TERTIARY ENTRANCE EXAMINATION, 1995

QUESTION/ANSWER BOOKLET

PHYSICS

Please place your student identification label in this box

SEA 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 Secondary Education Authority.

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	8	8*	100	50%
C: Comprehension and Interpretation	2	ALL	40	20%

Note that in Section B there is some internal choice in Questions 7 and 8.

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 Secondary Education Authority 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**" provide 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 space below or next to each question.

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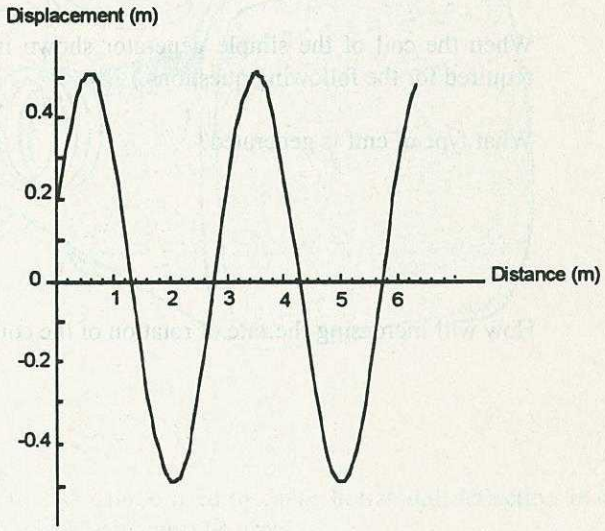
1. You can make a wave move along a rope by moving one end up and down. At a particular instant, the shape of such a rope is as shown in the diagram. Write down the amplitude and wavelength of the wave moving along the rope.

(No explanation required)



Amplitude _____

Wavelength _____

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2. An apple on a tree is attracted by the Earth. Is the Earth attracted by the apple? Explain your answer.

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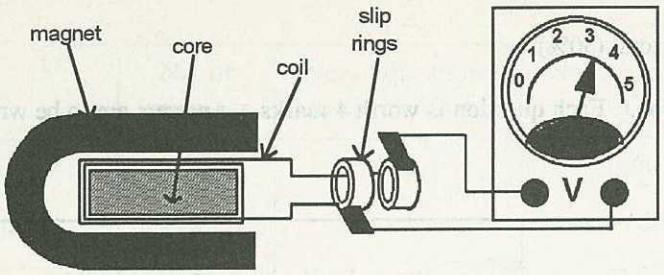
3.



When the coil of the simple generator shown is turned, an emf is induced. (No explanations are required for the following questions.)

What type of emf is generated?

How will increasing the rate of rotation of the coil affect the magnitude of the output emf?

What is the source of the electrical energy induced in the coil?

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4. In solar cells, radiation from the sun is used to move electrons from the valence band into the conduction band. If a photon energy of at least 1.12 eV is needed, what is the longest wavelength in the solar radiation which can do this?

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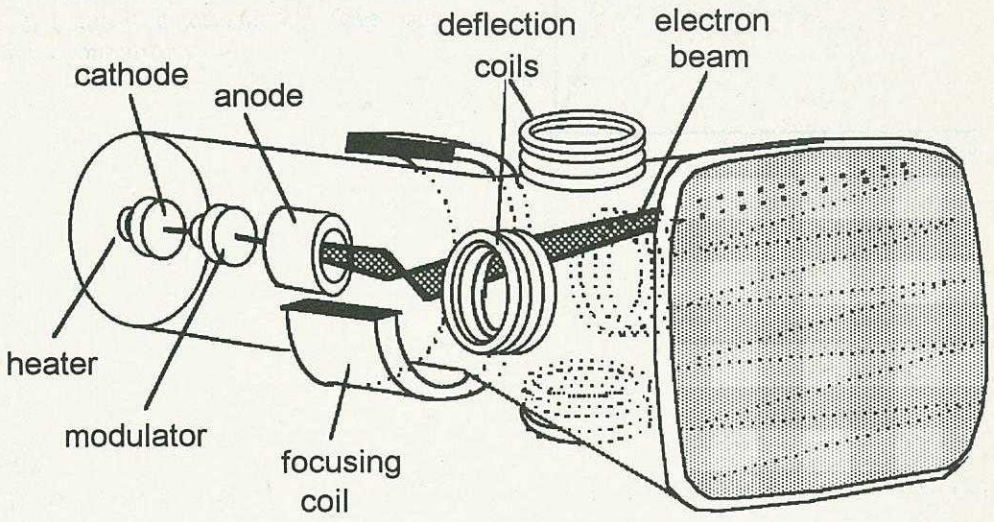
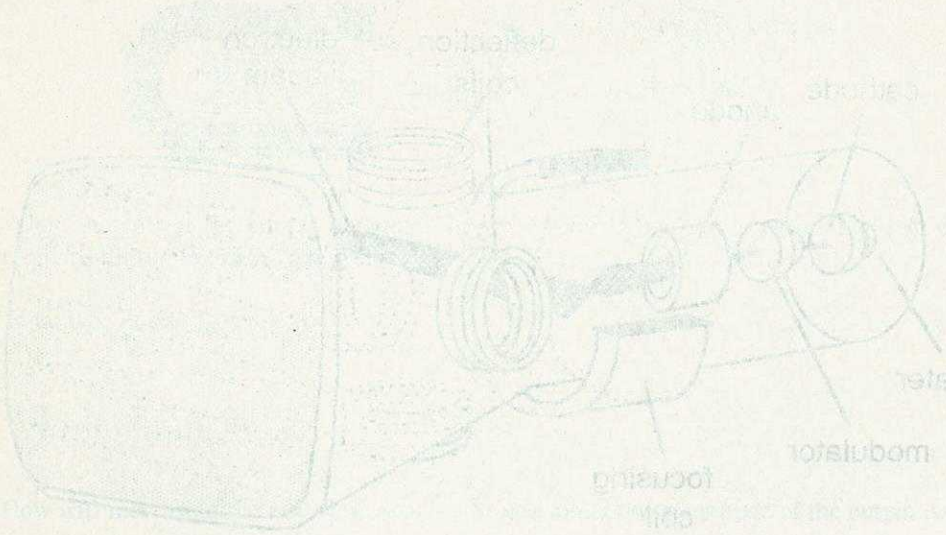
5. In a television tube the electron beam can be deflected by either an electric field or a magnetic field. The diagram shows a method of deflecting the electron beam by using deflection coils.



Explain how a current through the deflection coils can be used to cause horizontal deflection in the electron beam. Show clearly on the diagram which coils must be used.

6. A postal worker uses an elastic band to hold your letters together. If the band has a cross-sectional area of about 2 mm^2 , ESTIMATE the value of Young's modulus for the band.



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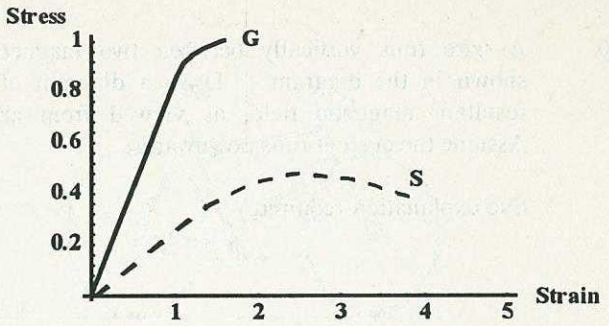
7. Some street lights use gases such as mercury vapour or sodium vapour at high temperatures. Why do gases such as these emit light when they are heated to a high temperature?

SEE NEXT PAGE

8. The stress-strain relationships of two new materials, goshium (G) and strewthium (S) are shown in the diagram. Which of these materials would be more suitable for a guitar string? Remember: A guitar string should resist permanent deformation. Give one reason for your answer.



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9. Central Park building in central Perth is 261 m high. Why is it more tiring to run up stairs to the top of the building than to run the same distance along level ground?

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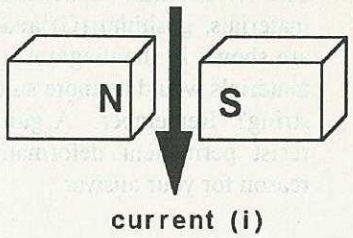
10. A wire runs vertically between two magnets as shown in the diagram. Draw a diagram of the resultant magnetic field, as viewed from above. Assume the current runs downwards.

(No explanation required.)



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11. In Question 10, the wire is 35.0 mm long and the magnetic field strength is 33.0 mT. If the current in the wire is 2.50 A, determine the magnitude and direction of the force acting on the wire.

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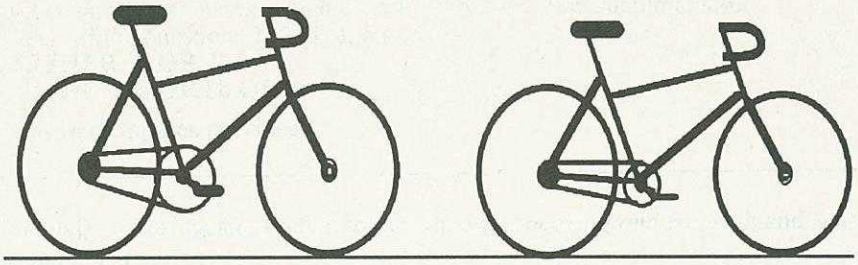
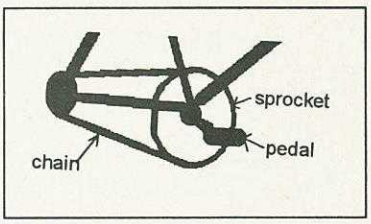
12.



Simon's bicycle Sally's bicycle

Sally's bicycle has a lower gear than Simon's (i. e., it has a smaller front sprocket). Sally has a greater acceleration than Simon, even though they both exert the same force on the pedals. Why is this?



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13. Consider this situation. You are driving at the speed limit on a suburban road on a dry day when you have to make an emergency stop. ESTIMATE the deceleration that you can achieve by maximum braking.

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14. Why is it important that the currents supplied to the two loudspeakers in a stereo pair are in phase?

15. A bus produces a sound level of 88 dB when it passes by. A large truck produces a sound level of 94 dB. What will be the sound level if they pass by at the same time?

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SECTION B : Problem Solving

This section contains 8 questions, two of which contain a choice. You should answer
ALL of the questions 1, 2, 3, 4, 5 and 6
EITHER 7a **OR** 7b
EITHER 8a **OR** 8b **OR** 8c

Answer the questions in the spaces provided

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1. (12 marks total) (This question refers to the contexts *Speaking and Hearing* and *Musical Instruments and Reproduction*.)

(a) Refer to an example from the context that you studied and using diagrams, describe how beats are produced. [5 marks]

(b) A quartz crystal microbalance operates by measuring the change in frequency of oscillation of a quartz crystal when mass is added to it. This can be done more conveniently by using a second reference crystal and measuring the beat frequency. If the measuring crystal oscillates at a frequency of 10.97430 MHz, and the reference crystal at 10.97278 MHz

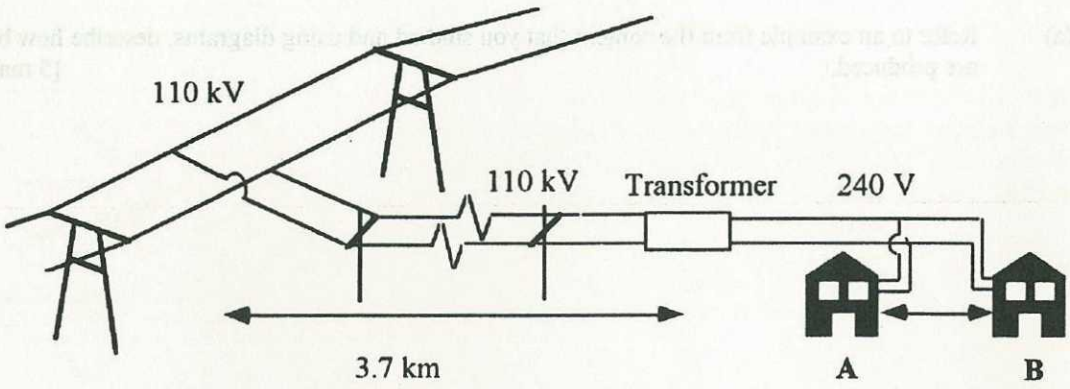
(i) calculate the beat frequency. [2 marks]

(ii) would a sound wave at this frequency be audible? [1 mark]

(c) The different frequencies of standing waves on a string or in a pipe are known as harmonics. The quality of a sound depends on the presence of these harmonics. Why do we not experience beats between the harmonics? [4 marks]

2. (12 marks total)

The buildings on a farm are situated 3.7 km from the 110 kV mains power lines. Two houses on the farm are to be connected to the electricity, as shown in the diagram. The wires from the transformer to the houses have a resistance of 2.250 $m\Omega\ m^{-1}$.



(a) Explain why the transformer, which drops the voltage from 110 kV to 240 V, is placed at the end of the 3.7 km line rather than at the beginning.

[4 marks]

(b) The farmer turns on an electric kettle of resistance 28.8 Ω in Farmhouse A. The total distance from the transformer to the farmhouse along the wires is 70 m. What power is actually delivered to the kettle?

[5 marks]

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(c) If an electric kettle is turned on in Farmhouse B as well as the one in Farmhouse A, would this change your answer to part (b)? Explain your answer. (No calculation is required.)

[3 marks]

3. (14 marks total)

A space station of mass 9700 kg is to be placed into orbit 450 km above the surface of the earth.

(a) Find the kinetic energy of the space station when in its orbit.

[5 marks]

(b) Assuming the energy content of rocket fuel is 15 MJ kg^{-1}, calculate the amount of fuel required to give the space station its orbital kinetic energy.

[2 marks]

(c) A certain amount of fuel is required to raise the space station off the Earth and place it in an orbit 450 km above the surface of the earth. Would it require twice the amount of fuel to place it in orbit 900 km above the earth? Justify your answer. Neglect the effects of air resistance.

[5 marks]

(d) Why do space scientists prefer to launch satellites from launch sites close to the equator?

[2 marks]

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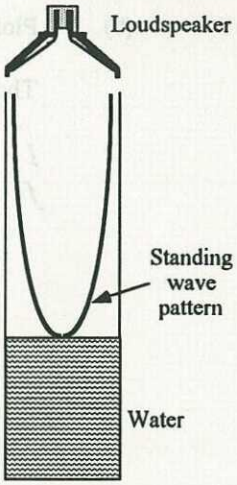
4. (14 marks total)



Longitudinal sound waves propagated down a tube are reflected at the closed end and a standing wave is produced by the interference of the incident and reflected waves. The air is at rest at the closed end, which is therefore a node. The antinode is actually a short distance e beyond the end of the tube, thus $l + e = \lambda/4$, where l is the length of the air column. The speed of sound in the laboratory is given by $v = f\lambda$. Hence

$$l = \frac{v}{4}\frac{1}{f} - e$$

In an experiment to determine the speed of sound, a student uses a tube in which the length of the air column can be adjusted by varying the height of water in the tube. A small loudspeaker is set up just above the tube. The length of the tube is set at a number of different values, and the sound frequency adjusted for resonance at each length.

The results obtained are given on page 16.

You are required to determine the speed of sound v in the laboratory and the distance e by drawing a **straight line graph**.

(a) Explain how you will process the data to obtain a straight line graph. [2 marks]

SEE NEXT PAGE

(b) Plot the straight line graph. [9 marks]

The results obtained were :

l	140	190	250	300	350	400	450	mm
f	513	408	307	263	235	200	187	Hz

(c) From the straight line graph determine:

(i) the speed of sound in the laboratory, v. [4 marks]

(ii) the distance e. [2 marks]

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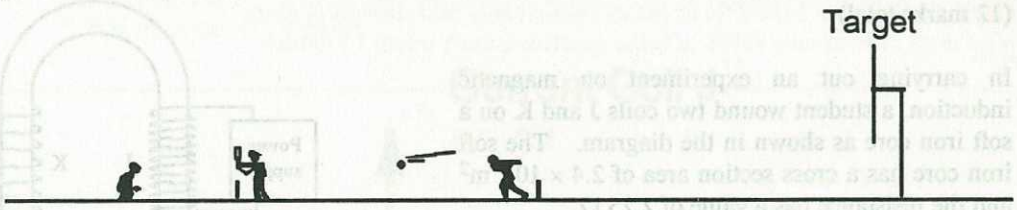
5. (12 marks total)



In the recent one-day cricket competition, players could win $10,000 by hitting targets hung around the ground. One target has its centre 4.5 m above the ground and 105 m from the batsman. Damien Martyn aims to earn the money by hitting a ball at an angle of 55° to the ground. He asks you to calculate how fast he must hit the ball.

(a) Calculate how fast the ball must be travelling when it leaves the bat. (Neglect the fact that the ball must be a little above the ground when it is hit.)

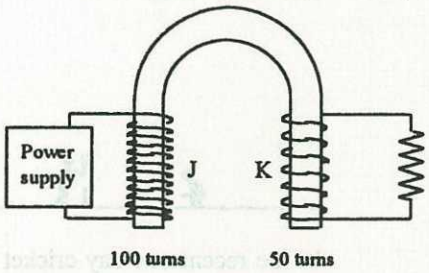
[8 marks]

(b) If Damien hits the ball at the correct speed but at too high an angle, would the ball go over or under the target? Use a diagram to assist your explanation.

[4 marks]

6. (12 marks total)

In carrying out an experiment on magnetic induction, a student wound two coils J and K on a soft iron core as shown in the diagram. The soft iron core has a cross section area of 2.4×10^{-4} m^2 and the resistance has a value of 2.25 Ω.



(a) What principle is the student using to generate a current in coil K? [3 marks]

(b) The student passes a current through coil J as shown. Sketch the current in coil K on the graph provided on page 21 (actual values of the current should be calculated). Assume the magnetic field strength in coil J is given by [5 marks]

$$B = 2.51 \times 10^{-3} I \quad \text{tesla}$$

where I is the current.

(c) Explain why the current graphed in (b) varies in this way. [2 marks]

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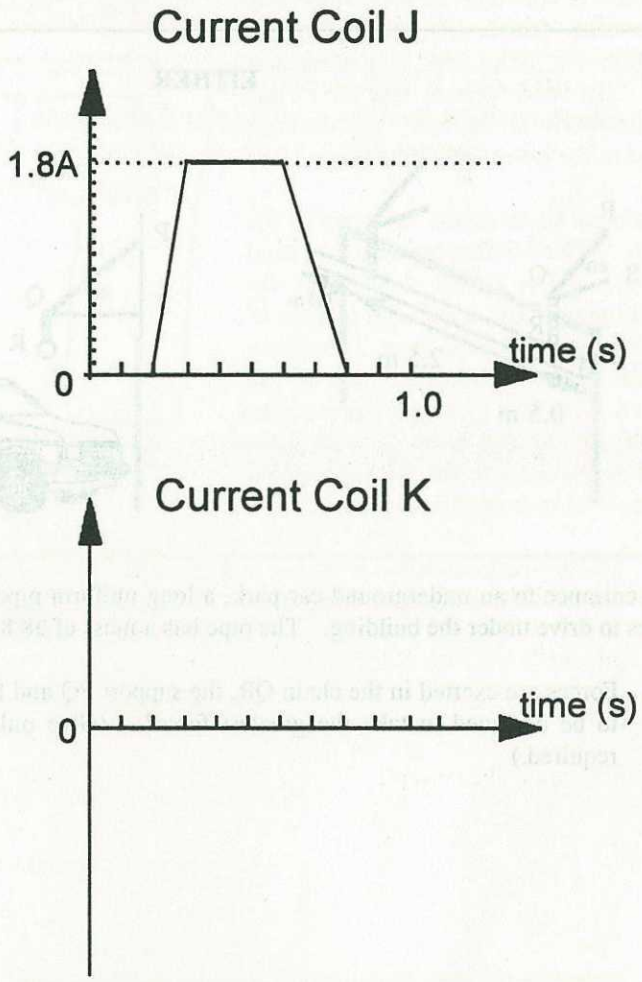
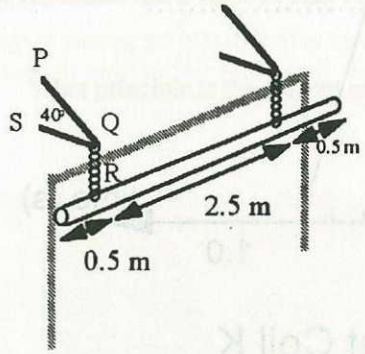
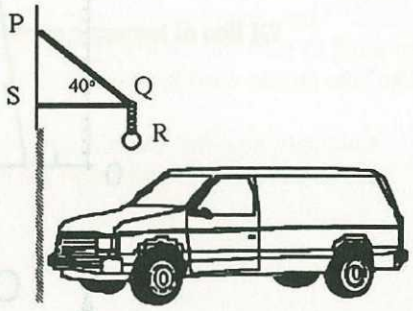


(d) How would your answer change if the number of turns in coil K were increased to 400? (do not calculate). [2 marks]

Question 7a (page 22) refers to the context *Structures.*
Question 7b (page 24) refers to the context *Human and Animal Frames.*
You must answer only **ONE** of these questions, each worth 12 marks.

EITHER





7a. At the entrance to an underground car park, a long uniform pipe is hung to show the safe height for vehicles to drive under the building. The pipe has a mass of 28.8 kg.

(i) Forces are exerted in the chain QR, the support PQ and the support SQ. Which of these has to be designed to take the greatest force? (Give only an explanation; no calculation is required.)

[4 marks]

(ii) To prevent injury to anyone who might jump up on the pipe, it is decided that one end of the pipe must not lift into the air should a 75 kg person hang on to the other end. Does the pipe meet this criterion?

[4 marks]

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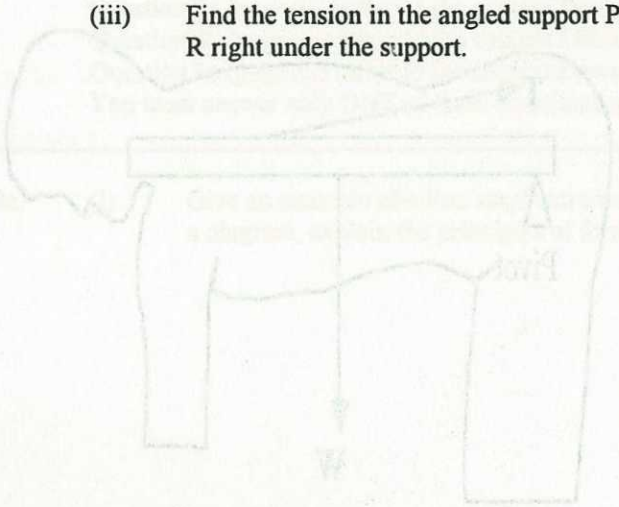
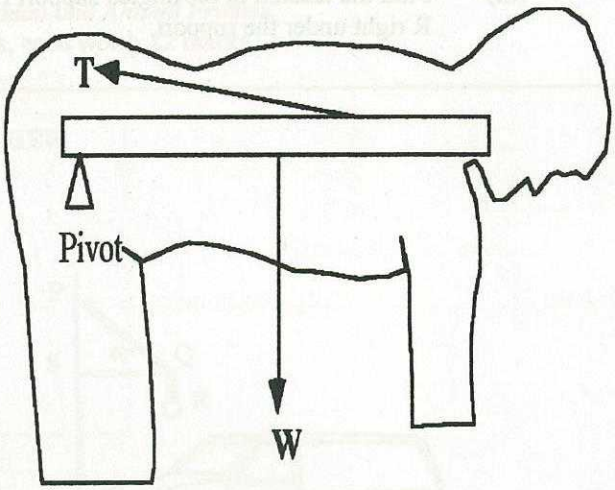
(iii) Find the tension in the angled support PQ if the 75 kg person hangs on to the pipe at a point R right under the support.

[4 marks]



OR

7b. Back pain is common in our community because many people lift incorrectly, e.g. when lifting a 10 kg bag in the manner shown. To bend forward and lift in this way, the work is done by the muscles attached to the lower end of the spine.



The back can be modelled as shown in the diagram. The bending motion is around the pivot. The centre of mass of the person's upper body, which has a mass of 35 kg, is 0.38 m from the pivot. The force T exerted by the back muscles acts on the spine at a point 0.55 m from the pivot at an angle of 12° to the spine. The force exerted by the arms to lift the bag acts on the spine 0.61 m from the pivot.

(i) Using your knowledge of torque and moments, explain why you should not lift objects in the manner illustrated in the diagram. (Give only an explanation; no calculation is required.)

[4 marks]

(ii) Calculate the force T exerted on the spine by the muscles.

[8 marks]

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Question 8a (page 25) refers to the context *Sunlight and Starlight.*
Question 8b (page 26) refers to the context *Medical Applications.*
Question 8c (page 27) refers to the context *Domestic / Industrial Applications.*
You must answer only **ONE** of these questions, each worth 12 marks.

8a. (i) Give an example of a line spectrum from the context *Sunlight and Starlight.* With the aid of a diagram, explain the principles of formation of a line spectrum.

[4 marks]

(ii) With the aid of a diagram, show how X-rays are generated. Hence explain why it is possible for X-rays to be generated in objects like the Crab Nebula.

[4 marks]

(iii) The thinning of the ozone layer has received a great deal of publicity. It has affected the composition of the solar radiation reaching the earth and you are now more likely to experience skin damage from exposure to sunlight. Why is this?

[4 marks]

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OR

8b. (i) Give an example of a line spectrum from the context *Medical Applications*. With the aid of a diagram, explain the principles of formation of a line spectrum.

[4 marks]

(ii) With the aid of a diagram, show how X-rays are generated. Show how this is achieved in a medical X-ray tube.

[4 marks]

(iii) In hospitals radiologists take particular care to minimise exposure to X-rays. They know that exposure to X-rays will cause damage to human tissue. Explain why X-rays can cause this damage.

[4 marks]

SEE NEXT PAGE

OR

8c. (i) Give an example of a line spectrum from the context *Domestic/Industrial Applications.* With the aid of a diagram, explain the principles of formation of a line spectrum.

[4 marks]

(ii) With the aid of a diagram, explain how X-rays are generated. Show how this is achieved in an industrial X-ray tube.

[4 marks]

(iii) Welders can get burns like sunburn from the light generated by their welding. However, models and actors work under bright lights and don't get burnt. Why is this?

[4 marks]

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SECTION C : Comprehension and Interpretation

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

BOTH questions should be attempted. Question 1 is worth 16 marks and Question 2 is worth 24 marks.

Read each passage carefully and answer all of the 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.

(Total 16 marks)

1. Read the passage on page 29 to answer the following questions.

(a) How would a recycling mirror increase the efficiency of a light globe? [5 marks]

(b) (i) Explain why the reflectance of the mirror is designed to vary with wavelength as shown in the graph.

[6 marks]

(ii) Does the high reflectance of the mirror for the ultraviolet region assist its function?

[2 marks]

(c) How much coal would the energy efficient replacement of a 500 W light globe require over the globe's lifetime? [3 marks]

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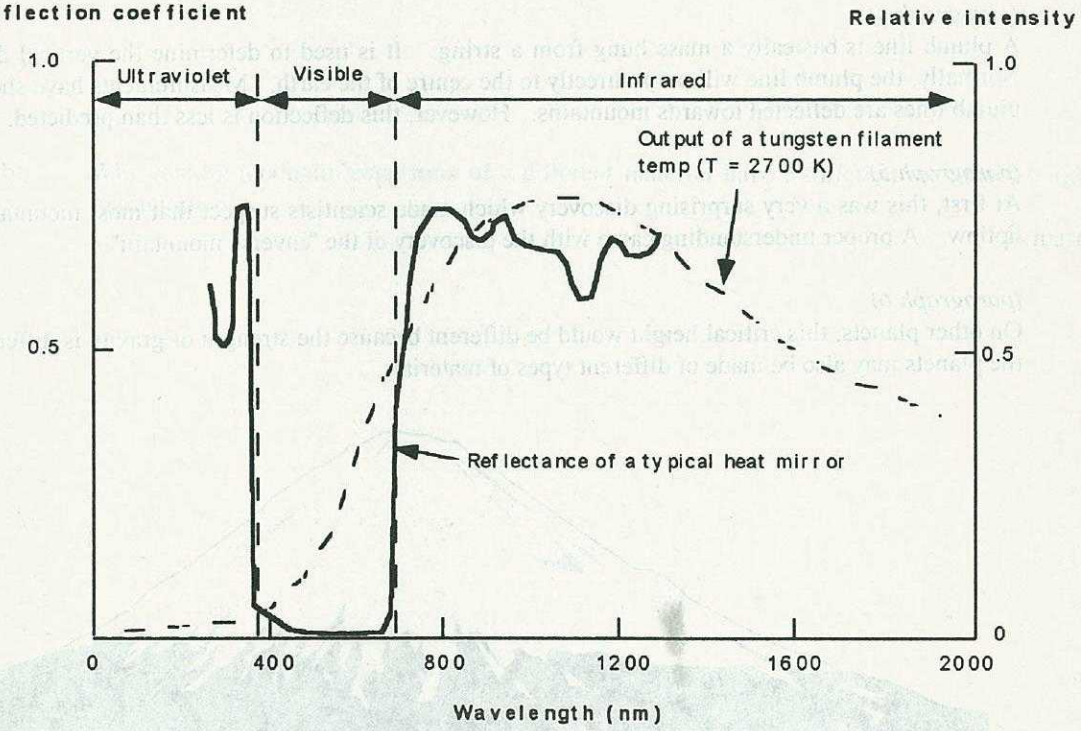
LASER TECHNOLOGY REVITALIZES THE INCANDESCENT LIGHT GLOBE

(Paragraph 1)
The modern light globe still has the same basic design as when it was invented in the 1870s. An electric current heats a thin tungsten filament (melting point 3653 K) to the point where it glows. Although numerous improvements have increased the light globe's efficiency twenty-fold, its efficiency is still only about 10% of what is theoretically possible.

(Paragraph 2)
A tungsten filament can only be heated to about 3000 K, and this results in 80-90% of the energy being radiated as infrared radiation. One option to increase the efficiency of the globe is to use a heat recycling mirror. This mirror is designed to reflect the emitted infrared radiation back on to the filament and forms part of the surface of the globe.

(Paragraph 3)
To produce such a mirror, the General Electric group borrowed methods used to construct high performance laser mirrors, which consist of alternating layers of transparent material with different refractive indices. By changing the relative thickness of the layers, the refractive properties for visible and infra-red radiation can be adjusted separately. The final design consists of 46 repeated layers and transmits more than 99% of visible light while reflecting over half the infrared radiation in the 1200 nm range.

(Paragraph 4)
The mirror reduces energy consumption of a 500 W globe to 375 W. Over a globe's lifetime, this represents about 200 kg of coal saved at the power station.



Reflectance of a typical heat mirror in terms of reflection coefficient and output of a tungsten filament lamp in terms of relative intensity, both plotted as a function of wavelength. The mirror transmits visible light, while reflecting a substantial portion of the infrared light from the lamp. The additional heating of the filament by the reflected radiation increases the globe's efficiency by 25%

SEE NEXT PAGE

2. WHY PEAKS PEAK (24 marks total)

(paragraph 1)
Have you ever wondered whether there can be a mountain on our planet significantly higher than Mount Everest? The answer, surprisingly, is no! Why not?

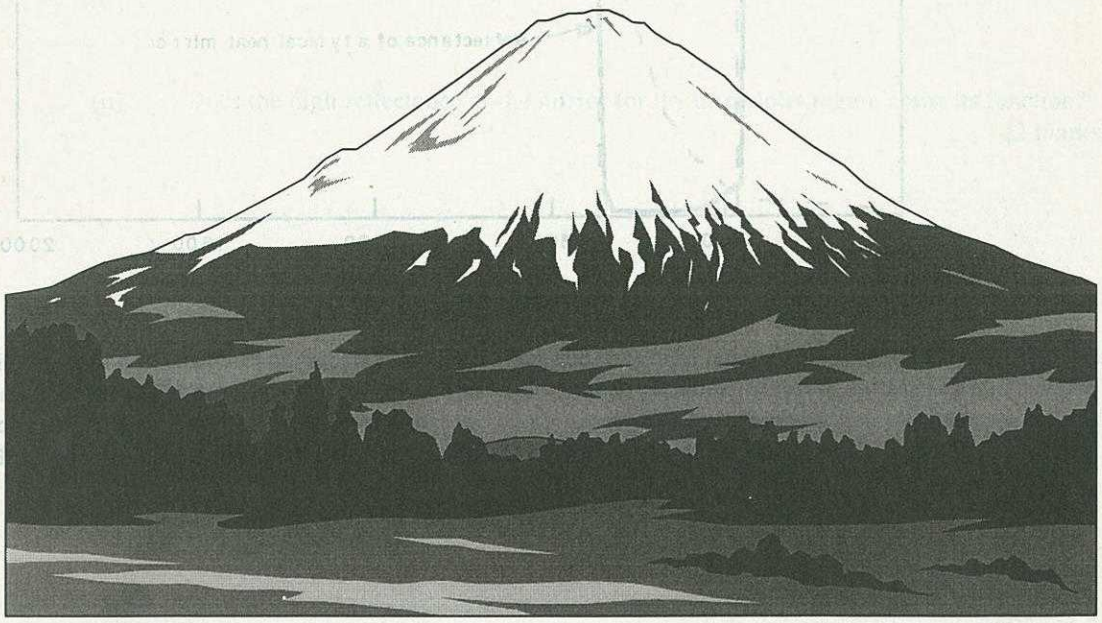
(paragraph 2)
If a mountain goes too high, it shrinks into the earth because the material comprising the earth's surface and the rocks at the base - the granite, quartz or silicon dioxide - cannot hold its weight. There is a limit beyond which a solid begins to yield when the bond between their atoms lose their directionality. In the words of the eminent physicist Victor Weisskopf : "... the whole bonds between the atoms are not broken, just the directionality of the bonds. This enables a liquid to flow, whereas a solid cannot because its bonds are held in fixed positions relevant to the constituent atoms" (lecture given at CERN, Geneva, 1967, in which Weisskopf discussed this problem). The energy necessary to break the directionality of the bonds, that is to liquefy, comes from the potential energy lost by the mountain as it sinks.

(paragraph 3)
Weisskopf did some quantitative estimates which show that a mountain on earth cannot be higher than 30 kilometres. A further reduction in height to about 10 km (the height of Mount Everest!) occurs because the mantle which supports the earth's crust is not rigid - it is plastic and the mountains float on it like giant icebergs. Geologists and physicists working together have found that every mountain indeed has an "inverse mountain" (the portion of it submerged in the mantle). This is why a plumb line near a mountain is not deflected towards it as much as one would expect had all the matter making up the mountain been contained in its visible volume.

(paragraph 4)
A plumb line is basically a mass hung from a string. It is used to determine the vertical direction. Normally, the plumb line will point directly to the centre of the earth. Measurements have shown that plumb lines are deflected towards mountains. However, this deflection is less than predicted.

(paragraph 5)
At first, this was a very surprising discovery which made scientists suspect that most mountains were hollow. A proper understanding came with the discovery of the "inverse mountain".

(paragraph 6)
On other planets, this critical height would be different because the strength of gravity is different, and the planets may also be made of different types of material.



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2 (a) With the aid of a diagram, explain in your own words why the height of mountains on earth is limited to 30 km.

[6 marks]

(b) Why could a mountain consisting of a different material have a different maximum height? (paragraph 6)

[4 marks]

(c) Explain why the plumb line should deflect towards the mountain (paragraphs 3,4).

[6 marks]

(d) ESTIMATE the acceleration due to gravity at the top of Mount Everest.

[8 marks]

END OF QUESTIONS

END OF PAPER

SPARE PAGE FOR WORKING