Sec 4 Physics

Exam papers with worked solutions

SET B
PAPER 2
QUESTION

Compiled by

THE PHYSICS CAFE

INSTRUCTIONS TO CANDIDATES

Write your name, register number and class on all the work you hand in.

Write in dark blue or black pen on both sides of the paper.

You may use a soft pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A (50 marks)

Answer **all** questions in the spaces provided.

Section B (30 marks)

Answer all **three** questions. Question 13 has a choice of parts to answer.

Write your answers in the spaces provided.

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Section A (50 marks)
Answer **all** the questions in this section.

1. Fig. 1.1a shows a gate which closes automatically after use. A heavy stone is attached by chains **JK** and **KL** to the top bar of the gate and to the top of a nearby vertical post.

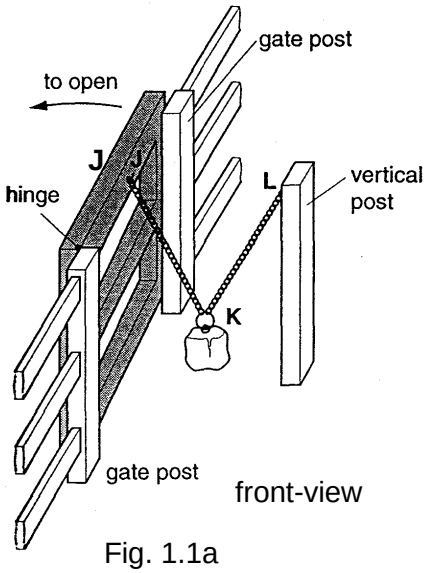

Fig. 1.1a

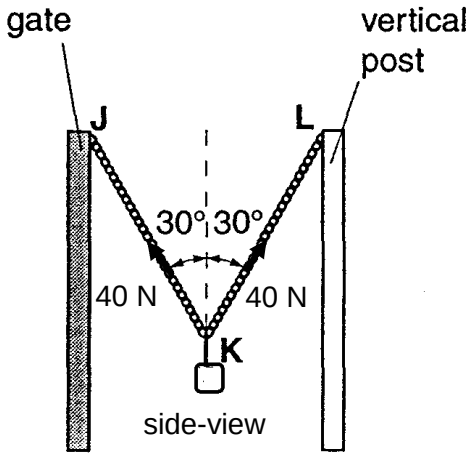

Fig. 1.1b

Opening the gate raises the stone; when the gate is released, the force exerted by the chains **JK** and **KL** closes the gate.

a) When the gate is closed, each chain is at 30° to the vertical (Fig. 1.1b) and the tension in each chain is 40 N. The plane containing the chains and the stone is at right angles to the gate.

By means of a scaled vector diagram, determine the weight of the stone. State the scale used [3]

Scale: …… Weight of stone ……

b) Fig. 1.2 shows the top view. The chain **JK** pulls at an angle to the horizontal and the horizontal component of the force in the chain **JK** that holds the gate closed is 20 N as shown. A force *F* is applied to the gate to start opening the gate.

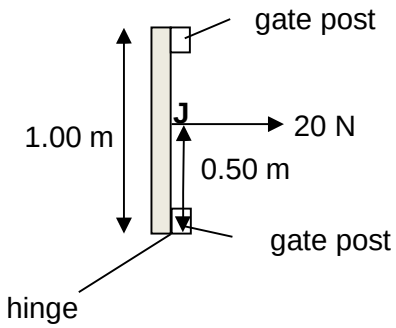

Fig. 1.2

i) By means of an arrow, indicate on Fig. 1.2 where the force *F* should be applied so that the magnitude of force *F* is minimum. Label the force as *F*. [1]

ii) Hence, calculate the minimum force *F* needed to start opening the gate. Assume that frictional forces at the hinges are negligible. [2]

2. Fig. 2 shows a block of mass 0.2 kg on a rough horizontal table. The block is acted on by two horizontal forces of magnitudes 7 N and 3 N.

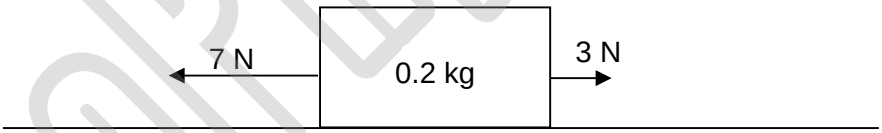

Fig. 2

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a) If the block moves with an acceleration of 15 ms^{-2}, calculate the frictional force. [2]

b) The same block is now placed on a different horizontal surface. The same two forces as shown in Fig. 2 continue to act on the block. However, the block does not move.

Subsequently, the 7 N force is removed and only the 3 N force continues to act on the block.

State and explain whether the block will move. [3]

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3. Fig. 3 shows a hydraulic press. A downward force of 100 N is applied to the small piston and this is just sufficient to raise a heavy load on the large piston.

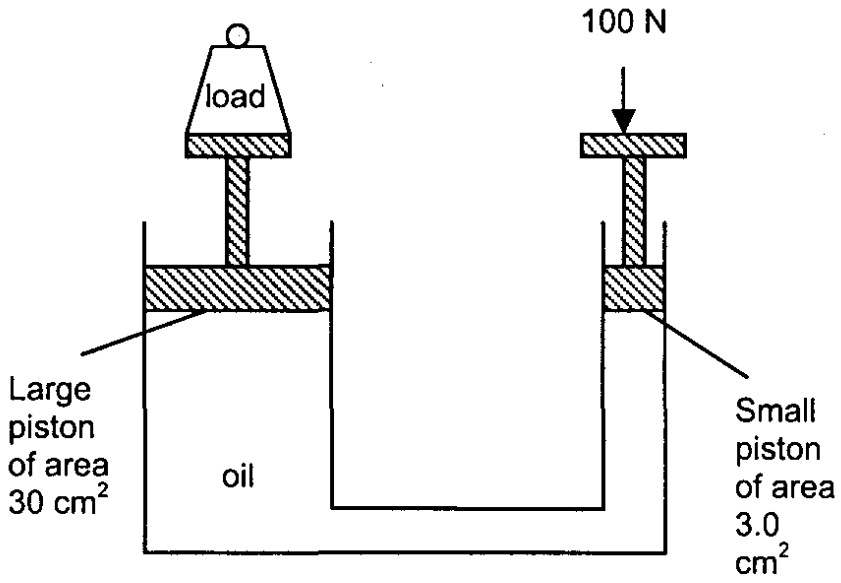

Fig. 3

a) Calculate the maximum load that can be lifted. [2]

b) Describe one change to the hydraulic press that enables it to lift a load heavier than the answer in (a) above without exerting a bigger force. [1]

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4. Fig. 4 shows an experimental setup from a student who wants to measure the amount of thermal energy from the sun that falls on a blackened piece of metal. The initial reading on the thermometer is the same as the room temperature.

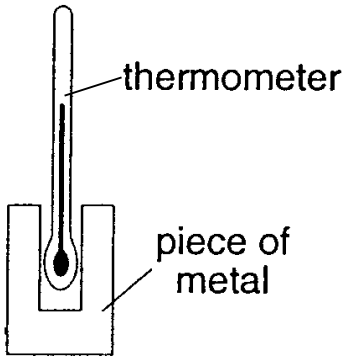

Fig. 4

a) The mass of the metal block is 0.20 kg and its specific heat capacity is 390 $Jkg^{-1}K^{-1}$. The reading on the thermometer increases by 2.1 K in one minute.

Calculate the power received by the metal block. [3]

b) State one source of error from the experimental setup other than thermal energy being lost to the surroundings. Hence, explain whether the actual power received by the block is higher or lower than the answer in (a) above. [2]

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5. Fig. 5 shows a series of floating balls that are used to bound the swimming area outside a beach. The balls are linked by identical light strings and the balls are 1.0 m apart. A sea wave is approaching the balls and ball 1 starts to vibrate.

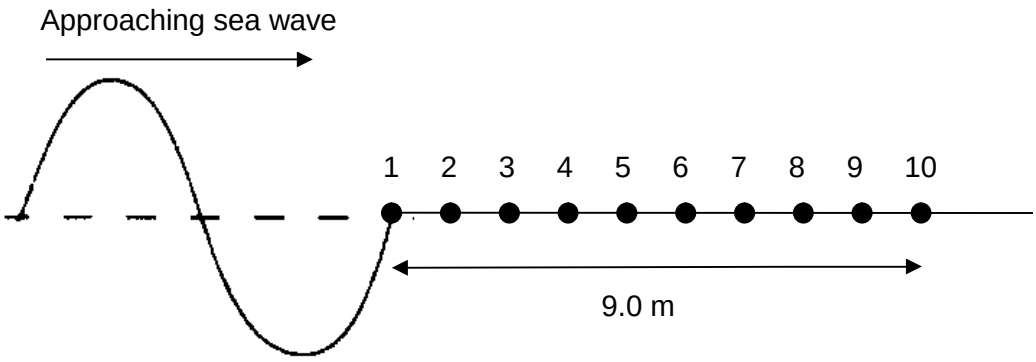

Fig. 5

a) It is observed that ball 1 makes 0.5 complete oscillation in 2.0 s. Calculate the frequency of the wave. [2]

b) Ball 9 starts to move at the time when ball 1 just finishes two complete oscillations.

i) Calculate the wavelength of the wave. [1]

ii) Calculate the velocity of the wave. [2]

6. Fig. 6 shows the arrangement to investigate a layer of rock underground. An explosion is made on the surface of the Earth. Sound wave from the explosion may travel to the detector through several paths as shown in Fig. 6.

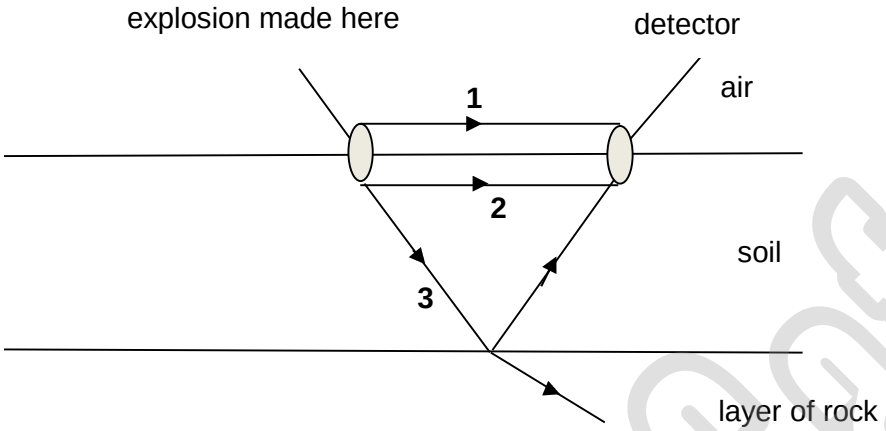

Fig. 6

a) State two properties of sound wave that Fig. 6 illustrates. [1]

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b) Based on information given in Fig. 6, state and explain whether sound waves travel faster or slower in the layer of rock than it does in soil. [2]

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c) The time taken for the sound to reach the detector via path **1** and path **2** is 0.100 s and 0.020 s respectively. Calculate the speed of sound in soil. Take the speed of sound in air as 320 ms^{-1}. [2]

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7. Fig. 7 shows a set up in which a horizontal plate **X** is vertically above horizontal plate **Y**. The two plates are connected to a high voltage d.c. supply with the use of a switch. With the switch closed, an oil drop placed mid-air between the two plates was observed to be stationary.

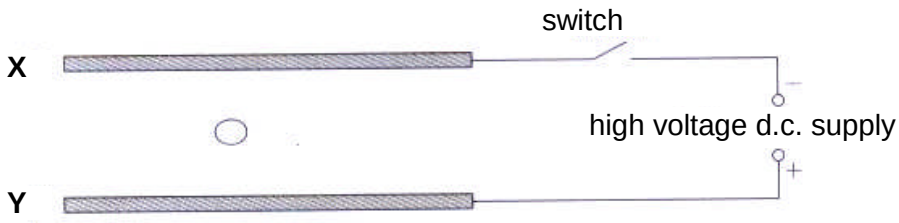

Fig. 7

a) Describe the flow of charges that occur between the voltage source and the respective plates **X** and **Y** when the switch is closed. [1]

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b) From the experiment, the oil drop can be deduced to be positively charged. Explain how this deduction can be made. Identify all the relevant forces. [3]

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c) State what will happen to the oil drop if the d.c. supply is replaced with an alternating source of voltage with the same maximum potential difference. [1]

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8. Several resistors are connected in a circuit as shown in Fig. 8. One of the resistors has an unknown resistance **R**. The potential difference across **YZ** is 1.0 V.

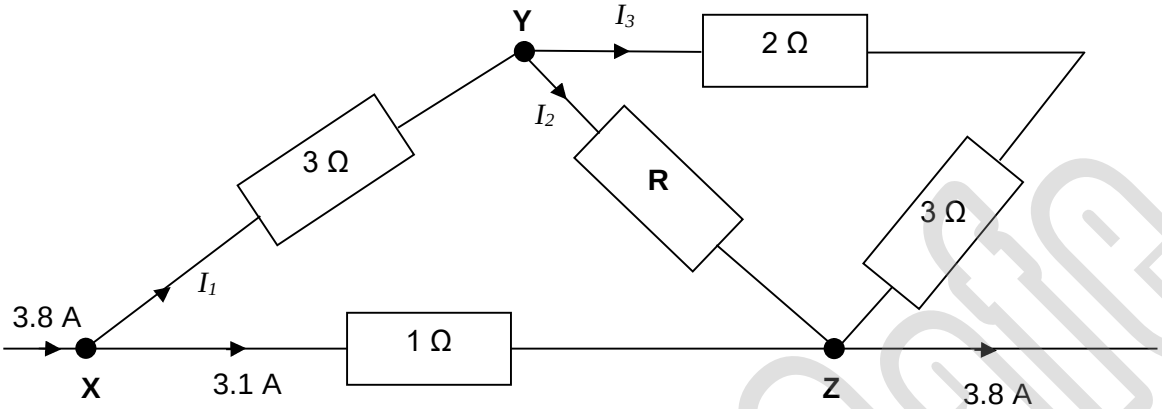

Fig. 8

a) Calculate the current I_3. [2]

b) Calculate the current I_2 [2]

c) Calculate the effective resistance between **X** and **Z**. [3]

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9. Fig. 9 shows an oven connected to a circuit breaker. The oven has a metal casing and is earthed.

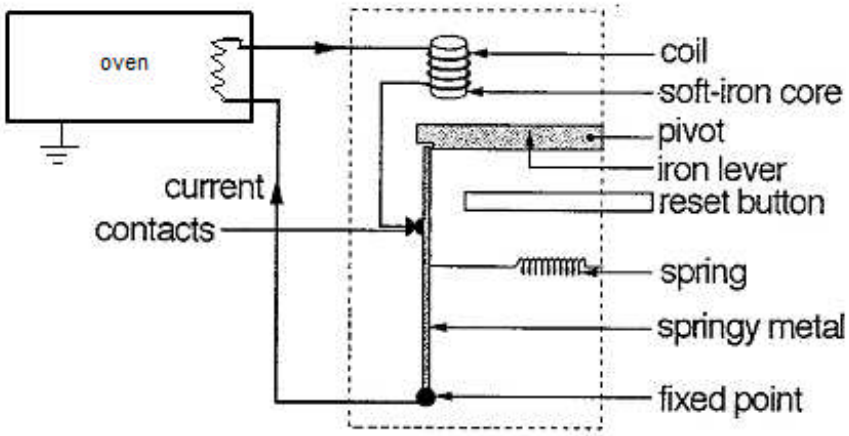

Fig. 9

a) Describe two possible electrical malfunctions in the oven that will result in a large current flowing through the circuit. [2]

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b) Explain how the above circuit breaker works. [3]

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10. In Fig. 10, the circuit consists of a light dependent resistor (LDR), a potentiometer **XY** and a lamp. When little light falls on the LDR, its resistance is 3000 Ω. When light of strong intensity falls on the LDR, its resistance is 500 Ω.

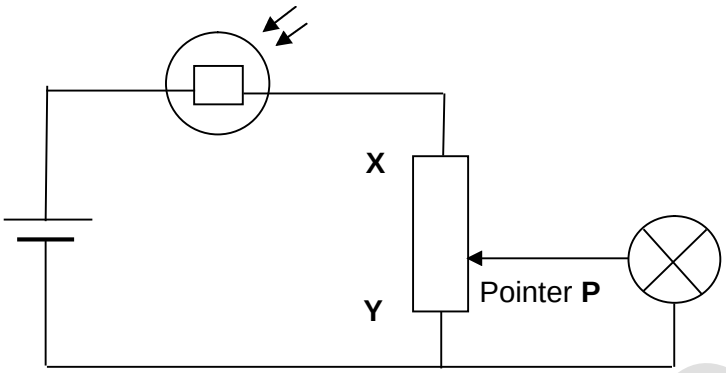

Fig. 10

Describe and explain the conditions where the light bulb will be at its brightest. [4]

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End of Section A

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Section B (30 marks)

Answer **all** the questions in this section.
Answer only one of the two alternative questions in **Question 13**.

11. Fig. 11a shows a flowmeter that measures the volume of oil passing through a pipe.

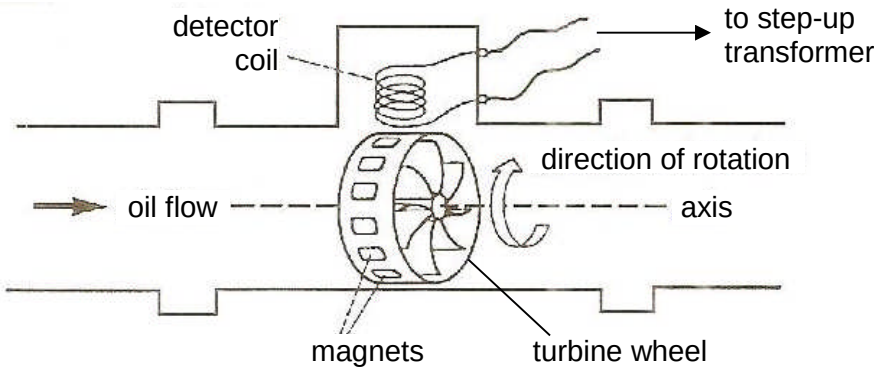

Fig. 11a

Twenty identical magnets are spaced equally around a turbine wheel. As oil flows, the turbine wheel rotates about the axis as shown. The detector coil is connected to the primary coil of a step-up transformer (Fig. 11b) to amplify the voltage signal, which is then displayed on a cathode ray oscilloscope.

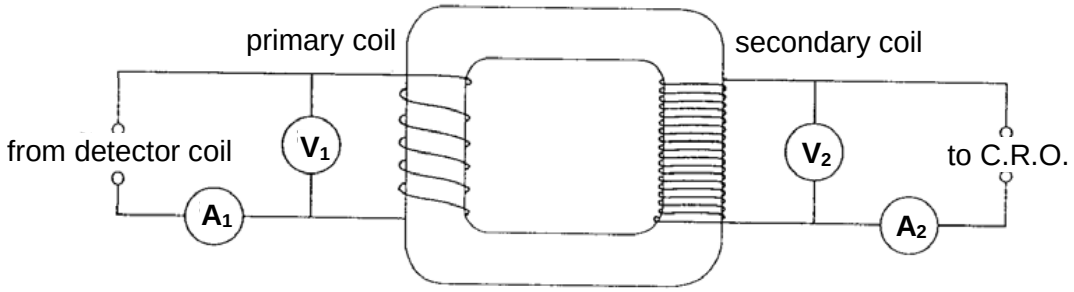

Fig. 11b

Table 11c shows the data for two different oil flow rates. Some values are missing from the table.

oil flow rate / cm^3s^{-1}	period of turbine spin / s	transformer			
		A_1 / A	**V_1** / V	**A_2** / A	**V_2** / V
15	2	1.8	6	0.8	12
30	1	1.8		0.8	

Table 11c

a) Explain why an alternating e.m.f. is induced in the detector coil. [3]

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b) Sketch a graph below to show how the induced e.m.f. in the primary coil varies with time for a flow rate of 15 cm^3s^{-1}. [2]

c) State if the transformer is 100% efficient. Explain by showing your working clearly. [2]

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d) Calculate the ratio of the number of turns in the secondary coil to the number of turns in the primary coil. [2]

e) Complete Table 11c by filling in the missing values for $\mathbf{V_1}$ and $\mathbf{V_2}$. [1]

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12. a) Fig. 12 shows the path of a light ray in a spherical water drop.

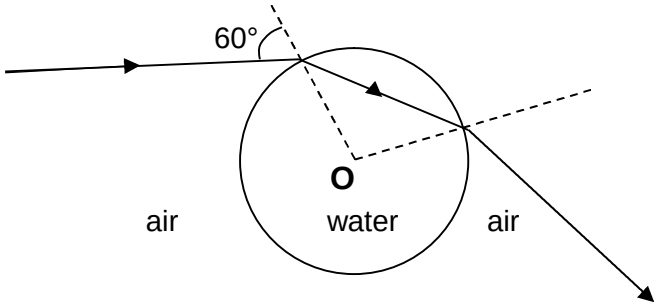

Fig. 12

O is the centre of the water drop. The angle of incidence of the light ray to the water drop surface is 60°.

i) Given the refractive index of water is 1.33, calculate the angle of refraction of the light ray in the water drop. [2]

ii) Calculate the critical angle of water. [2]

iii) Regardless of the angle of incidence of the light ray at the air-water boundary, the light ray will not exhibit total internal reflection at the water-air boundary as shown. By comparing the relevant angles at these two boundaries, explain why this is so. [2]

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b) The applications of ultraviolet rays and X-rays often make use of the phenomenon of *fluorescence* to obtain images.

i) Explain how ultraviolet rays are used to ensure that bank notes are genuine. [1]

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ii) X-rays cause fluorescence when absorbed by certain chemicals that can darken photographic film. Hence, by stating the relevant properties of X-rays, explain how X-rays are used to obtain images to detect broken bones. [2]

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iii) Explain why the process of X-ray imaging can be harmful to a patient if done too often. [1]

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EITHER

13. Fig. 13a shows a simple d.c. motor. Seen from the front, the coil rotates in a clockwise direction as shown.

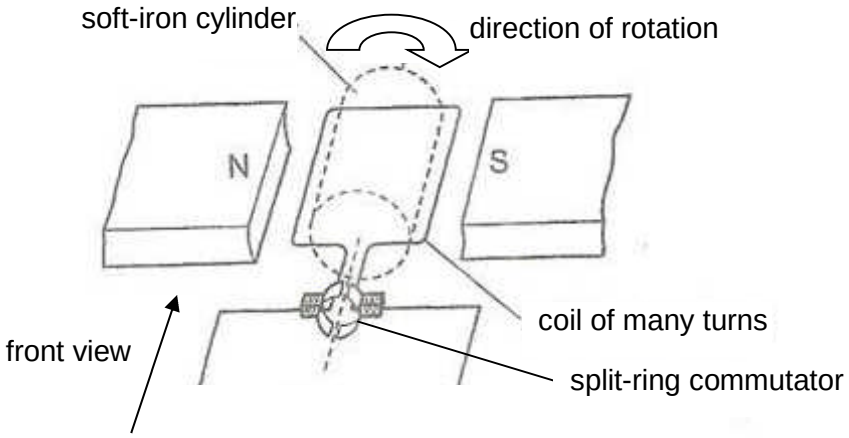

Fig. 13a

a) Complete the circuit in Fig. 13a by including a correctly connected battery and a variable resistor. [2]

b) Fig. 13b shows the permanent magnets and the wires as seen from the front view. Draw the magnetic field pattern between the permanent magnets. Indicate the direction of the current using dot and cross notation. The wires from the front view are represented by the two circles. [2]

Fig. 13b

c) Explain the purpose of the split-ring commutators in Fig. 13a. [2]

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d) State and explain the effect of removing the soft-iron cylinder from the setup on the movement of the coil. [2]

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e) After a prolonged period of use of the motor, the wires in the coil start to heat up. Explain why this has a slowing effect on the motor. [2]

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OR

13. Fig. 13c below shows a simple form of solar oven that makes use of sunlight to heat a cup of water.

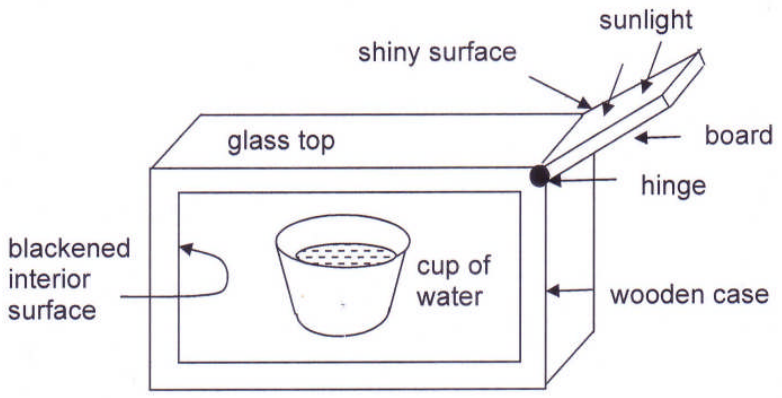

Fig. 13c

a) The oven has a glass top which allows sunlight to enter the solar oven. Identify and explain three other features of the oven's design that increase its effectiveness. [3]

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b) Explain whether any convection currents will be setup within the oven. [2]

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c) Explain why the pressure within the sealed solar oven increases when it is placed in the sun, given that air is unable to escape from the sealed solar oven. [3]

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d) Upon close examination, small flecks of dirt particles are observed which appear afloat within the closed oven. Explain why the dirt particles do not fall to the bottom of the oven. [2]

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End of Section B

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