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) (i) State Newton's second law of motion.

(ii) Use Newton's second law of motion to

a) distinguish between mass and weight

b) define the unit of force.

(iii) Identify the type of unbalanced force which acts on

a) an electron moving around a nucleus

b) car going around a bend in a flat road.

(b) The elevator in a high-rise building accelerates uniformly from rest to a speed of 4 m s\(^{-1}\) in the first 2 seconds of its upward motion. It then continues at constant speed for 4 seconds and thereafter decelerates uniformly to a complete stop in 3 seconds.

(i) Sketch a labelled velocity-time graph of this motion. **(Do not use graph paper)**

(ii) Calculate the acceleration in the first 2 seconds.

(iii) Determine the distance travelled by the elevator while it is decelerating.

(iv) Determine the total distance travelled by the elevator.

(12 marks)

Total 20 marks

2. (a) Explain the meaning of the following terms as they relate to a wave:

(i) Amplitude

(ii) Period

(b) (i) Draw a displacement-time graph to represent the movement of a floating buoy which has an amplitude of 0.5 m as a water wave passes with a period of 3 seconds.

(ii) Can the graph you drew in part (b) (i) be used to tell whether the wave is transverse or longitudinal?

(5 marks)
(c) The diagram in Figure 1 shows the wavefronts in a ripple tank as a water wave moves from deep water to water made shallower by a sheet of glass placed in the water.

Figure 1

(i) If the period of the incident wave is 0.1 seconds, the wavelength of the incident wave is 0.5 cm and the wavelength of the refracted wave is 0.3 cm, calculate the

a) speed of the incident and refracted wave

b) refractive index at the deep to shallow water boundary.

(ii) If the angle of incidence of the incident wave is 25°, determine the angle of refraction of the refracted wave.

(12 marks)

Total 20 marks
3. (a) Describe an experiment to show that a metal expands when heated. State the apparatus you would use, briefly describe your procedure and say how you would arrive at your conclusions. (8 marks)

(b) Figure 2 shows a diagram representing the heating system of a domestic electric iron. The temperature of the iron is regulated by a bimetallic strip. At point C the bimetallic strip makes contact with the live wire of the supply.

![Figure 2](image_url)

(i) Use your knowledge of the thermal characteristics of bimetallic strips to explain how this system regulates the temperature of the iron.

(ii) Sketch (no numbers required just labelled axes and a shape) a graph showing how the temperature of the iron would vary with time. Indicate on your graph the times when the heating coil is ON and OFF.

(iii) In a defective iron the contacts stick together so that current flow is continuous, but the temperature of the iron does not increase indefinitely. Explain. (12 marks)

Total 20 marks
4. (a) (i) Name the THREE methods by which thermal energy may be transferred. For EACH method describe ONE feature which is included in the design of the solar water-heater collector in order to minimize thermal energy losses.

(ii) Describe TWO other design features which improve the efficiency of solar water-heater collectors. (8 marks)

(b) 650 W of solar power is incident on every square metre of a solar water-heater collector with length 2 metres and width 1.5 metres. The solar water-heater is designed to heat 120 kg of water which is placed in a storage tank.

(i) Calculate the area of the solar water-heater collector and the power incident on it. (4 marks)

(ii) Given that the power incident is sustained for 6 hrs, calculate the energy input to the solar water-heater collector. (4 marks)

(iii) The solar water-heater collector supplies 18 MJ of energy to the water initially at 30°C. Calculate the temperature at which the water is stored. (4 marks)

Specific heat capacity of water = 4200 J Kg\(^{-1}\) K\(^{-1}\)

Total 20 marks
5. (a) (i) Sketch the magnetic field of a solenoid.

(ii) Figure 3 shows an electromagnetic relay. Describe the operation of this device. In your description you should refer to the components of the relay using the labels on the diagram.

![Diagram of an electromagnetic relay](image)

**Figure 3**

(8 marks)

(b) Figure 4 shows an apparatus which may be used to demonstrate the phenomenon of magnetic levitation. A copper ring placed around a solenoid can be suspended in space without apparent support by adjusting the a.c. supply to the coil.

![Diagram of magnetic levitation apparatus](image)

**Figure 4**
(i) Explain why a varying supply causes a current to flow in the ring.

(ii) At a given instant the a.c. supply voltage is increasing and the base of the coil is a north pole. Figure 5 shows a sketch of the ring and the magnetic field around it at that instant.

![Figure 5](image)

Redraw this diagram in your answer book. Show the direction of the induced current on your diagram. Explain how you arrived at your answer.

(iii) On your diagram indicate the vertical forces acting on the ring when it is suspended and in equilibrium. Give the nature and origin of these forces. 

(12 marks)

Total 20 marks

END OF TEST