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K&U PS

C

NATIONAL QUALIFICATIONS 2012

PHYSICS
STANDARD GRADE
Credit Level

MONDAY, 30 APRIL
10.50 AM – 12.35 PM

3220310 1

3220/31/01

Fill in these boxes and read what is printed below.

Full name of centre | Town

Forename(s) | Surname | Number of seat

Date of birth
Day | Month | Year | Scottish candidate number

Reference may be made to the Physics Data Booklet.

1 All questions should be answered.

2 The questions may be answered in any order but all answers must be written clearly and legibly in this book.

3 Write your answer where indicated by the question or in the space provided after the question.

4 If you change your mind about your answer you may score it out and rewrite it in the space provided at the end of the answer book.

5 If you use the additional space at the end of the answer book for answering any questions, you **must** write the correct question number beside each answer.

6 Before leaving the examination room you must give this book to the Invigilator. If you do not, you may lose all the marks for this paper.

7 Any necessary data will be found in the **data sheet** on page three.

8 Care should be taken to give an appropriate number of significant figures in the final answers to questions.

Use **blue** or **black ink**. Pencil may be used for graphs and diagrams only.

SQA ©

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DATA SHEET

Speed of light in materials

Material	*Speed in* m/s
Air	$3{\cdot}0 \times 10^8$
Carbon dioxide	$3{\cdot}0 \times 10^8$
Diamond	$1{\cdot}2 \times 10^8$
Glass	$2{\cdot}0 \times 10^8$
Glycerol	$2{\cdot}1 \times 10^8$
Water	$2{\cdot}3 \times 10^8$

Speed of sound in materials

Material	*Speed in* m/s
Aluminium	5200
Air	340
Bone	4100
Carbon dioxide	270
Glycerol	1900
Muscle	1600
Steel	5200
Tissue	1500
Water	1500

Gravitational field strengths

	Gravitational field strength on the surface in N/kg
Earth	10
Jupiter	26
Mars	4
Mercury	4
Moon	1·6
Neptune	12
Saturn	11
Sun	270
Venus	9

Specific heat capacity of materials

Material	*Specific heat capacity in* J/kg °C
Alcohol	2350
Aluminium	902
Copper	386
Glass	500
Glycerol	2400
Ice	2100
Lead	128
Silica	1033
Water	4180

Specific latent heat of fusion of materials

Material	*Specific latent heat of fusion in* J/kg
Alcohol	$0{\cdot}99 \times 10^5$
Aluminium	$3{\cdot}95 \times 10^5$
Carbon dioxide	$1{\cdot}80 \times 10^5$
Copper	$2{\cdot}05 \times 10^5$
Glycerol	$1{\cdot}81 \times 10^5$
Lead	$0{\cdot}25 \times 10^5$
Water	$3{\cdot}34 \times 10^5$

Melting and boiling points of materials

Material	*Melting point in* °C	*Boiling point in* °C
Alcohol	–98	65
Aluminium	660	2470
Copper	1077	2567
Glycerol	18	290
Lead	328	1737
Turpentine	–10	156

Specific latent heat of vaporisation of materials

Material	*Specific latent heat of vaporisation in* J/kg
Alcohol	$11{\cdot}2 \times 10^5$
Carbon dioxide	$3{\cdot}77 \times 10^5$
Glycerol	$8{\cdot}30 \times 10^5$
Turpentine	$2{\cdot}90 \times 10^5$
Water	$22{\cdot}6 \times 10^5$

SI Prefixes and Multiplication Factors

Prefix	*Symbol*	*Factor*
giga	G	$1\,000\,000\,000 = 10^9$
mega	M	$1\,000\,000 = 10^6$
kilo	k	$1000 = 10^3$
milli	m	$0{\cdot}001 = 10^{-3}$
micro	μ	$0{\cdot}000\,001 = 10^{-6}$
nano	n	$0{\cdot}000\,000\,001 = 10^{-9}$

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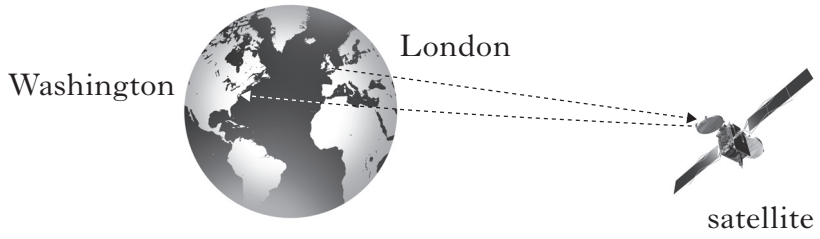
1. This summer the Olympic Games will be held in London.

Television pictures of the Games will be transmitted from London to Washington via a satellite, which is in a geostationary orbit.

Television signals are transmitted using microwaves.

The diagram shows the signals being transmitted from London to the satellite. This satellite transmits these signals to a ground station in Washington.



(*a*) State what is meant by a geostationary orbit.

.....

.....

..... **1**

(*b*) The frequency of the microwaves being used for transmission is 12 GHz.

(i) What is the speed of microwaves?

..... **1**

(ii) Calculate the wavelength of these microwaves.

Space for working and answer

2

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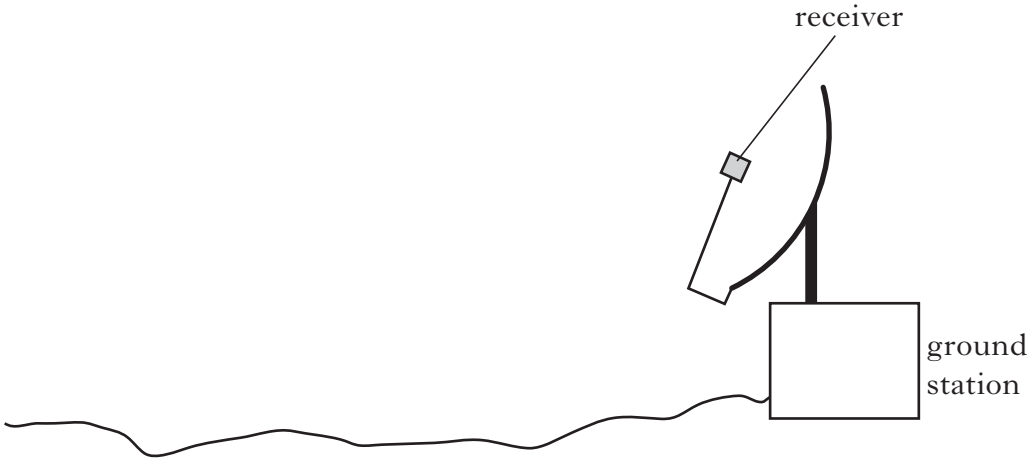
1. (continued)

(*c*) At the ground station the signals from the satellite are received by a curved reflector.

(i) Complete the diagram to show the effect of this curved reflector on the received signal.



2

(ii) Explain why the curved reflector at the ground station should be as large as possible.

.....

1

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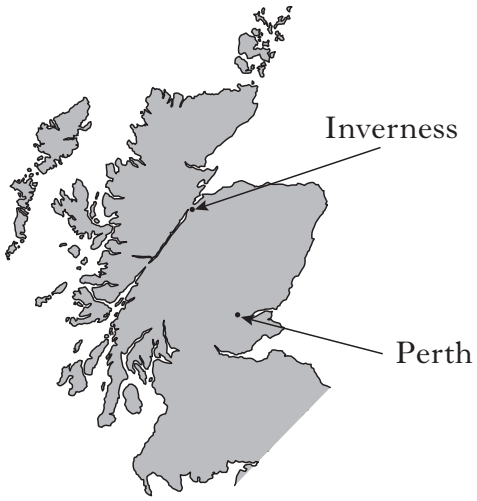
2. At an outdoor music festival in Perthshire, a member of the audience is standing 200 m in front of the main stage loudspeakers listening to a band performing.

The festival is also being broadcast live on radio.

A person in Inverness is listening to the broadcast on the radio.



(*a*) Explain why this person hears the performance before the member of the audience.

.....

1

2. (continued)

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(*b*) Drivers in two cars, A and B, are listening to the performance on the radio.

The performance is being broadcast on two different wavebands, from the same transmitter.

The radio in car A is tuned to an AM signal of frequency 1152 kHz.

The radio in car B is tuned to an FM signal of frequency 102·5 MHz.

Both cars drive into a valley surrounded by hills.

The radio in car B loses the signal from the broadcast.

Explain why this signal is lost.

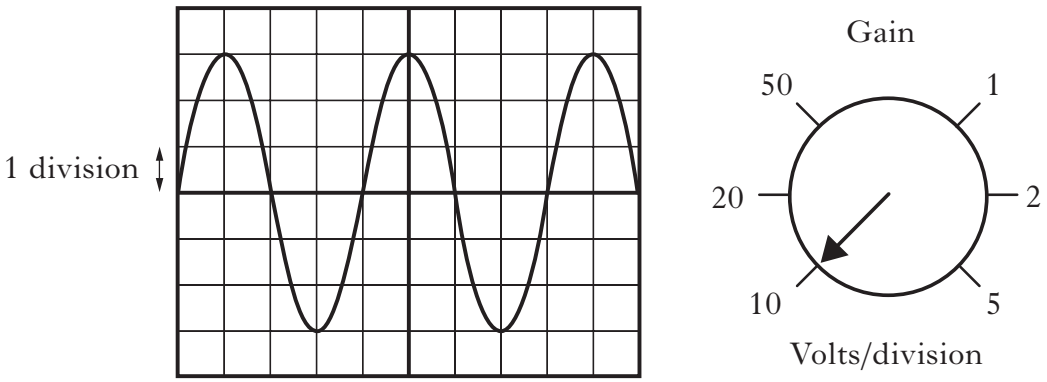
.....

.....

2

(*c*) A stage technician at the festival monitors the output voltage from one of the loudspeakers on an oscilloscope.

The oscilloscope trace and gain setting are shown.



Calculate the peak value of the output voltage.

Space for working and answer

2

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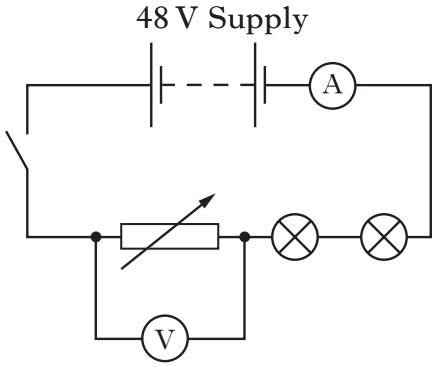
3. A student sets up a circuit to operate two identical 12 V, 36 W lamps from a 48 V supply.



(*a*) When the switch is closed, the lamps operate at their correct power rating.

Calculate:

(i) the reading on the ammeter;

Space for working and answer

2

(ii) the reading on the voltmeter;

Space for working and answer

1

(iii) the resistance of the variable resistor.

Space for working and answer

2

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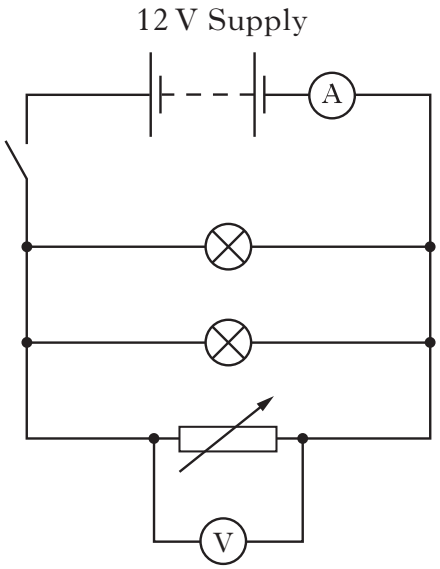
3. (continued)

(*b*) The student sets up a second circuit using a 12 V supply and the same lamps. Each lamp has a resistance of 4 Ω. The resistance of the variable resistor is set to 6 Ω.



(i) Calculate the total resistance of this circuit.

Space for working and answer

2

(ii) The variable resistor is now removed from the circuit.

(A) What happens to the reading on the ammeter?

.....

1

(B) Justify your answer.

.....

1

[Turn over

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4. A toy helicopter is operated using an infrared signal from a remote control. The helicopter has a receiver that can detect infrared radiation.

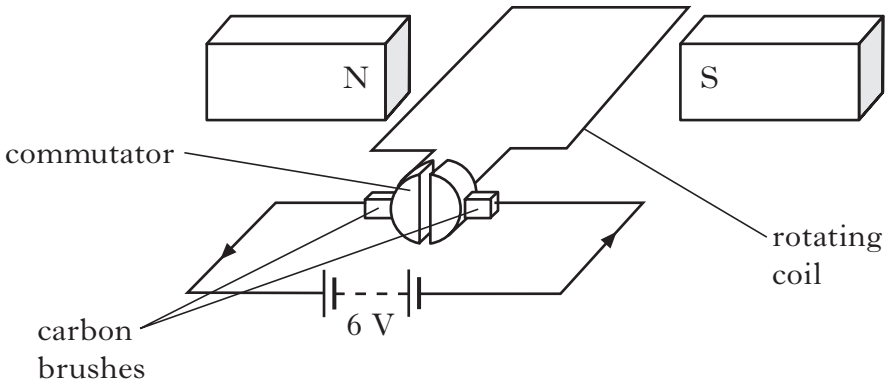
(*a*) State a suitable detector of infrared radiation.

.....

1

(*b*) The helicopter contains two d.c. electric motors.

A simple electric motor is shown below.



(i) What is the purpose of the brushes in a simple electric motor?

.....

1

(ii) State **two** ways in which the direction of rotation of the motor could be reversed.

.....

.....

1

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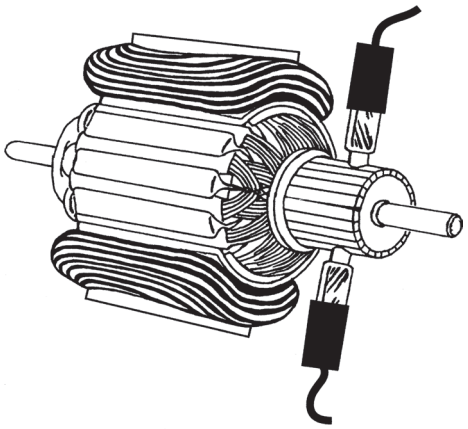
4. (*b*) (continued)

(iii) The helicopter uses commercial electric motors.

A commercial electric motor is shown below.



(A) State **one** difference between a simple d.c. motor and a commercial motor.

.....

1

(B) Explain the reason for this difference.

.....

1

[Turn over

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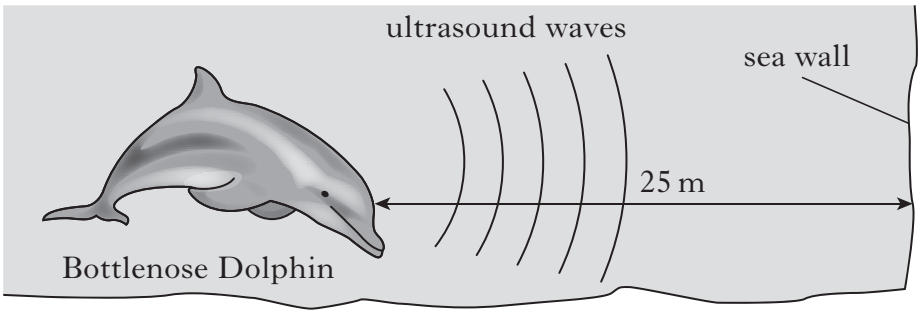
5. Bottlenose dolphins produce sounds in the frequency range 200 Hz – 150 kHz.

Echolocation is the location of objects by using reflected sound. Bottlenose dolphins use ultrasounds for echolocation.

not to scale



(*a*) State what is meant by ultrasound.

.....

1

(*b*) A sound of frequency 120 kHz is transmitted through the water by a bottlenose dolphin.

(i) Use the data sheet to find the speed of sound waves in water.

.....

1

(ii) When the dolphin is 25 m from the sea wall, it emits a pulse of ultrasound.

Calculate the time taken for this pulse to return to the dolphin.

Space for working and answer

3

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5. (*b*) (continued)

(iii) The dolphin changes the frequency of sound it produces to 100 kHz.

(A) What effect will this have on the time taken for the pulse to travel the 25 m?

..... **1**

(B) Explain your answer.

..... **1**

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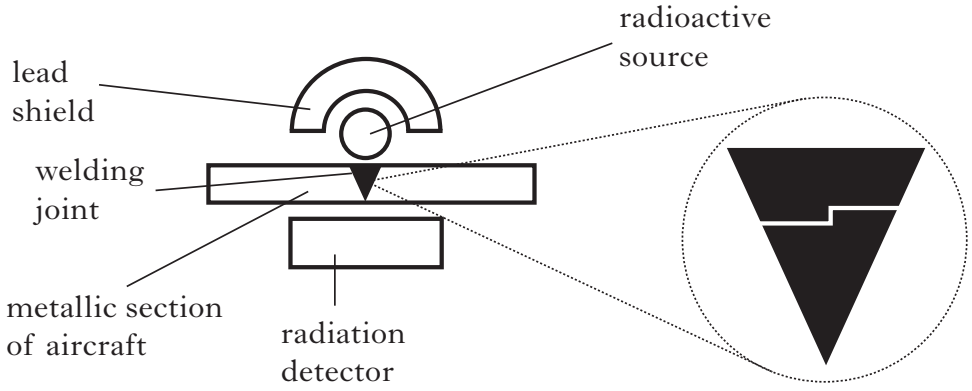
6. Aircraft welding joints must be checked regularly for cracks and other faults.

A radioactive source can be used to carry out these checks.



The radiation detector monitors the amount of radiation passing through the section of the aircraft being checked.

(*a*) Explain how a crack in the section of the aircraft would be detected.

.....

.....

1

(*b*) The aircraft has to be checked regularly.

These checks take 24 hours to complete.

The following radioactive sources are available.

Source	*Half-Life*	*Radiation Emitted*
W	20 years	Alpha
X	15 hours	Beta
Y	30 years	Gamma
Z	3 hours	Gamma

(i) State what is meant by the term *half-life*.

.....

.....

1

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6. (*b*) (continued)

(ii) Explain which source would be most suitable for the purpose of detecting cracks in the aircraft.

.....

.....

2

(*c*) The lead shield is used as a safety precaution to prevent workers being exposed to a large dose of radiation.

State **one** other safety precaution that is necessary when working with radioactive sources.

.....

1

(*d*) A different radioactive source has a half life of 12 hours.

The source has an initial activity of 128 MBq.

Calculate its activity after 2 days.

Space for working and answer

2

[Turn over

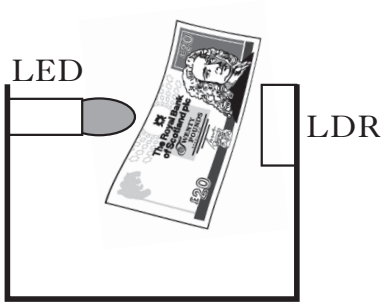
7. A bank has an alarm system which can be triggered by the cashiers who work behind the counter.

The alarm can be triggered by two methods.

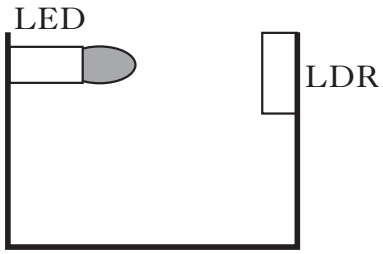
Method 1 – The cashier presses a foot switch.

Method 2 – The cashier removes an imitation £20 note from a cash drawer.

A circuit, inside the cash drawer, contains an LED which is directed at an LDR as shown. When the cashier removes the imitation £20 note the alarm is triggered.



Imitation note present



Imitation note removed

The table shows the resistance of the LDR in different light conditions.

Imitation £20 note	*Resistance* (kΩ)
present	24
removed	2

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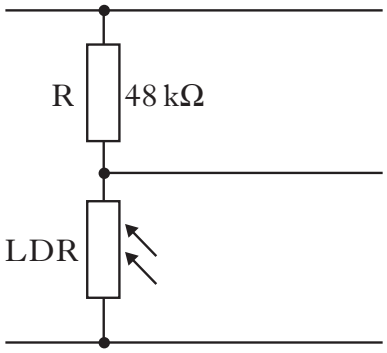
7. (continued)

Part of the cash drawer circuit is shown below.



(*a*) When the imitation £20 note is removed from the drawer, the voltage across the LDR is 0·36 V.

Calculate the voltage across R.

Space for working and answer

2

[Turn over

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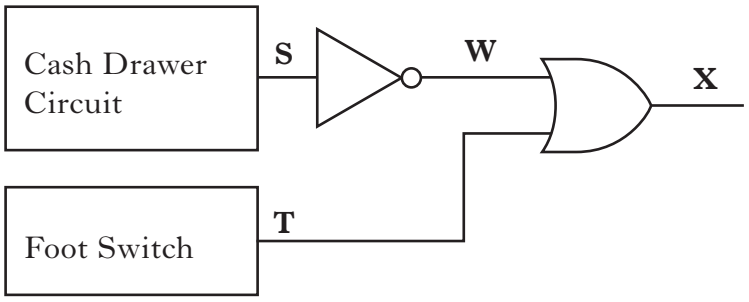
K&U	PS

7. (continued)

(*b*) Part of the control system for the alarm is shown below.



When the imitation £20 note is removed, the logic level at **S** changes from logic **1** to logic **0**.

When the foot switch is pressed, the logic level at **T** changes from logic **0** to logic **1**.

(i) Complete the truth table for the logic levels **W** and **X**.

Cash Drawer Circuit	Foot Switch	W	X
Imitation £20 Removed	Not Pressed		
Imitation £20 Removed	Pressed		
Imitation £20 Present	Not Pressed		
Imitation £20 Present	Pressed		

2

(ii) What effect does removing the NOT gate from the control system have on the operation of the alarm?

.....

1

7. (*b*) (continued)

Marks

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(iii) The alarm has a loudspeaker as an output device, which emits a sound when the alarm is triggered.

The loudspeaker has a resistance of 48 Ω and a power of 3·0 W.

Calculate the voltage across the loudspeaker when it sounds.

Space for working and answer

2

[Turn over

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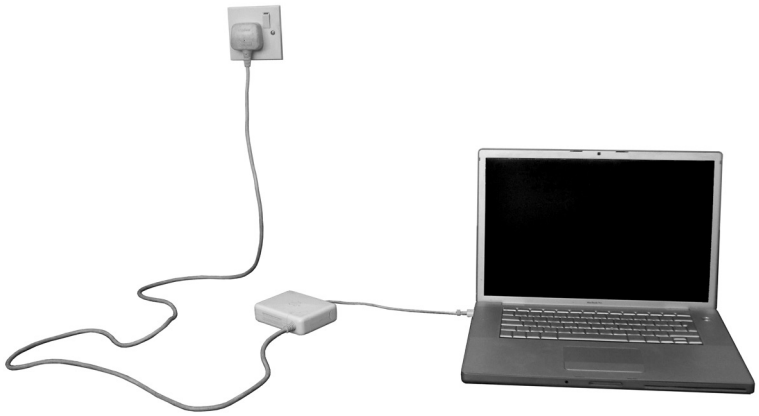
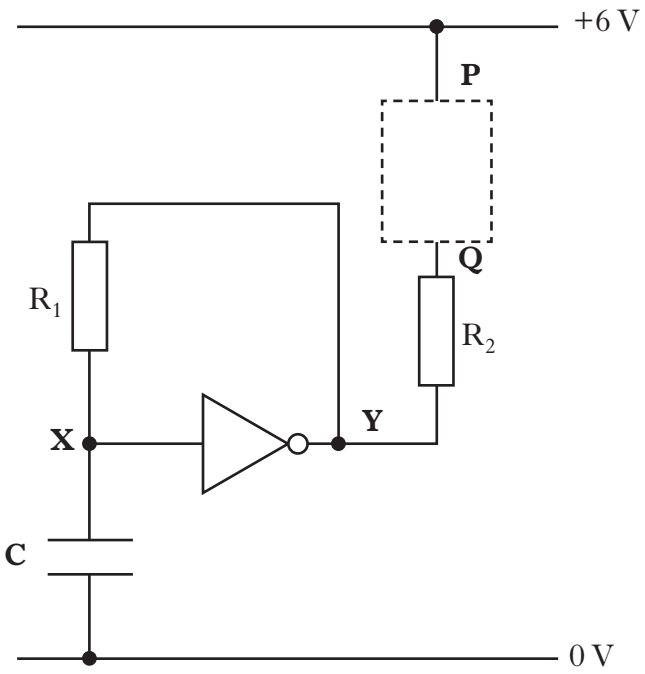
8. A laptop is plugged into the mains to charge. A blue LED flashes to indicate that the laptop is charging.



The LED is connected to a pulse generator.

The circuit diagram for the pulse generator is shown.



(*a*) (i) Complete the diagram to show the LED correctly connected between **P** and **Q**. **1**

(ii) State the purpose of resistor R_2 connected in series with the LED.

..... **1**

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Marks

8. (*a*) (continued)

(iii) When lit, the current in the LED is 15 mA and the voltage across it is 1·2 V.

Calculate the value of resistor R_2 in series with the LED.

Space for working and answer

3

(*b*) Capacitor **C** is initially uncharged.

Explain how the series of flashes is produced by referring to points **X** and **Y** in the circuit.

.....

.....

.....

.....

2

(*c*) The pulse generator produces an output of 5 pulses per second.

State **one** change that could be made to the circuit to produce an output of lower frequency.

.....

1

[Turn over

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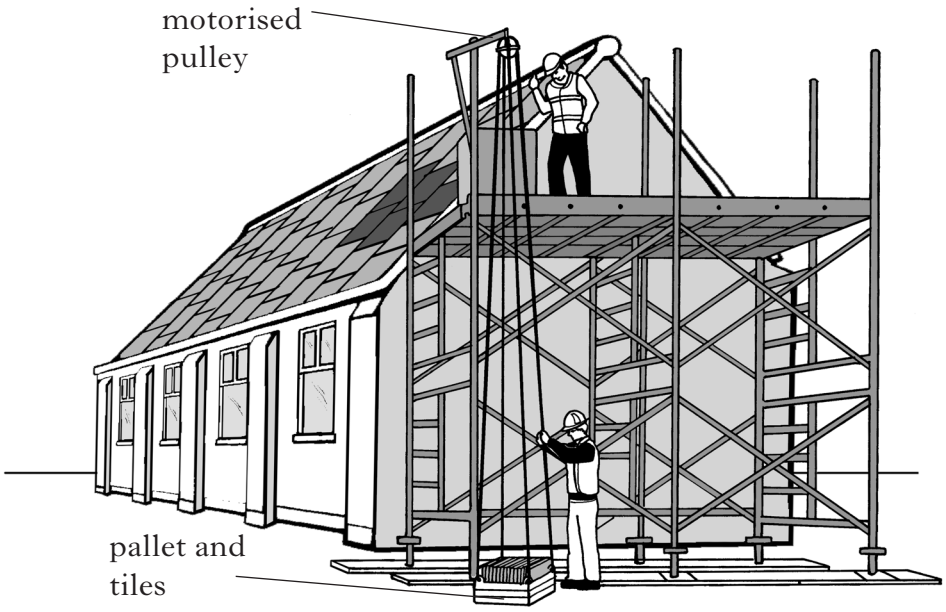
9. While repairing a school roof, workmen lift a pallet of tiles from the ground to the top of the scaffolding.

This job is carried out using a motorised pulley system.

The pallet and tiles have a total mass of 230 kg.



(*a*) Calculate the weight of the pallet and tiles.

Space for working and answer

2

(*b*) State the minimum force required to lift the pallet and tiles.

.....

1

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9. (continued)

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(*c*) The pallet and tiles are lifted to a height of 12 m.

Calculate the gravitational potential energy gained by the pallet and tiles.

Space for working and answer

2

(*d*) When the tiles are being unloaded onto the scaffolding, at a height of 12 m, one tile falls.

The tile has a mass of 2·5 kg.

(i) Calculate the final speed of the tile just before it hits the ground. Assume the tile falls from rest.

Space for working and answer

3

(ii) Explain why the actual speed is less than the speed calculated in (*d*)(i).

.....

1

DO NOT WRITE IN THIS MARGIN

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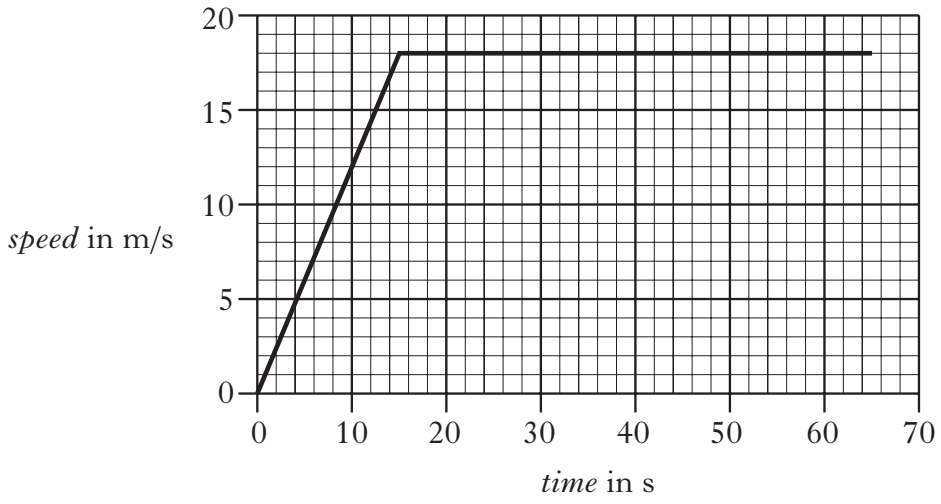
10. A competitor takes part in a speed cycling event.

The cyclist takes 65 s to complete the race.

The graph below shows how the cyclist's speed changes with time during the race.



(*a*) Calculate the acceleration of the cyclist during the first 15 s of the race.

Space for working and answer

2

(*b*) Calculate the distance travelled by the cyclist during the race.

Space for working and answer

2

10. (continued)

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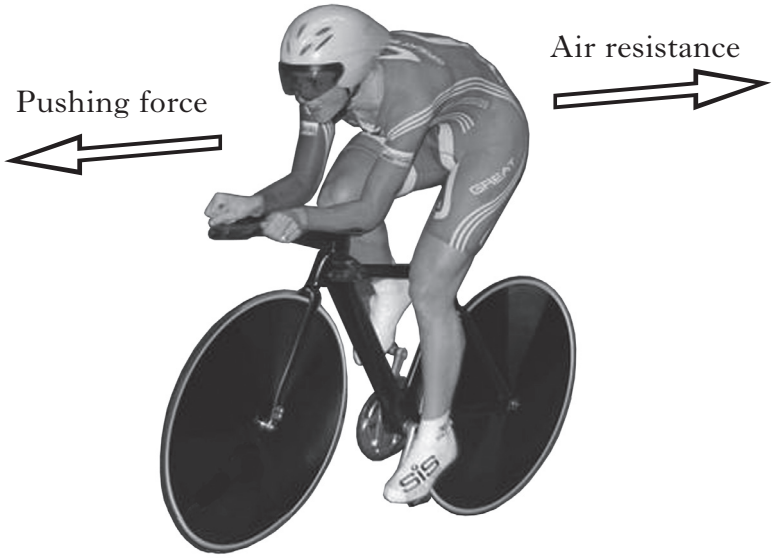
(*c*) The diagram shows some of the forces acting on the cyclist during the race.



(i) Suggest **one** way in which the cyclist reduces air resistance.

.....

1

(ii) Suggest **one** place where the cyclist requires friction.

.....

1

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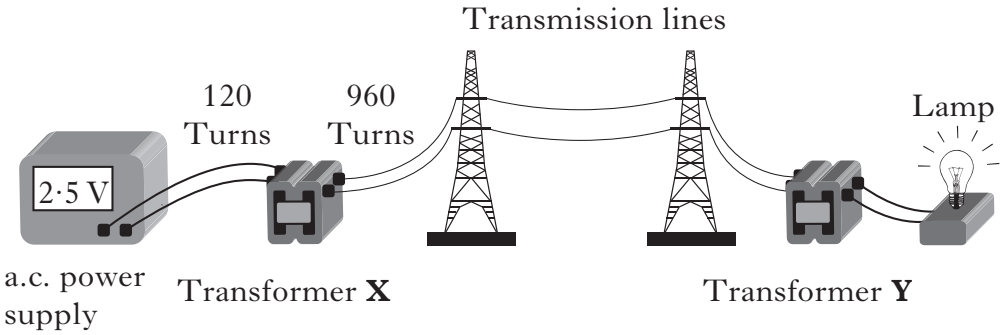
11. Model power transmission lines are set up to demonstrate how electricity is distributed from a power station to consumers.



(*a*) State the purpose of transformer **X**.

.....

1

(*b*) For safety reasons, in this model, the voltage in the transmission lines must not exceed 25 V.

Show that the transmission voltage is within this limit.

Space for working and answer

2

(*c*) The current in the transmission lines is 200 mA.

The transmission lines have a total resistance of 20 Ω.

Calculate the total power loss in these transmission lines.

Space for working and answer

2

[Turn over for Question 12 on *Page twenty-eight*

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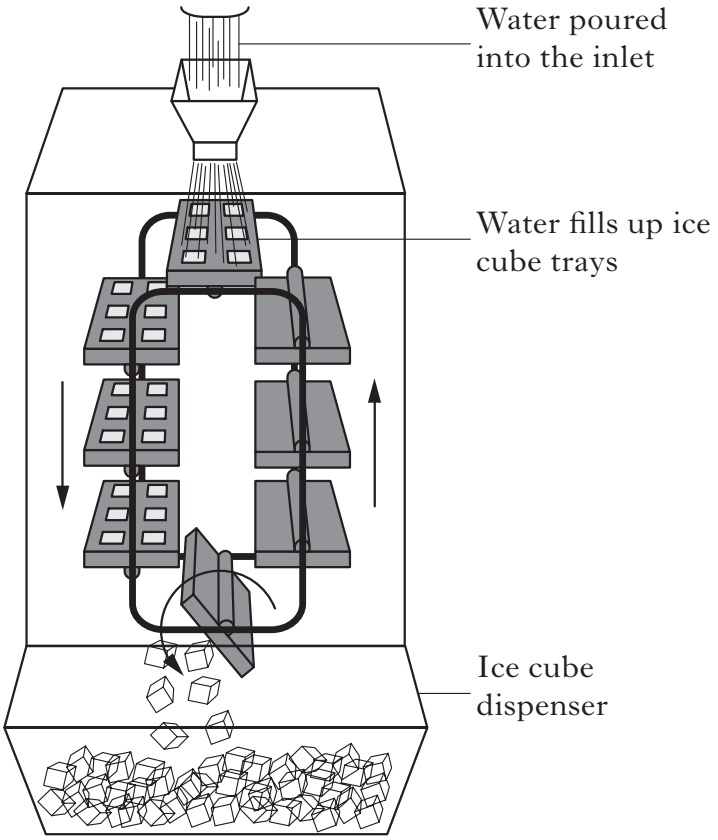
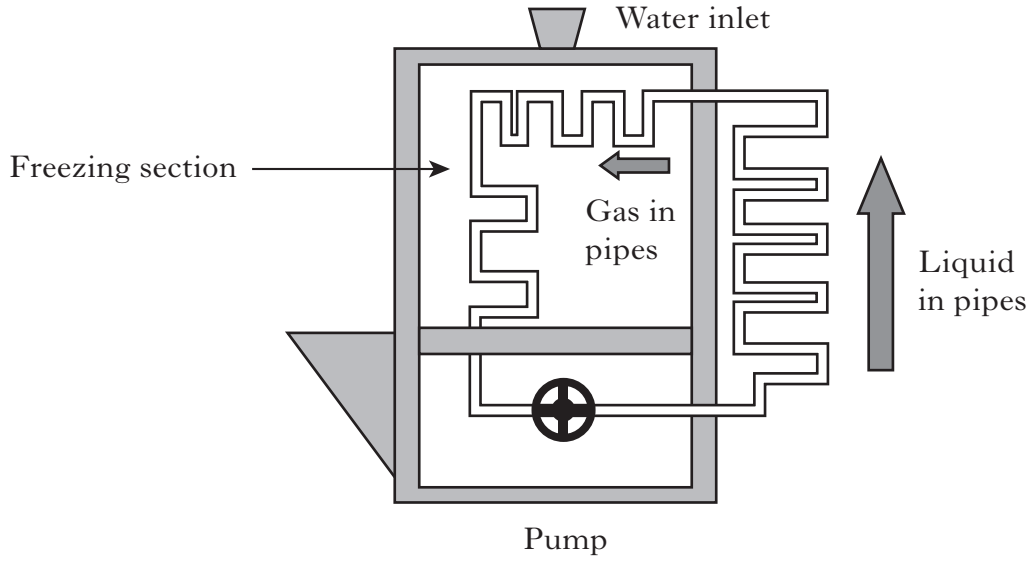
12. A restaurant has an ice-making machine.

Water is poured into ice trays through an inlet at the top of the machine.

The trays rotate inside the machine towards a dispenser where they are tipped and ice cubes fall out into the dispenser.



A simplified diagram of the machine showing the freezing operation is shown.



12. (continued)

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A substance called a coolant is circulated in the pipes by the pump.

(*a*) (i) What is the change in state of the **coolant** in the freezing section?

.....

1

(ii) Explain why this change in state of the coolant keeps the freezing section cold.

.....

.....

1

(*b*) When water is poured in at the top of the machine it fills up ice cube trays. The water is cooled to 0 °C and then freezes.

In 1 hour, 1·5 kg of water at 0 °C turns into ice.

Calculate how much heat energy is given out by the water when it freezes.

Space for working and answer

3

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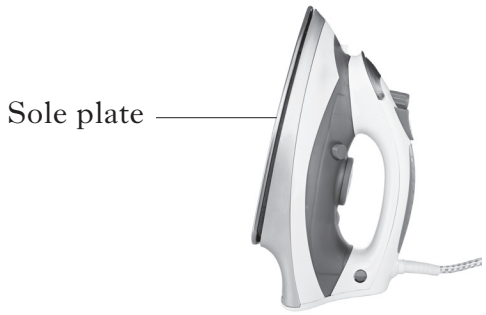
13. A manufacturer has developed an iron with an aluminium sole plate. A technician has been asked to test the iron.



The technician obtains the following data for one setting of the iron.

Starting temperature of sole plate:	24 °C
Operating temperature of the sole plate:	200 °C
Time for iron to reach the operating temperature:	35 s
Power rating of the iron:	1·5 kW
Operating voltage:	230 V
Specific Heat Capacity of Aluminium:	902 J/kg °C

(*a*) Calculate how much electrical energy is supplied to the iron in this time.

Space for working and answer

2

(*b*) Calculate the mass of the aluminium sole plate.

Space for working and answer

2

13. (continued)

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(*c*) The actual mass of the aluminium sole plate is less than the value calculated in part (*b*) using the technician's data.

Give **one** reason for this difference.

.....

1

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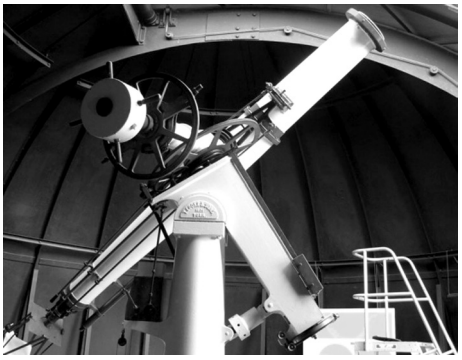
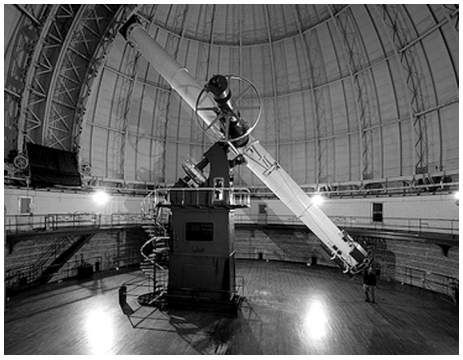
14. The Mills Observatory in Dundee and the Yerkes Observatory in Wisconsin, USA both have refracting telescopes.



Mills Observatory Telescope



Yerkes Observatory Telescope

Astronomers in both observatories are studying the Andromeda galaxy which is approximately 2·2 million light years away.

The diameters of the objective lens in the telescopes are given in the table.

Observatory	*Objective Lens Diameter* (m)
Mills	0·25
Yerkes	1·02

(*a*) Both telescopes produce an image of the Andromeda Galaxy.

State the difference between the two images.

.....

1

(*b*) A light year is defined as "*the distance that light travels in one year*".

Show by calculation that 1 light year = $9{\cdot}4608 \times 10^{15}$ m.

Space for working

2

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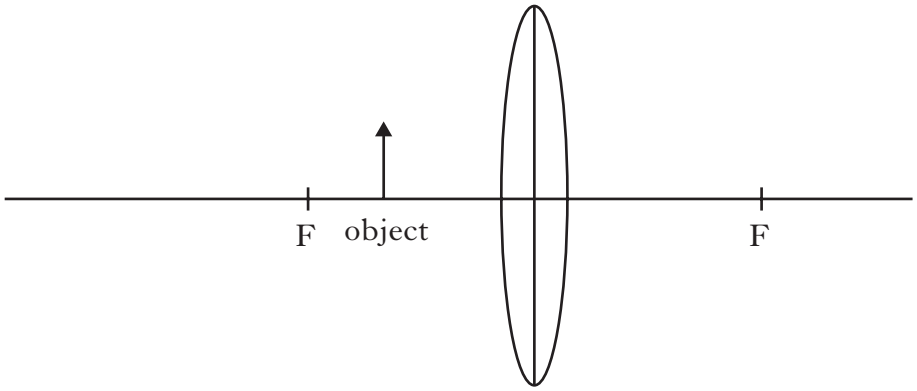
14. (continued)

(*c*) The eyepiece lens of a refracting telescope can be used on its own as a magnifying glass.

Complete the ray diagram to show how the eyepiece lens forms an image.

The points marked F are one focal length from the centre of the lens.



3

(*d*) Not all telescopes detect visible light.

Why are different kinds of telescope used to detect signals from space?

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1

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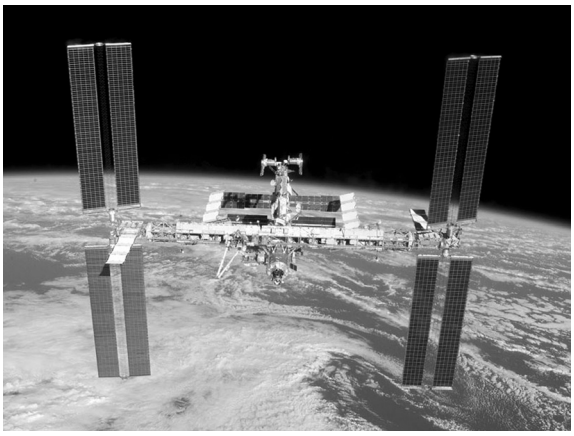
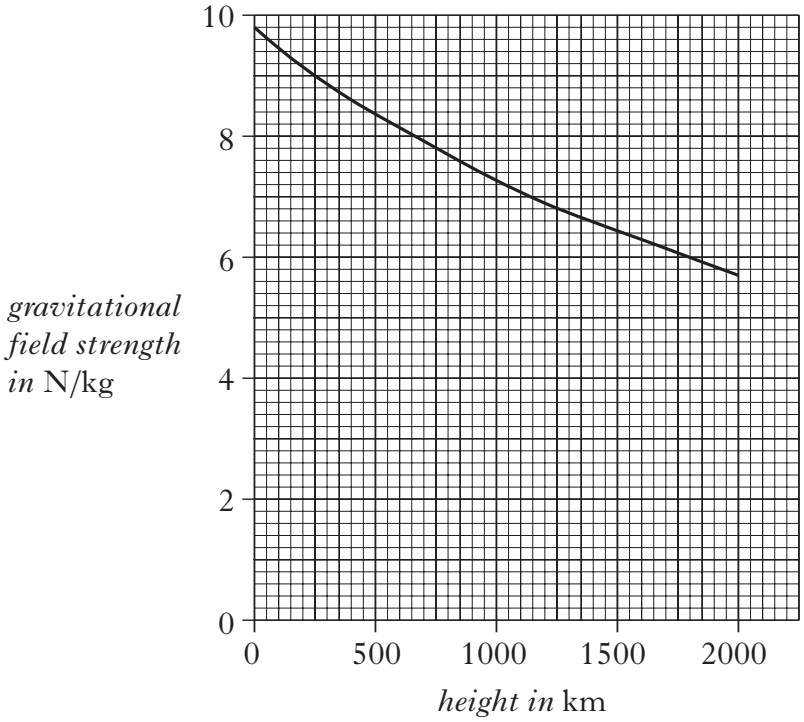
15. The International Space Station (ISS) orbits the Earth at a height of 400 km.



(*a*) The graph shows how the gravitational field strength varies with height above the surface of the Earth.



(i) State what is meant by *gravitational field strength*.

.....

1

(ii) What is the value of gravitational field strength at the orbital height of the ISS?

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1

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15. (continued)

(*b*) An astronaut of mass 75 kg is on board the ISS.

(i) Calculate the weight of the astronaut inside the ISS.

Space for working and answer

2

(ii) State the mass of the astronaut on the surface of the Earth.

.....

1

(*c*) The ISS receives its power from solar cells arranged in 4 panels. The maximum output power of each panel is 87·5 W/m^2.

Each panel has an area of 375 m^2.

(i) What is the maximum power available to the ISS from the panels?

Space for working and answer

2

(ii) State the main disadvantage of using solar cells to provide power.

.....

1

[*END OF QUESTION PAPER*]

ADDITIONAL SPACE FOR ANSWERS

Make sure you write the correct question number beside each answer.

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Question 4—Photograph of a GT model helicopter. Permission is being sought from GT Model Toy Factory, China.