Curriculum Council

TERTIARY ENTRANCE EXAMINATION, 1999

QUESTION/ANSWER BOOKLET

PHYSICS

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

MATERIAL REQUIRED/RECOMMENDED FOR THIS PAPER

TO BE PROVIDED BY THE SUPERVISOR

This Question/Answer Booklet
Physics: Formulae and Constants Sheet (inside front cover of this Question/Answer Booklet)

TO BE PROVIDED BY THE CANDIDATE

Standard Items: Pens, pencils, eraser or correction fluid, ruler

Special Items: MATHOMAT and/or Mathaid, compass, protractor, set square and calculators satisfying the conditions set by the Curriculum Council.

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 PAPER

Section	No. of questions	No. of questions to be attempted	No. of marks out of 200	Proportion of examination total
A: Short Answers	15	ALL	60	30%
B: Problem Solving	7	7*	100	50%
C: Comprehension and Interpretation	2	ALL	40	20%

* Note that in Section B there is some internal choice in Questions 6 and 7.

INSTRUCTIONS TO CANDIDATES

Write your answers in the spaces provided beneath each question. The value of each question (out of 200) is shown following each question.

The enclosed *Physics: Formulae and Constants Sheet* may be removed from the booklet and used as required.

Calculators satisfying the conditions set by the Curriculum Council may be used to evaluate numerical answers.

Answers to questions involving calculations should be evaluated and given in decimal form. Quote the final answer to not more than four significant figures. Despite an incorrect final result, credit may be obtained for method and working, providing these are clearly and legibly set out.

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

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

SEE NEXT PAGE

SECTION A: Short Answers

Marks allotted: 60 marks out of 200 total (30%)

Attempt **ALL** 15 questions in this section. Each question is worth 4 marks. Answers are to be written in the spaces provided.

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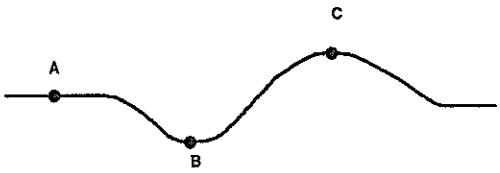
1. Some examples of waves are sound, radio, microwaves, water waves and X-rays.

   Classify each of these waves under the correct heading:

Mechanical Waves	Electromagnetic Waves

2. A bar magnet placed on a piece of polystyrene is floating in the middle of a plastic bowl of water. Describe the motion of the magnet until it comes to rest. Explain your answer.

3. The diagram shows a roller coaster track. Stationary roller coaster cars are at the positions A, B and C. State whether each car is in a state of stable, unstable or neutral equilibrium.



A: _____

B: _____

C: _____

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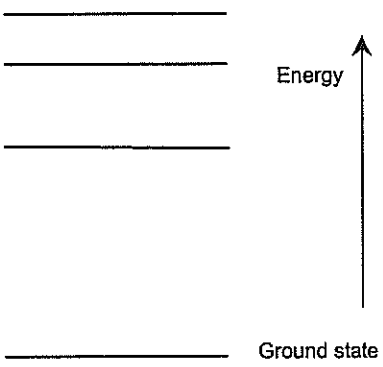
4. A certain gas is composed of excited atoms. The diagram illustrates the energy levels available to the electrons. How many lines would you expect in the emission spectrum?

Write answer in the square



Show in the diagram the transitions which give rise to these lines.

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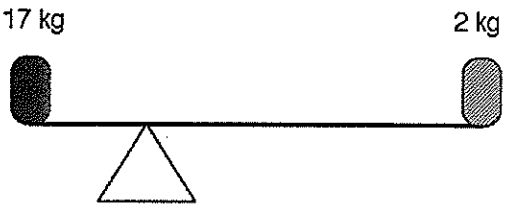
5. Estimate the maximum acceleration of a sprinter in a 100 m race.

6. Bridgette has just thought of a different way of measuring the mass of a plank. She has placed a mass of 2.0 kg on one end and a mass of 17 kg on the other. She finds the plank is balanced when pivoted at a point 2.9 m from the 2.0 kg mass. If the plank is 4.1 m long, what is its mass?



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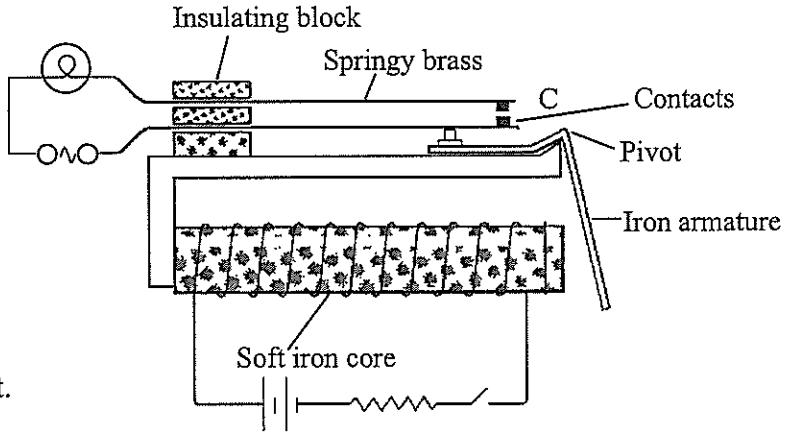
7. A piece of fresh human cartilage, with a 100 mm^2 cross-sectional area, is being studied in the laboratory. It is found that when loaded with 100 N, its length increases by 4.2%. Determine Young's modulus for the cartilage.

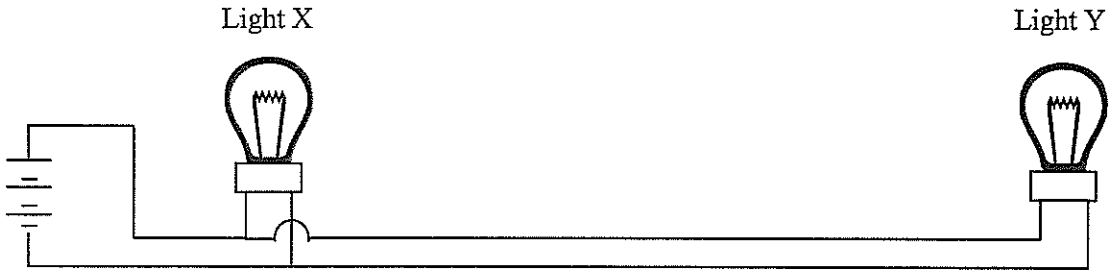
8. A mouse of mass 10 g runs up a large grandfather clock and clings on to the end of the minute hand, which happens to be 400 mm from the centre of the clock. What is the magnitude of the torque applied to the clock hand around the centre by the mouse if the time is ten minutes past five?

9.



The diagram shows a solenoid switch that can be used to turn on a light. Describe how the switch works, explaining how it can turn on the light.

10. Two identical high power lights are connected to a battery in the manner shown in the diagram, the second being connected by an extremely long pair of wires, similar to an extension cord. Because of the length of the wires, their resistance is not negligible. Explain any difference in the brightness of the lights.



11. Would the answer to Question 10 change if you used a high voltage power source (after replacing the lights with others of the same power but rated for the new voltage)? Explain.

12. When droplets of solutions of different chemical compounds are blown into a very hot flame, different colours are emitted from the flame depending on the elements in solution. Explain the physical principle by which these colours are produced.

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13. Explain why two different musical instruments sound different even if they are played at the same pitch.

SEE NEXT PAGE

14. Estimate the force a hammer thrower at the Sydney Olympics must exert on the handle to keep the 7 kg hammer moving in a circle.

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15. A laser beam used in surgery delivers 100 W of power to some tissue. If the laser emits red light of wavelength 680 nm, calculate the number of photons hitting the tissue each second.

SEE NEXT PAGE

SECTION B: Problem Solving

Marks allotted: 100 marks out of 200 total (50%)

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

NOTE that part (c) of questions 6 and 7 has two alternatives. Answer only **ONE** alternative for each question.

Answer the questions in the spaces provided.

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1. [8 marks total]

   (a) What is the speed of a satellite in a stable orbit 350 km above the surface of the earth?

   [4 marks]

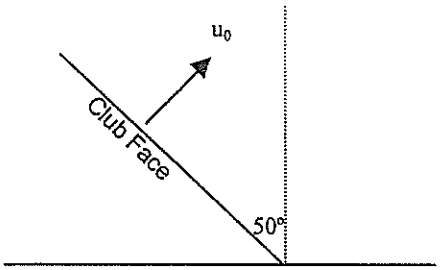
   (b) Justify the statement, ... *The acceleration due to Earth's gravity at the height of the orbit is only sightly less than at the surface of the earth.*

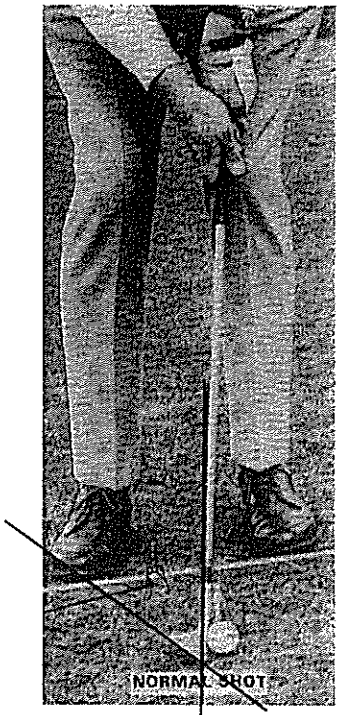
   [4 marks]

2. [15 marks total]

A wedge is a golf club designed to hit the ball over short distances. When correctly hit, the ball does not roll when it arrives at its destination, the green. To do this, the club face is lofted. This means that the club face is inclined to the vertical, as shown in the diagram.

Assume that when hit, the ball leaves the club face at right angles to the face.





(a) Write expressions giving the horizontal and vertical components of the ball's initial velocity u_0.

[2 marks]

(b) If you were given the vale of u_0, explain how you would calculate each of the following, giving appropriate equations: [6 marks]

(i) the horizontal distance travelled by the ball after a time *t*.

(ii) the height of the ball at any time *t*.

(iii) the horizontal distance from the ball to the green at any time *t*.

Tiger Smith, a champion golfer, is 100 m from the hole which is in the centre of the green. His wedge has a loft of 50°.

(c) With the help of the equations you gave in (b), find the velocity with which the ball must leave the club and the time the ball is in the air.

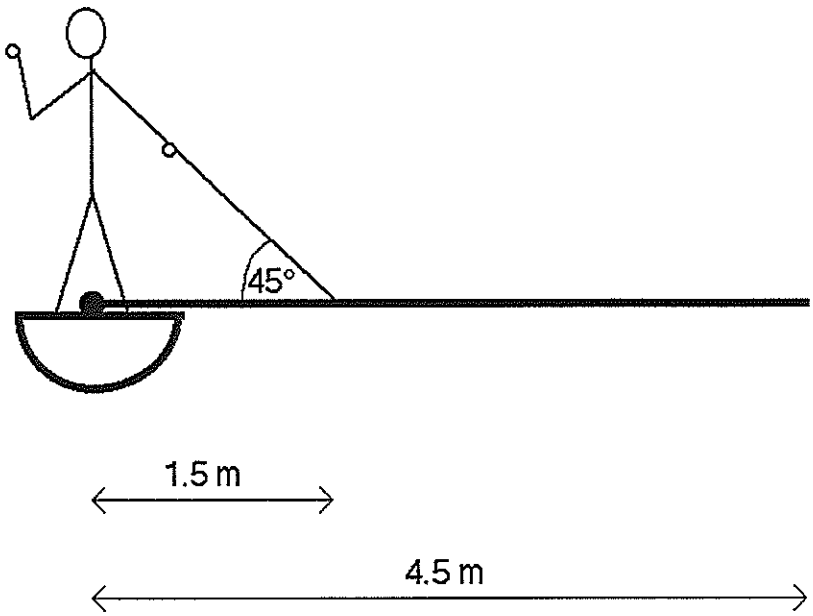
[4 marks]

(d) There is a large tree, 21 m tall, between Tiger and the green. If the tree is 70 m from Tiger, determine if the ball will clear the tree.

[3 marks]

3. [Total 15 marks]
As part of the training course for sailboarding, you have to practise lifting the sail and mast while on dry land and out of the wind. You lift the mast and sail by pulling on a rope that is attached to the mast 1.5 m from its base (see Figure 1). Assume that the centre of mass is 2.0 m from the base of the mast. The total mass of the mast and sail is 20 kg.

Figure 1



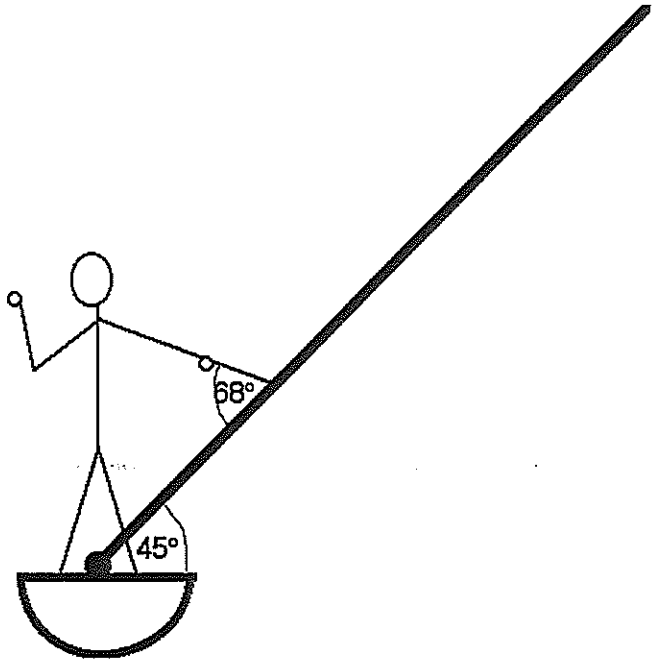
(a) Draw a diagram showing the directions of all the forces acting on the mast when it is in the horizontal position, indicating clearly the point at which each force is applied.

[3 marks]

(b) Calculate the magnitude of the tension in the rope when the mast has reached the position shown in the diagram (Figure 2).

[4 marks]

Figure 2



(c) As you slowly lift the mast from the horizontal to the vertical position, you would find that you have to pull hard at first, but it becomes easier the higher the mast is raised. Explain why this is so.

[4 marks]

(d) In the diagrams in 3(a) and 3(b), you are shown standing straight up while pulling on the rope and balancing the mast. In real life, this will not be the case. With the aid of a diagram, explain why.

[4 marks]

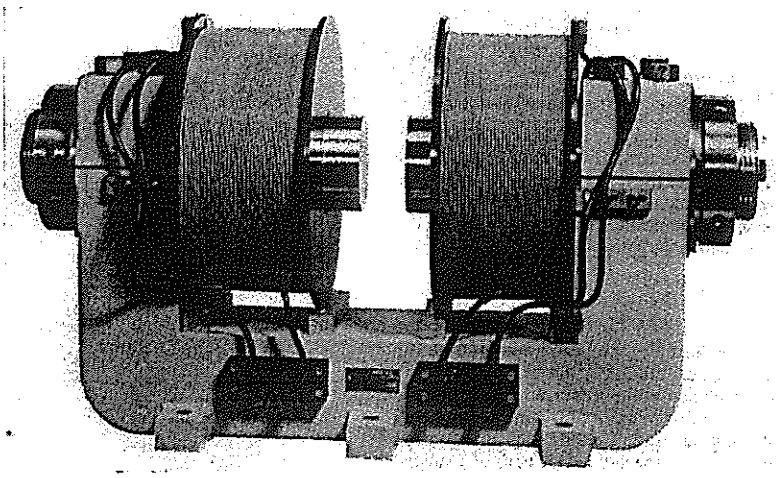
4. [Total 14 marks]

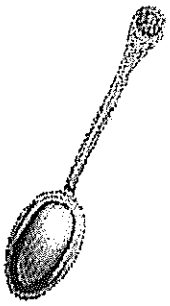
(a) A current is flowing through a long straight wire. With the aid of a diagram, describe the magnetic field associated with the wire. Show the direction a compass needle would take if placed below the wire.

[4 marks]

(b) The diagram shows a laboratory electromagnet capable of producing a strong magnetic field. Your classmate suggests that you could suspend a silver teaspoon in a magnetic field of 0.5 T using this electromagnet. Estimate the size of the current you would need to pass through the teaspoon.

[4 marks]





(c) State TWO methods of electricity generation. For each, give one important environmental consequence and its cause.

[6 marks]

Method 1 _____

Environmental consequence

Environmental consequence is caused by:

Method 2 _____

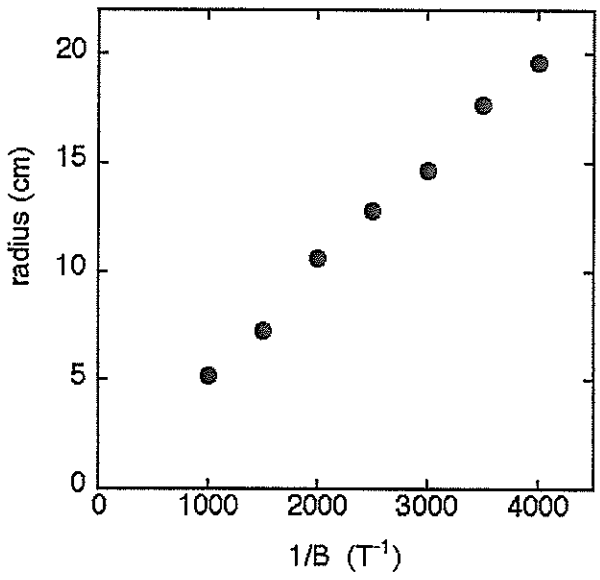
Environmental consequence:

Environmental consequence is caused by:

5. [Total 12 marks]

A team of physicists is studying a beam of electrons generated by an electron gun. They want to measure the speed v of the electrons as they enter a vacuum chamber. In order to do this, the team applies a magnetic field B to the vacuum chamber at right angles to the beam direction. The electrons are found to travel in a circular path in the magnetic field. They find that by increasing the magnetic field strength, the radius r of the circular path of the electrons decreases.

The diagram shows a plot of the radius of the circular path for different values of 1/B.



(a) Explain why the electrons move in a circular path and why the magnetic field affects the radius of the path.

[4 marks]

(b) Draw the straight line of best fit and determine its gradient.

[2 marks]

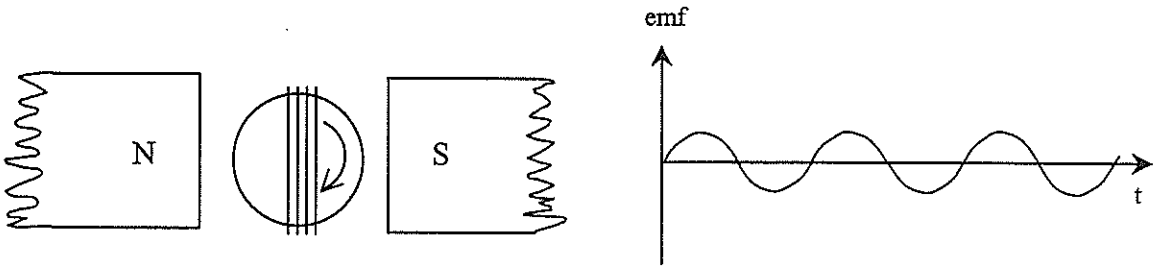
(c) Use the value you have calculated for the gradient to find the speed v of the electrons.

[4 marks]

(d) State TWO advantages of using a straight line graph to determine the value of v rather than using a single measurement.

[2 marks]

6. [Total 16 marks]
A coil is rotated in a magnetic field as shown. A graph of the voltage (emf) generated is also shown.



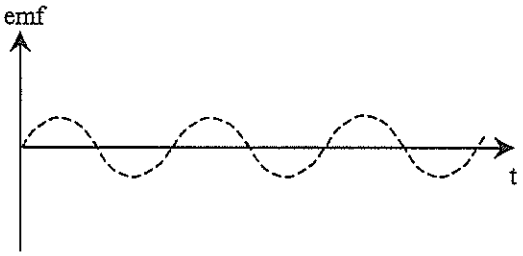
(a) Explain why the voltage is generated in the coil and why the graph of the output voltage takes the form shown.

[4 marks]

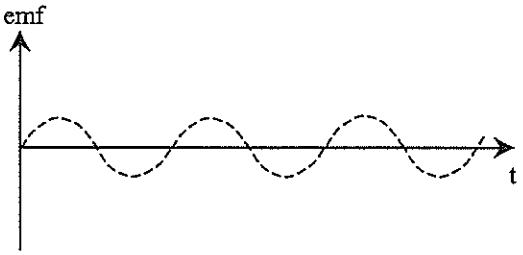
(b) In each of the following cases, sketch (on the diagram) a graph of the output voltage when the changes indicated are made. Give reasons for your answers. The dotted line represents the voltage before the change has been applied.

[6 marks]

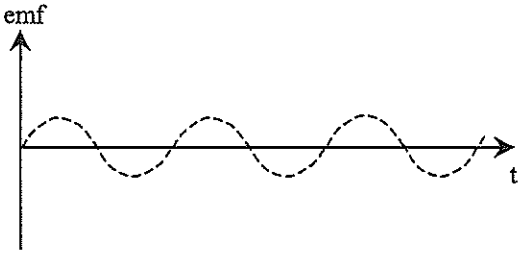
(i) The magnitude of the magnetic field is doubled.



(ii) The number of turns in the coil is doubled.



(iii) The rate of rotation of the coil is doubled.



Answer EITHER part (c) below **OR** part (d) on page 24.

If a student attempts more than one of these alternatives, only the first response will be marked. Cancel any response that you do not wish markers to consider.

(c) *Context: Power for transport*

Experiments have been carried out on magnetic levitation systems to replace rail transportation. In these, the mass of the train is supported by a magnetic system rather than wheels. With the aid of diagrams, explain the principle of this technique, using as an example a possible practical means of supporting the train.

[6 marks]

Answer EITHER part (d) below **OR** part (c) on page 23.

If a student attempts more than one of these alternatives, only the first response will be marked. Cancel any response that you do not wish markers to consider.

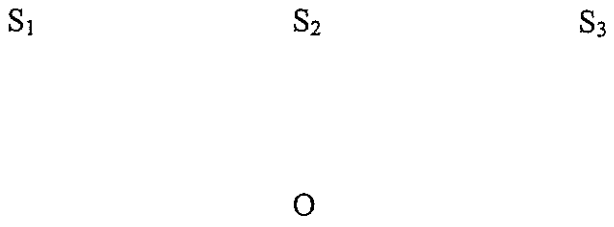
(d) *Context: Domestic power supply and consumption*
Magnetic tapes, such as audio cassettes and video cassettes, are used to store information. With the aid of diagrams, explain the principles used to store information on the tape and to read information from the tape.

[6 marks]

7. [Total 20 marks]

(a) At a concert, three loudspeakers S_1, S_2 and S_3 are arranged in a line as shown in the diagram. Bridgette is standing at point O, which is directly in front of the middle speaker S_2.

[5 marks]



With all three speakers playing music, the sound level heard by Bridgette is 88.5 dB. Determine the sound level heard when two speakers are disconnected, assuming all speakers contribute equally to the sound level.

(b) A low frequency test tone is now played. The sound level when only speakers S_1 and S_2 are connected is much lower than when only S_1 is playing. With the aid of a diagram, explain the cause of this.

[5 marks]

Answer EITHER part (c) below **OR** part (d) on page 28.

If a student attempts more than one of these alternatives, only the first response will be marked. Cancel any response that you do not wish markers to consider.

(c) *Context: Speaking and hearing.*
Sound waves of a particular frequency can set up a standing wave in a room.
[10 marks]

(i) How would you be able to tell there is a standing wave?

(ii) Explain how the standing wave is caused, describing the conditions necessary to cause a standing wave.

(iii) With the aid of a diagram, explain a method you could use to measure the wavelength of the standing wave.

Answer EITHER part (d) below **OR** part (c) on page 27.

If a student attempts more than one of these alternatives, only the first response will be marked. Cancel any response that you do not wish markers to consider.

(d) *Context: Musical instruments.*
Many instruments, such as the violin, work by setting up a standing wave in a string. [10 marks]

(i) How would you be able to tell there is a standing wave?

(ii) Explain how the standing wave is caused, describing the conditions necessary to cause a standing wave.

(iii) With the aid of a diagram, explain a method you could use to measure the wavelength of the standing wave.

SECTION C: Comprehension and Interpretation

Marks allotted: 40 marks out of 200 marks total (20%)

BOTH questions should be attempted. Each question is worth 20 marks.

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

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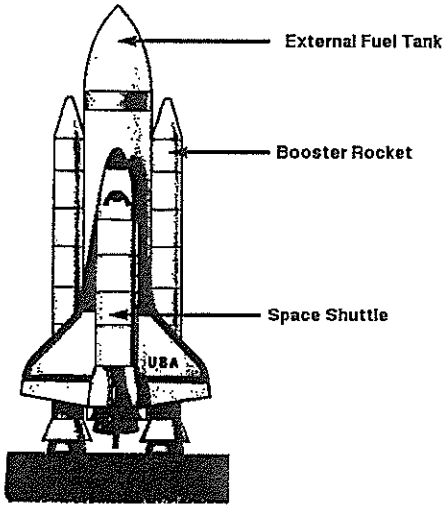
1. THE INTERNATIONAL SPACE STATION



(Paragraph 1)
The International Space Station (ISS) is a joint project between several European countries and the USA. When finished, the station will orbit 350 km above the surface of the earth. In December 1998, the first module, called Unity, was taken into orbit on board the space shuttle Endeavour.

(Paragraph 2)
There are several stages in a space shuttle mission. At launch, two booster rockets and a large external fuel tank are mounted on the under side of the shuttle (see diagram). The booster rockets supplement the thrust of the shuttle's own engines during lift off. The launch is arranged so that the rockets propel the shuttle towards the east as it rises. When the shuttle reaches a height of 50 km, the booster rockets have used up all of their fuel and are jettisoned. The shuttle continues its journey to the required height above the surface of the Earth. Just before going into orbit around the Earth, the empty external fuel tank is jettisoned. Once in orbit, the doors to the cargo bay can be opened in order to unload cargo such as a space station module.

(Paragraph 3)
When planning a space shuttle mission, calculations have to be made to determine the amount of fuel needed. The changes in kinetic and potential energy of the different components of the launched assembly have to be taken into account. The launch site for the shuttle is Cape Kennedy, which is in the south of the USA. Recently, consideration has been given to building a launch site at Cape York in northern Queensland in Australia because this site is nearer to the equator. Launches from nearer the equator enable greater payloads to be carried by the shuttle.

SEE NEXT PAGE

Shuttle Mission Specifications

	Mass when empty	Mass when fully fuelled
Shuttle	7.9×10^4 kg	9.3×10^4 kg
Booster rocket *	8.7×10^4 kg	5.0×10^5 kg
External fuel tank	3.0×10^4 kg	7.2×10^5 kg
Unity	1.2×10^4 kg	

*data refer to a single rocket

(a) What is the total mass that is launched from the launch site? What is the major component of this mass?

[2 marks]

(b) Explain the key reason why the booster rockets are ejected from the shuttle early in the mission (paragraph 2).

[3 marks]

(c) Is the acceleration of the space shuttle uniform during its journey into orbit? Justify your answer.

[4 marks]

(d) Why do launches from nearer the equator enable greater payloads to be carried by the shuttle (paragraph 3)?

[4 marks]

(e) Why is the launch arranged so that the rockets propel the shuttle in an easterly direction (paragraph 2)?

[3 marks]

(f) What forces are exerted on an astronaut resting inside the International Space Station while it is in orbit around the Earth? Describe the effect of any forces you mention.

[4 marks]

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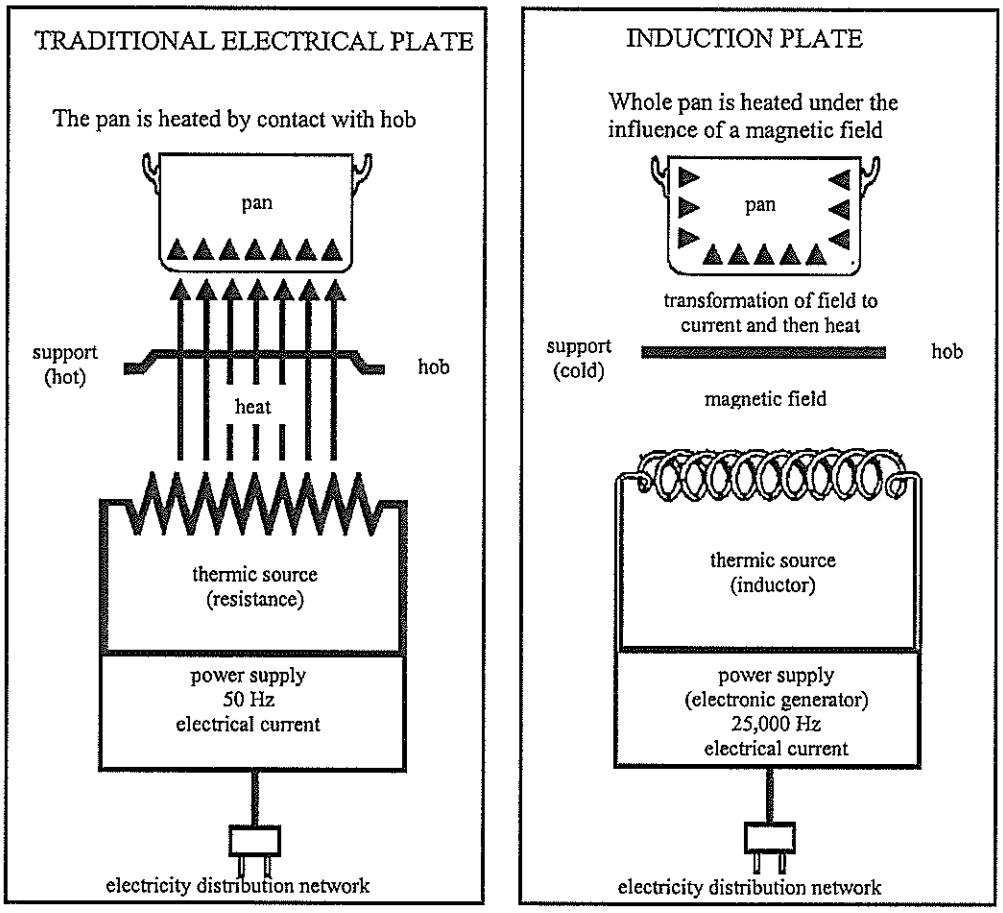
2. INDUCTION COOKERS



(Paragraph 1)
Cooking has come a long way since people first roasted meat over an open fire. The latest methods seem to use everything but flames to cook the food. The most radical method in recent years is the induction method, in which heat is literally induced in the saucepan. The heat flow mechanism is different from that in a traditional electric hot plate.

(Paragraph 2)
Electromagnetic induction is hardly new—it was discovered by Michael Faraday in the nineteenth century—but its application to cooking certainly is. To the user, the most dramatic departure from conventional heating methods is that the top of the cooker, called the hob, remains cool because the heating element is the utensil itself.

(Paragraph 3)
The hob is made of a ceramic material, which is an electrical insulator. Under the hob, there is a frequency transformer pack, which changes the the mains frequency of 50 Hz to 25,000 Hz. The alternating current under the hob generates an alternating magnetic field at the level of the saucepan. The alternating magnetic field induces an electric current in the saucepan or frying pan causing heat to be generated in the pan itself. For this to work, the pan must be made of metal.

(Paragraph 4)
The advantage of induction cookers is that they are as efficient as gas. They can boil water as quickly. When the pan is removed from the hob, it is no longer within the magnetic field and so heat generation ceases. In this sense, the pan "switches itself off" when it is removed from the hob. The hob stays cool throughout the cooking process and it is easy to keep clean since the surface is flat.

SEE NEXT PAGE

(a) With reference to the diagram, explain the major physical principles involved in the induction heating method.

[5 marks]

(b) Explain why the cooking pan needs to be made of metal (paragraph 3).

[2 marks]

(c) Using Faraday's Law, explain why it is necessary to change the frequency from 50 Hz to 25000 Hz.

[4 marks]

(d) Explain why induction cookers "switch off" when the cooking pan is removed (paragraph 4).

[2 marks]

(e) Predict what would happen if you switched on the cooker and put your hand on the hob. Explain your answer.

[4 marks]

(f) What difference do you think it would make if you replaced your cooking pan with one having a thicker base? Give your reason.

[3 marks]

END OF PAPER

Extra Work Space/Rough Work

ACKNOWLEDGEMENTS

Diagrams in Questions A9 and B4 adapted from "Ordinary Level Physics", A. F. Abbott, Heinemann (1969).

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