FOR OFFICIAL USE

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 1997

THURSDAY, 15 MAY
1.00 PM – 2.45 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.

SCOTTISH QUALIFICATIONS AUTHORITY

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	0·001 $= 10^{-3}$
micro	μ	0·000 001 $= 10^{-6}$
nano	n	0·000 000 001 $= 10^{-9}$

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1. The tuning dial on a radio displays three different bands which are labelled frequency modulation (FM), medium wave (MW) and long wave (LW). The frequency range for each band is shown below.

Band	*Frequency range*
FM	88 – 108 MHz
MW	540 – 1600 kHz
LW	150 – 270 kHz

(*a*) The radio receives a signal with a wavelength of 1190 m.

To which of the above bands is the radio tuned?

You **must** show clearly the calculation used to reach your conclusion.

Space for working and answer

(3)

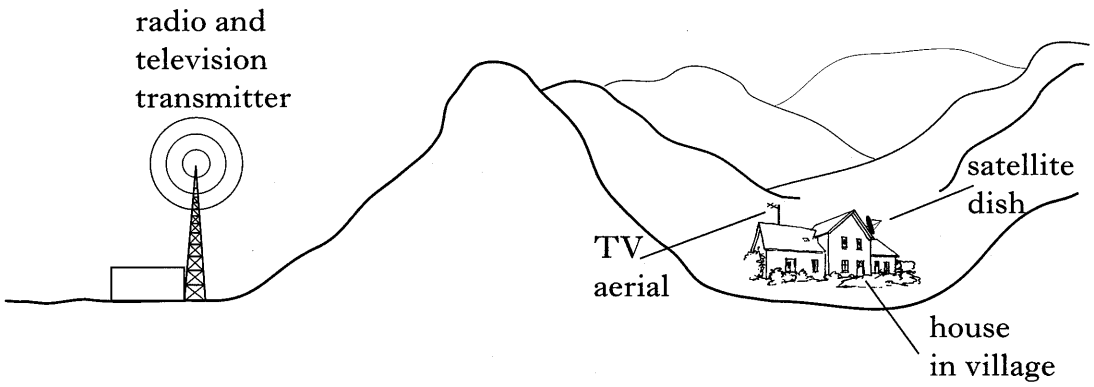
[Turn over

K&U	PS

Marks

1. (continued)

(*b*) Signals cannot be received from one of the bands when this radio is used in a village which lies in a deep valley surrounded by hills.



(i) Explain which band is not received.

.....

.....

.....

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

(ii) Houses in the village are unable to receive programmes from the local TV station but can receive satellite TV programmes broadcast on similar frequencies.

Suggest an explanation for this.

.....

.....

.....

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

Marks

2. The telecommunication system linking two towns uses copper wire. This system is being replaced by one which uses glass optical fibre.

(*a*) Give **two** advantages of the glass optical fibre system compared to the copper wire system.

(1) .....

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

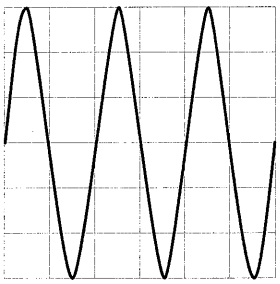
(*b*) A telephone engineer tests the time taken for signals to travel through each system. The distance travelled is the same in each case.

Explain which signal takes the shorter time.

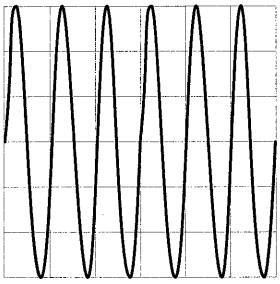
.....

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

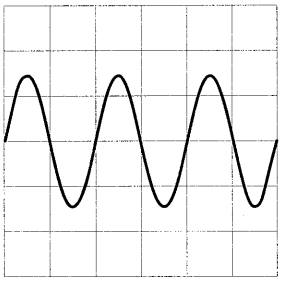
(*c*) The engineer sends three test signals X, Y and Z through the new system. An oscilloscope displays the test signals as shown in the diagrams below.



Test signal X



Test signal Y



Test signal Z

The settings on the controls of the oscilloscope are the same for each signal.

Test signal X has a frequency of 2·0 kHz and a peak voltage of 0·5 V.

(i) What is the frequency of test signal Y?

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

(ii) What is the peak voltage of test signal Z?

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

[Turn over

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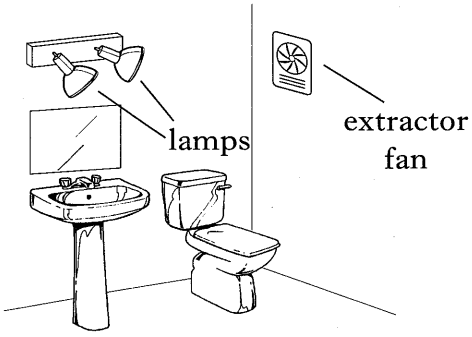
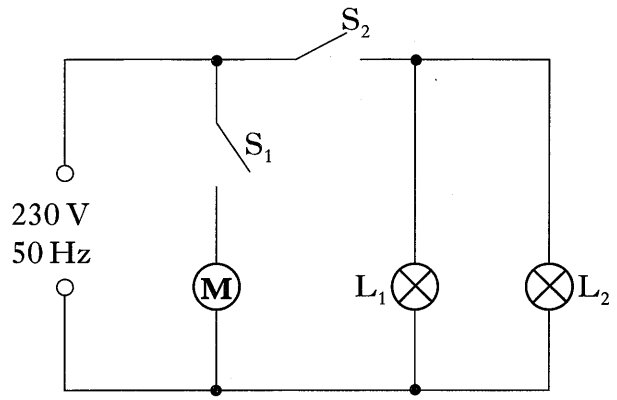
3. The electrical system in a bathroom consists of a motor in an extractor fan and two identical 60 W filament lamps connected to a 230 V supply. These are wired as shown in the circuit diagram below. *Marks*





The switches may be open or closed.

(*a*) Complete the table below, stating whether each of the motor and lamps will be ON or OFF.

Switch S_1	*Switch S_2*	*Motor*	*Lamp L_1*	*Lamp L_2*
Open	Open			
Open	Closed			
Closed	Open			
Closed	Closed			

(2)

(*b*) Show, by calculation, that one lamp has a resistance of 882 Ω.

Space for working and answer

(3)

(*c*) The motor has a resistance of 400 Ω.

Calculate the resistance of the bathroom circuit when the motor and both lamps are switched on.

Space for working and answer

(2)

K&U	PS

Marks

4. A technician measures the voltage across a component in a circuit using first a digital voltmeter and then an oscilloscope.

Figure 1 shows a digital voltmeter connected to the component and figure 2 shows an oscilloscope connected to the same component.

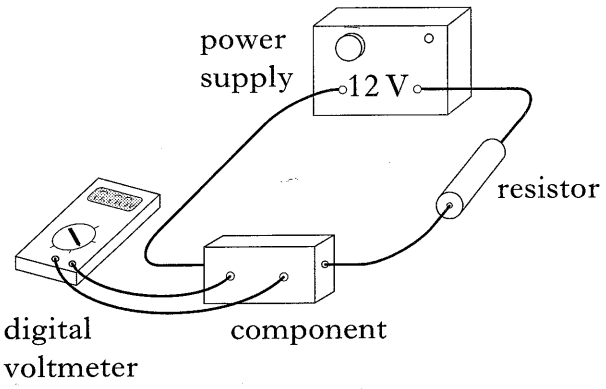


figure 1

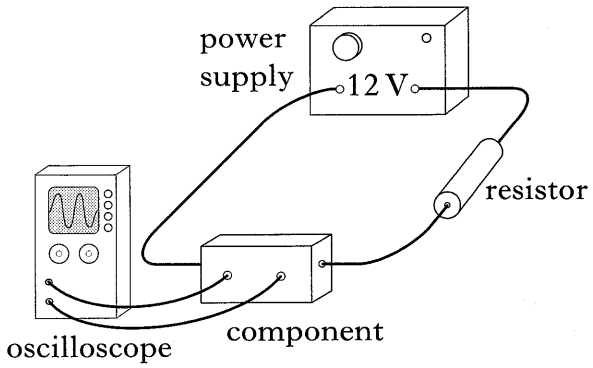
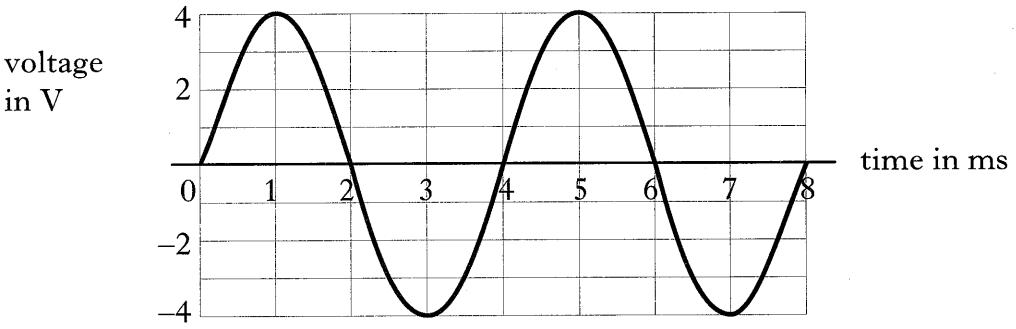


figure 2

(*a*) State whether the voltage across the component is direct or alternating.

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

(*b*) The graph below shows how the voltage across the component varies with time.



What is the peak voltage across the component?

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

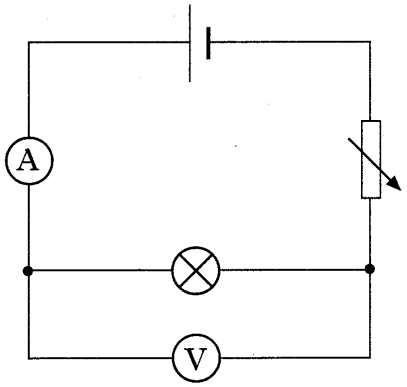
(*c*) How does the peak voltage compare with the voltage reading which would be shown on the digital voltmeter?

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

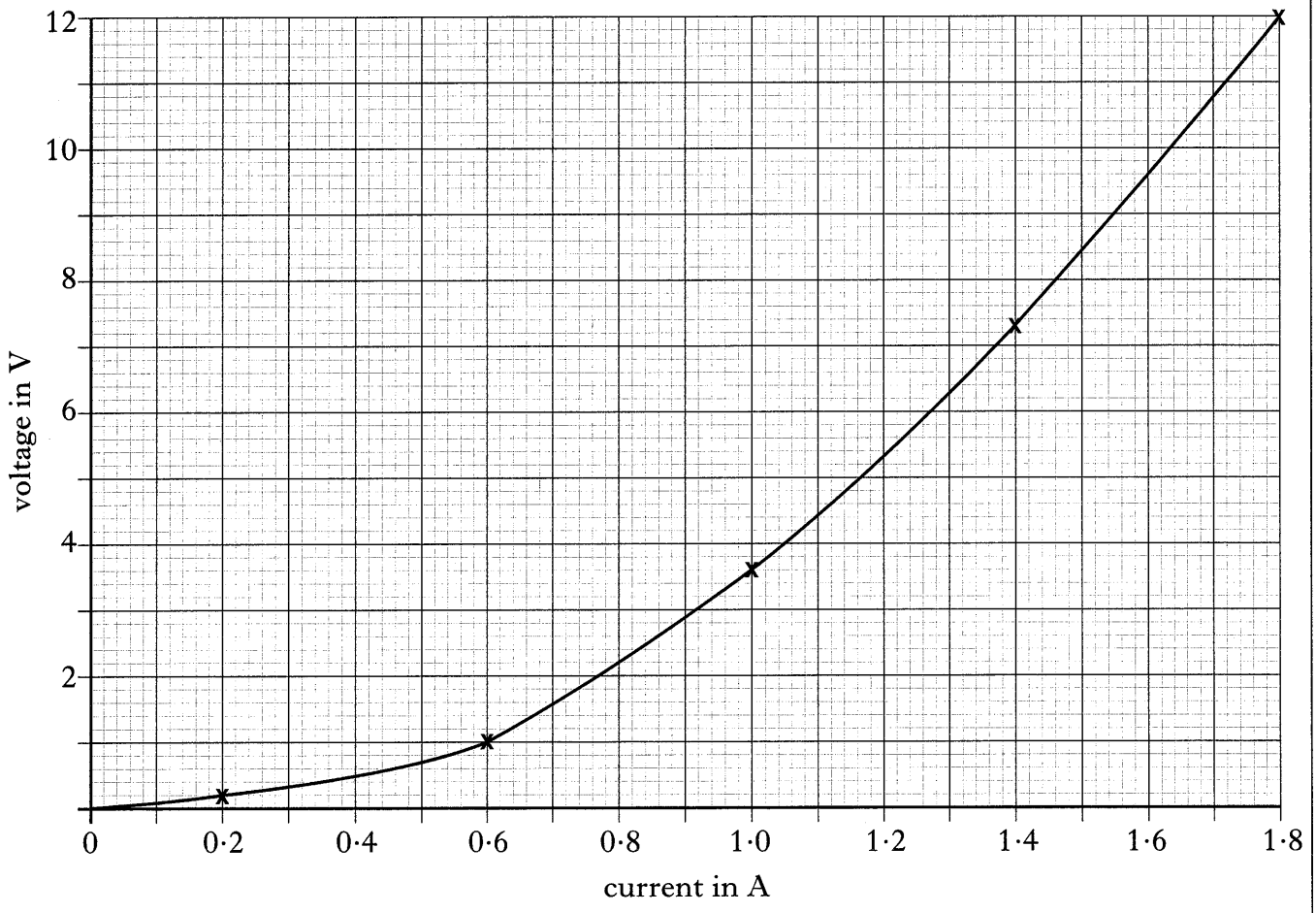
[Turn over

K&U	PS

5. A filament lamp is connected in a circuit as shown below.



The current in the lamp is altered. The voltage across the lamp is measured. The graph below shows how the voltage varies with the current for several values of current.



K&U	PS

Marks

5. (continued)

(*a*) State what happens to the resistance of the lamp as the current is increased. You **must** justify your answer by using information from the graph.

Space for working and answer

(3)

(*b*) The manufacturer states that the lamp has a power rating of 24 W when operating at 12 V.

Determine whether the power rating of this lamp is the same as that quoted by the manufacturer. You **must** clearly show the working which leads you to your answer.

Space for working and answer

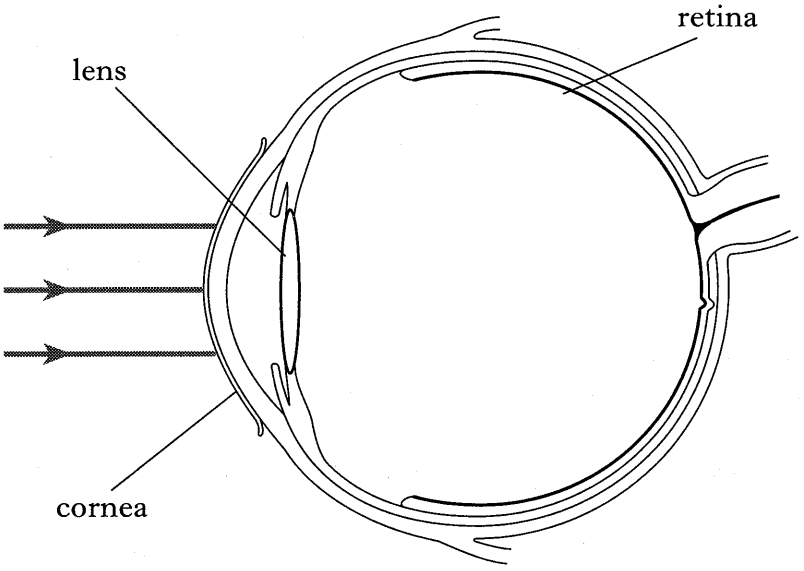
(3)

[Turn over

K&U	PS

Marks

6. (*a*) The diagram shows rays of light from a distant object reaching the eye of a person with normal sight. The focusing of the light is achieved by a combination of the cornea and the lens.



(i) Complete the diagram above to show the path of rays of light within the eye. **(2)**

(ii) This combination of cornea and lens has a power of + 59 D.

Calculate the focal length of the combination.

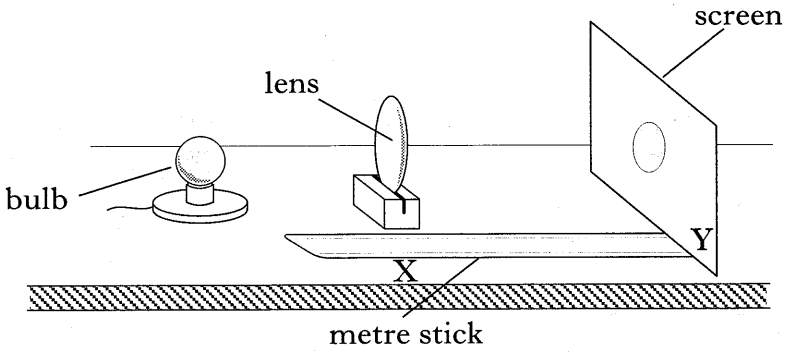
Space for working and answer

(2)

Marks

6. (continued)

(*b*) Alison wears spectacles for reading and decides to measure the focal length of one of her spectacle lenses. She sets up a screen, a brightly lit bulb and a metre stick as shown in the diagram below.



Alison moves the screen until a clear image of the bulb is obtained and then measures the distance XY between the lens and the screen.

(i) Give a reason why the distance XY is not equal to the focal length of the lens.

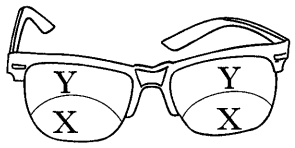
..... **(1)**

(ii) State the change Alison should make in carrying out her experiment so that she measures the focal length of the lens.

.....

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

(*c*) Alison's grandfather has used two pairs of spectacles for several years. One pair was for distance vision and the other for close work. The optician replaces the two pairs with one pair having lenses which are in two parts as shown below.



The parts of the lenses have power of +2D and +4D.

Part X is for close work and part Y is for distance vision.

Complete the table below to indicate the power of each part.

Lens part	*Power*
X	
Y	

(1)

K&U	PS

Marks

7. (*a*) A hospital uses radioactive Technetium in the diagnosis of tumours. The Technetium is injected into the patient.

The label on a sample which is delivered to the hospital is shown below.

TECHNETIUM	
Date of delivery	15/5/1997
Time of delivery	1.00 p.m.
Half-life	6 hours
Activity on delivery	600 MBq
Type of radiation	Gamma

(i) What is meant by the term "half-life"?

.....

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

(ii) Why is a sample with a short half-life used in diagnosis?

.....

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

(iii) If the sample of Technetium is not used, the hospital is allowed to dispose of it. This is permitted once its activity has fallen below 75 MBq.

Show, by calculation, the date and time when the sample will be ready for disposal.

Space for working and answer

(3)

Marks

7. (continued)

(*b*) The effect of radiation absorbed by living materials depends on a number of factors.

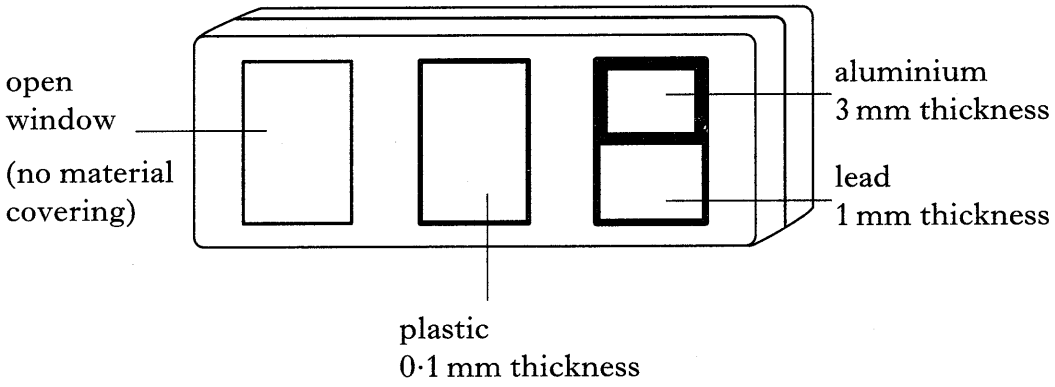
Name **two** of the factors.

(1) .....

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

(*c*) Members of the hospital staff wear film badges to monitor any radiation to which they may be exposed.

The film is contained in a plastic holder with windows of different materials as shown in the diagram. The whole badge is protected from light.



(i) Shade the window or windows on the diagram above where the film will be affected if the wearer is accidentally exposed to the radiation from the Technetium source. **(1)**

(ii) Describe how the badge is used to indicate how much radiation has been received.

.....

.....

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

[Turn over

K&U	PS

Marks

8. Figure 1 shows a conveyor belt in a supermarket. The belt is driven by a motor.

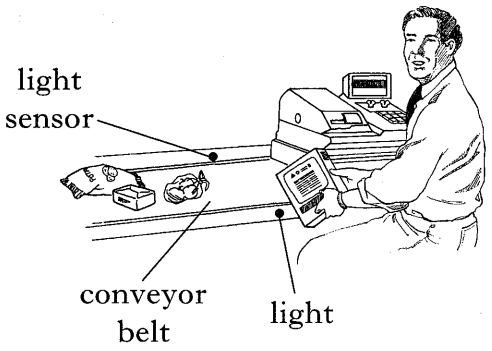


figure 1

Part of the mechanism which operates the motor uses a light-sensitive switch.

The conveyor belt stops when a package comes between the light and the light sensor.

(*a*) The light-sensitive part of the system is shown in figure 2.

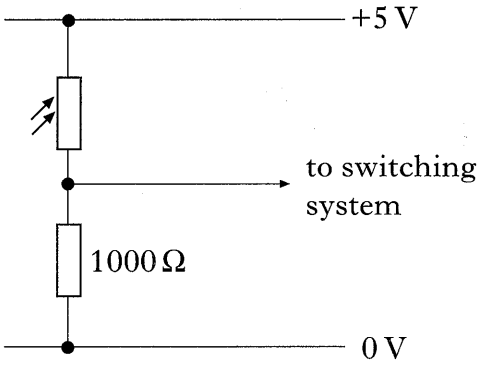


figure 2

The resistance of the light dependent resistor (LDR) in different lighting conditions is shown in the table below.

Lighting condition	*Resistance of LDR*
Light	100 Ω
Dark	10 000 Ω

Calculate the voltage across the 1000 Ω resistor when the LDR is in darkness.

Space for working and answer

(2)

Marks

8. (continued)

(*b*) The conveyor belt motor is connected to the light sensor using a transistor and relay as shown in figure 3.

The transistor switches off when the voltage across the 1000 Ω resistor drops below 0·7 V. The relay switch is used to switch the motor on and off.

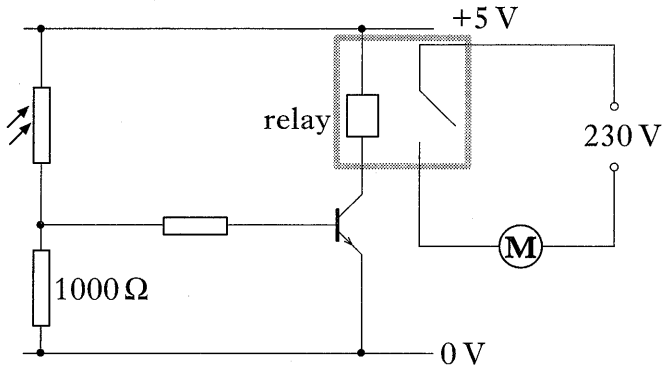


figure 3

Figure 4 shows the construction of the relay switch.

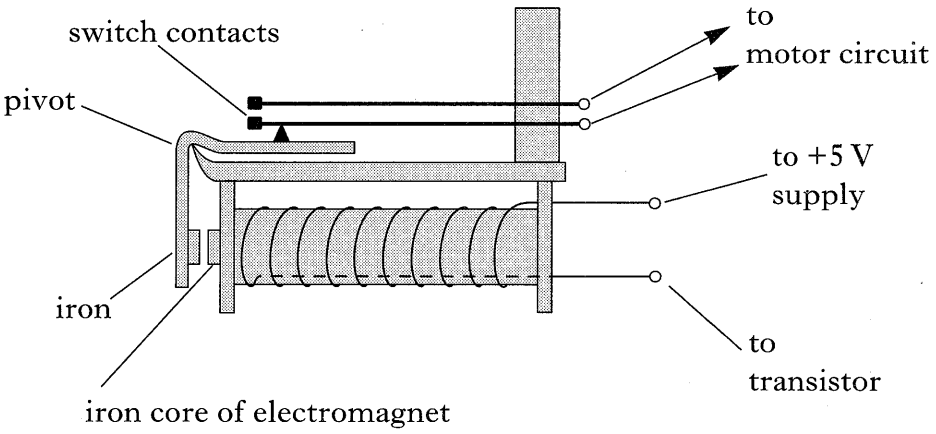


figure 4

Explain why the conveyor belt stops when a package comes between the light and the light sensor.

.....

.....

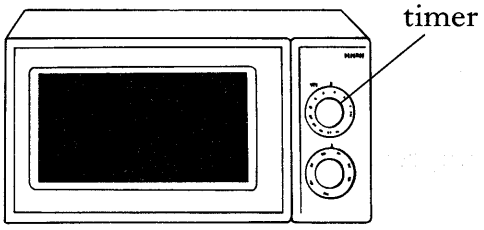
.....

.....

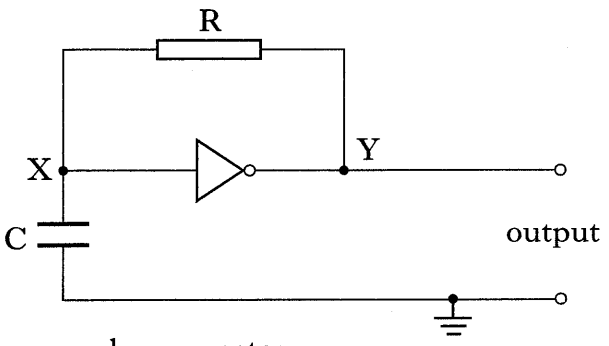
..... **(3)**

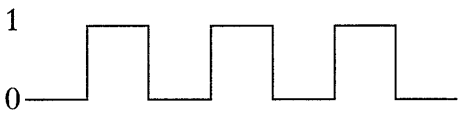
Marks

9. The timer in a microwave oven uses a circuit which produces pulses. The part of the circuit which generates the pulses is shown below. The voltage supply has not been included in the diagram.



Microwave oven





(*a*) Complete the table below to show the logic levels at X and Y when the capacitor in the circuit is charged and when it is uncharged.

	Logic level at X	*Logic level at Y*
Capacitor charged		
Capacitor uncharged		

(2)

(*b*) The output from the above circuit is connected to a counter and a seven segment display.

At what frequency should the pulses be generated for the seven segment display to change every second?

.....

(1)

(*c*) When tested, the timer was found to run slowly.

What change should be made to the circuit to correct this fault? Explain your answer.

.....

.....

(2)

K&U	PS

Marks

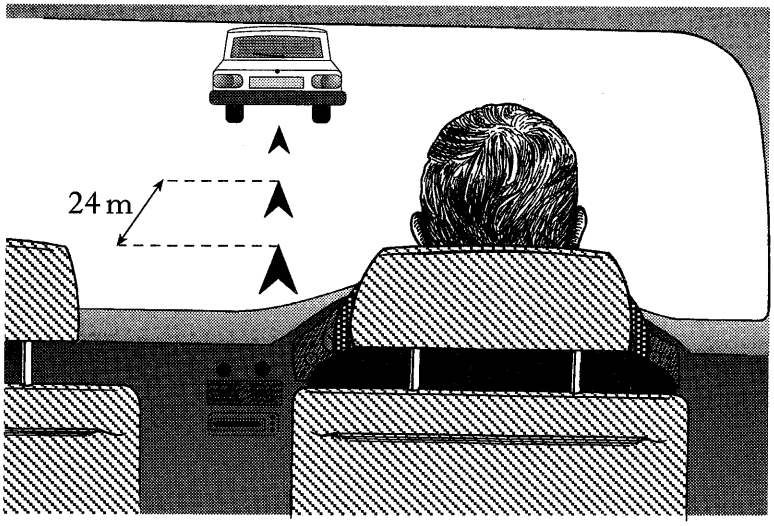
10. Two factors which contribute to road safety are:

(1) leaving a suitable distance between vehicles;

(2) using safety belts.

(*a*) Some motorists drive too close to the car in front on motorways. In an experiment, large arrows are painted 24 m apart on a road in an attempt to improve safety.

The advice to motorists travelling at the maximum speed of 70 mph is "*make sure that you can see at least three arrows between your car and the car in front*".



(i) A car took 0·8 s to travel from one arrow to the next.

Calculate the average speed of the car between the arrows.

Space for working and answer

(2)

(ii) Road safety experts extend the experiment to built up areas with a speed limit of 30 mph.

How would the distance between the arrows on such a road compare with that on the motorway where the speed limit is 70 mph?

.....

(1)

K&U	PS

Marks

10. (continued)

(*b*) (i) A car travelling at a speed of 30 m/s approaches slow moving traffic. The car decelerates at 4·5 m/s^2 for a time of 5 s.

Calculate the speed of the car on reaching the slow moving traffic.

Space for working and answer

(2)

(ii) During the above deceleration, the seat belt provides 50% of the force required to prevent the driver leaving the seat of the car. The mass of the driver is 72 kg.

Calculate the force exerted by the seat belt on the driver.

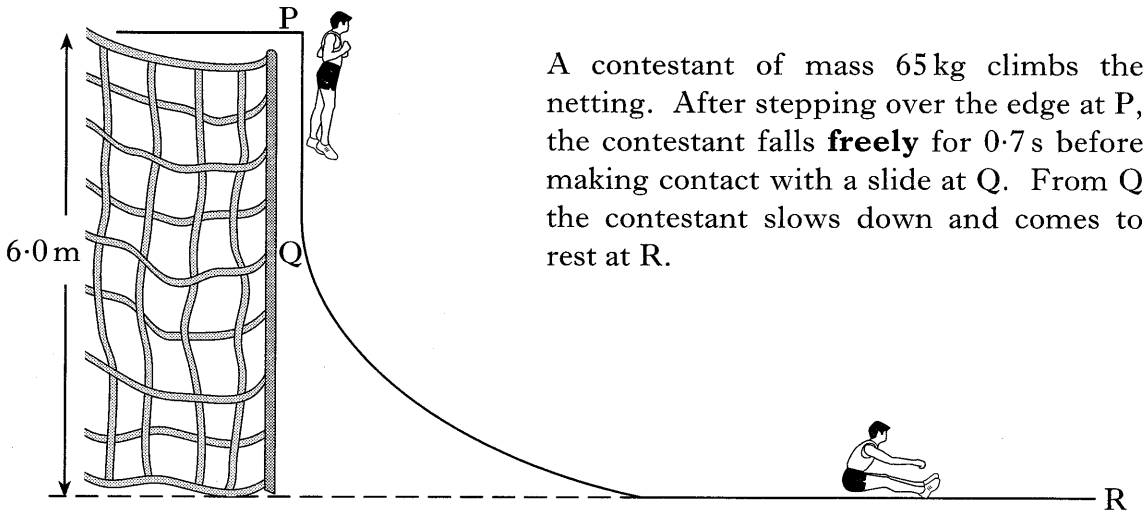
Space for working and answer

(3)

K&U	PS

Marks

11. Contestants in a competition shown on TV have to go round an assault course. On one of the obstacles they climb rope netting and then drop down the other side. The height of the netting is 6·0 m above the ground.



A contestant of mass 65 kg climbs the netting. After stepping over the edge at P, the contestant falls **freely** for 0·7 s before making contact with a slide at Q. From Q the contestant slows down and comes to rest at R.

(*a*) The 65 kg contestant climbs the netting from the ground to P.

Calculate the gravitational potential energy gained by the contestant.

Space for working and answer

(2)

(*b*) The contestant falls freely (ie without friction) between P and Q.

(i) Name the force acting on the contestant between P and Q.

(1)

(ii) Calculate the size of the force on the contestant between P and Q.

Space for working and answer

(2)

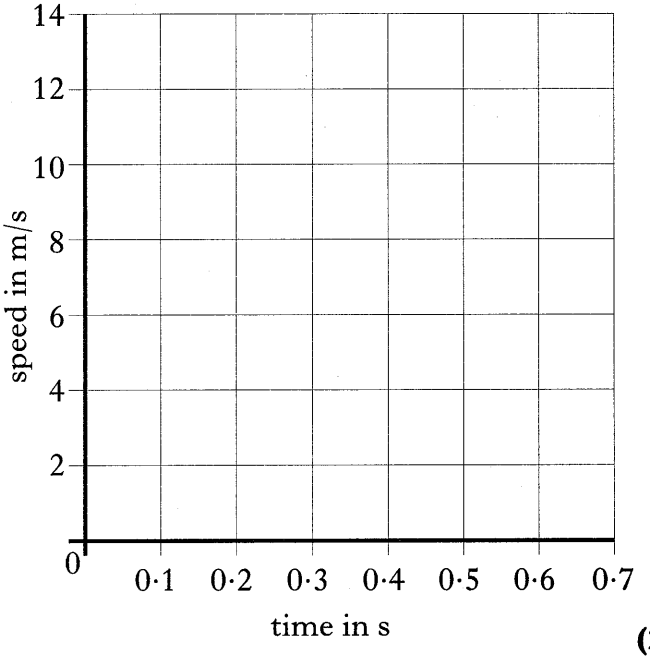
K&U	PS

Marks

11. (continued)

(*c*) Using the axes given below, draw the speed-time graph for the fall from P to Q.

Space for working



(2)

(*d*) Calculate the height of point Q above R.

Space for working and answer

(3)

K&U	PS

Marks

12. Figure 1 shows a dynamo fitted to a bicycle. Figure 2 shows how the dynamo is constructed.

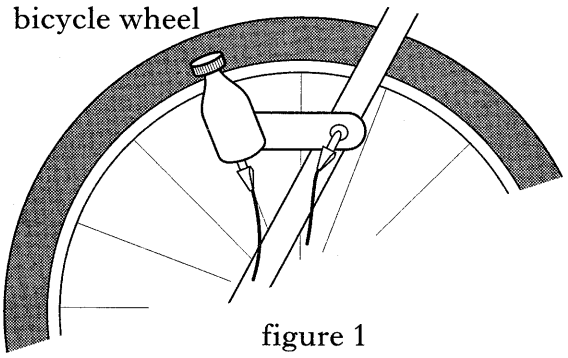


figure 1

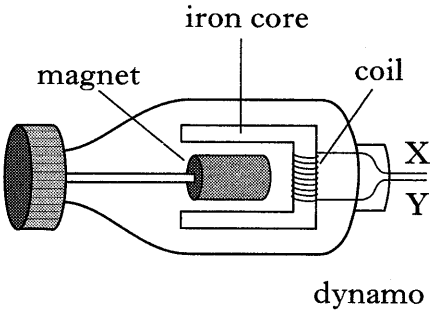


figure 2

The bicycle is pedalled along a level road at a steady speed and a voltage is produced across XY.

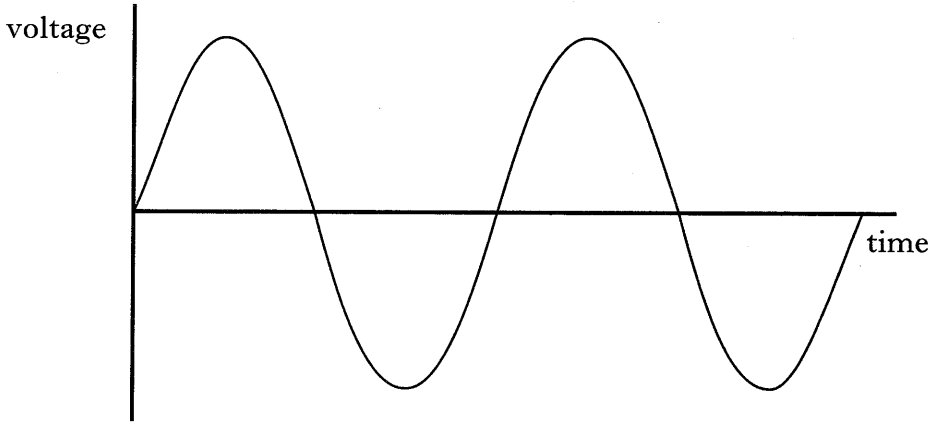
(*a*) Explain why a voltage is produced across XY.

.....

.....

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

(*b*) The diagram below shows how the output voltage from the dynamo varies with time when the pedals are turned at a steady speed.

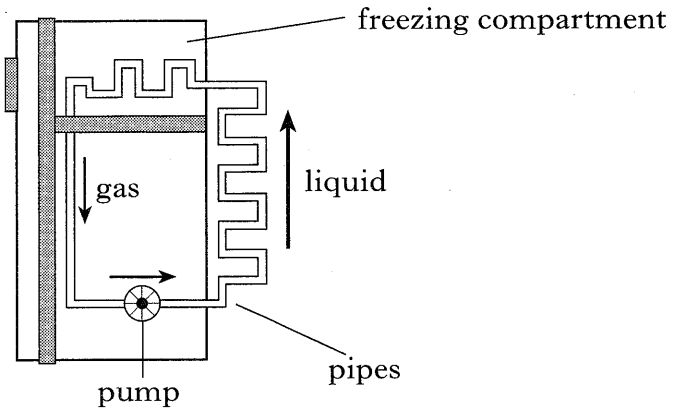


On the diagram above, sketch a curve which would be obtained if the bicycle was pedalled at a **slower** steady speed. **(2)**

[Turn over

Marks

13. The diagram below shows part of a refrigerator which has a freezing compartment.



(*a*) A substance which is called a coolant is circulated in the pipes by the pump.

(i) Name the change in state of the coolant in the freezing compartment.

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

(ii) Explain why this change of state keeps the freezer compartment cool.

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

(*b*) An ice tray containing 0·2 kg of water is placed in the freezing compartment. The water cools to 0 °C and then freezes.

Calculate how much heat is given out as the water in the tray freezes at 0 °C.

[Specific latent heat of fusion of water = $3{\cdot}34 \times 10^5$ J/kg]

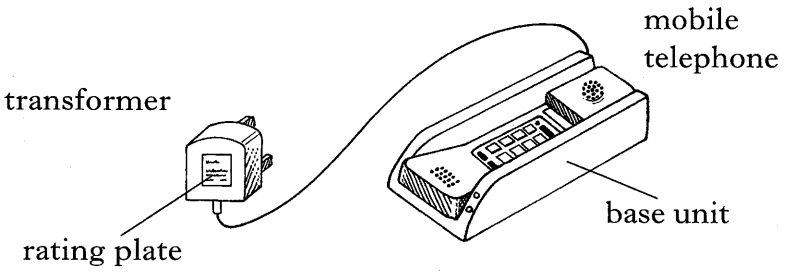
Space for working and answer

(2)

K&U	PS

Marks

14. A mobile telephone operates using rechargeable batteries. When not in use the batteries are recharged using a base unit. The base unit is connected to a 230 V a.c. supply using a transformer.



The rating plate on the transformer is shown below.

For overnight charges only
OUTPUT: 24 V 4·6 W
SPD 6204
INPUT: 230 V 50 Hz A.C. ONLY
MADE IN UK PX 450

(*a*) The primary coil of the transformer has 690 turns.

Calculate the number of turns on the secondary coil of the transformer.

Space for working and answer

(2)

(*b*) Calculate the current drawn from the supply if the transformer is 100% efficient.

Space for working and answer

(2)

(*c*) In practice, the transformer is not 100% efficient.

Give a reason for this.

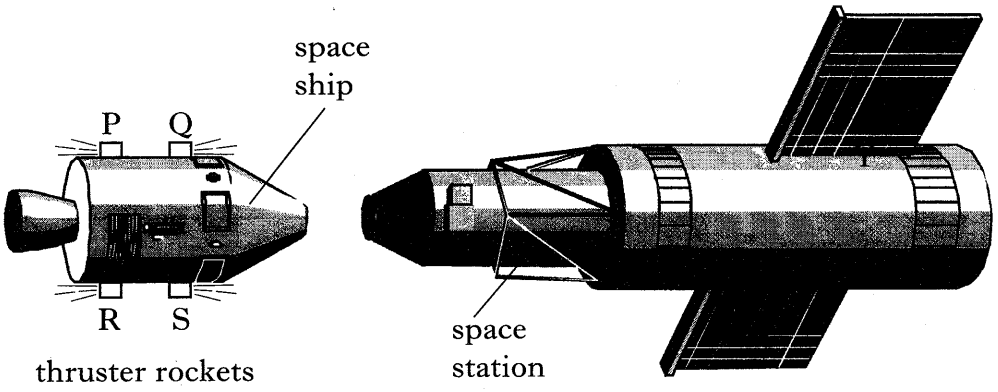
.....

(1)

K&U	PS

Marks

15. In deep space, a spaceship of mass 16 000 kg is trying to dock with a space station. The spaceship is stationary.



The spaceship has four small thruster rockets P, Q, R and S as shown, which are used when docking. In order to approach the space station, the crew of the spaceship fire two of the thruster rockets for 10 seconds and then switch them off. After 10 seconds the speed of the spaceship is 2 m/s.

(*a*) Calculate the gain in the kinetic energy of the spaceship after the 10 seconds.

Space for working and answer

(2)

(*b*) Describe and explain the motion of the spaceship **after** the motors are switched off.

.....

.....

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

(*c*) Describe what the crew must do to bring the spaceship back to rest.

.....

.....

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

K&U	PS

Marks

16. On one of the missions to the Moon, astronauts took a large mirror which they set up and left behind on the surface. Scientists on Earth determined the distance between the Earth and the Moon by reflecting laser light from the mirror.

(*a*) The astronauts found it easier to lift the mirror on the Moon than on the Earth.

Suggest a reason for this. You must quote figures from the data sheet on *Page two* to support your answer.

.....

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

(*b*) Using a powerful laser and a clock, scientists on Earth measured the exact time for the laser light to travel to the Moon and back. The reading on the clock was 2·56 s.

[Speed of light in air or vacuum = 3×10^8 m/s]

Calculate the distance from the Earth to the Moon.

Space for working and answer

(3)

(*c*) While setting up the mirror on the Moon, the astronauts were in radio communication with Earth.

How did the time taken for the radio waves to travel to the Moon compare with the time taken for the laser light to travel to the Moon?

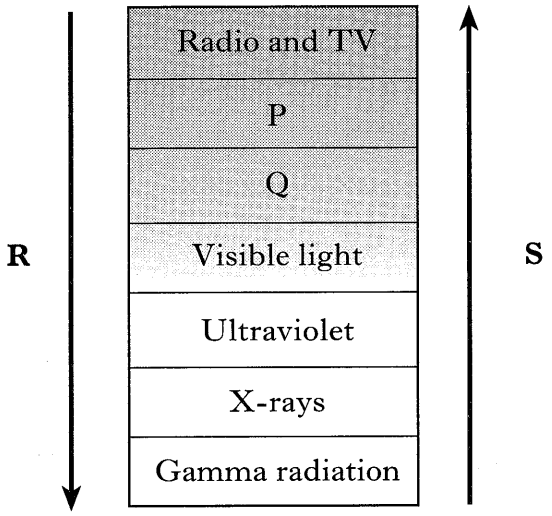
..... **(1)**

[Turn over for Question 16(*d*) on *Page twenty–six*

Marks

16. (continued)

(*d*) Visible light from the laser is one part of the electromagnetic spectrum. The diagram below shows the electromagnetic spectrum but two parts, P and Q are missing.



(i) Name radiation P and radiation Q.

Radiation P .....

Radiation Q ..... **(1)**

(ii) Which of the arrows, R or S, shows the direction of increasing wavelength of the electromagnetic radiation in the spectrum?

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

[*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.

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