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4EX

PHYSICS 6091/02

Paper 2 Theory [80 Marks]

PRELIMINARY EXAMINATION
August 2024

Candidates answer on the Question Paper.
No Additional Materials are required.

1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

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

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

You may use a pencil for any diagrams or graphs.

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

DO **NOT** WRITE IN ANY BARCODES.

Section A

Answer **all** questions.

Write your answers in the spaces provided.

Section B

Answer **one** questions.

Write your answers in the spaces provided.

FOR EXAMINER'S USE		
Paper		**Marks**
Paper 1 (MCQ)		/ 40
Paper 2		/ 80
A		/ 70
B	**Q ___**	/ 10

Candidates are reminded that **all** quantitative answers should include appropriate units.

The use of an approved scientific calculator is expected, where appropriate.

Candidates are advised to show all their working in a clear and orderly manner, as more marks are awarded for sound use of Physics than for correct answers.

Unless otherwise stated, take the gravitational field strength on earth *g* to be 10 N/kg.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

This question paper consists of **20** printed pages.

Setter: Mr Johnson Tay Vetter: Mrs Neo Peck Hoon

Section A

Answer **all** the questions in this section.

1 A skydiver of mass 76 kg is falling vertically in still air. At time t = 0 s, the skydiver opens his parachute.

Fig. 1.1 is the speed–time graph for the skydiver from t = 0 s.

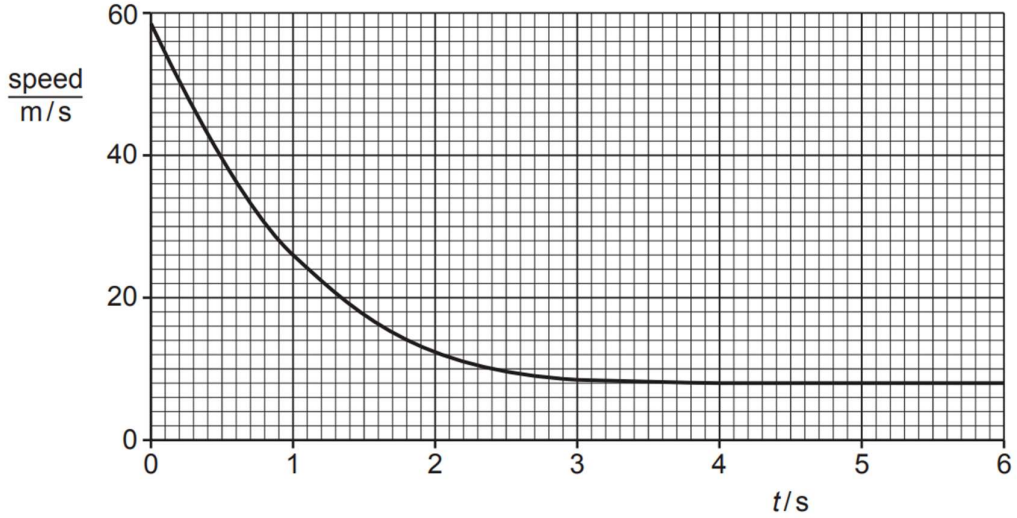

Fig. 1.1

(a) Using Fig. 1.1, determine:

(i) the deceleration of the skydiver immediately after the parachute opens.

deceleration = ...
[2]

(ii) the force due to air resistance acting on the skydiver immediately after the parachute opens.

force = ...
[3]

(b) Explain, in terms of the forces acting on the skydiver, his motion between t = 0 s and t = 6.0 s.

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.....

.....

[3]

2 Pluto is a dwarf planet. Fig. 2.1 shows the direction of motion of Pluto as it follows its elliptical orbit around the Sun.

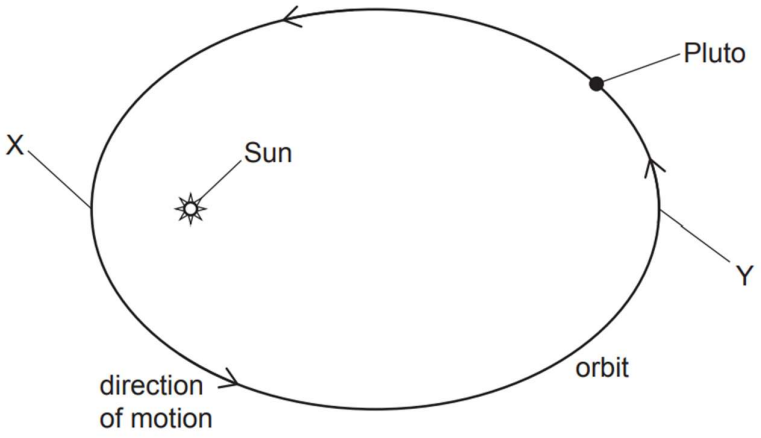

Fig. 2.1

(a) Point X is the point in the orbit closest to the Sun and point Y is the point furthest away. The orbital speed of Pluto varies as it orbits the Sun.

(i) Using ideas of gravitational field strength, explain and describe how the speed of Pluto varies as it moves from X to Y and then back to X.

.....

.....

.....

[2]

(ii) Using principle of conservation of energy and energy transfer, explain why the speed of Pluto varies in this way.

.....

.....

.....

[2]

(b) Pluto has a white surface, as shown in Fig. 2.2. As Pluto rotates, the white surface alternately faces towards and away from the Sun.

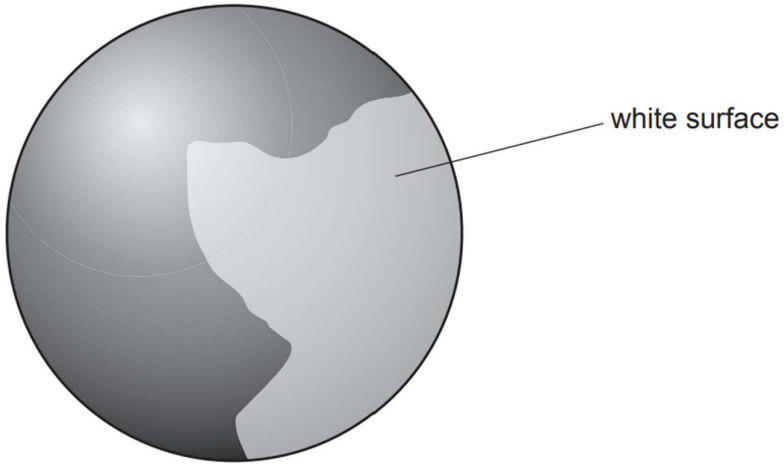

Fig. 2.2

Explain how this affects the temperature of Pluto as it rotates on its own axis.

.....

.....

.....

[2]

3 Fig. 3.1 shows a person moving across an ice-covered pond to reach a ball on the ice.

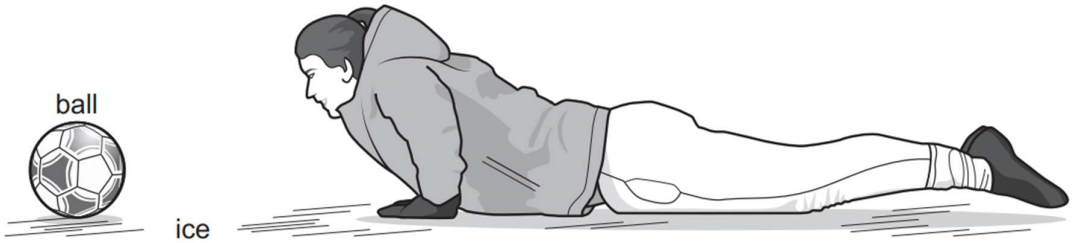

Fig. 3.1

(a) Using concept of pressure, explain why this way of moving across the ice is safer than walking.

.....

.....

.....

.....

.....

[3]

(b) Fig. 3.2 shows a side view of the pond with a layer of ice floating freely on the water.

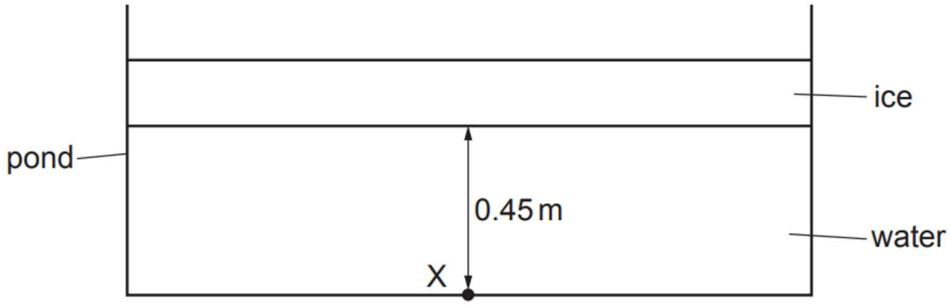

Fig. 3.2

The surface area of the pond is 5.0 m^2.
The mass of the ice is 690 kg.
The density of water is 1000 kg/m^3.
Point X is 0.45 m below the ice.

Calculate the pressure at point X due to only ice and water.

pressure = ...
[3]

4 A student investigates the efficiency of a filament lamp. Fig. 4.1 shows the filament lamp with its glass bulb immersed in water in a beaker.

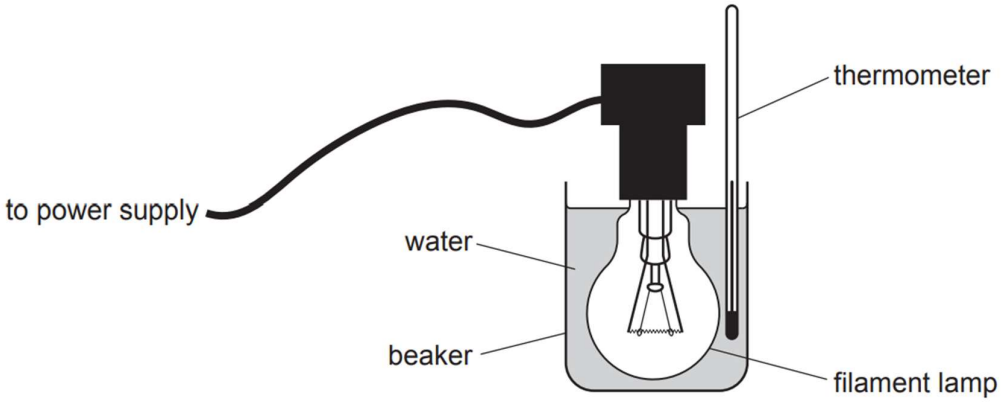

Fig. 4.1

The reading on the thermometer in the water is 19.0°C.

Only the glass of the lamp is in contact with the water and the electrical connections are completely insulated.

The lamp is switched on.

At the end of the experiment, the temperature of the water is 21.5 °C.

(a) The mass of the water in the beaker is 600 g and the specific heat capacity of water is 4200J/(kg°C).

(i) Show that the increase in the internal energy of the water is 6300 J.

[2]

(ii) In the experiment, the lamp is switched on for 500 s. The power supplied to the filament lamp is 13 W. The useful energy from the lamp is transferred as light. The energy that increases the temperature of the water is wasted energy.

Determine the maximum possible efficiency of the filament lamp.

maximum possible efficiency = ……
[3]

(b) The efficiency of the lamp is less than the value determined in **(a)(ii)**.

Suggest one reason for this

……

……
[1]

5 A rain sensor is attached to the glass windscreen of a vehicle to automatically control the windscreen wipers. Fig. 5.1 shows how the infrared light emitted from the LEDs in a rain sensor is received by infrared detectors.

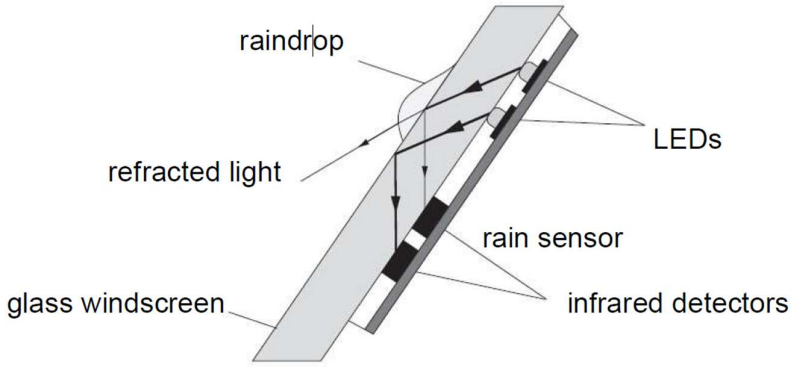

Fig. 5.1

(a) Explain why the infrared detectors are able to receive the infrared light.

.....

.....

.....

.....

[2]

(b) Some of the infrared light is refracted when travelling from the glass windscreen into a raindrop, as shown in Fig. 5.2.

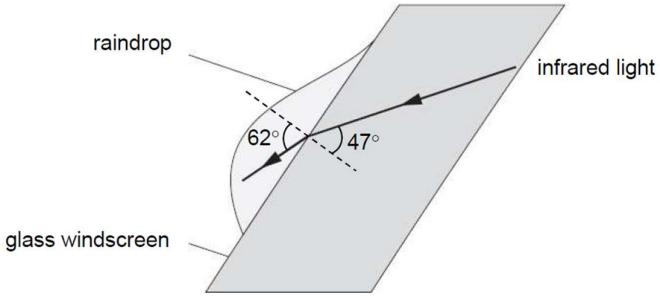

Fig. 5.2.

(i) Using Fig. 5.2, explain whether the raindrop or the windscreen is an optically denser medium.

.....

.....

.....

[1]

(ii) Calculate the refractive index for infrared light travelling from glass windscreen into raindrop.

refractive index = ……
[2]

(c) Explain how the percentage of infrared light received by the detectors can control the speed of the windscreen wipers.

……
……
……
[1]

6 Fig. 6.1 shows a beam of uncharged particles and a beam of gamma wave entering a region of strong electric field below a positively charged plate.

Fig. 6.1

(a) State what is meant by an *electric field*.

……
……
[1]

(b) On Fig. 6.1, draw the two paths below the charged plate for the beam of uncharged particles and the beam of gamma wave.
[2]

(c) Explain the path taken by the beams of uncharged particles and the gamma wave as shown in **(b)**.

……
……
……
……
[2]

7 Fig. 7.1 shows current–potential difference (p.d.) graphs for a resistor, a thermistor and a filament lamp.

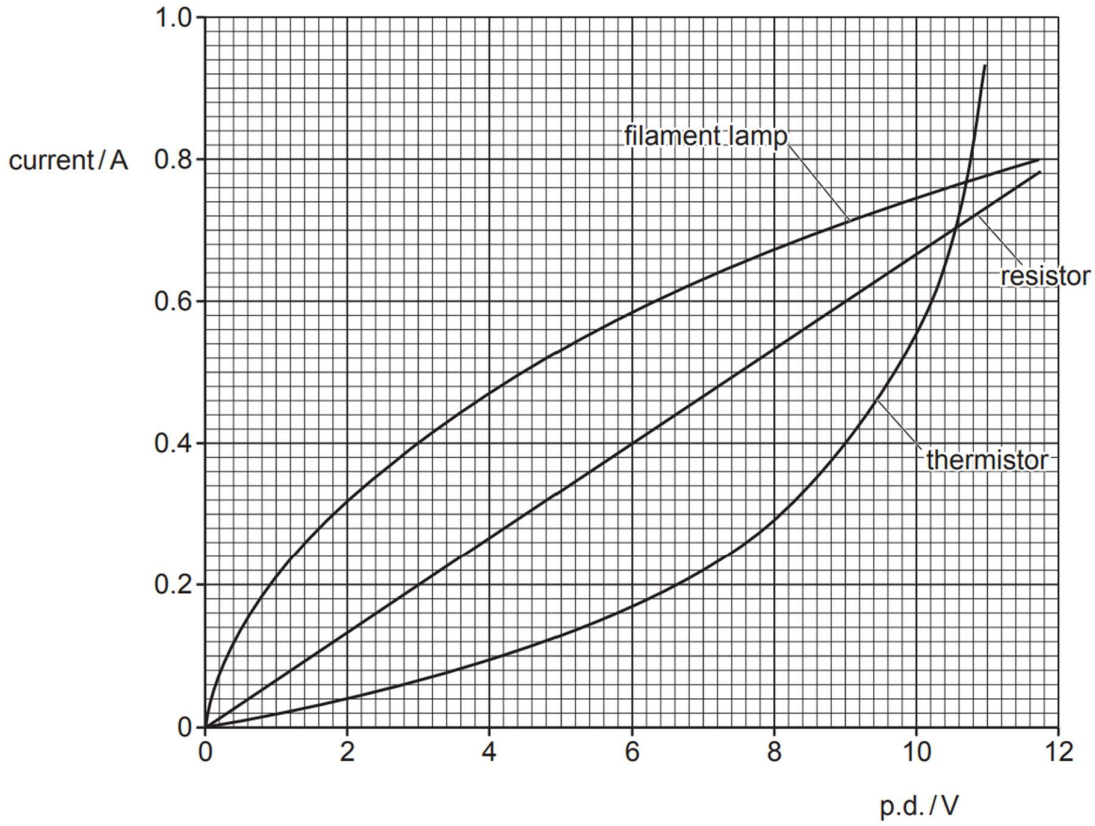

Fig. 7.1

(a) The resistor, the thermistor and the filament lamp are connected in series with a power supply.

(i) Draw a circuit diagram for this circuit.

[2]

(ii) Add a voltmeter to your circuit diagram in **(a)(i)** in a correct position to measure the p.d. across the resistor.

[1]

(iii) Using the graph in Fig. 7.1, determine the p.d. across the terminals of the power supply when the p.d. across the resistor is 6.0 V.

p.d. across the terminals of the power supply = ……

[3]

(b) Describe a practical use for a thermistor.

……

……

[1]

8 Fig. 8.1 shows an electrical circuit containing three resistors. A 50.0 cm long resistance wire of resistance 10 Ω per metre is added across points XY.

A jockey J is placed on the 40.0 cm mark of the resistance wire and the other end is connected to a voltmeter. Switches S_1 and S_2 are used to control the current in the circuit.

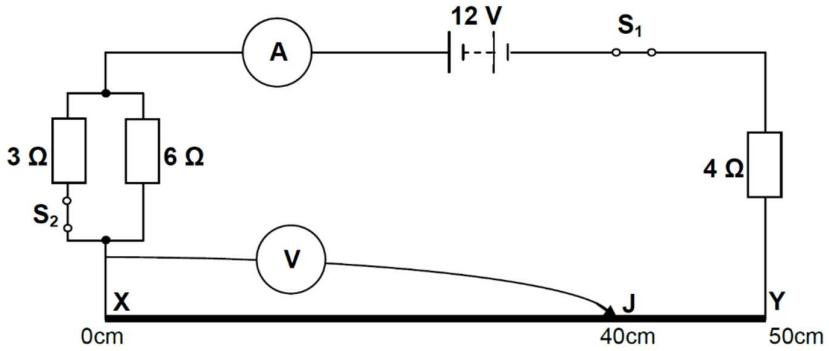

Fig. 8.1

(a) When switch S_1 is open, the ammeter reading is zero.

State the potential difference across switch S_1.

potential difference = ……

[1]

(b) Determine the ammeter and voltmeter readings when S_1 is closed and S_2 is open.

ammeter readings = ……

voltmeter readings = ……

[3]

(c) Without further calculation, state and explain whether there are changes in both meters when switches S_1 and S_2 are closed as compared to **(b)**.

……

……

……

……

[2]

9 Protactinium-234 ($^{234}_{91}\mathrm{Pa}$) is a radioactive isotope of protactinium that decays to uranium-234 ($^{234}_{92}\mathrm{U}$).

(a) Compare the nuclide notation $^{234}_{91}\mathrm{Pa}$ with the nuclide notation $^{234}_{92}\mathrm{U}$ and deduce what this shows about what is emitted from a nucleus of protactinium-234 as it decays to uranium-234.

Place a tick (✓) in the appropriate boxes of Table 9.1 to show what is deduced from comparing the nuclide notations.

Table 9.1

	yes	no	it is not possible to tell
an alpha-particle is emitted			
a beta-particle is emitted			
a gamma ray is emitted			

[2]

(b) A teacher places a radiation detector on a bench in a school laboratory and switches it on.

(i) The teacher measures and records the background radiation count rate.

Describe what is meant by 'background radiation' and state one significant source of the count rate recorded by the teacher.

background radiation……..……

……

source ...……

[2]

(ii) The teacher moves a sample of protactinium-234 so that it is next to the detector.

Suggest one precaution that ensures that the sample is moved in a safe way.

……

……

[1]

(iii) The count rate is measured every 20 s with the sample present, and then corrected for background radiation.

Fig. 9.1 shows a graph of the corrected count rate against time for the protactinium-234 sample.

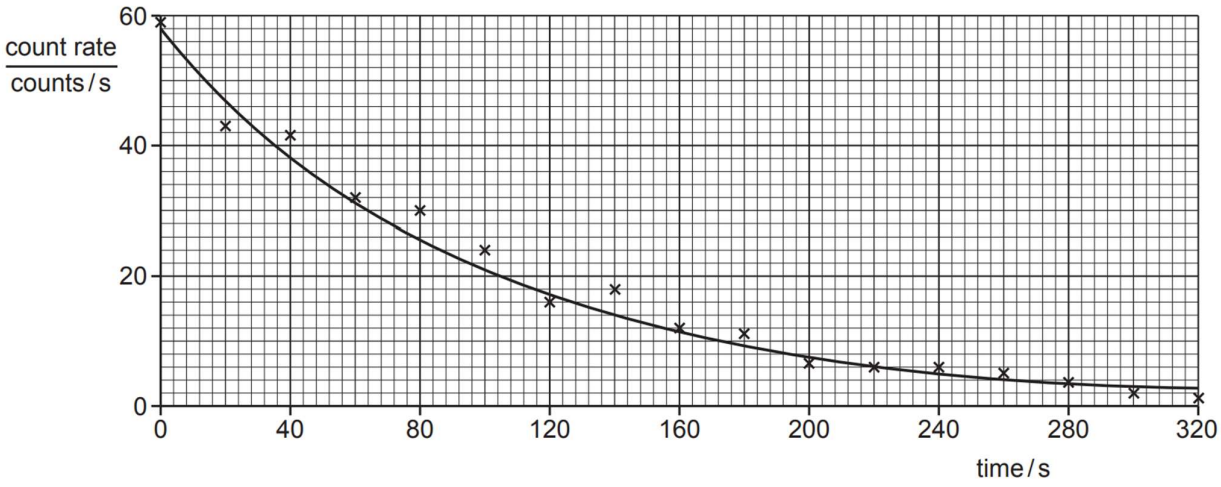

Fig. 9.1

The curve is the best-fit line.

Explain why many of the crosses do not lie on the curve.

……

……

……

[1]

(iv) Using Fig. 9.1, determine the half-life of protactinium-234.

Show your working.

half-life = ……

[2]

(v) The uranium-234 formed from the protactinium-234 is also radioactive. Its half-life is many thousands of years.

Explain why the radiation from uranium-234 does not affect the count rates measured in this experiment.

……

……

……

[2]

10 Fig. 10.1 shows a dual-filament bulb commonly used in cars. It contains two metal filaments made from the same type of metal and have the same length when uncoiled.

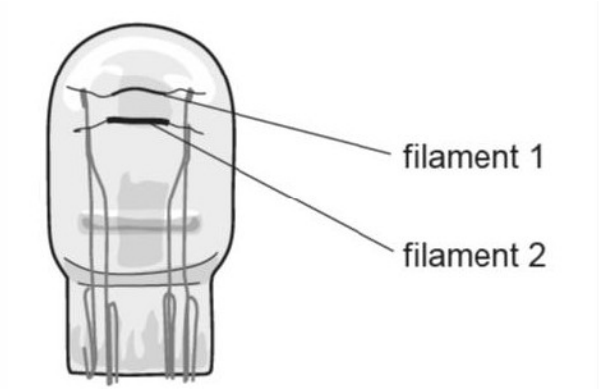

Fig. 10.1

The potential difference (p.d.) across the bulb is slowly increased and the current through each filament at various values of p.d. is measured. Table 10.2 shows the readings obtained.

Table 10.2

	filament 1	filament 2
p.d./ V	current / A	current / A
0	0	0
2.0	0.250	0.925
4.0	0.350	1.400
6.0	0.425	1.650
8.0	0.450	1.825
10.0	0.500	1.925
12.0	0.500	2.000

(a) State and explain, using data from Table 10.2, whether filament 2 obeys Ohm's Law.

……

……

……

[2]

(b) The two filaments are usually connected in parallel to a 12.0 V car battery.

(i) Calculate the total resistance of the two filaments.

total resistance = ……

[2]

(ii) Explain why the current through the filament is different when the p.d. across them are the same.

……

……

……

[2]

(c) The dual-filament bulb is used to provide both tail lighting and brake lighting. The dimmer filament serves as the tail light while the brighter filament serves as the brake light.

State and explain if filament 1 or 2 serves as the tail light.

……

……

……

[2]

(d) The dual-filament bulb is connected in series with a fixed resistor R_F and a battery of e.m.f. 12.0 V. The p.d. across the bulb is 8.0 V.

Fig. 10.3 shows the circuit diagram

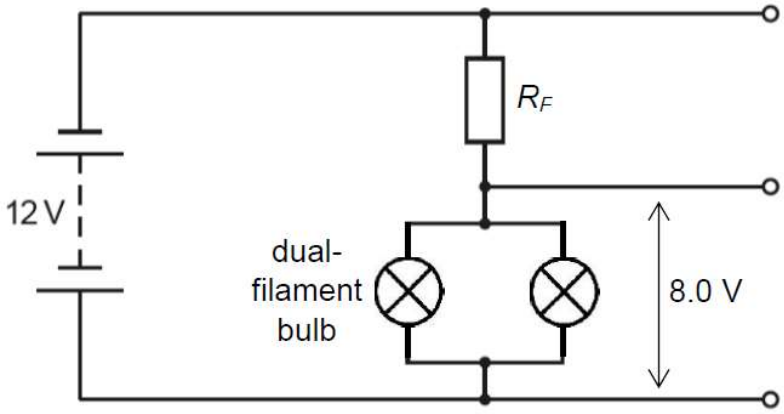

Fig. 10.3

Determine the resistance of the fixed resistor R_F.

resistance of the fixed resistor R_F = ...
[2]

-- END OF SECTION A --

Section B

Answer **one** question from this section.

11 Fig. 11.1 below shows a mobile phone and a wireless charger. The mobile phone can be charged wirelessly by placing it on the charger unit without any metal contacts to connect the phone to the charger.

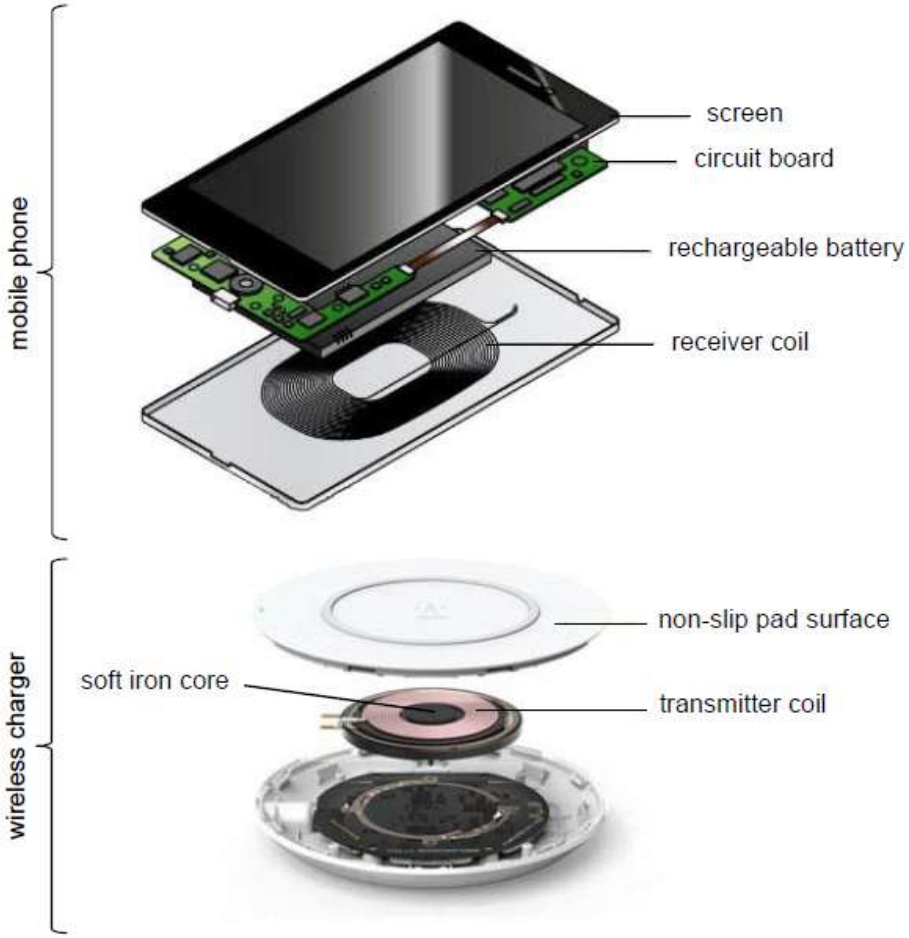

Fig. 11.1

The bottom of the mobile phone contains a receiver coil. The phone contains a rechargeable battery rated at 3.7 V. In the wireless charger, the transmitter coil is connected to the mains a.c. supply.

(a) Explain how the presence of an a.c current in the transmitter coil causes a current to flow in the receiver coil even though they are not in electrical contact.

.....

.....

.....

[3]

(b) Explain how the presence of the soft iron core in the transmitter coil improves the efficiency of charging the battery of the mobile phone.

……

……

[2]

(c) State what type of current is generated at the receiver and hence explain why the current cannot be used to directly charge the rechargeable battery.

……

……

[1]

(d) The mains is rated at 230 V a.c. and the rating of the rechargeable battery in the mobile phone is 3.7 V.

(i) Calculate the ratio of the number of turns in the receiver coil to that in the transmitter coil.

turns ratio = ……

[2]

(ii) The wireless charger is marked “230 V, 12 W”.

If the electricity cost is 24.2 cents per kWh, calculate the cost of using the charger for 2 hours to charge a mobile phone every day in a 30-day month.

cost = ……

[2]

12 Fig. 12.1 is a diagram of a simple d.c. motor.

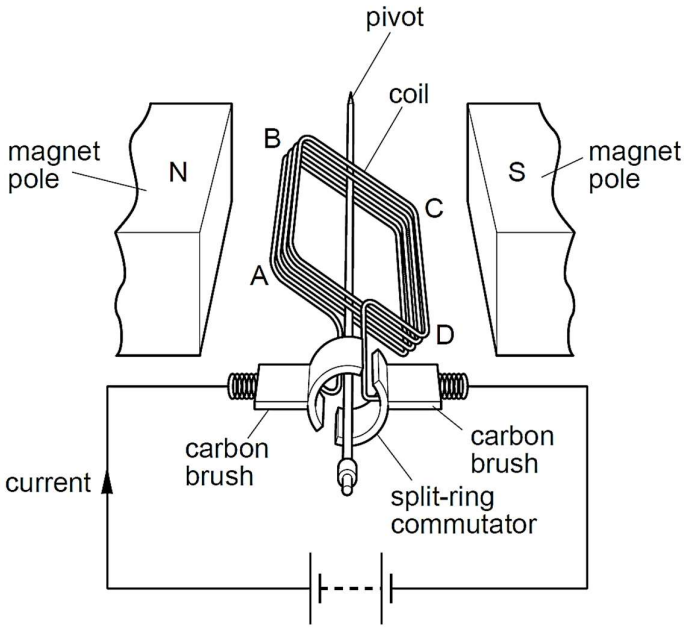

Fig. 12.1

The coil is rotated by vertical forces that act downwards on side AB and upwards on side CD. The current causes a constant force of 3.0 N on each side. The moment created by these forces varies as the coil turns. The moment is a maximum when the coil is horizontal. The distances AD and BC are 0.065 m respectively.

(a) Explain why side AB of the coil experiences a force.

……

……

……

[2]

(b) Explain why the carbon brushes must not be allowed to touch both halves of the split-ring at the same time.

……

……

[1]

(c) Explain what is meant by *moment of a force*.

……

……

[1]

(d) Calculate the value of the maximum moment created on the coil.

moment = ...
[2]

(e) Explain why the moment is a maximum when the coil is horizontal.

.....

.....
[1]

(f) Fig. 12.2 shows how the moment acting on the coil varies with time as the coil rotates at constant speed.

(i) On the time axis, mark with a 'T', the time taken for one revolution of the coil.
[1]

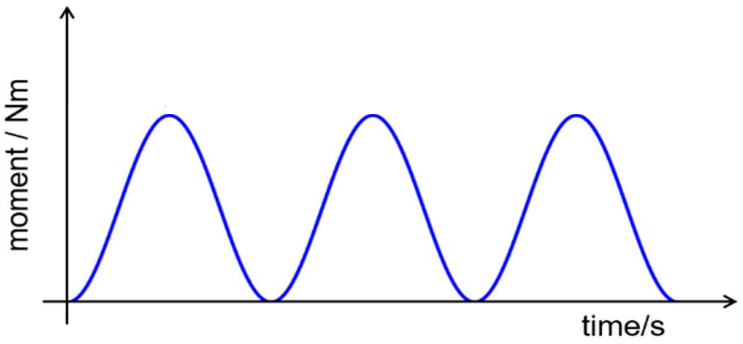

Fig. 12.2

(ii) Suggest why the voltage of the coil does not drop to zero immediately after the battery is removed.

.....

.....

.....
[2]

--END OF SECTION B--
-- END OF PAPER –