Name:.................................... Register/Index Number: .... Class: ....

PRESBYTERIAN HIGH SCHOOL

PHYSICS **6091/2**

Paper 2

28 August 2020 **Friday** **1 hour 45 minutes**

2020 SECONDARY FOUR EXPRESS PRELIMINARY EXAMINATION

INSTRUCTIONS TO CANDIDATES

DO NOT OPEN THIS QUESTION PAPER UNTIL YOU ARE TOLD TO DO SO

Write your class, register number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glues or correction fluid.

Section A
Answer all questions in the spaces provided.

Section B
Answer all **three** questions, the last question is in the form either/or.
Answer all questions in the spaces provided.

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

For Examiner's Use	
Section A	
Section B	
Total	

Setter: Mr Sherman See
Vetted by: Ms Michelle Goh

This document consists of **22** printed pages.

[Turn over

PHS P2+Ans (2)

Section A

Answer all the questions in the spaces provided.

1 Fig. 1.1 shows a modern Formula One car. It is a single-seat and open cockpit race car with substantial front and rear wings, and its engine is positioned behind the driver.

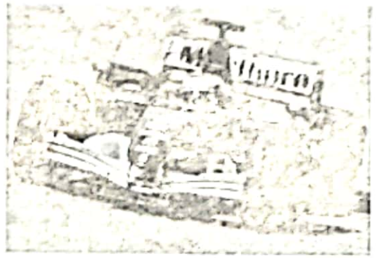


Fig. 1.1

An average F1 car with a mass of 600 kg can decelerate from 100 to 0 km/h in about 17 m.

A Formula One race car is defined as much by its aerodynamics as it is by its powerful engine. That is because any vehicle traveling at high speed must be able to do two things well: reduce air resistance and increase downforce. Airplane wings create lift, but the wings on a Formula One car produce downforce, which holds the car onto the track, especially during cornering.

(a) Find the time needed for the car to come to a complete stop.

time = ...[3]

[Turn over

(b) Calculate the deceleration of the car.

deceleration = ...[2]

(c) Hence calculate the forward force which the driver experiences if the total mass is 680 kg. Assume that frictional force is negligible.

forward force = ...[1]

(d) If the downforce, including the weight of the car, is 25000 N and the total area of contact of four tyres with the ground is 720 cm^2, find the downward pressure.

pressure = ...[2]

(e) State **two** features of the car which makes it stable at high speed.

....

....

.... [2]

2 Fig. 2.1 shows a leisure pursuit called paragliding. A person attached to a parachute is towed over the sea by a tow-rope attached to a motorboat.

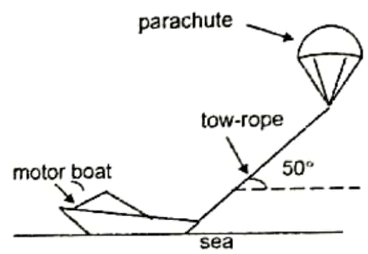


Fig. 2.1

Fig. 2.2 shows the directions of the forces acting on a person of weight 0.70 kN when being towed horizontally at a constant speed of 7.5 m/s. The 1200 N force is the tension in the tow-rope and the force labelled D is the drag force.

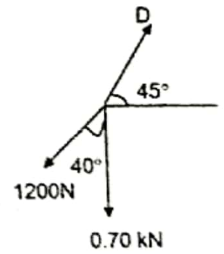


Fig. 2.2 (not to scale)

(a) State why the resultant force on the person must be zero.

....

.... [1]

(b) Using a vector diagram, determine the magnitude of the drag force.

magnitude of drag force = ... [3]

3 Fig. 3.1 shows a mercury barometer on a day when the atmospheric pressure is 750 mmHg. Vessel B has a cross sectional area four times that of the tube A. The difference in mercury levels A and B is shown. Take the density of mercury as 13.6×10^3 kg/m^3 and the density of water as 1.00×10^3 kg/m^3.

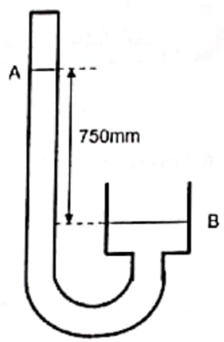


Fig. 3.1

(a) If more mercury is added to B such that the mercury level in B rises by 2.0 cm, what will happen to the mercury level in A?

....

.... [1]

(b) Explain how you arrived at your conclusion.

....

....

.... [2]

(c) If some air is introduced to the space above A, the difference in mercury level of A and B becomes 600mm.

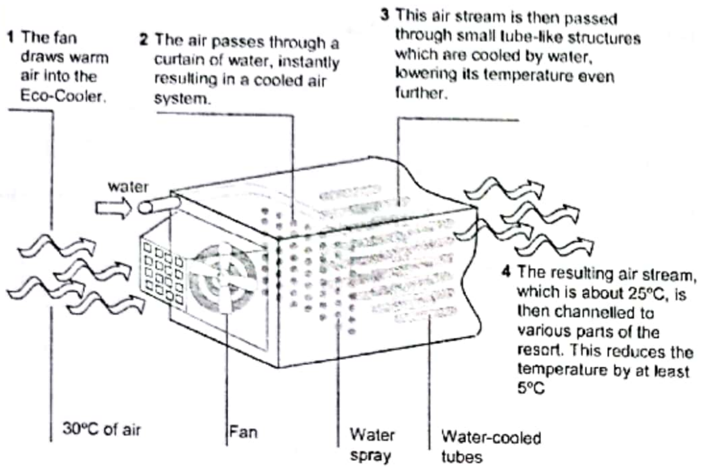
Calculate the pressure of the air in the space in Pa and then express it in terms of mmH_2O.

pressure = ... Pa [2]

pressure = ... mmH_2O [2]

4 Fig. 4.1 shows an article about Eco-Cooler in Resort World Sentosa.

Resort World at Sentosa will be using Eco-Cooler, the world's first environmentally friendly eco-cooling system, to cool outdoor areas within the integrated resort. Here is a look at how the system works.



Source: The Straits Times

Fig. 4.1

(a) Explain why the Eco-Cooler is an environmentally friendly eco-cooling system.

....

.... [1]

(b) The water curtain and the small tube-like structures are at the same temperature.

Explain why the small tube-like structures are able to cool the air to a lower temperature.

....

....

.... [2]

(c) Suggest a suitable material for the small tube-like structures.

.... [1]

[Turn over

(d) The invention of the Eco-Cooler is the result of many experimental trials. In one of the experiments, it was found that the drop in temperature of the air stream after it has passed through the water spray is 3 °C. The rise in temperature of the water spray is 1 °C.

Assuming the rate of flow of air entering the Eco-Cooler is 100 g/s and no thermal energy is lost to the surroundings, find the mass of water required to cool the air in 1 min. Take the specific heat capacity of air as 1.0 J g^{-1} $°C^{-1}$ and the specific heat capacity of water as 4.2 J g^{-1} $°C^{-1}$.

mass of water required = ... [3]

5 In Fig. 5.1, a car becomes electrically charged as it travels along a road.

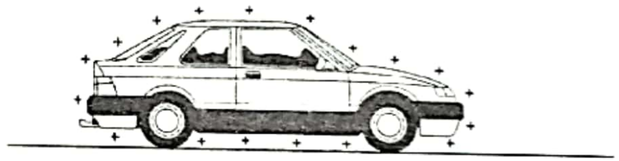


Fig. 5.1

(a) (i) Explain how a moving car becomes electrically charged.

....

.... [1]

(ii) Why does this charge remain on the car after it has stopped moving?

....

.... [1]

[Turn over

(b) Some people prefer to prevent their car from becoming charged. In Fig. 5.2, they do this by fixing a metal strap underneath the car. The metal strap is in contact with the ground as the car moves.

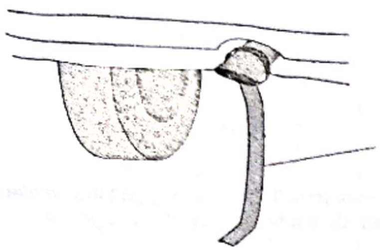


Fig. 5.2

(i) Suggest why it is not safe to have a buildup of electrical charges on a car.

....

.... [1]

(ii) Explain how the metal strap prevents the car in Fig. 5.1 from becoming charged.

....

.... [2]

6 A student constructs a thermometer using an electrical component X. Fig. 6.1 shows the circuit he sets up. The battery has an e.m.f. of 12.0 V.

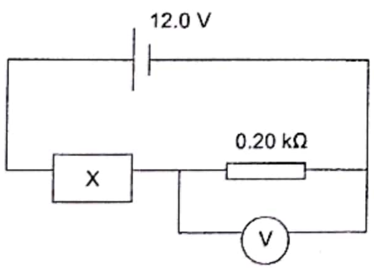


Fig. 6.1

Fig. 6.2 shows a graph of how the resistance of component X varies with temperature.

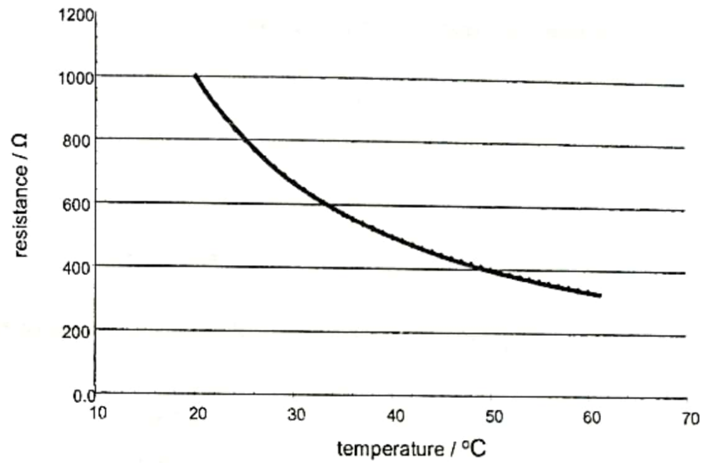


Fig. 6.2

(a) State the name of electrical component X.

.... [1]

(b) The probe can be used to measure temperature ranging from 20 °C to 60 °C.

(i) State the resistance of component X when the probe is measuring 33 °C.

.... [1]

(ii) Hence, calculate the voltmeter reading when the temperature of the probe is 33 °C.

voltmeter reading = ... [2]

(c) The student used the thermometer to measure the temperature of a glass of lemon juice. The voltmeter reading is 2.50 V.

Calculate the temperature of the lemon juice.

temperature = ... [2]

7 Fig. 7.1 shows an electric kettle which is rated at 240 V, 2000 W and connected by a flexible cable to a three-pin plug.

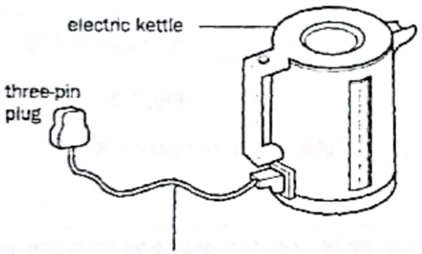


Fig. 7.1

Table 7.1 shows the maximum current which can flow safely through the wire of different diameters.

Table 7.1

diameter of wire / mm	maximum safe current / A
0.50	3.0
0.75	6.0
1.00	10.0
1.25	13.0
1.50	15.0

(a) Calculate the current flowing through the wire when the kettle is being used.

current = ... [2]

(b) (i) Using data from Table 7.1, suggest the smallest diameter of wire that should be used. Give a reason for your suggestion.

....

....

.... [2]

(ii) Explain why using a wire that is much thinner than your answer in **(b)(i)** is dangerous.

....

....

.... [2]

(c) State one possible fault in the cable that causes the fuse in the three-pin plug to melt.

.... [1]

8 Fig. 8.1 shows a diagram of a d.c. motor.

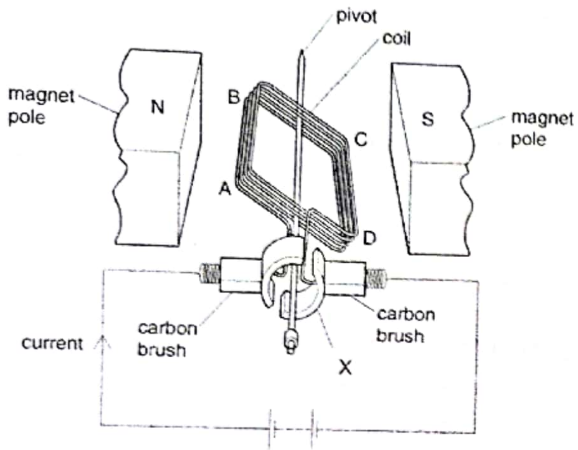


Fig. 8.1

(a) State the direction of movement of side AB and of side CD when the current is in the direction shown.

side AB .... side CD ....

[1]

(b) (i) Name the part which is labelled X.

.... [1]

(ii) Describe the function of part X.

....

.... [2]

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Section B

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

Answer only one of the two alternative questions in **Q11**

9 **(a)** When a spacecraft returns to Earth from space, it must first re-enter the atmosphere. A high speed spacecraft has a very large amount of kinetic energy. As it is slowed down, the kinetic energy is converted into thermal energy. The temperature rise during re-entry is a major problem for spacecraft designers - the astronauts inside must not be cooked!

During the re-entry of the American Mercury capsules, the air outside the capsule reach a temperature of 5260°C and turned orange. The outside of the capsule itself reached a temperature of 1648°C. A special resin, on a fiberglass screen, was attached to the surface. The resin boiled and evaporated during this re-entry journey.

State and explain the function of this special resin coating on the surface of the American Mercury capsules.

....

....

.... [3]

(b) In Fig. 9.1, the Space shuttle uses special silica tiles to protect it. The bottom and the leading edge are covered with glossy black tiles and a black reinforced carbon material covers the nose and wing leading edges.

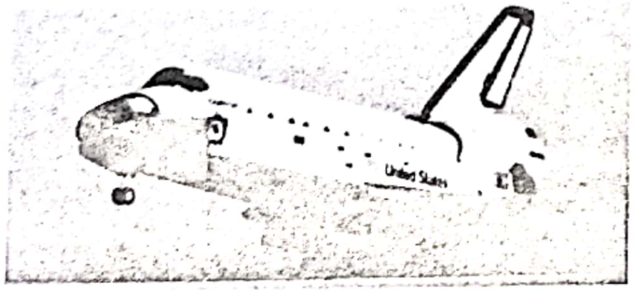


Fig. 9.1

[Turn over

Explain how the following properties of the material used to cover the outer surface of a spacecraft keep the insides of the space shuttle cool.

(i) colour;

....

.... [1]

(ii) specific heat capacity;

....

....

....

.... [2]

(iii) thermal conductivity.

....

.... [1]

(c) During the launch of the NASA space shuttle, the used rocket thruster will be ejected just before the space shuttle exits the atmospheric layer.

An aluminium section of a used rocket thruster has a mass of 1 kg. It returns to Earth at a speed of 5000 m/s. The boiling point of aluminium is 2467 °C.

(i) Assume that all the kinetic energy of the rocket thruster is converted into thermal energy as it enters the atmosphere.

Find the temperature rise of the section given that the specific heat capacity of aluminium is 900 J/(kg°C).

temperature rise = ... [2]

(ii) Explain why it is not likely for such small sections of the rocket thruster to be found on the surface of the Earth.

....

.... [1]

[Turn over

10 A shot putter holds a shot of mass 7.0 kg in the palm of her hand. Her upper arm is vertical and her forearm, of mass 1.5 kg, is horizontal.

Fig. 10.1 shows the forces exerted on the forearm. F_1 is the upward force exerted by the biceps muscle. F_2 is the downward force exerted by the humerus bone.

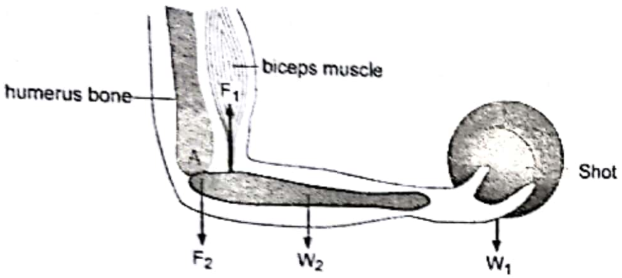


Fig. 10.1

Fig. 10.2 simplifies this.

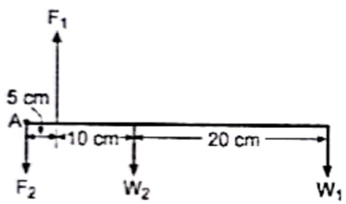


Fig. 10.2

(a) **(i)** Calculate W_1, the weight of the shot.

weight of shot = ... [1]

(ii) In order to lift the shot, describe what her biceps would have to do.

....

.... [1]

[Turn over

(b) Determine the upward force exerted by the biceps when holding the shot in the position shown in Fig. 10.1 and Fig. 10.2.

upward force exerted = ... [2]

(c) Calculate F_2, the force exerted by the humerus bone on the forearm.

F_2 = ... [2]

(d) Next the athlete raises the shot 35 cm to about shoulder height so that her forearm is vertical.

(i) Calculate the increase in potential energy of the shot.

potential energy of the shot = ... [2]

(ii) Suggest and explain whether the work done by the athlete is greater or less than the energy calculated in **(d)(i)**.

....

....

....

.... [2]

[Turn over

11 EITHER

(a) Fig. 11.1 shows part of a ray diagram, drawn to scale.

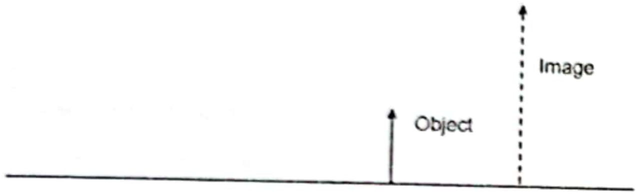


Fig. 11.1

(i) By drawing **two** rays from the object, locate the position of the lens and its principal focus. Label your diagram clearly. [3]

(ii) State an optical device that uses the lens in this arrangement.

.... [1]

(b) Fig. 11.2 shows a light ray travelling from glass to air. The angle of incidence, i, of the light ray is changed several times and the intensity of the respective refracted ray, r, is measured.

In Fig. 11.3, the intensity of the refracted ray is plotted against i.

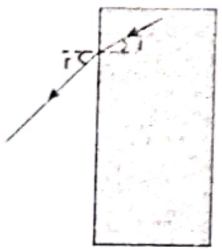


Fig. 11.2

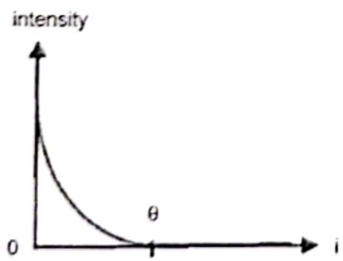


Fig. 11.3

(i) State and explain what happens to the light ray when the angle of incidence, i, is greater than θ.

....

....

.... [2]

(ii) Given that the refractive index of glass is 1.5, calculate θ.

θ = ... [2]

(iii) Fig. 11.4 (not drawn to scale) shows a light ray at an angle of incidence of 50°.

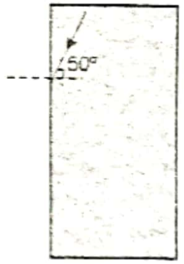


Fig. 11.4

Complete the path of the light ray in Fig. 11.4. [2]

11 OR

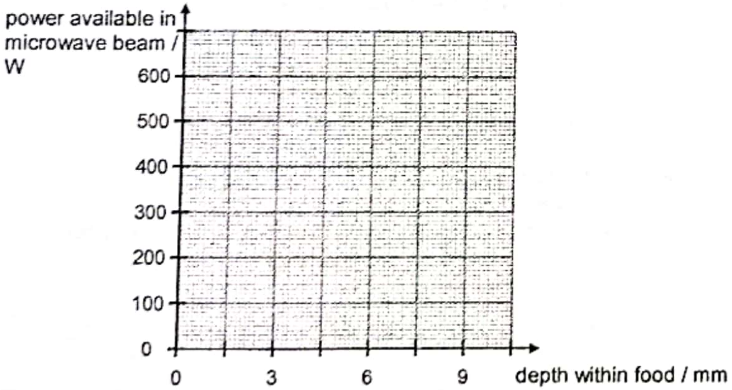
The microwave oven is now commonly used in kitchens to quickly heat up pre-prepared and fresh food. It produces microwave radiation of frequency 2500 MHz that is absorbed by water molecules. The water molecules have charge distributions which are not symmetric and when the electric field in the microwave radiation is incident on them, the water molecules increase in vibration.

The microwaves can only penetrate a short distance inside the food. The typical power in the microwave beam is 600 W. Over each distance of 3 mm, the power available from the microwave decreases by 60%. Thicker food can, however, be cooked in the microwave oven using other processes than the absorption of microwave energy.

(a) Calculate the wavelength of the microwaves used in the microwave oven. The speed of light in air is 3.0×10^8 m/s.

wavelength = ... [2]

(b) Sketch a graph showing how the power available from the microwave varies with depth. Plot points at depths of 0, 3, and 6 mm on grid below.



[2]

(c) Suggest how food thicker than 9 mm is cooked thoroughly in the microwave oven.

....

.... [1]

(d) Explain what is meant by an electric field and how the electric field of the microwave radiation causes a water molecule to vibrate.

....

....

....

.... [2]

(e) The soup is initially at -18 °C and is to be just turned into liquid at 0 °C. The soup can be assumed to be made entirely of water.

Estimate the minimum time it will take a 600 W microwave oven to thaw 0.25 kg of frozen soup.

Take the specific heat capacity of ice as 2100 J/(kg °C) and the specific latent heat of fusion of water as 334 0000 J/kg.

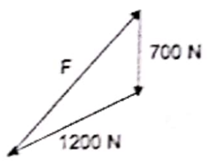
minimum time = ... [3]

END OF PAPER

PRESBYTERIAN HIGH SCHOOL
SCIENCE DEPARTMENT
SUGGESTED ANSWERS

Subject: PHYSICS
Setter: MR SHERMAN SEE
Level: SEC 4 EXPRESS

Exam: PRELIM EXAM PAPER 2
Year: 2020

Qn	Answers	Marks
	SECTION A	
1(a)	100 km/h = 28 m/s ½ x t x 28 = 17 t = 1.21 s	1 1 1
(b)	a = (0 – 28) / 1.21 = -23.1 m/s² deceleration = 23.1 m/s²	1 1
(c)	F = ma = 680 x 23.1 = 15708 N = 15700 N	1
(d)	$P = \frac{F}{A} = \frac{25000}{720}$ = 34.7 N/cm²	1 1
(e)	low centre of gravity broad/large base area	1 1
2(a)	Since the person is being towed at a constant speed, the resultant force must be zero.	1
(b)	Scale  F = 1700N	1 1 1

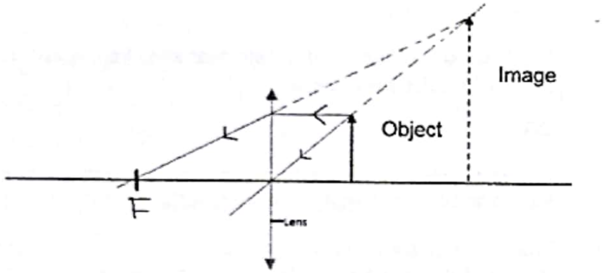
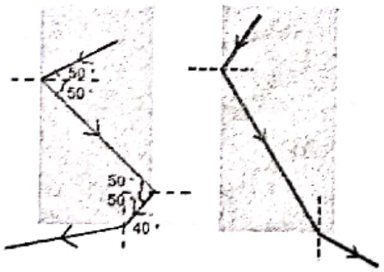
Qn	Answers	Marks
3(a)	The mercury will rise by 2cm	1
(b)	The difference in mercury level gives the atmospheric pressure value. Since the atmospheric value remains the same, the mercury level difference should also remain the same, regardless of cross-sectional area.	1 1
(c)	Pressure of air in space = (750-600) mmHg = 150 mmHg $P = \rho_{mercury} gh$ P=13.6 x 10³ (g) (0.15) P = 20400 Pa $\rho_{mercury} gh = \rho_{water} gh$ 13.6 x 10³ (g) (150) = 1.00 x 10³ (g) h h = 2040mm Pressure of air in space = 2040 mmH_2O	1 1 1 1
4(a)	Any of the one point: • energy efficient / uses very little electricity • does not cause pollution	1
(b)	increases surface area of contact with water thermal energy of air is transferred to water by conduction	1 1
(c)	metal (any metal is acceptable)	1
(d)	Heat gain by water = heat lost by air m_w x 4.2 x 1 = (100 x 60) x 1 x 3 m_w = 4290 g	1 1 1
5(a)(i)	Friction between car and ground / air causes electrons to be lost from car to ground.	1
(a)(ii)	Any of the one point: • Tyres are non-conductors. • Tyres act as insulating material between car and ground.	1
(b)(i)	There will be a risk of spark / fire.	1
(b)(ii)	Metal strap conducts electrons from the ground to the car to neutralise the excess positive charges on the car	1 1
6(a)	thermistor	1
(b)(i)	600 Ω	1

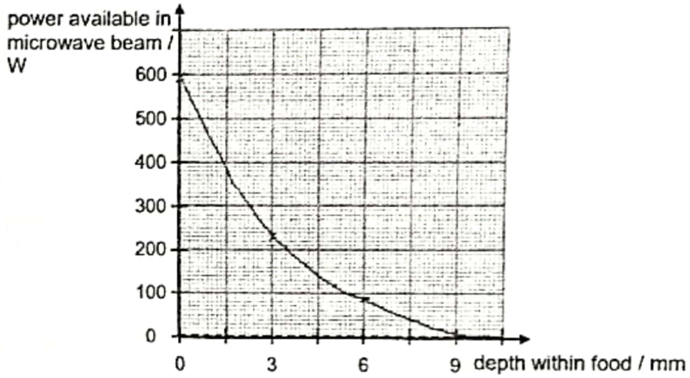
(b)(ii)	V = (12 / 800) x 200 = 3V	1 1
(c)	V = R / (R + X) x 12 V 2.5 V = 200 / (200 + X) x 12 X= 760 Ω 27 °C (accept 26 °C to 28 °C)	1 1
7(a)	P = VI $I = \frac{2000}{240} = 8.3A$	1 1
(b)(i)	1.00 mm Since the maximum safety wire is 10.0 A, current through the kettle of 8.3 A will be able to flow without causing overheating of wires. Wire with diameter 1.00 mm is the best choice.	1 1
(b)(ii)	A thinner wire has a higher resistance. When large current flows through it, it becomes overheated and may burn and cause a fire.	1 1
(c)	When there is short-circuit (the live wire touches the neutral wire), a very high current may flow to cause an overheating of the fuse and melt the fuse wire.	1
8(a)	AB: downwards , CD : upwards	1
(b)(i)	Split rings / commutators	1
(b)(ii)	It changes the direction of current every half a revolution / 180 °. So that it can rotate continuously in one direction.	1 1

[Turn over

SECTION B		
9(a)	The function of the resin is to cool the spacecraft. When the resin evaporates and boils it takes away large amount of heat energy, latent heat of vaporization, from the surface of the aircraft, hence cooling the surface of the aircraft when the surfaces loses this energy.	1 1 1
(b)(i)	A large amount of heat is generated due to friction as the spacecraft moves through the atmospheric layer. The black colour helps to dissipate heat away from space shuttle since black colour is a good radiator. OR The white colour helps to reflect away heat generated externally due to friction since white colour is a good reflector/emitter of radiation.	 1 1
(b)(ii)	The silica tiles should have a very high specific heat capacity so that it requires a very large amount of heat energy to raise the temperature of one unit mass of the silica tiles by 1°C, this will keep the temperature of the surface lower.	1 1
(b)(iii)	The silica tiles is a poor conductor of thermal energy. This helps to insulate the inside of the space shuttle from the extreme temperature.	1
(c)(i)	$\frac{1}{2} mv^2 = mc\Delta\theta$ $\frac{1}{2}$ (1kg)(5000m/s)^2=(1kg)(900J/kg/°C) $\Delta\theta$ $\Delta\theta$= 13 888.89°C = 13900°C	 1 1
(c)(ii)	The rise in temperature is much higher than the boiling point (2467°C) of aluminium. Hence, the aluminium sections would have vaporized into the air.	1
10 (a)(i)	W_1 = 7.0 x 10 = 70 N	1
(a)(ii)	His biceps would have to contract.	1
(b)	Sum of clockwise moments = sum of anticlockwise moments 0.05 x F_1 = 0.15 x W_2 + 0.35 x W_2 0.05 x F_1 = 0.15 × 15 + 0.35 × 70 F_1 = 535 N	 1 1
(c)	Sum of upwards forces = sum of downwards forces $F_2 = F_1 - W_1 - W_2$ F_2 = 535 – 70 – 15 F_2 = 450 N	 1 1

[Turn over

(d)(i)	$\Delta E_p = mgh$ $= 7.0 \times 10 \times 0.35$ $= 24.5$ J	 1 1
(d)(ii)	The work done is greater than 24.5 J Energy is lost as thermal energy and/or friction in the muscles and joints.	1 1
11	EITHER	
(a)(i)		1 mark Light ray to locate lens position 1 mark Light ray to locate focal point 1 mark directions of light rays from object to lens
(a)(ii)	magnifying glass	1
(b)(i)	At θ, the light intensity of the refracted ray is almost zero. This implies no refraction of light captured. This is because the light ray will undergo total internal reflection when the incident angle is greater than θ.	1 1
(b)(ii)	θ is the critical angle. $n = 1/\sin c$ $1.5 = 1/\sin\theta$ $\theta = \sin^{-1}(1/n) = \sin^{-1}(1/1.5) = 41.8°$	 1 1
(b)(iii)		1 mark 2 sets of reflected light rays 1 mark refracted light ray all angles to be labelled except the angle of refraction.

11	OR	
(a)	$v = f\lambda$ $\lambda = 3 \times 10^8 / 2\ 500\ 000\ 000$ $= 0.120$ m	 1 1
(b)		1 mark for correct plotted points 1 mark for smooth curve
(c)	thermal conduction / conduction	1
(d)	An electric field is a region where an electric charge will experience an electric force. Thus, water molecules will vibrate as there are charges around the water molecules / the water molecules are charged as they slide over one another.	1 1
(e)	$Q = mc\Delta\theta + ml_f$ $= 0.25 \times 2100 \times 18 + 0.25 \times 3340000$ $= 92950$ J $T = E/P = 92950 / 600$ $= 155$ s	 1 1 1