Government of **Western Australia**
Curriculum Council

WACE
Western Australian Certificate of Education

Western Australian Certificate of Education Examination, 2010

Question/Answer Booklet

PHYSICS

Stage 3

Please place your student identification label in this box

Student Number: In figures | | | | | | | | |

In words _____

_____

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.

Ref: 10-110

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Short answer	13	13	50	54	30
Section Two: Extended answer	8	8	90	90	50
Section Three: Comprehension and data analysis	2	2	40	36	20
				Total	100

Instructions to candidates

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

See next page

Section One: Short answer **30% (54 Marks)**

This section has **13** questions. Attempt **all** questions.

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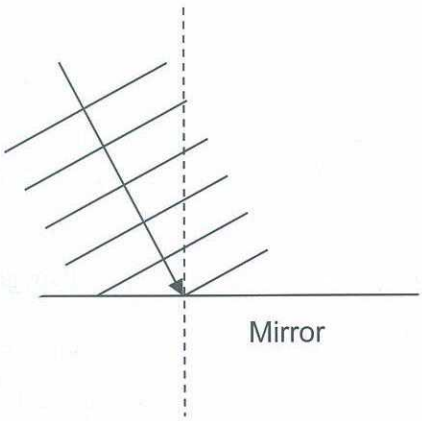
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time: 50 minutes.

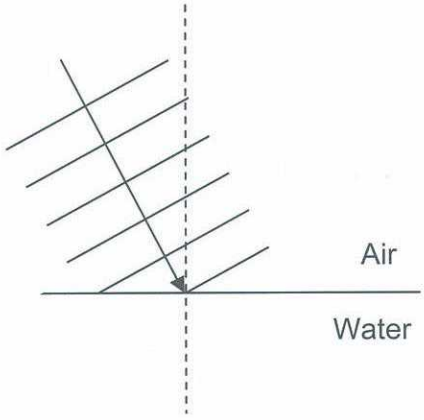
Question 1 **(4 marks)**

The diagrams below show wavefronts of light incident on two different surfaces. In diagram (a) the wavefronts are incident on a mirror. In diagram (b) the wavefronts are incident on an air-water interface. In both diagrams a dotted line at 90° to the surface has been drawn. Complete the diagrams showing how the wavefronts behave as they interact with the surface. In both cases you should draw four wavefronts. The direction of travel of the wavefronts is included.

(a)



(b)



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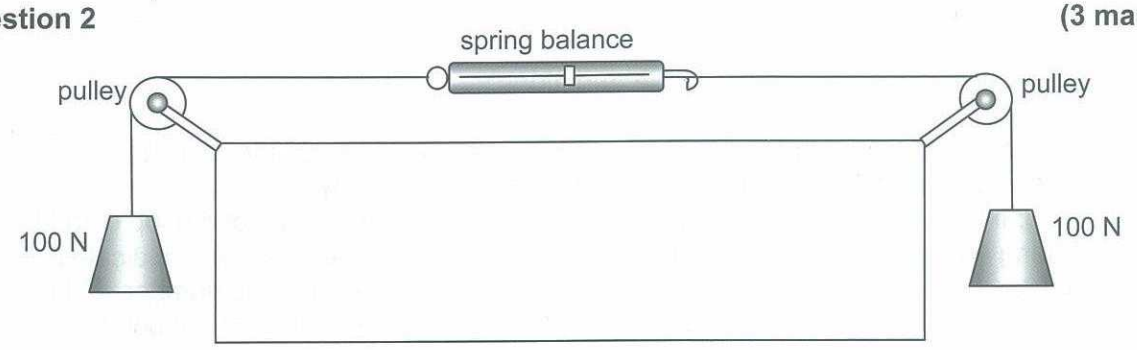
Question 2 **(3 marks)**



(a) What is the reading on the spring balance? Circle your answer. (1 mark)

(i) 100 N (ii) Zero (iii) 200 N

(b) Choose **one** of the answers that you **rejected** and give your reason why you rejected it. (2 marks)

Answer: _____ Reason: _____

_____

Question 3 **(3 marks)**

Particles called *quarks* are the 'building blocks' of other sub-atomic particles. Table 1 lists the names of some quarks and two of their quantum numbers; charge q and strangeness S.

Table 1: Some properties of quarks

Quark	Charge, q	Strangeness, S
up	$+{}^{2}/_{3}$	0
down	$-{}^{1}/_{3}$	0
charm	$+{}^{2}/_{3}$	0
strange	$-{}^{1}/_{3}$	-1
top	$+{}^{2}/_{3}$	0
bottom	$-{}^{1}/_{3}$	0

When quarks combine their individual quantum numbers 'add'. For example, a fictitious particle, the Joton, made of two charm quarks and one top quark would have a charge of $+{}^{2}/_{3} + {}^{2}/_{3} + {}^{2}/_{3} = {}^{6}/_{3} = 2$ and a strangeness of 0+0+0 = 0.

Use Table 1 to determine the values of the charge and strangeness quantum numbers for the particles in Table 2.

Table 2: Properties of some sub-atomic particles

Particle	Quark composition	Charge, q	Strangeness, S
Lambda	up, down, strange		
Xi	up, strange, strange		
Sigma minus	down, down strange		

See next page

Question 4 **(5 marks)**

In April 2009 *New Scientist* magazine reported the discovery of several species of fish that emit red light as a means of communication. This was surprising because these fish swim at depths where wavelengths corresponding to red light do not penetrate but blue light does. The fish might produce red light using a fluorescent protein that absorbs blue light and then emits red.

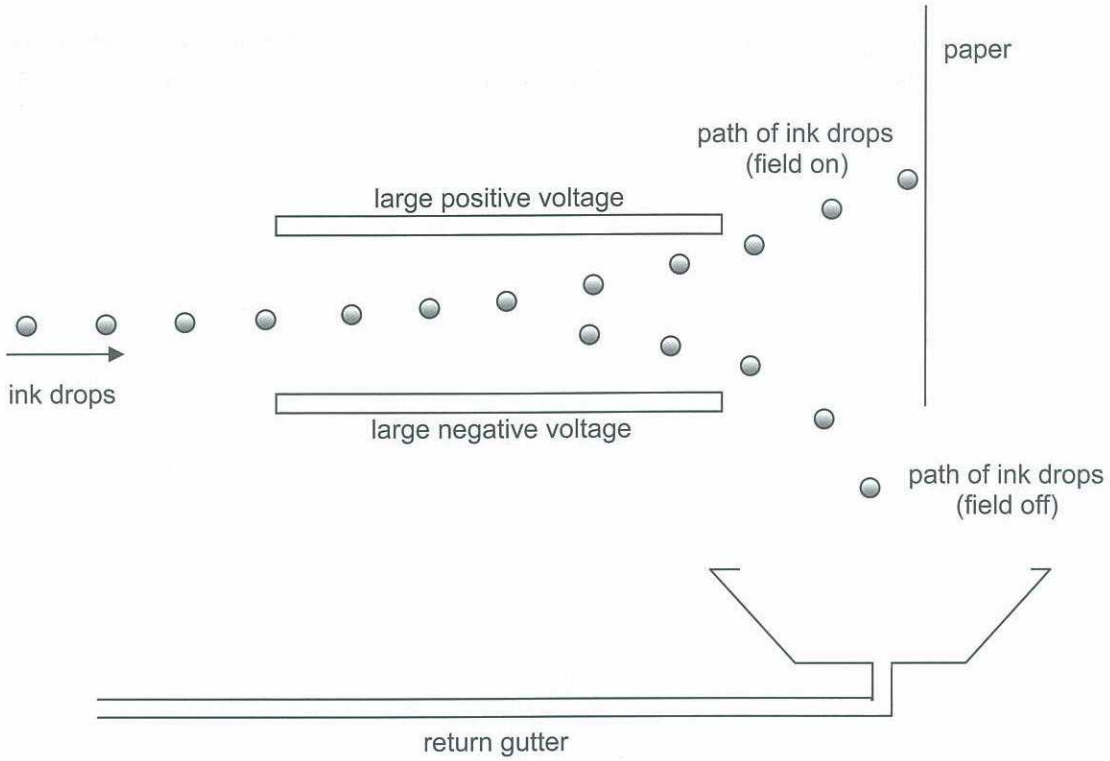
(a) Draw an energy level diagram showing possible electron transitions taking place in the atoms of the fluorescent protein that could give rise to the observed phenomenon. (2 marks)

(b) Calculate the energy in joules of a photon of blue light and a photon of red light. Blue light has wavelength of 400 nm and red light 700 nm. Use the energy values to label the transitions in the diagram you drew in part (a). (3 marks)

See next page

Question 5 **(5 marks)**

The principle of inkjet printing depends on the physics of charged particles in electric fields. The diagram below shows charged ink drops entering an electric field. The field is caused by high voltage deflection plates. The field on the plates switches on and off to direct drops to the paper rather than the gutter. Drops that do not impact on the page are 'recycled' via the gutter.



(a) The plates are separated by 0.025 m and the voltage difference between the plates is 1000 V. Calculate the electric field intensity. (2 marks)

(b) If the force required to cause a black spot on the paper is 1.00×10^{-8} N, calculate the charge on each drop. (3 marks)

See next page

Question 6 **(4 marks)**

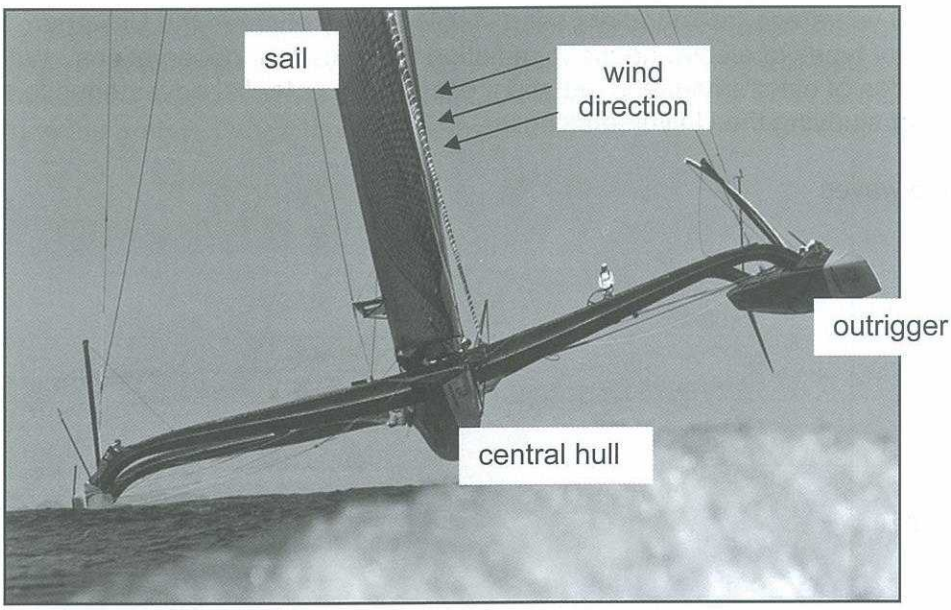
Until about 50 years ago, astronomers used visible light to observe the Universe. They now use a variety of types of electromagnetic radiation to make their observations. With reference to the properties of electromagnetic radiation, explain the potential advantages to an astronomer of studying the Universe using:

(a) radio waves

(b) X-rays

See next page

Question 7 **(4 marks)**



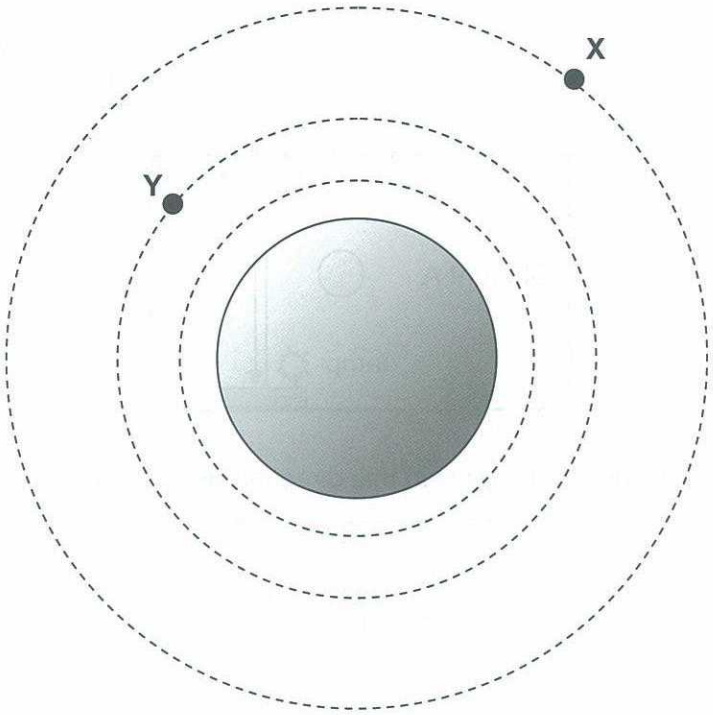
The photograph shows the yacht *BMW Oracle*, which has both a length and width of 28 m.

Estimate the torque, exerted by the wind blowing on the sails, that would just begin to tip the *BMW Oracle* as shown. The sail has a mass of 3.5×10^3 kg, the central hull 1.0×10^3 kg and each outrigger 0.5×10^3 kg.

See next page

Question 8 **(5 marks)**

This question is about the gravitational field around an asteroid. The asteroid is spherical and of uniform density. The diagram below shows lines of equal gravitational field strength as dashed lines. There is a constant difference in the value of the field strength between each line.



(a) Describe what the diagram shows about the gravitational field strength as the distance from the asteroid increases. (1 mark)

(b) Draw the gravitational field at points X and Y. (2 marks)

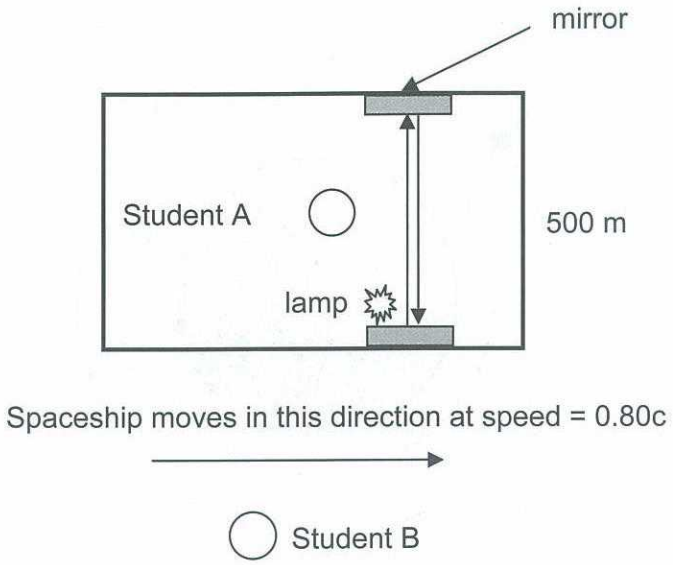
(c) The asteroid has a radius of 1.25×10^5 m. If the gravitational field strength on its surface is 0.194 N kg^{-1}, calculate the mass of the asteroid. (2 marks)

See next page

Question 9 **(4 marks)**

Many hundreds of years in the future, two students are measuring the time it takes for a pulse of light to travel between a lamp and a mirror placed on opposite sides of a spaceship. The spaceship is 500 m wide and can travel at a speed equal to 0.80c (0.80 × the speed of light).

Top down view



Student A is in the spaceship moving at 0.80c. Student B is stationary outside the spaceship.

The students start stopwatches when a light pulse leaves a lamp closest to Student B and stops them when it returns reflected off the second mirror furthest from B.
Student A measures the time for the pulse of light to travel to the mirror and back to be 3.30 μs.
Student B measures the time for the pulse of light to travel to the mirror and back to be 5.50 μs.
Both students have recorded their times correctly.

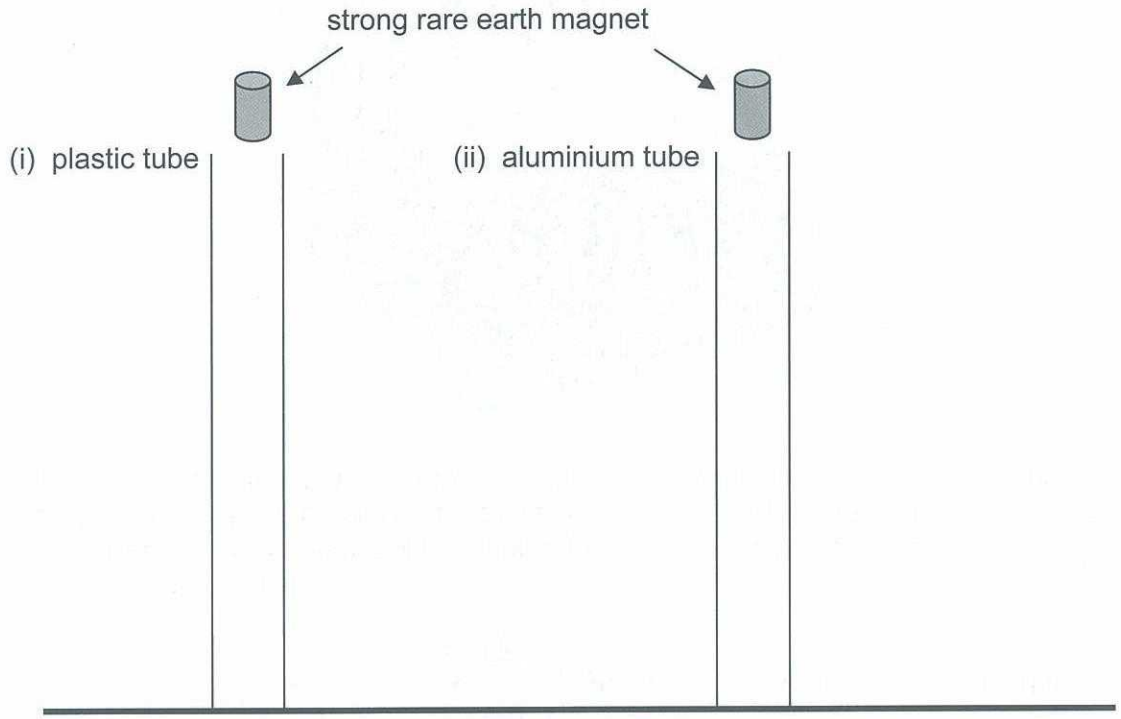
Explain why Student B measures a longer time than Student A, using a labelled diagram to aid your explanation. Calculations are not required.

See next page

Question 10 **(4 marks)**

A physics teacher set up the equipment shown below.

One tube was made of plastic and the other of aluminium. The teacher dropped a strong rare earth permanent magnet down each tube.



The magnet falling through the plastic tube travelled much faster than the magnet falling through the aluminium tube.

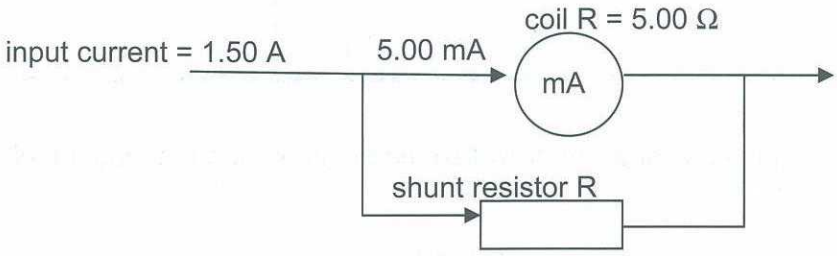
Explain, indicating clearly the physics principles involved. (4 marks)

See next page

Question 11 **(5 marks)**

The ammeter shown below can be used to measure a range of electric currents up to 500 mA by selecting the appropriate terminals.

The coil inside the meter is not designed to take large currents. If the ammeter is required to measure a maximum reading of 1.50 A, an additional resistor called a *shunt* has to be added as shown below. The meter has a coil resistance of 5.00 Ω. This arrangement is shown here:

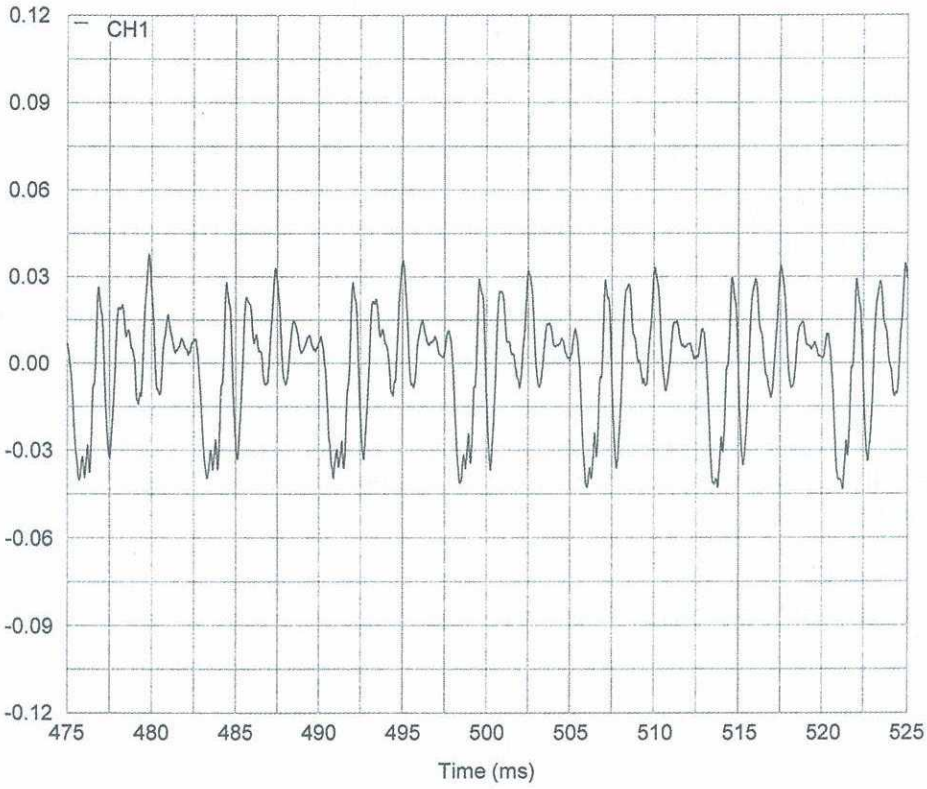


Find the value of the shunt resistor R.

See next page

Question 12 **(4 marks)**

The graph below shows the trace of a sound displayed on a cathode ray oscilloscope (CRO). The horizontal (x) axis is time and the vertical (y) axis is amplitude.



(a) Is the above trace noise or a musical note? Explain your reasoning. (2 marks)

(b) Describe the effect on the trace if the sound wave was **louder.** (2 marks)

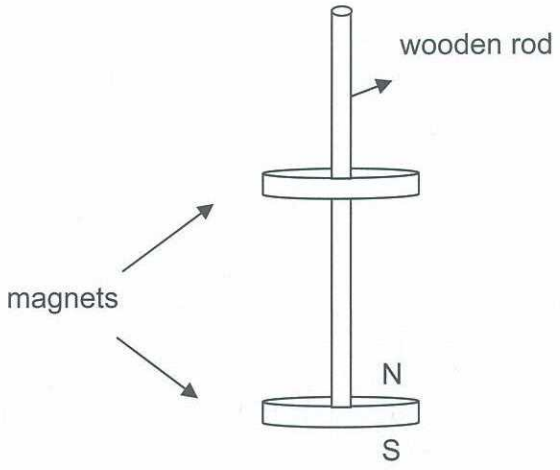
(i) Effect on the shape of the trace: _____

(ii) Effect on the amplitude of the trace: _____

See next page

Question 13 **(4 marks)**

Below is a diagram of a wooden rod on which there are two powerful magnets, one 'floating' above the other.



(a) Indicate the north pole of the floating magnet and draw the magnetic field lines between the magnets. (2 marks)

(b) Explain why the top magnet 'floats'. (2 marks)

End of Section One

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See next page

Section Two: Extended answer **50% (90 Marks)**

This section has **eight (8)** questions. You must answer **all** questions. Write your answers in the spaces 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: 90 minutes.

Question 14 **(11 marks)**

There are three lines in the emission spectrum of hydrogen that occur in the visible part of the electromagnetic spectrum. These involve transitions to the n = 2 energy level.

The three lines have the wavelengths 6.60×10^{-7} m, 4.90×10^{-7} m and 4.40×10^{-7} m.

(a) Draw an energy level diagram to illustrate the transitions from the n = 3, 4, 5 levels to the n = 2 level. Label the levels n = 2, 3, 4, 5. (4 marks)

(b) Which value of wavelength from the list above corresponds to the transition with the largest energy difference? Explain your answer. (2 marks)

See next page

(c) The n = 2 level has an energy of -3.4 eV. The photon with wavelength 4.9×10^{-7} m corresponds to the transition between the n = 4 and n = 2 energy levels. Calculate the energy of the n = 4 energy level in eV. (3 marks)

The following passage describes how the redshift of a star or galaxy can be measured:

'To determine the redshift, the absorption or emission spectra of the astronomical object are looked for. These can be compared with known spectra of various elements and compounds existing on Earth. If the same pattern of lines is seen in a spectrum from a distant source but occurring at shifted wavelengths, it can be identified as originating from the same element or compound. If the same spectral line is identified in both spectra but at different wavelengths then the redshift can be calculated.'

Redshift is expressed in terms of a parameter z.

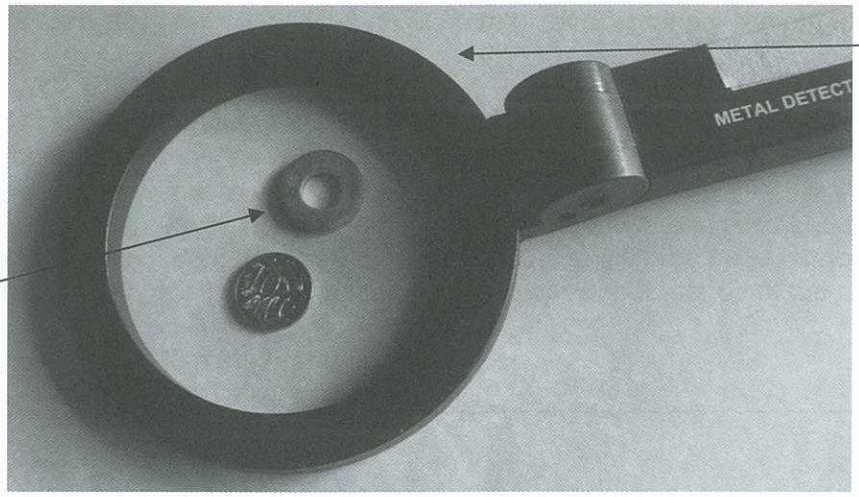
$$z = \frac{\lambda_{observed}}{\lambda_{earth}} - 1$$

The redshift of the galaxy 8C is z = 4.25.

(d) Calculate the wavelength of the n = 4 to n = 2 transition in hydrogen that would be observed by an astronomer studying the galaxy 8C. (2 marks)

See next page

Question 15 **(12 marks)**



Above is a picture of a metal detector and a metal object. A ten cent coin has been added to give a sense of scale. The detector consists of a DC battery connected to a primary coil. There is a secondary coil connected to a buzzer that makes a sound when the primary coil moves over a metal object.

(a) Explain the principle of operation of this metal detector. In your answer, explain why the coil has to be moved while locating metal objects. (4 marks)

(b) What type of metal can the detector find? Circle the correct answer. (1 mark)

copper and tin iron and steel any metal

See next page

(c) Use the following data to **estimate** the voltage in the secondary buzzer circuit. (5 marks)

Magnetic field strength within primary coil = 0.0500 Wb

Number of turns in secondary coil = 10

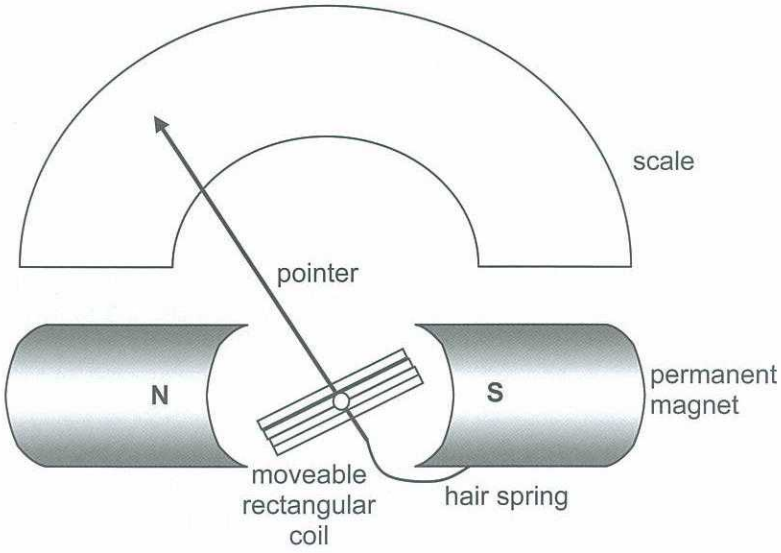
Time of sweep = 0.5 s

(d) How would the sound change if the metal detector was held stationary near a nail? Give a brief reason for your answer. (2 marks)

See next page

Question 16 **(13 marks)**

Analogue meters, like the one shown in the diagram below, have many applications: for example, in pool chlorination systems. The interaction of the electric current in the coil and the permanent magnet creates a torque. A fine spring (hair spring) provides a restoring torque.



(a) When a current flows in the rectangular coil, a force is produced on each side of the coil that interacts with the magnetic field. Explain the reason for this force and comment on its direction. You must draw a diagram to illustrate your explanation. (3 marks)

See next page

(b) The coil has a length of 0.100 m and a width of 0.0800 m and has 50.0 turns. There is a current of 4.00 A in the coil and it is in a uniform magnetic field of 0.0100 T.

(i) Calculate the force on one of the long sides of the coil. (4 marks)

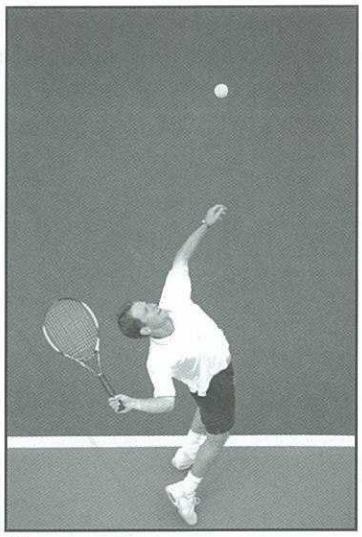
(ii) Hence determine the torque acting on the coil. (3 marks)

(c) Why will the coil rotate? (2 marks)

(d) The loosely-coiled spring provides a torque that opposes the coil's rotation. When the coil is stationary, with a current flowing in it, state the relationship between the torque acting on the coil because of the magnetic field, and the torque provided by the spring. (1 mark)

See next page

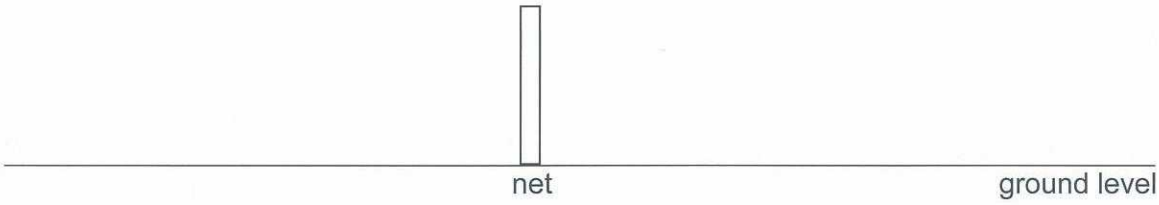
Question 17 **(11 marks)**



Clipart

While serving a tennis ball, a tennis player aims to hit the ball horizontally so that it lands in the opponent's court 5.50 m from the net. The height of the net is 0.900 m, the distance between the service point and the net is 11.9 m and the ball is hit from a height of 2.80 m. Ignore air resistance.

(a) Draw a diagram to illustrate the path of the ball with all relevant distances labelled. (2 marks)



(b) Calculate the time taken for the tennis ball to reach the net and the minimum initial speed that the tennis ball would need to just clear the net. (3 marks)

See next page

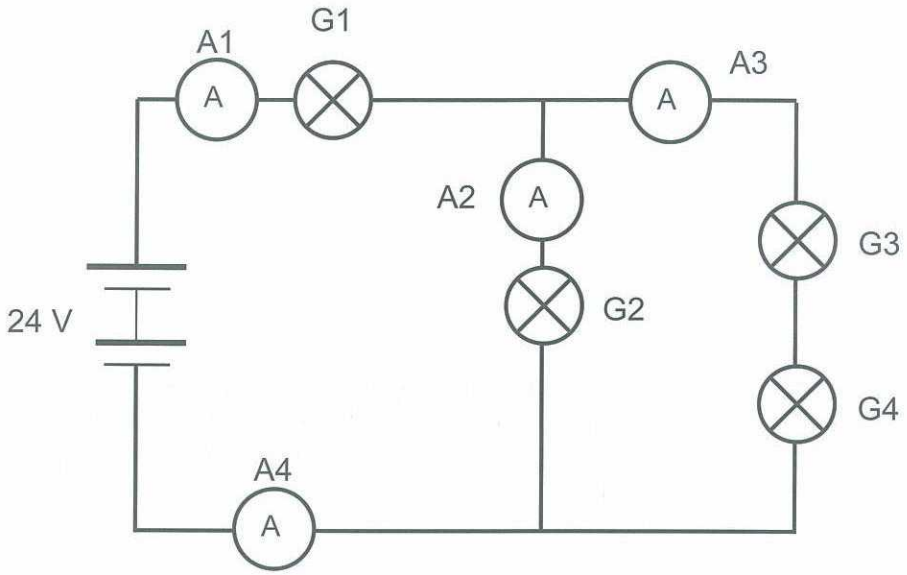
(c) Calculate the length of time the ball is in the air. (3 marks)

(d) Calculate the distance from the net that the ball will land on the opponent's side of the court. If you were unable to determine an answer in part (c) you should assume that the time of flight is 0.900 s and if you were unable to determine an answer to part (a) you should assume that the minimum initial speed is 20.0 m s^{-1}. (3 marks)

See next page

Question 18 **(14 marks)**

Four identical light globes, G1, G2, G3 and G4, are connected in a circuit as shown below. The DC supply voltage is 24.0 V and ammeter A3 connected in the circuit reads 0.096 A.



(a) Calculate the current in each of the ammeters A1, A2 and A4. (3 marks)

(b) Calculate the resistance of each light globe. (3 marks)

See next page

(c) Which light globe will be the brightest? Justify your answer. (2 marks)

(d) Calculate the total power consumed by all four light globes. If you were unable to determine an answer to part (a) you should assume the current in ammeter A4 is 0.300 A. (2 marks)

(e) If globe G3 is broken, describe how the brightness of each of the light globes G1 and G2 changes. Give a reason in each case. (4 marks)

The brightness of G1 will _____

because _____

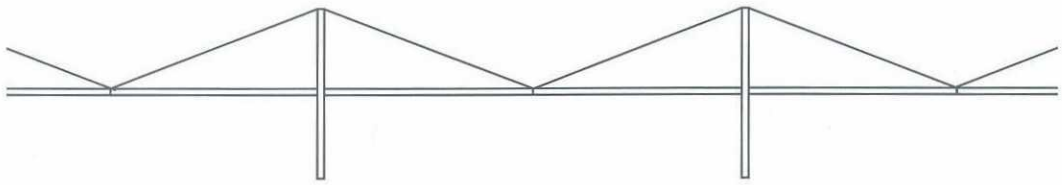
The brightness of G2 will _____

because _____

See next page

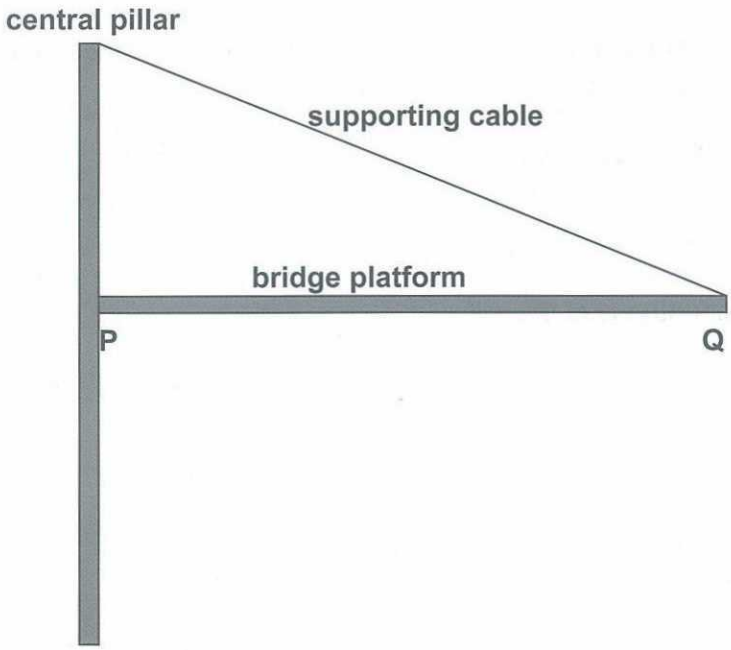
Question 19 **(9 marks)**

A concrete bridge structure is being built. It consists of vertical pillars that support horizontal platforms, as shown below.



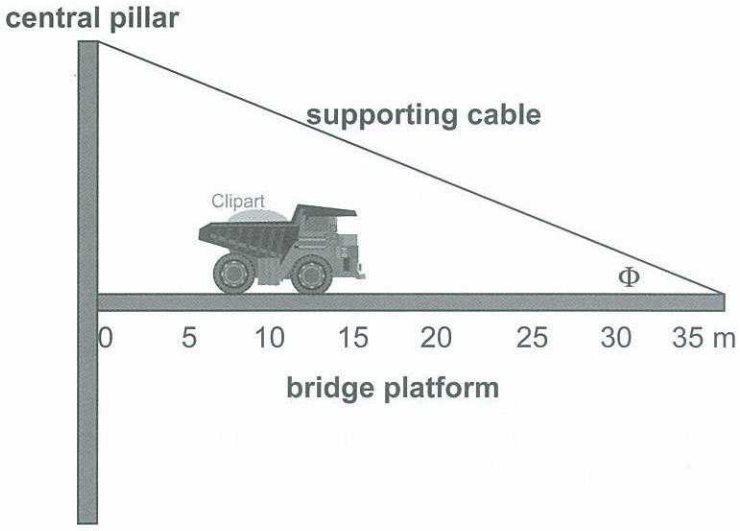
(a) The section of bridge platform labelled PQ on the diagram below is in equilibrium even though three forces act on it. Draw and label these three forces on the diagram.

(3 marks)



The diagram below shows a heavy truck moving along the bridge during construction. The distances in metres from the central pillar are shown on the diagram. The centre of mass of the truck is at the 10.0 m mark and the bridge platform extends to 35.0 m from the pillar, the top of which is 17.5 m above the platform.

The section of bridge platform shown has a mass of 420 tonnes and the truck has a mass of 50.0 tonnes.



(b) Calculate the angle Φ. (1 mark)

(c) By taking moments about a suitable point calculate the vertical component of the tension. (3 marks)

Vertical component = _____

(d) Using the vertical component from (c), determine the tension in the cable. If you could not calculate the vertical component, use 4.20×10^6 N. (2 marks)

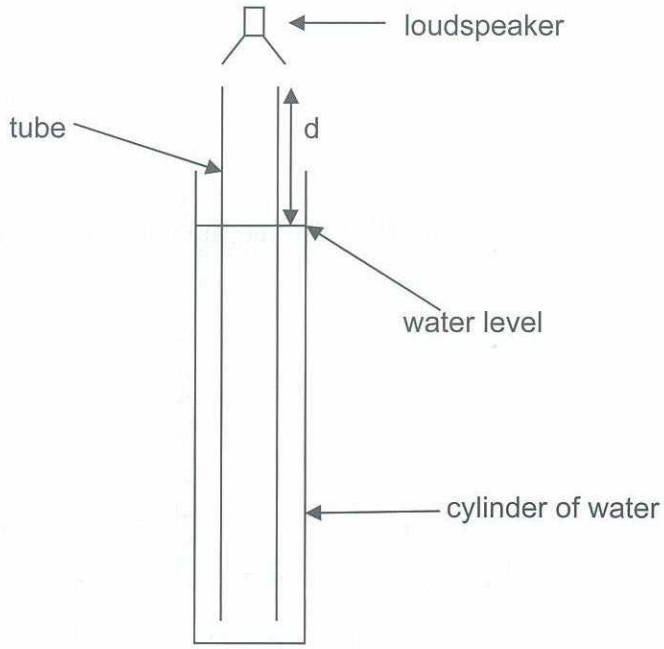
Tension in cable = _____

See next page

Question 20 **(11 marks)**

(a) Apart from the phenomenon of vibrating air columns, provide one example in which resonance may be observed. Explain how resonance occurs in the example that you have chosen. (3 marks)

A loudspeaker emitting a single frequency is held over a tube which has one end placed in a cylinder of water at 25°C. As the length of tube in the water is changed, the sound heard also changes. The equipment is illustrated in the diagram below.



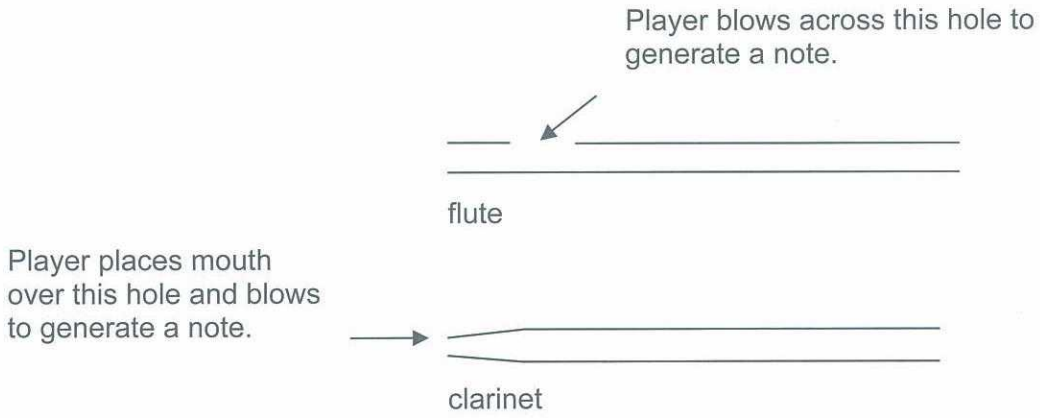
The first resonance is heard when the length of the air column above the water (labelled **d** in the diagram) is 17.0 cm and a second is heard when the length of the air column is 49.0 cm.

(b) Calculate the wavelength of sound in the cylinder. (2 marks)

See next page

(c) Calculate the frequency being emitted by the loudspeaker. (2 marks)

(d) The diagrams below show very simple versions of a flute and a clarinet.



(i) The ratio of the first three frequencies heard in the flute $f_1:f_2:f_3$ is 1:2:3. Determine the ratio of the first three frequencies heard in the clarinet. (1 mark)

(ii) Using your knowledge of vibrations in air columns, explain the differences between the frequencies heard in the flute and those in the clarinet. (3 marks)

See next page

Question 21 **(9 marks)**

(a) The radius of the orbit of Venus around the Sun is 1.08×10^{11} m.

(i) Derive an expression that relates the orbital period of Venus to the orbital radius of Venus and the mass of the Sun. (3 marks)

(ii) Calculate the time in Earth days for Venus to orbit the Sun. (3 marks)

See next page

The passage of the planet Venus between the Earth and the Sun is a predictable regular occurrence. It is known as the 'transit of Venus'. Captain Cook sailed to Tahiti to measure the time Venus took to cross the Sun's surface.

A is the point at which Venus appears to intersect with the surface of the Sun. This occurs at different times for observers at different positions on the Earth's surface.

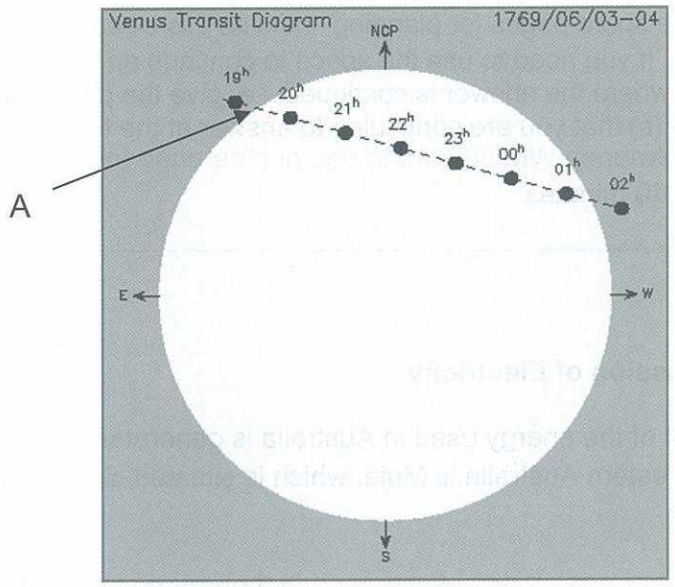
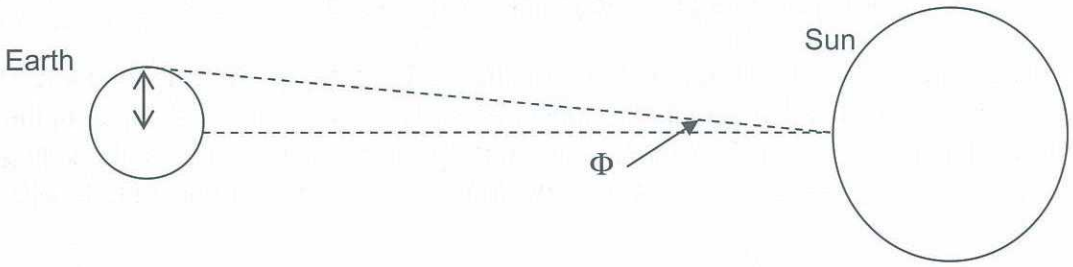


Diagram is **not** to scale

(b) By measuring the time difference between the occurrence of A at different locations on Earth (Tahiti and California) astronomers were able to measure the solar parallax angle Φ as shown in the diagram below, which is not to scale. In this way the distance from the Earth to the Sun was calculated in 1769 with amazing accuracy.



Calculate the Earth – Sun distance in kilometres if the solar parallax angle $\Phi = 0.00250°$. (3 marks)

End of Section Two

See next page

Section Three: Comprehension and data analysis. **20% (36 Marks)**

This section contains **two (2)** questions. You must answer both questions. Write your answers in the spaces 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: 40 minutes.

Question 22 **(13 marks)**

Generation and Transmission of Electricity

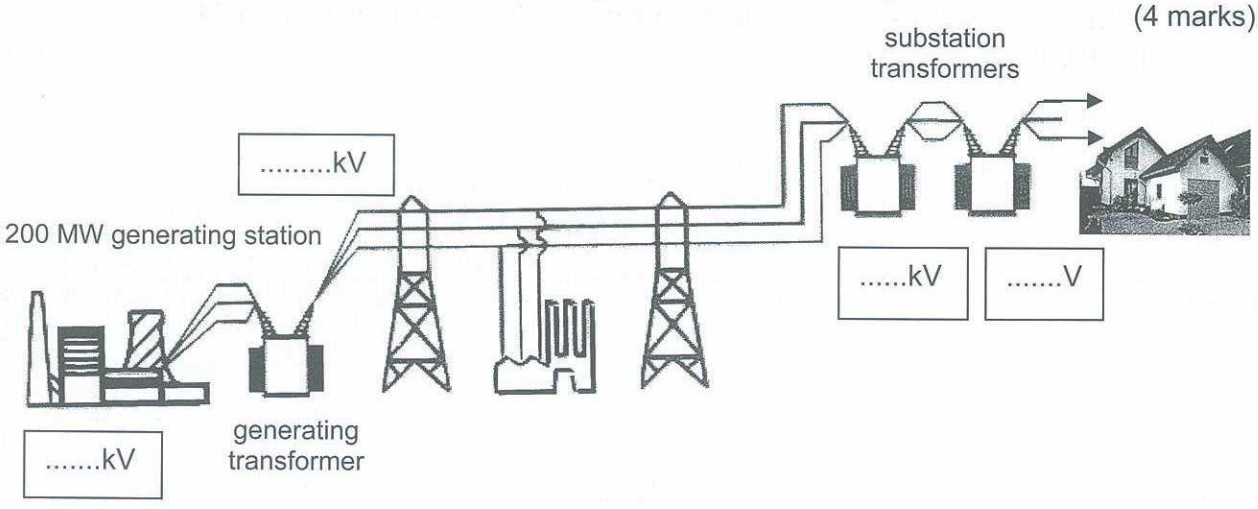
Approximately 30 per cent of the energy used in Australia is generated by power stations. The largest power station in Western Australia is Muja, which is situated close to the coalmining town of Collie.

At Muja coal is ground to the consistency of powder and then burned to heat water until it turns to steam. Steam at a temperature of 540°C and pressure of 16 MPa is used to drive turbines at a rate of 3000 revolutions per minute.

Muja power station generates at a total rate of 1040 MW from its 8 generators. There are four 60 MW generators and four 200 MW generators. The 60 MW generators produce power at 11.8 kV and the 200 MW generators produce power at 16 kV. Generators feed the electricity produced into transformers where the voltage can be increased or decreased.

Before the electricity is distributed, transformers are used to step up the voltage to 330 kV. High voltage transmission has advantages in reducing energy lost due to the resistance of the transmission lines. On the outskirts of Perth there is a substation that reduces the voltage to 11 kV and in the local park is a further small transformer that reduces the voltage to 240 V.

(a) On the diagram below show the voltages at the different stages of the transmission. (4 marks)



See next page

(b) Explain why the generator is designed to produce alternating current and not direct current. (2 marks)

(c) Calculate the current generated in one of the 200 MW generators. (2 marks)

(d) Explain why the voltage is increased to 330 kV before it is distributed to users. (2 marks)

See next page

(e) Calculate the turns ratio of a transformer used to increase the voltage from a 60 MW generator to 330 kV. (2 marks)

(f) Suggest a possible difference between the 60 MW and the 200 MW generators that would result in a difference in output voltage. (1 mark)

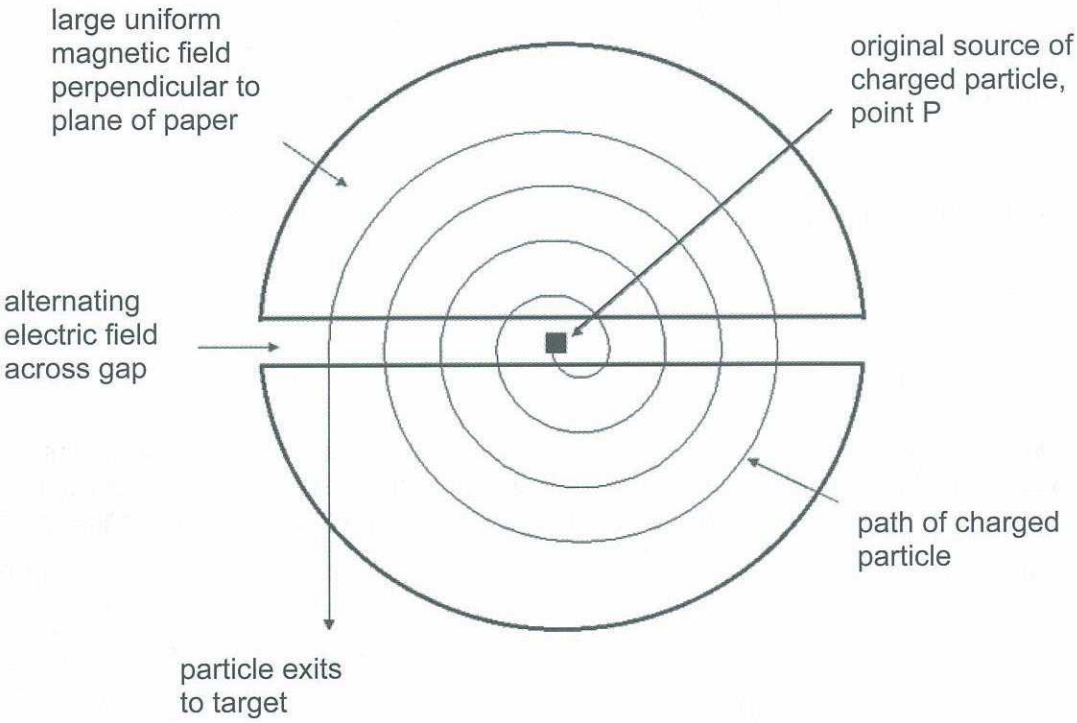
See next page

Question 23 **(23 marks)**

Introduction

A cyclotron is a device in which heavy charged particles such as protons, deuterons (deuterium nuclei, ${}^{2}_{1}H$) and alpha particles can be accelerated to high energies. The high energy charged particle beam can then be used to study nuclear reactions and can also be used in hospitals to produce short-lived radioisotopes for diagnostic purposes. One such medical cyclotron is located at Sir Charles Gairdner Hospital in Perth. It can accelerate protons and deuterons to very high energies.

Cyclotron



How a cyclotron works

A cyclotron consists of two hollow D-shaped semicircular metal electrodes (called 'dees'), an ion source, an electromagnet and an alternating power supply.

The dees are mounted inside a vacuum chamber that fits between the two flat pole pieces of an electromagnet. The dees are connected to a high frequency alternating voltage supply that provides an alternating electric field across the gap between the dees.

When charged particles are injected at the centre of the dees (point P), they are accelerated by the electric field and then move into a semicircular path inside the hollow space of the dee under the influence of the uniform magnetic field that acts perpendicular to the path of the charged particles. Once inside the dee they are shielded from the electric field and thus do not gain any further energy.

Because the dees are connected to an alternating voltage supply, the charged particles are accelerated by the electric field each time they cross the gap, increasing their energy by a small amount qV. Therefore their speed increases and they move into larger and larger path radii. If the charged particles do not arrive at the gap when the polarity is correct, they will fall out of synchronisation and the beam will be lost. So for the satisfactory operation of the cyclotron, the frequency of the alternating voltage must be equal to the orbital or cyclotron frequency of the charged particles. This condition is valid only when the speed of the charged particles is much less than the speed of light. At higher particle speeds (above about 10% of the speed of light) the frequency of the circulating particle decreases steadily due to relativistic effects. Thus the particle goes out of step with the frequency of the oscillator and its energy stops increasing.

See next page

In the normal operation of the cyclotron, when the charged particles reach the outside perimeters of the dees, they are deflected by the electric field of an ejector plate and strike the outside target.

Charged particle data

Type of charged particle	Mass of charged particle (kg)	Charge of the particle (coulombs)	$\frac{q}{m}$
electron	9.11×10^{-31}	1.60×10^{-19}	
proton	1.67×10^{-27}	1.60×10^{-19}	
deuteron	3.34×10^{-27}	1.60×10^{-19}	

(a) What provides the centripetal force that acts on the charged particle? (1 mark)

(b) The operation of the cyclotron is based on the principle that frequency of revolution is independent of the speed of charged particles and the radius of the circular path. Use the equations given in the Formulae and Constants Sheet to show that frequency, f is given by $f = \frac{qB}{2\pi m}$. (4 marks)

See next page

(c) Suppose a cyclotron with a dee radius of 53.0 cm is tuned to accelerate protons at an oscillator frequency of 12.0 MHz. Calculate the strength of the magnetic field needed to accelerate deuterons with the same frequency. (3 marks)

(d) A conventional cyclotron begins to fail beyond a proton energy of 50 MeV.

(i) Explain why is this so. (2 marks)

(ii) At what electron energy will the same cyclotron begin to fail? (2 marks)

See next page

(e) An unknown particle was tested and gave the following values of high voltage oscillator frequency and the corresponding magnetic field:

Frequency of high voltage oscillator × 10^6 hertz	Magnetic field B (tesla)
1.0	0.10
3.2	0.42
6.0	0.78
9.0	1.20
12.0	1.62
15.0	1.95

(i) Using the graph paper on the next page, plot a straight line graph with magnetic field on the *x*-axis and frequency on the *y*-axis. (3 marks)

(ii) Calculate the gradient of this graph. (3 marks)

(iii) Use the gradient to find the ratio $\frac{\text{charge on the particle}}{\text{mass of particle}}$ for the unknown particle. (3 marks)

(If you could not complete (ii), use a gradient of magnitude 2.9×10^{10}.)

(iv) Circle the unknown particle involved and justify your selection. (2 marks)

(I) electron (II) proton (III) neutron (IV) deuteron

Justification: _____

_____

_____

End of questions

If you wish to have a second attempt at this item, the graph is repeated at the end of the examination booklet. Indicate clearly on this page if you have used the second graph and cancel the working on the graph on this page.