Willetton Senior High School

Semester 2 Examination, 2010

Question/Answer Booklet

PHYSICS 3A and 3B

Name: _____

Teacher: _____

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/tape, ruler, highlighters
Special items: non-programmable calculators satisfying the conditions set by the Curriculum Council for this course, drawing templates, drawing compass and a protractor

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

Structure of this paper

Section	Number of questions	Number of questions to be attempted	Marks available	Marks obtained
A: Short Answers	13	ALL	49	
B:Problem Solving	7	ALL	94	
C: Comprehension and Data Analysis	2	ALL	37	
			Total out of 180 marks	

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 A: Short Answers 49 marks out of total of 180 marks (27%)

Attempt **ALL** 13 questions in this section. The marks for each question are indicated in brackets. Answers are to be written in the space below or next to each question.

1. a) Explain the conditions under which **sound beats** are produced.

_____

_____

_____

_____

_____

[2 marks]

b) Whilst tuning up, a member of an orchestra noticed that she can hear a note pulsating at a rate of 6 beats per second. Below is a list of frequencies produced by various instruments in the orchestra.

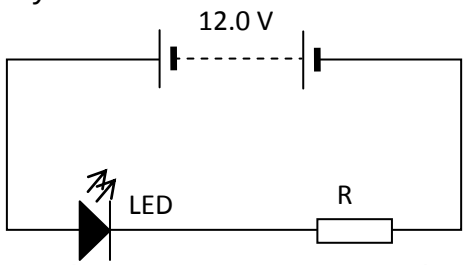
Oboe: 476 Hz Violin: 480 Hz Cello: 244 Hz Flute: 312 Hz Saxophone: 250 Hz.

Which two instruments are producing the beats?

_____

[1 mark]

2. A light-emitting diode (LED) can run at a safe voltage of 2.0 V and yet it can be connected effectively into a 12 volt circuit if a series resistor is used.



The circuit above shows an LED connected correctly into a 12 volt circuit. If the LED must not carry a current exceeding 10.0 mA, calculate the value of the resistor R to be used.

[4 marks]

3. Jacob is freewheeling his mountain bike down a hillside track composed of gravel and sand. The bike remains stable when Jacob is going in a straight line but when he reaches a curved section of the track his wheels slide away and he crashes.

   Explain why Jacob is more likely to crash when going into a curved section of the track.

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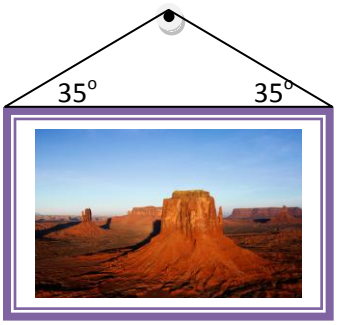
   [3 marks]

4. A picture of mass 4.20 kg is hung from a nail in the wall by a wire, as shown in Figure 1. If the wire makes an angle of 35^{o} to the picture, calculate the tension in the wire. Draw a diagram.



   [3+1 marks]

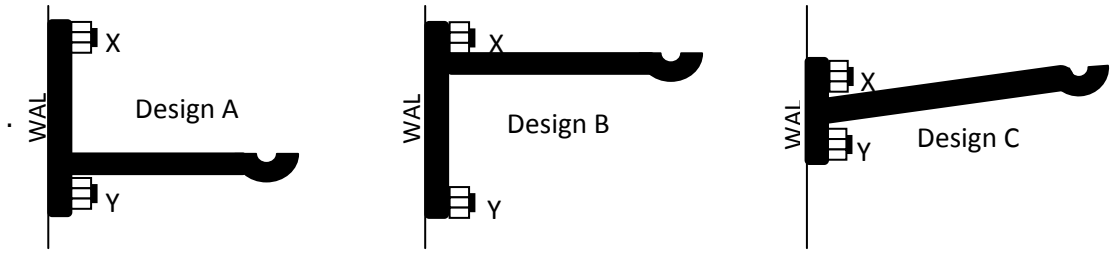
5. A golf ball and a table-tennis ball with the same diameter are both dropped from the Leaning Tower of Pisa. The golf ball has a mass of 100 g and the table-tennis ball has a mass of 5.0 g.

   Neglecting air resistance complete the table below to indicate which of the statements below are correct. Place a tick or a cross in each box to indicate your choice.

		Tick / Cross
A	Both balls will have the same downward force on them at all times	
B	Both balls will have the same acceleration when they are dropped	
C	Both balls will have the same acceleration as they hit the ground	
D	Both balls will hit the ground at the same time	

[2 marks]

6. A company has produced three designs for coat hangers, shown below, each held to the wall with two bolts, X and Y. The hangers are all of the same length.



a) Which bolt, X or Y, is moist likely to be pulled out when a heavy coat is on the hanger? _____

b) In which design A, B or C, is the most force exerted on bolt X? _____

c) Explain your answer to part b) above.

_____

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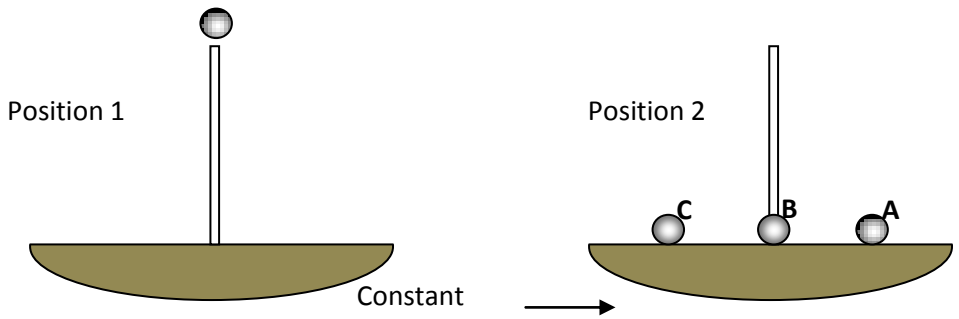
[1+1+4 marks]

7. The Hubble constant can be expressed as 71 km s^{-1} Mpc^{-1}, 1 Mpc = 3.086 x 10^{19} km.
If a star is 3 x 10^{20} m away from the Earth, predict how fast this planet is moving away from it. using, $v = H_o d$.

[3 marks]

8. Galileo set up a "thought" experiment where a ship was moving to the right with a constant velocity and a sailor, who was sitting at the top of the mast, dropped a cannon ball. He asked the question as to where this cannon ball would land as it hit the deck.



a) Circle the point where you think the ball will land : A B C
[1 mark]

b) Explain your choice of answer to part a).

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[3 marks]

9. By the year 1964 there had been over 100 sub-atomic particles discovered – so many that physicists of the time referred to the list as a “particle zoo”. Later that year Zweig and Gell-Mann suggested a simpler model, where less particles were required to describe the make-up of atoms.

a) Name this model and explain how it simplified our understanding of matter

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[2 marks]

b) Explain the role of **gluons** in the Zweig/Gell-Mann model.

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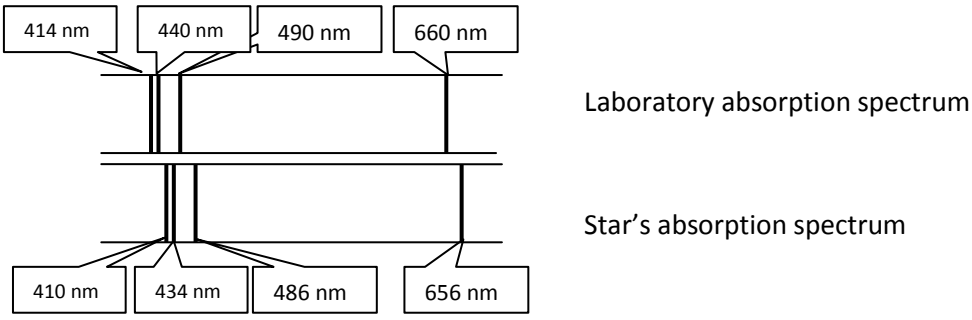
[2 marks]

10. Scientists compared the spectrum of light absorbed by hydrogen in the laboratory with the spectrum of hydrogen absorbed by the atmosphere of a distant star. They noticed that the pattern of spacing between the lines was the same, but the wavelengths of the absorption lines were in a slightly different place, as shown below.



a) Name this phenomenon observed with stars where the wavelength of spectral lines changes

_____

[1 mark]

b) Explain how this observed effect comes about.

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[3 marks]

c) What data can be obtained from the change in wavelength of light emitted from stars?

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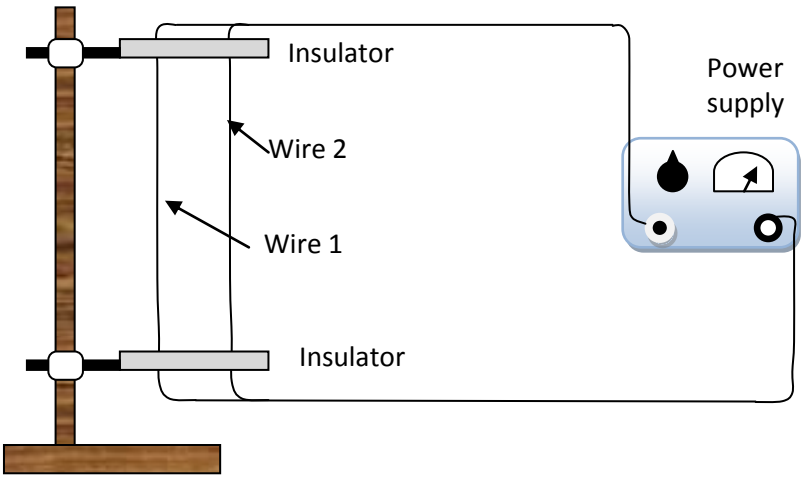
[1 mark]

11a).



Two straight wires are suspended vertically from a stand, each held by a strip insulator, as shown in the diagram above. Which of the statements below concerning the force between the wires is true? Circle the correct answer.

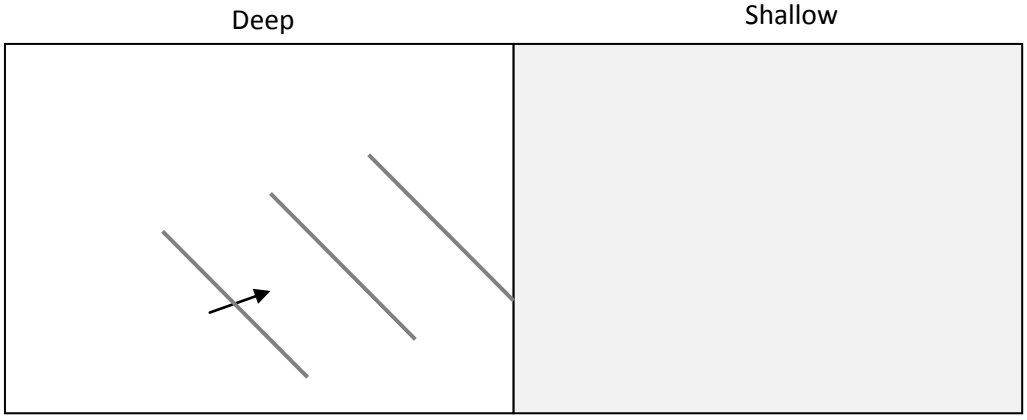
[1 mark]

A. There will be a magnetic force of attraction between the two wires
B. There will be a magnetic force of repulsion between the two wires
C. The force between the wires cannot be determined without knowing the direction of current
D. There will be no magnetic force between the two wires

b) The diagram below represents the current flow in the wires in a different experiment, as seen from above.

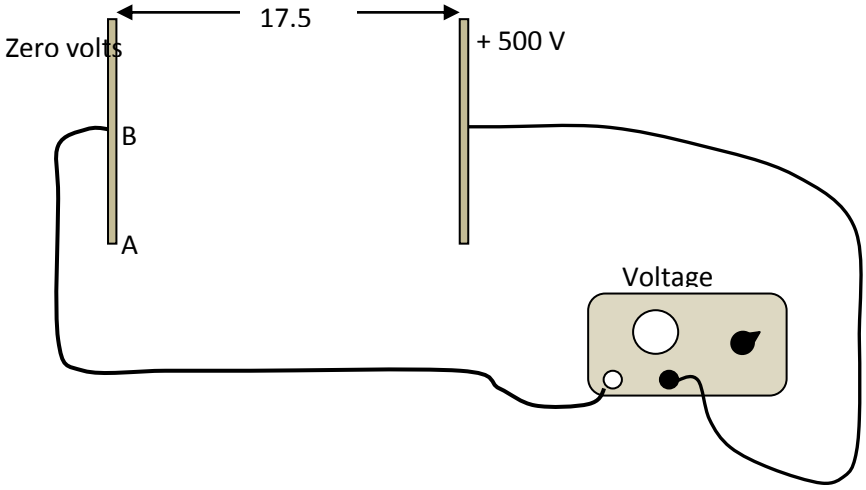
Draw in the shape of the resultant magnetic field around the wires. [3 marks]

12. Water waves move slower in shallower water than in deep water, which is that cause of surf breakers in Western Australia. Complete the diagram below to show the accurate shape and pattern of waves coming into shore at an angle as they move from the deep to the shallower water near the beach. Draw in 4 more wavefronts on the diagram below as they move through the shallow water.



[3 marks]

13.



In an experiment two metal plates are attached to a 500 V power supply to produce an electric field, E between the plates.

a) Calculate a value for E when the plates are placed 17.5 cm apart. [2 marks]

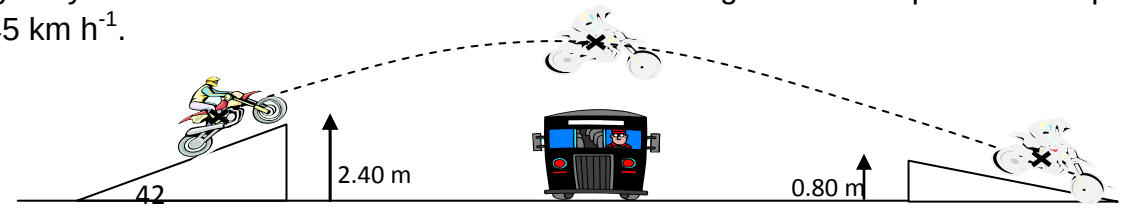
b) Two electrons are released at points A and B on the left hand plate which are attracted towards the right hand plate. Draw in on the diagram the paths of each of these electrons as they move from left to right. [2 marks]

Section B Problem-Solving 94 marks out of 180 (51%)

Attempt **ALL** 7 questions in this section.

1. (12 marks)

Plucky McGinty likes to jump over buses on his trail bike. In an exhibition one day he drives his motorcycle up a ramp, over a bus and lands safely on the ramp at the other side. The left hand ramp has an incline of 42^{o} and when he takes off, the centre of gravity of him and his machine is 2.4 m above the ground. His speed at this point is 45 km h^{-1}.



a) How fast is the height of his machine above the ground increasing in a vertical direction when he takes off?

[2 marks]

b) What is the maximum height reached by Plucky and his bike (centre of gravity) above the ground?

[3 marks]

The motorcyclist and his machine lands on another ramp at the other side of the bus, at which point the centre of mass of the combination is 0.80 m above the ground.

c) What is the vertical speed of the motorcycle when Plucky lands?

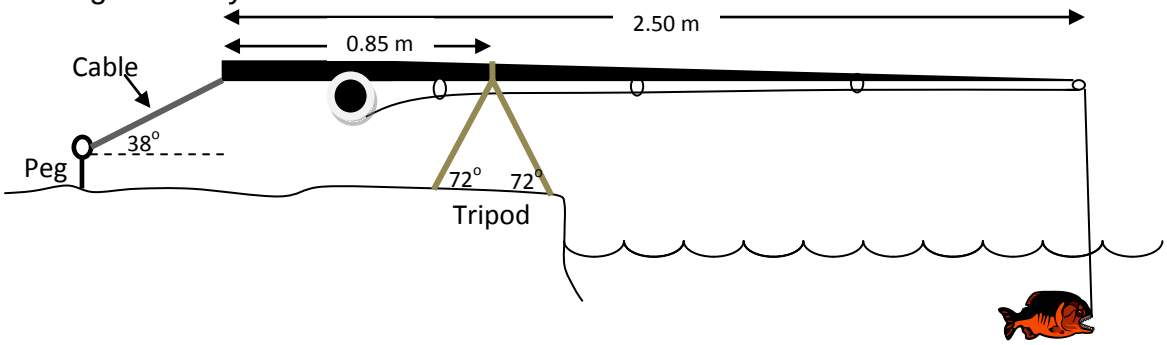
[3 marks]

d) Calculate how far away horizontally the motorcycle is from its take-off position when it lands.

[4 marks]

2. (14 marks)

Ged decides to go fishing one day with his new rod and tripod. He sits on the banks of the Swan river and sets the 900 gram rod up with the tripod close to the bank and a cable at the left hand end anchored into the ground with a tent peg. The centre of mass of the rod is 1.00 m from the left hand end of the rod. He has not caught a fish yet!



a) Explain why Ged needs to secure the end of the rod with a peg and cable.

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[2 marks]

b) Name all the forces acting on the rod, using arrows to show their directions.

[3 marks]

Ged eventually manages to hook a 1.50 kg fish on the end of his line.

c) Calculate the **downwards** force that cable has to exert to keep the rod in a horizontal position.

[3 marks]

d) If the cable makes an angle of 38^{o} to the ground, calculate the total force needed in the cable when the fish is caught. If you need to use the answer from 2c) and were unable to calculate it, use a value of 35 N.

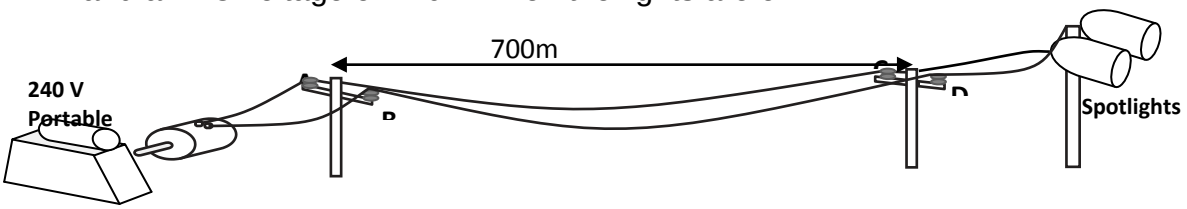
[2 marks]

e) If the legs of the tripod make an angle of 72^{o} to the ground, calculate the compressive force in each leg of the tripod when the fish is on the end of the line.

[4 marks]

3. (12 marks)

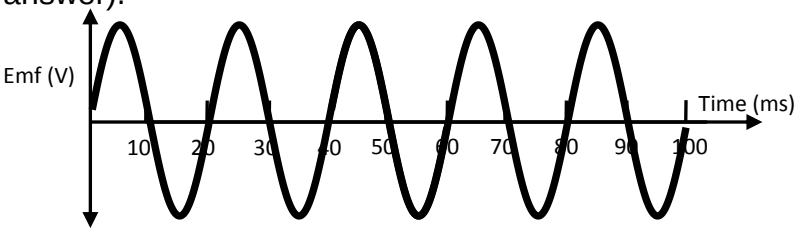
A portable AC generator is hired by a country cricket team to power the spotlights needed for a night game. The cable linking the generator to the lights has to cover a length of 700 m and a **total resistance** of 7.50 Ω. The generator produces an electrical power of 2.40 kW at a frequency of 50.0 Hz and an AC voltage of 240 V when the lights are on.



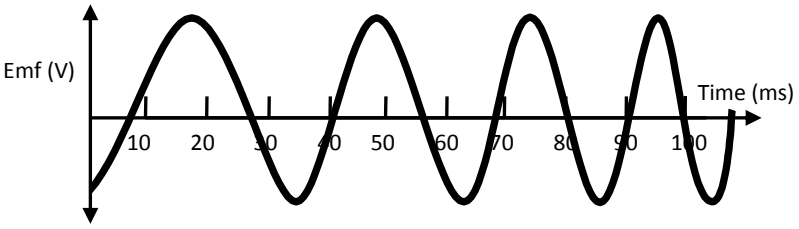
When testing the system a voltmeter is connected across points A and B and the generator started up.

a) (i) Which of the graphs below would display the voltage across points A and B as the generator starting up and reaching full speed? (Circle the correct answer).

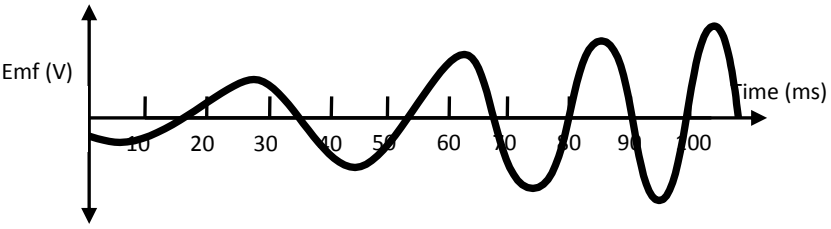
A.



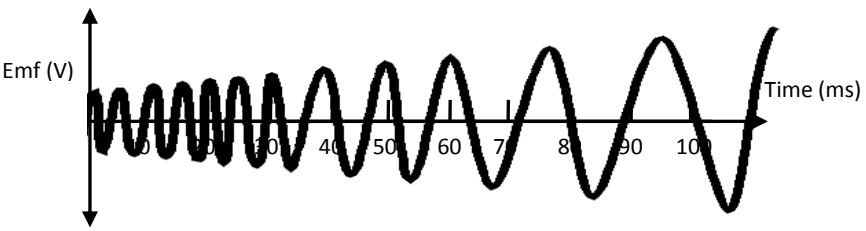
B.



C.



D.



[1 mark]

(ii) Explain your answer to 3(a)(i). [2 marks]

_____

_____

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_____

b) When the technicians test the voltage in the powerlines across points C and D they find that the voltage is no longer 240 V. Calculate the voltage delivered to the spotlights at CD.

[4 marks]

c) What is the power loss in the wires?

[2 marks]

When the lights are turned on they appear much dimmer than they should be and the technicians realise that there is a design fault in the system. They remedy this by installing transformers at points AB and CD in the cables.

d) Explain how this modification produces brighter lights at the cricket ground.

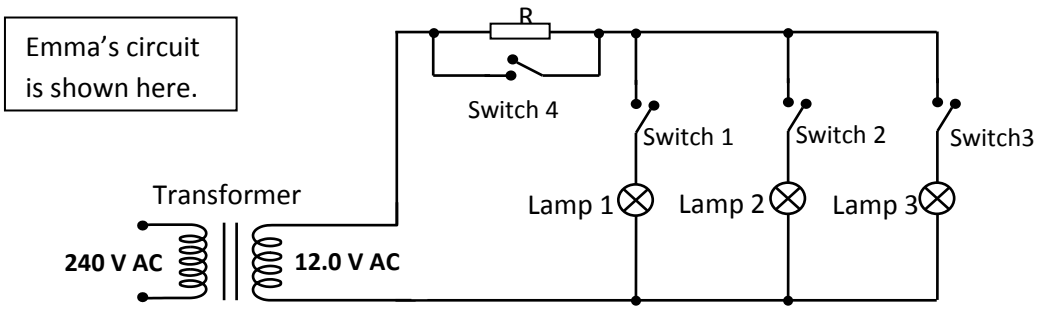
[3 marks]

4. (14 marks)

Emma has just made a model doll's house for her brother and has designed a lighting system for the 3 rooms with facility for dimming the lights and for turning each one on separately.

a) Explain why Emma should use a parallel circuit for the lighting system, instead of a series circuit.

[1 mark]



b) Explain how switch 4 and the resistor are able to produce a dimming effect on the three lamps when all three lamps are switched on.

[3 marks]

c) Each of the lamps is manufactured to run on 12.0 volts and uses a power of 4.80 W. Calculate the current supplied by the secondary coil of the transformer when all 3 lamps are on and **not dimmed**.

[3 marks]

d) Assuming that the transformer is 90% efficient, calculate the input current required to the primary coil of the transformer when all three lamps are connected into the circuit at full brightness.

[3 marks]

e) The value of R has been chosen so that when it is connected into the circuit, with all three lamps included in the circuit, only **half** the normal current runs through them. Calculate a value for the resistor R.

[4 marks]

5.(15 marks)

A 200 kg GPS satellite orbits the Earth at a height of 19,300 km above its surface.

a) Calculate the Earth's gravitational force on the satellite in its orbit.

[3 marks]

b) Show that this satellite orbits the Earth at a rate of about twice per 1 Earth day.

[4 marks]

a) Explain why the height of GPS satellites remains the same and yet they are said to be 'Falling towards the Earth".

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[3 marks]

b) A digital signal is sent from the satellite to the GPS receiver in a car on Earth and is received back again after a time delay of 233 ms. What is the distance of the car from the satellite?

[2 marks]

The planet Syzygy has been discovered in another galaxy which could possibly have conditions to support life if its gravitational field strength is large enough to attract and hold molecules of oxygen, which is estimated to be > 5.6 N kg^{-1}.

c) If the radius of the planet is 0.85 times Earth's radius and its mass is 0.34 times Earth's mass, calculate a value for 'g' on the surface of Syzygy and state whether it is likely to be able to support life.

[3 marks]

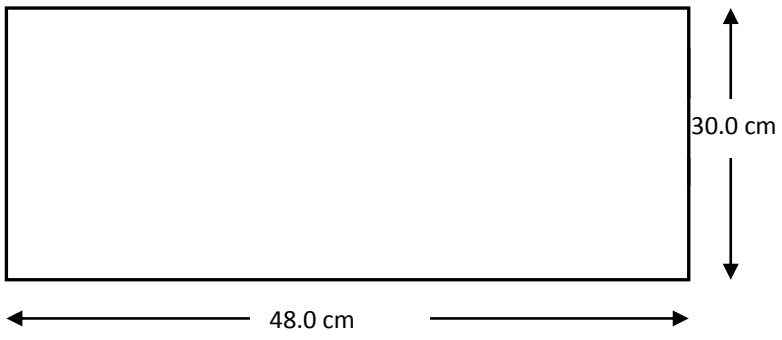
6.(15 marks)

A domestic microwave oven is rated at 500 W and uses a frequency of 2500 MHz.

a) How many microwave photons would be produced in the 50 seconds it takes to heat a mug of coffee in the oven?

[3 marks]

b) The microwaves emitted inside a microwave oven can form standing waves as they are reflected off the metal walls. The distance between the left and right hand walls of the microwave is 48.0 cm and the distance from the top to the bottom is 30.0 cm. Calculate the wavelength of the microwaves and use the result to draw the shape to illustrate the standing wave existing inside the oven in the diagram below.



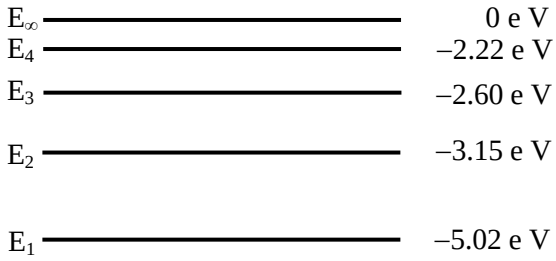
[2 marks]

When a solution of calcium chloride is sprayed into a Bunsen burner flame, a red colour is produced (due to the calcium atoms). With a solution of copper chloride a green colour is produced (due to the copper atoms).

c) Explain why calcium and copper produce different coloured flames.

[3 marks]

The diagram shows the energy levels for an element X. E_1 is the lowest energy state that an electron can have.



d) Explain why gaseous elements in a flame only give out a series of coloured lines in their spectrum and not a complete spread of colours of the rainbow.

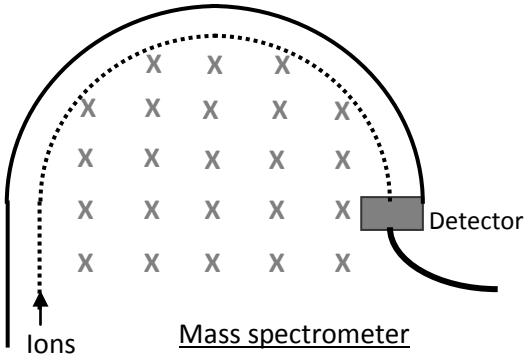
[3 marks]

e) Calculate the wavelength of the spectral line produced when a transition occurs between energy levels E_3 and E_2.

[4 marks]

7.(12 marks)

In an experimental Australian physics laboratory a mass spectrometer is being used to identify different elements from a forensic experiment. The specimens are first vaporised and ionised, then these ions are accelerated to a common velocity of 2.00×10^5 m s^{-1}. These singly-charged ions are injected into the magnetic field in the chamber so that the ion beam falls a certain distance away on the detector.



a) If the magnetic field in the chamber extends downwards into the page, state the sign on the particles reaching the detector (circle the answer below).

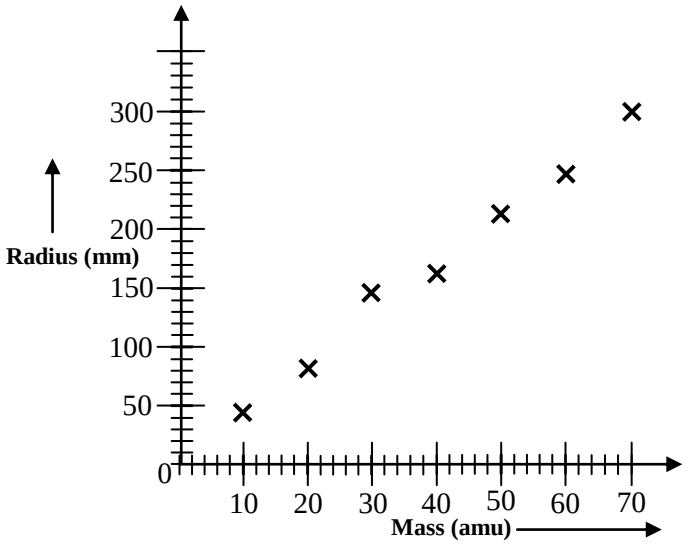
Negative **Neutral** **Positive**

[1 mark]

b) Derive the expression $r = \frac{mv}{Bq}$ linking the radius of the ionic path with the mass of the ion and use it to explain why ions with a particular mass-to-charge ratio must move in a circle with one value of radius.

[2 marks]

A graph is shown below of the radius of the curve against the mass of each ion. The masses are plotted in atomic mass units (amu). 1 amu = 1.67 x 10^{-27} kg.



b) It was suggested by a researcher that one of the results had an error in it. Circle the result that you think is in error and draw a line of best through the rest of the points.

[2 marks]

c) Calculate a value for the gradient of the graph and use this to estimate a value for the magnetic flux density in the chamber.

[4 marks]

d) Mention one change that has to be made if the particle is of the opposite sign to your answer in 7a) above. Explain your answer with a diagram.

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[3 marks]

Section C **Comprehension and data analysis** 36 marks out of 180 (20%)

Question 1 (18 marks) **The Australian Synchrotron**

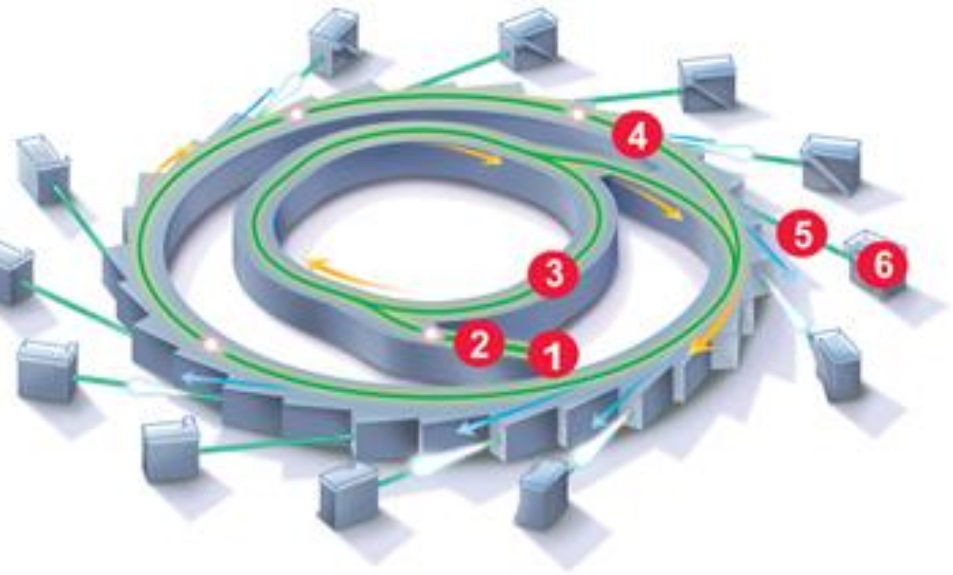

Figure 1

1. **electron gun**
2. linac
3. booster ring
4. storage ring
5. beamline
6. end station

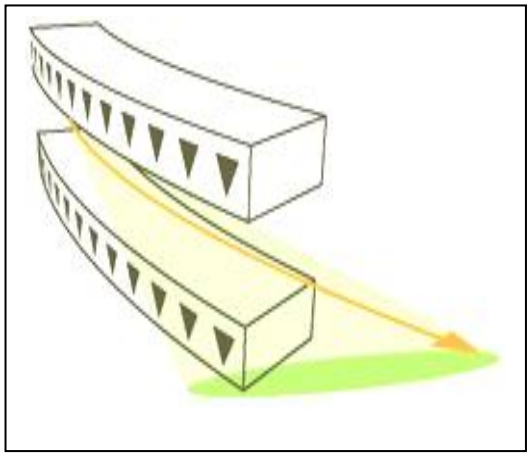

Figure 2

Illustration of a bending magnet. At each deflection of the electron path a beam of light is produced. The effect is similar to the sweeping of a search light.

Synchrotron light is the electromagnetic radiation emitted when electrons, moving at velocities close to the speed of light, are forced to change direction under the action of a magnetic field. The electromagnetic radiation is emitted in a narrow cone in the forward direction, at a tangent to the electron's orbit.

Synchrotron light is unique in its intensity and brilliance and it can be generated across the range of the electromagnetic spectrum: from infrared to x-rays.

Beamline specifications:
Source: 1.9 tesla wiggler magnet
Available energy range 4->50 keV in 16 m diameter storage ring
Beam size at sample (horizontal x vertical) is 0.5 mm (h) x 0.2 mm (v)
Photon flux at sample > 5×10^{12} photons / second

Features

• phase-contrast and analyser based x-ray imaging, which allows much greater contrast from weakly absorbing materials such as soft tissue than is possible using conventional methods
• two and three-dimensional imaging at high resolution
• lower tissue doses than conventional x-ray methods, making longitudinal studies (serial imaging) possible
• tuneable beam energy, which enables the imaging of specific elements with very high sensitivity

Examples

• Studies of lung function and development are assisting the development of better asthma treatments and improved clinical practice options for neonatal care
• Measurements of bone density and porosity, enhanced mammography techniques, and studies of nerve cell regrowth to assist the development of biopolymers to treat spinal injuries
• The contrast mechanisms used to visualise soft tissues can also be used to study structures inside plants, and are of particular interest for investigating drought- and salt-tolerant plants to develop more efficient crops for Australian conditions

The observation that normal tissue has remarkable resistance to cell death when irradiated with very thin X-ray beams has led to the development of microbeam radiation therapy (MRT). Dr Peter Rogers and colleagues from the Monash Medical Centre and Monash Centre for Synchrotron Science have found that normal tissue tolerates doses up to 100 times greater than those permitted in treatments using conventional methods, and that entire tumours are destroyed when only 10 per cent of their volume has been irradiated. These beams can be captured and focussed to a specific wavelength appropriate for a particular technique.

Questions.

a) Draw in the direction of the magnetic field in Figure 2 on page 25. [2 marks]

b) Assuming that the electrons are accelerated to close to the speed of light, show that this would take them about 1.4 million times around outer storage ring in one second. However, in the *frame of reference* of an electron in the ring, it would appear that they had travelled round many more times than this in the same time. Explain this in terms of Einstein's Special Theory of relativity. (No calculations are required)

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[3 marks]

c) Why is synchrotron radiation preferable to normal x- or γ-ray therapy in the treatment of cancers?

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[2 marks]

d) One of the features of synchrotron radiation is that the site of specific elements can be accurately located within the body.

Give an example where this ability could be valuable for use in Forensic Science.

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[2 marks]

e) By equating the 50 keV electrical energy given by the Linac with the kinetic energy, calculate a value for the velocity of the electrons emerging from it.

[3 marks]

f) The final energy of photons colliding with the target sample is around 4×10^{-14} J. What would the wavelength of the emerging electromagnetic waves be?

[3 marks]

g) From the beam size data given, calculate a value for the power absorbed per square metre when 5×10^{12} photons strike the target per second.

[3 marks]

Question 2 (18 marks) **Vehicles moving through fluids**

You may have wondered why all vehicles such as cars and boats reach a maximum speed and cannot go any faster, even though they have a constant driving force on them. The answer is that, as a vehicle goes faster, the force opposing the motion (called drag) increases, according to the formula

$$F_D = \frac{1}{2} \rho v^2 C_d A \quad (\textit{Equation 1}) \text{ where}$$

F_D is the drag force
ρ is the density of the fluid
v is the velocity of the vehicle
A is the frontal area of the vehicle.
C_d is called the Drag Coefficient of the object and is a constant which depends on how streamlined the object is. For a car, C_d ranges from about 0.25 to about 0.45.

a) Calculate a value for the Drag Force on a car with a frontal area of 2.45 m^2 and a Drag Coefficient of 0.35 moving at a speed of 72 km h^{-1} (take the density of air as 1.20 kg m^{-3}).

[2 marks]

b) When the car referred to in part a) is moving at its maximum velocity of 198 km h^{-1} (terminal velocity), what force is being exerted by the engine moving the car forwards?

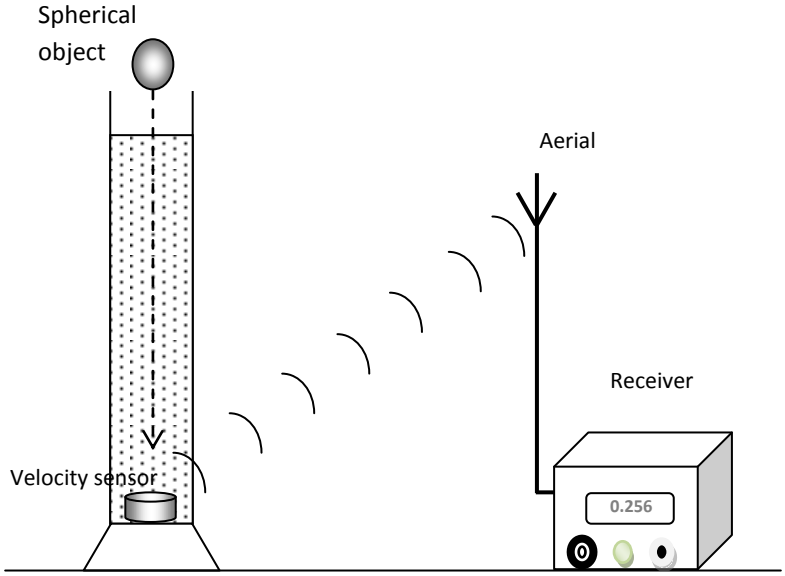
[2 marks]

The Terminal velocity of any object moving in a fluid is given by *Equation 2*:

$$v_T = \sqrt{\frac{2W}{\rho A C_d}}$$

v_T is the Terminal Velocity of the object
W is the weight of the object
ρ is the density of the fluid
A is the frontal area of the object
C_d is the Drag Coefficient of the object

An experiment was set up at the Naval Base laboratory to investigate the terminal velocity of a spherical ball shaped object moving through water. It was hoped that this might help in the design of more efficient submarine hulls. A diagram of the experiment is shown below in Figure



The sphere was allowed to fall in a column of water with a radar velocity sensor positioned at the bottom. The velocity of the ball was transmitted via radio waves to a receiver which gave a digital read-out of the sphere's velocity. Various balls of the same diameter but different masses were used and readings of V_T recorded for each different sphere.
The results are shown in the table below.

Velocity v_T (m s^{-1})	**Mass (gram)**	**Weight (N)**	**v_T^2 (m^2 s^{-2})**
0.37	10		
0.55	22		
0.69	42		
0.83	50		

1.02	75		

c) Fill in the last two columns of Table 2, inserting values for the weight of the sphere and the square of the sphere's terminal velocity. (ρ of water is 1000 kg m^{-3}) [2 marks]

d) Explain why a plot of v_T^2 against W would give a straight line graph.

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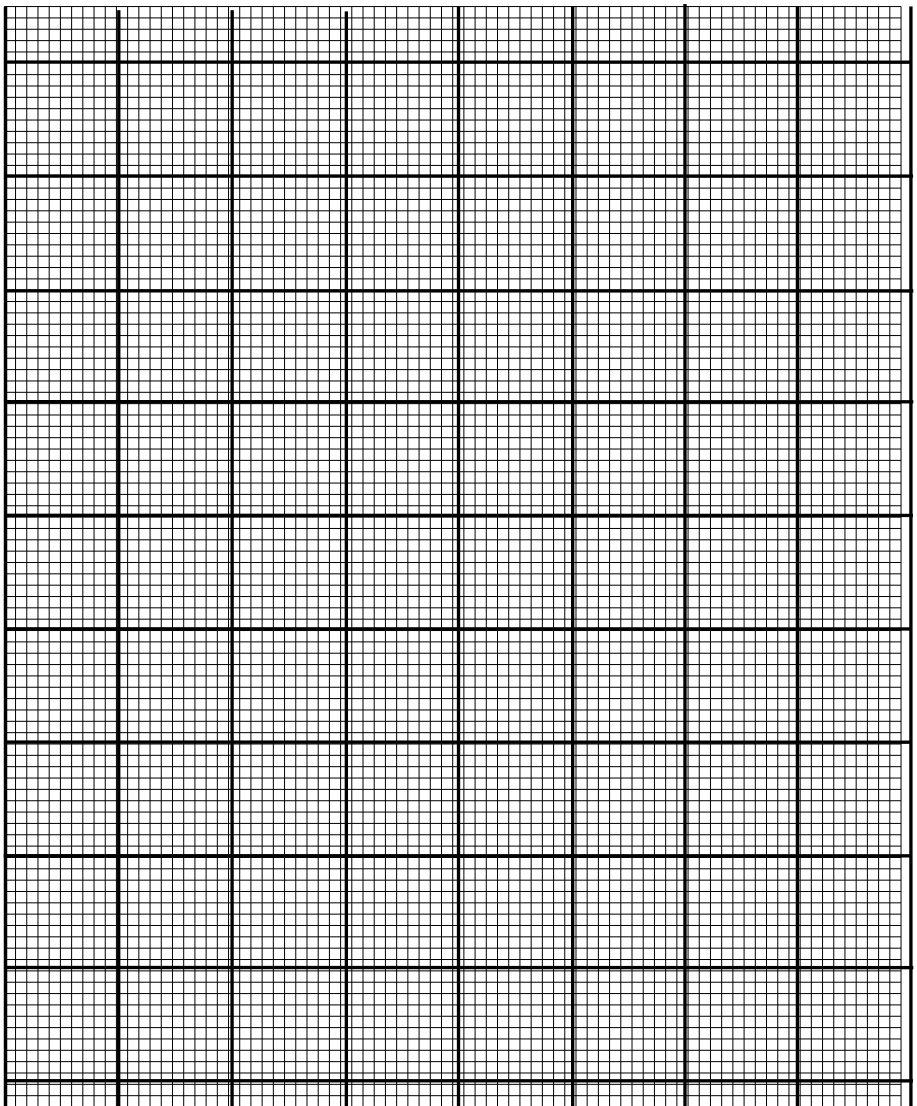
[2 marks]

e) Plot the points of the graph of v_T^2 (up) against W (along) on the graph space below. [4 marks]

f) Draw a line of best fit. [2 marks]



g) Calculate the gradient of your line of best fit. Show points on the graph used in your calculation.

[2 marks]

h) From Equation 2 above, calculate a value for C_d for the sphere, given that:

$\rho = 1.10 \times 10^3$ kg m^{-3}

$A = 2.8 \times 10^{-3}$ m^2

[2 marks]

Reference for Section C, Question 1 www.synchrotron.org.au