Curriculum Council

TERTIARY ENTRANCE EXAMINATION, 1998

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.

 Ref: 239

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.

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. A person fishing from a jetty notices that the foam float on their fishing line gently bobs up and down as regular waves pass by. The person counts 13 full oscillations of the float in one minute. What is the period of the water waves?

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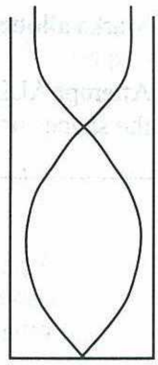
2. An example of a longitudinal wave is: ____________________

   An example of a transverse wave is: ____________________

   Explain the difference between transverse and longitudinal waves.

3. Bridgette has seen a diagram of standing waves in a tube, and asks you what the curved lines mean. Explain clearly what these lines represent.



4. A musician at a party plays a steady note on a wind instrument by blowing into the instrument and exciting a fundamental tone with a frequency of 440 Hz. She then plays a party trick by inhaling helium gas from a balloon and blowing into the instrument again to excite the fundamental tone. Estimate the frequency emitted by the instrument when it is filled with helium. Show working.

5. When you throw a rock horizontally, the rock moves in a curved path. Why doesn't it move in a straight line?

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6. Street lamps emit light of different colours – some emit blue and some emit yellow, for example. Explain the process which causes these lights to have different colours.

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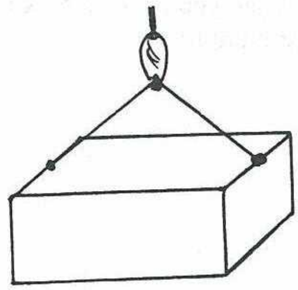
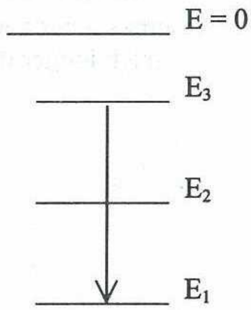
7. A student is swinging a yo-yo of mass 125 g in a vertical circle of radius 0.95 m at a speed of 4.5 m s^{-1}. Find the tension in the string when the yo-yo is at the lowest point of its path.

8. A container having a mass of 3500 kg is suspended by two steel cables attached to the ends of the container as shown. If the length of the container is 12 m and the length of each cable is 9.5 m, find the tension in each cable.
Show working.

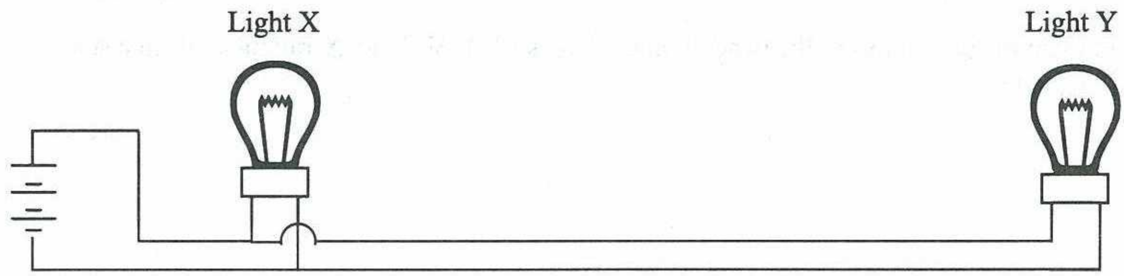


9. You are leaning on the balcony on the tenth floor of an apartment block when you carelessly knock a flowerpot off the balcony. Estimate the speed of the flowerpot when it hits the ground.

10. An electron makes a transition between two energy levels as shown in the diagram and a photon of wavelength 591 nm is emitted. If E_3 is – 2.56 eV, what is the value of E_1?



11. Two identical floodlights are connected to a battery as shown in the diagram, the second being connected by an extremely long pair of wires, similar to an extension cord. Will one light be brighter than the other? Explain.



12. A house brick is suspended from the roof of the school gymnasium on a copper wire which has a cross section area of 1.8×10^{-6} m^2 (this corresponds to a wire diameter of 1.5 mm). Estimate how much longer the wire will be when the brick is hung on it. Show working.

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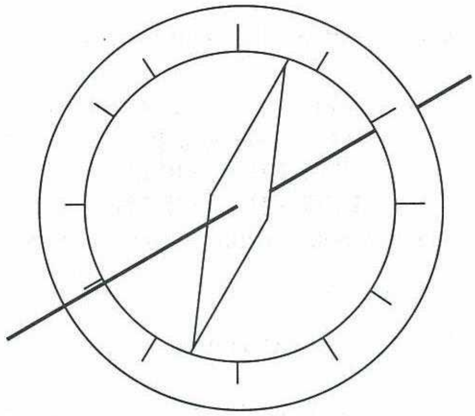
13. Explain the **principles** of the generation of X-rays EITHER in an X-ray tube OR in a stellar X-ray source.

14. A dip needle is a magnet suspended on a horizontal axis. The magnet is free to rotate in a vertical plane. A student in Perth sets up a dip needle and notes that it takes up an angle of 70° to the horizontal. Why do dip needles usually not take up a horizontal orientation? Where on the earth would they be horizontal? Use a diagram in your explanation.



15. Why is a ladder leaning against a wall more likely to slip as the angle between the ladder and the ground is decreased? Use a diagram showing all the forces exerted on the ladder.

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]

Suppose that NASA has decided to put a satellite in orbit around the moon.

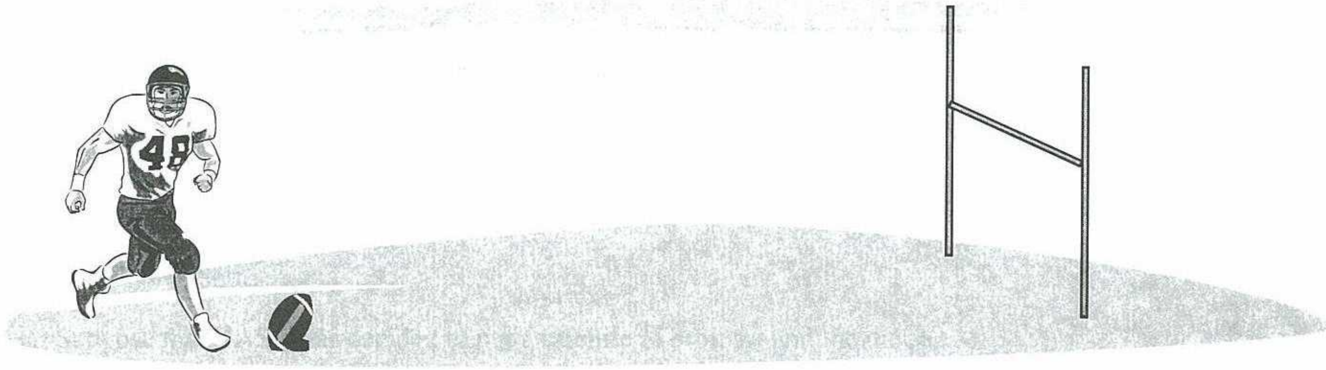
(a) Show in a diagram the direction of the force exerted on the satellite by the moon.
[2 marks]

(b) What is the acceleration due to the moon's gravity at a height of 2500 km above the surface of the moon?
[4 marks]

(c) If the satellite is to have an orbital period of 24 hours, find the height of the orbit above the moon's surface.

[6 marks]

2. [12 marks total]
In a football game, a place kicker kicks a football 36 m from the goalposts, and the ball must clear the crossbar which is 3.1 m from the ground, as shown in the diagram.



When kicked, the ball leaves the foot at 20 m s^{-1} at an angle of 53° to the horizontal.

(a) How long does it take the ball to travel the distance to the goalposts? [3 marks]

(b) How far above or below the crossbar is the ball when it passes through the goal posts? [4 marks]

(c) Show on a sketch the path of the football. Include the goalposts in your sketch. Explain why you have drawn the path this way, showing any necessary working.

[5 marks]

3. [15 marks total]

A mass spectrometer is an instrument for analysing unknown substances. It works by ionising the substance, accelerating the ions to a known speed and then allowing them to enter a uniform magnetic field perpendicular to their motion. For one such instrument, the ion speed is 4.52×10^{6} m s $^{-1}$ and the magnetic field is 0.115 T.

(a) Draw a diagram to show the path of the ions once they enter the field. Show the directions of the ion and the magnetic field.

[3 marks]

(b)

(i) Explain why ions of different masses move along different paths.

[3 marks]

(ii) How would the paths of the ions change if their speed were increased? Explain.

[3 marks]

(c) An ion has a mass of 9.63×10^{-26} kg and a single positive charge. What is the acceleration of this ion in the magnetic field?

[4 marks]

(d) Why is it necessary for the magnetic field to be perpendicular to the path of the ions?

[2 marks]

4. [11 marks total]

A compass is represented as shown in Figure (a), when only the earth's magnetic field is present.

Figure (b) shows a solenoid through which a constant current is flowing. Figure (c) shows a cross section through this solenoid. Each of the small circles in the diagram represents cross sections through the wire. A dot in the wire indicates current flowing in a direction out of the plane of the page, while a cross in the wire represents current flowing into the plane of the page. Five compasses have been placed in and around the solenoid, as shown by the larger circles. The compass needles are not shown.

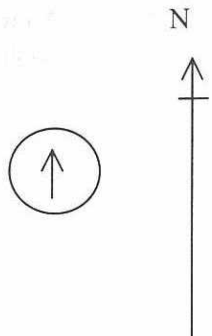


Figure (a)

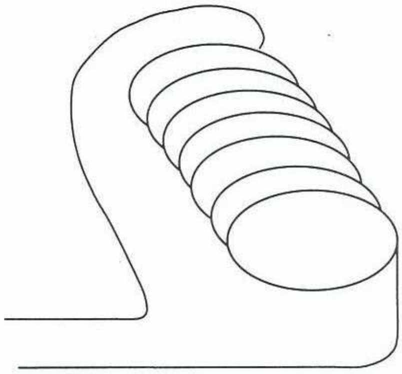


Figure (b)

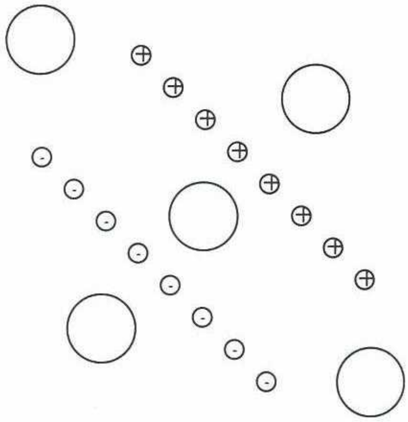


Figure (c)

(a) Sketch, on Figure (c), the directions of the compass needles. [3 marks]

(b) If the magnetic flux passing through each of the loops in the solenoid is 3.0×10^{-5} Wb and the solenoid has a radius of 20 mm, calculate the magnetic field strength in the centre of the solenoid.

[4 marks]

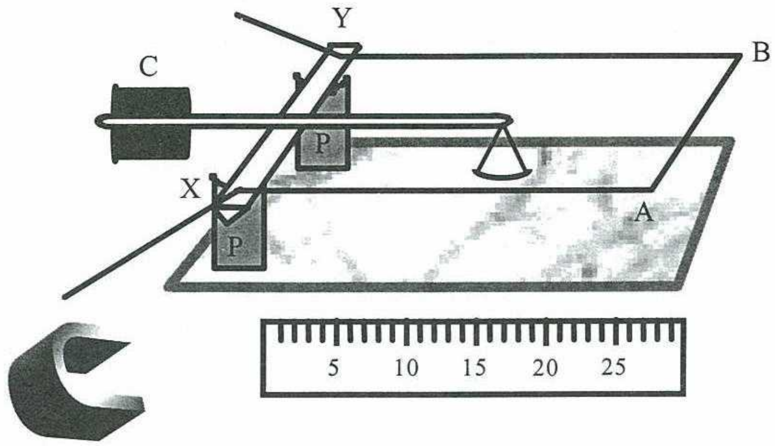
(c) If the current is turned off so that the magnetic field drops to zero in 55 ms, find the magnitude of the emf induced in the coil. Show working.

[4 marks]

5. [19 marks total]

You have been asked to set up an experiment to show that a wire carrying an electric current experiences a force in a magnetic field, and to measure this force.

You are provided with the apparatus shown in the diagram, where a wire AB is mounted in a frame which is free to pivot on two pivot points P. AB is balanced by the counterweight C. The length XY is an insulator.



(a) How would you arrange the horseshoe magnet illustrated in the diagram to carry out the experiment? Give your reasons.

[4 marks]

(b) You are provided with a large battery, resistors, a rheostat, a voltmeter, a switch, an ammeter, connecting wires and some small weights. Draw a diagram to show how you would arrange all the necessary equipment and connect it to the apparatus. Indicate the directions of the current and magnetic field.

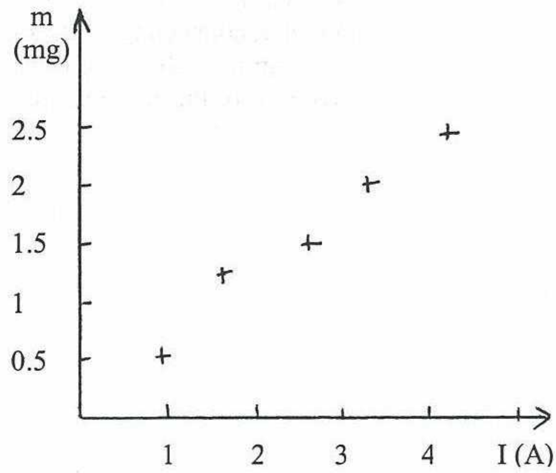
[5 marks]

(c) Wire AB should be in exactly the same position for each measurement of force. Why is this? How would you measure the force on the wire?

[4 marks]

(d) The results obtained from the experiment are shown in the graph. Use the gradient of the graph to estimate the magnetic field B of the horseshoe magnet.

[6 marks]



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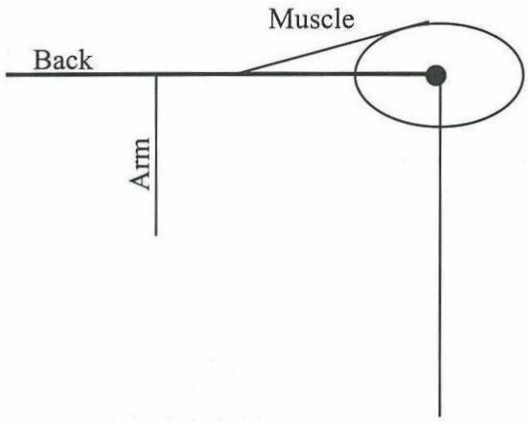
6B. A person bends over and holds a 20 kg object as shown in the picture. Her back is horizontal. The back muscle is attached to a point half way along the upper body (which includes the head), and the angle between the spine and the muscle is 12°. The shoulders are two thirds of the way along the upper body. Assume that the object is vertically below the shoulders. This is modelled in the schematic diagram on the right.



(a) Show all the forces acting on the back on the schematic diagram above.

[4 marks]

(b) Find the tension in the back muscle in the position shown. Take the length of the upper body to be 1.00 m and its mass as 35 kg.

[5 marks]

(c) The back muscle will be injured if a force greater than 3500 N is applied. Find the maximum mass that the person can lift, without injury, in the manner shown in the picture.

[5 marks]

Question 7A refers to the context *Speaking and Hearing*
Question 7B refers to the context *Musical Instruments and Reproduction*
You must answer only **ONE** of these questions, each worth 17 marks.
Some parts of this question are common to both 7A and 7B. This is not an error.

7A. A firework explodes 200 m above a sound level meter which registers an intensity level of 90 dB.

(a) What is the intensity of sound at the sound meter (in W m^{-2})? [3 marks]

(b) What intensity level (in dB) would be recorded by the meter if three identical fireworks exploded simultaneously 200 m above the sound meter? Show your working.
[4 marks]

(c) Both dolphins and bats use "echo-ranging" by emitting ultrasound pulses and detecting the reflected waves. Dolphins typically emit frequencies up to 100 kHz underwater whereas bats emit at frequencies up to 150 kHz in air. What are the shortest wavelengths emitted by dolphins and bats respectively?
[4 marks]

(d) When the principal addresses the school in an auditorium, it sounds much louder than when done on the school oval. Why is this?

[3 marks]

(e) People can change the pitch of their voices, for example when they are singing. What causes this change in pitch? What is the physical principle involved?

[3 marks]

7B. A firework explodes 200 m above a sound level meter which registers an intensity level of 90 dB.

(a) What is the intensity of sound at the sound meter (in W m^{-2})? [3 marks]

(b) What intensity level (in dB) would be recorded by the meter if three identical fireworks exploded simultaneously 200 m above the sound meter? Show your working.

[4 marks]

(c) Both dolphins and bats use "echo-ranging" by emitting ultrasound pulses and detecting the reflected waves. Dolphins typically emit frequencies up to 100 kHz underwater whereas bats emit at frequencies up to 150 kHz in air. What are the shortest wavelengths emitted by dolphins and bats respectively?

[4 marks]

(d) When violinists are tuning their instruments, they play the same note together. One person tunes his violin until he can't hear any fluctuations in sound intensity. Why are there no more fluctuations when the instruments are tuned?

[3 marks]

(e) The pitch of a tuba is much lower than a trumpet. Why are tubas made much longer than trumpets?

[3 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 expression in the answers. Diagrams (sketches) and equations and/or numerical results should be included if they are appropriate.

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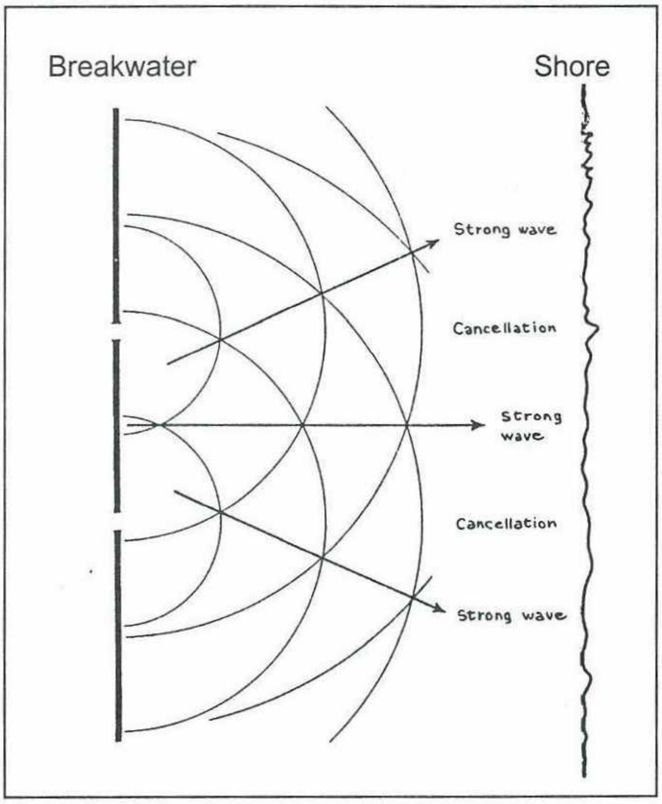
1. HOW LIGHT WAS SHOWN TO BE A WAVE

(paragraph 1)
In 1789, Thomas Young used an experiment to settle a long standing controversy about the nature of light. Newton, who did extensive studies on optical effects, favoured a theory that represented light as a hail of tiny particles. The Dutch physicist, Christian Huygens, favoured a wave theory.

(paragraph 2)
The experiment Young chose was that of *two-slit interference.* This is easiest to visualise in two dimensions, such as for water waves. Imagine a breakwater which is parallel to the shore and has two small gaps, as in the diagram. The waves striking this breakwater will produce two circular patterns on the other side, and in due course these will overlap, as shown on the Figure.



(paragraph 3)
At a point on the shore, opposite and half way between the two gaps, the waves always meet crest to crest, because the point is equidistant from both gaps. The waves from each gap arrive simultaneously and the interference is constructive, giving a wave twice as high as that from one gap. As we move along the shore from this point, the synchronisation is destroyed, for we are closer to one gap than the other. Eventually, we reach a point where the crests of the waves from one gap reach the troughs in the waves from the other. Here the interference is destructive; the waves are small or absent altogether.

(paragraph 4)
Moving along further, we reach a point where the wave from the nearer gap meets the *preceding* wave from the farther gap. Once again, the interference is constructive, and the waves are high. If we continue, we again reach a point of destructive interference, and so on.

(paragraph 5)
The rule is really quite simple: if the difference between the distance to one gap and the distance to the other is an integer multiple of a wavelength, the interference is constructive. If it is ½, 1½, 2½, 3½ … wavelengths, destructive interference results.

(paragraph 6)
Now to Young's experiment: replace the breakwater with an opaque screen, the gaps with narrow slits, water waves with light and the shore with a white screen. On the white screen, placed well back from the slits, one observes a pattern of bright and dark bars parallel to the slits – a bright one in the centre, dark ones to either side and so on. If the spacing of these lines is measured, a little work with geometry enables us to calculate the wavelength of light. The result is fantastically small; light waves have wavelengths which range from 0.0007 mm for red light to 0.0004 mm for blue light. The slits must be very narrow and the viewing screen well back from the slits to make the effect visible.

(a) Express the range of wavelengths in nm (paragraph 6). [2 marks]

(b) What do the semicircles drawn in the figure represent? What is the significance of the distance between consecutive semicircles?

[3 marks]

(c) The waves spread out after passing through the slits. Name this phenomenon.

[1 mark]

Answer: ____________________

(d) The statement is made "*if the difference in the distances travelled by the two waves is an integer multiple of a wavelength, the interference is constructive*" (paragraph 5). With the aid of a diagram, explain why this is so.

[4 marks]

(e) In a sketch, show what you would expect to observe on the screen if light consisted of waves, and if it consisted of particles. Why can this demonstrate light is a wave and not a stream of particles?

[4 marks]

Expected screen image if light is waves

Expected screen image if light is particles

(f) How would you expect the pattern to change if you moved the screen so as to double the distance from the slits?

[2 marks]

(g) How would the pattern on the screen change in Young's experiment if the wavelength of the light were halved? (HINT: You could modify the diagram to see what changes occur.)

[4 marks]

2. THE ROTATING ANODE X-RAY TUBE

(paragraph 1)
Alternating current motors used for rotating the anodes in X-ray tubes are induction motors. The stator (the stationary part of the motor) is arranged so that it produces a rotating magnetic field.

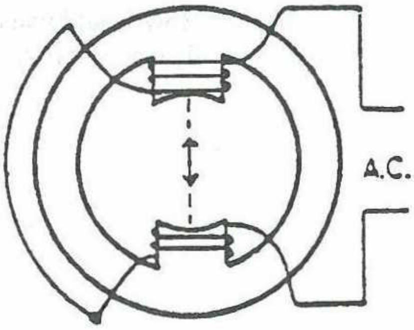


Figure 1

(paragraph 2)
In order to produce the magnetic field, a circular core with radially projecting poles is found convenient. An alternating current is fed through the windings on the poles, as shown in Figure 1. This creates a magnetic field which repeatedly alternates (reverses its polarity).

(paragraph 3)
The rotating magnetic field is produced with a stator like that shown in Figure 2. The same current is passed through the windings on poles 1A and 1B. Another current is passed through the windings on poles 2A and 2B. This current is 90° out of phase with the first (i.e. has a time lag of one quarter of a period). These currents are illustrated in Figure 3, where curve 1 shows the current through poles 1A and 1B, and curve 2 the current through poles 2A and 2B. The combined effect of these poles and the currents passing through them is a rotating magnetic field in the middle of the stator.

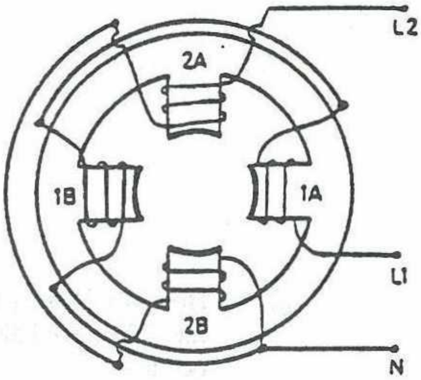


Figure 2

(paragraph 4)
To complete the induction motor, the rotor, which is a suitable cylindrical conductor fitted on a shaft, is positioned in the space in which the field rotates between the poles, as shown in Figure 4. When the current is turned on, the conductor rotates, turning the anode at a rate dependent on the frequency of the AC current fed to the poles.

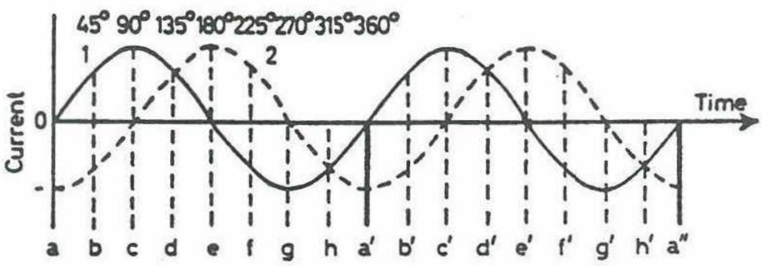


Figure 3

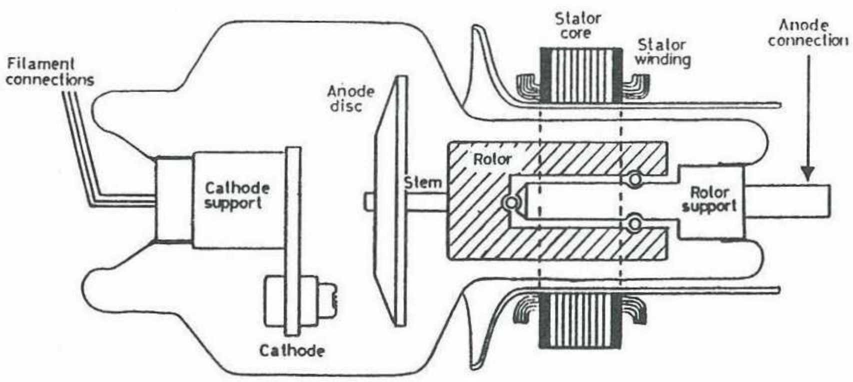
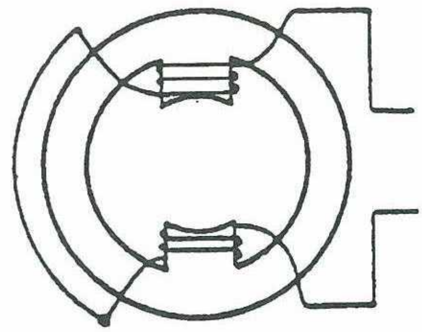


Figure 4

(a) (i) In a copy of Figure 1 (on the right), sketch the magnetic field lines in both the space and the core when a DC current is flowing such that the upper pole is a north pole.

Figure 1 (copy)

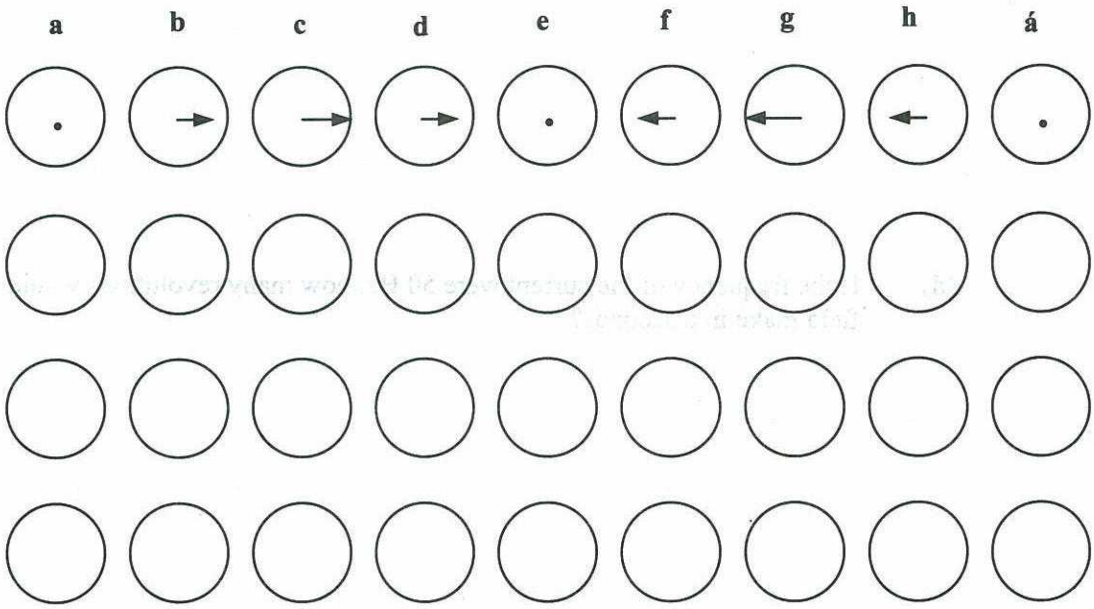


[3 marks]

(ii) Explain why the magnetic field alternates (Paragraph 2). [3 marks]

(b)

[6 marks]



The arrows in the first row of circles represent the direction and magnitude of the magnetic field in the centre of the stator due only to the current in poles 1A/1B at the times indicated in Figure 3.

(i) Show in the second row of circles the magnetic field in the centre of the stator due only to the current on poles 2A/2B.

(ii) Show in the third row of circles the total magnetic field.

(iii) Show in the fourth row of circles the net magnetic field if the same current were passed through poles 1A/1B and 2A/2B (i.e. there is no time lag).

(c) (i) What is the most important reason that the rotor is a conductor (paragraph 4)?
[3 marks]

(ii) Using Lenz's law, explain why the rotor rotates.
[3 marks]

(d) If the frequency of the current were 50 Hz, how many revolutions would the magnetic field make in 8 seconds?
[2 marks]

Extra Work Space/Rough Work