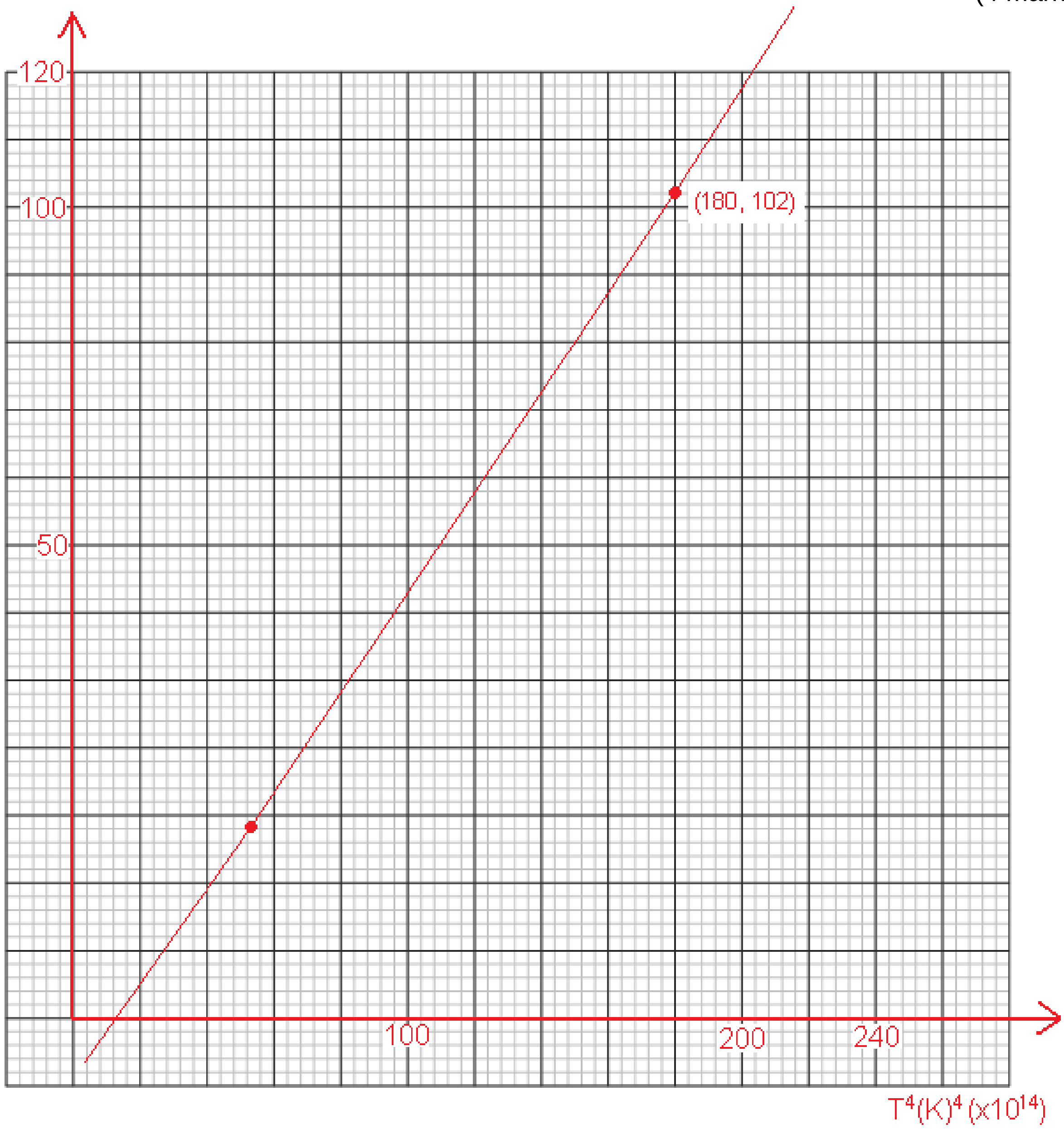
Variable	Units	1	2	3	4	5
Colour		White	White - yellow	Yellow	Orange	Red
Temperature	K	12500	8500	6000	4500	3500
Temperature^4	K^4	2.44×10^{16}	5.22×10^{15}	1.296×10^{15}	4.10×10^{14}	1.500×10^{14}
Intensity	W/m^2	1.38×10^9	2.96×10^8	7.35×10^7	2.33×10^7	8.51×10^6
I						

b) Manipulate one of the above variables in preparation for producing a straight line graph. Be sure to complete the variable and units column.

(2 marks)

c) Graph the straightened data on the graph paper below.

(4 marks)



Title, axis units, axis units, data points accurate, lines of best fit, axis scales even.

d) Calculate from the graph the value of the constant σ? Show all working leaving evidence on the graph.

(4 marks)

$$v = \frac{102 \, x \, 10^{7}}{180 \, x \, 10^{14}}$$

o = 5.6 x 10^{-8} Wm^{-2} K^{-4}

e) Use the formula of the line to calculate the intensity of a blue star.

(1 mark)

I = oT^4

I = 5.6 x 10^{-8} x 30000^4

I = 4.536 x 10^{10} Wm^{-2}

End of Section Two

Section Three: Comprehension 20% (36 Marks)

Question 24

(18 marks)

Gravitational Red Shift

Paragraph 1
Red shift is often explained as being similar to the Doppler Effect. An example of the Doppler Effect is the alteration in sound that occurs when a car passes. As the car approaches the observer the sound of the engine is higher than after the car has passed.

Paragraph 2
Cosmological Red shift and Blue shift occurs in a similar way. Instead of sound being emitted by a car moving towards or away from you however, it is light being emitted by a star as it moves towards or away from the earth. If the star is moving towards the earth all of the frequencies emitted will be slightly increased. This is called Blue shift. Conversely if the star is moving away from the earth all of the frequencies emitted will be slightly lowered. This is called Red shift.

The formula for cosmological red-shift is

$$f_L = \left(\sqrt{\frac{c-v}{c+v}} \right) f_S$$

Where

Symbol	Definition	Units
f_L	Frequency observed by the person on earth.	Hz
f_S	Frequency of the source	Hz
c	Speed of light in a vacuum (3×10^8 m s^{-1})	m s^{-1}
v	Speed of the object producing the electromagnetic radiation (light) v = away from earth → v = positive. v = towards the earth → v = negative.	m s^{-1}

Paragraph 3
Instead of considering blue and red shift purely as a frequency effect, a better understanding can be found by consider the energy of the situation. When photons are blue shifted they have a higher frequency. This means they have more energy. Red shift reduces the energy that a photon has. This can be considered analogous to kinetic energy.

Paragraph 4
Let's do 3 thought experiments …

i) A stationary person throws a 100g ball forwards at 10 m s^{-1}.
ii) A person riding a bike forwards at 5 m s^{-1} throws a 100g ball forwards at 10 m s^{-1}.
iii) A person riding a bike backwards at 5 m s^{-1} throws a 100g ball forwards at 10 m s^{-1}.

The velocities of the each ball are 10 m s^{-1}, 15 m s^{-1} and 5 m s^{-1} respectively.
The kinetic energies of each ball are 5 J, 11.25J and 1.25J respectively.

Paragraph 5
In the above thought experiment we see that the velocity of the bike effected the kinetic energy of the ball. When the movement of the bike was in the same direction as the ball the kinetic energy increased and when they were in opposite directions it decreased.

Paragraph 6
Light from a star is actually a stream of photons being thrown from the star out into space. Photons have different properties to a ball however and so the formula for calculating the energy of a photon will be different from the energy of a ball. Both of these energies (ball or photon) can be regarded as kinetic energies.

Paragraph 7
So to summarise the story so far we see that the kinetic energies of particles can be modified by the speed of the object that throws them.

Paragraph 8
Kinetic energies of objects can also be modified by gravity. When a ball is thrown up into the air, the kinetic energy of the ball drops as its speed decreases. The potential energy of the ball increases as the distance of separation between the centre of the earth and the centre of the ball increases.

Paragraph 9
It is not surprising to discover therefore that gravity can also alter the energy of a photon. Gravity cannot alter the speed at which light / photons travel. This speed is constant regardless of the situation. If we cannot alter speed we will have to alter another variable that is related to photon energy. We will alter frequency.

Paragraph 10
When photons are emitted by stars they have to escape the gravitational field of the star. This means that as the photon travels outwards it will lose “kinetic” energy and its frequency will be progressively red shifted. The stronger the gravitational field of the star, the more red shifted the photons produced by the star. This is called Gravitational Red Shift.

The formula for gravitational red shift is

$$f_L = f_S \left(1 - \frac{GM}{Rc^2}\right)$$

Where

Symbol	Definition	Units
f_L	Frequency of the photon observed by the person outside stars gravitational field.	Hz
f_S	Frequency of the photon observed in the stars gravitational field	Hz
c	Speed of light in a vacuum (3×10^8 m s^{-1})	m s^{-1}
G	The gravitational constant 6.67×10^{-11}	N m^2 kg^{-2}
M	Mass of the star.	kg
R	Distance from the centre of the star.	m

Paragraph 11
Let’s suppose the “kinetic” energy required to escape a particular star’s gravitational field is larger than the energy of the most energetic photon. Based on this logic the photon will not escape. In this situation the star will be called a black hole.

a) State two similarities and 2 differences between the gravitational red shift of a photon and the ionisation energy of an electron and atom.

(4 marks)

	Grav. Red Shift	Ionisation Energy
Similarities	Fields. Ionisation energy lost vs gravitational potential lost Min energy required to escape	
	Energy loss due to escape. Word done in escaping.	
Differences	Loss of Ek	Loss of f
	Virtual particle	Mass particle

b) Based on cosmological red shift what will be the frequency of an originally blue photon of wavelength 5000 Å that that has been emitted from an electric torch moving away from an astronaut in empty space at a speed of 20 000 km s^{-1}?

(3 marks)

$$f_L = \left(\sqrt{\frac{c-v}{c+v}}\right) f_S$$

$$F_S = \frac{3 x 10^8}{5000 x 10^{-10}}$$

$$f_L = \left(\sqrt{\frac{3 x 10^8 - 2 x 10^7}{3 x 10^8 + 2 x 10^7}}\right) 6 \times 10^{14}$$

$F_S = 6 \times 10^{14}$ Hz

$$f_L = \left(\sqrt{\frac{2.8 x 10^8}{3.2 x 10^8}}\right) 6 \times 10^{14}$$

$f_L = 5.61 \times 10^{14}$ Hz

c) To which part of the electromagnetic spectrum does the photon received by the astronaut belong?

(1 mark)

Visible (green) (4 to 7 rule)

d) The astronaut returns to earth and is looking through a telescope at the torch which is still flying away one hour later. Explain **two** ways in which the photons from the torch will now look different from your answer to part b).

(2 marks)

- Dimmer - further away
- On passing through the earth's atmosphere – twinkles
- Frequency acted on by earth's gravitational field. f_L slightly **increased**.

e) Using the gravitational red shift formula, state the new frequency of a 9.00×10^{15} Hz photon originating at the surface of our sun. The new frequency is received / measured in empty space outside the sun's gravitational field.

(4 marks)

$$f_L = f_S \left(1 - \frac{Gm}{Rc^2}\right)$$

$f_L = 9.00 \times 10^{15}$ ¿

$f_L = 9.00 \times 10^{15}$ Hz (unchanged when rounded to 3 sig fig)

f) Would Edwin Hubble need to take gravitational red shift into account in formulating his theory of an expanding universe? Explain why or why not.

(2 marks)

Yes – Light from big (large mass) stars is increasingly red shifted and so appears to be receding faster.

No – Unless light emitting object is very massive gravitational red shift is only slight.

g) A satellite orbiting the earth is set to receive signals at a frequency of 3.00×10^{6} Hz. Should the signal be sent from the transmitter at the surface of the earth at a frequency above, equal to or below 3×10^{6} Hz taking into account gravitational red shift? Do not calculate your answer.

(2 marks)

Above.
Photon will lose frequency as it leaves earth's gravitational field.

Question 25

(18 marks)

Electricity from the Ocean

Paragraph 1

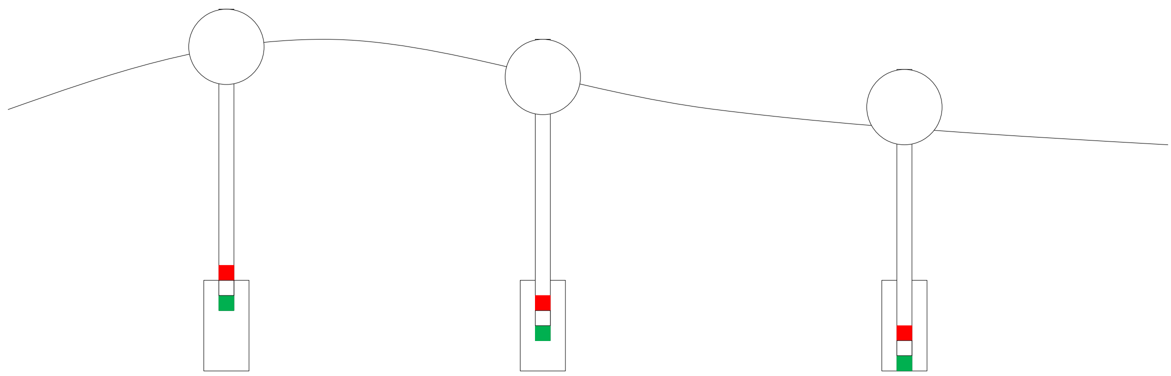
With the demand for electrical energy always on the increase, scientists are on the lookout for new ways of generating electricity.

Paragraph 2

The latest invention is a "wave rider electricity generator". The device consists of a permanent magnet attached to a rigid plastic pole with a large white foam float on top. As the waves pass under the float it rises lifting the magnet from the sea floor. The magnet is contained in a plastic pipe around which a coil of copper wire has been wrapped. The magnet moving past the wire generates electricity in the coil.

Diagram 1

3 wave rider electricity generators. Motion of the float is shown by the arrows.



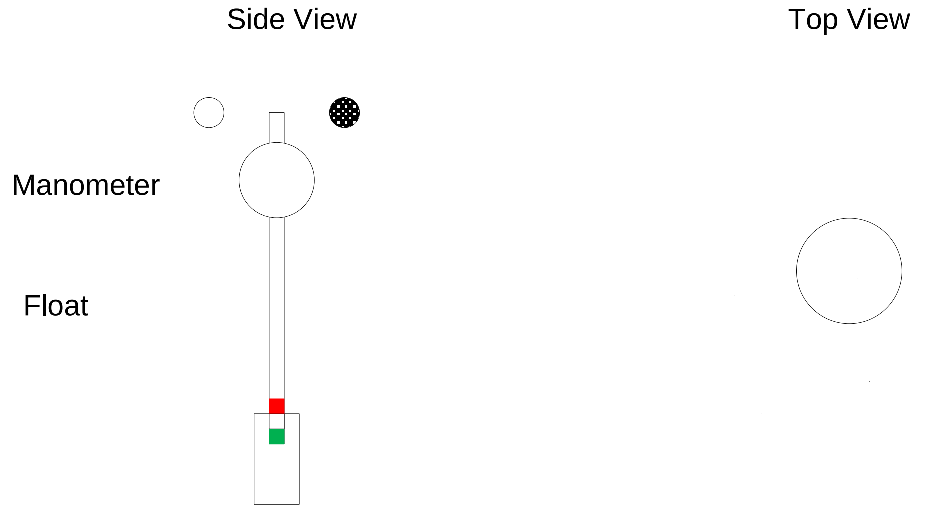
Paragraph 3

It was expected when the riders were first put into the ocean for testing that the buoys would ride lightly on the surface. Instead however it was observed that the motion of the buoys showed a delay in movement. For example …

- when a wave rose the float was substantially more submerged than normal.
- when a wave fell the float came clear of the water and descended slowly.

Consequently the amplitude executed by the wave rider was somewhat less than that of the ocean swell.

Paragraph 4
In the next prototype the scientists are going to attach a manometer (wind turbine) to the top of the floats in an attempt to get the float, pipe and vertical magnet to spin.



Physicists are predicting that this will produce little additional electrical energy.

Questions
a) How does the rise and fall of the waves generate electricity?

(2 marks)

ΔB induces EMF Faradays Law / Lenz's Law

b) Why does the buoy at the top of the wave rider refuse to follow identically the rise and fall of the waves?

(3 marks)

A force acts to oppose the motion that generates the electricity (Lenz's Law)

ΔB → I → B in opposite → delays movement

c) What will scientists discover about the motion of the wave riders if they try to wire together 2 or more of these devices in series? Why?

(2 marks)

Current supplied from one coil to the next will create a force alter the movement of the buoy.

d) If 3 waves past in 22 seconds on average and the amplitude of the rise and fall of the wave rider is 1 m, what will be the average voltage induced in a coil of 200 turns and area 30 cm^2. Assume that the magnet has a field of 0.65 T and one upward movement of the buoy changes the flux from zero to maximum to zero. State any assumptions.

(4 marks)

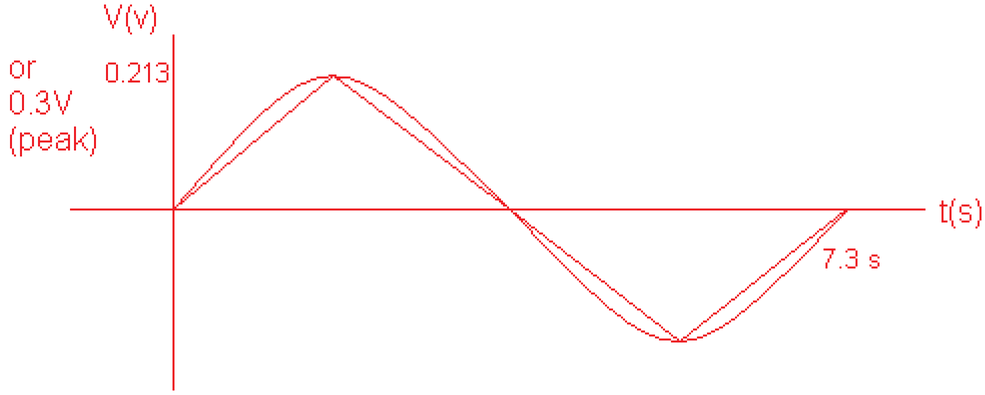
1 wave = $7.\overline{3}$ s = T

½T = $3.\overline{6}$ s   EMF = $\frac{-200\,x\,30\,x\,10^{-4}(-0.65-0.65)}{3.\overline{6}\,s}$

EMF = 0.213 V

e) Draw the voltage output of one wave rider buoy under the conditions mentioned in part d)

(3 marks)



f) Explain one advantage and one disadvantage to the environment of using wave rider electricity generators.

(2 marks)

Advantage	Disadvantage
Electricity generated by renewable source (No CO_2 emissions)	Clutters the ocean, ugly (offends aesthetics). Interferes with whale migration.

g) Why is the spinning of the magnet unlikely to produce any voltage? Explain.

(2 marks)

No ΔB or ΔA

∴

No ΔI

∴ no voltage

End of Exam