FOR OFFICIAL USE

C

K & U	PS

Total Marks

3220/402

NATIONAL QUALIFICATIONS 2003

MONDAY, 19 MAY
10.50 AM – 12.35 PM

PHYSICS
STANDARD GRADE
Credit Level

Fill in these boxes and read what is printed below.

Full name of centre | Town

Forename(s) | Surname

Date of birth
Day Month Year | Scottish 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.

SAB 3220/402 6/3/3/25870

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	$22{\cdot}6 \times 10^5$

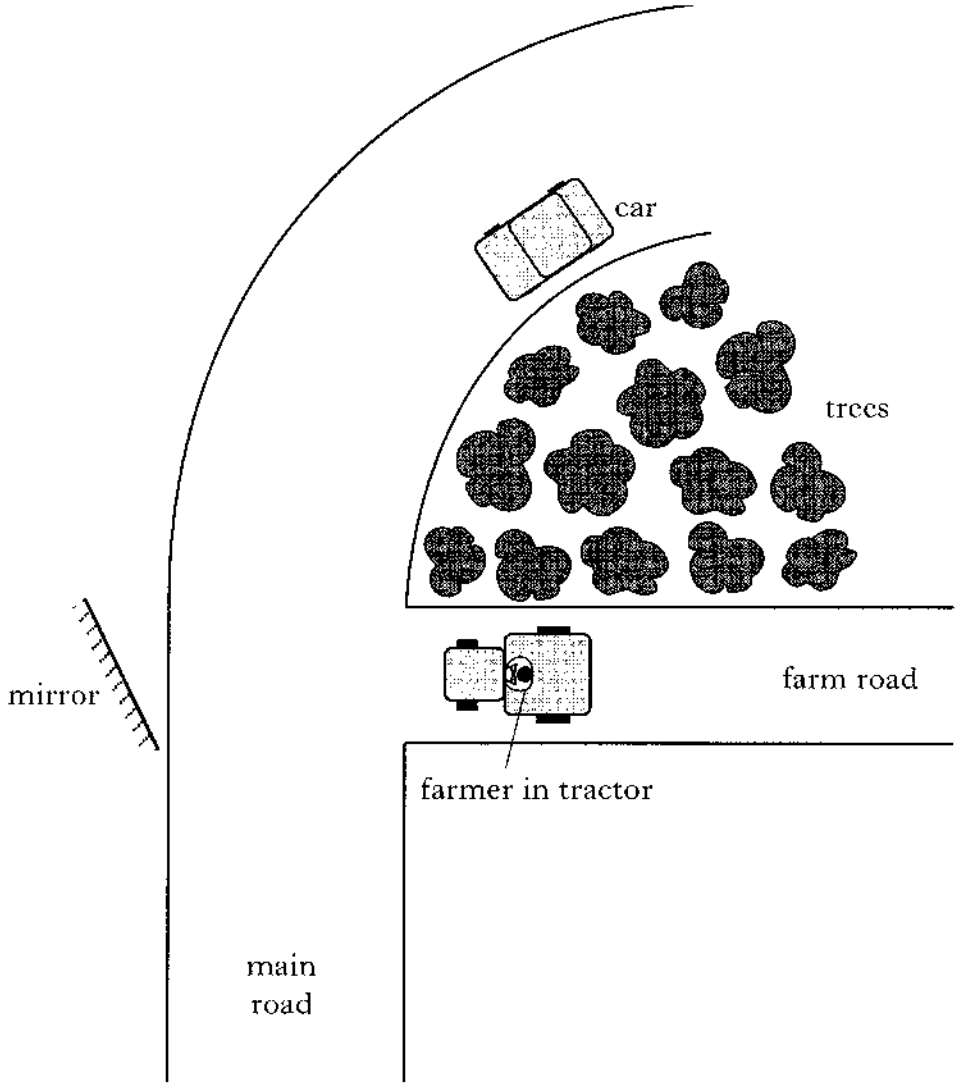
SI Prefixes and Multiplication Factors

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

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

1. A farm road joins a main road at a bend. The farmer has placed a mirror as shown so that he can see when cars are approaching.



(*a*) On the diagram, draw rays to show how the farmer in the tractor can see the car by using the mirror.

You must label the angle of incidence and the angle of reflection on your completed diagram. **3**

(*b*) State why the driver of the car can **also** see the tractor using the mirror.

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..... **1**

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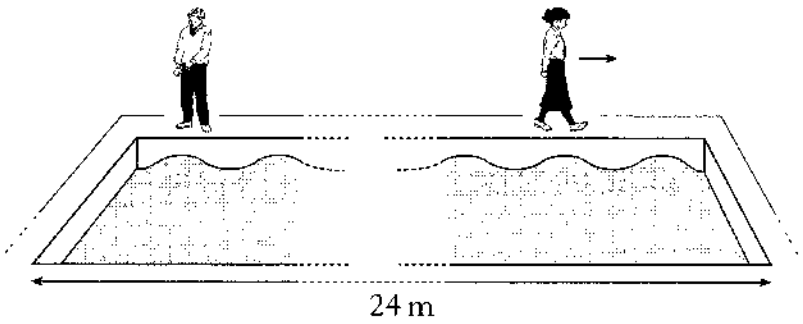
Marks	K&U	PS

2. Two students watch the waves produced by a wave machine at a swimming pool.



One student walks beside a wave as it travels along the pool. The wave goes from one end of the pool to the other in 20 s. The length of the pool is 24 m.

(*a*) Calculate the speed of the waves.

Space for working and answer

2

(*b*) In the same time interval, the other student counts 5 waves going past the point where he is standing.

Calculate the frequency of the waves.

Space for working and answer

2

DO NOT WRITE IN THIS MARGIN

	Marks	K&U	PS

2. (continued)

(*c*) The students note that there are 5 complete waves in the pool at any time.

Calculate the wavelength of the waves.

Space for working and answer

2

(*d*) Explain why "distance divided by time" and "frequency times wavelength" are equivalent for a wave.

Space for working and answer

2

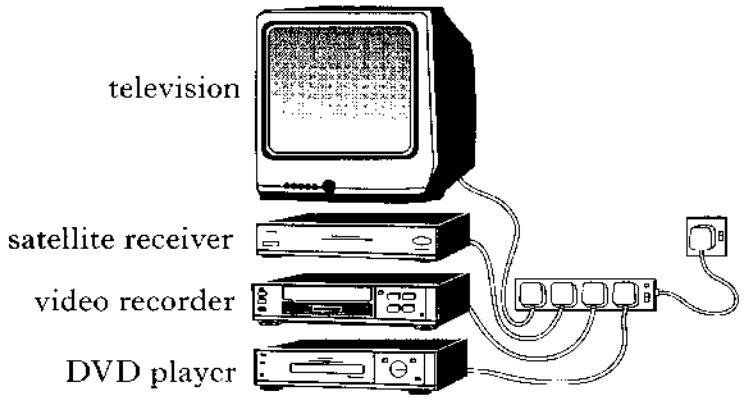
[Turn over

Marks | K&U | PS

3. A home entertainment centre consists of four appliances. The table gives the power rating of each appliance.

Appliance	*Power rating* (W)
television	110
video recorder	22
satellite receiver	20
DVD player	18

To operate properly, each appliance must be connected to mains voltage. The appliances are connected to the mains using a multiway adaptor.



(*a*) (i) State the value of the operating voltage of the appliances.

..... **1**

(ii) The connections in the multiway adaptor are arranged to ensure that each appliance is connected to mains voltage.

State how the connections in the multiway adaptor are arranged to achieve this.

..... **1**

(*b*) Calculate the current from the mains when all four appliances are operating at the power ratings shown in the table.

(You must use an appropriate number of significant figures in your answer to this question.)

Space for working and answer

3

DO NOT WRITE IN THIS MARGIN

	Marks	K&U	PS

3. (continued)

(*c*) Calculate the resistance of the television when it is operating at the power rating stated in the table.

Space for working and answer

2

(*d*) The plug on the flex of the multiway adaptor contains a fuse.

What is the purpose of this fuse?

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[Turn over

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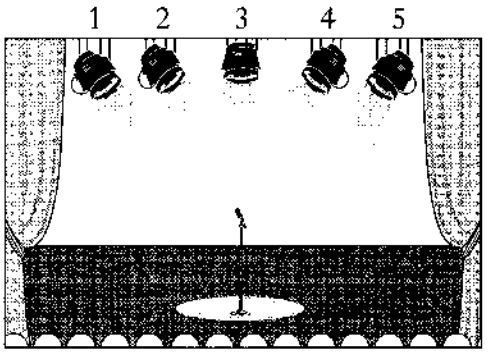
Marks	K&U	PS

4. A show uses five spotlights of equal brightness, pointing at the same place on the stage.



The spotlights can be turned on and off individually. The colour of light from each spotlight is shown in the table.

Spotlight	*Colour*
1	green
2	blue
3	red
4	blue
5	green

(*a*) State **three** spotlights that could be on to produce white light on the stage.

.....

..... **1**

(*b*) One scene requires yellow light.

State **two** spotlights that could be on to produce yellow light on the stage.

.....

..... **1**

(*c*) Another scene requires **pale** green light. This needs **four** of the spotlights to be on.

State **one** spotlight that could be **off** so that the other four produce pale green light.

..... **1**

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

5. A textbook has three diagrams showing how an eye lens changes when looking at objects that are different distances away. The diagrams below are copies of these three diagrams, with parts omitted.

Diagrams 1 and 3 are not complete.

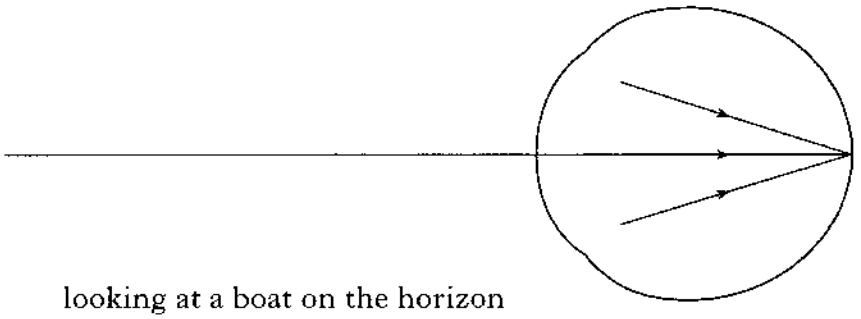


Diagram 1 looking at a boat on the horizon

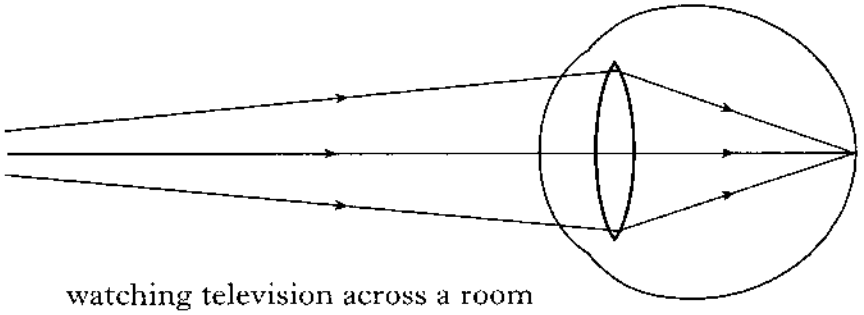


Diagram 2 watching television across a room

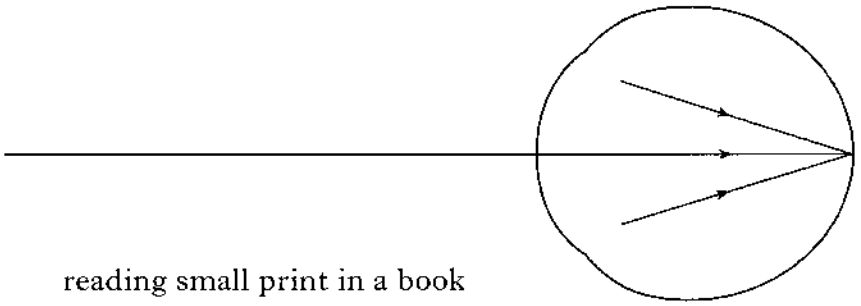


Diagram 3 reading small print in a book

(*a*) On diagrams 1 **and** 3:

(i) draw two rays to show light coming from each object to the eye;

(ii) draw a lens to show how the shape of the eye lens is different from the shape of the lens in diagram 2. **4**

(*b*) The focal length of an eye lens system (the cornea and the eye lens together) is 2·5 cm.

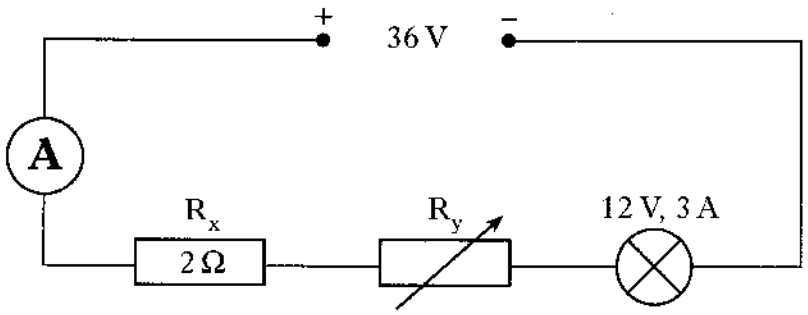
Calculate the power of this eye lens system.

Space for working and answer **2**

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

6. A student designs the circuit shown to operate a 12 V, 3 A lamp from a 36 V supply.



(*a*) What is the reading on the ammeter when the lamp is operating at its correct power rating?

..... 1

(*b*) The resistance of R_x is 2 Ω.

Calculate the voltage across R_x when the lamp is operating correctly.

Space for working and answer 2

(*c*) Calculate the resistance of R_y when the lamp is operating correctly.

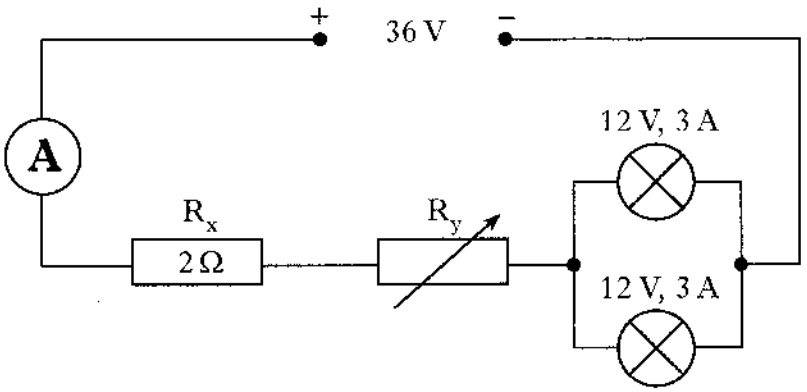
Space for working and answer 3

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

6. (continued)

(*d*) The student connects a second, identical lamp as shown in the diagram below.



Explain why the resistance of R_y has to be adjusted for both lamps to operate correctly.

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[Turn over

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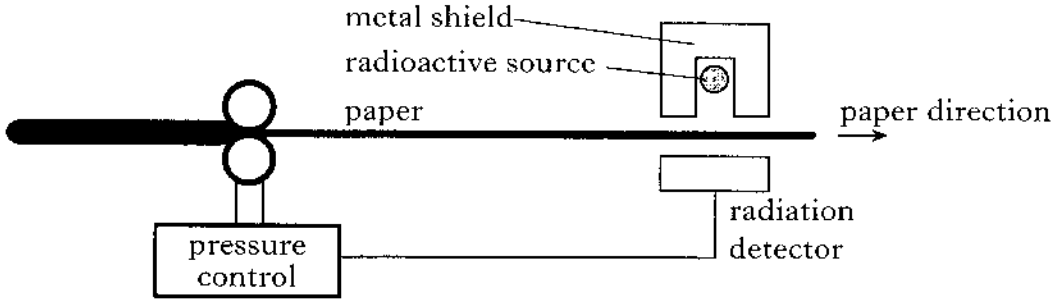
Marks | K&U | PS

7. A paper mill uses a radioactive source in a system to monitor the thickness of paper.



The count rate detected by the radiation detector changes as the thickness of the paper varies. The radiation detector sends signals to the pressure control to maintain an even thickness of paper. The radioactive source emits a type of radiation that is partly absorbed by the paper. The source also has a half-life that allows the mill to run continuously, for several days.

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

.....

..... **1**

(*b*) The following radioactive sources are available.

Source	*Half-life*	*Radiation emitted*
P	500 years	alpha
Q	20 hours	beta
R	450 years	beta
S	300 years	gamma

(i) Explain why source P cannot be used in this system.

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.....

..... **1**

(ii) Which source should be used? Explain your answer.

.....

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..... **2**

DO NOT WRITE IN THIS MARGIN

Marks | K&U | PS

7. (continued)

(*c*) Why does the radioactive source in the paper mill have a metal shield?

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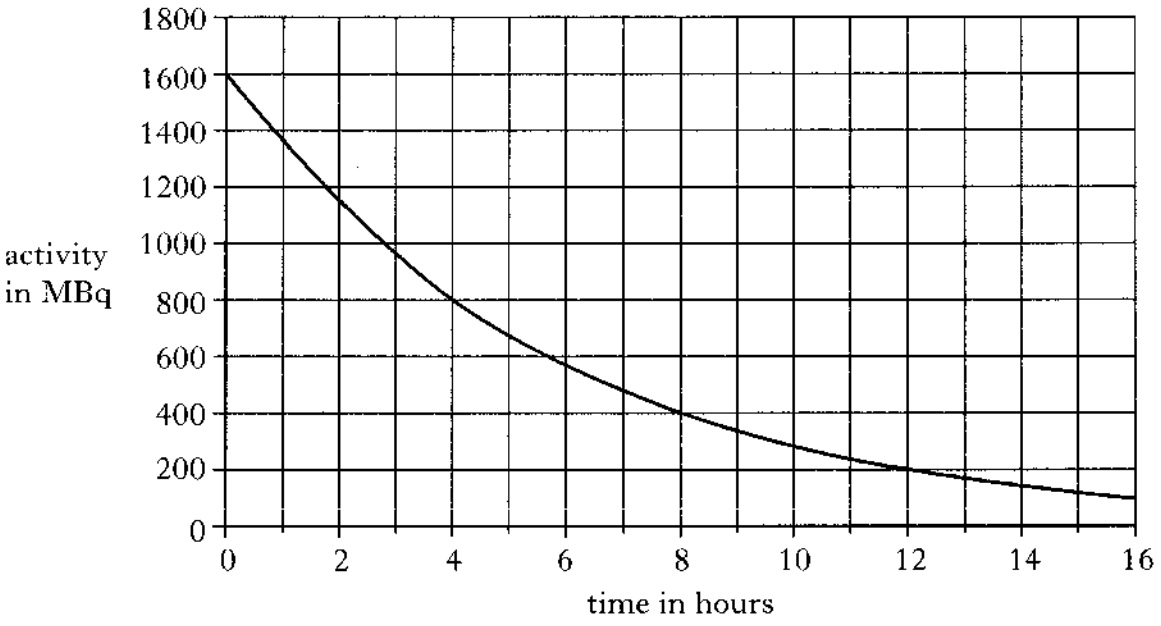
..... 1

(*d*) Another radioactive source emits gamma radiation. The graph shows how the activity of this source decreases with time.



Calculate the half-life of this radioactive source.

Space for working and answer

1

[Turn over

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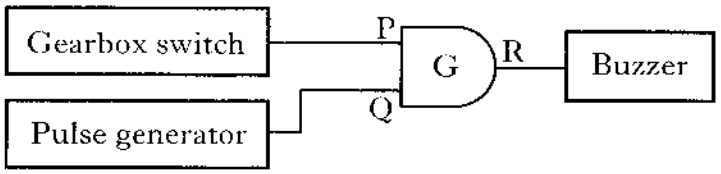
Marks	K&U	PS

8. A bus is fitted with a buzzer that sounds only when the bus is reversing. Part of the circuit that operates the buzzer is shown.



The output from the gearbox switch is high (logic 1) when the bus is reversing.

(*a*) Name logic gate G.

..... 1

(*b*) The table shows the different possible combinations of logic levels (0 or 1) for input P and input Q to gate G.

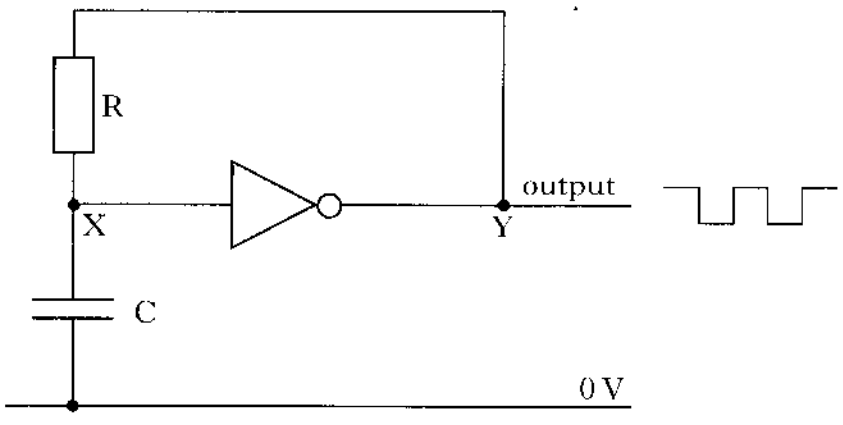
Complete the last column of the table by **drawing** the output R from gate G for each combination of inputs.

Input P	*Input Q*	*Output R*
1 0 ———	1 0 ———	1 0
1 0 ———	1 0 ⊓⊓	1 0
1 ———	1 0 ———	1 0
1 ———	1 0 ⊓⊓	1 0

2

(*c*) The pulse generator part of the circuit is shown below.

The power supply to the NOT gate has been omitted for clarity.



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	Marks	K&U	PS

8. (*c*) (continued)

(i) Capacitor C is initially discharged.

Explain the operation of the pulse generator circuit, by referring to points X and Y in the circuit.

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.....

.....

.....

..... **2**

(ii) The pulse generator produces an output with a high frequency.

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

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..... **1**

[Turn over

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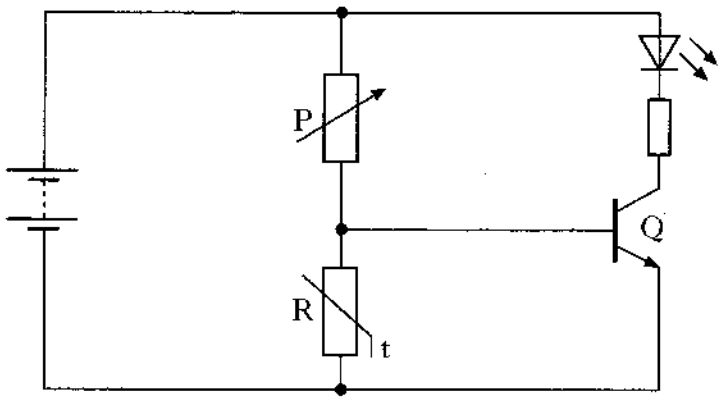
	Marks	K&U	PS

9. An electronic circuit is shown below. Component R is a thermistor.



(*a*) Name component P.

..... **1**

(*b*) (i) Name component Q.

..... **1**

(ii) **In this circuit**, what is the function of component Q?

..... **1**

(*c*) Explain how the circuit operates.

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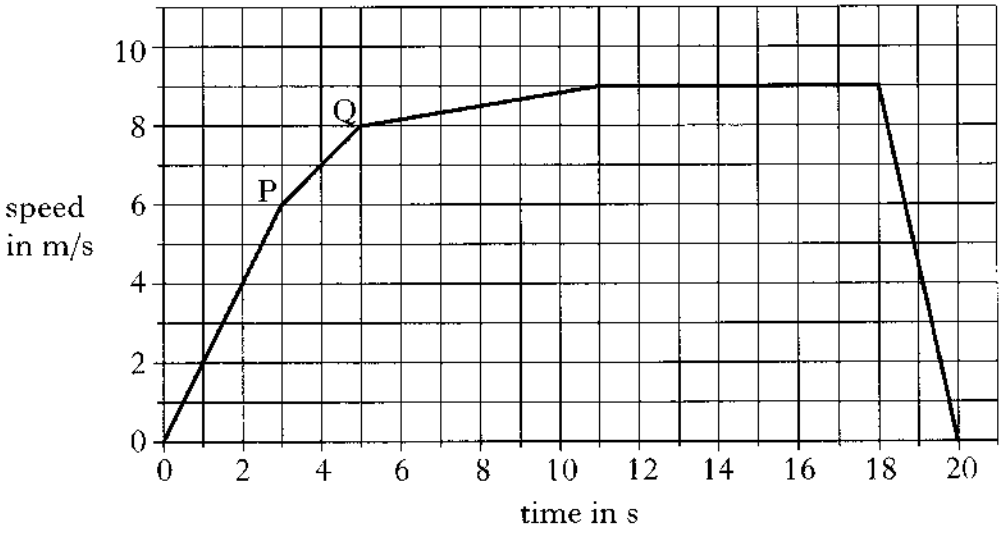
DO NOT WRITE IN THIS MARGIN

Marks | K&U | PS

10. A cyclist starts a journey in first gear and uses two other gears during the journey. After a short time the cyclist is forced to brake sharply and comes to a halt. A speed-time graph of the journey is shown.



At point P the cyclist changes from first gear to second gear.
At point Q the cyclist changes from second gear to third gear.

(*a*) (i) Before braking, which gear is the cyclist using when the acceleration is greatest?

..... **1**

(ii) Which gear does the cyclist use for the shortest time?

..... **1**

(*b*) Calculate how far the cyclist travels in second gear.

Space for working and answer

3

(*c*) Calculate the deceleration.

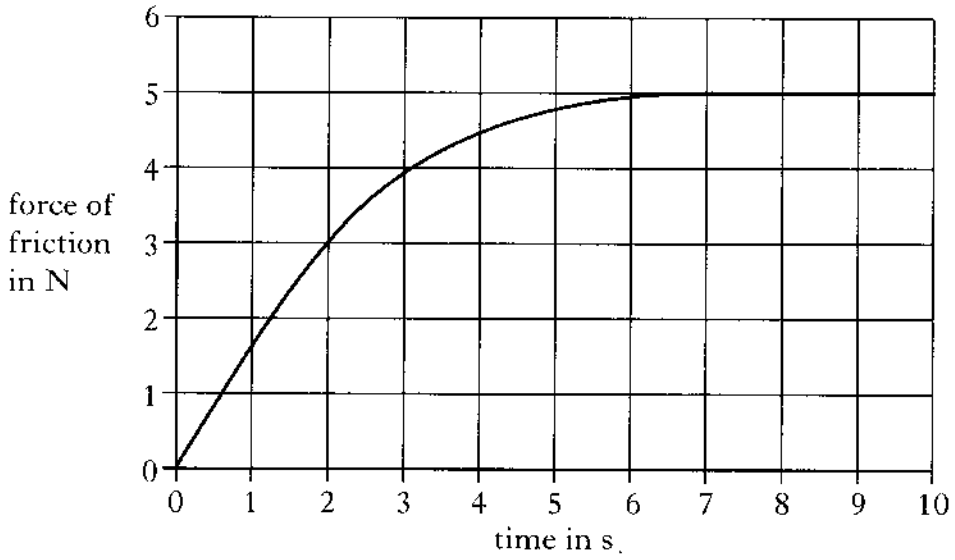
Space for working and answer

2

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

11. A model motor boat of mass 4 kg is initially at rest on a pond. The boat's motor, which provides a constant force of 5 N, is switched on. As the boat accelerates, the force of friction acting on it increases. A graph of the force of friction acting on the boat against time is shown.



(*a*) (i) State the force of friction acting on the boat 2 s after the motor is switched on.

..... **1**

(ii) Calculate the acceleration of the boat at this time.

Space for working and answer

3

(*b*) Describe and explain the movement of the boat after 7 s.

.....

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..... **2**

DO NOT WRITE IN THIS MARGIN

12. A battery charger with an input voltage of 230 V is used to recharge a car battery. The charger contains a transformer that has an output voltage of 13·8 V.

Marks | K&U | PS

(*a*) What type of transformer does the battery charger contain?

..... 1

(*b*) There are 4000 turns in the primary coil of the transformer.

Assuming the transformer is 100% efficient, calculate the number of turns in the secondary coil.

Space for working and answer

2

(*c*) (i) When charging the battery, the current in the secondary coil is 4·7 A.

(A) Calculate the power output of the transformer.

Space for working and answer

2

(B) In practice, the transformer is only 94% efficient.
Calculate the current in the primary coil.

Space for working and answer

3

(ii) State and explain **one** reason why a transformer is not 100% efficient.

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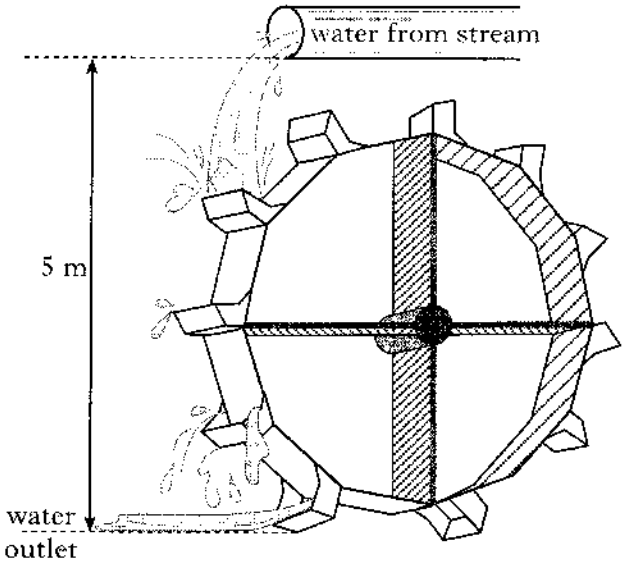
.....

..... 2

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

13. Water from a stream is used to drive a water wheel. The stream provides 6000 kg of water per minute to the wheel. The water falls a vertical height of 5 m.



(*a*) Show that the maximum power available to the wheel from the water is 5000 W.

Space for working and answer

3

(*b*) The water wheel turns an electrical generator. The generator produces an output of 2990 W.

(i) Calculate the efficiency of the water wheel and generator system.

Space for working and answer

2

DO NOT WRITE IN THIS MARGIN

	Marks	K&U	PS

13. (*b*) (continued)

(ii) Give **two** reasons why the efficiency of this system is not 100%.

.....

.....

.....

..... **2**

(iii) The generator is connected to a heater in a shed. The heater heats the air in the shed. The mass of air in the shed is 161 kg. The specific heat capacity of air is 1000 J/kg °C.

Calculate the minimum time to increase the temperature of the air in the shed by 13 °C.

Space for working and answer

3

(iv) Give **one** reason why the actual time taken to increase the temperature of the air in the shed is greater than the value calculated in (iii).

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..... **1**

[Turn over

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

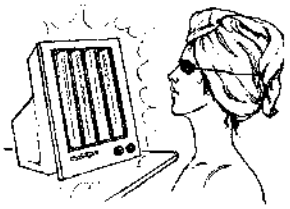
14. Gamma rays, ultraviolet and infrared are three members of a family of waves. Every member of this family travels at the speed of light.

(*a*) What name is given to this family of waves?

..... **1**

(*b*) Some uses of waves in this family are shown below.

Photographing bones inside a body

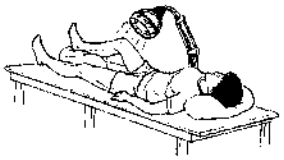


Tanning with a sun-ray lamp

Sterilising medical instruments

Communicating with mobile phones

Linking networked computers through optical fibres



Treating injuries using a heat-lamp

(i) From the examples above, give a use for:

gamma rays .....

ultraviolet .....

infrared..... **3**

(ii) Which of the three waves in (i) has:

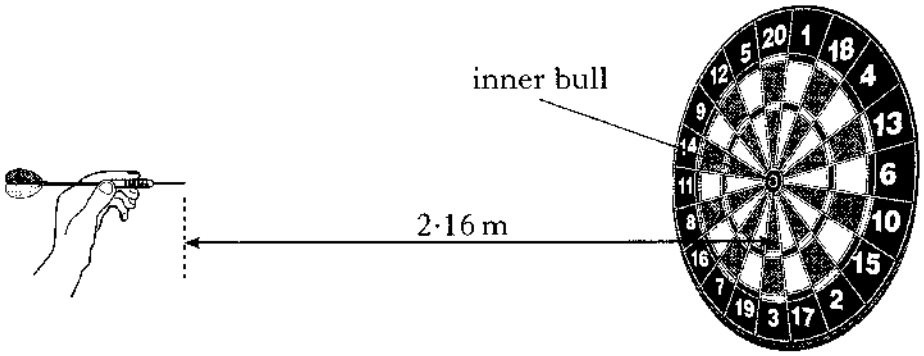
the longest wavelength .....

the highest frequency? **2**

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

15. A darts player throws a dart horizontally at the centre of the inner bull. The dart leaves the player's hand at a distance of 2·16 m from the dartboard and with a horizontal speed of 12·0 m/s.



(*a*) Calculate the time taken for the dart to travel from the hand to the board.

Space for working and answer

2

(*b*) Explain why the dart follows a curved path in its flight to the board.

.....

.....

..... **2**

(*c*) The average vertical speed of the dart during its flight to the board is 0·9 m/s.

How far below the centre of the inner bull does the dart hit the board?

Space for working and answer

2

[END OF QUESTION PAPER]

DO NOT WRITE IN THIS MARGIN

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.