1. This paper consists of seven questions, each carrying 15 marks. Answer any SIX questions.

2. Some questions contain parts marked with an asterisk (*). In answering these parts, candidates are required to give paragraph-length answers. In each of these parts, one mark is allocated to assess candidates' ability in effective communication.

3. Take $g = 10 \text{ m s}^{-2}$.

4. Unless otherwise specified, all the cells are assumed to have negligible internal resistance.

5. The last page of this question paper contains a list of physics formulae which you may find useful.

Figure 1 shows the layout of a runway $ABC$ in an amusement park. $AB$ is an icy smooth inclined plane and $BC$ is a rough horizontal surface. At time $t = 0$, a boy sitting on a sledge slides down from rest at $A$ along the runway. At $t = 5 \text{ s}$, the sledge reaches $B$ with a speed of 8 m s$^{-1}$. The sledge then decelerates uniformly along $BC$ and finally stops at point $D$ at $t = 15 \text{ s}$.

(a) Sketch the graph of the speed of the sledge against time from $t = 0$ to $15 \text{ s}$. (3 marks)

(b) Consider the sledge and the boy as one body. Draw a labeled diagram to show all the forces acting on the body as it slides along $AB$. (2 marks)

(c) Find

(i) the acceleration of the sledge as it slides along $AB$,

(ii) the stopping distance $BD$,

(iii) the frictional force acting on the sledge as the sledge travels along $BC$. (Given: Total mass of the sledge and the boy = 60 kg.) (6 marks)
Suppose the angle of inclination of the smooth plane is increased. (See Figure 2.) Then the boy sitting on the sledge slides down from rest at a point $P$ on this runway, where $P$ is at the same height as point $A$ in the original runway. Would there be any change in the stopping distance along $BC$ when compared with (c) (ii)? Explain your answer.

* (d)
3. Peter is suffering from an eye defect and his sight is corrected by wearing spectacles made of two identical convex lenses.

(a) (i) What kind of eye defect is Peter suffering from?  

(ii) Draw a ray diagram to illustrate how the correction is made.  

(b) Peter wants to know the focal length of the above lens. Describe a simple laboratory method of measuring the focal length of the lens.  

(c) Suppose the focal length of the above lens is 50 cm. An object of height 10 cm is placed 25 cm in front of the lens.

(i) Using a scale of 1 cm to represent 10 cm, draw on graph paper a ray diagram to show how the image of the object is formed.  

(ii) Find the magnification of the image.  

(iii) Suppose the shortest distance Peter can see clearly without wearing spectacles is 40 cm. If Peter is wearing the spectacles and the object is placed 25 cm in front of his lenses, explain whether he can see the object clearly.  

4. Figure 5 shows a 3-pin plug and a kettle.

(a) To which of the A, B and C of the plug should each of the wires X, Y and Z of the kettle be connected?  

(b) (i) Explain why it is safer to have pin A of the plug longer than the other two pins.  

(ii) Explain why switch S of the kettle is connected in wire X instead of wire Y.  

(c) The rating of the kettle is ‘220V, 2000 W’.

(i) If the kettle is switched on for half an hour, calculate the cost of electricity. (Given: One kilowatt-hour of electricity costs $0.9.)  

(ii)
c) (ii) (continued)

A housewife plugs the kettle and an oven of rating ‘220 V, 2500 W’ into a 15 A socket. (See Figure 6.) Explain why this connection is dangerous. Show your calculations.

(3 marks)

*(d) A student makes the following note in his book:

In case either wire X or Y touches the metal case of the kettle accidentally, the kettle will stop working.

Explain whether the student’s note is correct. (4 marks)

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5.

Figure 7 shows a type of motor. PQ and RS are solenoids. The solenoids and the coil ABCD are connected in parallel to a battery.

(a) State

(i) the polarity at end Q of the solenoid PQ,

(ii) the direction of rotation of the coil as seen by the observer.

(2 marks)

(b) Name the component E and explain its function. (3 marks)

(c) Suggest two ways of increasing the rotating speed of the coil. (2 marks)

*(d) A student says “If the battery in Figure 7 is replaced by a 50 Hz a,c, supply, the coil will only oscillate to and fro. Hence the motor will not function properly.”

Explain why the student is incorrect. (5 marks)

(e) Describe, with the help of a diagram, how the motor in Figure 7 can be converted to a direct current generator. (3 marks)
6. The radioactive isotope of sodium, $^{24}_{11}\text{Na}$, decays by emitting a $\beta$ particle to form a stable isotope of magnesium (Mg).

(a) Write down an equation for the decay. (2 marks)

(b) Suppose you are given the following apparatus:

- a GM counter
- a sheet of paper
- a 5 mm thick aluminium sheet

Describe how you can demonstrate that $^{24}_{11}\text{Na}$ emits $\beta$ particles and does not emit $\alpha$ particles. (5 marks)

c) The half-life of $^{24}_{11}\text{Na}$ is 15 hours. A sample of $^{24}_{11}\text{Na}$ having an activity of $32 \times 10^3$ disintegrations per second is injected into the bloodstream of a patient. After 45 hours, 6 cm$^3$ of blood is taken out from the patient’s body and its activity is found to be 5 disintegrations per second.

(i) How many half-lives of $^{24}_{11}\text{Na}$ will have elapsed after 45 hours? (1 mark)

(ii) Estimate the volume of blood in the patient’s body. (3 marks)

(iii) Suggest two reasons for using $^{24}_{11}\text{Na}$ as a medical tracer. (2 marks)

(d) State an application of radioactive isotopes, other than tracers, in each of the following fields:

(i) Medicine. (2 marks)

(ii) Industry. (2 marks)

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7. A longitudinal wave is traveling from left to right in a medium. Figure 8 shows the equilibrium positions of some particles A to K in the medium. Figure 9 shows the positions of the particles at a certain time $t$ when the wave is passing through them.

(a) What is meant by a longitudinal wave? Give an example of a longitudinal wave. (2 marks)

(b) Point out a particle in Figure 9 which is

(i) at the centre of a compression, (2 marks)

(ii) at the centre of a rarefaction. (2 marks)

(c) Table 1 shows the displacements of particles A and B at time $t$.

(Note: Displacement to the right is taken to be positive.)

(i) Using Figures 8 and 9, find the displacements of the other particles and complete Table 1. (2 marks)

(ii) In Figure 10, draw a graph showing the displacements of the particles along the wave at time $t$. (2 marks)

(iii) Find the amplitude and wavelength of the wave. (2 marks)

(iv) If each particle takes 0.25 s to complete one oscillation, find the speed of the wave. (2 marks)
If you attempt Question 7, fill in the details in the first three boxes above and tie this sheet into your answer book.

(d) Suppose the wave travels into another medium where it travels more slowly.

(i) How would the frequency and wavelength of the wave be affected?

(2 marks)

(ii) Name this wave phenomenon.

(1 mark)

<table>
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<tr>
<th>Particle</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
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<td>-6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Table 1

Useful Formulae in Physics

(a) Relationships between initial velocity \( u \), constant acceleration \( a \), final velocity \( v \) and displacement travelled \( s \) after time \( t \):

\[ v = u + at \]

\[ s = ut + \frac{1}{2}at^2 \]

\[ v^2 = u^2 + 2as \]

(b) Potential energy gained by a body of mass \( m \) when raised through a height \( h \) is \( mgh \).

(c) Kinetic energy of a body of mass \( m \) moving with speed \( v \) is \( \frac{1}{2}mv^2 \).

(d) Power = force \( \times \) velocity

(e) Equivalent resistance of two resistors \( R_1 \) and \( R_2 \):

(i) in series \( R = R_1 + R_2 \)

(ii) in parallel \( R = \frac{R_1R_2}{R_1 + R_2} \)

(f) Power = potential difference \( \times \) current