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OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE (PILOT)

PHYSICS B (ADVANCING PHYSICS) PILOT 7733/01

Rise and Fall of the Clockwork Universe

Wednesday **6 JUNE 2001** Afternoon 1 hour 10 minutes

Candidates answer on the question paper.
Additional materials:
Data, Formulae and Relationships Booklet
Electronic calculator

Candidate Name	Centre Number	Candidate Number

TIME 1 hour 10 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name in the spaces above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Show clearly the working in all calculations, and round answers to only a justifiable number of significant figures.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- The values of standard physical constants are given in the Data, Formulae and Relationships Booklet. Any additional data required are given in the appropriate question.
- You will be awarded marks for the quality of written communication in Section B.
- You are advised to spend about 20 minutes on Section A and 50 minutes on Section B.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
A	20	
B	50	
TOTAL	70	

This question paper consists of 16 printed pages.

For Examiner's Use

Section A

1 Two samples, A and B, of the same radioactive isotope were prepared at the same time. At that time sample A was found to have a count rate of 1600 counts per second and sample B a count rate of 200 counts per second.
The half-life of the isotope is 6 hours.

(a) Account for the difference in count rates.

[2]

(b) Calculate the expected count rate of sample A after 24 hours have passed.

[2]

2 $2.0\,m^3$ of an ideal gas at a pressure of $1.0 \times 10^5\,Pa$ is compressed to a volume of $0.50\,m^3$.

(a) Calculate the new pressure of the gas.

Pressure = ... Pa [2]

(b) State an assumption that you have to make in order to perform this calculation.

[1]

For Examiner's Use

3 The luminosity of a star depends upon its surface temperature. Fig. 3 shows the luminosity relative to the Sun and the surface temperature of two stars X and Y.

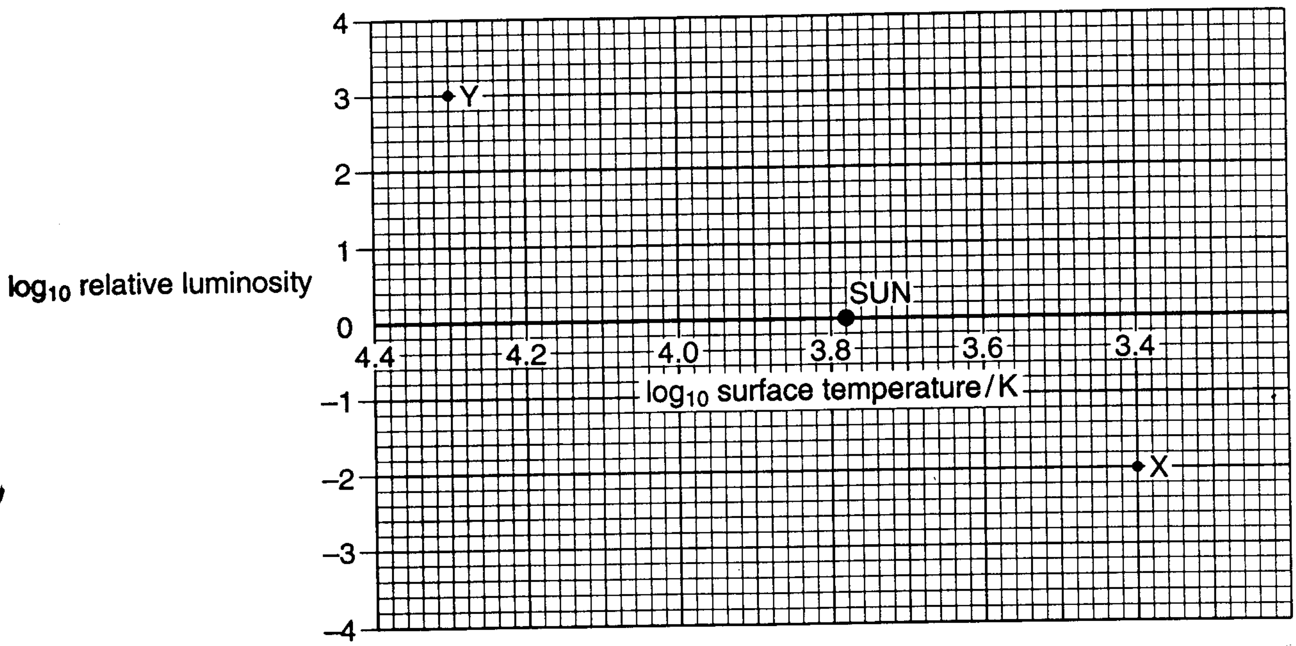

Fig. 3

(a) Suggest an advantage of using logarithmic scales on this graph.

[1]

(b) Use the graph to calculate the ratio: $\frac{\text{luminosity of X}}{\text{luminosity of Y}}$.

ratio = ... [2]

For Examiner's Use

4 Fig. 4 shows a child sitting on a playground roundabout. She is moving at a speed of $1.9\,m\,s^{-1}$. Her mass is 25 kg.

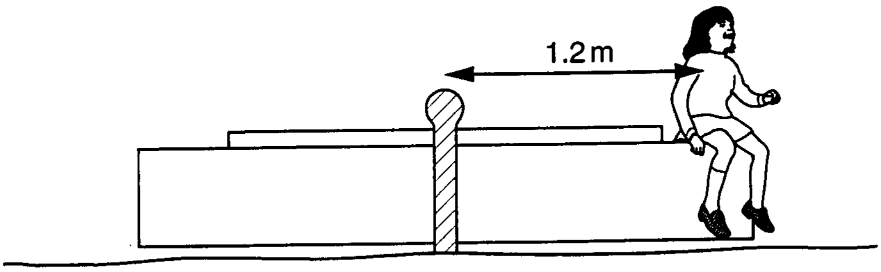

Fig. 4

Calculate the centripetal force on the child.

Centripetal force = ...N [3]

5 Fig. 5 shows how the combined gravitational potential of the Earth and Moon varies with distance. A point X is marked on the graph.

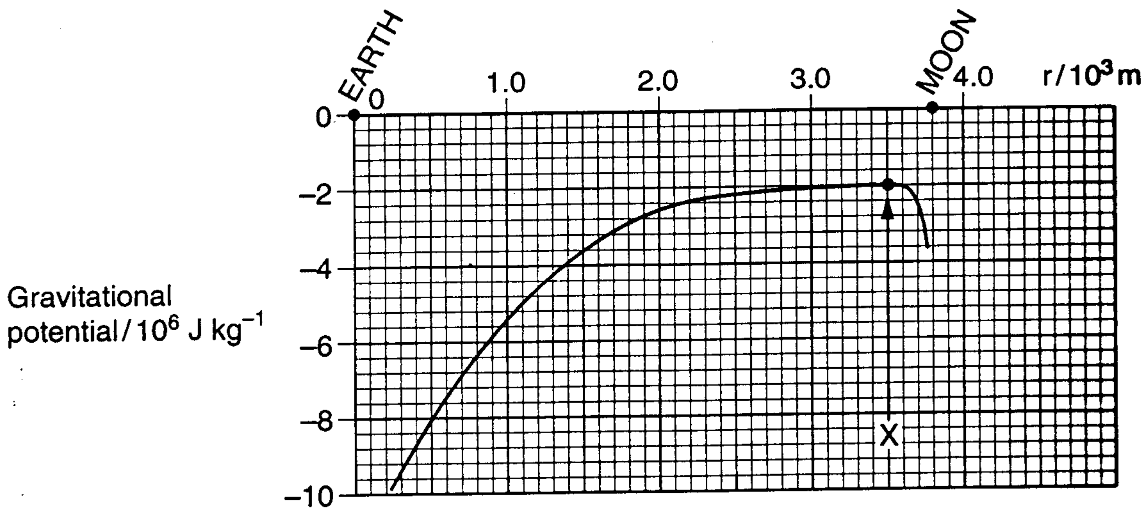

Fig. 5

(a) Use the graph to find the gravitational potential at point X.

Potential at X = ...J kg^{-1} [1]

(b) The gradient of the graph is zero at point X. This shows that the combined gravitational field strength of the Earth and Moon at that point is zero. Explain why point X is nearer the Moon than the Earth.

[2]

6 A volume of $2.5 \times 10^{-3}\,m^3$ of helium gas at a pressure of $1.5 \times 10^{-10}\,Pa$ contains approximately 1×10^8 atoms. Helium atoms have a mass of $6.8 \times 10^{-27}\,kg$. Helium gas behaves ideally under such conditions.

(a) Calculate the root mean square speed of the atoms.

Root mean square speed = ...$m\,s^{-1}$ [2]

(b) The absolute temperature of the gas is doubled. State how the root mean square speed of the molecules will change.

[2]

For Examiner's Use

Section B

Four marks in this section are awarded for quality of communication.

7 This question is about resonance.

A student uses the apparatus shown in Fig. 7.1 to investigate how the amplitude of vertical oscillation of a mass on a spring varies as the frequency of the vibration generator is changed.

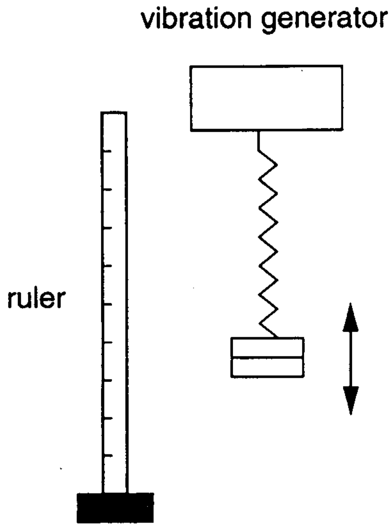

Fig 7.1

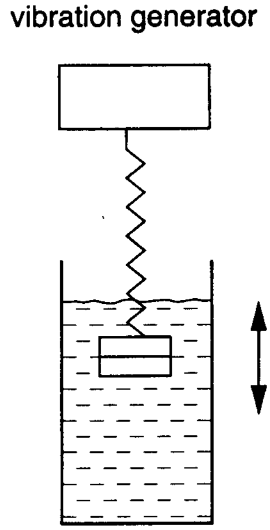

Fig 7.2

Fig. 7.3 shows the graph obtained from the experiment.

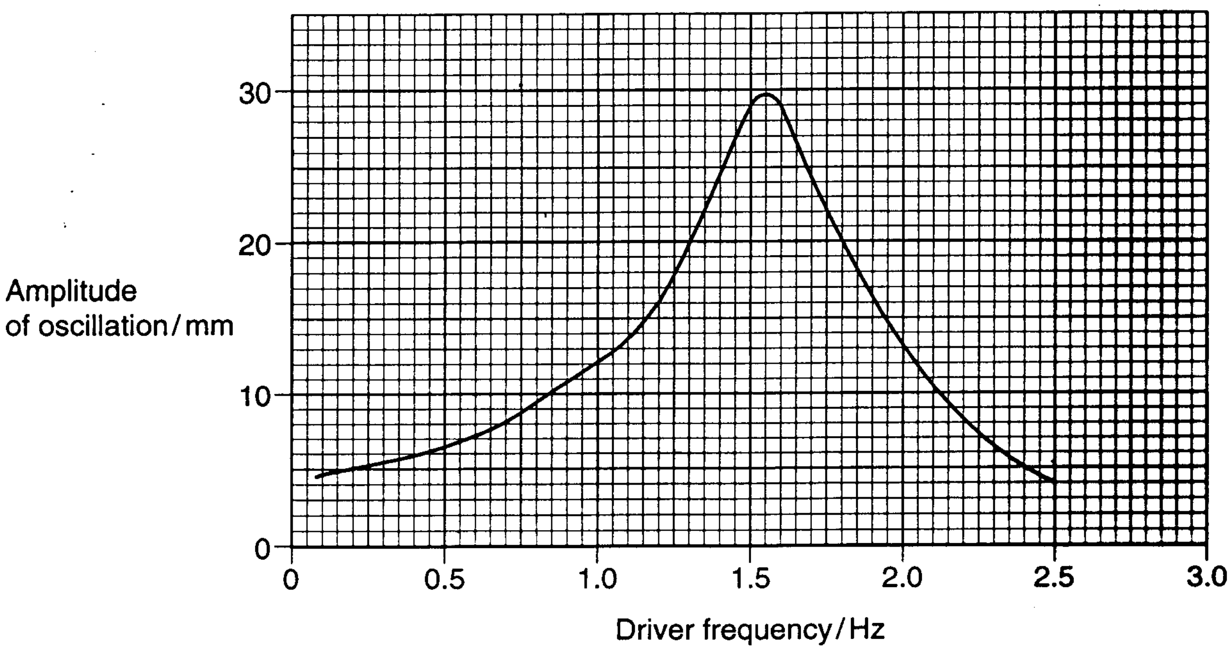

Fig. 7.3

For Examiner's Use

(a) **(i)** State the natural frequency of the oscillator.

Natural frequency = ...Hz

(ii) The mass is then placed in a beaker of water to damp the oscillation as in Fig 7.2. Sketch on Fig 7.3 the graph you would expect with greater damping. [4]

(b) The hydrogen chloride (HCl) molecule strongly absorbs infra-red of a specific frequency. This is an example of resonance. Assume the hydrogen atom acts like a mass on a spring and vibrates at the same frequency as the radiation. The more massive chlorine atom hardly vibrates at all.

(i) Explain why the molecule strongly absorbs radiation at a specific frequency.

(ii) The mass of a hydrogen atom is approximately 1.7×10^{-27} kg. Assume the stiffness of the bond between the hydrogen and chlorine atoms is $510\,\text{N m}^{-1}$.

Calculate the frequency of oscillation of the hydrogen atom.

Frequency = ...Hz [5]

[Turn over

For Examiner's Use

8 This question uses the Boltzmann factor to compare the rate of evaporation of ethanol and water at body temperature.

You will find the following data useful:
Molar mass of ethanol = 46 g mol^{-1}
Energy required to evaporate 1 kg of ethanol = 8.4×10^5 J kg^{-1}
Avogadro constant, $N_A = 6.0 \times 10^{23}$ mol^{-1}
Boltzmann constant, $k = 1.38 \times 10^{-23}$ J K^{-1}

(a) (i) Show that the energy, E, required for one molecule of ethanol to evaporate is 6.4×10^{-20} joule.

(ii) Human body temperature is 310 K. Show that the average energy of a molecule at body temperature is of the order of 4×10^{-21} J.

(iii) Show that the Boltzmann factor, which estimates the proportion of ethanol molecules with enough energy to vaporize at 310 K, is approximately 3×10^{-7}.

[7]

For Examiner's Use

(b) The Boltzmann factor for water at 310 K is 1×10^{-7}.

Use this information to explain why a drop of an ethanol-based product, such as perfume or after shave, feels cooler on the skin than a drop of water.

[3]

For Examiner's Use

9 This question is about the physics of hitting a golf ball.
Fig. 9 shows how the force exerted by a golf club on a ball varies during time of contact.

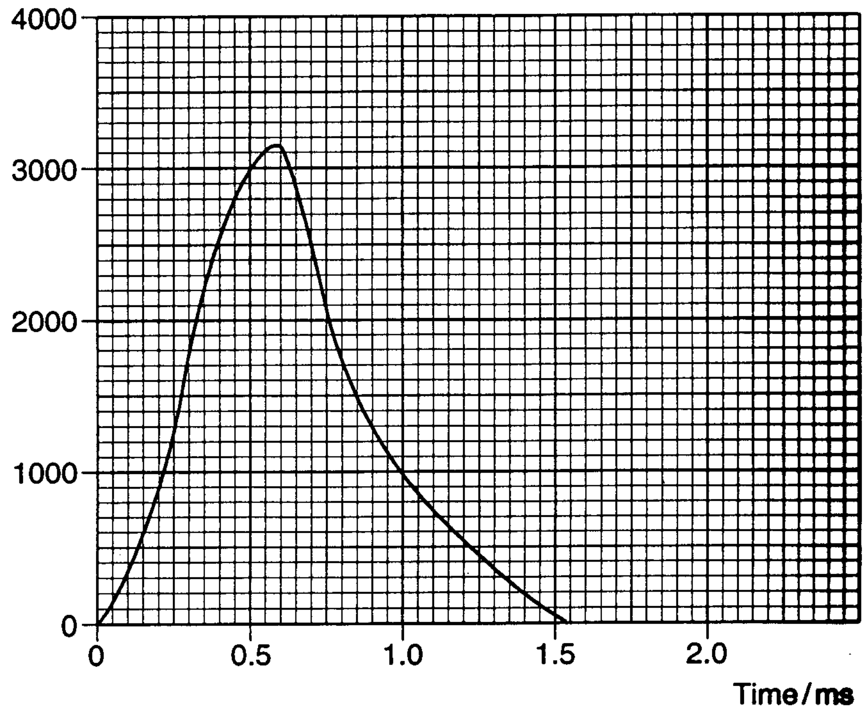

Fig. 9

(a) Show that the change of momentum of the ball during the **time of contact** is approximately 2 kg m s^{-1}.

[3]

For Examiner's Use

(b) The mass of the golf ball is 0.045 kg.

Calculate the speed of the golf ball at the instant it leaves the club.

[3]

(c) Explain why golfers practise their swing so as to keep the golf club in contact with the ball for as long as possible.

[3]

For Examiner's Use

10 This question is about modelling the motion of a simple pendulum (Fig. 10.1).

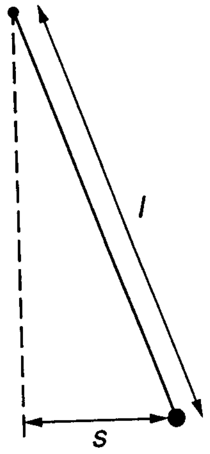

Fig. 10.1

Length of pendulum, $l = 3.0\,\text{m}$

For small oscillations the acceleration, a, of the pendulum bob is given by

$$a = -\underline{gs}$$

where $g = 9.8\,\text{N kg}^{-1}$.

A student attempts to model the motion of the pendulum by assuming that the acceleration is uniform over time intervals of 0.2 s. Making this assumption in your calculations:

(a) **(i)** Show that the initial acceleration when the pendulum is released from a displacement of 0.050 m is $-0.16\,\text{m s}^{-2}$.

(ii) Show that the change of displacement over the 0.2 s period is $3.2 \times 10^{-3}\,\text{m}$.

(iii) Hence calculate the displacement of the bob from the equilibrium position after the first 0.2 s.

displacement = ...m [4]

For Examiner's Use

(b) The student now calculates the acceleration for the beginning of the next 0.2 second interval using the displacement in **(a) (iii)**. This process is repeated step by step to obtain the graph in Fig. 10.2.

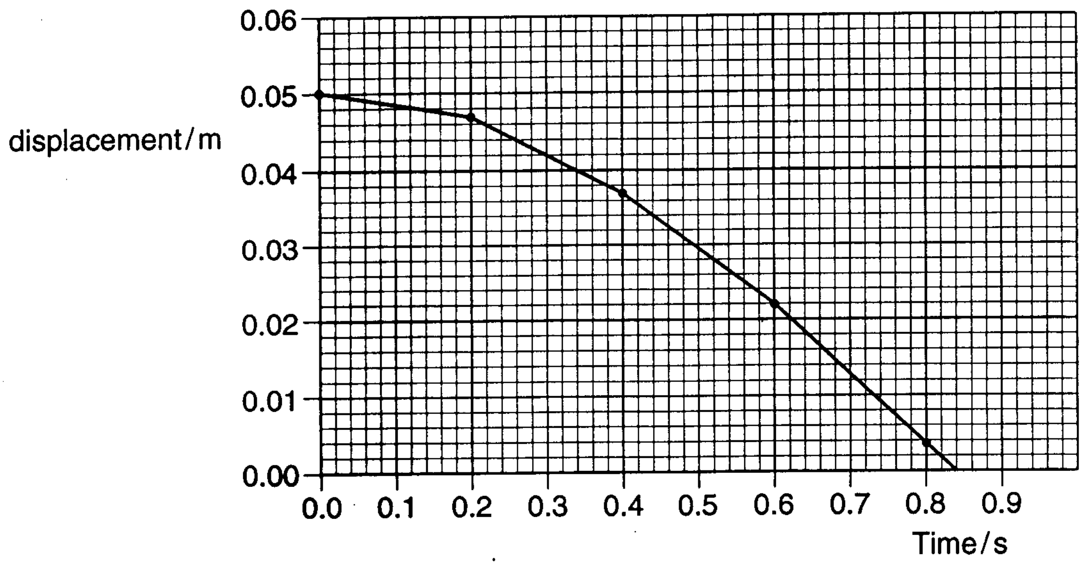

Fig. 10.2

Use the graph to calculate the predicted period of the pendulum.

Period = ...s [1]

(c) **(i)** The model always overestimates the changes of displacement. Explain why this is the case.

(ii) The actual period of the pendulum was 3.5 s. Explain how the model could be improved to give an answer closer to the actual value.

[3]

[Turn over

11 This question is about using a capacitor to measure reaction times.
When switch A in Fig. 11.1 is moved from P to Q the capacitor begins to discharge. Opening switch B stops the discharge. In a measurement of reaction time switch A is moved from P to Q to start the discharge of the capacitor. The student under test opens switch B as soon as he sees the reading on the voltmeter begin to fall.

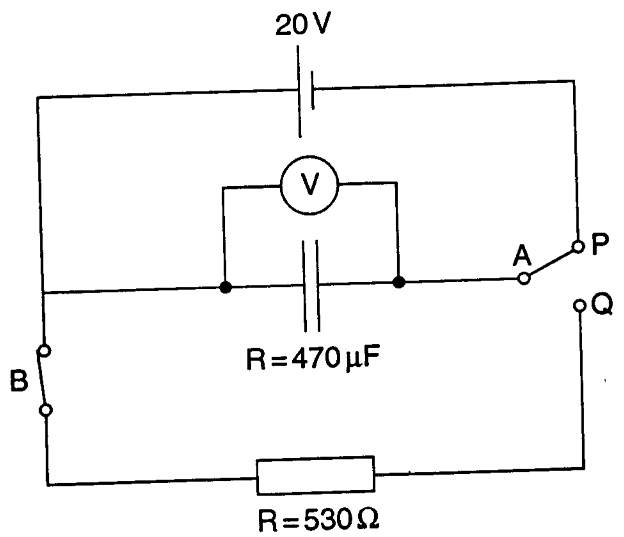

Fig. 11.1

(a) **(i)** Show that the value of the time constant, τ, for the capacitor discharge circuit in Fig. 11.1 is 0.25 s.

(ii) Show that the units of the time constant, τ, are second (s).

[3]

For Examiner's Use

(b) 0.25 s after discharge starts the potential difference across the capacitor will have fallen to approximately 37% of its original value of 20 V.

(i) Show that the potential difference across the capacitor after 0.25 seconds will be 7.4 V.

(ii) Complete the table below:

time/s	potential difference/V
0.00	20.0
0.25	7.4
0.50	
0.75	

(iii) Plot a graph on Fig. 11.2 to show how potential difference varies with time of discharge.

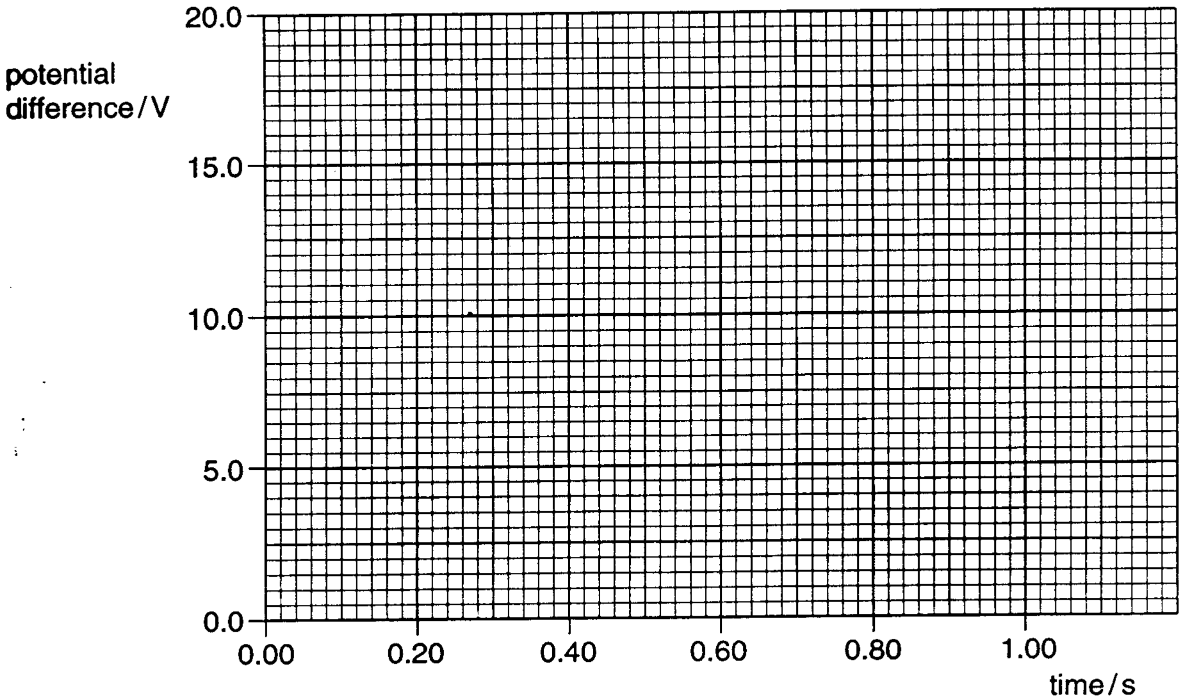

Fig. 11.2

Question 11 continued over the page

For Examiner's Use

(iv) In one experiment a student stopped the discharge when the potential difference had fallen to 12 V. Use your graph to find the reaction time of the student.

Reaction time = ...s [5]

(c) Describe how you would change the circuit to measure times of a few milliseconds.

[2]

QoWC [4]