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Presenting Centre No.	Subject No. 3220	Level	Paper No.	Group No.	Marker's No.

C

K & U	PS

Total Marks

3220/102

SCOTTISH CERTIFICATE OF EDUCATION 1998

FRIDAY, 15 MAY
10.45 AM – 12.30 PM

PHYSICS
STANDARD GRADE
Credit Level

Fill in these boxes and read what is printed below.

Full name of school or college

Town

First name and initials

Surname

Date of birth
Day Month Year

Candidate number

Number of seat

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 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.

6 Any necessary data will be found in the **data sheet** on page two.

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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
Diamond	530
Glass	500
Glycerol	2400
Ice	2100
Lead	128
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	0·001 $= 10^{-3}$
micro	μ	0·000 001 $= 10^{-6}$
nano	n	0·000 000 001 $= 10^{-9}$

K&U	PS

Marks

1. Information may be passed between a telephone exchange and a receiver in a number of ways.

(*a*) Electrical signals from the telephone exchange are converted to light signals. The light signals are then transmitted through an optical fibre to the receiver.

Complete the diagram in figure 1 to show the path of a ray of light as it passes along the optical fibre.

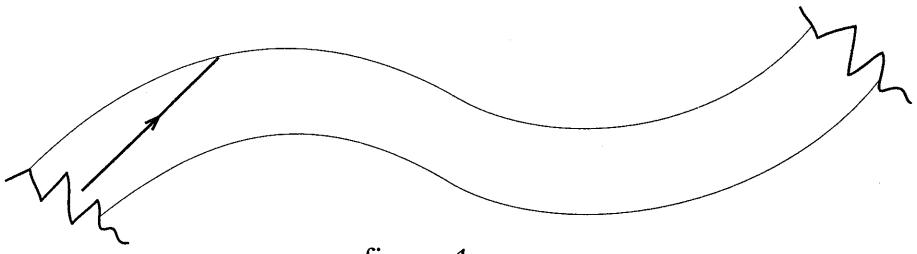


figure 1

(1)

(*b*) Electrical signals from the telephone exchange are converted to microwaves. The microwaves are transmitted via a satellite to the receiver as shown in figure 2.

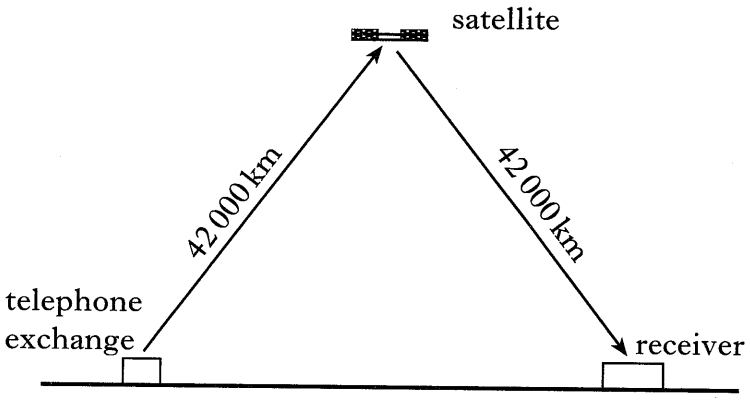


figure 2

Calculate the time taken for the microwave signal to travel from the telephone exchange to the receiver.

Space for working and answer

(3)

[Turn over

K&U	PS

Marks

2. (*a*) Firefighters use special viewers which detect radiations from the part of the electromagnetic spectrum marked Q in figure 1.

Gamma rays	X-rays	P	Visible	Q	Micro-waves	TV	Radio

figure 1

(i) Name radiation Q.

..... **(1)**

(ii) Describe how the viewer is able to detect an unconscious person in a dark, smoke-filled room.

.....

.....

..... **(1)**

(*b*) The display screen on the viewer produces a black and white picture.

A pupil suggests that it would be better to produce a colour picture on the screen using a system of phosphor dots which can emit red, green or blue light.

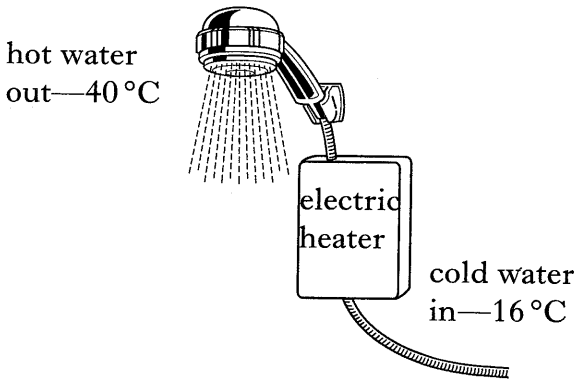
Which dots would glow to produce cyan on the display screen?

..... **(1)**

K&U	PS

Marks

3. An electric shower unit is supplied with cold water at a temperature of 16 °C as shown below. An electric heater in the unit is used to increase the temperature of the water so that it comes out of the shower at 40 °C. The shower provides 5 kg of hot water every minute.



(*a*) Calculate the heat energy supplied to the water every minute.

[specific heat capacity of water = 4 180 J/kg °C]

Space for working and answer

(2)

(*b*) Calculate the power output of the heater **in watts**.

Space for working and answer

(2)

(*c*) The manufacturer of the shower states that the flow rate may have to be adjusted in winter if a hot water temperature of 40 °C is to be maintained.

Explain whether the flow rate would be greater or less than 5 kg per minute.

.....

.....

..... **(2)**

Marks

4. A car starter motor is operated when the driver closes the ignition switch.

Figure 1 shows the system used to operate the starter motor.

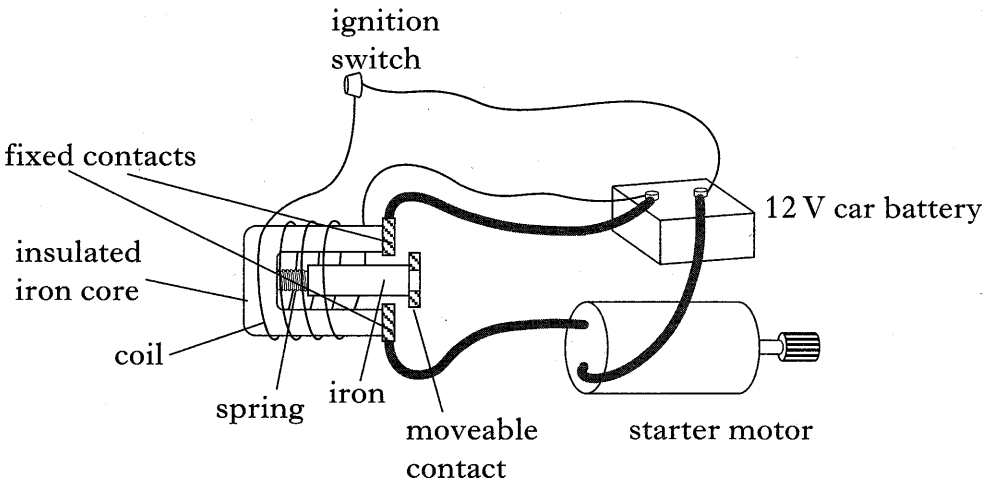


figure 1

(*a*) Explain why closing the ignition switch makes the starter motor operate.

.....

.....

.....

..... **(3)**

(*b*) The voltage across the cable connecting the battery to the starter motor is 0·25 V when the current in the cable is 400 A. The cable has a resistance of 5×10^{-4} ohm per metre.

Calculate the length of this cable.

Space for working and answer

(3)

K&U	PS

4. (continued)

Marks

(*c*) A diagram of the starter motor is shown in figure 2.

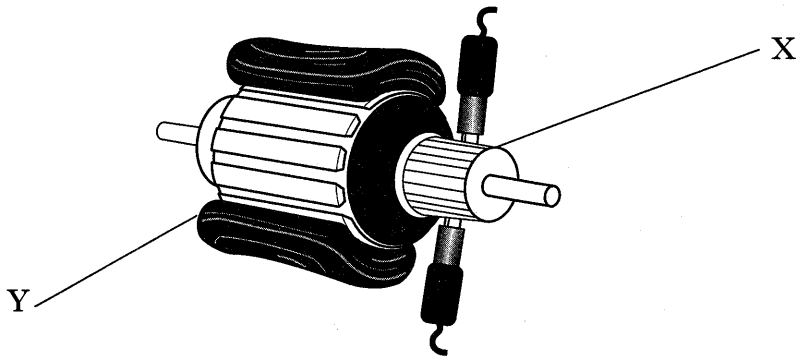


figure 2

Name the parts labelled X and Y on the diagram.

X ..... Y ..... **(1)**

(*d*) When the starter motor operates, a charge of 360 C is drawn from the battery.

How long will it take to recharge the battery if a charging current of 5 A is used?

Space for working and answer

(2)

[Turn over

K&U	PS

Marks

5. An illuminated food cabinet, used in a canteen, has warm and hot areas as shown in figure 1. Separate heating elements provide heat for the warm and hot areas.

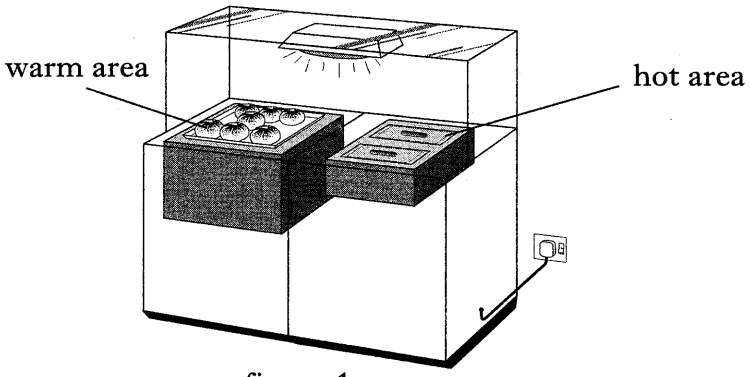


figure 1

The heating elements and lamp are connected to the 230 V mains supply as shown in figure 2. The resistance of each heating element and the lamp is indicated in figure 2.

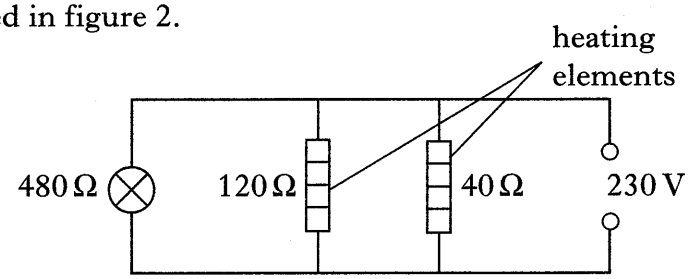


figure 2

(*a*) Calculate the power of the lamp.

Space for working and answer

(2)

(*b*) Calculate the combined resistance of the lamp and the heating elements.

Space for working and answer

(2)

K&U	PS

Marks

5. (continued)

(*c*) Calculate the current drawn from the supply when the cabinet is operating.

Space for working and answer

(2)

[Turn over

K&U	PS

Marks

6. A motorist has to wear spectacles to read the number plate on a car which is 20 m away. However, the information on the instrument panel in a car can be read easily by the motorist without wearing spectacles.

(*a*) Explain whether the spectacle lenses are convex or concave.
(*You may draw diagrams to illustrate your answer if you wish.*)

Space for answer

.....

.....

.....

.....

.....

(3)

(*b*) The focal length of one of the spectacle lenses is 67 cm.
Calculate the power of the lens.

Space for working and answer

(2)

K&U	PS

Marks

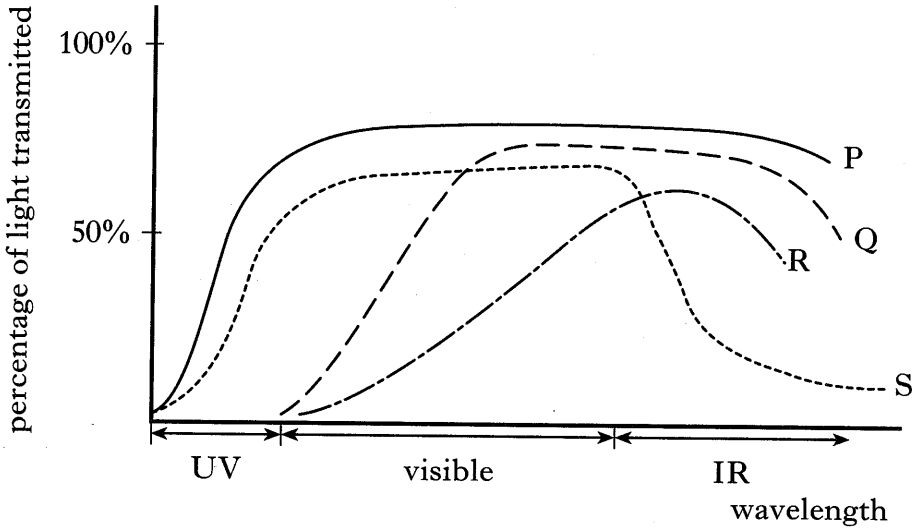
7. Read the following passage about eye protection.

Certain groups of people may be exposed to high levels of ultraviolet light. Their eyes must be protected. Spectacle lenses can be treated with special coatings to give protection.

Scientists who regularly use illuminated microscopes must use protective spectacles. These must allow the maximum transmission of visible light but protect against ultraviolet light.

People taking part in winter sports also require spectacles to protect their eyes from ultraviolet light. The spectacles also cut down light received from the sun and reflected from the snow.

The graphs P, Q, R and S below provide information on spectacle lenses with four different coatings.



(*a*) Which spectacle lens should be used by scientists using illuminated microscopes? Give a reason for your answer.

.....

.....

..... **(2)**

(*b*) Which spectacle lens should be used by people taking part in winter sports? Give a reason for your answer.

.....

.....

..... **(2)**

[Turn over

K&U	PS

Marks

8. Doctors use radioactive technetium to investigate different parts of the human body. A solution of technetium is injected into the body and a gamma camera is used to detect the radiation emitted.

(*a*) The half-life of technetium is 6 hours.

What is meant by the term "half-life"?

.....

.....

..... **(1)**

(*b*) The table below indicates the minimum activity of the technetium solutions which are used to investigate various parts of the body.

Part of body to be investigated	*Minimum activity of solution* (MBq)
Brain	800
Lungs	80
Liver	200
Thyroid	40

A solution is made up with 800 MBq of technetium at 8 am.

(i) What is the latest possible time that the solution could be used for investigating a patient's liver?

Space for working and answer

(2)

(ii) At 10 pm, which part or parts of the body listed in the table could still be investigated using the solution? Explain your answer.

.....

.....

..... **(3)**

K&U	PS

Marks

8. (continued)

(*c*) The third column in the table below lists values which give a measure of the biological effect of the radiation on the absorbing tissue.

Part of body to be investigated	*Minimum activity of solution* (MBq)	.... (.....)
Brain	800	0·0170
Lungs	80	0·0003
Liver	200	0·0027
Thyroid	40	0·0020

Complete the table by adding the name and unit of the quantity whose value is listed in the third column. **(2)**

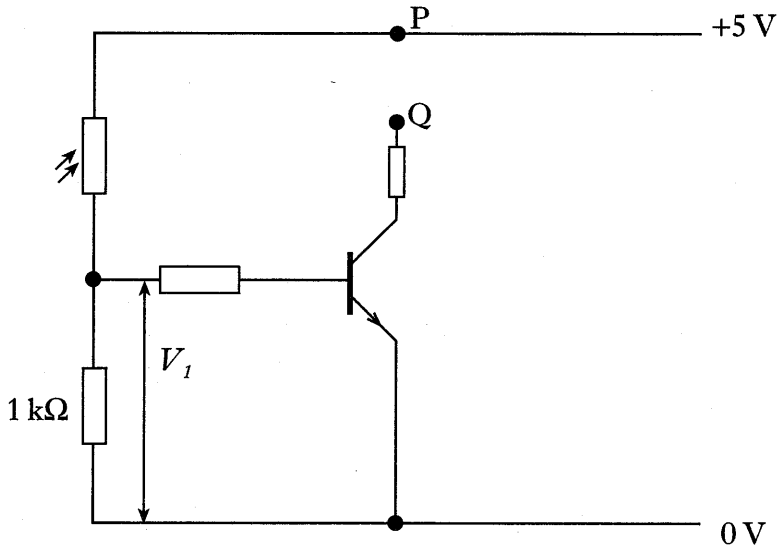
[Turn over

K&U	PS

Marks

9. A pupil is asked to devise a circuit which will switch on automatically a light emitting diode (LED) when a room becomes dark.

Part of the circuit the pupil sets up is shown in the diagram below.



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

(*b*) The properties of the light dependent resistor (LDR) in the circuit used by the pupil are shown in the table below.

Lighting conditions	*Resistance of LDR*
Bright	100 Ω
Dark	10 kΩ

V_1 is the input voltage to the transistor. The transistor switches on fully when V_1 rises above 0·7 V.

(i) Calculate the value of the input voltage V_1 in dark conditions.
(Use an appropriate number of figures in your answer.)

Space for working and answer

(3)

K&U	PS

Marks

9. (*b*) (continued)

(ii) When the room is dark and the LED is correctly connected, it will **not** light. Explain.

.....

.....

.....

..... **(2)**

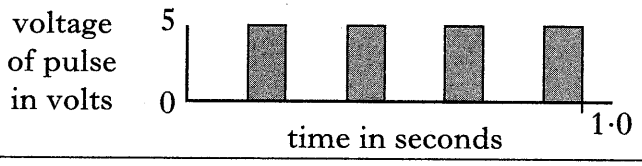
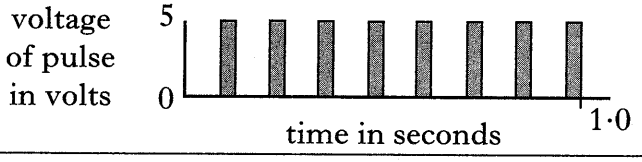
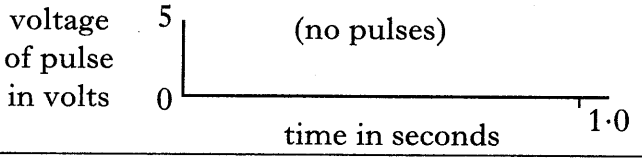
(*c*) Using only the components shown in the circuit diagram, state one change which should be made to the circuit to make it operate properly.

..... **(1)**

[Turn over

Marks

10. A driverless train is operated by sending voltage pulses of different frequency along the railway track to a motor control in the train. The different frequencies of pulse that are used to give different instructions to the motor control of the train are represented by the pulse pattern in the table below.

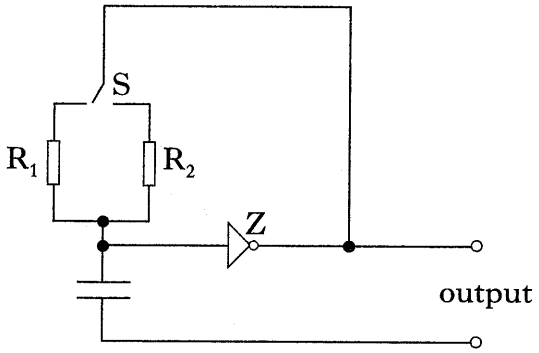
Instruction to motor control	*Pulse pattern*
Start train	
Travel at constant speed	
Stop train	

(*a*) State the frequency of the pulses used to start the train.

..... **(1)**

(*b*) The pulses are produced by the pulse generator shown in figure 1. The supply voltage is not shown.

figure 1



(i) Name component Z.

..... **(1)**

(ii) Switch S makes a connection with resistor R_1 to start the train and with resistor R_2 to run the train at constant speed.

Which of the resistors has the lower resistance? Give a reason for your answer.

.....

.....

..... **(2)**

K&U	PS

Marks

10. (continued)

(*c*) The train cannot start until its doors are closed. An electronic circuit is used to give an output which shows whether a door of the train is open or closed.

The circuit gives an output of +5 V (logic 1) when the door is closed and an output of 0 V (logic 0) when the door is open. Two circuits P and Q are shown in figure 2. Switch S is closed when the train door is closed.

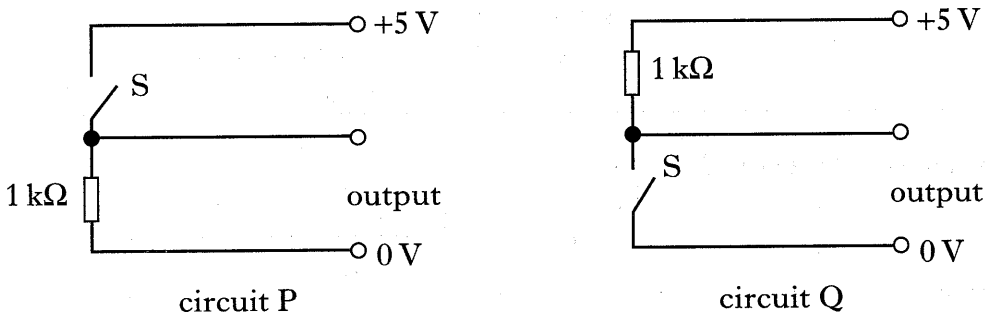


figure 2

State which of the circuits P or Q is used and give a reason for your answer.

.....

.....

..... **(2)**

[Turn over

K&U	PS

Marks

11. A roller coaster is designed with a vertical drop as shown below. A vehicle is moved from P to the top of a slope at Q. At the top of the slope the vehicle is released and it falls vertically from R to S.

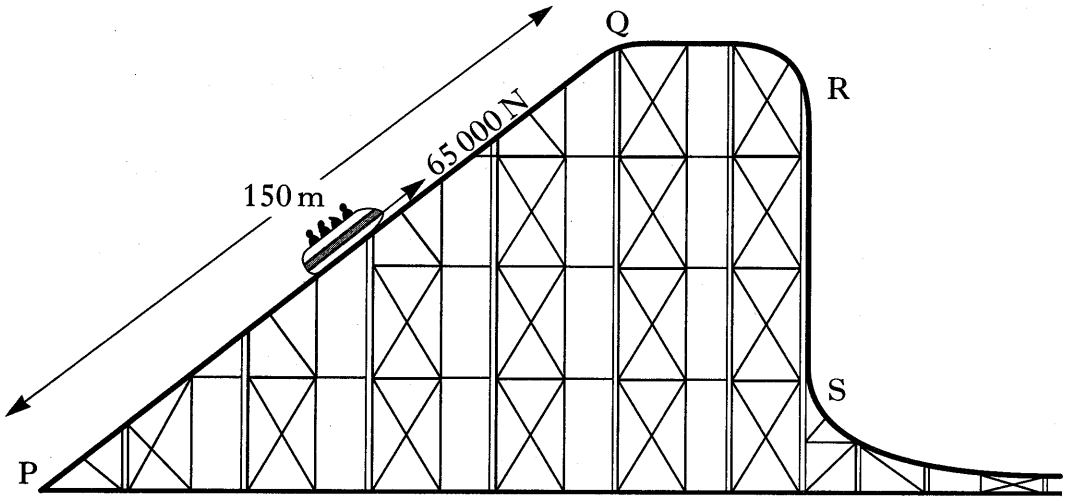


figure 1

(*a*) A force of 65 000 N is applied over a distance of 150 m to move the vehicle at a constant speed from P to Q.

How much work is done by the force in moving the vehicle?

Space for working and answer

(2)

(*b*) The vehicle and passengers reach a maximum height of 110 m. The total mass of vehicle and passengers is 8500 kg.

Calculate the potential energy gained by the vehicle and passengers.

Space for working and answer

(2)

K&U	PS

Marks

11. (continued)

(*c*) The vehicle is designed to travel at 5 m/s at R and to travel vertically for 4 s to S. A pupil draws a speed–time graph of the motion between R and S as shown in figure 2.

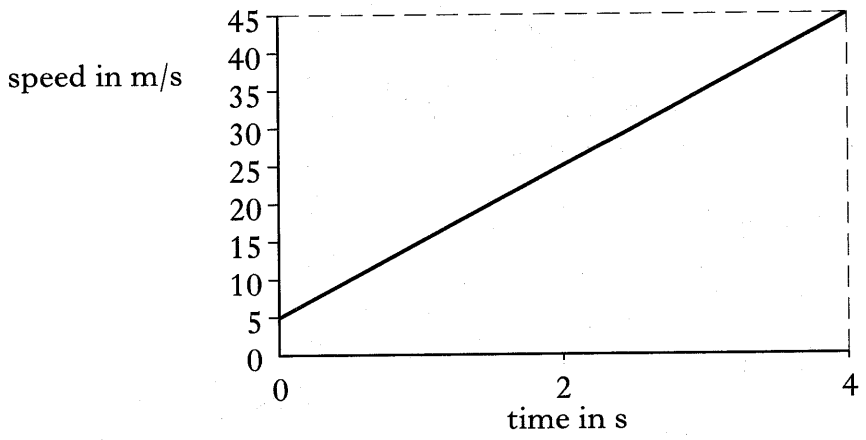


figure 2

Calculate the value the pupil's speed-time graph predicts for the length of the vertical drop from R to S.

Space for working and answer

(2)

(*d*) In drawing the speed-time graph, the pupil has assumed that the acceleration of the vehicle is 10 m/s^2.

Explain whether the actual value for the vertical drop would be greater or less than the value predicted from the pupil's speed-time graph.

.....

.....

..... **(2)**

(*e*) Describe how the speed of the vehicle at S could be measured.

.....

.....

.....

.....

..... **(2)**

K&U	PS

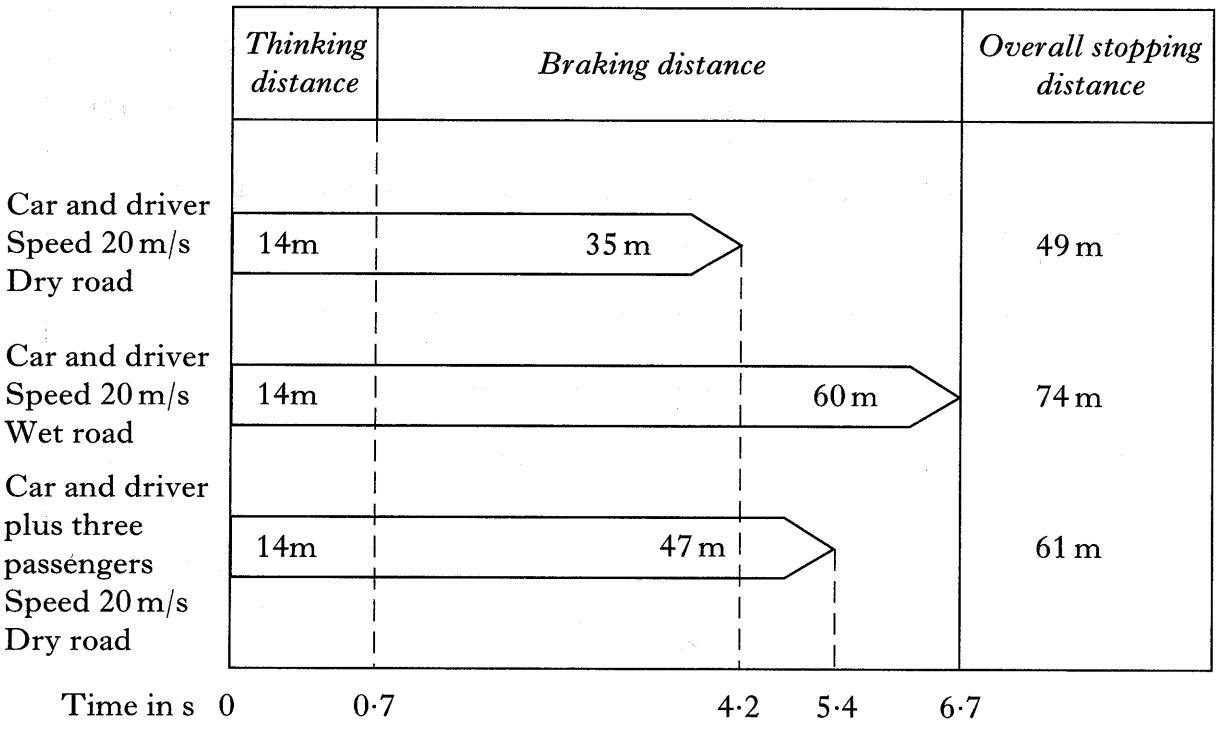
Marks

12. The highway code requires drivers to know about the overall stopping distance for vehicles. The overall stopping distance is made up of:

(1) the **thinking distance**—the distance travelled while the driver "thinks" about braking;

(2) the **braking distance**—the distance travelled while braking.

The following diagram gives information about the overall stopping distance of a car and the time for the car to come to rest under different conditions. Timing starts from the moment the driver recognises there is a need to brake and stops when the car comes to a halt.



(*a*) Explain why the thinking distance is the same for the different conditions.

.....

..... **(2)**

(*b*) Calculate the deceleration of the car on the wet road.

Space for working and answer

(2)

K&U	PS

Marks

12. (continued)

(*c*) The total mass of the car and driver is 1500 kg.
Calculate the unbalanced force on the car while braking on the wet road.

Space for working and answer

(2)

(*d*) Explain why the stopping distance on a dry road increases when the car has passengers.

.....

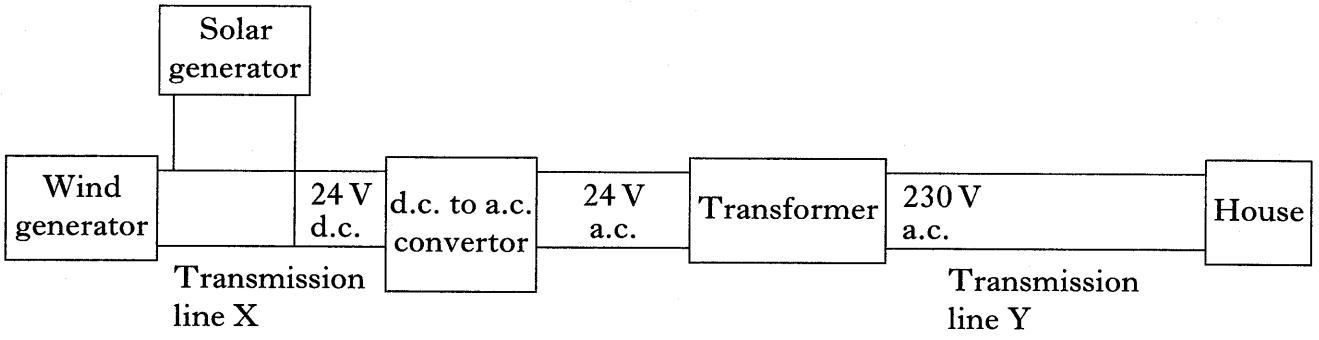
.....

..... **(2)**

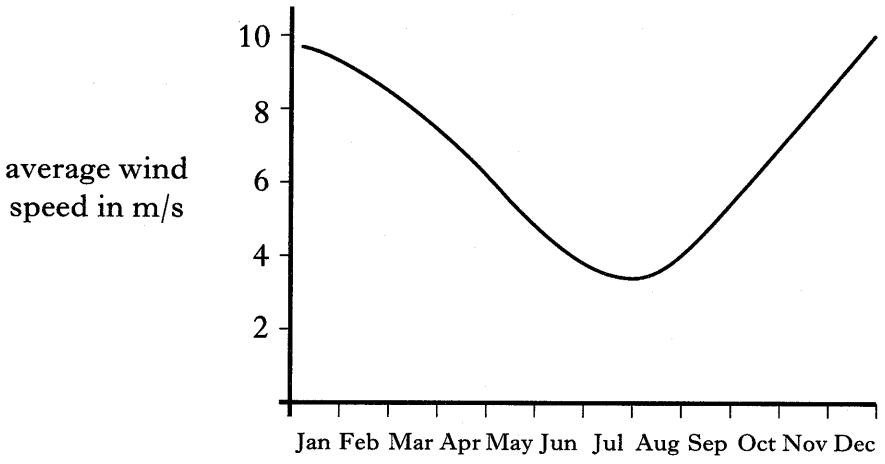
[Turn over

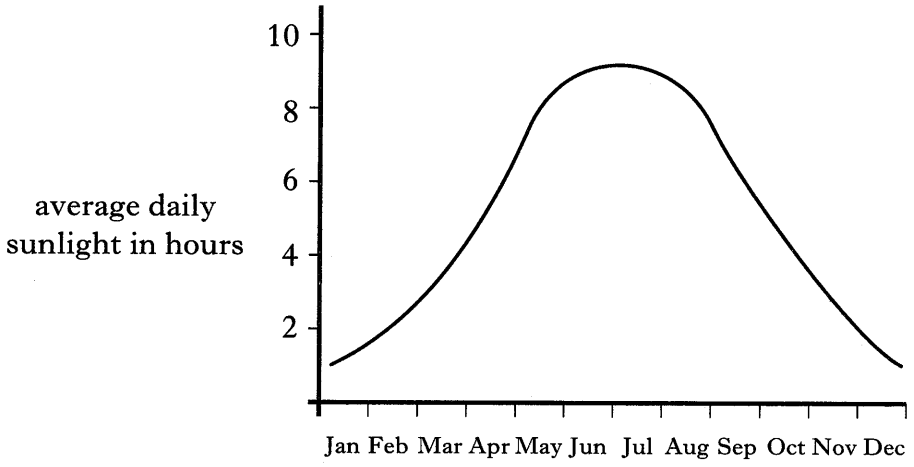
Marks

13. Electrical power may be provided to remote homes by a combination of wind and solar generators as shown in the diagram below.



(*a*) The following graphs show how the average wind speed and average daily sunlight vary over a year.





Explain why the combination of wind and solar generators provides an effective system.

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.....

.....

..... **(2)**

K&U	PS

Marks

13. (continued)

(*b*) The output voltage from the solar and wind generators is 24 V d.c.

Explain the need for the d.c. to a.c. convertor between the generators and the transformer.

.....

..... **(1)**

(*c*) The transformer steps up the voltage from 24 V to 230 V. There are 480 turns on the primary coil of the transformer.

Calculate the number of turns on the secondary coil.

Space for working and answer

(2)

(*d*) The electrical power loss is less in transmission line Y than in transmission line X although the resistance of line Y is greater.

Explain.

.....

.....

..... **(2)**

[Turn over

Marks

14. (*a*) Figure 1 shows a space shuttle consisting of an orbiter, called *Discovery*, and booster rockets. At lift off *Discovery* and the booster rockets have a total mass of $2{\cdot}05 \times 10^6$kg and the thrust of the rocket engines is $2{\cdot}91 \times 10^7$N. The frictional forces acting on the shuttle at lift off are negligible.

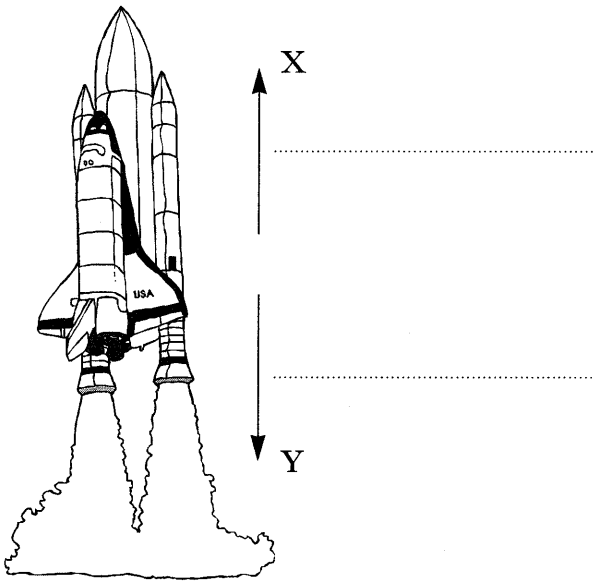


figure 1

At lift off:

(i) label, on figure 1, the two forces X and Y acting on the shuttle in the directions shown; **(1)**

(ii) calculate the weight of the shuttle;

Space for working and answer

(2)

(iii) calculate the acceleration of the shuttle.

Space for working and answer

(3)

K&U	PS

Marks

14. (continued)

(*b*) The booster rockets are parachuted to Earth before *Discovery* enters orbit around the Earth. In orbit, *Discovery's* rocket engines are switched off. Figure 2 shows *Discovery* in orbit around the Earth.

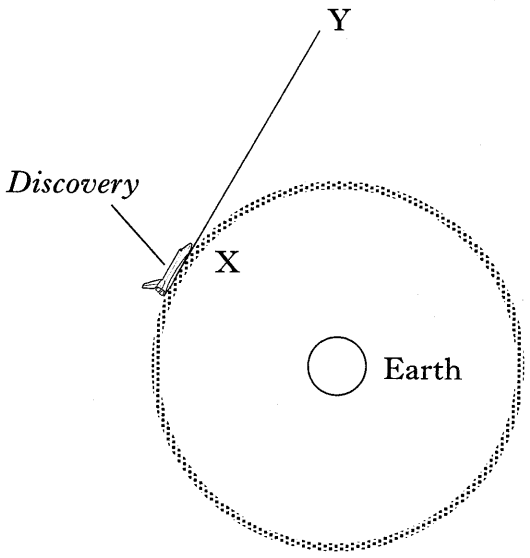


figure 2

Explain why *Discovery* remains in orbit and does not:

(i) move closer to the Earth;

.....

.....

.....

(ii) move off into space along XY.

.....

.....

..... **(2)**

[Turn over

Marks

15. (*a*) In 1971, a lunar module carrying two astronauts landed on the Moon's surface. The gravitational field strength on the Moon is different from that on Earth.

(i) What is meant by "gravitational field strength"?

.....

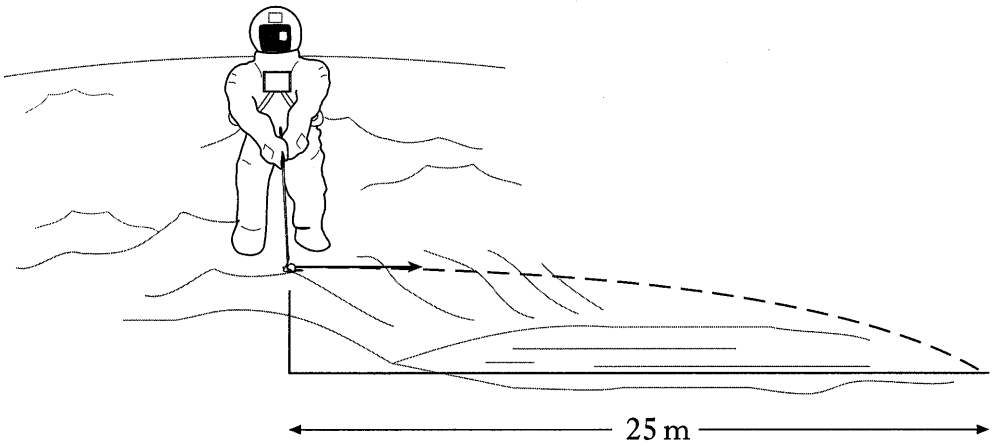
..... **(1)**

(ii) The gravitational field strength at the surface of the Moon is 1·6 N/kg.

What is the value of the acceleration due to gravity at the surface of the Moon?

..... **(1)**

(*b*) One of the astronauts played golf on the moon. The golf ball was struck horizontally from the edge of a steep crater. It landed 2 seconds later, 25 m away as shown in the diagram below.



(i) Calculate the horizontal speed of the ball after being struck.

Space for working and answer

(2)

K&U	PS

Marks

15. (*b*) (continued)

(ii) Calculate the vertical speed of the ball on landing.

Space for working and answer

(2)

(iii) How would the horizontal distance travelled by a ball projected with the same horizontal speed from the same height on Earth compare with that on the Moon?

Explain your answer.

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..... **(3)**

[END OF QUESTION PAPER]

K&U	PS

YOU MAY USE THE SPACE ON THIS PAGE TO REWRITE ANY ANSWER YOU HAVE DECIDED TO CHANGE IN THE MAIN PART OF THE ANSWER BOOKLET. TAKE CARE TO WRITE IN CAREFULLY THE APPROPRIATE QUESTION NUMBER.