

Advanced GCE

PHYSICS B (ADVANCING PHYSICS)

Unit G494: Rise and Fall of the Clockwork Universe

Specimen Paper

Candidates answer on the question paper.

Time: 1 hour 15 minutes

Additional Materials:

Data, Formulae and Relationships Booklet
Electronic calculator

G494 QP

Candidate Name

Centre Number

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Candidate Number

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INSTRUCTIONS TO CANDIDATES

- Write your name, Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [] at the end of each question or part question.
-  Where you see this icon you will be awarded marks for the quality of written communication in your answer.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- The total number of marks for this paper is **60**.

FOR EXAMINER'S USE		
Section	Max.	Mark
A	15	
B	45	
TOTAL	60	

This document consists of **17** printed pages and **3** blank pages.

Answer **all** the questions.

Section A

- 1 Fig 1.1 shows three possible paths, **A**, **B** and **C**, of a spacecraft moving near the Earth, but well above the atmosphere.

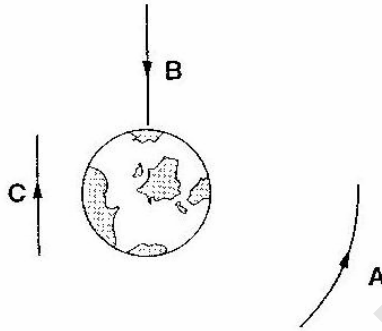


Fig. 1.1

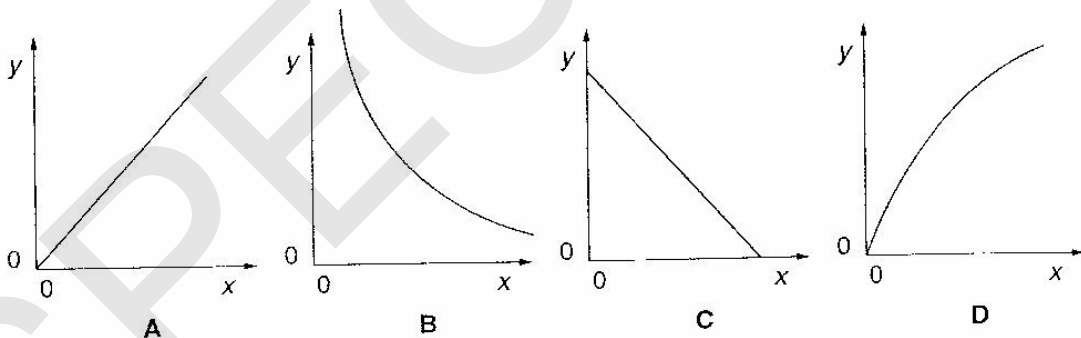
- (a) Which path follows a gravitational field line of the Earth?

answer [1]

- (b) Which path follows a gravitational equipotential line of the Earth?

answer [1]

- 2 Study the graphs A, B, C, D.



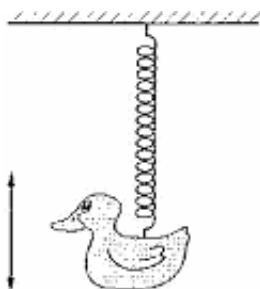
- (a) Which graph shows the variation in volume (y) of a fixed mass of ideal gas at constant pressure with absolute temperature (x)?

answer [1]

- (b) Which graph shows the variation in pressure (y) of a fixed mass of ideal gas at constant temperature with volume (x)?

answer [1]

- 3 A plastic duck hangs from a long spring. The duck oscillates vertically with a frequency of 0.42 Hz.



The displacement x of the duck at time t is given by the equation

$$x = A \cos(2\pi ft)$$

where $A = 0.20$ m.

Choose the value from the list below which gives the displacement of the duck when $t = 2.0$ s.

0.11 m

0.20 m

-0.11 m

-0.20 m

chosen value = [1]

- 4 2.0 mol of an ideal gas is kept at a pressure of 1.5×10^5 Pa and a temperature of 310 K.

Calculate the volume occupied by the gas under these conditions.

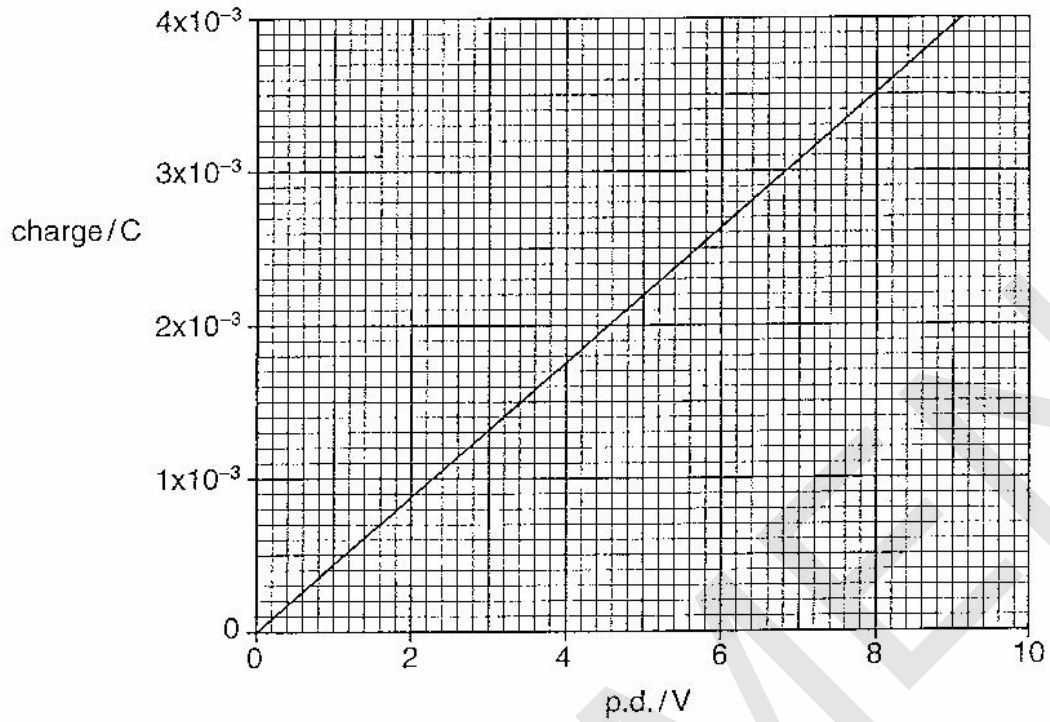
$$R = 8.3 \text{ J K}^{-1} \text{ mol}^{-1}$$

volume = m³

[2]

[Turn over

5 The graph show how the charge on a capacitor varies with p.d. across the capacitor.



Here are a number of values:

440

210

350

700

Use information from the graph to choose from the list the best value for

(a) the capacitance of the capacitor in microfarad

value = μF [1]

(b) the energy in μJ stored on the capacitor when a p.d. of 4.0 V is applied across it.

value = μJ [1]

- 6 A circus clown fires a water gun that ejects water horizontally at a speed of 7.3 m s^{-1} . The water leaves the gun at a rate of 2.7 kg s^{-1} .

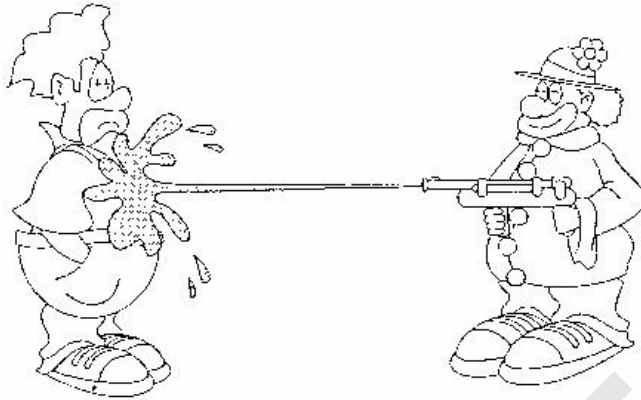


Fig. 6.1

Explain why the clown holding the gun experiences a backward force of about 20 N.

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[3]

[Turn over

7 Fig 7.1 shows a circuit diagram of a capacitor discharging through a resistor.

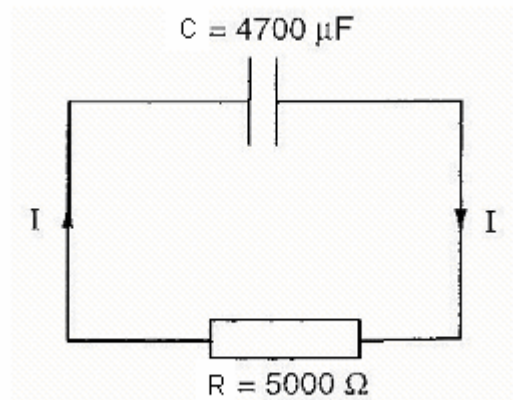
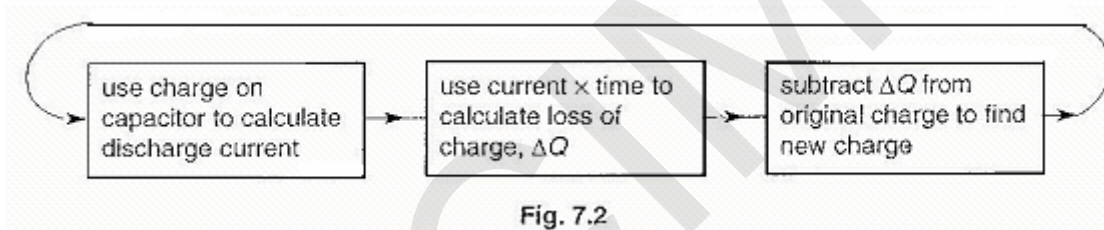


Fig. 7.1

A simple mathematical model of the discharge of the capacitor is shown in Fig. 7.2. It is assumed that the current I is constant over each small time interval Δt . This process is repeated as shown.



(a) Complete the table for the discharge of the 4700 μ F capacitor. The small time interval used is $\Delta t = 2.0$ s.

Q	$I = \frac{V}{R} = \frac{Q}{RC}$	$\Delta Q = I \Delta t$	$Q_{\text{new}} = Q - \Delta Q$
$5.64 \times 10^{-2} \text{ C}$			$5.16 \times 10^{-2} \text{ C}$
$5.16 \times 10^{-2} \text{ C}$			

[2]

(b) Suggest one reason why mathematical models are useful in physics.

.....

[1]

[Section A Total: 15]

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SPECIMEN

[Turn over

Section B

- 8 This question is about the time it takes a planet to orbit once around the Sun. This is called the orbital period of the planet.

In this question, the following symbols will be used:

orbital period T

mean radius of orbit R

mass of Sun M_s

mass of planet M_p

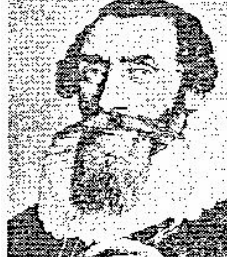


Fig. 8.1

Taken from *Measuring the universe*, Kitty Ferguson, Reproduced by permission of headline publishing group limited

- (a) The seventeenth century astronomer Johannes Kepler (Fig. 8.1) suggested a relationship between the orbital period of a planet T and its radius of orbit R .

This relationship can be written as

$$T^2 \propto R^3$$

Kepler found this mathematical relationship by trial and error.

Data for four of the planets are shown in Fig. 8.2.

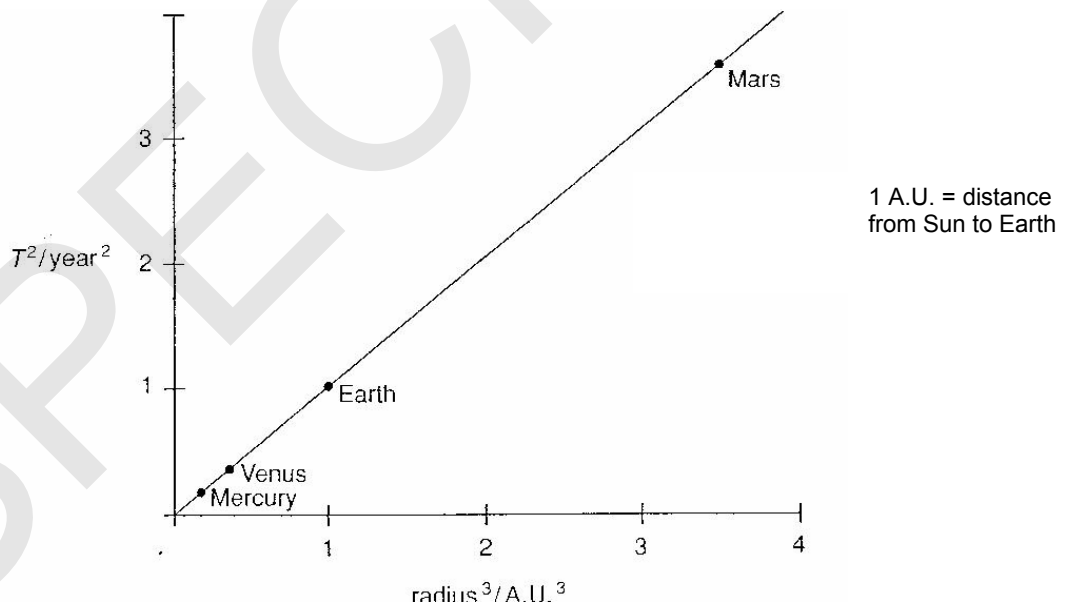


Fig. 8.2

State which features of the graph show that T^2 is proportional to R^3 .

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..... [2]

- (b) Isaac Newton (Fig. 8.3) developed a description of gravity that confirmed Kepler's work.

Newton's confirmation of Kepler was based on his laws of motion and his gravitational law.



Fig 8.3

The centripetal force on a planet of mass M_p orbiting with period T at radius R is given by

$$F = - M_p (2\pi)^2 / T^2 R$$

Use Newton's Gravitational Law $F = - GM_p M_s / R^2$ to show that $T^2 / R^3 = (2\pi)^2 / GM_s$ and hence find the mass of the Sun.

$$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$$


$$\text{Mean radius of Earth's orbit} = 1.5 \times 10^{11} \text{ m}$$

$$1 \text{ year} = 3.2 \times 10^7 \text{ s}$$

mass of Sun = kg [4]

[Turn over

- (c) The Sun loses mass at a rate of $6.2 \times 10^{11} \text{ kg s}^{-1}$. Discuss whether this will have had any significant affect on the orbit the Earth over the 40 000 years that humans have made an impact on the planet.

 You will be awarded marks for the quality of your written communication.

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[3]

- (d) Although Kepler's findings were hugely important, Newton's are considered to be more significant.

Give **one** reason why Newton's approach is considered an advance on Kepler's approach.

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[1]

[Total: 10]

9 This question is about heating soup with microwaves.

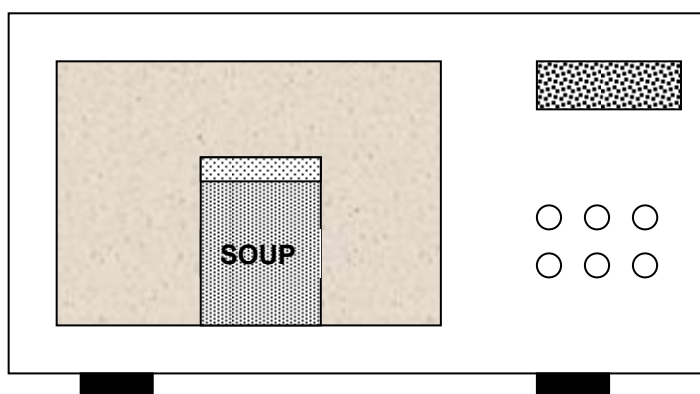


Fig. 9.1

- (a) The microwave oven supplies energy to the soup at a rate of 600 W. The soup, of mass 0.40 kg, has an initial temperature of 20 ° C. Show that, after three minutes, the maximum temperature will be about 85 ° C. specific thermal capacity of soup = 4200 J kg⁻¹ K⁻¹

[2]

- (b) The Boltzmann factor is given as $f = e^{-E/kT}$. Describe what the Boltzmann factor indicates and use it to explain why increasing numbers of molecules evaporate from the soup as its temperature rises.

You will be awarded marks for the quality of your written communication.

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[4]

10 This question is about some of the physics of the human ear.

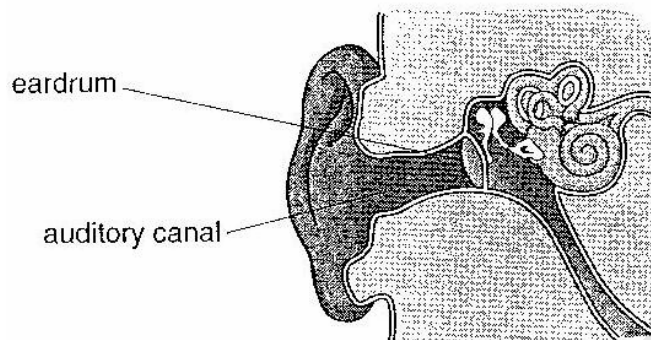


Fig. 10.1

A given sound wave striking the ear drum sets it oscillating in simple harmonic motion. The ear drum oscillates at a frequency of 2500 Hz with an amplitude of 1.0×10^{-7} m.

(a) (i) Calculate the period of the oscillation.

period = s [1]

(ii) On the axes of Fig. 10.2, draw a graph to show how the displacement of the eardrum varies with time for one oscillation. Assume that the displacement is zero at $t = 0$.

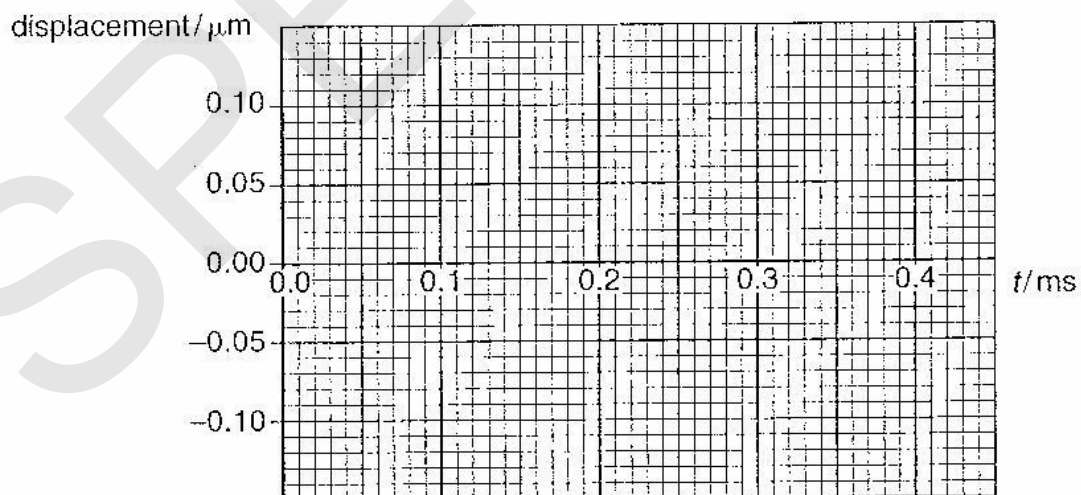


Fig. 10.2

[3]

[Turn Over

11 This question is about calculating the age of stars using the radioactive decay of uranium-238.

- (a) A sample containing 1.0×10^{-6} kg of uranium-238 contains 2.5×10^{18} uranium-238 atoms.

The activity of the sample is 12 Bq.

Show that the half-life of uranium-238 is about 4.5 billion years.

$$1 \text{ year} = 3.2 \times 10^7 \text{ s}$$

[3]

- (b) A small sample of rock contains 10 atoms of uranium-238. Estimate, **without calculation**, the number of atoms of uranium-238 that would have been present in that rock at the time when the Solar System is believed to have formed, 5.6 billion years ago, and explain how you obtained that estimate.

Explain clearly why a precise calculation would not have given an accurate answer of the number originally present.

[4]

[Turn Over

- (c) Astronomers have observed the spectrum of a very old nearby star to determine how much uranium-238 it contains. This value is compared with the amount that is thought to have been present when the star was formed.

Recent observations suggest that the amount of uranium-238 in the star has fallen to 12 % of its original value.

Calculate the age of the star in years.

age of star = years [2]

- (d) The Hubble Law, based on observation of cosmological red shifts, suggest that the universe is much older than the age of the stars measured by finding how much uranium-238 it contains.

Explain the meaning of the term cosmological red shift.

[1]

- (e) The Hubble Law suggests that the age of the universe is of the order $1/H_0$ where H_0 is the Hubble parameter. Estimating the value of H_0 is an extremely important task. Values for H_0 have ranged from $1.6 \times 10^{-18} \text{ s}^{-1}$ to $3.2 \times 10^{-18} \text{ s}^{-1}$.

- (i) Estimate the minimum and maximum age of the universe in years from the value of H_0 .

minimum age =years

maximum age = years [2]

- (ii) Explain how data from the uranium-238 method of finding the age of stars can be used to help astronomers choose between these values of H_0 .

[1]

[Total: 13]

[Section B Total: 45]

Paper Total [60]

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Sources

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