FOR OFFICIAL USE

C

K & U	PS

Total Marks

3220/402

NATIONAL QUALIFICATIONS 2007

WEDNESDAY, 16 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

Reference may be made to the Physics Data Booklet.

1 All questions should be answered.

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

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

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

5 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.

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

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 pupil is sent exam results by a text message on a mobile phone. The frequency of the signal received by the phone is 1900 MHz.

The mobile phone receives radio waves (signals).

(*a*) What is the speed of radio waves?

..... **1**

(*b*) Calculate the wavelength of the signal.

Space for working and answer

2

(*c*) The pupil sends a video message from the mobile phone. The message is transmitted by microwaves. The message travels a total distance of 72 000 km.

Calculate the time between the message being transmitted and received.

Space for working and answer

2

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

2. Radio waves have a wide range of frequencies.

The table gives information about different wavebands.

Waveband	*Frequency Range*	*Example*
Low frequency (LF)	30 kHz – 300 kHz	Radio 4
Medium frequency (MF)	300 kHz – 3 MHz	Radio Scotland
High frequency (HF)	3 MHz – 30 MHz	Amateur radio
Very high frequency (VHF)	30 MHz – 300 MHz	Radio 1 FM
Ultra high frequency (UHF)	300 MHz – 3 GHz	BBC 1 and ITV
Super high frequency (SHF)	3 GHz – 30 GHz	Satellite TV

(*a*) Coastguards use signals of frequency 500 kHz.

What waveband do these signals belong to?

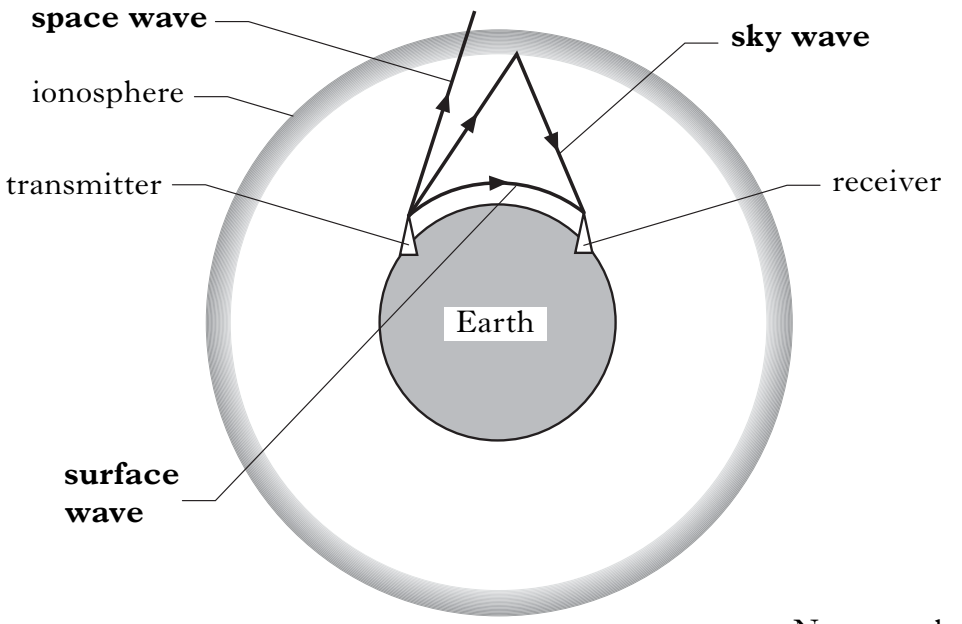
..... **1**

DO NOT WRITE IN THIS MARGIN

2. (continued)

Marks | K&U | PS

(*b*) The diagram shows how radio signals of different wavelengths are sent between a transmitter and a receiver.



Not to scale

(i) Which of the waves in the diagram shows diffraction?

..... **1**

(ii) What does this indicate about the wavelength of the diffracted wave compared to the other two waves?

..... **1**

(iii) The Earth's ionosphere is shown on the diagram. The ionosphere is a layer of charged particles in the upper atmosphere. High frequency waves are transmitted as sky waves.

Explain how the transmitted waves reach the receiver.

..... **1**

(iv) Super high frequency (SHF) signals are shown as space waves on the diagram. Although they can only travel in straight lines, they can be used for communications on Earth between a transmitter and receiver.

Describe how the SHF signals get to the receiver.

.....

.....

..... **2**

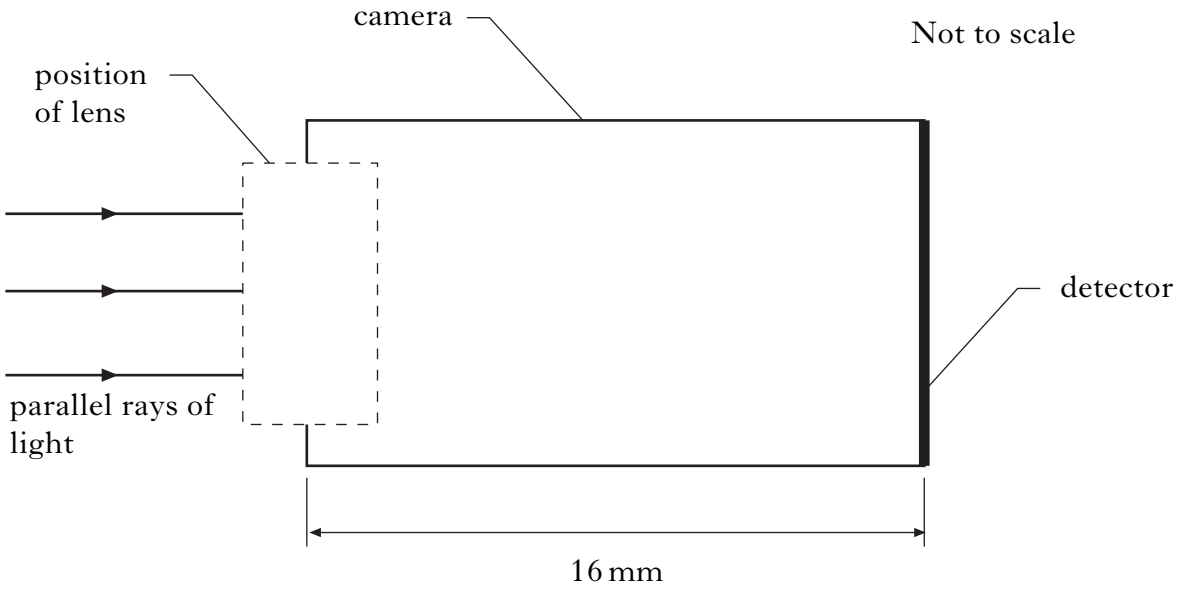
DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

3. A door entry system in an office block allows video and audio information to be sent between two people.

(*a*) A camera at the entrance uses a lens to focus parallel rays of light onto a detector.

Part of the camera is shown in the diagram below.



(i) Complete the diagram above by:

(A) drawing the lens used;

(B) completing the path of the light rays. **2**

(ii) Using information from the diagram, calculate the power of the lens used in the camera.

Space for working and answer **2**

DO NOT WRITE IN THIS MARGIN

	Marks	K&U	PS

3. (continued)

(*b*) The door entry system uses a black and white television screen.
Describe how a moving picture is seen on the television screen.
Your description must include the terms:

line build up **image retention** **brightness variation**.

.....

.....

.....

.....

.....

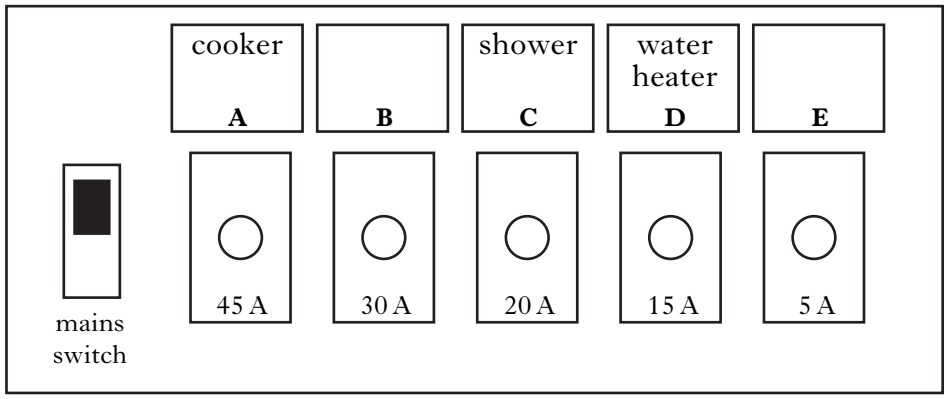
..... **3**

[Turn over

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

4. The consumer unit in a house contains a mains switch and circuit breakers for different circuits.



(*a*) (i) What is the purpose of the mains switch?

..... **1**

(ii) Two of the circuits have not been labelled.

Which circuit is: the ring circuit? .....

the lighting circuit? **1**

(iii) The current ratings for the ring circuit and the lighting circuit are different.

State another difference between the ring circuit and the lighting circuit.

..... **1**

DO NOT WRITE IN THIS MARGIN

	Marks	K&U	PS

4. (continued)

(*b*) (i) A 25 W lamp is designed to be used with mains voltage.
Calculate the resistance of the lamp.

Space for working and answer

3

(ii) Four of these lamps are connected in parallel.
Calculate the **total** resistance of the lamps.

Space for working and answer

2

[Turn over

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

5. Two groups of pupils are investigating the electrical properties of a lamp.

(*a*) Group 1 is given the following equipment:

ammeter; voltmeter; 12 V d.c. supply; lamp; connecting leads.

Complete the circuit diagram to show how this equipment is used to measure the current through, and the voltage across, the lamp.

3

(*b*) Group 2 uses the same lamp and is only given the following equipment:

lamp; ohmmeter; connecting leads.

What property of the lamp is measured by the ohmmeter?

..... **1**

(*c*) The results of both groups are combined and recorded in the table below.

I(A)	V(V)	R(Ω)	IV	I^2R
2	12	6		

(i) Use these results to complete the last two columns of the table.

Space for working

2

(ii) What quantity is represented by the last two columns of the table?

..... **1**

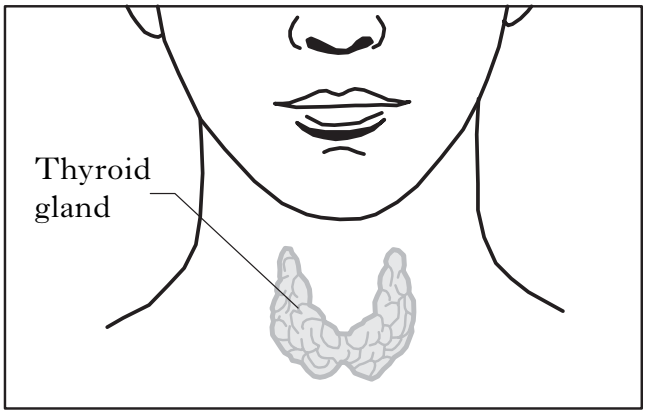
(iii) What is the unit for this quantity?

..... **1**

DO NOT WRITE IN THIS MARGIN

	Marks	K&U	PS

6. The thyroid gland, located in the neck, is essential for maintaining good health.



(*a*) (i) A radioactive source, which is a gamma radiation emitter, is used as a radioactive tracer for the diagnosis of thyroid gland disorders.

A small quantity of this tracer, with an activity of 20 MBq, is injected into a patient's body. After 52 hours, the activity of the tracer is measured at 1·25 MBq.

Calculate the half life of the tracer.

Space for working and answer

2

(ii) Another radioactive source is used to **treat** cancer of the thyroid gland. This source emits only beta radiation.

Why is this source unsuitable as a **tracer**?

.....

..... **1**

(iii) The equivalent dose is much higher for the beta emitter than for the gamma emitter.

Why is this higher dose necessary?

..... **1**

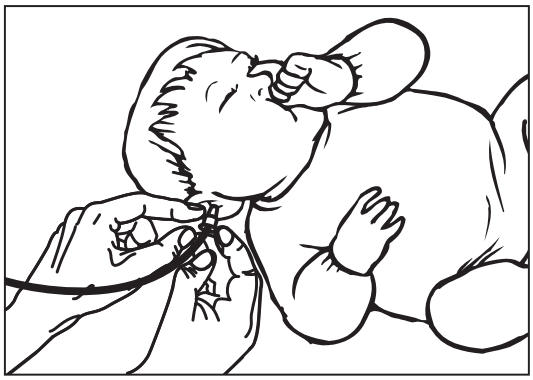
(*b*) What are the units of equivalent dose?

..... **1**

DO NOT WRITE IN THIS MARGIN

	Marks	K&U	PS

7. A newborn baby is given a hearing test. A small device, containing a loudspeaker and a microphone, is placed in the baby's ear.



(*a*) A pulse of audible sound lasting 10 μs is transmitted through the loudspeaker. The sound is played at a level of 80 dB.

(i) Give a reason why this pulse of sound does not cause damage to the baby's hearing.

.....

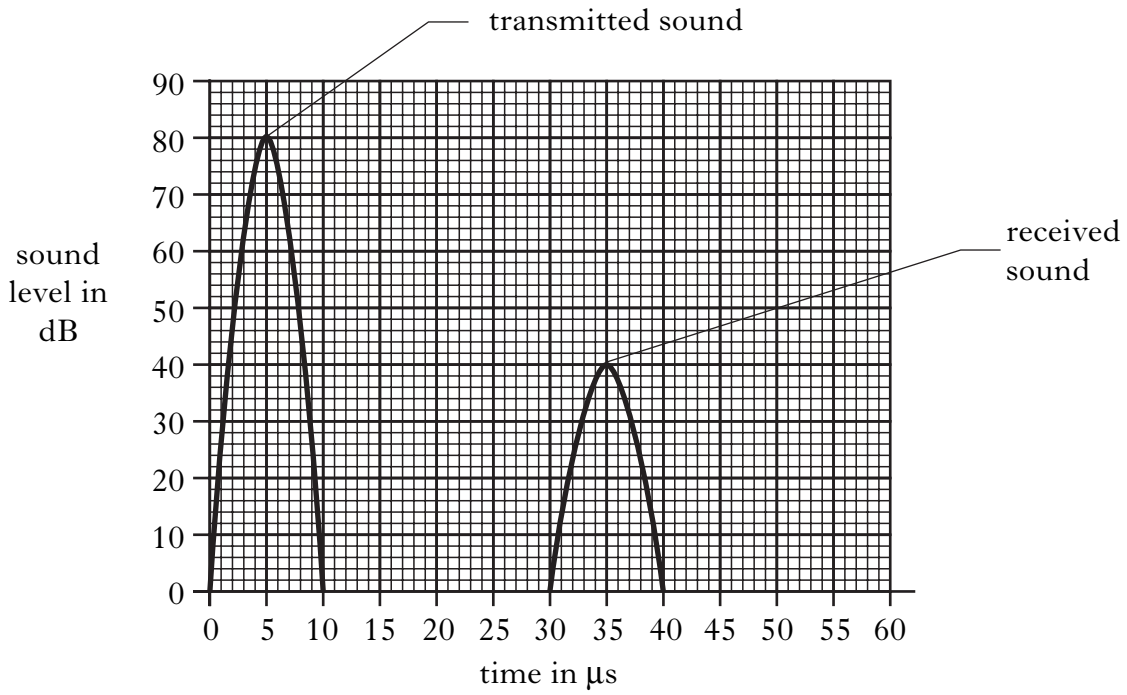
..... **1**

7. (*a*) (continued)

Marks | K&U | PS

(ii) The transmitted pulse of sound makes the inner ear vibrate to produce a new sound, which is received by the microphone.

Signals from the transmitted and received sounds are viewed on an oscilloscope screen, as shown below.



The average speed of sound inside the ear is 1500 m/s.

Calculate the distance between the device and the inner ear.

Space for working and answer

3

(iii) Suggest a frequency that could be used for the hearing test.

.....

1

(*b*) An ultrasound scan can be used to produce an image of an unborn baby. Explain how the image of an unborn baby is formed by ultrasound.

.....

.....

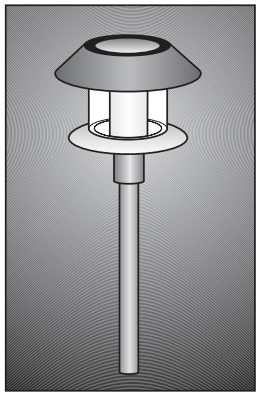
.....

2

DO NOT WRITE IN THIS MARGIN

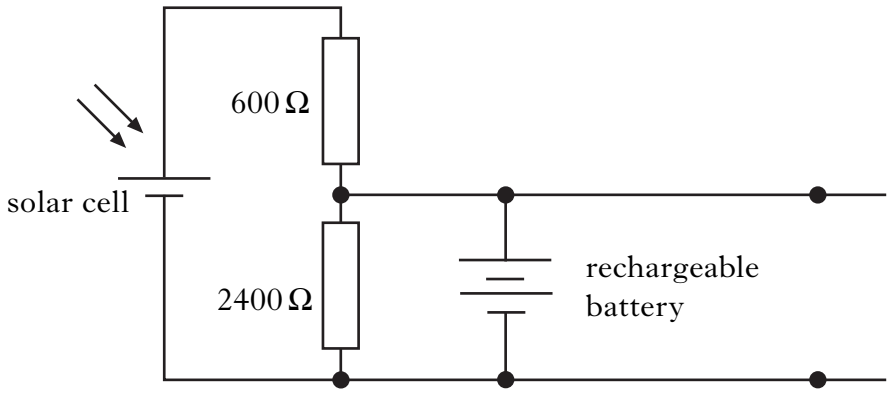
Marks	K&U	PS

8. A high intensity LED is used as a garden light. The light turns on automatically when it becomes dark.



The light also contains a solar cell which charges a rechargeable battery during daylight hours.

(*a*) Part of the circuit is shown below.



(i) State the energy transformation in a solar cell.

..... **1**

(ii) At a particular light level, the voltage generated by the solar cell is 1·5 V.

Calculate the voltage across the rechargeable battery at this light level.

Space for working and answer

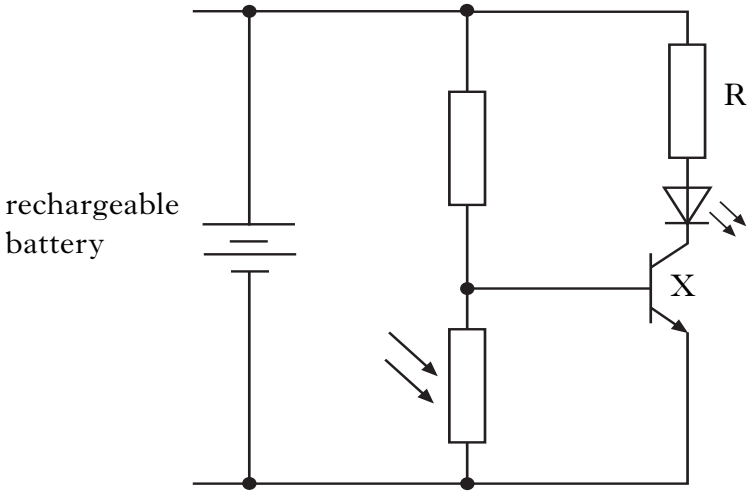
2

DO NOT WRITE IN THIS MARGIN

8. (continued)

Marks | K&U | PS

(*b*) The LED is switched on using the following circuit.

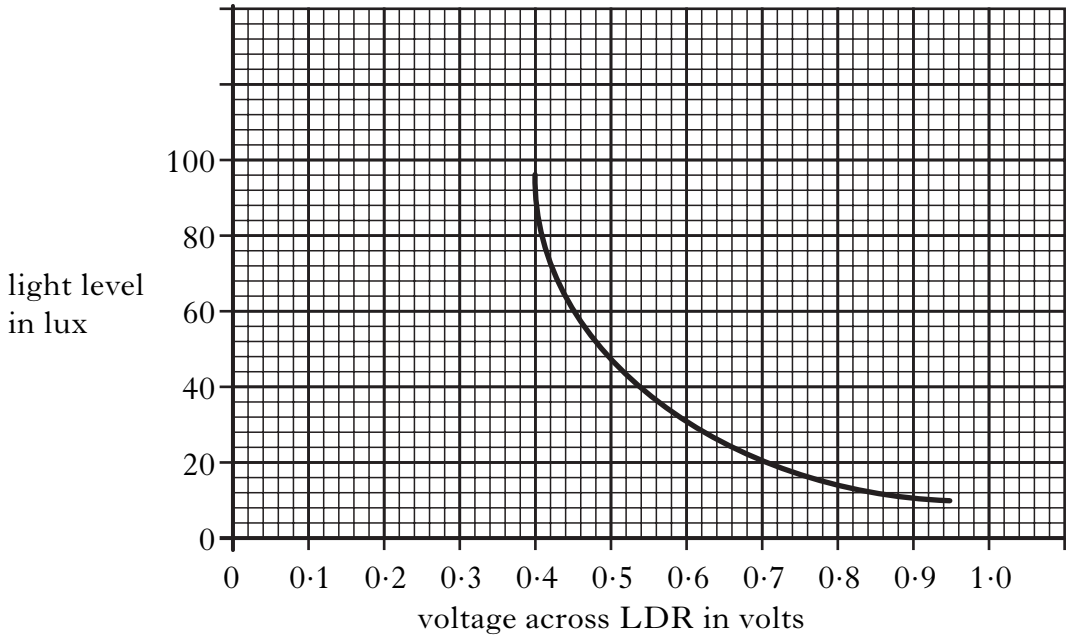


(i) Name component X.

..... **1**

The graph below shows the voltage across the LDR in this circuit for different light levels.

Light level is measured in lux.



(ii) For the LED to be lit, the voltage across the LDR must be at least 0·7 V.

What is the maximum light level for the LED to be lit?

..... **1**

(iii) Explain the purpose of resistor R.

..... **1**

DO NOT WRITE IN THIS MARGIN

	Marks	K&U	PS

9. An electronic tuner for a guitar contains a microphone and an amplifier. The output voltage from the amplifier is 9 V.

(*a*) The voltage gain of the amplifier is 150.

Calculate the input voltage to the amplifier.

Space for working and answer

2

(*b*) The tuner is used to measure the frequency of six guitar strings.

The number and frequency of each string is given in the table below.

Number of string	*Frequency* (Hz)
1	330·0
2	247·0
3	196·0
4	147·0
5	110·0
6	82·5

The tuner has an output socket which has been connected to an oscilloscope. The trace for string 5 is shown in Figure 1.

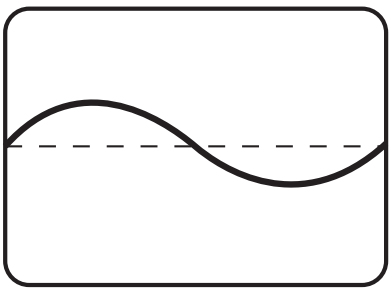


Figure 1

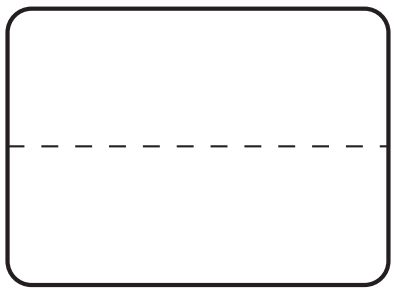


Figure 2

(i) The controls of the oscilloscope are **not** altered.

In Figure 2, draw the trace obtained if string 1 is played **louder** than string 5. **2**

(ii) String 3 is played.

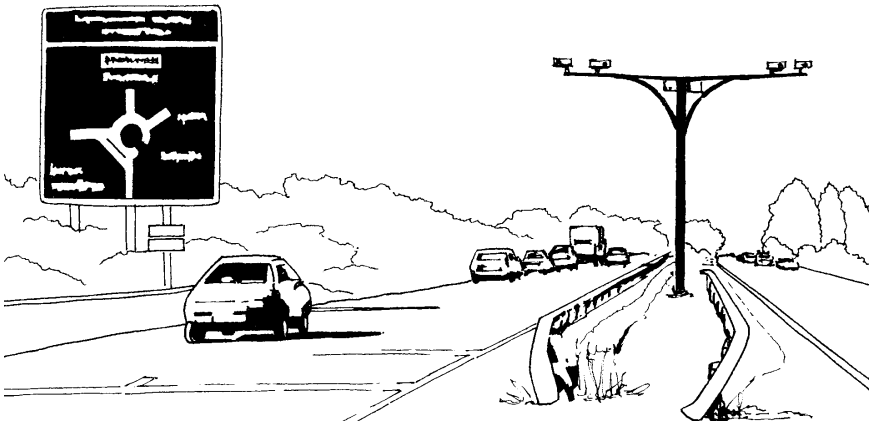
What is the frequency of the output signal from the amplifier?

..... **1**

DO NOT WRITE IN THIS MARGIN

	Marks	K&U	PS

10. Cameras placed at 5 km intervals along a stretch of road are used to record the average speed of a car.



The car is travelling on a road which has a speed limit of 100 km/h. The car travels a distance of 5 km in 2·5 minutes.

(*a*) Does the average speed of the car stay within the speed limit?

You must justify your answer with a calculation.

Space for working and answer

3

(*b*) At one point in the journey, the car speedometer records 90 km/h.

Explain why the average speed for the entire journey is not always the same as the speed recorded on the car speedometer.

.....

.....

.....

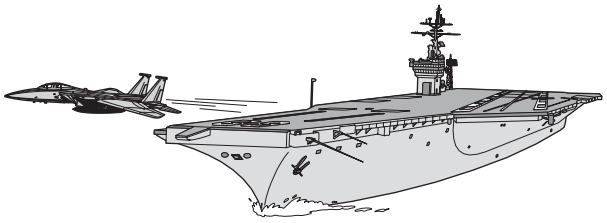
..... **2**

[Turn over

DO NOT WRITE IN THIS MARGIN

	Marks	K&U	PS

11. An aeroplane on an aircraft carrier must reach a minimum speed of 70 m/s to safely take off. The mass of the aeroplane is 28 000 kg.



(*a*) The aeroplane accelerates from rest to its minimum take off speed in 2 s.

(i) Calculate the acceleration of the aeroplane.

Space for working and answer

2

(ii) Calculate the force required to produce this acceleration.

Space for working and answer

2

(iii) The aeroplane's engines provide a total thrust of 240 kN. An additional force is supplied by a catapult to produce the acceleration required.

Calculate the force supplied by the catapult.

Space for working and answer

1

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

11. (continued)

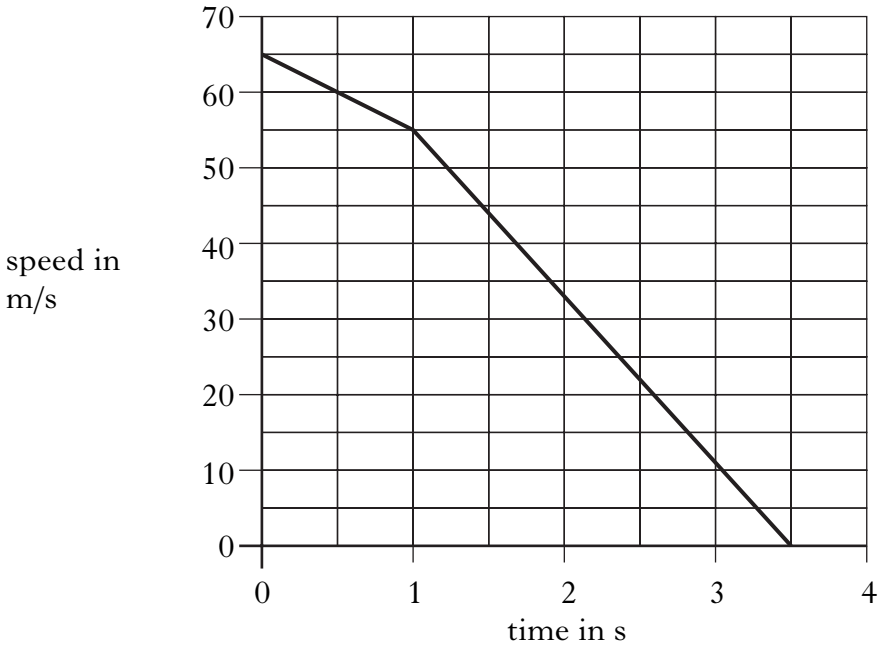
(*b*) Later, the same aeroplane travelling at a speed of 65 m/s, touches down on the carrier.

(i) Calculate the kinetic energy of the aeroplane at this speed.

Space for working and answer

2

(ii) The graph shows the motion of the aeroplane from the point when it touches down on the carrier until it stops.



Calculate the distance travelled by the aeroplane on the carrier.

Space for working and answer

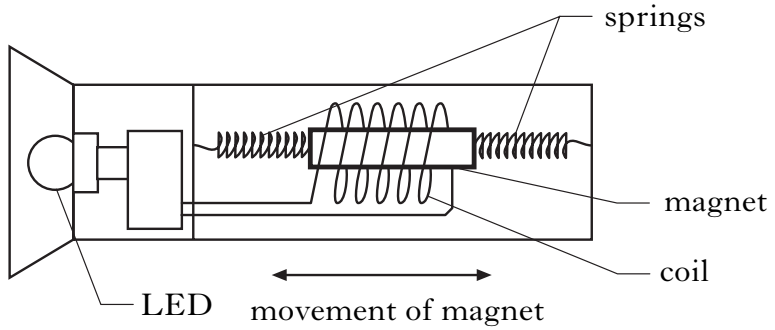
2

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

12. The advertisement below is for a new torch.

Kinetic Torch
No batteries needed – magnet powered!
Bright white LED won't burn out!
30-40 seconds of gentle shaking produces 10-15 minutes of light!
Capacitor holds the charge generated by passing the magnet through the coil.



(*a*) (i) Explain how a voltage is induced in the coil.

.....

..... **2**

(ii) What is the effect of shaking the torch faster?

..... **1**

(iii) Draw the circuit symbol for a capacitor.

Space for symbol

1

(*b*) When lit, the current in the LED is 20 mA .

Calculate how much charge flows through the LED in 12 minutes.

Space for working and answer

2

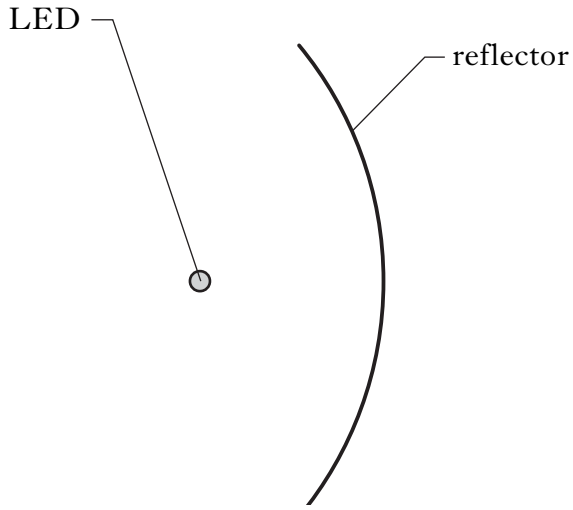
DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

12. (continued)

(*c*) The torch produces a beam of light.

The diagram shows the LED positioned at the focus of the torch reflector.



Complete the diagram by drawing light rays to show how the beam of light is produced. **2**

[Turn over

DO NOT WRITE IN THIS MARGIN

	Marks	K&U	PS

13. An electric kettle is used to heat 0·4 kg of water.

(*a*) The initial temperature of the water is 15 °C.

Calculate how much heat energy is required to bring this water to its boiling point of 100 °C.

Space for working and answer

3

(*b*) The automatic switch on the kettle is not working. The kettle is switched off 5 minutes after it had been switched on.

The power rating of the kettle is 2000 W.

(i) Calculate how much electrical energy is converted into heat energy in this time.

Space for working and answer

2

(ii) Calculate the mass of water changed into steam in this time.

Space for working and answer

3

DO NOT WRITE IN THIS MARGIN

Marks | K&U | PS

14. The diagram represents the electromagnetic spectrum in order of increasing wavelength. Some of the radiations have not been named.

Electromagnetic Spectrum

Gamma rays	**P**	Ultraviolet	**Q**	Infrared	**R**	TV and Radio

increasing wavelength

(*a*) (i) Name radiation: **P** .....

Q .....

R **2**

(ii) Which radiation in the electromagnetic spectrum has the highest frequency?

..... **1**

(*b*) Stars emit **ultraviolet** and **infrared** radiation.

Name a detector for **each** of these two radiations.

Infrared.....

Ultraviolet..... **2**

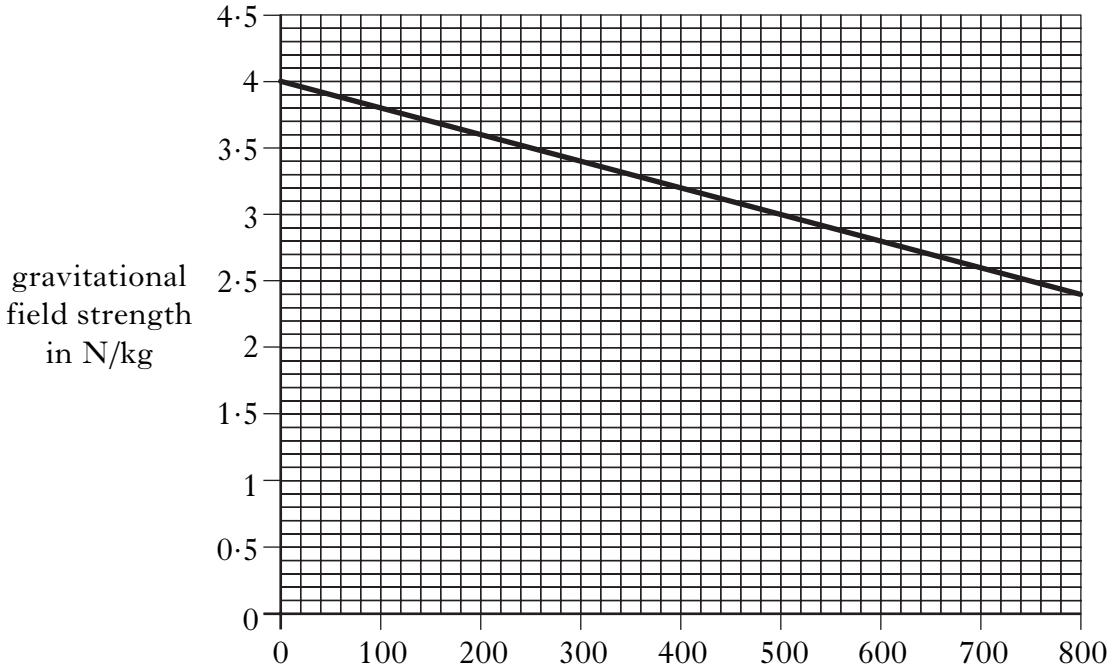
[Turn over

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

15. In June 2005, a space vehicle called Mars Lander was sent to the planet Mars.

(*a*) The graph shows the gravitational field strength at different heights above the surface of Mars.



(i) The Mars Lander orbited Mars at a height of 200 km above the planet's surface.

What is the value of the gravitational field strength at this height?

..... **1**

(ii) The Mars Lander, of mass 530 kg, then landed.

Calculate the weight of the Mars Lander on the surface.

Space for working and answer

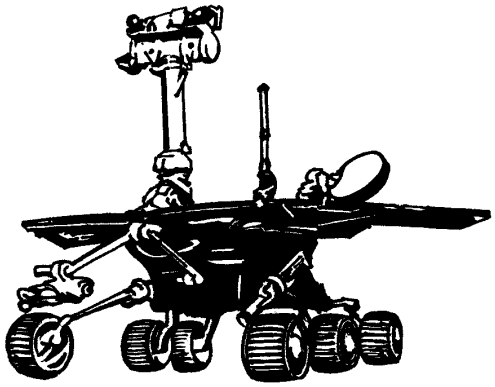
3

DO NOT WRITE IN THIS MARGIN

Marks	K&U	PS

15. (continued)

(*b*) The Mars Lander released a rover exploration vehicle on to the surface of Mars.



To collect data from the bottom of a large crater, the rover launched a probe horizontally at 30 m/s. The probe took 6 s to reach the bottom of the crater.

(i) Calculate the horizontal distance travelled by the probe.

Space for working and answer

2

(ii) Calculate the vertical speed of the probe as it reached the bottom of the crater.

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.

[BLANK PAGE]

[BLANK PAGE]