READ THE FOLLOWING DIRECTIONS CAREFULLY

1. You MUST use this answer booklet when responding to the questions. For each question, write your answer in the space indicated and return the answer booklet at the end of the examination.

2. ALL WORKING MUST BE SHOWN in this booklet, since marks will be awarded for correct steps in calculations.

3. Attempt ALL questions.

4. The use of calculators is allowed.

5. Mathematical tables are provided.

6. Specific latent heat of fusion of ice = $3.3 \times 10^5$ J kg$^{-1}$
   
   1 ton = 1 000 kg
1. A girl on a bicycle accelerates uniformly from rest and reaches a velocity of 10 m s\(^{-1}\) after 4 s. She continues at this speed for a further 24 s and then decelerates uniformly to come to rest in 5 s.

(a) On the axes below, sketch a velocity-time graph to illustrate the girl’s journey.

\[\begin{array}{c}
\text{\(v/\text{m s}^{-1}\)} \\
20 \quad 15 \quad 10 \quad 5 \\
0 \quad 10 \quad 20 \quad 30 \quad 40
\end{array}\]

(b) Find the initial acceleration and the final deceleration of the girl.

\[\text{( 4 marks)}\]

(c) How far did the girl travel?

\[\text{( 3 marks)}\]

(d) What was the average velocity for the first 10 seconds of the journey?

\[\text{( 3 marks)}\]
(e) In the space below, sketch the displacement-time graph for the whole journey.

(4 marks)

(f) If the mass of the girl and the bicycle is 80 kg, how much useful work does she do in reaching a velocity of 10 m s\(^{-1}\)?

(3 marks)

Total 20 marks
2. (a) An air-conditioner is a device used for cooling buildings. An insurance company plans to build a block of offices which is to be air-conditioned. State and explain THREE features of the design which could reduce the amount of solar radiation entering the building during the day and hence reduce the cost of cooling the building.

(b) **DIAGRAM OF AIR-CONDITIONER**

An air-conditioner, (see diagram above), works in such a way that a fluid is evaporated on the room side of the conditioner and, with the help of the compressor, it is condensed back to the liquid state outside the room.

Explain how this process is able to transfer thermal energy from the room to the outside.

( 6 marks)

( 4 marks)
(c) The heat capacity of a room is $3 \times 10^4 \text{ J K}^{-1}$. The room is cooled by an air-conditioner extracting heat at a rate of 500 W. By how much will the temperature of the room fall in five minutes?

(4 marks)

(d) Architects quote the power of air-conditioning systems in a strange unit called the ‘ton’ of air-conditioning. A system is rated at 1 ‘ton’ if it extracts the same amount of heat in 1 day as 1 ton of ice would need to melt at its normal melting point.

Using the data provided on the cover page, calculate how many kilowatts are equivalent to the ‘ton’ of air-conditioning.

(6 marks)

Total 20 marks
The diagram above represents an atom.

(a)  (i)  Identify the components X, Y and Z.

X .................................................................

Y .................................................................

Z .................................................................

(3 marks)

(ii) State whether or not the atom is neutral.

Explain your answer.

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Record the mass (nucleon) number of the atom.

.................................................................

(3 marks)
(iii) Draw a similar diagram to represent an isotope of the atom in (ii), and record its mass (nucleon) number.

(b) (i) $^{232}_{90}\text{Th} \rightarrow ^{228}_{88}\text{Ra} \rightarrow ^{228}_{89}\text{Ac} \rightarrow ^{228}_{90}\text{Th}$

The sequence above represents the radioactive decay of a thorium source. It is known that ALL the radioactive emissions are obtained from the source. Enter, above each arrow, the symbols for the radiations that are likely to be emitted.

(3 marks)

(ii) If someone is exposed to all three radiations from the thorium source, which one do you think is most likely to cause the greatest harm? Explain your answer.

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(3 marks)
(iii) Calculate the half-life of a radioactive substance whose activity falls to 25\% in 10 hours.

(2 marks)

(iv) The activity of a substance falls from 3 000 Bq to 750 Bq in 10 hours. What is its activity after a further fifteen hours?

(2 marks)

Total 20 marks
4. (a) State the MAIN differences between the magnetic properties of iron and steel. 

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(2 marks)

(b)

The diagram above represents the circuit for the operation of an electric bell.

(i) Identify the components A and B.

A ........................................................................................................................................

B ........................................................................................................................................

(2 marks)

(ii) Describe clearly the function of EACH of the components X, Y and Z.

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(6 marks)
The circuit above was connected by a student in an attempt to measure the resistance of the resistor \( R_X \). The battery and ammeter had negligible resistance.

(i) What is wrong with the circuit?

What was the ammeter reading?

What was the voltmeter reading?

(ii) Redraw the circuit as it should have been connected.

(iii) If the current through \( R_X \) when the circuit is correctly wired is 0.16 A, what is the voltmeter reading?
5. (a) 

The diagram above represents a vibrating source, S, generating ripples in a shallow trough of water at a rate of 5 per second. The wavelength of the ripples is 1.5 cm.

(i) Describe the motion of the source S and state its frequency.

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(2 marks)

(ii) With reference to the diagram above, write TWO statements describing the motion and frequency of a particle, P, of the medium (water).

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(2 marks)

(iii) Calculate the velocity of the travelling wave.

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(iv) State TWO differences between travelling and standing waves.

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(2 marks)

(v) With reference to the diagram above, mention ONE step that could be taken to obtain a standing wave from the travelling ripples in the trough.

.........................................................................................................................................................

.........................................................................................................................................................

(1 mark)
The figure above shows wave fronts striking a boundary, AB, between deep and shallow water. The distance apart of these wave fronts is 1.5 cm (drawn to scale).

The angle of incidence, $\theta$, is such that

$$\sin \theta = \frac{4}{5}.$$ 

The refractive index for waves travelling into the shallow water is 2.

(i) Calculate the wavelength in shallow water.

(ii) Complete the diagram above to show the refracted wave fronts with their correct separation.
(iii) Calculate the value of $\phi$, the angle of refraction of the waves.

(iv) Calculate the velocity of the wave fronts in shallow water if the velocity in deep water is 4 cm s$^{-1}$. 

(3 marks)

(3 marks)

Total 20 marks

END OF TEST
READ THE FOLLOWING DIRECTIONS CAREFULLY

1. Attempt Question 1 and any THREE of the other questions.
2. ALL WORKING MUST BE SHOWN in your answer booklet, since marks will be awarded for correct steps in calculations.
3. The use of calculators is allowed.
4. Mathematical tables are provided.
5. Use the following data where required:

<table>
<thead>
<tr>
<th></th>
<th>( \text{g} )</th>
<th>( \text{A} )</th>
<th>( \rho )</th>
<th>( s )</th>
<th>( e )</th>
<th>( m_e )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceleration due to gravity</td>
<td>10 m s(^{-2})</td>
<td>( 1 \times 10^5 ) N m(^{-2})</td>
<td>( 1 \times 10^3 ) kg m(^{-3})</td>
<td>( 4.2 \times 10^3 ) J kg(^{-1}) K(^{-1})</td>
<td>( 1.6 \times 10^{-19} ) C</td>
<td>( 9.0 \times 10^{-31} ) kg</td>
</tr>
</tbody>
</table>
SECTION I

You must answer the question in this section.
No more than \( \frac{1}{2} \) hour should be spent on this question.

1. A student measured the variation of potential difference, \( V \), across two components A and B with the current, \( I \), passing through them. Plots of \( V \) against \( I \) produced the following graphs:

(i) Read off and tabulate SIX pairs of values of \( V \) and \( I \) from Graph X. (6 marks)

(ii) Plot the resistance against current for component A. (8 marks)

(iii) What can you deduce from the graph you have plotted about the resistance of component A? (2 marks)

(iv) Give ONE possible physical interpretation of the intercept on the \( V \) axis of Graph X. (2 marks)

(v) Calculate the resistance of component B when \( V = 0.5 \text{ V}, 2.7 \text{ V} \) and \( 5.0 \text{ V} \).
Suggest the nature of component B. (8 marks)

(vi) Discuss whether either of the components obeys Ohm's law. (4 marks)

Total 30 marks
SECTION II

Answer any THREE questions in this section.

2. (a) A bubble of air has a volume of 10 cm$^3$ at the bottom of a pond of depth $h$. On reaching the surface, where the pressure is atmospheric, the volume is 12 cm$^3$. If the temperature of the pond is constant, find $h$. (7 marks)

(b) Explain, with the aid of a diagram, how the transmission of hydraulic pressure can provide a force large enough to stop a motor car. Make it particularly clear how a small applied force can be magnified into a large one. (8 marks)

(c) Use Archimedes’ principle to explain how a submarine can both float and sink. (5 marks)

Total 20 marks

3. (a) A small-scale demonstration solar cooker is to be set up for an exhibition. Explain, with the aid of diagrams, why it would be better if the mirror were parabolic rather than circular in cross-section. (6 marks)

(b) A small can containing 100 g of water is to be hung at the focus of the parabolic mirror to demonstrate to visitors how the cooker could boil water. How would you prepare the can to make it suitable for this purpose?

If the heat energy received per second by the can is 500 J, estimate how long it would take for the temperature of the water to be raised from 30 $^\circ$C to 100 $^\circ$C. (6 marks)

(c) In practice, the time is longer than predicted by the calculation in (b) above. Suggest TWO possible reasons why this is so. (4 marks)

(d) In rural areas of some parts of the Caribbean, it is quite common to see crops being dried on roof tops and at the edge of tarred roads. Mention TWO reasons why these methods of drying crops may be very effective. (4 marks)

Total 20 marks

4. (a) Discuss Newton’s and Young’s views about the nature of light. Describe, briefly, Young’s experiment to support his views. (8 marks)

(b) Describe a laboratory experiment similar to that performed by Young, which could be used to show that sound is transmitted as a wave. (3 marks)

(c) Two students perform an experiment to measure the speed of sound. One student stands 45 m from a wall and claps at a steady rate. Her partner counts 40 intervals between claps in 20 s. Echoes return only mid-way between successive claps. What value does this experiment give for the speed of sound in air? (4 marks)

State THREE possible sources of error in the experiment. In your view, which of these errors is likely to be the most serious? Give a reason for your choice. (5 marks)

Total 20 marks

GO ON TO THE NEXT PAGE
5. (a) What important principle is involved in the operation of a pin-hole camera? (1 mark)

(b) A simple pin-hole camera, 20 cm long, is used to view a bright object 2 cm high, placed 50 cm in front of the pin-hole. By means of a scale drawing on graph paper, show how the image is formed, and find the magnification of the image. (5 marks)

(c) If the camera were only 10 cm long, how big would the image be? (2 marks)

(d) With the aid of ray diagrams, describe the effect of using a large hole instead of a pin-hole. (4 marks)

(e) In order to form a visible image on the screen of a pin-hole camera a bright object is required. To get a good image of a non-luminous object, a student cuts a circular hole in the front of his camera and fits a converging lens of focal length 15 cm in the hole. He now finds he can get a clear image on the screen, which is 20 cm from the lens, only when the object is at a certain fixed distance away.

On graph paper, draw a ray diagram to scale to show how the image is formed. Find the distance from the object to the lens. (8 marks)

Total 20 marks

6. (a) Draw and label a diagram of a dry cell (torch cell) and describe the function of EACH of its main parts. (6 marks)

(b) When the circuit shown below is switched on, the voltmeter reading changes from 3.0 V to 2.5 V. Explain why this happens.

(c) A radio has a battery of four 1.5 V dry cells in series which delivers a current of 0.5 A. The battery runs ‘flat’ after about six hours of continuous use. If EACH dry cell costs $1.50, estimate the cost of one kilowatt-hour of electrical energy from these dry cells. Compare your estimate with the likely cost of mains electricity. (7 marks)

(d) Some low voltage d.c. radios can also be operated from the a.c. mains. Name TWO extra devices that must be built into these radios, and explain why EACH is necessary. (5 marks)

Total 20 marks

GO ON TO THE NEXT PAGE
7. (a) With clear diagrams for EACH step in the process, describe how a metal sphere on an insulating stand might be charged by induction, using a negatively charged polythene rod. (5 marks)

Explain, in terms of electron flow, how the sphere acquires a charge, and state the sign of the charge. (3 marks)

(b) When a conducting sphere, fixed on an insulating stand, is raised to a high potential, a spark passes between it and a nearby earthed sphere. (See diagrams below).

(i) Explain how the air between the two spheres is able to pass a current. (3 marks)

(ii) The microammeter registers an average current of 40 \( \mu \)A as a charge of 2.0 \( \mu \)C passes through it. For how long did the current flow? (3 marks)

(c) There is a potential difference of 5 kV between the cathode and anode of a discharge tube. An electron leaves the cathode and travels towards the anode. Find the work done on the electron and hence calculate the speed of the electron when it reaches the anode. (6 marks)

Total 20 marks

END OF TEST
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2. ALL WORKING MUST BE SHOWN in this booklet, since marks will be awarded for correct steps in calculations.

3. Attempt ALL questions.

4. The use of non-programmable calculators is allowed.

5. Mathematical tables are provided.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO
1. A transformer consists of a primary winding of 1200 turns and a secondary winding of 300 turns. An experiment is performed in which a resistive load on the secondary is varied. The values of the secondary current, \( I_s \), and the corresponding primary current, \( I_p \), are recorded and then plotted on a graph as shown in Figure 1 below.

![Graph showing relationship between \( I_s \) and \( I_p \)]

**Figure 1**

(a) Draw a circuit diagram for the experiment. Label the primary and secondary windings.

(3 marks)
(b)  (i) Find, from the graph, the value of $I_p$ when $I_s = 1.00$ A.

(1 mark)

(ii) Determine the slope of the line and hence write an equation relating $I_s$ and $I_p$.

(4 marks)

(iii) State and explain what you would have expected the equation to be if the transformer had been an ideal one.

(3 marks)

(iv) What would have been the value of $I_p$ for the ideal transformer when $I_s = 1.00$ A?

(1 mark)

(c) Describe TWO measures you would take in the construction of a transformer to make its behaviour close to that of an ideal one.

(i) 

(4 marks)

(ii) 

(4 marks)

Total 16 marks
2. (a) \[ \text{Air} \quad \text{Glass} \]

![Figure 2](image)

The diagram above, drawn to scale, shows plane wavefronts before and after refraction at an air-glass boundary.

(i) Find the refractive index of the glass for these waves. Clearly show on the diagram (Figure 2) all measurements made.

(ii) What is the value of the angle of incidence for these wavefronts?

(b) Light is incident at $60^\circ$ at an air-water boundary and is refracted at $40^\circ$, as shown in Figure 3 below.

![Figure 3](image)
(i) Calculate the refractive index of water.

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.........................
.........................
.........................
.........................

(3 marks)

(ii) Draw a wavefront diagram to represent this refraction at an air-water boundary. (Your diagram need not be to scale.)

Mark, on the diagram, the size of the angle between the incident wavefronts and the boundary, and also between the refracted wavefronts and the boundary.

(5 marks)

(c) (i) The functioning of the human eye depends on refraction. Name the TWO parts of the eye where refraction takes place.

.........................
.........................

(2 marks)

(ii) Explain why the amount of refraction at one of the two parts is much greater than that at the other.

.........................

(1 mark)

Total 16 marks
3. (a) Potential energy may be considered to be energy of state or position, whereas kinetic energy is energy of motion.

Write ‘YES’ or ‘NO’ in EACH of the boxes below to show whether the system possesses the energy indicated at the top of the column.

<table>
<thead>
<tr>
<th>Potential Energy</th>
<th>Kinetic Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>State</td>
<td>Position</td>
</tr>
<tr>
<td>A wound-up spring in a stationary toy car</td>
<td></td>
</tr>
<tr>
<td>A space craft orbiting 100 km above the earth’s surface</td>
<td></td>
</tr>
<tr>
<td>A mixture of fuel and air in a cylinder of a motor car just before firing</td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="Diagram" /></td>
<td>Balloon</td>
</tr>
</tbody>
</table>

(b) The mass of a car and its occupants is 900 kg. It is travelling at 90 km h\(^{-1}\) (25 m s\(^{-1}\)). When it stops suddenly, its kinetic energy is converted to internal energy in the iron brake drums.

(i) Calculate the kinetic energy of the moving car.

<table>
<thead>
<tr>
<th>Kinetic Energy</th>
<th>2 marks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(ii) Each of the four brake drums has a mass of 2.5 kg. Find the rise in temperature which occurs when the car is brought to rest. [Specific heat capacity of iron = 450 J kg\(^{-1}\) K\(^{-1}\).]

<table>
<thead>
<tr>
<th>Kinetic Energy</th>
<th>3 marks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
When a car stops suddenly, a driver might hit the windscreen like the one in Figure 4 above. With reference to Newton’s laws of motion explain

(i) why this might happen

(ii) how the wearing of a seat-belt helps to prevent such an accident.

A car, carrying a passenger, stops suddenly. Describe the energy changes which take place as the passenger is brought to rest by his seat-belt.

Total 16 marks

2492/F 89
4.  (a) Complete the following statement by filling in EACH blank space with an appropriate word.

Most non-physicists think that a force is needed to keep an object moving. This corresponds with the ideas put forward by ______________ more than two thousand years ago. It was ____________ who, in the sixteenth century, first realized that this was not so, although the law stating that bodies move with constant ___________ unless acted upon by an ___________ force is named after ______________. Physicists nowadays realize that objects usually need a force to keep them moving because their motions are opposed by ______________ forces.

(6 marks)

(b) A girl of mass 50 kg starts running along a straight level road and stops after 70 seconds. The variation of her speed with time is shown in Figure 5 below.

![Graph showing speed vs. time](image)

**Figure 5**

(i) Calculate the total distance the girl runs.

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..........................................................

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(4 marks)
(ii) What is her acceleration over the first 20 seconds?

( 1 mark)

(iii) What is the magnitude of the force that produces this acceleration?

( 1 mark)

(iv) How does the force in (iii) above arise?

( 2 marks)

(c) Calculate the girl’s momentum after

(i) 10 seconds

( 1 mark)

(ii) 40 seconds.

( 1 mark)

Total 16 marks
5. (a) Figure 6 below shows TWO bar magnets lying parallel, close to and opposite each other. The magnetic field lines are found to be as shown. Complete the figure by putting in the polarity of EACH of the magnets, and marking the field direction in the four blank spaces.

(b) Insert the magnetic field lines in EACH of the arrangements shown at (i) and (ii) below.

(i) The arrangement shows a wire placed between the N and S poles of a magnet, and carrying a conventional current down into the paper.
(ii) The arrangement below shows a soft iron ring placed between two magnets.

![Diagram of a soft iron ring between two magnets]

(2 marks)

(c) (i) An ordinary torch battery is connected to a moving coil loudspeaker. State how the coil will move.

(ii) What would you expect to hear?

(2 marks)
FIGURE 7

Figure 7(a)

Figure 7(b)

Figure 7(c)
(d) A low voltage alternating supply, a graph of which is shown in Figure 7(a) opposite, is connected to a loud-speaker and a sound is heard.

(i) What is the frequency of the sound that is heard?

(ii) On the axes of Figure 7(b) on page 12, draw a graph to show how the applied voltage would vary with time if the sound were louder than that represented in 7(a), but of the same frequency.

(iii) On the axes of Figure 7(c) on page 12, draw another graph to show how the applied voltage would vary with time if the sound were higher in pitch than that represented in Figure 7(a), but of the same loudness.

Total 16 marks

END OF TEST
CARIBBEAN EXAMINATIONS COUNCIL

SECONDARY EDUCATION CERTIFICATE EXAMINATION

PHYSICS

Paper 3

General Proficiency

1 3/4 hours

In addition to the 1 3/4 hours, candidates are allowed a reading time of 15 minutes. No writing must be done during the 15-minute period.

READ THE FOLLOWING DIRECTIONS CAREFULLY

1. Attempt Question 1 and any THREE of the other questions.

2. ALL WORKING MUST BE SHOWN in your answer booklet, since marks will be awarded for correct steps in calculations.

3. The use of non-programmable calculators is allowed.

4. Mathematical tables are provided.
SECTION I

You MUST answer the question in this section.
No more than ½ hour should be spent on this question.

1. A student was provided with about 4 metres of thin copper wire and asked to investigate how the extension of the wire depended on the force stretching it. The graph provided in Figure 1 shows the results of her investigation up to the point where the wire broke.

(a) (i) Draw and label a diagram of the arrangement you would use to carry out the investigation. State how the extension would be measured. (5 marks)

(ii) What difference would you expect to observe if a thicker copper wire of the same length were used instead? (2 marks)

(iii) By referring to the graph in Figure 1, describe what you would feel if you were to pull on the wire until it broke. (2 marks)

(iv) Explain what is meant by the term ‘elastic limit’. Estimate the load at the elastic limit for the piece of wire tested. (3 marks)

(v) Find the gradient of the straight part of the graph below the elastic limit. (3 marks)

(b) (i) The student performing the experiment used the following values for the load, F:

\[ F/N\ 2;\ 4;\ 6;\ 8;\ 10;\ 12;\ 14;\ 15;\ 16;\ 17;\ 17.5;\ 18. \]

Construct a table to show the corresponding extensions. (7 marks)

(ii) Why was it a good idea for the experimenter to add loads 1 N at a time and then 0.5 N as the load increased? (2 marks)

(c) The work done in stretching the wire may be calculated from the area under the curve (graph).

(i) Using the scale marked on the graph, calculate the amount of work (in joules) represented by an area of 1 cm². (1 mark)

(ii) Calculate the work done in stretching the wire by 4 mm. (1 mark)

(iii) Estimate the work done in changing the extension of the wire from 20 mm to 50 mm. Show clearly on the graph how you would perform this calculation. (Remember to tie the graph paper in your answer booklet at the appropriate place.) (4 marks)

Total 30 marks

GO ON TO THE NEXT PAGE
SECTION II

Answer any THREE questions in this section.

2. (a) With the aid of a labelled diagram, describe the structure of a simple mercury barometer. How do barometer readings provide an indication of the approach of a hurricane? (6 marks)

(b) An open-ended mercury manometer is connected to a cylinder containing gas at room temperature of 27 °C, as shown in Figure 2 below. The manometer reading is 25 cm and the mercury barometer reading at the time is 75 cm.

![Figure 2](image_url)

(i) Calculate the pressure, in Pa, of the gas in the cylinder. (4 marks)

(ii) To what temperature must the gas be raised in order to increase the manometer reading to 50 cm? (5 marks)

(c) (i) A boy is riding a bicycle with tyres pumped to a pressure of 5.0 \times 10^5 \text{ Pa}. Given that the combined mass of the boy and the bicycle is 75 kg, calculate the area of the tyres that is in contact with the road. (3 marks)

(ii) Why is the pressure in the tyre of a racing bicycle usually higher than that in a motor-car tyre? (2 marks)

(Density of mercury = 1.36 \times 10^4 \text{ kg m}^{-3}; g = 10 \text{ N kg}^{-1})

Total 20 marks

GO ON TO THE NEXT PAGE
6. (a) (i) Describe how you would demonstrate that no change of temperature takes place as the phase of a substance changes from LIQUID to SOLID. 

(ii) Discuss the ways in which heat is lost from the substance, and explain how it is possible for the temperature to remain constant even though heat is lost. 

(b) A 1000 W, 120 V electric kettle contains 0.5 kg of water at 30 °C. It is used to heat the water to its boiling point of 100 °C.

(i) Find the resistance of the heating element of the kettle.

(ii) Estimate how long it will take for the water to reach 100 °C after the kettle is switched on. From the data provided here, your answer can only be approximate. State TWO assumptions that you had to make while doing this calculation.

(iii) If the kettle were left switched on after the water had reached 100 °C, 100 g of water would be converted to vapour in 4 minutes. Calculate the specific latent heat of vaporization of water using this data. (Specific heat capacity of water = 4200 J kg⁻¹ K⁻¹)

Total 20 marks

4. (a) With reference to a converging lens, what is meant by the term ‘focal length’?

(b) By means of well-labelled diagrams, show how a converging lens can form (i) a REAL IMAGE and (ii) a VIRTUAL IMAGE. Give a practical example of a useful application of EACH type of image.

(c) An object placed 20 cm from a converging lens and along its axis produces an image 60 cm from the lens. Determine by scale drawing, the focal length of the lens if the image is formed on the opposite side of the lens from the object. (Use graph paper.)

(d) If the object were now placed 60 cm from the lens, state where the image would be formed and what its height would be, relative to that of the object.

Total 20 marks
5. (a) (i) Describe the model of the atom proposed by J.J. Thomson early in this century and compare it with the model put forward by Ernest Rutherford. (5 marks)

(ii) Briefly describe the Geiger-Marsden experiment, and discuss how the results were used to decide which of the two models was better. (6 marks)

(b) You are told that a particular radioactive source emits only β-particles. Describe how you would check this in the laboratory, taking care to state what equipment you would use. (5 marks)

(c) The power output of the sun is about \( 4 \times 10^{26} \) J s\(^{-1}\). Assuming that all of the energy produced is the result of nuclear reactions within the sun, calculate the rate at which the sun is losing mass, (c = \( 3 \times 10^8 \) m s\(^{-1}\)). (4 marks)

Total 20 marks

6. (a) Draw a labelled diagram of a dry cell and indicate the purpose of the main parts. (8 marks)

(b) Two 1.5 V cells of negligible resistance are connected in series to a combination of resistors as shown in the circuit diagram below.

![Circuit Diagram]

Calculate

(i) the total resistance in the circuit (3 marks)

(ii) the current flowing in the 4 Ω resistor (2 marks)

(iii) the current flowing in the 6 Ω resistor (2 marks)

(iv) the charge that flows through the cells in a time of 20 s. (2 marks)

(c) If a high resistance voltmeter were connected between the points A and B, what would you expect it to read? Explain your answer. (3 marks)

Total 20 marks
(a) Describe, with the aid of a labelled diagram, the structure of a simple d.c. motor. Explain how the motor operates. (10 marks)

(b) State TWO features that a practical d.c. motor might possess to make it work more efficiently. (2 marks)

(c) A 24 V d.c. motor operating at an efficiency of 75% is used to raise a load of 20 kg through a height of 9 m. It lifts the load at a steady rate and takes 4 s to do so.

Calculate

(i) the useful power (4 marks)

(ii) the current drawn from the d.c. supply. (4 marks)

\( g = 10 \text{ N kg}^{-1} \)

Total 20 marks

END OF TEST
GRAPH OF LOAD (F) AGAINST EXTENSION (x) FOR A THIN COPPER WIRE

Figure 1
READ THE FOLLOWING DIRECTIONS CAREFULLY

1. You MUST use this answer booklet when responding to the questions. For each question, write your answer in the space provided and return the answer booklet at the end of the examination.

2. ALL WORKING MUST BE SHOWN in this booklet, since marks will be awarded for correct steps in calculations.

3. Attempt ALL questions.

4. The use of non-programmable calculators is allowed.

5. Mathematical tables are provided.
1. (a) Figure 1 represents a transverse wave on a string vibrating with a frequency of 100 Hz.

![Graph of a transverse wave with labels on the x-axis: 0, 2.0, 4.0, 6.0, 8.0 and on the y-axis: -2, -1, 0, 1, 2.]

(i) State the amplitude and wavelength of the wave.
Amplitude .................................................................
Wavelength ....................................................................

(2 marks)

(ii) Calculate the period and velocity of the wave.
....................................................................................
....................................................................................
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(3 marks)
The diagrams in Figure 2 above show series of plane wavefronts approaching (i) a narrow gap and (ii) a wide gap. Complete the diagrams to show the wavefronts after they have passed through EACH gap.

(4 marks)
(c) Figure 3 below shows plane electromagnetic wavefronts travelling in air with velocity of $3.0 \times 10^8$ m s$^{-1}$, and meeting a plane refracting surface at an angle of $30^\circ$. The wavelength of the waves in air is $4.0 \times 10^7$ m and the velocity of the waves in the second medium is $2.2 \times 10^8$ m.

![Figure 3](image)

Calculate:

(i) The frequency of the waves in air

(ii) The wavelength of the waves in the second medium and the angle of refraction

Total 16 marks
2. (a) A car engine converts chemical energy into mechanical energy. Even in well designed engines, however, the efficiency is not usually greater than 35%.

(i) Give the formula for calculating the efficiency of the engine.

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(2 marks)

(ii) A car uses gasoline of energy content 40 MJ per litre. If its engine is 30% efficient, how much useful work does it do for every litre of gasoline consumed?

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(2 marks)

(iii) The car, travelling at constant speed, experiences an average retarding force of 1200 N. How far can the car travel on 1 litre of gas?

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(3 marks)
(b) The diagram in Figure 4 below represents a hydraulic machine used for lifting cars.

![Figure 4 - Hydraulic Machine Diagram](image)

A small force applied at the small movable piston A, is capable of supporting a large weight at the large piston B, for example a car on the hoist.

(i) State the principle on which the action of this machine is based.

(ii) Explain how the principle is applied to obtain a force great enough to support a car.

(iii) A force of 480 N is applied to the piston, A, which has an area of 0.01 m². What is the resulting pressure on the liquid?

(iv) What is the pressure on the large piston?

(v) What is the total force exerted on the large piston if its area is 0.15 m²?

Total 16 marks
In the Geiger-Marsden experiment represented in Figure 5 above, a stream of alpha-particles, travelling in a vacuum, struck a piece of thin gold foil. The behaviour of the alpha-particles was observed.

(i) State the composition of an alpha-particle.

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(2 marks)

(ii) Why was a vacuum necessary?

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......................................................................................................................................................
(2 marks)

(iii) How were the alpha-particles detected?

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(1 mark)

(iv) Explain why most of the alpha-particles were able to pass through the foil undeviated.

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(2 marks)

GO ON TO THE NEXT PAGE
(v) The Geiger-Marsden experiment supported a particular model of the atom. Name ONE scientist who had proposed another model just before this one.

Briefly describe the model proposed before the one supported by the Geiger-Marsden experiment.

(b) The following represents two nuclear reactions:

\[ ^{216}\text{Po} \rightarrow ^{212}\text{Pb} + \ X \]

\[ ^{212}\text{Pb} \rightarrow ^{212}\text{Bi} + \ Y \]

Name the emissions X and Y and write the symbols for them.

(c) The activity of a sample of a radioactive element decreases to \( \frac{1}{4} \) of its original value in one hour. Calculate the half-life of the sample.

Total 16 marks
4. (a) (i) There is evidence that suggests that all matter is made up of particles. With reference to this statement, draw diagrams to illustrate the difference between the structure of liquids and that of gases.

(3 marks)

(ii) Explain why gases are more easily compressed than liquids.

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(3 marks)
(b)

Figure 6

Figure 6 above shows the experimental arrangement used to investigate how the volume of a fixed mass of air varies with temperature. Readings were taken of the length of the air column for a range of temperatures which was then converted to kelvin temperatures.

(i) Using the axes below, sketch the graph you would expect to obtain as a result of plotting the length of the air column against the kelvin temperature, T.

(ii) State the 'law' which this experiment is used to investigate.

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(2 marks)

GO ON TO THE NEXT PAGE
(iii) Theory suggests that the volume of the gas becomes zero at a certain temperature. What is the value of this temperature?

(1 mark)

c) A container used for storing compressed gas is fitted with a valve which opens when the pressure is $1 \times 10^6$ Pa. The cylinder contains gas at $10^6$ C and $8.5 \times 10^5$ Pa. At what temperature will the valve open?

(5 marks)

Total 16 marks
5. (a) ![Graph of current vs time for an a.c. generator and a dry cell.](image)

The graphs above represent the variation with time of the output current from an alternating current (a.c.) generator and a dry cell in separate circuits.

(i) State the essential difference between direct current and alternating current.

(ii) A split-ring commutator is now connected to the a.c. generator. On the axes below, draw a graph to represent the output current assuming no other change in the circuit.
The commutator is removed and a p-n diode is placed in series with the a.c. generator.

(iii) Distinguish between the p-type material and n-type material of which the diode is made.

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(4 marks)

(iv) On the axes below, draw a graph of current against time to represent the output of the a.c. generator and diode.

\[ I/A \]

\[ +2 \]

\[ 0 \]

\[ -2 \]

\[ t/s \]

...........................................................................................................................................

(3 marks)

(b) A 5.0 \( \Omega \) resistor has a maximum power rating of 5.0 W. It is connected to a d.c. power supply.

(i) Calculate the maximum permissible current in the resistor.

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(3 marks)

(ii) The resistor is then connected to an a.c. supply and an alternating current flows with a peak value equal to the maximum permissible current. The rate of energy conversion using a.c. will be less than that using d.c. Explain this fact.

...........................................................................................................................................

(1 mark)

Total 16 marks

END OF TEST
C A R I B B E A N  E X A M I N A T I O N S  C O U N C I L
SECONDARY EDUCATION CERTIFICATE EXAMINATION

PHYSICS

Paper 3

General Proficiency

$1 \frac{3}{4}$ hours

In addition to the $1 \frac{3}{4}$ hours, candidates are allowed a reading time of 15 minutes. No writing must be done during the 15-minute period.

READ THE FOLLOWING DIRECTIONS CAREFULLY

1. Attempt Question 1 and any THREE of the other questions.

2. ALL WORKING MUST BE SHOWN in your answer booklet, since marks will be awarded for correct steps in calculations.

3. The use of non-programmable calculators is allowed.

4. Mathematical tables are provided.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO
SECTION I

You MUST answer the question in this section.
No more than $\frac{1}{2}$ hour should be spent on this question.

1. Some students performed an experiment to investigate the relationship between the centripetal force and the time for one revolution for an object moving in a circle. A diagram of the experimental arrangement is shown below.

![Diagram of experimental setup showing rubber bung, glass tube, and weights.]

A length of string was tied to a rubber bung and the other end passed through a glass tube. Weights were then added to this end of the string. The radius of the circular orbit was found to be 0.5 m and the bung was whirled in a horizontal circle. The time taken for the rubber bung to complete 50 revolutions was recorded. The procedure was repeated using a range of weights. The radius of the circle was kept constant throughout the experiment.

Results of the experiment are tabulated below:

<table>
<thead>
<tr>
<th>Weight $W/N$</th>
<th>Average time for 50 revolutions /s</th>
<th>Time for 1 revolution $T/s$</th>
<th>$T^2/s^2$</th>
<th>$\frac{1}{T^2}$/s$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.50</td>
<td>42.0</td>
<td>0.840</td>
<td>0.706</td>
<td>1.42</td>
</tr>
<tr>
<td>0.75</td>
<td>36.8</td>
<td>0.736</td>
<td>0.542</td>
<td></td>
</tr>
<tr>
<td>1.00</td>
<td>31.6</td>
<td>0.632</td>
<td>0.399</td>
<td></td>
</tr>
<tr>
<td>1.25</td>
<td>28.5</td>
<td>0.570</td>
<td>0.325</td>
<td></td>
</tr>
<tr>
<td>1.50</td>
<td>26.8</td>
<td>0.536</td>
<td>0.287</td>
<td></td>
</tr>
<tr>
<td>1.75</td>
<td>25.5</td>
<td>0.510</td>
<td>0.260</td>
<td></td>
</tr>
<tr>
<td>2.00</td>
<td>23.5</td>
<td>0.470</td>
<td>0.221</td>
<td></td>
</tr>
</tbody>
</table>

GO ON TO THE NEXT PAGE
1. (a) Calculate the missing values of \( \frac{1}{T^2} \) and IN YOUR ANSWER BOOKLET tabulate these values of \( \frac{1}{T^2} \) along with the corresponding values of weight. 
(4 marks)

(b) What provided the centripetal force needed for the bung to maintain its circular path? 
(2 marks)

(c) The students found the time for 50 revolutions in EACH case. What TWO sources of error does this help to reduce? 
(2 marks)

(d) Plot a graph of weight, \( W \) (y axis) against \( \frac{1}{T^2} \) (x axis). 
(9 marks)

(e) Calculate the slope of the graph. 
(5 marks)

(f) Theory shows that the slope = \( 4 \pi^2 mr \). 
where \( m \) is the mass of the bung and \( r \) is the radius of its orbit.

Use your value for the slope to find the mass of the bung. 
(4 marks)

(g) How would you alter the procedure to investigate the relationship between the radius of the orbit, \( r \), and the time for one revolution, \( T \)? 
(4 marks)

Total 30 marks

SECTION II

Answer any THREE questions in this section.

2. In a tape recorder (cassette player), an electric motor rotates the tape in the cassette. The magnetic tape of the cassette is used to generate a current which drives a loudspeaker.

(a) Draw a diagram to represent the arrangement of the components in a simple direct current motor and state the purpose of EACH component.

The tape is noticed to be rotating too slowly. Suggest TWO reasons why this might occur. 
(10 marks)

(b) The tape is coated with a magnetic material which must be demagnetised before it is used for recording. Suggest how this may be done. 
(3 marks)

(c) To record a song, a moving-coil microphone is plugged into the tape-recorder. This connects the microphone to an electromagnet known as the recording head. As the tape passes this head, it is magnetised.

Explain how the sound entering the microphone causes a varying magnetic field in the recording head.

When the singing is louder, the magnetisation of the tape is greater. Briefly explain this fact. 
(7 marks)

Total 20 marks

2493/F 90

GO ON TO THE NEXT PAGE
3. (a) The diagram below shows part of the apparatus used to measure the specific heat capacity of a 1 kg copper block. An immersion heater and a thermometer are inserted into holes drilled in the block.

![Diagram of apparatus with thermometer and heater](image)

(i) The heater operates from a d.c. supply. Draw a diagram of a circuit which may be used to determine the power supplied by the heater. What readings should be taken to obtain a value for the specific heat capacity of the copper? Show how these readings would be used.

(ii) The block is now replaced by one of equal mass, made of iron, which has a larger specific heat capacity. What effect would this have on the temperature rise if the other factors remain the same?

(10 marks)

(b) Explain EACH of the following:

(i) The engines of most motor cars are water-cooled, whereas smaller engines e.g. those of motor-cycles are usually air-cooled.

(ii) The difference in the specific heat capacity of land and water gives rise to land and sea breezes.

(iii) When ice cubes at 0°C are added to a cup of hot coffee, they are more effective in cooling the coffee than adding an equal mass of water at 0°C.

Specific heat capacity of air $1\,000\, \text{J kg}^{-1}\,\text{K}^{-1}$
Specific heat capacity of water $4\,200\, \text{J kg}^{-1}\,\text{K}^{-1}$

(10 marks)

Total 20 marks

GO ON TO THE NEXT PAGE
(a) The table below shows the values for frequency and wavelength of certain waves, A, B and C, travelling on deep sea water.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength /m</td>
<td>10</td>
<td>1.5</td>
<td>6</td>
</tr>
<tr>
<td>Frequency /Hz</td>
<td>4</td>
<td>1</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Calculate the speed of the waves in EACH case and state TWO ways in which the speed of deep sea waves differs from that of electro-magnetic waves in a vacuum.  

(5 marks)

(b) A circular wave-front is created by dropping a stone into a lake. Suggest TWO reasons why the amplitude of the wave-front decreases as it spreads out.  

(3 marks)

(c) Sound waves are used in echo sounding to find the depth of the sea at different places e.g. under oil-rigs. The sound wave sent out at the surface of the sea is reflected from the sea bed and the time taken for the echo to return is measured.

Near an oil-rig, the echo returns in 4.6 seconds. If the speed of sound in water is 1 500 m s\(^{-1}\), calculate the depth of the sea near this oil rig.  

(4 marks)

(d) State TWO conditions necessary for total internal reflection to occur.

Draw a diagram showing sound waves striking an air-water boundary at the critical angle. (Represent the sound by a ray.)

Calculate the value of the critical angle.  

(8 marks)

Speed of sound in air = 300 m s\(^{-1}\)
Speed of sound in water = 1 500 m s\(^{-1}\)

Total 20 marks
5. (a) During the 19th century, Michael Faraday conducted experiments on electrolysis. He investigated the factors which determine the masses of substances liberated. Suggest TWO difficulties which Faraday might have experienced in attempting to obtain reliable results.

(b) A student wished to cover a metal coin with a coating of copper using the process of electrolysis. Draw a clearly labelled diagram of the circuit he might have used to achieve this. State TWO precautions which he should have taken to obtain a good coating of copper.

(c) In the process described above in (b), a current of 0.1 A flowed for 12 minutes and the potential difference between the electrodes was 2 V.

Calculate:

(i) The charge which has flowed round the circuit

(ii) The number of electrons which has flowed round the circuit

(iii) The energy needed to move the electrons between the electrodes of the voltmeter.

Would you expect a temperature change to have occurred in the electrolyte? Give a reason for your answer.

\[
\text{Charge on electron} = 1.6 \times 10^{-19} \text{ C}
\]

Total 20 marks
6. (a) Define the moment of a force and state the principle of moments. A cardboard lamina hangs freely from a horizontal nail with its plane vertical. What is the moment of the weight of the lamina when in equilibrium? Give a reason for your answer. Describe how this arrangement may be used to find the centre of gravity of the lamina.

(10 marks)

(b)

A UNIFORM plank of length 3 m is supported by two wooden trestles L and M as shown in the diagram above. L exerts a force of 80 N upwards and M a force of 160 N upwards. M is 0.5 m from the centre of gravity of the plank.

(i) Calculate the weight, W, of the plank and, by taking moments about the centre of gravity, find the value of x.

(ii) A boy of weight 200 N walks along the plank from M towards T. How far from M will he be when the plank just rises from L?

(10 marks)

Total 20 marks

7. (a) The human eye is optically similar to a simple lens camera. State how EACH achieves the following:

(i) Control of the amount of light entering

(ii) Formation of sharp images of objects at different distances

Where is the image formed in EACH case? Name TWO surfaces of the human eye at which refraction of light occurs.

( 8 marks)

(b) An object is placed perpendicular to the principal axis of the converging lens in a camera used for close-up photography. The object is 30 cm from the lens and an inverted real image is formed at a distance of 10 cm from the lens.

Calculate the magnification of the image and, by means of a scale drawing on graph paper, determine the focal length of the lens.

( 8 marks)

(c) The lens is removed from the camera and held at a distance of 4 cm from an ant of length 2 mm. Use a scale diagram to find the length of the image of the ant.

( 4 marks)

Total 20 marks

END OF TEST
READ THE FOLLOWING DIRECTIONS CAREFULLY

1. You MUST use this answer booklet when responding to the questions. For each question, write your answer in the space provided and return the answer booklet at the end of the examination.

2. ALL WORKING MUST BE SHOWN in this booklet, since marks will be awarded for correct steps in calculations.

3. Attempt ALL questions.

4. The use of non-programmable calculators is allowed.

5. Mathematical tables are provided.
1. (a) Refrigerator-Freezer
Capacity: 14.0 Cubic Feet (0.40 m³)
Type of Defrost: Automatic

ENERGYGUIDE

Based on an average cost of 50¢ per kWh

Model with lowest energy cost $450

|

Model with highest energy cost

\$410 THIS MODEL $530

Estimated yearly energy cost


Figure 1

(i) How much energy does the refrigerator referred to in the ‘Energy guide’ above use per month?

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(3 marks)

(ii) Assuming 1 month = 30 days, what is the average power consumption (in watts) of the refrigerator?

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(3 marks)

GO ON TO THE NEXT PAGE
(b) (i) The plug on the refrigerator has 3 pins. Name EACH pin.

_________________________  __________________________  ___________________________

(3 marks)

(ii) Although the refrigerator would work if a two-pin plug were used, explain why the manufacturer insists that the third pin must not be cut off.

_________________________  __________________________  ___________________________

_________________________  __________________________  ___________________________

(2 marks)

(c) Mothers often complain about their children wasting electricity by repeatedly opening the refrigerator door because "the cold air falls out". Using the following data, calculate how much energy, in kilowatt hours, has to be removed for the air in the refrigerator to be cooled from 30 °C to 5 °C.

Volume of refrigerator = 0.40 m³
Density of air = 1.29 kg m⁻³
Specific heat capacity of air = 600 J kg⁻¹ K⁻¹

1 kW h = 3.6 x 10⁶ J

(5 marks)

Total 16 marks
2. (a)  

![Diagram of apparatus for observing graphite in water through a microscope.]

Figure 2

Figure 2 above shows the apparatus used to observe, through a microscope, small graphite particles suspended in water. The graphite is seen as bright points of light.

(i) Describe what would be seen through the microscope as the particles are observed for a few seconds.

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(2 marks)

(ii) If warmer water were used instead, what change in your observation would you expect?

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(1 mark)

(iii) What conclusions can be drawn from these observations?

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(2 marks)
(b) The average speed of a perfume molecule at room temperature is about 100 metres per second. The speed at which the scent of perfume travels across a room, however, is much less than this. Explain this difference.

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(3 marks)

c) Use the kinetic theory to explain why

(i) putting more air in a car tyre increases its pressure

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(2 marks)

(ii) the pressure in a car tyre increases when it is hot.

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(2 marks)

d) Nitrous oxide gas in a cylinder at 17 °C exerts a pressure of 5.0 x 10^5 Pa. Before it is used it is warmed to 37 °C. What is the new pressure?

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(4 marks)

Total 16 marks

GO ON TO THE NEXT PAGE
(a) Complete the following statements of Newton’s 1st and 3rd laws of motion.

1st Law: An object remains at rest .................................................................
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3rd Law: If an object A exerts a force on object B ........................................
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(4 marks)

(b) A passenger travelling on a bus falls forward when the bus stops suddenly. Account for this in terms of Newton’s first law.
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(2 marks)

(c) The diagram below shows the Moon in its orbit around the Earth. The Moon moves at constant speed.

(i) Draw on the diagram any force or forces acting on the Moon.

 Orbit

 Moon

 Earth

(2 marks)
(i) How does Newton's third law apply in this case?

(ii) Draw on the diagram any force or forces acting on the ball at points A and B, IGNORING AIR RESISTANCE.

(iii) State the magnitude of the acceleration of the ball at A and at B.

At A: .................................................................

At B: .................................................................

(2 marks)

Figure 3

A ball is thrown vertically upwards. Figure 3 above shows the position of the ball at equal intervals of time. At A it is moving upwards and at B it has reached its highest point.

(6 marks)

Total 16 marks
(a) A nuclide of uranium-238 is represented by the symbol

\[ ^{238}_{92} U \]

(i) How many neutrons does this nuclide have?

How many protons does this nuclide have?

(2 marks)

(ii) The mass number of the uranium nuclide is 238. Using the same notation, an electron is represented by

\[ ^{0}_{-1} e \]

Its mass number is 0. Does this mean that the electron has zero mass? Explain your answer.

(2 marks)

(b) Uranium-238 decays by emitting an alpha-particle to form thorium-234 (symbol Th). Complete the equation for this reaction.

\[ ^{238}_{92} U \longrightarrow ^{234}_{90} Th + He \]

(2 marks)

The thorium-234 decays, in turn, by beta - decay to form protactinium (symbol Pa). Complete the equation for this decay.

\[ ^{234}_{90} Th \longrightarrow ^{234}_{91} Pa + e \]

(3 marks)
(c) A radioactive material decays with a half-life of 3 days.

(i) On the grid below, plot a graph to show how an initial mass of 8.00 g decays over a period of 15 days. (5 marks)

(ii) How much of the radioactive material remains after 5 days?

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(1 mark)

(iii) If the pressure on the material were 10 times greater, how much would remain after 9 days?

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(1 mark)

Total 16 marks
5.

Figure 4

(a) Label the parts A, B, C, D in the diagram of the eye above. (4 marks)

The eye in Figure 4 above is long-sighted. By drawing rays on the diagram, show how the long-sightedness is corrected with the use of the converging lens. (4 marks)

(b) The spectacle lens used in Figure 4 above has a focal length of 80 cm. It produces a virtual image of the object being viewed. If the object is 10 cm high and 40 cm from the lens, find, by completing the scale drawing below, the position and magnification of the image.

Magnification: Position: (8 marks)

Total 16 marks

END OF TEST
CARIBBEAN EXAMINATIONS COUNCIL
SECONDARY EDUCATION CERTIFICATE
EXAMINATION

PHYSICS

Paper 3

General Proficiency

$1 \frac{3}{4}$ hours

In addition to the $1 \frac{3}{4}$ hours, candidates are allowed a reading time of 15 minutes. Writing may begin during the 15-minute period.

READ THE FOLLOWING DIRECTIONS CAREFULLY

1. Attempt Question 1 and any THREE of the other questions.

2. ALL WORKING MUST BE SHOWN in your answer booklet, since marks will be awarded for correct steps in calculations.

3. The use of non-programmable calculators is allowed.

4. Mathematical tables are provided.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO

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SECTION I

You must answer the question in this section.
No more than $\frac{1}{2}$ hour should be spent on this question.

1. The graph on the opposite page shows the current drawn by a small light bulb for various applied p.d.'s.

(a) With the aid of a circuit diagram, describe how these values might have been obtained. (4 marks)

(b) Use the graph to find the resistance of the bulb when the p.d. is 0.70 V. (3 marks)

(c) Using the graph, draw up a table of values of the current $I$ and the resistance $R$ for at least eight different values of the p.d., $V$.

Plot a graph to show how the resistance of the light bulb varies with the applied p.d.
(Attach this sheet to your answer booklet.)

What conclusion can you draw from the graph you have plotted? (20 marks)

(d) The bulb is usually operated from a 2.8 V supply. Find its normal power. (3 marks)

Total 30 marks

GO ON TO THE NEXT PAGE
SECTION II

Answer ANY THREE questions in this section.

2. (a) "Velocity is a vector quantity but speed is a scalar”. Explain what this statement means, giving TWO other examples of vectors and TWO examples of scalars. (4 marks)

(b) The following extract is taken from a letter to a Barbados newspaper:

“A truck with open platform, obviously intent on ‘beating’ the light rushes onto the highway and turns sharply to the left . . . . On the platform are . . . . . about a dozen concrete blocks.

I am sitting at the wheel of my car awaiting the green light. Well, the truck duly makes its turn on to the highway but the concrete blocks . . . have other ideas . . . they prefer to continue going straight . . . towards me!

Fortunately, nearly all disintegrate into a powdery mess on the road, while one . . . crashes into my hub-cap and wheel”.

Mark on a diagram the direction of the truck’s velocity at TWO different instants. Hence, show that the truck is accelerating even though it has constant speed. Add the direction of the acceleration to your diagram.

Explain why the blocks “prefer to continue going straight”. (6 marks)

(c) A helicopter heads due North and has an airspeed of 80 km h^-1. The wind is blowing to the North-East at 33 km.h^-1. By means of a scale drawing, find the magnitude and direction of the helicopter’s velocity relative to the ground.

How far does the helicopter travel in 15 minutes? (10 marks)

Total 20 marks
3. (a) Describe the processes by which energy is (i) produced in the sun, (ii) transmitted to the earth, and (iii) trapped by the atmosphere (the 'glass-house effect').

(8 marks)

(b) Each square metre of the earth receives energy from the sun, at the rate of 730 W. A solar panel of area 12 m² is exposed to the sun. Calculate the amount of energy incident on the panel in 6 hours.

What mass of water could it heat from 30 °C to 80 °C between 9 a.m. and 3 p.m.? 

(9 marks)

(c) A number of assumptions have been made in order to simplify the problem at (b) above. State THREE of these assumptions.

(The specific heat capacity of water is 4.2 x 10³ J kg⁻¹ K⁻¹.)

Total 20 marks

4. (a) Describe, with the aid of diagrams where appropriate, observations which lead us to believe that:

(i) Light has wave properties.

(ii) The wavelength of light is much smaller than the wavelength of sound.

(8 marks)

(b) Plane sound waves travelling IN AIR are incident, at an angle, on a flat water surface. Their wavelength is 5.0 m. The speed of sound in air is 300 m s⁻¹, but in water it increases to 1500 m s⁻¹.

Draw a diagram showing the approximate directions and wavelengths of the waves as they cross the air-water boundary.

Calculate the frequency and wavelength of the sound waves in the water.

(7 marks)

(c) The sound waves can only enter the water if the angle of incidence is small enough. Account for this observation and calculate the maximum size of the angle of incidence for the sound to enter the water.

(5 marks)

Total 20 marks
5. (a) A positively charged rod can attract an uncharged object such as a small piece of paper. Explain how this occurs.

Describe how a metal ring on an insulating handle may be given a negative charge by induction. Explain the process in terms of electron flow.

In a typical case, the ring might hold a charge of $4 \times 10^{-9}$ C at a potential of 2000 V.

If the metal ring is touched by a wooden rule in a person's hand, the ring quickly discharges. This is possible even though the resistance of the metre rule may be as high at 10 MΩ. To explain this, calculate the average current which flows through the metre rule and the time for the discharge to take place. (13 marks)

(b) In the modern spraying of crops with insecticide, portable diesel generators are used to charge the drops of liquid as they are being sprayed.

Explain how this process helps the spray to be applied MORE WIDELY, and to STICK MORE EFFECTIVELY to the surface of the leaves.

One such generator provides EACH kilogram of liquid with 0.8 mC of charge at a potential of 4 kV. Calculate the energy required to charge up one kilogram of spray. (7 marks)

Total 20 marks

6. (a) State the difference between n- and p-type semi-conductors.

Draw a circuit diagram, including a semi-conductor diode, to show how a secondary cell, such as a car battery, may be safely recharged using a mains supply. (8 marks)

(b) The diagram above shows a form of a magnetic relay. Explain how direct current in the solenoid will cause the contacts to close.

State whether the relay would work if alternating current were passed through the solenoid, and give your reasons.

State and explain the effect of replacing the iron strips with (i) steel and (ii) copper. (12 marks)

Total 20 marks

GO ON TO THE NEXT PAGE

2493/F 91
7. (a) What is the principle of conservation of energy? Outline the contributions of Joule and Rumford to the establishment of this principle. (8 marks)

(b) In a large Caribbean hurricane, continuous winds of 180 km h\(^{-1}\) spread over an area of 30 000 km\(^2\), up to a height of 8 km.

Calculate the mass of moving air.

Making the simplifying assumption that all the air is moving at the same speed, calculate the kinetic energy of the air within the hurricane.

The source of energy of a hurricane is the condensation of water that has evaporated from the sea. Account for the fact that hurricanes are more likely to occur in the Caribbean between the months of June to October than at other times of the year.

(Density of air = 1.3 kg m\(^{-3}\)) (12 marks)

Total 20 marks

END OF TEST
READ THE FOLLOWING DIRECTIONS CAREFULLY

1. You MUST use this answer booklet when responding to the questions. For each question, write your answer in the space provided and return the answer booklet at the end of the examination.

2. ALL WORKING MUST BE SHOWN in this booklet, since marks will be awarded for correct steps in calculations.

3. Attempt ALL questions.

4. The use of non-programmable calculators is allowed.

5. Mathematical tables are provided.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO
1. (a) Identify the following materials as good or poor thermal and electrical conductors by writing the words 'GOOD' or 'POOR' in the spaces provided.

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>THERMAL CONDUCTOR</th>
<th>ELECTRICAL CONDUCTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mercury</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminium</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(3 marks)

(b) The diagram below represents an ice-cream maker in which the temperature of the ice-cream mixture is reduced by surrounding it with ice and salt.

(i) Indicate on the diagram by means of an arrow, the direction of heat flow between the mixture and the ice/salt. (1 mark)

(ii) Explain why the inner container is made of a good thermal conductor while the outer container is made of a poor thermal conductor.

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(2 marks)
(c) 0.30 kg of ice at 0°C is placed in a container.

(i) How much energy is required to completely melt the ice?

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(3 marks)

(ii) How much energy is required to raise the temperature of the melted ice to 15°C?

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(3 marks)

(iii) Some water at 30°C is added to 0.30 kg of ice at 0°C. The ice melts and the final temperature of all the water is 15°C.

Use your answers to (i) and (ii) above to determine the mass of water added.

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(4 marks)

[Specific heat capacity of water = 4.2 \times 10^3 \text{ J kg}^{-1} \text{ K}^{-1}]

[Specific latent heat of fusion of ice = 3.3 \times 10^5 \text{ J kg}^{-1}]

Total 16 marks
2. There are now several artificial satellites orbiting the earth. A student suggests that these satellites can remain in orbit because they have escaped the earth's gravity.

(i) Explain why these satellites would not stay in orbit if the student's suggestion were correct.

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(2 marks)

(ii) A weather satellite orbits at a height of 800 km above the surface of the earth.

Calculate the time taken for radio waves to arrive at the earth's surface after being transmitted from the satellite.

[Speed of electromagnetic waves = $3.0 \times 10^8 \text{ m s}^{-1}$]

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(3 marks)

(iii) If the mass of the satellite is 27 kg, what is the gain in gravitational potential energy by the satellite as it is lifted from the earth's surface to its orbital height?

[Assume that there is no change in the force of gravity up to this height.]

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(3 marks)
(iv) If the satellite takes 100 minutes to complete one revolution of the earth, calculate its speed and kinetic energy given that the length of its orbit is $4.5 \times 10^7$ m.

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(5 marks)

(v) The radio signal is received from the satellite by an aerial with a concave parabolic reflector. With the aid of a diagram, explain why a parabolic reflector is used.

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........................................................................................................................................................................
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(3 marks)

Total 16 marks
3. (a) At the beginning of the twentieth century, scientists believed that neither matter nor energy could be created or destroyed. The work of a great scientist showed that in fact, for a closed system, the total amount of mass-energy remains constant.

(i) Name the scientist referred to in the statement above.

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(1 mark)

(ii) Give the equation for the mass-energy relationship in a nuclear reaction. State clearly what EACH symbol represents.

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(3 marks)

(b) During a nuclear fission reaction, the uranium isotope \( ^{235}_{92} \text{U} \) absorbs a neutron and splits into Barium (Ba), Krypton (Kr) and two neutrons, with the release of energy. This is represented in the equation below:

\[
^{235}_{92} \text{U} + ^{1}_{0} \text{n} \rightarrow ^{144}_{56} \text{Ba} + ^{90}_{36} \text{Kr} + 2^{1}_{0} \text{n} + \text{energy}
\]

The table below gives the masses of the particles involved in this reaction.

<table>
<thead>
<tr>
<th>PARTICLE</th>
<th>MASS/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutron</td>
<td>(1.675 \times 10^{-27})</td>
</tr>
<tr>
<td>Uranium</td>
<td>(390.989 \times 10^{-27})</td>
</tr>
<tr>
<td>Barium</td>
<td>(238.893 \times 10^{-27})</td>
</tr>
<tr>
<td>Krypton</td>
<td>(149.241 \times 10^{-27})</td>
</tr>
</tbody>
</table>

(i) What is the total mass of the uranium nucleus and the neutron?

.................................................................................................................................

(1 mark)
(ii) What is the total mass of the two nuclei and the two neutrons produced as a result of the fission of $^{235}_{92}$U?

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(2 marks)

(iii) How much energy is produced as a result of the fission reaction?

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[Speed of light = $3.0 \times 10^8$ m s$^{-1}$]

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(3 marks)

(c) The fission of $^{235}_{92}$U yields approximately one million times as much energy as the burning of an equal mass of oil. Fission is therefore used in nuclear reactors to provide electrical energy. However, there are disadvantages in using this method.

(i) State TWO DISADVANTAGES of generating electrical energy using nuclear fission reactors.

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(2 marks)

(ii) Scientists estimate that every second the sun’s mass is reduced by $4 \times 10^9$ kg. Name and explain the process that leads to this reduction in mass.

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(4 marks)

Total 16 marks
4.

(a) The diagram above represents a d.c. dynamo.

(i) Write in the name of the components labelled A, B, C and D on the dotted lines provided. (4 marks)

The terminals X and Y are connected to a 2 Ω resistor. The peak value of the potential difference is 4 V.

(ii) Calculate the peak value of the output current. (1 mark)

(iii) The coil makes 10 revolutions in one second. On the axes below, sketch a graph to represent the variation of output current with time during the first two revolutions of the coil. Indicate the scale used on EACH axis.

\[ \begin{array}{c|c}
\text{I/A} & \text{time/s} \\
\hline
\end{array} \]

(3 marks)

If the number of turns of wire on the coil is increased, with no other change, state the effect, if any, on

(iv) the frequency of the output current (1 mark)

(v) the peak value of the output current. (1 mark)
If instead of increasing the number of turns of wire, the speed of rotation of the coil is increased with no other change, state the effect, if any, on

(vi) the frequency of the output current

........................................................................................................................................

(1 mark)

(vii) the peak value of the output current.

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(1 mark)

(b) A mechanic states that a transformer cannot be used with the d.c. dynamo to obtain a higher potential difference as transformers work only with alternating current.

State whether the mechanic is correct and explain your answer.

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(4 marks)

Total 16 marks

5. (a) The diagram below shows plane water waves incident on a gap.

\[ \text{Diagram of water waves incident on a gap} \]

(i) Draw the waves after they have passed through the gap. (2 marks)

(ii) What name is given to this effect? (1 mark)
Some sound systems have three loudspeakers to cater for the full range of frequencies to be transmitted. The following table gives the wavelength ranges for three speakers and frequency ranges for two of them.

<table>
<thead>
<tr>
<th>SPEAKER</th>
<th>FREQUENCY RANGE /Hz</th>
<th>WAVELENGTH RANGE /m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woofer (low-range)</td>
<td></td>
<td>14 – 0.35</td>
</tr>
<tr>
<td>Squawker (medium-range)</td>
<td>1 000 – 10 000</td>
<td>0.35 – 0.035</td>
</tr>
<tr>
<td>Tweeter (high-range)</td>
<td>3 500 – 20 000</td>
<td>0.10 – 0.018</td>
</tr>
</tbody>
</table>

(i) From the information given for the squawker, calculate the velocity of sound.

(2 marks)

(ii) Determine the missing frequency range and insert it in the table above.

(2 marks)

An observer notices that when she stands at X, she hears equally well from the three speakers. However, when she stands at Y, she hears mainly from one speaker and much less from the others.

(iii) From which speaker does she hear most sound when standing at Y?

(1 mark)
(iv) With reference to the data in the table and diagram on page 10, give an explanation for her observations while at Y.

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(2 marks)

(c) The waveforms shown in the diagrams below represent three different sounds.

![Waveforms P, Q, R](image)

Compare the loudness and pitch of

(i) P and Q

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(2 marks)

(ii) Q and R

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........................................................................................................................................
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(2 marks)

(iii) Explain in what other way sounds P and Q differ.

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........................................................................................................................................
........................................................................................................................................
(2 marks)

Total 16 marks

END OF TEST
FORM TP 92102

CARIBBEAN EXAMINATIONS COUNCIL

SECONDARY EDUCATION CERTIFICATE EXAMINATION

PHYSICS

Paper 3

General Proficiency

$1 \frac{3}{4}$ hours

In addition to the $1 \frac{3}{4}$ hours, candidates are allowed a reading time of 15 minutes. Writing may begin during the 15-minute period.

READ THE FOLLOWING DIRECTIONS CAREFULLY

1. Attempt Question 1 and any THREE of the other questions.

2. ALL WORKING MUST BE SHOWN in your answer booklet, since marks will be awarded for correct steps in calculations.

3. The use of non-programmable calculators is allowed.

4. Mathematical tables are provided.

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2493/F 92
In pole vaulting, most of the kinetic energy that an athlete possesses at the end of his run-up is converted into gravitational potential energy. The centre of gravity of the athlete is raised from a height, \( h_0 \), to a height, \( h \). It is known that the height that he achieves depends on his speed at the end of his run-up. The data in the table below were obtained for an athlete while pole vaulting.

<table>
<thead>
<tr>
<th>Height achieved, ( h ) / m</th>
<th>Speed, ( v ) / m s(^{-1})</th>
<th>( v^2 ) / m(^2) s(^{-2})</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.3</td>
<td>7.25</td>
<td></td>
</tr>
<tr>
<td>3.8</td>
<td>7.80</td>
<td></td>
</tr>
<tr>
<td>4.2</td>
<td>8.40</td>
<td></td>
</tr>
<tr>
<td>4.5</td>
<td>8.80</td>
<td></td>
</tr>
<tr>
<td>4.9</td>
<td>9.35</td>
<td></td>
</tr>
<tr>
<td>5.3</td>
<td>9.70</td>
<td></td>
</tr>
</tbody>
</table>

(a) Calculate the values of \( v^2 \) and, IN YOUR ANSWER BOOKLET, tabulate these values of \( v^2 \) along with the corresponding values of the height achieved. (3 marks)

(b) Starting both scales from 0, plot a graph of \( v^2 \) (y axis) against \( h \) (x axis). (9 marks)

(c) Determine the slope of the graph. (5 marks)

(d) The intercept \( h_0 \) on the x axis represents the height of the centre of gravity of the athlete above the ground before he takes off. Determine \( h_0 \) from the graph. (2 marks)

(e) Read off from the graph the value of \( h \) which corresponds to \( v = 9.0 \) m s\(^{-1}\). (2 marks)

(f) (i) Calculate the kinetic energy the athlete would have when his speed was 9.0 m s\(^{-1}\), if his mass were 80 kg.

(ii) If this kinetic energy were all converted into potential energy, what increase in height of the centre of gravity would you expect?

(iii) What total height would he achieve in this case? \( [ g = 10 \) m s\(^{-2}\) ]

(g) Suggest TWO possible causes to account for the difference between this total height and the corresponding value from the graph. (2 marks)

Total 30 marks
SECTION II

Answer ANY THREE questions in this section.

2. (a) Aristotle and Newton had different ideas about forces and the relationship between force and motion. State Aristotle’s and Newton’s views on any forces acting on

(i) a stationary car
(ii) the car moving at a constant velocity, \( v \)
(iii) the same car moving at a higher constant velocity, \( 2v \).  

(b)

\[ \begin{array}{c}
\text{v / m s}^{-1} \\
25 \\
20 \\
15 \\
10 \\
5 \\
0 \\
\hline
0 & 2 & 4 & 6 & 8 & 10 & 12 & \text{time/s}
\end{array} \]

The graph above represents the motion of a car of mass 500 kg. The car accelerates from rest to a velocity of 25 m s\(^{-1}\).

(i) Define acceleration and use the graph to determine the acceleration of the car. Calculate the net force acting on the car to produce this acceleration.  

(ii) The 500 kg car travelling at 25 m s\(^{-1}\) now collides head-on with another of mass 800 kg travelling at 18 m s\(^{-1}\) in the opposite direction and they move together after impact. What is the magnitude of their velocity just after impact and in what direction do they move off?  

Total 20 marks
3. The diagram below represents apparatus which can be used to investigate the relation between the pressure and volume of a fixed mass of gas at a constant temperature.

(a) Describe how you might use this apparatus to carry out the investigation. How would you attempt to maintain a constant temperature? (6 marks)

(b) (i) A bottle is partially filled with hot water at 70 °C and then corked. Calculate the pressure of the air in the bottle when the water has cooled to 30 °C. (Assume that the volume of air is constant.)

Atmospheric pressure = 100 kPa. (4 marks)

(ii) Use the kinetic theory to explain what causes the pressure of the air in the bottle and why it changes when the temperature is lowered. (4 marks)

(c) (i) A weather balloon, made of rubber, is used to carry instruments into the upper atmosphere. Why should it be only partially inflated when it is released from the ground?

(ii) Manufacturers recommend a specific pressure for car tyres to ensure best performance. Explain why the pressure of the air in car tyres should be checked only after the car has been driven for some distance. (6 marks)

Total 20 marks
4. (a) Describe, with the aid of a diagram, an investigation to measure the critical angle of glass or perspex. (8 marks)

(b) An object is at the bottom of a water-filled tank. When it is viewed from above it does not appear to be at its actual position. Draw a ray diagram to illustrate this and state what is observed. (4 marks)

(c) The figure above represents a ray of light leaving a light pipe through the face YZ. The light ray is incident at M at an angle of 68° to the normal. Given that the critical angle is 42° for the glass-air interface, calculate

(i) the refractive index of the glass

(ii) the angle of refraction at the face YZ. (8 marks)

Total 20 marks

5. (a) Describe, with the aid of a circuit diagram, how you could investigate the relationship between current and potential difference for a small (24 W) filament lamp, using a d.c. source. Sketch the graph of I against V that you would expect to obtain from this investigation. (8 marks)

(b) Four 6 W parklights connected in parallel to the 12 V battery of a motorcar are left on for a period of 8 hours. Calculate

(i) the total current drawn from the battery

(ii) the resistance of a single parklight when it is on

(iii) the total energy supplied by the battery. (9 marks)

(iv) A 15 V battery charger is used to replace the energy supplied by the battery. This provides a net e.m.f. of 3 V. If the charging current is 3 A, how long would it take to recharge the battery? (3 marks)

Total 20 marks

GO ON TO THE NEXT PAGE
6. (a) (i) The diagram below shows a Geiger-Muller tube.

![Diagram of a Geiger-Muller tube]

Name the parts A, B and C and explain how the tube acts as a detector of radioactive emissions.  
(6 marks)

(ii) Explain why α particles have a range of only a few centimetres in air.  
(2 marks)

(iii) You are provided with a Geiger-Muller tube and ratemeter and two unmarked radioactive sources. One source emits only β particles and the other emits β particles and γ rays. How would you differentiate between the two sources?  
(5 marks)

(b) A sample of radioactive material was investigated by measuring its activity (the number of disintegrations per minute) at intervals of one hour. The results were plotted on a graph and the curve obtained is shown in Figure 1 on page 7. Determine

(i) the time at which the activity was $3 \times 10^4$ min$^{-1}$

(ii) the half-life of the material.

Use your answer to (ii) to calculate the time at which the activity would be $5 \times 10^3$ min$^{-1}$.

(7 marks)

Total 20 marks
7. (a) A television set contains a cathode ray tube similar to that used in an oscilloscope.

(i) An electron gun which is at one end of the evacuated tube produces a beam of electrons which strikes a fluorescent screen at the other end. State the function of the fluorescent screen and explain why the tube is evacuated.

(ii) The electron beam is deflected by a set of coils which carry an electric current. Explain why a deflection occurs.

(iii) The television is connected to a 120 V mains supply but the electron gun requires a 12 V supply. Suggest how this may be achieved. (7 marks)

(b) Within the electron gun electrons pass through a p.d. of 15 kV. Calculate the work done on an electron. Explain the effect on the speed at which the electrons strike the screen if the p.d. of 15 kV were to decrease. (6 marks)

(c) The flow of charge in the electron beam is a current of $9.6 \times 10^{-6}$ A. Calculate

(i) the number of electrons striking the screen in one second

(ii) the total charge incident on the screen in one hour. (7 marks)

[Charge of electron, $e = 1.6 \times 10^{-19}$ C]

Total 20 marks

END OF TEST
CARIBBEAN EXAMINATIONS COUNCIL

SECONDARY EDUCATION CERTIFICATE EXAMINATION

PHYSICS

Paper 02

General Proficiency

1 hour

READ THE FOLLOWING DIRECTIONS CAREFULLY

1. You MUST use this answer booklet when responding to the questions. For each question, write your answer in the space provided and return the answer booklet at the end of the examination.

2. ALL WORKING MUST BE SHOWN in this booklet, since marks will be awarded for correct steps in calculations.

3. Attempt ALL questions.

4. The use of non-programmable calculators is allowed.

5. Mathematical tables are provided.

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002492/F 93
1. A length of paper tape is pulled through a timer by a toy car. The timer makes one dot on the tape every 0.02 s. A section of the tape, drawn full size, is shown in Figure 1 below.

![Figure 1](image)

A second length of paper tape is pulled through the same timer by a toy truck. A section of this tape, also drawn full size, is shown in Figure 2 below.

![Figure 2](image)

(i) What time interval is represented between the first and last dots on the tape in Figure 1 and in Figure 2?

Figure 1 .................................................................

Figure 2 .................................................................

(2 marks)

(ii) By considering displacements from A in EACH case, complete the following tables:

<table>
<thead>
<tr>
<th>Time/s</th>
<th>0</th>
<th>0.02</th>
<th>0.04</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Displacement/cm</td>
<td>0</td>
<td>1.2</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CAR – Table 1

<table>
<thead>
<tr>
<th>Time/s</th>
<th>0.0</th>
<th>0.02</th>
<th>0.04</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Displacement/cm</td>
<td>0.0</td>
<td>0.2</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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TRUCK – Table 2

(4 marks)

(iii) Use the information in the completed Tables 1 and 2 above to plot displacement (x) – time (t) graphs on the axes provided on the next page.
(iv) Describe briefly the motion of the toy car and the toy truck.

**Toy car**

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**Toy truck**

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(2 marks)

(v) Use the information in the completed Table 2 to determine the average speed of the truck over the total time interval.

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(2 marks)

Total 16 marks

GO ON TO THE NEXT PAGE
2. (a) (i) Define ‘specific heat capacity’.

(ii) Explain what is meant by the term ‘efficiency’.

(4 marks)

(b) A large amount of the thermal energy produced in modern power stations is wasted.

(i) State the useful energy changes taking place in an oil-fired power station.

(3 marks)

(ii) In such a power station, thermal energy is wasted at the rate of 660 MW. How many joules of energy are wasted in ONE second?

(1 mark)

(iii) A nearby river is used to absorb the waste heat. A mass of $6 \times 10^4$ kg of water passes the power station every second. What is the temperature rise of the water if it absorbs all the waste heat? [Specific heat capacity of water $= 4 \, 200 \, \text{J kg}^{-1} \, \text{K}^{-1}$]

(3 marks)
(iv) An alternative way of disposing of the waste heat is to use it to evaporate water in the power station.

How much water would have to be evaporated EACH second if the latent heat of vaporisation of water is $2.3 \times 10^6$ J kg$^{-1}$?

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(3 marks)

(v) The electricity is produced in the power station at a potential of 6 600 V a.c and this is raised to 132 000 V for distribution.

State how the potential is raised and give ONE advantage of transmitting at a higher potential.

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(2 marks)

Total 16 marks

3. (a) The danger of electrical shock to the human body depends largely on the body’s resistance. With dry hands, this resistance is about 100 k$\Omega$, but it falls to 1 k$\Omega$ when the hands are wet. A current of about 10 mA causes a slight shock, whereas a current of about 1.0 A can cause death.

(i) No current flows when someone touches just ONE terminal of a 12 V car battery. Explain this fact.

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(1 mark)
(ii) A boy touches one terminal of a 12 V car battery with his right hand and the other terminal with his left hand at the same time. Calculate how much current flows in EACH of the cases below:

With dry hands .................................................................
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With wet hands .................................................................
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What effect, if any, does the current have on the boy in EACH case?
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(7 marks)

(b) During a heart attack, the heart beats very irregularly. The heart may resume its normal beat if a large current is passed through the body for a short time. This current can be supplied by a machine which stores a charge of \(4 \times 10^{-2} \text{ C}\) at a potential of \(6000 \text{ V}\).

(i) Calculate the electrical energy that is stored in the machine.
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(3 marks)

(ii) The total charge is passed in a current which lasts 5 ms. Calculate this current.
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(3 marks)

Total 14 marks
4. Short wavelength radio waves (microwaves) have many applications, e.g. in weather stations.

(i) The radar used in weather stations transmits microwaves of frequency $3 \times 10^9$ Hz. These are emitted in pulses EACH of $1.0 \times 10^{-6}$ s duration.

Calculate:
- the wavelength of the radiation
- the number of waves emitted in a pulse

[Speed of electromagnetic waves $= 3 \times 10^8$ m s$^{-1}$]

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(6 marks)

(ii) The power of the transmitter is 200 kW. What is the total energy in a pulse?

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(3 marks)

(iii) After the emission of a pulse, nothing is transmitted for one millisecond.

Calculate how far the pulse travels in this time.

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(3 marks)

(iv) To detect a distant object, the pulse is reflected from it and must return to the weather station before another pulse is emitted. What is the furthest distance at which an object may be detected using this system?

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(2 marks)

Total 14 marks

END OF TEST
FORM TP 9393

CARIBBEAN EXAMINATIONS COUNCIL

SECONDARY EDUCATION CERTIFICATE
EXAMINATION

PHYSICS

Paper 03

General Proficiency

1 hour

In addition to the 1 hour, candidates are allowed a reading time of 10 minutes. Writing may begin during the 10-minute period.

READ THE FOLLOWING DIRECTIONS CAREFULLY

1. Answer ANY THREE questions.

2. ALL WORKING MUST BE SHOWN in your answer booklet, since marks will be awarded for correct steps in calculations.

3. The use of non-programmable calculators is allowed.

4. Mathematical tables are provided.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO

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1. (a) Distinguish between kinetic energy and gravitational potential energy. (2 marks)

(b) A stone is dropped from the top of a building onto the ground. Neglecting air resistance, compare its kinetic energy and its gravitational potential energy (i) at the point of release and (ii) half-way down.

Explain whether or not the stone possesses any kinetic energy or gravitational potential energy when it is lying on the ground. (4 marks)

(c) For smaller buildings, engineers design elevators to travel slowly because it is more economical.

An elevator driven by an electric motor carries a group of people, of total mass 900 kg, to the upper floor of a building. The mass of 900 kg accelerates uniformly from rest to a speed of 4 m s\(^{-1}\), in a time of 3 s, and continues at this speed until it is brought to rest by applying brakes.

(i) Calculate the acceleration of the total mass and the force required to produce this acceleration.

(ii) Determine the maximum kinetic energy attained by the 900 kg mass.

(iii) If the maximum speed reached were 2 m s\(^{-1}\), what would have been the value of the accelerating force and of the maximum kinetic energy?

(iv) Explain why it is more economical to run slow elevators. (14 marks)

Total 20 marks

2. (a) The atmospheric pressure on a roof is 1.0 \(\times\) 10\(^5\) Pa.

(i) Give an equivalent unit for the Pascal (Pa).

(ii) Explain, in terms of the particle theory of gases, how this pressure arises. (4 marks)

(b) When a volatile liquid evaporates, the remaining liquid cools. Explain the cooling in terms of the particle theory of matter. (4 marks)

(c) A solar cooker consists mainly of a curved reflecting metal surface that focusses sunlight onto a pot containing food to be cooked. The reflecting surface has an area of 0.6 m\(^2\) and the solar power incident on it is 800 W m\(^{-2}\). Seventy-five per cent of the incident energy is absorbed by the pot and its contents and its temperature rises by 70 \(^\circ\)C in one hour.

(i) Calculate the energy that is incident on the reflecting surface every second.

(ii) Determine how much energy is absorbed by the pot and its contents during the hour.

(iii) How much thermal energy is required to increase the temperature by 70 \(^\circ\)C if the heat capacity of the pot and its contents is 8 000 J K\(^{-1}\)? Explain why this value of energy is not the same as that in (ii) above. (12 marks)

Total 20 marks
3. (a) Newton investigated light and observed that light of several colours appeared on a screen when white light was passed through a prism.

Use fully labelled diagrams to illustrate how Newton used two prisms to show that

(i) the different colours were merely components of white light and not the result of the interaction of white light with the material of the prism

(ii) any single colour produced by one prism could NOT be split into other colours.  (8 marks)

(b) A converging lens of focal length 10.0 cm is used in a projector to form an enlarged image of a slide on a screen. The slide is 4.0 cm high and is placed 12.0 cm from the lens. Determine by scale drawing on graph paper (i) the position at which the screen should be placed to receive a sharp image and (ii) the size of the image.  (7 marks)

(c) In some older people, the eye lens becomes opaque. This condition is known as a cataract and is sometimes corrected by removal of the eye lens. Use a diagram to illustrate what effect this removal of the lens will have on the eye's ability to form images on the retina and state what type of spectacle lens may correct this problem.  (5 marks)

Total 20 marks

4. (a) Outline (i) the Rutherford model of the atom and (ii) the Thomson model of the atom. Explain how the results of the Geiger-Marsden experiment supported only one of these two models.  (8 marks)

(b) Cobalt 60 ($^{60}_{27}$Co) is one of the most widely used radio-isotopes in the treatment of cancer. It is formed from natural cobalt by the capture of a neutron and it has a half-life of 5.2 years. It decays into Nickel (Ni) by the simultaneous emission of a beta particle and two gamma rays.

(i) Which of the two emissions is more likely to be used in the treatment of cancer and why?

(ii) Represent the formation and decay of cobalt 60 by two balanced nuclear equations.

(iii) Determine the number of half-lives for cobalt 60 in a period of 26 years and hence calculate how much of a 8.0 g sample of cobalt 60 will remain after this period.  (12 marks)

Total 20 marks
5. (a) State what is meant by the term ‘magnetic field’ and state how the direction of the field is defined.  

(b) Sketch
(i) the magnetic flux pattern (magnetic field) around a long straight current-carrying wire
(ii) the magnetic flux pattern around the current-carrying wire when it is placed perpendicular to a uniform magnetic field. Indicate on the diagram the direction of the force on the wire.

(c) The diagram below shows the earpiece of a telephone. Explain how the earpiece produces sound.

(d) A step-up transformer, which may be considered to be ideal, has an output voltage, \( V_s \), of 1800 V when its primary is connected to a 120 V mains supply.

(i) If the number of turns in the primary is 100, how many turns are there in the secondary?

(ii) If the current drawn by the load in the secondary is 0.5 A, what is the current in the primary?

(e) Someone suggests that for an ideal step-up transformer, the law of conservation of energy is violated since the output voltage, \( V_s \), is greater than the input voltage, \( V_p \). How would you convince him that the law is not violated?

Total 20 marks

END OF TEST
READ THE FOLLOWING DIRECTIONS CAREFULLY

1. You MUST use this answer booklet when responding to the questions. For each question, write your answer in the space provided and return the answer booklet at the end of the examination.

2. ALL WORKING MUST BE SHOWN in this booklet, since marks will be awarded for correct steps in calculations.

3. Attempt ALL questions.

4. The use of non-programmable calculators is allowed.

5. Mathematical tables are provided.

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1. (a) State Archimedes' principle.

(b) A hot-air balloon, as shown in Figure 1 above, has a volume of 700 m$^3$ and the density of the air inside the balloon is 0.90 kg m$^{-3}$. The mass of the balloon's material and load is 280 kg.

   (i) Calculate the mass of air inside the balloon.

   (ii) Determine the total weight, in newtons, of the material, load and air. $(g = 10 \text{ N kg}^{-1})$
(iii) The balloon remains stationary about 100 m above the ground. State what forces are acting on the balloon, and explain how they result in no motion.

(3 marks)

(iv) If the density of the air outside the balloon is 1.3 kg m$^{-3}$, calculate the weight of the air which is displaced by the balloon.

(2 marks)

(v) Explain why the balloon begins to rise when the air is heated to a higher temperature.

(2 marks)

Total 14 marks
2. (a) Table 1 below represents the first three periods of the Periodic Table of elements.

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Table 1

(i) The atomic number of chlorine (Cl) is 17. How many protons are there in one atom of silicon (Si)?

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(1 mark)

(ii) The most common isotope of boron (B) may be represented as $^{11}_5$B. A boron atom has two shells of electrons, with two electrons in the first shell. In the space below, draw a clear diagram to represent the number and distribution of protons, neutrons and electrons in a neutral $^{11}_5$B atom.

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(4 marks)

(iii) Write the symbol for another possible isotope of boron.

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(1 mark)
(b) The count-rate (activity) is measured for two radioactive samples, A and B, and graphs of count-rate against time are plotted, as shown in Figure 2 below.

![Graph showing count-rate against time for samples A and B.]

**Figure 2**

(i) By reading off values of the count rate at suitable times, show that the half-life of Sample A is constant, and find its value.

(ii) By considering the relevant graph, comment on the half-life of Sample B.

(iii) Why are the points on the graph of Sample B not exactly on the line even though the ratemeter was not faulty?

(iv) What difference, if any, would be noticed in the graph if Sample B were heated?
Sample B is an isotope of thorium (Th), with a proton number of 90 and a neutron number of 142. It decays by the emission of an alpha particle to form radium (Ra). Write a nuclear reaction to represent this decay.

(3 marks)

Total 16 marks

3. A family uses electricity for heating water used in their home. The 1.5 kW electric water-heater is controlled by a thermostat so that it is switched on for an average of four hours each day.

(a) A simplified diagram of the thermostat is shown in Figure 3 below.

![Thermoset Diagram](image)

Figure 3

(i) Explain how the thermostat works.

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(b) (i) What is the cost per year of the operation of the water-heater if one kilowatt-hour costs 40 cents?

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Figure 5 below shows a wire, $XY$, between the poles of a magnet connected to a centre-zero galvanometer, $G$.

![Diagram of a wire between magnet poles connected to a galvanometer](image)

**Figure 5**

(a) What would you expect to observe on the galvanometer if the following actions were carried out?

(i) The wire is moved up and down.

(ii) The wire is moved up and down faster.

(iii) The wire is moved from pole to pole horizontally.

(iv) The magnet poles are moved up and down with the wire stationary.

(2 marks)

(1 mark)

(1 mark)

(1 mark)
Figure 6 below shows two coils, side by side, in separate circuits, A and B.

Figure 6

Describe what you would expect to observe on the centre-zero galvanometer when the switch in Circuit A

(i) is closed

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(1 mark)

(ii) remains closed

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(1 mark)

(iii) is opened.

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(1 mark)
(c) The symbol for a transformer is shown above. Complete the circuit diagram to show how a transformer, together with the components listed below, could be used to charge a 12 V car battery from a 120 V mains supply.

Components: Rectifier diode, variable resistor, ammeter

The variable resistor and ammeter are used to obtain the correct charging current through the battery. (5 marks)

(ii) The potential difference from the secondary coil of such a transformer is 18 V, and the charging current through the 12 V battery is 2 A. What is the value of the variable resistance?

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(3 marks)

Total 16 marks

END OF TEST
FORM TP 95103
CARIBBEAN EXAMINATIONS COUNCIL
SECONDARY EDUCATION CERTIFICATE EXAMINATION
PHYSICS
Paper 03 – General Proficiency

1 hour

08 JUNE 1995 (a.m.)

In addition to the 1 hour, candidates are allowed a reading time of 10 minutes. Writing may begin during the 10-minute period.

READ THE FOLLOWING DIRECTIONS CAREFULLY

1. Answer ANY THREE questions.

2. ALL WORKING MUST BE SHOWN in your answer booklet, since marks will be awarded for correct steps in calculations.

3. The use of non-programmable calculators is allowed.

4. Mathematical tables are provided.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO

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Two mechanics use ropes to lift an engine out of a car. The ropes are at an angle of 45° to the horizontal. See diagram below. Both men pull with the same force, i.e., 400 N.

(a) Draw a vector diagram showing how the TWO forces can be added to give an upward force to balance the weight of the engine, and find the weight of the engine. (5 marks)

(b) (i) Explain why it is easier to use a pulley system than to use the ropes attached to the engine. (1 mark)

(ii) Suggest TWO ways that energy would be wasted by the pulley system so that it would not be 100% efficient. (2 marks)

(iii) Describe fully how you would measure the efficiency of such a pulley system in the laboratory. (5 marks)

(c) The forearm is a lever in which the bicep muscles provide an upward force which can raise the arm and carry a load. The diagram below represents the forearm as it holds a load of 60 N. The forearm has a weight of 25 N and the centre of gravity, G, of the forearm is marked along with the point, P, at which it pivots on the adjoining bone.

(i) Use the principle of moments to calculate the force, B, exerted by the biceps to hold the arm and load stationary. (7 marks)

(ii) The adjoining bone pushes down on the forearm at the point, P, with a force, R. By considering the upward and downward forces, calculate the value of R. (7 marks)

Total 20 marks
2. (a)  

The diagram above shows a double mains outlet of a type common in the Caribbean. Are these outlets in series or parallel? Explain why they are connected in this way.  

(3 marks)

(b) An extension cord is rated at 10 A – meaning that it might overheat if the current exceeds this value. Use the information below to calculate the current that would flow through the extension cord if both appliances were used at the same time.

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Power</th>
<th>Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Iron</td>
<td>960 W</td>
<td>120 V</td>
</tr>
<tr>
<td>Hair-drier</td>
<td>600 W</td>
<td>120 V</td>
</tr>
</tbody>
</table>

Would it be safe to use the cord with an electric iron and a hair-drier at the same time?  

(4 marks)

(c) Describe how you would perform an experiment to test the hypothesis that the sum of the currents in the branches of a parallel circuit is equal to the current entering the parallel section. Include with your description a circuit diagram showing clearly the position(s) of any meter(s) you would use.  

(5 marks)

(d)  

Three resistors are arranged as in the diagram above.

(i) Calculate the total effective resistance between A and B.  

(4 marks)

(ii) A p.d. of 12 V is found to exist between A and B. Calculate the value of the current, \( I \), flowing into the junction at A.  

(2 marks)

(iii) Determine the current in the 6 \( \Omega \) resistor.  

(2 marks)

Total 20 marks
3. (a) Given a straight vibrator and a ripple tank, describe how you would demonstrate the reflection and refraction of water waves. Draw diagrams to represent what would be observed in EACH case. (8 marks)

(b) Ultra-sound (high frequency sound) is used in medicine to perform internal investigations upon patients.

As the ultra-sound passes from muscle into bone, some is reflected and some is refracted. The diagram below represents a beam of ultra-sound incident upon a muscle/bone boundary.

\[ \frac{\sin \theta_1}{\sin \theta_2} = \frac{v_1}{v_2} \]

When a wave, travelling at a speed, \( v_1 \), strikes a boundary at an angle of incidence, \( \theta_1 \), the relation between its angle of refraction, \( \theta_2 \), and its speed in the next medium, \( v_2 \), is given by

The table below shows the speed of ultra-sound in certain media:

<table>
<thead>
<tr>
<th>Medium</th>
<th>Speed of Ultra-sound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>330 m s(^{-1})</td>
</tr>
<tr>
<td>Muscle</td>
<td>1 600 m s(^{-1})</td>
</tr>
<tr>
<td>Bone</td>
<td>4 000 m s(^{-1})</td>
</tr>
</tbody>
</table>

(i) The ultra-sound used has a frequency of \( 8.0 \times 10^6 \) Hz. Calculate the wavelength of the ultra-sound in bone. (3 marks)

(ii) Use the information in the table to calculate the angle of refraction in the bone. Copy and complete the diagram to show what happens to the ultra-sound. (5 marks)

(iii) Ultra-sound can be totally reflected at certain boundaries. What is the critical angle for ultra-sound incident upon the muscle-bone boundary? Is total reflection possible as ultra-sound, travelling in muscle, meets the air? Explain your answer. (4 marks)

Total 20 marks
4. Suppose you are employed by a school as a temporary laboratory technician. One day the physics teacher asks you to set out and test equipment so that the students can perform an experiment to determine the specific heat capacity of a liquid, using an electrical heating method.

(a) List the apparatus you would set out, apart from the electrical heater and the liquid, for EACH group of students. (5 marks)

(b) Draw and label a diagram of the circuit you would use to perform the experiment. (3 marks)

The teacher then tells you that EACH group is to be provided with 200 g of a liquid with a specific heat capacity of 2 200 J K$^{-1}$ kg$^{-1}$. She would like the liquid to have a temperature rise of 15 K in 5 minutes, but there are no suitable heaters in the laboratory. She asks you to make some heaters using nichrome wire. (See diagram below.)

![Diagram of circuit with nichrome wire and copper leads]

(c) Determine the quantity of thermal energy required for this temperature rise, and the power of the required heater. (6 marks)

(d) If the supply voltage is 11 V, calculate the resistance of the wire and the length needed for EACH heater if the resistance is 10 Ω per meter. (6 marks)

Total 20 marks

5. (a) State Newton’s THREE laws of motion.

A communication satellite travels in a circular orbit around the Earth. Explain (i) how this circular motion is maintained and (ii) the way in which Newton’s third law applies to the satellite. (8 marks)

(b) An oil drilling platform, of mass 8.0 x 10$^7$ kg, is being towed at a speed of 0.75 m s$^{-1}$ by tugs to its working position. When the platform is near to its working position, the tugs are disconnected and the platform slows down.

(i) If the deceleration of the platform is 7.5 x 10$^{-3}$ m s$^{-2}$, what is the unbalanced force acting on it, and how long would it take to come to a halt? (6 marks)

(ii) What momentum did the platform possess when it was moving with a speed of 0.75 m s$^{-1}$, and what was the change of momentum per second as it slowed to a halt? (6 marks)

Total 20 marks

END OF TEST
READ THE FOLLOWING DIRECTIONS CAREFULLY

1. You MUST use this answer booklet when responding to the questions. For each question, write your answer in the space provided and return the answer booklet at the end of the examination.

2. ALL WORKING MUST BE SHOWN in this booklet, since marks will be awarded for correct steps in calculations.

3. Attempt ALL questions.

4. The use of non-programmable calculators is allowed.

5. Mathematical tables are provided.
1. (a) A teacher asks her students to measure the density of the glass from which marbles are made. Each group of students is provided with 20 identical marbles.

The students are told that the volume of a sphere is \( \frac{4}{3}\pi r^3 \), where \( r \) is the radius. Thus, the volume may be calculated if the radius \( \left( = \frac{\text{diameter}}{2} \right) \) is known.

They measure the diameter of one of the marbles with a micrometer. The reading obtained is shown in the magnified diagram below.

Figure 1

(i) What is the reading shown in Figure 1 above?

\[ \text{Diameter} = \text{................. mm.} \quad (1 \text{ mark}) \]

(ii) Express this reading in metres using, standard scientific form.

\[ \text{Diameter} = \text{................. m.} \quad (1 \text{ mark}) \]

(iii) Find the volume of ONE marble.

\[ \text{Volume} = \text{................. m}^3 \]

\[ \text{Volume} = \text{................. m}^3 \]

\[ \text{Volume} = \text{................. m}^3 \]

\[ \text{Volume} = \text{................. m}^3 \quad (2 \text{ marks}) \]

(iv) If the only available balance is calibrated to measure to the nearest gram, suggest a method, which students could use, to accurately find the mass of ONE marble.

\[ \text{Mass} = \text{................. g} \]

\[ \text{Mass} = \text{................. g} \]

\[ \text{Mass} = \text{................. g} \]

\[ \text{Mass} = \text{................. g} \quad (2 \text{ marks}) \]

(v) The mass of one marble was found to be 1.1 g. Express the mass in kilograms.

\[ \text{Mass} = \text{................. kg.} \quad (1 \text{ mark}) \]
(vi) Calculate the density of the glass used to make the marbles.

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(2 marks)

(b) Figure 2 below shows the outline of a girl’s shoe heel, drawn on graph paper.

![Graph paper with shoe heel outline](image)

Figure 2

(i) Estimate the area of the heel of her shoe.

Area of heel = ........................................

(2 marks)

(ii) The girl’s mass is 45 kg. What pressure does she exert on the ground when she is standing on one heel? \((g = 10 \text{ N kg}^{-1})\)

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(3 marks)

Total 14 marks
2. (a) If an object is allowed to fall in the laboratory, it accelerates.
   (i) Define the term *acceleration*.
   (1 mark)
   (ii) Explain why the object accelerates.
   (1 mark)
   (iii) Why is the acceleration of free fall the same for all objects at the same place, if air resistance is negligible?
   (2 marks)

![Diagram of apparatus](image)

*Figure 3*

(b) The apparatus shown in Figure 3 above, may be used to determine the acceleration due to gravity, of the small iron ball. The height of fall, *h*, and the time of fall, *t*, need to be measured.
   (i) Explain how the apparatus works.
   (3 marks)
(ii) Using this apparatus, a student obtains a value of 0.490 s for \( t \), when \( h \) is 1.16 m. Calculate the average speed of the ball during the fall.

Hence, calculate the final speed of the ball just before its impact with the trap door.

(iii) In the space below, sketch the velocity-time graph for the motion of the ball.

Using the graph, or otherwise, calculate the acceleration of the ball during its fall.

Total 15 marks
3. (a) Figure 4 below shows the structure of a neutral atom of carbon. The nucleus has six protons. Complete the diagram to show the correct number of electrons in the outer shell of the atom.

![Figure 4]

(1 mark)

Fill in the blanks in the following sentences.

(i) The other particles in the nucleus are known as ......................... .

The nuclide can be represented by the symbol \(^{A}_{Z}C\).

(1 mark)

(ii) \(A\) is known as the ................................. and its value is ................. .

(2 marks)

(iii) \(Z\) is known as the ................................. and its value is ................. .

(2 marks)

(b) Three isotopes of carbon are radioactive, with half lives as shown in Table 1 below.

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Half Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon – 10</td>
<td>10 seconds</td>
</tr>
<tr>
<td>Carbon – 14</td>
<td>5730 years</td>
</tr>
<tr>
<td>Carbon – 15</td>
<td>2.5 seconds</td>
</tr>
</tbody>
</table>

Table 1

In Figure 5 opposite, the decay curve for 4 g of the carbon – 10 isotope has been drawn. On the same axes, draw graphs to show

(i) the decay of 4 g of carbon – 14

(ii) the decay of 4 g of carbon – 15.

Label the graphs CLEARLY.
When the carbon – 14 isotope decays by β emission, it becomes an isotope of nitrogen.
The mass of a carbon – 14 nucleus is $2.324538 \times 10^{-26}$ kg, and the mass of a nitrogen – 14 nucleus is $2.324510 \times 10^{-26}$ kg.

(i) Calculate the difference in mass between nuclei of carbon – 14 and nitrogen – 14.

(ii) Determine the energy released when one carbon – 14 nucleus decays.
($c = 3.00 \times 10^8$ m s$^{-1}$)

Total 15 marks
4.

Figure 6

(a) The circuit shown in Figure 6 above, may be used to investigate the relationship between applied potential difference and current, for a 10 Ω carbon resistor. The battery has an e.m.f. of 3.0 V and negligible internal resistance. The ammeter has negligible resistance. A 20 Ω rheostat is used to control the current.

(i) Draw a circuit diagram to represent this arrangement of components.

(3 marks)
(ii) Explain why it is necessary for the voltmeter to have a high resistance.

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(1 mark)

(iii) Complete Table 2 below, to show how the meter readings change when the sliding contact on the rheostat is moved from end X to the other end Y.

(You may use the space below the table for your calculations.)

<table>
<thead>
<tr>
<th>Rheostat setting</th>
<th>Resistance of whole circuit/Ω</th>
<th>Ammeter reading/A</th>
<th>Voltmeter reading/V</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2

(5 marks)
(b) The graph in Figure 7 below, shows how the currents through a small lamp and a piece of resistance wire change as the potential difference across each is varied.

![Graph showing current (I/A) vs. voltage (V/volt) for a lamp and resistance wire.]

Figure 7

(i) Find the resistance of the resistance wire.

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(3 marks)
(ii) Find the resistance of the lamp when the current flowing is 0.20 A.

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(2 marks)

(iii) The lamp, resistance wire and a battery are now connected in series. If the current in the circuit is 0.20 A, determine the total potential difference across the lamp and resistance wire.

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(2 marks)

Total 16 marks

END OF TEST
in addition to the 1 hour, candidates are allowed a reading time of 10 minutes. Writing may begin during the 10-minute period.

READ THE FOLLOWING DIRECTIONS CAREFULLY

1. Answer ANY THREE questions.

2. ALL WORKING MUST BE SHOWN in your answer booklet, since marks will be awarded for correct steps in calculations.

3. The use of non-programmable calculators is allowed.

4. Mathematical tables are provided.
1. This question is about some of the physical principles involved in scuba diving.

Scuba divers breathe air from steel tanks carried on their backs. The tanks contain air at a pressure of $2.0 \times 10^7$ Pa. At atmospheric pressure, this air would occupy a volume of $2.5 \text{ m}^3$.

(a) Explain, in terms of the kinetic theory of gases:
   (i) How the air exerts a pressure on the inside of the steel tank
   (ii) Why the pressure in the tank increases when the tank is left out in the sun
   (iii) Why the pressure inside the tank decreases as air is released (8 marks)

(b) Determine the volume of the air when inside the tank at a pressure of $2.0 \times 10^7$ Pa. (3 marks)

(c) When the tank is in the sun, the temperature of the air inside reaches $40^\circ$C and its pressure is $2.1 \times 10^7$ Pa. Under the water, the temperature of this air goes down to $10^\circ$C.
   (i) Assuming that the volume of the tank does not change when it is underwater, determine the pressure of the air in the tank, when it is underwater. (4 marks)
   (ii) Express the change in air pressure, when the tank is underwater, as a percentage of the air pressure when the tank is in the sun. (1 mark)

(d) Because of increasing pressure with depth underwater, there is a limit to the depth to which a scuba diver can safely go. Calculate the total pressure exerted on a diver who is 24 m under the surface. (4 marks)

DATA: Density of water $g = 1.0 \times 10^3 \text{ kg m}^{-3}$
       $g = 10 \text{ N kg}^{-1}$
       Atmospheric pressure $= 1 \times 10^5 \text{ Pa}$
       $0^\circ \text{C} = 273 \text{ K}$

Total 20 marks

2. (a) (i) Draw a ray diagram to show the formation of an image by a diverging lens. State, with ONE reason, whether you think the image is real or virtual (4 marks)
   (ii) One defect of the eye is ‘short-sight’. Explain what this term means.
       Draw a ray diagram to show how a diverging lens may be used to correct this defect. (4 marks)

(b) When a converging lens forms a real image, the magnification of the image can be calculated from the equation

$$\text{magnification} = \frac{\text{image distance}}{\text{object distance}}.$$ 

With the aid of a ray diagram, show that this relationship is true. (3 marks)

(c) A converging lens is used to form a real image of an object placed 15 cm away from it. Given that the image is twice as high as the object, by means of a scale drawing, determine the focal length of the lens. (9 marks)

Total 20 marks

GO ON TO THE NEXT PAGE
3. (a) A teacher used the following experiment to demonstrate the law of conservation of momentum:

She lined up three identical steel balls (A, B and C) on a track, and rolled Ball A towards the other two (see Figure 1). After the collision, Ball A came to rest next to Ball B, but Ball C moved off with, apparently, the same velocity that Ball A originally had.

Before the collision

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
</table>

After the collision

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
</table>

Figure 1

(i) Explain the term ‘linear momentum’.  
(ii) State the law of conservation of linear momentum and explain how it applies in the experiment above.  
(iii) In terms of the forces acting, explain how Ball A came to rest and why Ball B remained stationary.

(b) A car of mass 800 kg, and a small van of mass 1800 kg, travelling in opposite directions, collided head-on and both came completely to rest.

(i) State the magnitude of the total momentum possessed by the two vehicles before the collision and explain how you arrived at your answer.  
(ii) The van was travelling at 12 m s\(^{-1}\). Determine the speed at which the car was travelling.

(iii)

![Velocity-time graph](image)

Figure 2

The graph in Figure 2 above, shows the change in the velocity of the van during the crash. Determine the magnitude of the force acting on the van during the crash.

(iv) What was the magnitude of the force acting on the car during the crash?

Total 20 marks

GO ON TO THE NEXT PAGE
4. Most of the electricity used in the Caribbean comes from oil or natural gas. This question is about generating electricity from alternative, renewable, sources of energy instead of using fossil fuels.

(a) Discuss the possible use of TWO alternative sources of energy, other than wind or nuclear, to generate electricity in your country.

Include in your answer, a description of the energy changes which take place in each process. (6 marks)

(b)

![Horizontal axis windmill](image)

Figure 3

A wind-powered generator is an example of the utilisation of a renewable energy source. Large blades are turned by the wind, and the rotation of the blades is used to run an electrical generator.

The average speed of the wind is 10 m s\(^{-1}\) and the circular area swept out by the blades is 1300 m\(^2\). Consider the cylinder of air passing this area in one second. (See Figure 4 below.)

![Wind](image)

Figure 4

(i) Calculate the volume of air passing the blades in EACH second. (3 marks)

(ii) What is the mass of this air? (3 marks)

(iii) Calculate the kinetic energy of the air passing the blades in each second. (3 marks)

(iv) The efficiency of the generator is 15%. Calculate the power output of the generator. (3 marks)

(v) Describe what happens to the other 85% of the energy which is not converted into electrical energy. (2 marks)

(Dense air = 1.3 kg m\(^{-3}\))

Total 20 marks

GO ON TO THE NEXT PAGE
5. (a) Explain, in terms of electron flow, the difference between a direct current and an alternating current. (2 marks)

(b) Figure 5 below shows an a.c. generator, and the graph, in Figure 6 below, shows the variation, with time, of the current from the generator.

Figure 5

(i) Use the graph to find the frequency of the a.c. supplied by the generator. (3 marks)

(ii) Using the same scales as were used in Figure 6, draw a graph to show the effect of turning the generator at TWICE the ORIGINAL speed. (2 marks)

(iii) With the aid of a diagram, describe a modification that would enable direct current to be obtained from the generator.

Sketch a graph of the output of the modified generator when it is rotated at the ORIGINAL speed. (4 marks)

(c) At a power station, the output power from a 10 kV generator is $4 \times 10^5$ W.

(i) Calculate the current in the transmission cables. (3 marks)

(ii) If the transmission cables have a total resistance of 20 Ω, how much power is available to the consumers at the end of the line? (4 marks)

(d) Explain why electricity is distributed over long distances as a.c. at high voltage, even though consumers use low voltages, such as 110 V or 220 V. (2 marks)

Total 20 marks

END OF TEST
READ THE FOLLOWING DIRECTIONS CAREFULLY

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2. ALL WORKING MUST BE SHOWN in this booklet, since marks will be awarded for correct steps in calculations.

3. Attempt ALL questions.

4. The use of non-programmable calculators is allowed.

5. Mathematical tables are provided.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO
1. (a) Figure 1 below shows a small, positively charged object near to a small, negatively charged object. Indicate, with a short arrow, labelled $F$, the direction of the force exerted on the negatively charged object.

Draw the electric field in the region of the two charges. Use arrows to show the direction of the field. (3 marks)

![Figure 1](image)

(b) A conductor, carrying current into the paper, is represented by $\bigotimes$ in Figure 2 below. The conductor is at right angles to the uniform magnetic field shown.

(i) On Figure 2 below, indicate, with an arrow, the direction of the force exerted by the magnetic field on this conductor.

![Figure 2](image)

How could the force on this conductor be increased?

........................................................................................................................................
........................................................................................................................................ (2 marks)
(ii) Draw a labelled diagram to show how you could produce a uniform magnetic field like the one on page 2. (2 marks)

(c) 

Figure 3

(i) A coil of wire is mounted on an axle and placed between the poles of a permanent magnet. Explain why the coil begins to rotate when a current is passed through it.

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(3 marks)

(ii) What extra device is needed to ensure that the coil continues to rotate?

..................................................................................................................................................
(1 mark)
(d) (i) Figure 4 below shows a conductor, $\bigotimes$, carrying current into the paper. Draw the magnetic field near to the conductor, using arrows to indicate the direction of the field.

Figure 4

(ii) Another wire, parallel to the first, carrying current in the SAME direction, is positioned at Point P. On Figure 4 above, show the direction of the force on this conductor and clearly label it with an $F$.

Total 15 marks
2. (a) Distinguish between vector and scalar quantities.

(2 marks)

Figure 5

(b) A small car travels at a constant speed around the circular race track shown in Figure 5 above, starting and finishing at Point A. The track has a radius of 70 metres and it takes 20 seconds to complete the journey. (Take \( \pi \) as \( \frac{32}{7} \) and circumference = \( 2 \pi r \), where \( r \) is the radius.)

(i) Find the distance travelled in the 20 s.

(1 mark)

(ii) Find the average speed of the car.

(2 marks)

(iii) What is the average velocity for the complete journey?

(1 mark)

(c) A car is travelling along a level road at 50 km h\(^{-1}\). The car speeds up to 80 km h\(^{-1}\). The driver finds that she has to keep her foot pressed harder on the gas pedal if she wishes to stay at this speed.

(i) How would Aristotle’s ‘law of motion’ explain this observation?

(2 marks)
(ii) Complete the following statement of Newton’s first law of motion:

If the resultant force on a body is zero it will remain at rest or

(1 mark)

(iii) Explain why the driver of the car must push harder on the gas pedal to keep the car moving at 80 km h⁻¹.

(2 marks)

(d) St. Lucia is 80 km due south of Martinique. A small aeroplane flies from Martinique to St. Lucia on a day when a strong wind of 50 km h⁻¹ is blowing from the east, as shown in Figure 6 below.

![Diagram showing the location of Martinique and St. Lucia with a wind blowing from the east.]

Figure 6
The pilot flies the plane at 80 km h⁻¹, due south relative to the air. **Use a scale diagram** to find with what velocity and in what direction the plane will travel relative to the Earth.

( 5 marks)

Total 16 marks
3. (a) The scale diagram, Figure 7 below, shows plane wavefronts incident on a barrier which has a narrow gap in it.

(i) Determine the wavelength of the waves before they reach the barrier.

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(1 mark)

(ii) What will be the wavelength of the waves after they pass through the gap?

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(1 mark)

(iii) Complete Figure 7 below to show what happens to the waves.

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Figure 7

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(iv) On Figure 8 below, show what happens when the gap in the barrier is wider.

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Figure 8

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(b) Two speakers, vibrating in phase, are positioned some distance apart in an open space. The crests of the waves from the speakers are shown on Figure 9 below.

![Figure 9]

(i) Explain the term 'constructive interference'.

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(1 mark)

(ii) Mark, with the letter C, TWO places on Figure 9 where constructive interference is taking place.

(2 marks)

(iii) Explain the term 'destructive interference'.

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(1 mark)

(iv) Mark, with a letter D, TWO places on Figure 9 where destructive interference is occurring.

(2 marks)

(v) Describe what you would expect to hear as you walk along the line, PQ.

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(2 marks)

(vi) If the two speakers were moved closer together, what effect would this have on what you hear as you walk along the line PQ?

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(1 mark)

Total 15 marks
4. (a) The graph below shows how the boiling point of water varies with the pressure of the air above the water. Use the graph to answer the questions on pages 11 and 12.
(i) A school in Jamaica is situated at an altitude of 1000 m. At the school, air pressure is usually about 90 kPa. At what temperature would you expect water to boil?

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(1 mark)

(ii) What TWO factors lead to the pressure being lower at greater altitudes?

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(2 marks)

(b) Inside a pressure cooker, the pressure is higher than normal. Figure 10 below shows the pressure cooker being used to cook some food.

![Pressure Cooker Diagram]

Figure 10

The lid is airtight except for a small hole, which has an area of $1 \times 10^{-5} \text{ m}^2$, at the top. A weight is placed on top of the hole to close it.

(i) If the weight used is 0.5 N, what is the pressure due to this weight? Convert your answer to kPa.

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(4 marks)

(ii) What is the total pressure acting on the contents if atmospheric pressure is 100 kPa?

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(1 mark)
(iii) At what temperature would the water in the pressure cooker boil?

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(1 mark)

(iv) What effect might the temperature identified in (iii) above have on the time it takes for the food to cook?

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(1 mark)

(v) To prevent accidents, the safety valve opens if the pressure inside the pressure cooker exceeds twice the pressure of the atmosphere. At what temperature does this occur?

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(1 mark)

(c) In terms of the kinetic theory of gases, why does the pressure of the gas in a sealed container rise when the temperature rises?

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(3 marks)

Total 14 marks

END OF TEST
In addition to the 1 hour, candidates are allowed a reading time of 10 minutes. Writing may begin during the 10-minute period.

READ THE FOLLOWING DIRECTIONS CAREFULLY

1. Answer ANY THREE questions.

2. ALL WORKING MUST BE SHOWN in your answer booklet, since marks will be awarded for correct steps in calculations.

3. The use of non-programmable calculators is allowed.

4. Mathematical tables are provided.
1. (a) The graph below shows the current through the resistor in the a.c. circuit shown in Figure 1.

\[ I \]
\[ 10 \quad 20 \quad 30 \quad 40 \quad \text{tms} \]

Supply

\[ \sim \]

Resistor

Figure 1

(i) Find the period and frequency of the alternating supply. (3 marks)

(ii) With the aid of a circuit diagram, describe how the current through the resistor could be rectified. Draw a graph to show how the rectified current would vary with time.

What is the difference between this direct current and the direct current from a battery? (5 marks)

(iii) A cassette recorder is normally powered by four 1.5 V cells. It can also be operated from the a.c. mains supply if a suitable adaptor is used. What components are required in such an adaptor? (3 marks)

(b) An electric stove, connected to a 120 V a.c. supply, has TWO ‘burners’, EACH with a resistance 24Ω, and TWO others, EACH with a resistance of 12Ω. The FOUR elements can be operated independently.

(i) Of a 24Ω and 12Ω burner, which one takes the greater current and which delivers the greater power? (2 marks)

(ii) Draw a diagram to show how the burners are connected, and find the equivalent resistance of the circuit when they are all switched on at the same time. (The symbol for a heating element is the same as the symbol for a resistor.) (4 marks)

(iii) The stove is connected, via a circuit breaker, to a special high current circuit in the kitchen. What would be the minimum current rating for the circuit breaker? (3 marks)

Total 20 marks
2. (a) The table below shows some of the properties of the emissions from radioactive substances.

<table>
<thead>
<tr>
<th>Type of Radiation</th>
<th>Range in Air</th>
<th>Penetration</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Greater than 1 m</td>
<td>Passes through thin sheet of lead</td>
</tr>
<tr>
<td>B</td>
<td>6 cm</td>
<td>Stopped by sheet of paper</td>
</tr>
<tr>
<td>C</td>
<td>70 cm</td>
<td>Stopped by sheet of aluminium 3 mm thick</td>
</tr>
</tbody>
</table>

Identify A, B and C. (3 marks)

(b) The diagram below shows a method that is used in some factories to check on the thickness of the polythene being produced. The Geiger-Muller tube is about 15 cm from the radioactive source, and is used to detect radiation that has passed through the polythene.

(i) State, giving TWO reasons, which type of radiation would be most suitable for this purpose. (2 marks)

(ii) State and explain the effects on the ratemeter reading of variation in the thickness of the polythene. (2 marks)

(c) A magnesium (Mg) nucleus contains 15 neutrons and 12 protons. It emits a beta-particle and becomes a nucleus of aluminium (Al).

(i) Write an equation for this decay. (3 marks)
(ii) In the laboratory, a scientist attempts to find the half-life of this isotope of magnesium. The source is placed near a detector and the count rate recorded every five minutes. Her results are shown below.

<table>
<thead>
<tr>
<th>Time/min</th>
<th>0</th>
<th>5.0</th>
<th>10.0</th>
<th>15.0</th>
<th>20.0</th>
<th>25.0</th>
<th>30.0</th>
<th>35.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count rate/min(^{-1})</td>
<td>460</td>
<td>267</td>
<td>156</td>
<td>104</td>
<td>60</td>
<td>50</td>
<td>32</td>
<td>34</td>
</tr>
</tbody>
</table>

In the absence of the radioactive source, the ratemeter records 20 counts per minute.

- Why is it necessary to find the count rate without the source being present? (1 mark)
- Plot a graph of corrected count rate against time and use it to find the average value of the half-life. (8 marks)
- Explain why the graph does not necessarily pass through all the plotted points. (1 mark)

Total 20 marks

3. (a) (i) Explain, with the aid of a diagram, what is meant by the moment of a force.

(ii) What do you understand by the term ‘centre of gravity’?

   Explain why, in the absence of other forces, an object may be balanced at its centre of gravity. (4 marks)

(b) The diagram below represents a wheelbarrow containing a load of sand.

![Diagram of a wheelbarrow with sand and handles]

The container and load are pivoted at P and have a mass of 40.0 kg. Their centre of gravity, G, is 0.5 m from P and the handles of the wheelbarrow are 1.4 m from P. The handles are being held so that the wheelbarrow is in equilibrium as shown in the diagram above.

(i) Name the principle that must be satisfied for the wheelbarrow to be balanced. Explain how this principle applies in this case. (2 marks)

(ii) Calculate the upward force which is being provided at the handles. (3 marks)
(iii) Calculate the upward force at the axle, \( P \), of the wheelbarrow. \( (3 \text{ marks}) \)

(iv) Explain the advantage of redesigning the wheelbarrow so that the centre of gravity is much closer to the point, \( P \). \( (2 \text{ marks}) \)

(v) More sand is added to the wheelbarrow. Explain why this makes the wheelbarrow more likely to tip over to one side. \( (2 \text{ marks}) \)

(c)

![Diagram of a wheelbarrow on a ramp]

The wheelbarrow (mass 40 kg) is now wheeled up a ramp and gains 2 m in height, as shown in the diagram above. The work done is 1400 J.

Calculate the change in the gravitational potential energy of the wheelbarrow. Treating the ramp as a machine, calculate its efficiency.

\[ (g = 10 \text{ Nkg}^{-1}) \]

\( (4 \text{ marks}) \)

Total 20 marks

4. (a) (i) When you drill a hole in metal the drill bit becomes very hot.

How could this observation be explained using

- the eighteenth century caloric theory of heat?

- the modern kinetic theory of heat? \( (4 \text{ marks}) \)

(ii) How did the evidence from Count Rumford’s experiments in drilling the barrels of cannons convince scientists that the kinetic theory was better than the caloric theory? \( (2 \text{ marks}) \)

(iii) Use the kinetic theory of heat to explain the melting of a solid, at constant temperature, when it is heated. \( (2 \text{ marks}) \)
(b) A student is asked to determine the specific latent heat of fusion of water. She starts by warming some water and carefully pouring it into a styrofoam cup. (This cup is used because it has negligible heat capacity). She finds the mass of the water and measures its initial temperature. She then dries some small pieces of ice and slowly adds them to the water, stirring until the ice is completely melted. The final temperature and mass of the water are noted.

The student’s table of results is shown below:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial mass of water</td>
<td>250 g</td>
</tr>
<tr>
<td>Final mass of water</td>
<td>299 g</td>
</tr>
<tr>
<td>Initial temperature of water</td>
<td>39 °C</td>
</tr>
<tr>
<td>Final temperature of water</td>
<td>19 °C</td>
</tr>
<tr>
<td>Specific heat capacity of water</td>
<td>4 200 J kg⁻¹</td>
</tr>
<tr>
<td></td>
<td>4.2 J g⁻¹</td>
</tr>
</tbody>
</table>

(i) How much thermal energy did the original mass of water lose? \( \text{(3 marks)} \)

(ii) What was the gain in energy of the MELTED ice as its temperature rose from 0 °C? \( \text{(3 marks)} \)

(iii) Using your answers to (i) and (ii) above, find the amount of thermal energy required to melt the ice at 0 °C. \( \text{(1 mark)} \)

(iv) What value does this experiment give for the specific latent heat of fusion? Express your answer in J kg⁻¹. \( \text{(3 marks)} \)

(v) In her list of precautions, the experimenter stated that she dried the ice with filter paper and she started with the water temperature 10 degrees above the room temperature of 29 °C. Explain why these precautions would make her result more accurate. \( \text{(2 marks)} \)

\[ \text{Total 20 marks} \]
5. The diagram below shows a boy doing his homework. He has difficulty reading his book under the small light bulb.

(a) In your answer booklet, draw a ray diagram to show the shadow produced by his head on the table. What difference would it make to the shadow if the light bulb were replaced by a long fluorescent tube? Draw a diagram to illustrate this case. (5 marks)

(b) Light is a form of electromagnetic (e.m.) waves. Name THREE other types of e.m. waves and state which of the three has the longest wavelength. (3 marks)

(c) (i) Low-frequency e.m. radiation is used to communicate with submarines. The frequency used is 30 Hz. If the speed of e.m. waves in air is $3.0 \times 10^8$ m s$^{-1}$, what is the wavelength of the low-frequency radiation in air? (3 marks)

(ii) A beam of low-frequency radiation is incident upon the surface of the sea at an angle of 15° as shown in the diagram below.

```
  Air
  \_  
     \_  
      \_  
      Sea
```

If the speed of the radiation is reduced to $2.5 \times 10^8$ m s$^{-1}$ in water, determine the angle of refraction. What is the wavelength and frequency of the radiation in water? (6 marks)

(iii) If radiation of the same frequency is emitted by a submarine which is under water, at what angle of incidence would total internal reflection occur in the sea? (3 marks)

Total 20 marks

END OF TEST
READ THE FOLLOWING DIRECTIONS CAREFULLY

1. You MUST use this answer booklet when responding to the questions. For each question, write your answer in the space provided and return the answer booklet at the end of the examination.

2. ALL WORKING MUST BE SHOWN in this booklet, since marks will be awarded for correct steps in calculations.

3. Attempt ALL questions.

4. The use of non-programmable calculators is allowed.

5. Mathematical tables are provided.
You should NOT spend more than 30 minutes on this question.

1.

![Diagram of apparatus](image)

**Figure 1**

The apparatus shown in Figure 1 above may be used to investigate how the volume of a fixed mass of gas at constant temperature varies when the pressure is changed. Air is trapped in a uniform glass tube which has a scale behind it calibrated in cm³. As the pressure in the oil chamber is increased using the pump, oil is forced into the glass tube, decreasing the volume of the air. The pressure, in kPa, is indicated by a gauge fitted to the oil chamber.

<table>
<thead>
<tr>
<th>Volume/cm³</th>
<th>60</th>
<th>55</th>
<th>50</th>
<th>45</th>
<th>40</th>
<th>35</th>
<th>30</th>
<th>25</th>
<th>20</th>
<th>15</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure/kPa</td>
<td>50</td>
<td>75</td>
<td>100</td>
<td>125</td>
<td>150</td>
<td>175</td>
<td>200</td>
<td>225</td>
<td>250</td>
<td>275</td>
<td>300</td>
</tr>
</tbody>
</table>

GO ON TO THE NEXT PAGE
The graph on page 2 was plotted from data gathered using the apparatus shown in Figure 1.

(a) How would you make sure that the temperature of the gas was constant during the experiment?

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(1 mark)

(b) It is suggested that if the temperature is constant, the pressure, \( P \), of a fixed mass of gas is inversely proportional to the volume, \( V \), that is

\[
\frac{1}{V} = k \times P \text{ where } k \text{ is a constant.}
\]

To test whether the relationship applies in this case, read off values of \( V \) from the graph to complete Table 1 below. Calculate the corresponding values of \( \frac{1}{V} \).

<table>
<thead>
<tr>
<th>Pressure, ( p )/kPa</th>
<th>Volume, ( V )/cm(^3)</th>
<th>( \frac{1}{V} )/cm(^{-3})</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>230</td>
<td></td>
<td></td>
</tr>
<tr>
<td>270</td>
<td></td>
<td></td>
</tr>
<tr>
<td>300</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1

(9 marks)

(c) On page 5, plot a graph of \( \frac{1}{V} \) against \( P \).

(8 marks)

(d) What conclusion can you draw from the graph you have plotted? Give a reason for your answer.

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(2 marks)
(e) The gradient of the graph is equal to the value of \( k \). Find \( k \).

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(5 marks)

(f) (i) What would be the volume of the air in the tube if the pressure could be increased to 550 kPa? (Assume the equation in (b) on page 3 applies.)

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(3 marks)

(ii) The maximum volume of the air in the tube is 65 cm\(^3\). Calculate the pressure of the air for this volume.

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(2 marks)

Total 30 marks
Figure 2

Figure 2 above shows a polythene rod, resting on two watch glasses which act as a low-friction pivot. A negatively charged rod is brought near to the polythene rod.

(i) If the polythene rod is attracted, what TWO possible conclusions might be drawn?

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(2 marks)

(ii) What conclusion could be drawn if the rods repelled each other?

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(1 mark)
(b) A negatively charged sphere is connected by a copper wire to a positively charged sphere, causing a current to flow, as shown in Figure 3 below.

![Diagram](image)

**Figure 3**

(i) Mark, on Figure 3 above, the direction of conventional current flow.  
(1 mark)

(ii) What kind of charge actually moves in the wire?  
.............................................................................................................  
(1 mark)

(iii) In which direction do the charges move?  
From ......................... to .........................  
(1 mark)

(iv) Name the SI unit of electric charge and give its definition.  
.............................................................................................................  
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(2 marks)

(v) If the current in the wire is 3 \( \mu \)A and it flows for 2 ms, how much charge is transferred through the wire?  
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(4 marks)
(c) The charge stored in a car battery is usually stated using the non-SI unit amp-hours. One amp-hour is defined as the charge stored in a battery when a current of one ampere is used to charge it for a period of one hour.

Calculate the charge stored in a 40 amp-hour battery using the SI unit for charge.

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(3 marks)

Total 15 marks

3. (a) Table 2 below lists types of waves and their sources. Complete the table by filling in the blank spaces. In the third column, state whether the waves are transverse or longitudinal.

<table>
<thead>
<tr>
<th>Type of Wave</th>
<th>Source</th>
<th>Transverse or longitudinal?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infra-red radiation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sound waves</td>
<td>Loud-speaker</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TV transmitter</td>
<td></td>
</tr>
</tbody>
</table>

Table 2

(5 marks)

(b) Figure 4 below shows a wave spreading out from the point S. The wave hits the barrier and is reflected. On the diagram, draw TWO reflected wavefronts and mark, with an X, the point from which they appear to come.

(3 marks)
Figure 5 below is a graph which represents the variation of the displacement, $y$, with time, $t$, as a wave passes a certain point.

![Graph showing displacement vs time](image)

Figure 5

(i) Use the graph to find the amplitude of the wave.

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(1 mark)

(ii) How long does one complete cycle of the wave take?

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(1 mark)

(iii) Calculate the frequency of the wave.

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(2 marks)

(iv) What other information would be needed to calculate the wavelength of the wave?

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(1 mark)

(v) On Figure 5 above, draw another wave which has the SAME amplitude but HALF the frequency.

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(2 marks)

Total 15 marks
4. (a) Radioactive tracers are sometimes used in medicine. Describe how a radioactive isotope is used as a tracer in the human body.

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(2 marks)

(b) Nuclei which emit only $\alpha$-particles are NOT normally used as radioactive tracers in the human body. Give TWO reasons why this is so.

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(2 marks)

(c) The radioactive isotope of iodine, $^{131}_{53}$I, is used to study blood circulation. This isotope has a half-life of 8 days.

(i) Explain what is meant by the HALF-LIFE of the isotope.

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(1 mark)

(ii) Give the symbol for another possible isotope of iodine.

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(2 marks)

(iii) Other isotopes are available with half-lives of 20 seconds and 2 years. Explain why 8 days is a suitable half-life for medical uses.

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(2 marks)
(iv) A sample of $^{131}_{53}$I is introduced into a person's body. After how many days will $\frac{7}{8}$ of the sample have decayed?

(3 marks)

(d) When a nucleus of $^{131}_{53}$I decays, it emits a $\beta$-particle and $\gamma$-radiation and becomes xenon, for which the symbol is Xe. Write an equation for a nuclear reaction to represent this decay.

(2 marks)

Total 14 marks
5. (a) State Archimedes’ principle.

(b) A tree is many times heavier than a nail. In terms of the forces acting on the two objects, explain why a tree floats in water but a nail sinks.

(c) The apparatus shown in Figure 6 below is used in the determination of the density of a rock.

![Figure 6](image)
(i) Use the information given in Figure 6 to find the volume of the rock in cm$^3$.

........................................................................................................................................

........................................................................................................................................

........................................................................................................................................ (3 marks)

(ii) State the volume of the rock in m$^3$. ................................................................. (1 mark)

$1 \text{ m}^3 = 1 \times 10^6 \text{ cm}^3$

(iii) If the rock has a mass of 0.12 kg, find its density in kg m$^{-3}$.

........................................................................................................................................

........................................................................................................................................ (3 marks)

(iv) Would the rock float or sink in the liquid bromoform which has a density of 4 000 kg m$^{-3}$? Explain your answer.

........................................................................................................................................

........................................................................................................................................ (2 marks)

(d) On Earth, the gravitational field strength is much larger than that on the Moon. If a piece of rock were taken from the Moon to the Earth, state what change, if any, there would be in the mass, weight and density of the rock.

Mass ................................................................................................................................

Weight ................................................................................................................................

Density ................................................................................................................................ (3 marks)

Total 16 marks

END OF TEST