K & U   PS

Total Marks

3220/402

NATIONAL QUALIFICATIONS 2002	MONDAY, 27 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.

SCOTTISH
QUALIFICATIONS
AUTHORITY

DATA SHEET

Speed of light in materials

Material	Speed in m/s
Air	3.0×10^8
Carbon dioxide	3.0×10^8
Diamond	1.2×10^8
Glass	2.0×10^8
Glycerol	2.1×10^8
Water	2.3×10^8

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	0.99×10^5
Aluminium	3.95×10^5
Carbon dioxide	1.80×10^5
Copper	2.05×10^5
Glycerol	1.81×10^5
Lead	0.25×10^5
Water	3.34×10^5

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	11.2×10^5
Carbon dioxide	3.77×10^5
Glycerol	8.30×10^5
Turpentine	2.90×10^5
Water	22.6×10^5

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	$= 10^{-9}$

Marks | K&U | PS

1. Radio Alba transmits on a range of frequencies from different transmitters throughout Scotland.

On a car journey from Aberdeen to Stirling a driver listens to Radio Alba. At the start of the journey she tunes to the signal transmitted from transmitter P.

(*a*) Complete the following passage, using some of the words from the list below. Do not use any word more than once.

amplitude   **audio**   **carrier**
frequency   **modulation**   **radio**

The transmitter transmits a...............................signal, which consists

of an.................................wave and a.................................wave. The

process of combining these waves is known as **2**

(*b*) During the journey the driver finds that the signal from transmitter P fades.

(i) Suggest a reason why the signal fades.

....

....   **1**

(ii) To continue to listen to Radio Alba, the driver re-tunes the radio to pick up the signal from transmitter Q.

What is the difference between the carrier wave from transmitter P and that from transmitter Q?

....

....   **1**

2. The table gives information about artificial satellites that orbit the Earth.

Name of satellite	Period (minutes)	Height above Earth (km)	Use
Landsat	99	705	Land mapping
ERS-1		780	Monitoring sea levels
NOAA-12	102	833	Distribution of ozone layer
Early Bird	1440	35 900	Continuous telecommunication

(a) NOAA-12 uses radio waves to transmit signals relating to the ozone layer.

   (i) What is the speed of radio waves?

....

       1

  (ii) Calculate the time for signals to travel from NOAA-12 to an Earth station immediately below the satellite.

```
Space for working and answer




```

       2

 (iii) Signals transmitted from NOAA-12 have a frequency of 137·5 MHz.
Calculate the wavelength of these signals.

```
Space for working and answer




```

       2

2. **(continued)**

(b) Using information about the period of Early Bird, explain why this satellite is used for continuous telecommunication between two points on the Earth's surface.

....

....

.... **2**

(c) Give an approximate value, **in minutes**, for the period of orbit of ERS-1.

.... **1**

(d) Landsat monitors heat emission from the land to build up a thermographic image.

Which part of the electromagnetic spectrum is detected by Landsat?

.... **1**

(e) As well as artificial satellites, there is one natural satellite that orbits the Earth. Name this natural satellite.

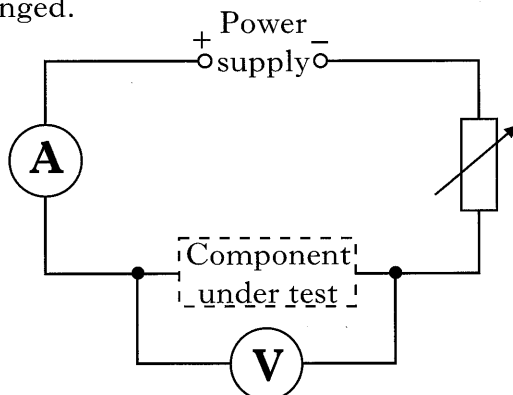.. **1**

[Turn over

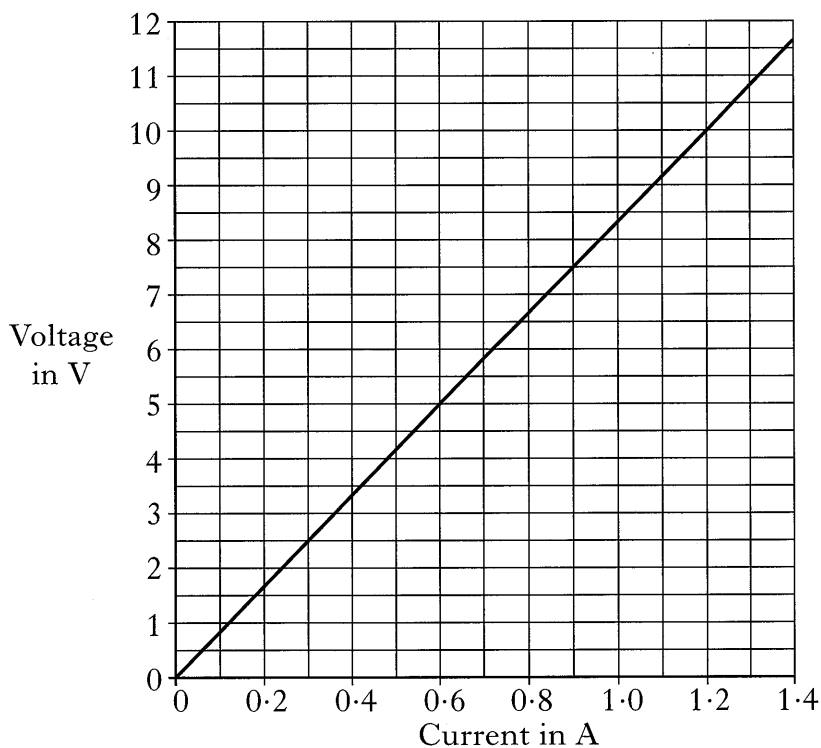**3.** A student uses the circuit below in experiments to investigate how the voltage across different components varies when the current in the components is changed.

(a) The student places component X in the circuit and carries out an experiment. The graph below shows how the voltage across component X varies with current.

(i) Calculate the resistance of component X when the current is 1·2 A.

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

Space for working and answer

2

3.   (*a*)   (continued)

(ii)   Using information from the graph, explain what happens to the resistance of component X as the current is increased.

Justify your answer by calculation or otherwise.

....
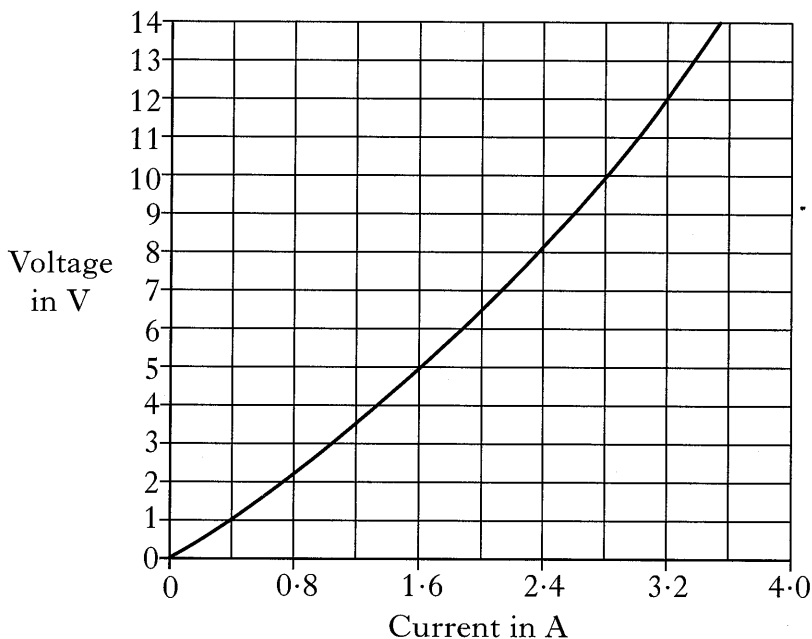
....

....

....

....

....

| Space for working |

3

(*b*)   The student replaces component X with component Y, repeats the experiment and obtains the following graph.

14
13
12
11
10
9
Voltage   8
in V   7
6
5
4
3
2
1
0

0   0·8   1·6   2·4   3·2   4·0

Current in A

(i)   The student concludes that the resistance of component Y is not constant.   Why is the student correct in coming to this conclusion?

....

....

1

[Turn over

3. **(b)** **(continued)**

(ii) (A) From the graph, what is the current in component Y when the voltage across component Y is 12 V?

.... 1

(B) Calculate the power dissipated in component Y when the voltage across it is 12 V.

Space for working and answer

2

4. The diagram shows three household circuits, connected to a consumer unit.
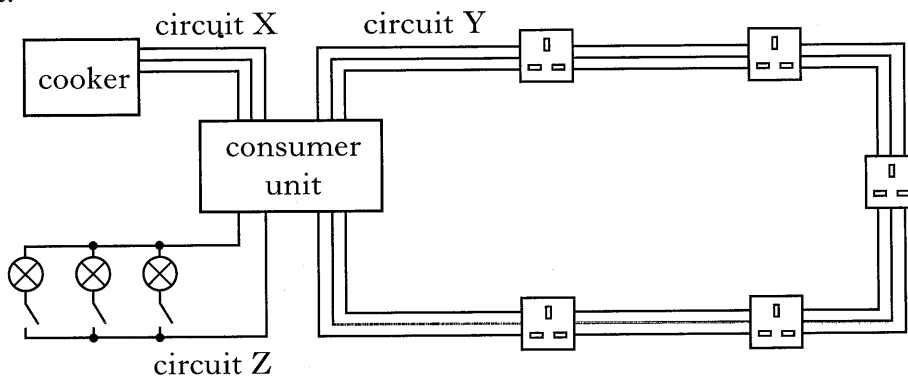
(a) (i) Which circuit is a ring circuit?

.... 1

(ii) Give **two** advantages of using a ring circuit.

....

.... 2

4. (continued)

(*b*) State and explain **one** difference between a lighting circuit and a ring circuit.

....

....

.... **2**

(*c*) (i) Why does a cooker need a separate circuit?

....

....

.... **1**

(ii) One heating element of the cooker has a power rating of 2·2 kW. Calculate how many joules of energy are transferred by this element in 2 hours.

Space for working and answer

2

(*d*) (i) What is the purpose of an earth wire?

....

.... **1**

(ii) Explain how an earth wire works.

....

....

.... **2**

[Turn over

Marks

5. Ultrasound is used by doctors for treatment and diagnosis.

(a) Pulses of ultrasound are used to produce local heating of muscle deep inside the body. This heating effect can help relieve pain in the muscles.

(i) What is meant by ultrasound?

....

.... 1

(ii) Calculate the time for a pulse of ultrasound to travel through 2 cm of muscle.

(Data you require will be found in the Data Sheet on *page two*.)

Space for working and answer

3

(b) Ultrasound is also used to build up images of an unborn baby.

(i) Explain how ultrasound is used to build up such images.

....

....

....

.... 2

(ii) Why is ultrasound safer than X-rays for this sort of medical application?

....

.... 1

Marks | K&U | PS

6. A student investigates the effect of glass shapes on rays of light.

   (*a*) The student places glass shapes in the path of three rays of red light as shown.

rays
of
red
light

   (i) Complete the diagram to show the paths of the rays of light through and out of the three glass shapes.

   3

   (ii) The student has drawn line PQ on the diagram at shape X at right angles to the glass surface.

   What name is given to this line?

   ....

   1

   (iii) **On the diagram**, label **one** angle of incidence as *i* and **one** angle of refraction as *r*.

   2

   (*b*) Name the type of lens that would have a similar effect on the rays of light as the three glass shapes, arranged as in part (*a*).

   ....
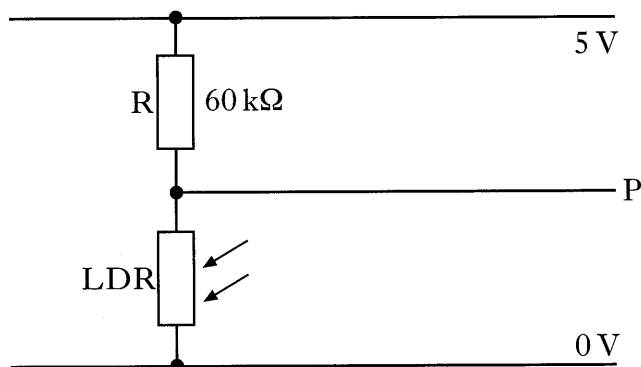
   1

[Turn over

7. The exit of an underground car park has an automatic barrier. The barrier rises when a car interrupts a light beam across the exit and money has been put into the pay machine. The barrier can also be operated by using a manual switch.
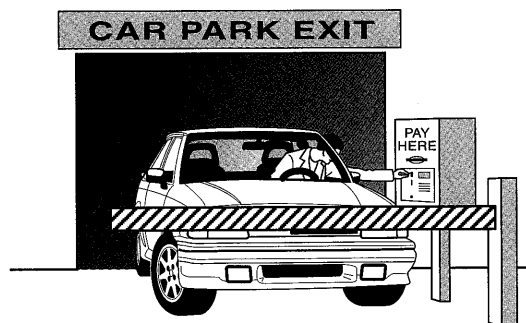
The light beam is directed at an LDR that is connected as shown in the circuit below.

(*a*) Calculate the voltage across the LDR when its resistance is $15\,k\Omega$.
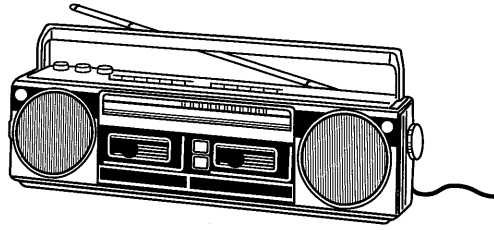
> *Space for working and answer*

2

7. (continued)

(b) Part of the control circuit for the automatic barrier is shown below.

When a car interrupts the light beam, the logic level at P changes from logic 0 to logic 1.

When money is put into the pay machine, the logic level at Q changes from logic 0 to logic 1.

When the manual switch is operated, the logic level at S changes from logic 0 to logic 1.

(i) Name logic gate X.

.... 1

(ii) Name logic gate Y.

.... 1

(iii) Complete the truth table below for the control circuit shown, by filling in the values of the logic levels at R and T.

P	Q	R	S	T
0	0		0	
0	1		0	
1	0		0	
1	1		0	
0	0		1	
0	1		1	
1	0		1	
1	1		1	

4

(iv) Describe a situation where it would be necessary to operate the barrier by using the manual switch.

....

.... 1

[Turn over

8. A radio has three types of output device.

filament lamp **LED** **loudspeaker**

(a) Which of these output devices transforms electrical energy into sound energy?

.... 1

(b) Which of these output devices is most suitable for illuminating the front panel of the radio?
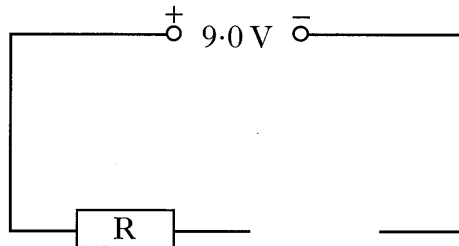
Explain your choice.

....

....

.... 2

(c) The LED is connected in series with resistor, R, to the 9·0 V power supply of the radio.

$$\overset{+}{\circ}\ 9{\cdot}0\,\text{V}\ \overset{-}{\circ}$$

R

(i) In the space in the circuit above draw the LED connected correctly. 2

(ii) When lit, the voltage across the LED is 2·4 V and the current in the LED is 20 mA.
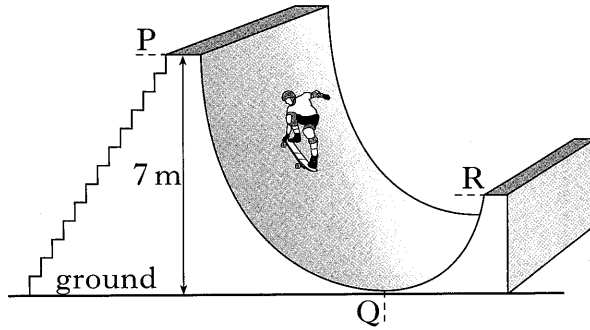
Calculate the resistance of R.

Space for working and answer

3

9. A skateboarder is practising on a ramp. The total mass of the skateboarder and the board is 60 kg.

(a) Calculate the increase in potential energy of the skateboarder and board in moving from the ground to position P.

Space for working and answer

2

(b) The skateboarder moves along the ramp from P to R, and rises into the air above R.

(i) At what point **on the ramp** is the kinetic energy of the skateboarder greatest?

.... 1

(ii) The vertical speed of the skateboarder at R is 6 m/s.

Calculate the height that the skateboarder rises to, above R.

Space for working and answer

3

(iii) Explain why the skateboarder does not rise to the same height as P.
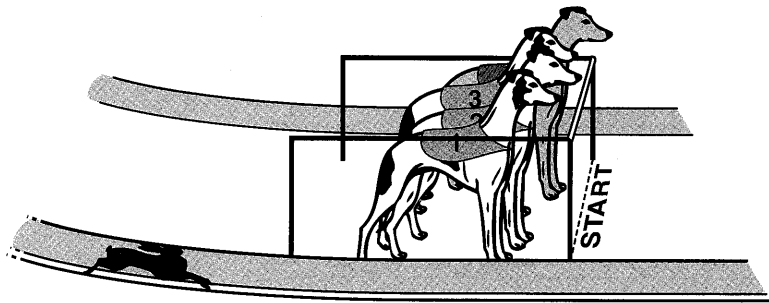
....

....

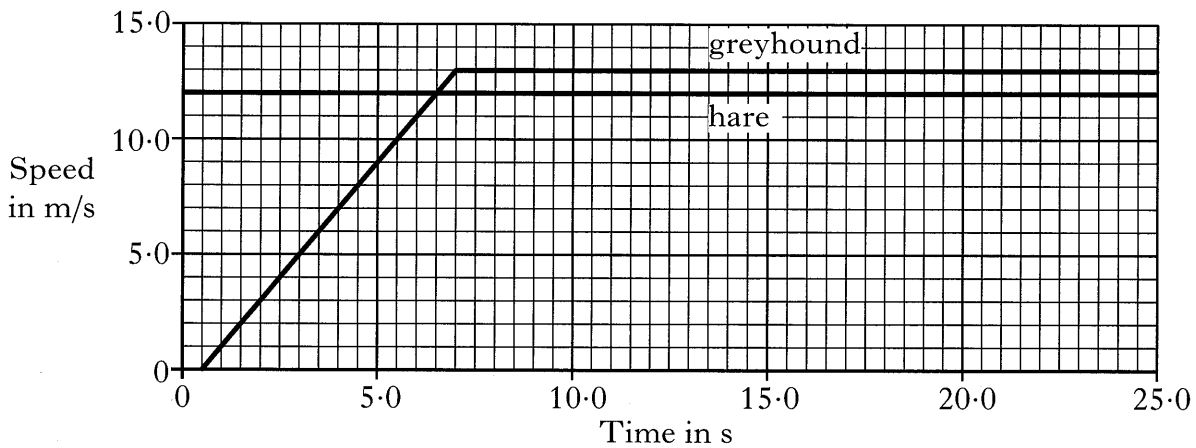.. 2

10. At a greyhound racing track, the greyhounds are automatically released when an artificial hare crosses the starting line.

The speed-time graph shows the motion of one greyhound and the hare from the time when the hare crosses the starting line.

(a) How long does it take for the greyhound to start moving after the hare crosses the starting line?

.... **1**

(b) Calculate the acceleration of the greyhound when it starts moving.

Space for working and answer

2

10. (continued)

(*c*) The hare crosses the finishing line 20 s after crossing the starting line.

    (i) Over what distance is the race run?

Space for working and answer

   2

    (ii) How far behind the hare is the greyhound when the **hare** finishes the race?

Space for working and answer

   3

[Turn over

11. A lighting system in a shop window uses three identical 18 W, 12 V filament lamps. The lamps are operated at their correct rating from the 230 V mains supply using a transformer as shown below.
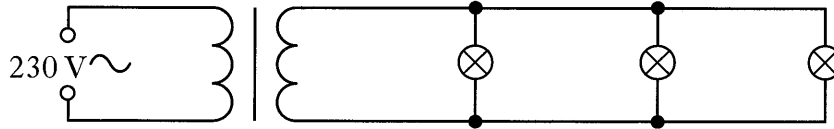
There are 5750 turns on the primary coil of the transformer.

(a) Calculate the number of turns on the secondary coil of the transformer.

Space for working and answer

2

(b) (i) The current in each lamp is 1·5 A.

Calculate the total current in the secondary circuit of the transformer.

Space for working and answer

1

(ii) Assuming that the transformer is 100% efficient, calculate the current in the primary coil.

Space for working and answer

2

Marks

11. **(continued)**

    (c)   (i)   Show that the resistance of one of the filament lamps, when it is operating normally, is $8 \cdot 0 \, \Omega$.

Space for working and answer

2

           (ii)   Calculate the combined resistance of the three lamps in parallel.

Space for working and answer

2

[Turn over

12. A student sets up the apparatus shown to measure the specific heat capacity of an aluminium block.

to power
supply ～ ‖thermometer

heater

aluminium
block

The student obtains the following results:

mass of aluminium block $m = 0.8\,\text{kg}$
temperature change $\Delta T = 19\,°\text{C}$
time taken $t = 5.0$ minutes
heater current $I = 4.2\,\text{A}$
heater voltage $V = 12\,\text{V}$

(a) Show, by calculation, that $15\,120\,\text{J}$ of electrical energy are supplied to the heater in 5.0 minutes.

Space for working and answer

2

(b) (i) Assuming all of the electrical energy is transferred to the aluminium block as heat energy, calculate the value of the specific heat capacity of aluminium obtained from this experiment.

Space for working and answer

2

Marks

12. **(b)** **(continued)**

(ii) The accepted value of the specific heat capacity of aluminium is 902 J/kg °C.

(A) Give a reason for the difference between your answer in (b)(i) and this value.

....

....

.... 1

(B) How could the experiment be improved to reduce this difference?

....

....

.... 1

[Turn over

13. During the Apollo 11 expedition to the Moon, 21 kg of soil samples were brought from the Moon to the Earth. The gravitational field strength was not constant throughout the journey.

(*a*) What is meant by gravitational field strength?

....

.... **1**

(*b*) Complete the table to show the mass and weight of the soil samples at various stages of the journey.

Stage	Gravitational field strength (N/kg)	Mass (kg)	Weight (N)
on the Moon	1·6	21	
at a point during the journey	0		
on the Earth	10		

3

[*END OF QUESTION PAPER*]

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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