GOVERNMENT OF WESTERN AUSTRALIA

CURRICULUM COUNCIL

TERTIARY ENTRANCE EXAMINATION, 1997

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.

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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. Choose an appropriate number of significant figures, usually no more than three. Despite an incorrect final result, credit may be obtained for method and working, providing these are clearly and legibly set out.

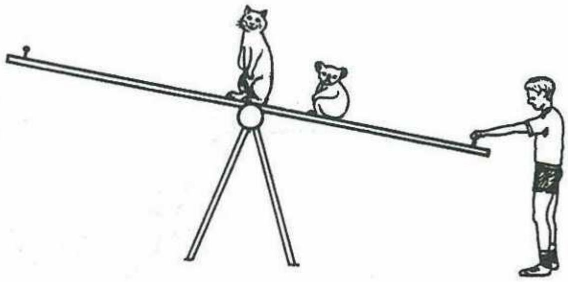
Questions containing the instruction 'estimate' may give insufficient numerical data for their solution. Students should provide appropriate figures to enable an approximate solution to be obtained.

SECTION A: Short Answers

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

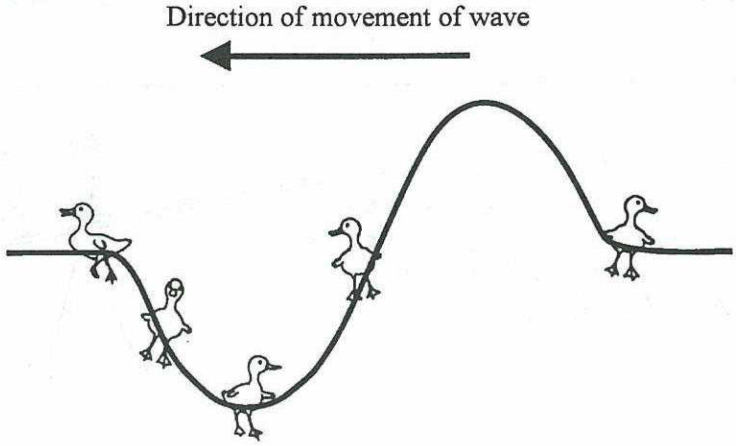
Attempt ALL 15 questions in this section. Each question is worth 4 marks. Answers are to be written in the spaces provided.

1. Ben is showing an interest in science at an early age. He has placed two toys on his see-saw. As he pushes down the end of the see-saw, which toy will tip over first? Why is this? (Assume the toys are of similar construction.)



2. What is the wavelength of the radiation emitted from 50 Hz electric power lines? What is the energy of a photon of this wavelength?

3. Brigette is watching some ducklings, which are paddling on a pond, when a wave approaches them. Use arrows to show the direction of movement of each duckling at the instant shown on the diagram. If there is no movement, label "no motion".



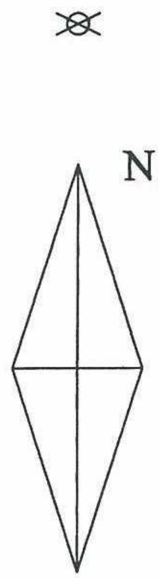
4. With the aid of a diagram, explain the mechanism which causes fluorescence.

5. Sound waves have different velocities from electromagnetic waves. List two other differences between sound waves and electromagnetic waves.

6. A vertical wire is placed a short distance from the north pole of a compass. A current is then passed downwards through the wire. On the diagram (which is viewed from above), sketch

(i) the magnetic field due just to the wire.

(ii) the direction of the compass after the current has been turned on.



7. Calculate the force of attraction the Moon exerts on the Earth.

8. Brigette is at the swimming pool to carry out an experiment on sound. She hits the metal ladder at one end of the pool with her spanner. The sound travels through both the air and the water. Estimate the difference in the times of arrival of the two sounds at the far end of the pool.

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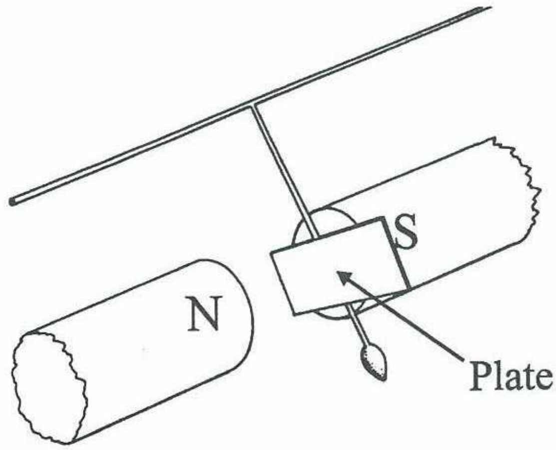
9. An oscillating pendulum can be brought to rest more rapidly (ie damped) by having an aluminium plate attached to it that passes between the poles of a magnet.

   (i) State the principle being employed here.

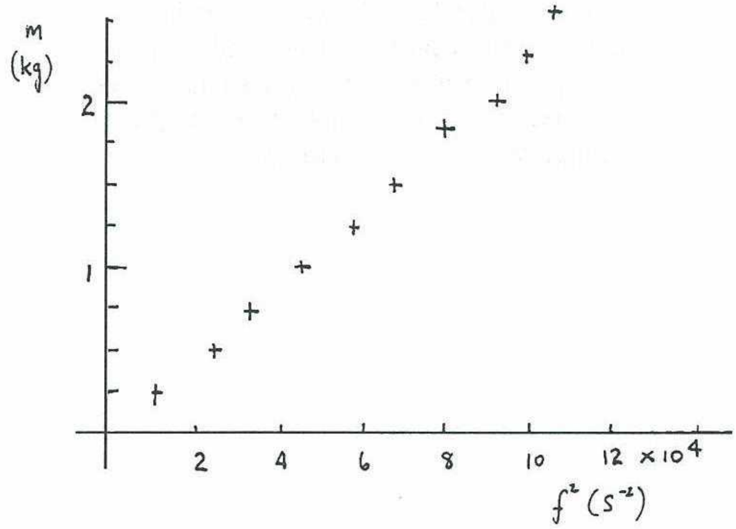
   (ii) State two ways in which the damping may be increased.

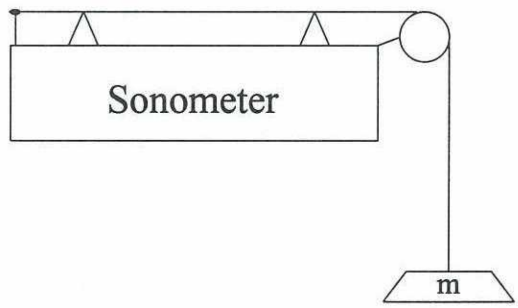


10. Brigette has found that the fundamental frequency of a stretched wire depends on the tension. She has borrowed a sonometer and carried out experiments, applying a tension to a wire of length L = 0.585 m by using different masses m, and drawn the graph shown. She wants to work out the mass per unit length μ of the wire using the slope of the graph and the relationship

$$m = \frac{4\mu L^2}{g} f^2$$

Show how it is done.





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11. Distribution of electric power involves the loss of a significant proportion of the energy. State two sources of "transmission" loss.

12. Brigette's room is rather cold, and she wants to replace her 2500 W heater. She has seen this advertisement for a heater. She asks you to explain what the "mj" means and whether this heater will be warmer than her present heater. What would you say to her?

13. The light coming from the Sun is a continuous spectrum, except there are some specific wavelengths missing (called the Fraunhofer lines). Explain what causes these lines.

14. In a satellite experiment there was an attempt to stretch a wire between a space shuttle and a satellite at higher orbit to generate electricity. The wire was 20.7 km long and the voltage to be generated was 5000 V when the shuttle had a velocity of 7.92 km s^{-1}. Find the magnitude of the component of the Earth's magnetic field perpendicular to the motion of the wire.

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15. You have made a coil by winding a long length of copper wire around the cardboard centre of a toilet roll. You now place a magnet near the end of the coil. If the magnetic field near the end of the magnet is 0.12 T, estimate how quickly (ie in what time) you must pull the magnet away from the coil in order to generate an emf of about 1 V in the coil.

SEE NEXT PAGE

SECTION B : Problem Solving

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

This section contains 7 questions, two of which contain a choice. You should answer
ALL of the questions 1, 2, 3, 4, and 5
EITHER 6A OR 6B
EITHER 7A OR 7B
Answer the questions in the spaces provided.

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1. [12 marks total]

"That's not music, it's just a horrible loud noise".
Have your parents ever made these comments about your favourite music?

(a) What is the difference between music and noise? [4 marks]

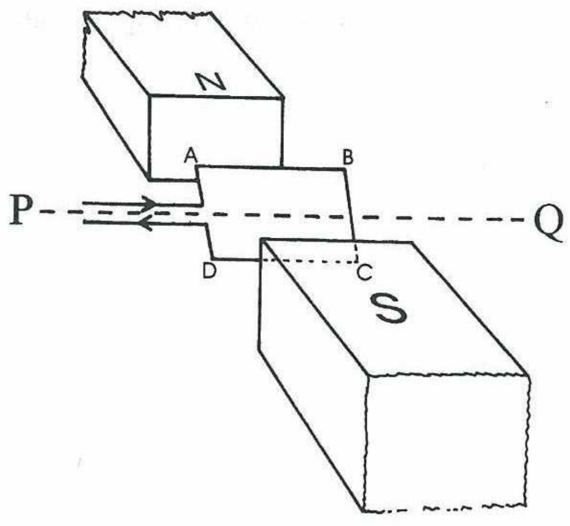
(b) You are playing your CD in your room at 96 dB when you decide to dry your hair with a rather noisy hair dryer, which operates at 99 dB. Calculate the total sound level. [4 marks]

(c) You notice that during some passages of the music on your CD, an ornament on the cupboard vibrates, but for most of the music, it doesn't. Explain why the ornament vibrates only during particular passages.

[4 marks]

2. [14 marks total]

The coil ABCD, which is free to rotate about the axis PQ, is placed in a magnetic field of 98 mT. The coil consists of 25 turns and a current of 2.2 A is passing through it. The coil is rectangular, with AB = 55 mm and BC = 35 mm.



(a) Show on the diagram the direction of the force exerted on each of the four sides of the coil.

[2 marks]

(b) Calculate the force exerted on side AB of the coil.

[4 marks]

(c) [4 marks]

(i) On the graph below, sketch the torque on the coil as it is rotated through 360°. (No calculation required.)

(ii) At which positions of the coil does it experience maximum and minimum torque? Give reasons for your answer.

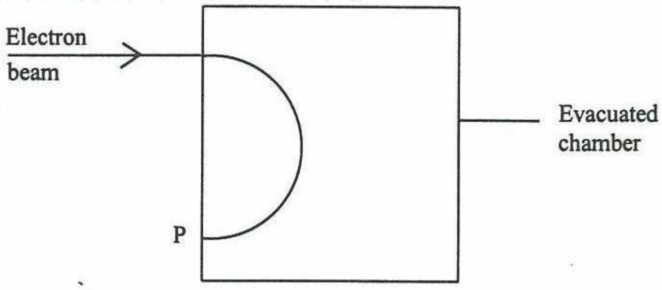
(d) [4 marks]

(i) Explain what you must do to convert the arrangement in part (a) into a motor.

(ii) State two ways in which you could increase the power of the motor.

3. [15 marks total]

A beam of electrons having energies between 10 and 100 keV passes through a slit into an evacuated chamber as shown. A magnetic field makes the electrons move in a semicircle and those with a particular velocity hit the wall at the point P. The chamber is approximately the size of a cereal packet.



(a) What is the direction of the magnetic field needed to make the electrons move in this path? *(Circle the correct answer).*

[2 marks]

A. Out of the page	D. To the left
B. Into the page	E. Top to bottom
C. To the right	F. Bottom to top

(b) [4 marks]

(i) Explain why electrons of a particular velocity go to point P.

(ii) Sketch on the diagram the path taken by an electron with a higher velocity.

(c) When the electrons hit the metal walls of the chamber, most of their energy appears as heat. What happens to the remainder?

[2 marks]

(d) Estimate the magnitude of the magnetic field required to make the electrons move in this path.

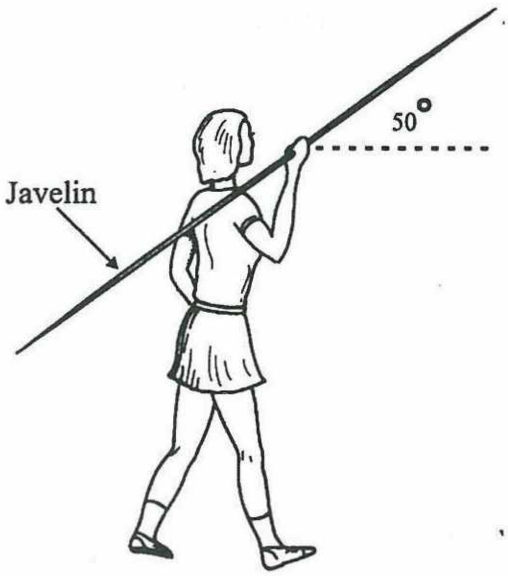
[4 marks]

(e) What two changes would you have to make in order to carry out this experiment on a beam of protons so that protons of a similar velocity to that of the electrons in part (b) arrive at P? Briefly justify.

[3 marks]

4. [18 marks total]

Deanne, a world class javelin thrower, is shown preparing to throw. At the instant of release, the 0.600 kg javelin has a velocity of 27.5 ms^{-1} at an angle of 50.0° to the ground. The javelin is 2.10 m from the ground when released.



(a) How long is it before the javelin reaches its maximum height?

[4 marks]

(b) What height above ground level does the javelin reach?

[4 marks]

(c) How far away from Deanne does the javelin hit the ground?

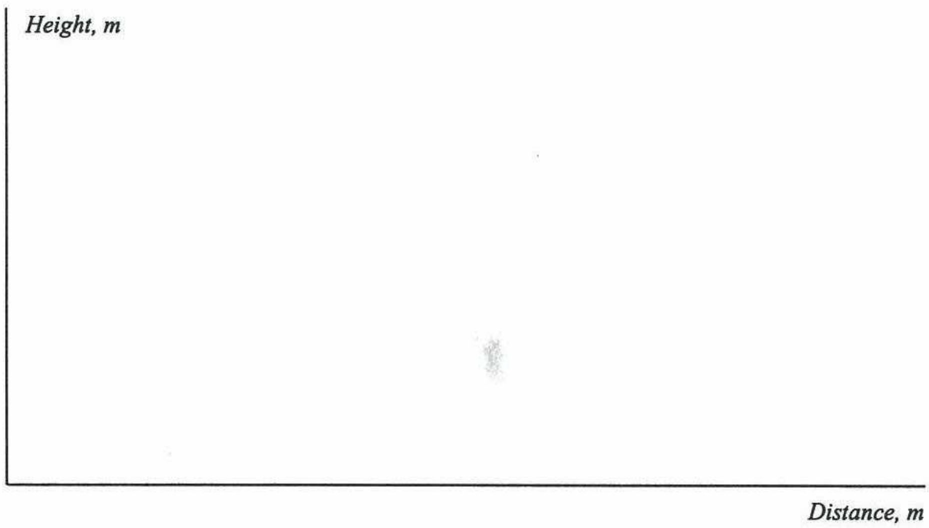
[4 marks]

(d) (No calculations are required for the following) [6 marks]

(i) Sketch the trajectory of the javelin on the graph below. Label this i.

(ii) Sketch on the graph the trajectory of the javelin showing how it would be changed if you allowed for air resistance. Label this ii. Explain why the trajectory changes in this way.

(iii) Sketch on the graph the path of the javelin if it is thrown at an angle of 45° rather than 50° (neglecting air resistance). Label this iii.



5. [12 marks total]

You are asked to set up an experiment to measure the wavelengths of harmonics by finding the positions of nodes in a pipe. You are provided with:

(i) a transparent perspex tube closed at one end, apart from a small hole
(ii) a small loudspeaker
(iii) a microphone on the end of a thin rod about 1 m long (the rod exactly fits the small hole in the end of the perspex tube)
(iv) a metre rule
(v) a sinewave generator
(vi) an oscilloscope (CRO)
(vii) lots of leads

(a) Briefly explain the principle of the experiment, using appropriate sketches and equations.

[6 marks]

(b) In a sketch, show how you would arrange the experimental equipment to carry out the measurements.

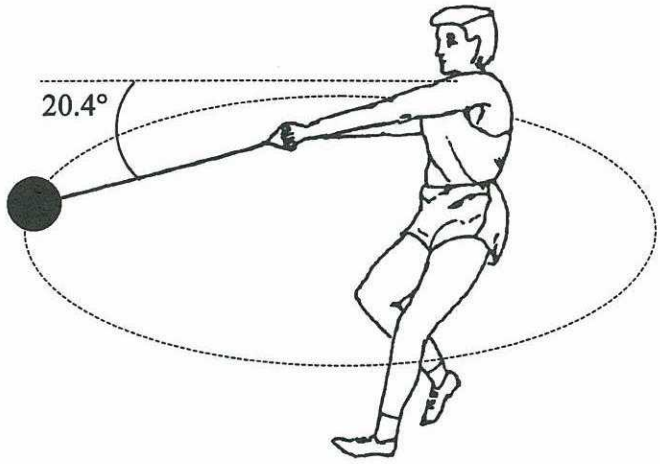
[3 marks]

(c) Draw a table to show how you would set out your results.

[3 marks]

Question 6A (page 20) refers to the context *Sport and Physics*
Question 6B (page 22) refers to the context *Playgrounds, Funfairs and Physics*
You must answer only **ONE** of these questions, each of which is worth 13 marks.

6A. Simon is practising the hammer throw. He spins the 7.26 kg hammer in a horizontal circle of radius 1.60 m, rotating once every 1.55 s. Assume Simon's arms make a straight line with the hammer handle. At this speed the hammer makes an angle of 20.4° to the horizontal.



(a) Calculate the tension in the wire handle of the hammer.

[5 marks]

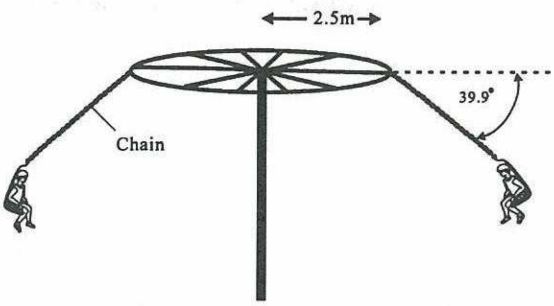
(b) Explain why Simon is leaning back.

[4 marks]

(c) How does the angle the hammer makes with the horizontal change if Simon increases his rate of rotation? Explain.

[4 marks]

6B. James is enjoying a thrilling ride at the Perth Royal Show on the hanging chair merry-go-round. The support rim has a radius of 2.5 m and the chains are 3.5 m long. The ride rotates once every 4.18 s and James has a mass of 50 kg. At this speed the supporting chain makes an angle of 39.9° to the horizontal.



(a) Find the force the seat exerts on James.

[5 marks]

(b) Explain why James does not fall out of the seat.

[4 marks]

(c) How does the angle the chains make with the horizontal change as the merry-go-round speeds up? Explain.

[4 marks]

Question 7A (page 24) refers to the context *Bridges and Buildings*
Question 7B (page 26) refers to the context *Human and Animal Frames*
You must answer only **ONE** of these questions, each worth 16 marks

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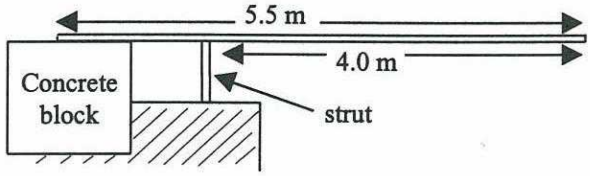
7A. A diving board is constructed as shown in the diagram. One end is fixed firmly to a concrete block and the board is supported by a single wrought iron strut. The board has a mass of 75 kg.



(a) Calculate the force on the strut if safety standards specify that it has to support 10 times the mass of an 85 kg diver acting at the end of the board.

[5 marks]

(b) What is the minimum cross-sectional area of the strut required so that it does not break?

[3 marks]

(c) If the strut has the minimum cross-sectional area from part (b), and is 0.3 m long when unstressed, by how much will it shorten when under maximum load?

[4 marks]

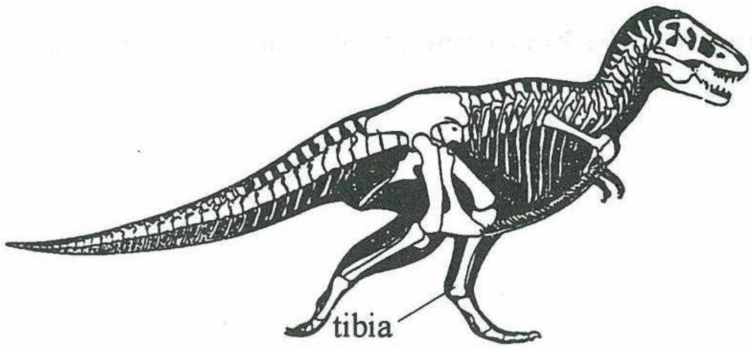
(d) The end of the diving board is firmly attached to a large mass of concrete. Explain why this is necessary.

[4 marks]

7B. Albert, an albertosaurus, is a cousin of tyrannosaurus. Albert is 3.4 m tall and has a mass similar to a family car (1500 kg). He walks on two legs, and at times his whole mass must be supported by one leg.

(a) Bipedal dinosaurs like Albert had massive tails as shown in the drawing. Explain how this would make it possible for them to bend over to eat their prey while standing on two legs.

[4 marks]



(b) Find the minimum total cross-sectional area of Albert's tibia if it is to support his entire mass without fracture.

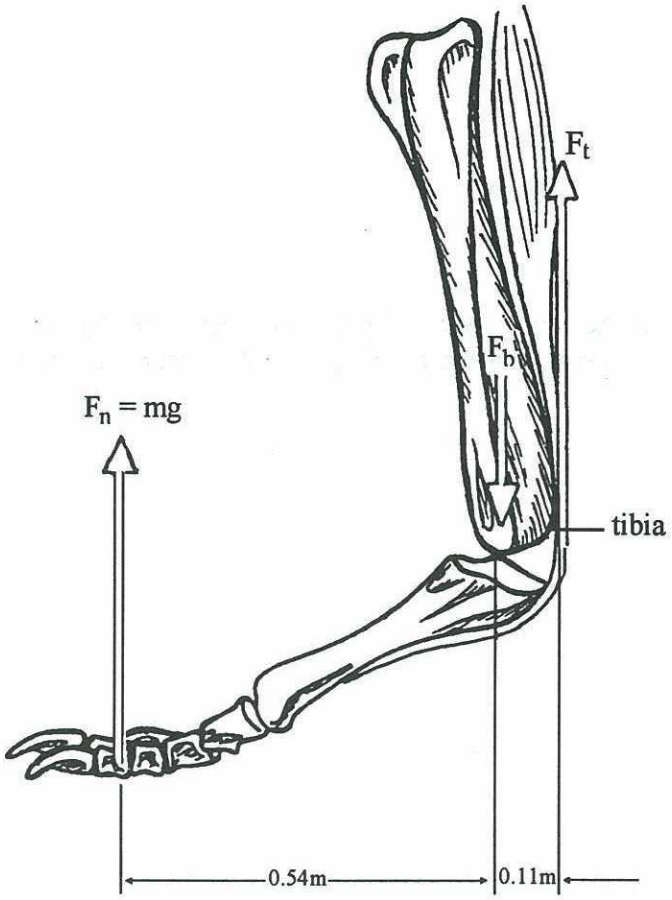
[3 marks]

(c) If the tibia is 0.5 m long when unstressed, by how much will it be shortened when Albert's full mass is resting upon it? Assume the tibia is uniform.

[4 marks]

(d) Using the dimensions shown, calculate the force F_b when Albert is standing on one leg.

[5 marks]



Section C: Comprehension and Interpretation

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

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

Read each passage carefully and answer all the questions referring to the passage. Candidates are reminded of the need for clear and concise interpretation of the answers. Diagrams (sketches) and equations and/or numerical results should be included if they are appropriate.

The following questions refer to the passage on page 30.

1. (a) What is a "ground"? Use a diagram to illustrate. Hence explain how it can protect you against electrocution (paragraph 2).

[6 marks]

(b) Why is the ground wire either fastened to a pipe driven into the ground or fastened to a cold-water pipe (paragraph 3), instead of, for example, the ground wire just being buried in the ground?

[2 marks]

1. ELECTRICAL SAFETY

(Paragraph 1)
It was inevitable that the increasing use of electricity would present increasing electrical dangers. The problem is not one of bare wires. Instead, the insulation on a wire often ages and breaks.

(Paragraph 2)
Once the insulation is broken, it is possible for the current to pass throughout the metal housing, as well as through the wiring. If you were to hold a defective appliance and touch a water pipe or furnace vent, you would "ground" the appliance and probably electrocute yourself. A ground is a short circuit to the ground, which is capable of handling all the current in the circuit. Grounding an appliance by allowing current to go through your body sets up the condition needed for your electrocution!

(Paragraph 3)
In order to provide some protection against unwanted ground connections, modern household, commercial, and industrial electrical wiring has a built-in grounding circuit. Modern homes and buildings have a third hole in the electrical outlet. The third hole connects an appliance to a ground wire that is either fastened to a pipe driven into the ground or fastened to a cold-water pipe. This connection provides a low-resistance electrical path for any unwanted current.

(Paragraph 4)
If for some reason you have a short circuit, there will be an immediate increase in the current through the wiring. The voltage will remain at the rated 120 volts, but the current can easily surge from a few amperes to dozens of amperes. Left alone, this high current will heat the wiring and can cause a fire. Your electrical protection, however, is a fuse or circuit breaker, designed to limit the current to a safe level, typically, 15 or 20 amperes. If a fuse is burned out, it may be that too many appliances are plugged into the same circuit. Unplug some of the appliances and replace the fuse. Never replace a fuse with a nail. A nail will not limit the current to a safe level. Houses have burned down because of this foolish action.

(Paragraph 5)
The important factor in electrocution is the amount of current flowing through the body. The table lists the physiological effects of various currents flowing between your arms.

Current (mA)	Physiological effect
1	Threshold of feeling
5	Accepted maximum harmless current
7-15	"Can't let go" current (paralysis)
50	Pain, possible fainting and exhaustion
100-300	Ventricular fibrillation and death
>300	Ventricular paralysis and burns

(Paragraph 6)
Low values of current produce a tingling sensation. If the current should be larger, the electrical jolt is painful and sometimes paralyzes the muscles. When your muscles become paralyzed, you cannot open your hands and break the circuit.

(Paragraph 7)
If the current should be even larger, the current flowing through your body can disrupt the beating of your heart. Your heart stops its rhythmic pumping and flutters uselessly (so-called ventricular fibrillation). During ventricular fibrillation, blood stops flowing and you die from lack of oxygen in the brain after a few minutes. Surprisingly, currents larger than about 0.3 amperes paralyze your heart instead of causing ventricular fibrillation.

(Paragraph 8)
Since the current needed for electrocution is much less than the limit set by a fuse or circuit breaker, is there any protection available? The resistance between the hands can be as high as 1,000,000 Ω for very dry skin and can fall to 1000 Ω for damp skin. However, skin resistance is not a dependable protection, because the resistance depends greatly upon perspiration and skin oils.

(c) What are the two main dangers associated with the use of electricity, according to the article?

[3 marks]

1. ______________________________

2. ______________________________

(d) Why isn't it safe to replace a fuse with a nail (paragraph 4)? Explain.

[4 marks]

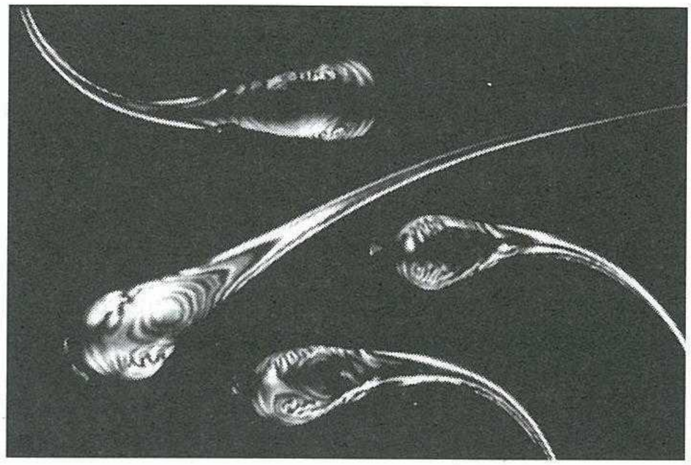
(e) Does the information given in the article indicate that the American voltage (120 V) is any safer than the Australian voltage (240 V)? Explain your reasoning.

[5 marks]

2. PRINCE RUPERT'S DROPS

(Paragraph 1)
In London at the end of the 17th century, scientific toys were popular. Fashionable among them were curious, tadpole-shaped glass drops – known in England as Prince Rupert's Drops – that already had been tantalizing both the scientific and non-scientific intelligentsia in Europe since at least 1625.

(Paragraph 2)
Prince Rupert's Drops, so-named because the German prince presumably brought them to England, were made by letting molten drops of glass fall into cold water in which they would rapidly cool and solidify. Making them was hit-and-miss; many would disintegrate in the making. However, "Every one that cracks not in the water and lies in it, till it be quite cold, is sure to be good", as Sir Robert Moray had recorded in 1661 when he was president of the Royal Society in London.



(Paragraph 3)
Successfully made drops often took the form of a glass 'teardrop' tapered over one or several centimetres to a pointed end. The most puzzling trait of these small glass structures, and for which they gained fame, was the ability of their 'heads' to withstand hammer blows, yet if the tail were broken with the gentlest of finger pressure, they explosively disintegrated.

(Paragraph 4)
After initial experiments by the Royal Society, Robert Hooke undertook his own set of more systematic studies with the drops. By encasing the drops in fish glue, for example, he was able to trigger disintegration of the drops, yet preserve the fracture pattern for observation through his microscopes. In his *Micrographia* (1665), Hooke provided a beautiful illustration of a drop with many linear cracks angularly radiating from what appears to be a central spine out of the drop's surface.

(Paragraph 5)
Hooke's theory, which has only been elaborated on in recent years, held that the outermost portion of the drop solidifies more quickly than the interior leaving the inside in a state of tension so that the structure resembled an arch whose entire integrity vanishes if broken anywhere.

(Paragraph 6)
Isaac Newton found enough interest in the phenomenon and Hooke's explanation that, in his notes, he paraphrased Hooke : "... so that this drop being like an arched roof dissolves all into dust when the equilibrium of pressure towards the centre etc. is destroyed by breaking the least snip of its tail or scratching it". The metaphor of the arched roof suggests that Newton and Hooke both guessed that the surface was in a state of compression even as the interior was in a tensile state, a double-charged situation which later generations of scientists would use to explain the particularly catastrophic mode of the drops' disintegration.

(Paragraph 7)
The spectacular fracture behaviour of Prince Rupert's Drops could be explained more precisely in terms of microcracks that grow only so long as they are in a tensile environment like the inside of a drop and only so long as the product of the stress and the square of the crack's diameter exceed a certain threshold. Any intact drop has surface microcracks approximately perpendicular to the surface, but these are initially under compressive forces that prevent the cracks from expanding and propagating. Breaking a drop's tail, however, introduces a local tensile stress in the surface, or unleashes the tensile stress inside the drop, leading to a comprehensive network of cracks that speedily reduces the entire structure to rubble.

SEE NEXT PAGE

(a) Sketch the outline of one of these Prince Rupert's Drops and show on your sketch the regions in which the glass is in tension and those in which the glass is under compression.

[4 marks]

(b) Why did Hooke say the structure resembled an arch (paragraph 5)?

[3 marks]

(c) With the aid of a diagram, explain why the microcracks grow when the tail is broken (paragraph 7).

[4 marks]

(d) Draw and describe the stress-strain diagram for a brittle material such as glass. Use this diagram to explain why the drops fracture rather than deform.

[5 marks]

(e) The drops could withstand hammer blows (paragraph 3), but this is not normal behaviour for glass. Explain why the drops behave in this way.

[4 marks]

END OF PAPER