FOR OFFICIAL USE

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

C

K & U	PS

Total Marks

3220/102

SCOTTISH CERTIFICATE OF EDUCATION 1996

FRIDAY, 17 MAY
1.30 PM – 3.15 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
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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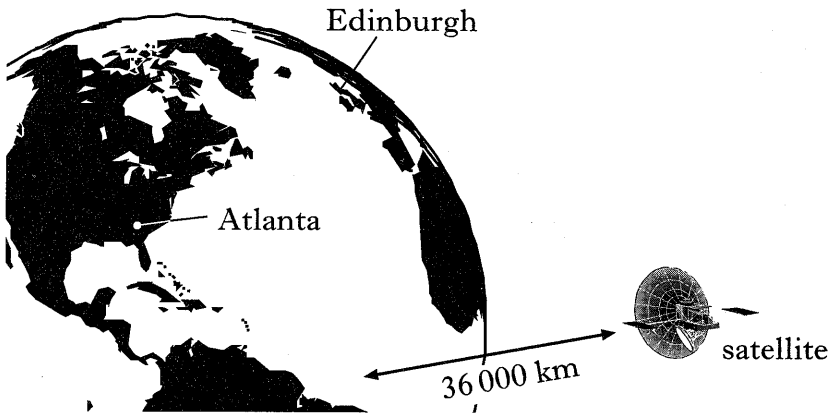
1. Later this year, the Olympic Games will be held in the city of Atlanta in the United States of America (USA).

(*a*) Television pictures of the Games will be transmitted from the USA to Britain. The TV signals will be carried by microwaves. The microwaves will travel from the USA to Britain via a geostationary satellite positioned 36 000 km above the surface of the Earth as shown in the diagram below.



(i) What is meant by saying that the satellite is geostationary?

.....

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

(ii) The frequency of the microwaves to be used in the transmission is 12 GHz.

Calculate the wavelength of the microwaves used in the transmission.

Space for working and answer

(2)

[Turn over

K&U	PS

Marks

1. (continued)

(*b*) Newspaper reporters at the games will be able to fax their reports back to Britain by a telephone link. The telephone link uses an 8000 km length of glass optical fibre. The telephone signals are carried by light which is transmitted through the glass fibre.

How long will it take the telephone signals to travel from the USA to Britain?

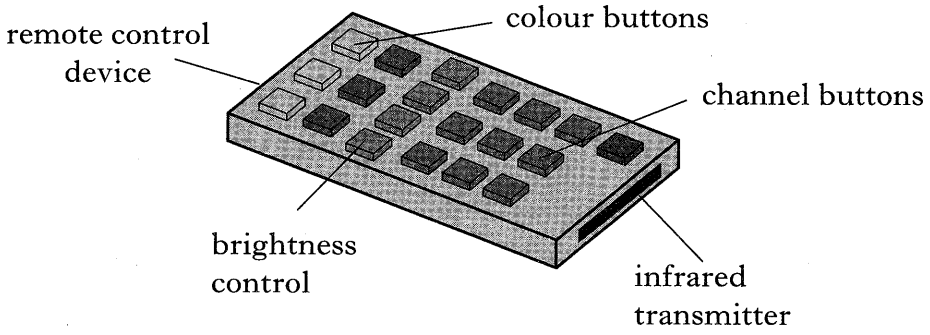
Space for working and answer

(3)

K&U	PS

Marks

2. A remote control device for a television set has buttons which are used to produce signals to change the channels, the brightness and the colour of the picture. The remote control has an infrared transmitter as shown in the diagram below.



The signals are carried by the infrared radiation from the transmitter to a detector on the TV set.

(*a*) Name a detector of infrared radiation.

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

(*b*) The channel buttons on the remote control are used to change to different stations on the TV.

Which part of the TV circuit selects one particular station?

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

(*c*) Describe what happens inside the tube of the TV set when the brightness control button is pressed to increase the brightness of the picture on the screen.

.....

.....

.....

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

(*d*) The screen of a colour TV is made up of red, green and blue phosphor dots which glow to produce colours on the screen.

Which phosphor dots will glow if the screen is

(i) white; .....

(ii) yellow? ..... **(2)**

(*e*) Describe how different shades of yellow are produced on the screen.

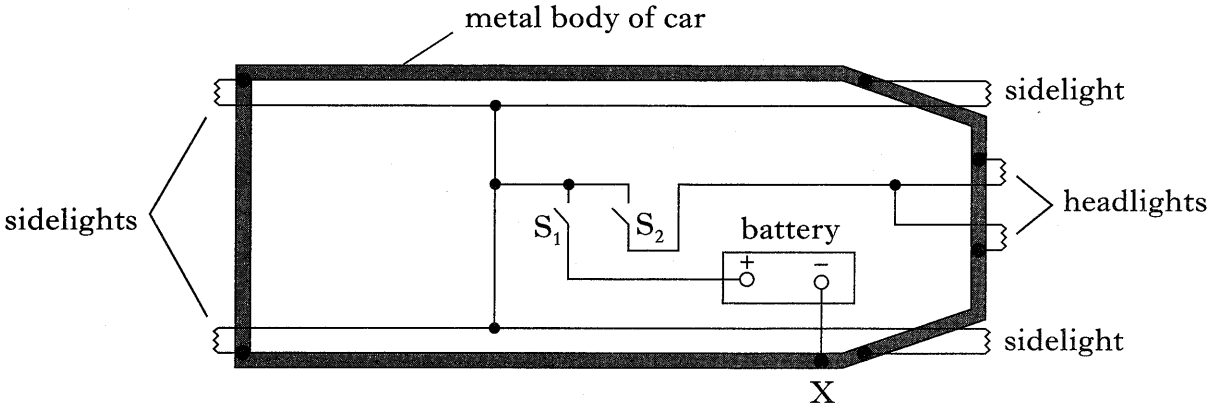
.....

.....

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

Marks

3. The diagram below shows a simplified version of part of the lighting system of a car. The negative terminal of the battery is connected to the metal body of the car at X.



(*a*) Which lights, if any, are on when:

(i) switch S_1 alone is closed; .....

(ii) switch S_2 alone is closed? ..... **(1)**

(*b*) The sidelights are rated at 12V, 5W and the headlights at 12V, 21W.

(i) Calculate the current drawn from the battery when all the sidelights and headlights are switched on.

Space for working and answer

(3)

(ii) Explain which type of light, sidelight or headlight, has the lower resistance.

.....

.....

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

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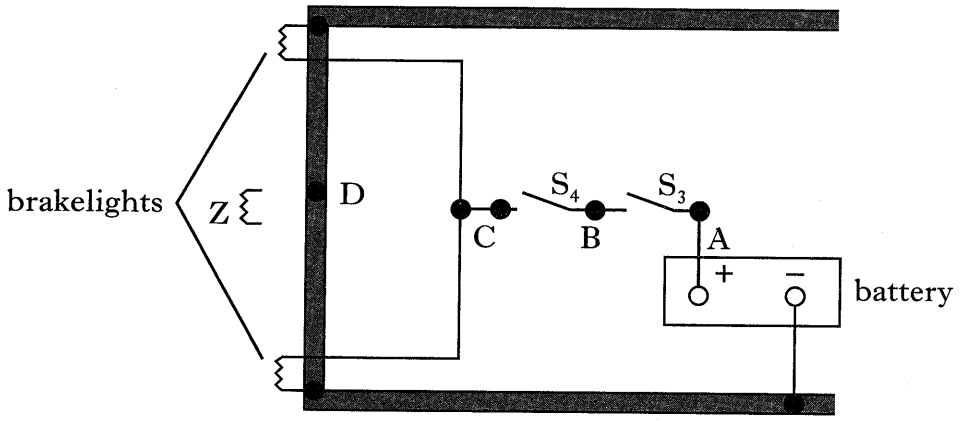
3. (continued)

(*c*) The diagram below shows how the brakelights of the car are connected to the battery. S_3 is the ignition switch of the car and S_4 is the switch which is closed when the brake pedal is pressed.

The owner of the car wishes to install a third brakelight Z in the back window of the car. Connection points to the electric circuit are available at A, B, C and D as shown.



Complete the diagram above to show the points to which the brakelight Z should be connected so that it comes on only when the brake pedal is pressed and the ignition switch is closed. **(1)**

[Turn over

Marks

4. (*a*) A current carrying wire is placed between the poles of a magnet. The direction of the electron current in the wire is as indicated in figure 1. The conductor experiences an upward force as shown in figure 1.

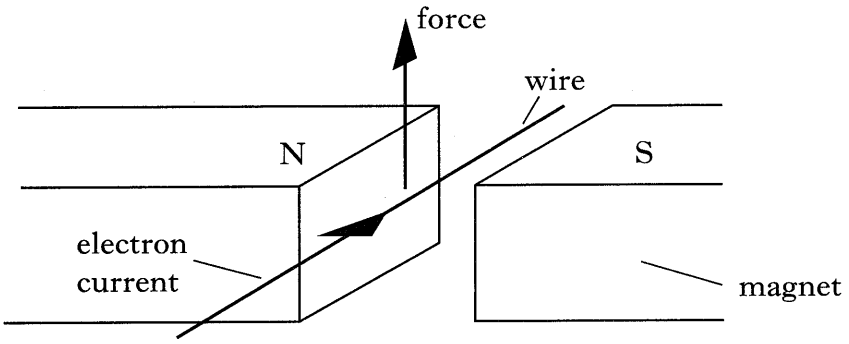


figure 1

Figures 2 and 3 show other current carrying wires placed between the poles of magnets.

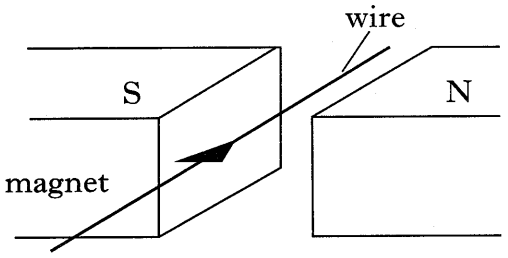


figure 2

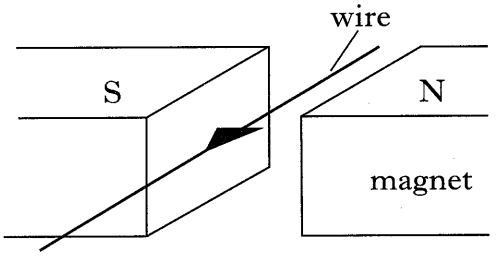


figure 3

In each case, indicate on figures 2 and 3 the direction of the force on the wire. **(2)**

Marks

4. (continued)

(*b*) Figure 4 shows a simple electric motor with a coil WXYZ free to spin about a shaft PQ.

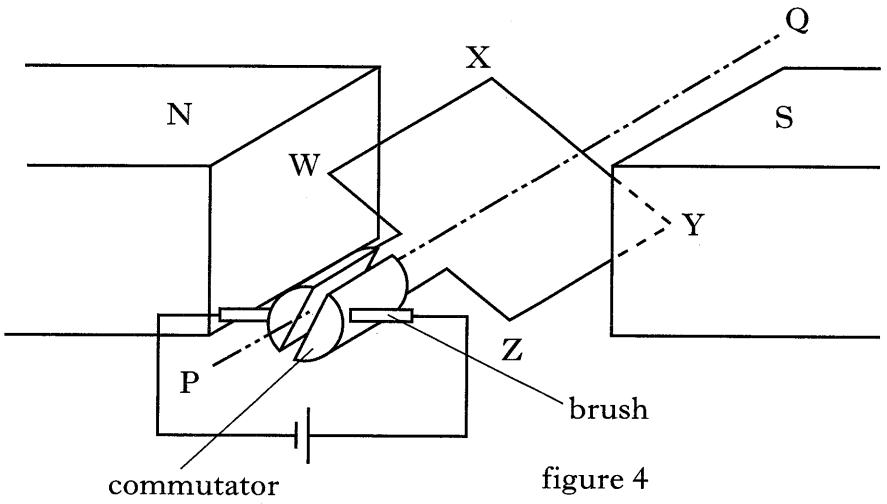


figure 4

(i) By looking at the diagram and using the conclusions you reached in part (*a*), mark on figure 4 above:

(A) the direction of the electron current in the coil;

(B) the directions of the forces on the coil;

(C) the direction of rotation of the coil. **(3)**

(ii) Describe how the brushes and the commutator allow the coil to keep spinning.

.....

.....

.....

.....

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

(*c*) In commercial motors, explain why:

(i) more than one rotating coil is used;

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

(ii) field coils rather than permanent magnets are used.

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

Marks

5. During a game, a player injures a knee. An X-ray is taken to check whether the leg has been broken. Ultrasound is used to determine if any fluid has formed in the knee. Figure 1 shows the position of the X-ray transmitter and figure 2 the position of the ultrasound transmitter and receiver in front of the knee.

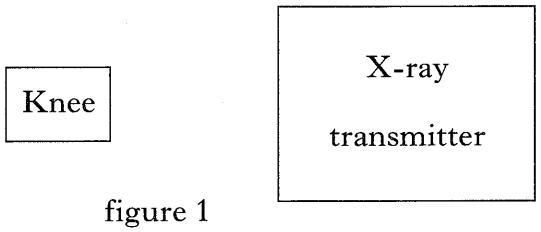


figure 1

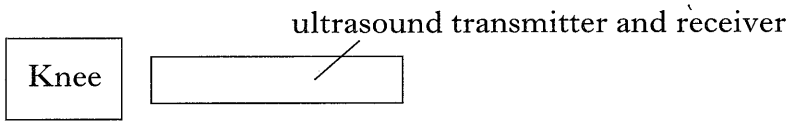


figure 2

(*a*) (i) Indicate on figure 1 where the receiver for the X-rays should be placed. **(1)**

(ii) State why the ultrasound transmitter and receiver are on the same side of the knee as shown in figure 2.

.....

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

(iii) It is decided to treat the knee injury using ultrasound to speed the healing process. The ultrasound used in the treatment has a power of 8 W. The energy to be delivered to the site of the injury is 2400 J at each treatment.

How many minutes should each treatment last?

Space for working and answer

(2)

Marks

5. (continued)

(*b*) Read the following passage.

The limit of human hearing is 20 kHz but other animals, such as bats and dolphins, make use of sound in the 30–100 kHz range. Sound above the range of human hearing is called ultrasound. Ultrasound behaves in a similar manner to audible sound, having a speed of 340 m/s in air, a speed of 1500 m/s in soft tissue and a speed of 4100 m/s in bone. Ultrasound is used not only to diagnose the cause of an injury but also to help in the healing of injuries. When used in the healing process absorption of the ultrasound takes place.

(i) State the lowest frequency of ultrasound.

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

(ii) What is the speed of ultrasound in soft tissue?

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

(iii) State whether energy is absorbed or reflected when ultrasound is used to help the healing process.

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

6. A school Physics department owns a number of radioactive sources.

(*a*) When carrying out an experiment, a teacher placed a radioactive source in front of a detector.

After allowing for background radiation, the following observations were made.

1. Placing a sheet of paper between the source and the detector greatly reduced the reading on the detector.
2. Placing a block of lead 2 cm thick between the source and the detector reduced the reading on the detector to zero.

A pupil suggested that the source was emitting only alpha and gamma radiation.

Explain whether or not the pupil's suggestion is correct.

.....

.....

.....

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

(*b*) Describe briefly a precaution which should be taken when working with radioactive sources.

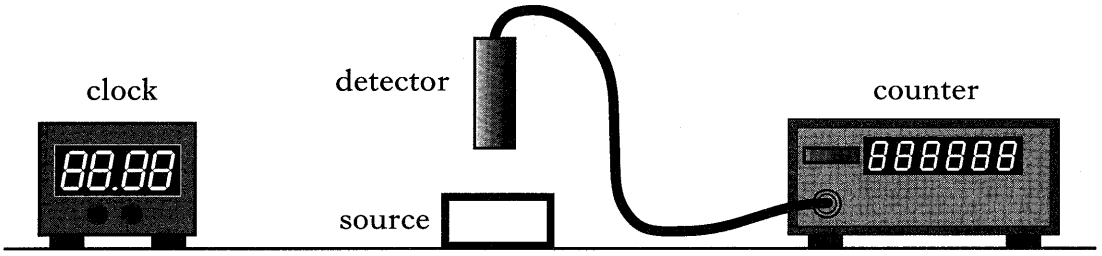
.....

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

Marks

6. (continued)

(*c*) The teacher set up an experiment, as shown in the diagram below, to determine the half life of another radioactive source. Before the source was placed in position, it was noted that there was a reading on the counter.



The source was placed in position and the count rate noted at the start of the experiment and again at regular intervals.

A pupil suggested that the half life of the source might be found from the time taken for the count rate to drop to half its original value.

(i) Explain why the pupil's suggestion may not give an accurate value for the half life.

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

(ii) How could the half life of the source be determined from the experiment described above?

.....

.....

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

(*d*) The source used in the above experiment had an original activity of 800 kBq and a half life of 30 s.

Calculate the activity of the source after 2 minutes.

Space for working and answer

(2)

7. The diagram below shows an automatic hand washing unit in a restaurant.

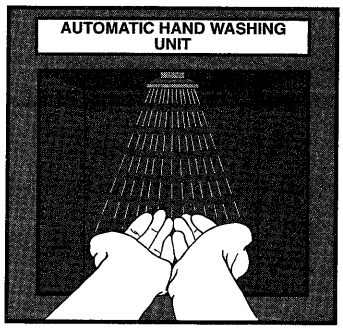


figure 1

Inserting the hands into the unit breaks a light beam and causes a stream of water to be turned on for ten seconds.

(*a*) The light beam is directed at a light dependent resistor (LDR) which is part of the circuit shown in figure 2.

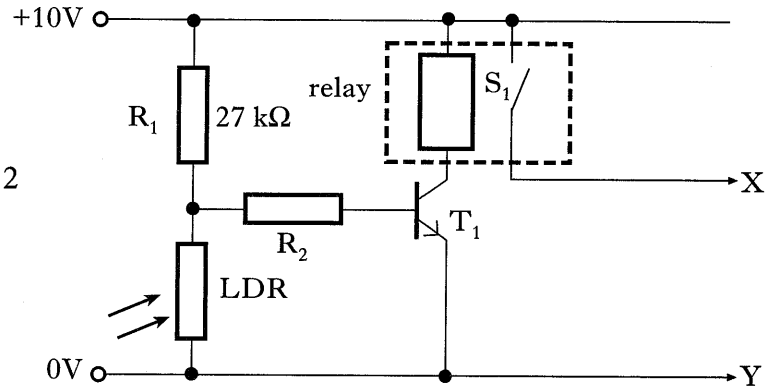


figure 2

(i) When hands are inserted into the unit, the circuit in figure 2 causes the switch S_1 in the relay to close. Explain why this happens.

.....

.....

.....

.....

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

(ii) Calculate the voltage across the LDR when its resistance is 9·0 kΩ.

Space for working and answer

(2)

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Marks

7. (continued)

(*b*) When the relay switch in figure 2 is closed, another circuit connected to X and Y as shown in figure 3 opens a water valve for ten seconds.

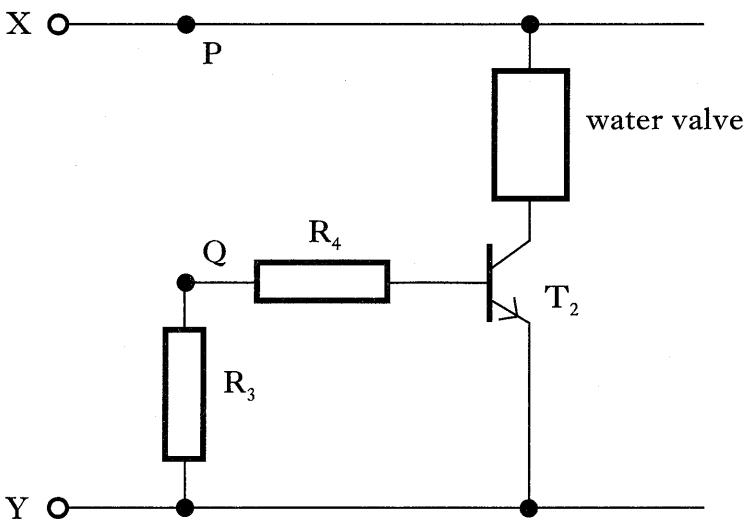

figure 3

Complete the diagram in figure 3 to show the component which should be connected between P and Q so that the water is turned on for ten seconds. **(1)**

Marks

8. Traffic engineers use metal loops to detect the number of vehicles travelling along a road. The loops are buried under the road surface. When a vehicle passes over a loop, a single digital pulse is sent to a control circuit. The diagram below shows a situation where traffic must move in single file on each side of a road. Loops X and Y are buried under each side of the road at the positions shown.

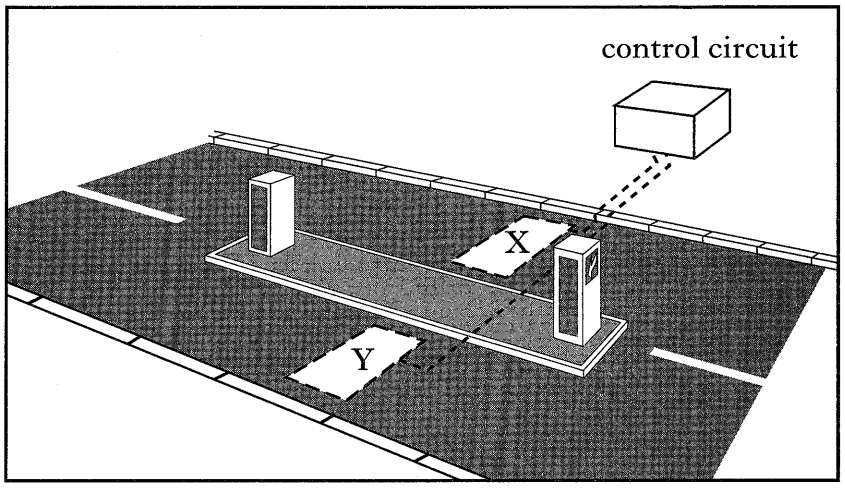

figure 1

(*a*) Part of the control circuit is shown in figure 2.

During the time a vehicle passes over loop X, the logic level at P changes from logic 0 to logic 1.

During the time a vehicle passes over loop Y, the logic level at Q changes from logic 0 to logic 1.

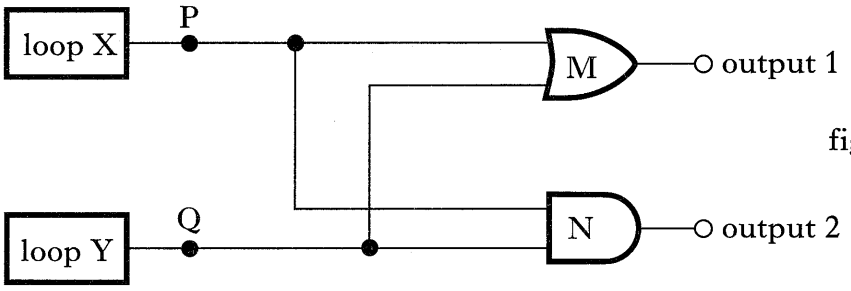

figure 2

(i) Name logic gate M.

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

(ii) Name logic gate N.

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

(iii) Complete the truth table below for this part of the circuit.

Input P	*Input Q*	*Output 1*	*Output 2*
0	0		
0	1		
1	0		
1	1		

(2)

Marks

8. (continued)

(*b*) The two outputs from the above circuit are displayed on a computer screen. The outputs observed over a one minute period are shown in figure 3.

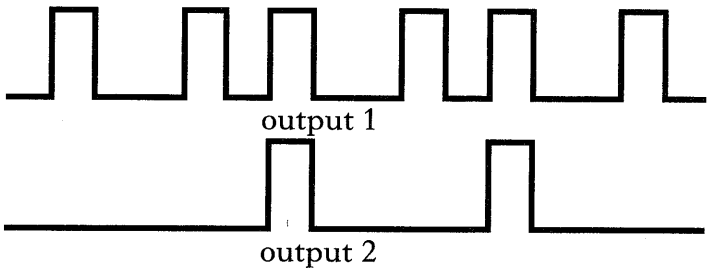

figure 3

(i) Explain why more pulses are seen on output 1 than on output 2.

.....

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

(ii) How often, during the period shown, were vehicles detected at the same time?

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

(iii) How many vehicles were detected during the period shown?

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

(*c*) As shown in figure 4, a light emitting diode (LED) is connected across the 6 V supply of the control circuit, to indicate when the supply is switched on.

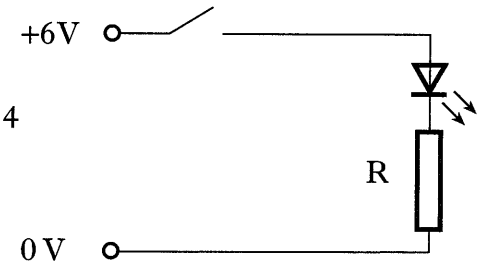

figure 4

When lit, the current in the LED is 20 mA and the voltage across it is 1·6 V.

Calculate the resistance of the resistor R.

Space for working and answer

(3)

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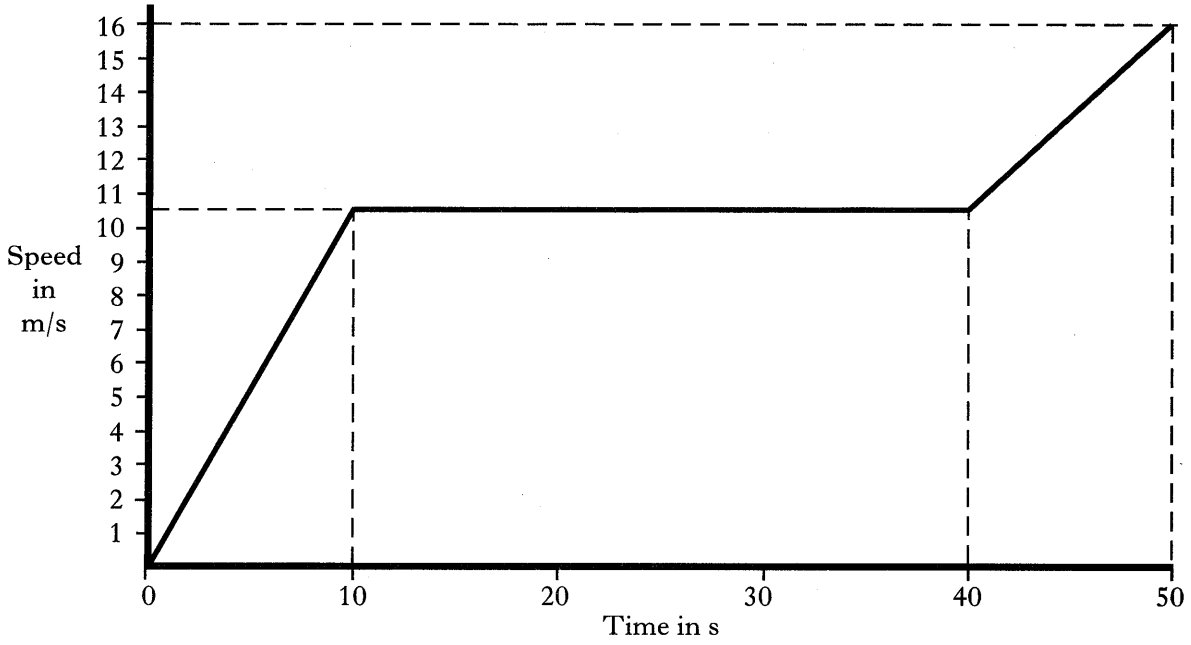
9. A competitor takes part in a speed skating race. The competitor takes 50 seconds to complete the race. The graph below shows how the competitor's speed changes with time during the race.



(*a*) (i) Calculate the acceleration of the skater at the start of the race.

Space for working and answer

(2)

(ii) Calculate the distance over which the skater raced.

Space for working and answer

(3)

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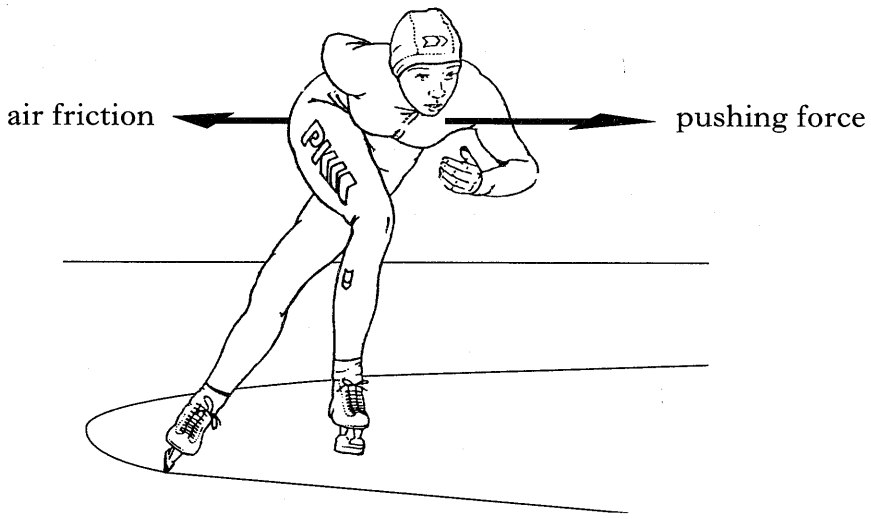
9. (continued)

(*b*) The diagram shows the horizontal forces acting on the skater during the race.



(i) How do these forces compare:

(A) during the first 10 seconds of the race;

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

(B) between times of 10 s and 40 s during the race?

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

(ii) Suggest **one** way in which the skater reduces the air friction acting on her during the race.

.....

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

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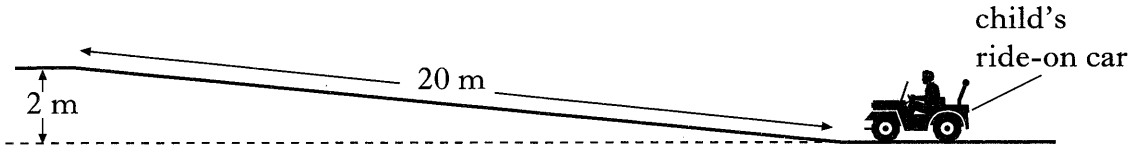
10. A child's electric ride-on car is driven up a ramp as shown in the diagram below. The length of the ramp is 20 m and it rises to a height of 2 m above the level surface.



(*a*) The child and ride-on car have a total mass of 60 kg.

Calculate the potential energy gained by the child and car in travelling from the bottom to the top of the ramp.

Space for working and answer

(2)

(*b*) The ride-on car takes 25 seconds to travel from the bottom of the ramp to the top.

Ignoring frictional losses, calculate the average power output from the ride-on car motor if the car travels up the ramp at constant speed.

Space for working and answer

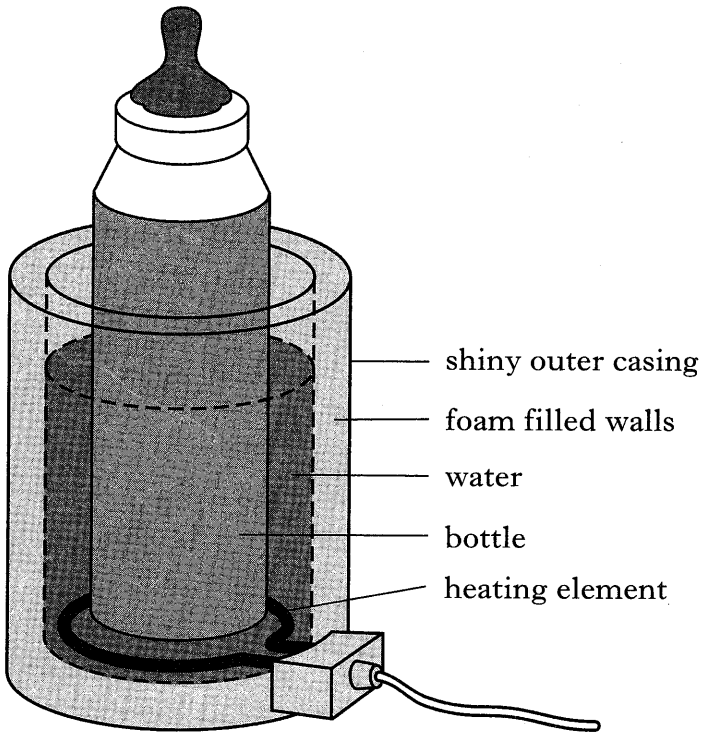
(2)

[Turn over

K&U	PS

Marks

11. A baby's milk bottle is heated using a bottle warmer. The bottle warmer has foam filled walls and a shiny outer casing as shown in the diagram below.



Heat to the warmer is provided by a 100 W heating element. The heating element raises the temperature of the water in the warmer to 40 °C.

(*a*) State the difference between the terms **heat** and **temperature**.

.....

.....

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

(*b*) Explain why the rate of loss of heat from the bottle warmer is reduced by:

(i) the foam filled walls;

.....

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

(ii) the shiny outer casing.

.....

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

K&U	PS

Marks

11. (continued)

(*c*) The warmer contains 0·5 kg of water at a temperature of 25 °C. The warmer is set to switch off when the water reaches a temperature of 40 °C.

When there is no bottle in the warmer, calculate the minimum time taken to raise the temperature of the water to 40 °C.

(Specific heat capacity of water = 4180 J/kg °C)

Space for working and answer

(3)

(*d*) When a bottle of milk is placed in the warmer the time taken to reach 40 °C is much longer than the value calculated in part (*c*).

Give a reason why the time is much longer although the initial temperature and the mass of the water remain the same.

.....

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

[Turn over

Marks

12. A shop hires out transformers for use with appliances which are designed to run from 110 V supplies. The table below lists the maximum power output of transformers P, Q, R and S which are available for hire.

Transformer	*Maximum power output from transformer in kW*
P	0·5
Q	1·1
R	1·5
S	3·0

All the transformers are designed to give a 110 V secondary output when the primary is connected to a 240 V supply.

(*a*) A person hires one of the transformers to operate a 110 V electric drill. The primary of the transformer is connected to a 240 V supply and the electric drill to the 110 V secondary output. The current in the drill is 18 A.

(i) Calculate the power of the drill.

Space for working and answer

(2)

(ii) Which transformer was used to operate the drill?

.....

(1)

(*b*) The primary coil of each transformer has 1200 turns.

How many turns has each secondary coil?

Space for working and answer

(2)

Marks

12. (continued)

(*c*) (i) When the drill is used the primary of the transformer draws a current of 11 A from the 240 V supply.

Calculate the efficiency of the transformer.

Space for working and answer

(3)

(ii) State **one** reason why transformers are not 100% efficient.

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

13. The following extracts are taken from a record of the Apollo 11 mission which resulted in the first Moon landing in 1969.

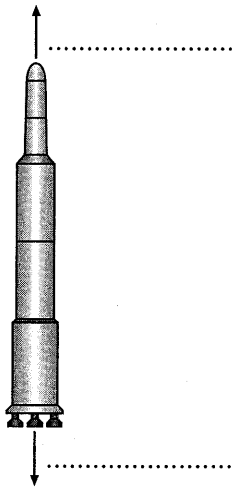
Wednesday 16 July

3.15 am *Astronauts Armstrong, Aldrin and Collins put on their space suits*

8.32 am *The rocket lifts off from Kennedy Space Centre*

8.35 am *Speed of rocket 10 000 km/h*

8.41 am *Speed of rocket 25 000 km/h*



(*a*) On the diagram above, label the forces acting on the rocket at lift off. **(1)**

(*b*) Explain, in terms of the forces you have labelled in part (*a*), why the rocket was able to lift off.

.....

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

Marks

13. (continued)

(*c*) Calculate the acceleration, **in km/h/s**, of the rocket in the six minutes between 8.35 am and 8.41 am on Wednesday 16 July 1969.

Space for working and answer

(2)

(*d*) Each astronaut wore a spacesuit of mass 83 kg.

Calculate the weight of the spacesuit on the Moon.

Space for working and answer

(2)

(*e*) Why does a spacecraft experience an increase in temperature on re-entry into the atmosphere?

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

[END OF QUESTION PAPER]

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