| Surname | | Other Names | |
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| Centre Number | | Candidate Number | |
| Candidate Signature | | | |

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General Certificate of Education
January 2005
Advanced Level Examination

**PHYSICS (SPECIFICATION B)** **PHB6/2**
**Unit 6 Exercise 2**

Wednesday 2 February 2005 Morning Session

**In addition to this paper you will require:**
- a calculator;
- a ruler.

Time allowed: 1 hour 30 minutes

**Instructions**
- Use blue or black ink or ball-point pen.
- Answer **all** questions.
- *Formulae Sheets* are provided on pages 3 and 4. Detach this perforated page at the start of the examination.
- There are two questions in this paper. 45 minutes are allowed for Question 1 and 45 minutes for Question 2.
- All working must be shown. Do all rough work in this book. Cross through any work you do not want marked.

**Information**
- The maximum mark for this paper is 39.
- Mark allocations are shown in brackets.
- You are expected to use a calculator where appropriate.
- You will be assessed on your ability to use an appropriate form and style of writing, to organise relevant information clearly and coherently, and to use specialist vocabulary where appropriate.
- The degree of legibility of your handwriting and the level of accuracy of your spelling, punctuation and grammar will also be taken into account.

| For Examiner's Use | | | |
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| Number | Mark | Number | Mark |
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| TOTAL | | | |
| Examiner's Initials | | | |

**Advice**
- Before commencing the first part of any question, read the question through completely.
- Ensure that **all** measurements taken, including repeated readings, gradients, derived quantities, etc., are recorded to an appropriate number of significant figures with due regard to the accuracy of measurement.
- If an experiment does not operate correctly, you should request assistance from the Supervisor. The Supervisor will give the minimum help necessary to make the experiment operate and will report the action taken to the Examiner. If the fault is due to your inability to make the experiment operate, a deduction of marks will be made, but it will be possible for you to complete the remainder of the question and gain marks for the later parts of that question.

Answer **all** questions in the spaces provided.

45 minutes are allowed for this question.

**Total for this question:** ***20 marks***

1 You are going to investigate how the volume of a fixed mass of gas varies with pressure and go on to determine a value for atmospheric pressure.

You have been provided with a clamped syringe. The open end of the syringe has been sealed.

(a) (i) Record the volume of air trapped in the syringe to the nearest 0.5 of a scale division.

*(1 mark)*

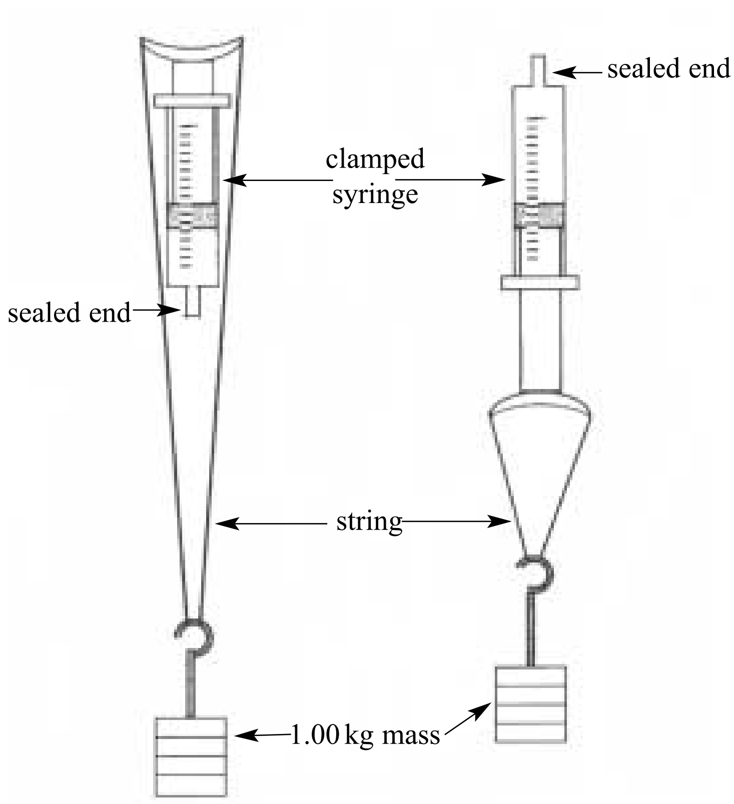



**Figure 1** **Figure 2**

(ii) Measure and record:

$V_1$, the volume of air trapped in the syringe when the 1.00 kg mass is suspended from the syringe as shown in **Figure 1**;

$V_2$, the volume of trapped air when the 1.00 kg mass is suspended as shown in **Figure 2**.

**Detach this perforated page at the start of the examination.**

## Foundation Physics Mechanics Formulae

moment of force $= Fd$

$v = u + at$

$s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2as$

$s = \frac{1}{2}(u + v)t$

for a spring, $F = k\Delta l$

energy stored in a spring $= \frac{1}{2}F\Delta l = \frac{1}{2}k(\Delta l)^2$

$T = \frac{1}{f}$

## Foundation Physics Electricity Formulae

$I = nAvq$

terminal p.d. $= E - Ir$

in series circuit, $R = R_1 + R_2 + R_3 + \ldots$

in parallel circuit, $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$

output voltage across $R_1 = \left(\frac{R_1}{R_1 + R_2}\right) \times$ input voltage

## Waves and Nuclear Physics Formulae

fringe spacing $= \frac{\lambda D}{d}$

single slit diffraction minimum $\sin\theta = \frac{\lambda}{b}$

diffraction grating $n\lambda = d\sin\theta$

Doppler shift $\frac{\Delta f}{f} = \frac{v}{c}$ for $v << c$

Hubble law $v = Hd$

radioactive decay $A = \lambda N$

### Properties of Quarks

| Type of quark | Charge | Baryon number |
|---|---|---|
| up u | $+\frac{2}{3}e$ | $+\frac{1}{3}$ |
| down d | $-\frac{1}{3}e$ | $+\frac{1}{3}$ |
| $\overline{\text{u}}$ | $-\frac{2}{3}e$ | $-\frac{1}{3}$ |
| $\overline{\text{d}}$ | $+\frac{1}{3}e$ | $-\frac{1}{3}$ |

### Lepton Numbers

| Particle | Lepton number $L$ | | |
|---|---|---|---|
| | $L_e$ | $L_\mu$ | $L_\tau$ |
| $e^-$ | 1 | | |
| $e^+$ | –1 | | |
| $\nu_e$ | 1 | | |
| $\overline{\nu}_e$ | –1 | | |
| $\mu^-$ | | 1 | |
| $\mu^+$ | | –1 | |
| $\nu_\mu$ | | 1 | |
| $\overline{\nu}_\mu$ | | –1 | |
| $\tau^-$ | | | 1 |
| $\tau^+$ | | | –1 |
| $\nu_\tau$ | | | 1 |
| $\overline{\nu}_\tau$ | | | –1 |

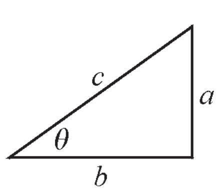
## Geometrical and Trigonometrical Relationships

circumference of circle $= 2\pi r$

area of a circle $= \pi r^2$

surface area of sphere $= 4\pi r^2$

volume of sphere $= \frac{4}{3}\pi r^3$




$\sin\theta = \frac{a}{c}$

$\cos\theta = \frac{b}{c}$

$\tan\theta = \frac{a}{b}$

$c^2 = a^2 + b^2$

**Detach this perforated page at the start of the examination.**

## Circular Motion and Oscillations

$$v = r\omega$$

$$a = -(2\pi f)^2 x$$

$$x = A \cos 2\pi f t$$

$$\text{maximum } a = (2\pi f)^2 A$$

$$\text{maximum } v = 2\pi f A$$

$$\text{for a mass-spring system, } T = 2\pi\sqrt{\frac{m}{k}}$$

$$\text{for a simple pendulum, } T = 2\pi\sqrt{\frac{l}{g}}$$

## Fields and their Applications

$$\text{uniform electric field strength, } E = \frac{V}{d} = \frac{F}{Q}$$

$$\text{for a radial field, } E = \frac{kQ}{r^2}$$

$$k = \frac{1}{4\pi\varepsilon_0}$$

$$g = \frac{F}{m}$$

$$g = \frac{GM}{r^2}$$

$$\text{for point masses, } \Delta E_p = GM_1M_2\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

$$\text{for point charges, } \Delta E_p = kQ_1Q_2\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

$$\text{for a straight wire, } F = BIl$$

$$\text{for a moving charge, } F = BQv$$

$$\phi = BA$$

$$\text{induced emf} = \frac{\Delta(N\phi)}{t}$$

$$E = mc^2$$

## Temperature and Molecular Kinetic Theory

$$T/\text{K} = \frac{(pV)_T}{(pV)_{tr}} \times 273.16$$

$$pV = \tfrac{1}{3} Nm\langle c^2\rangle$$

$$\text{energy of a molecule} = \tfrac{3}{2} kT$$

## Heating and Working *(3 marks)*

$$\Delta U = Q + W$$

$$Q = mc\Delta\theta$$

$$Q = ml$$

$$P = Fv$$

$$\text{efficiency} = \frac{\text{useful power output}}{\text{power input}}$$

$$\text{work done on gas} = p\Delta V$$

$$\text{work done on a solid} = \tfrac{1}{2} F\Delta l$$

$$\text{stress} = \frac{F}{A}$$

$$\text{strain} = \frac{\Delta l}{l}$$

$$\text{Young modulus} = \frac{\text{stress}}{\text{strain}}$$

## Capacitance and Exponential Change

$$\text{in series, } \frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$\text{in parallel, } C = C_1 + C_2$$

$$\text{energy stored by capacitor} = \tfrac{1}{2} QV$$

$$\text{parallel plate capacitance, } C = \frac{\varepsilon_0 \varepsilon_r A}{d}$$

$$Q = Q_0 e^{-t/RC}$$

$$\text{time constant} = RC$$

$$\text{time to halve} = 0.69\, RC$$

$$N = N_0 e^{-\lambda t}$$

$$A = A_0 e^{-\lambda t}$$

$$\text{half-life, } t_{\frac{1}{2}} = \frac{0.69}{\lambda}$$

## Momentum and Quantum Phenomena

$$Ft = \Delta(mv)$$

$$E = hf$$

$$hf = \Phi + E_{k(max)}$$

$$hf = E_2 - E_1$$

$$\lambda = \frac{h}{\ldots}$$

(b) (i) Calculate the change in pressure, $\Delta p$, of the trapped air when the $(1.00 \pm 0.01)$ kg mass is suspended from the syringe.

The area of cross-section $A$ of the syringe and its uncertainty is on a card near your apparatus.

gravitational field strength = $(9.8 \pm 0.1)\,\text{N kg}^{-1}$.

*(3 marks)*

(ii) The value of atmospheric pressure is given by

$$p = \Delta p \left\{ \frac{V_2 + V_1}{V_2 - V_1} \right\}$$

Calculate a value for atmospheric pressure.

*(2 marks)*

(c) (i) State the absolute uncertainty in the values for $V$.

*(1 mark)*

(ii) Calculate the percentage uncertainty in the value for atmospheric pressure.

*(3 marks)*

**QUESTION 1 CONTINUES ON THE NEXT PAGE**

(iii) Your calculated value for atmospheric pressure is unreliable. Discuss **three** ways of modifying the apparatus or procedure to improve the reliability of the result obtained using such an arrangement as this.

You could begin by explaining how using a syringe with different dimensions would be advantageous.

Two of the 7 marks in this question are available for the quality of your written communication.

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*(7 marks)*

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20

45 minutes are allowed for this question

**Total for this question:** ***19 marks***

**2** You are provided with the circuit shown in **Figure 3**.

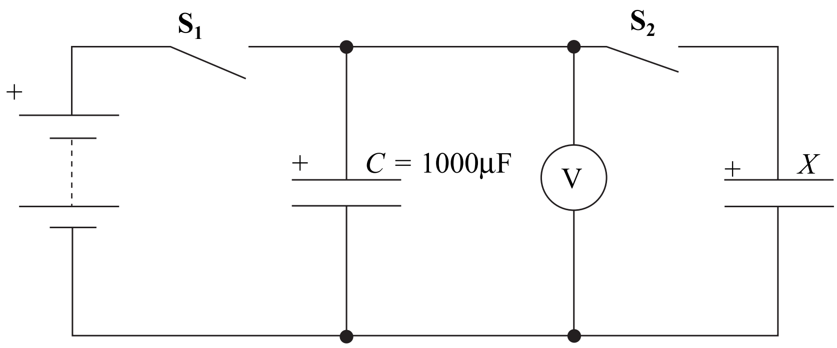


**Figure 3**

(a) (i) Explain why it is important to ensure that components are connected with the labelled positive terminals connected exactly as shown in **Figure 3.**

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*(1 mark)*

(ii) State and explain an important factor other than the capacitor value that had to be considered when choosing the capacitors for use in this circuit.

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*(2 marks)*

(b) (i) Open both switches (i.e. switch off) then discharge both capacitors using the spare lead provided.

Close $\mathbf{S}_1$ (i.e. switch on) and after a few seconds record the voltmeter reading $V_1$.

Open $\mathbf{S}_1$, quickly close $\mathbf{S}_2$ and immediately record the initial voltmeter reading $V_2$.

*(2 marks)*

**QUESTION 2 CONTINUES ON THE NEXT PAGE**

(ii) Explain how the ratio of the charges on the capacitors $\frac{Q_c}{Q_x}$ is related to the capacitances $C$ and $X$, when $\mathbf{S_2}$ is closed.

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*(2 marks)*

(iii) State and explain how you would expect the reading $V_2$ to change if a larger value than 1000 μF were used for $C$.

*(2 marks)*

(iv) The equation relating $X$ and $C$ is

$$X = \left(\frac{V_1}{V_2} - 1\right)C$$

Calculate a value for $X$.

*(1 mark)*

(c) Describe how you would show practically that the fractional change in the potential difference across $C$ is independent of the initial potential difference.

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*(3 marks)*

(d) Suppose that a 10 kΩ resistor is used to replace capacitor *X*. Describe how this would change the operation of the circuit and describe how you would proceed to investigate the operation of the circuit practically.

Two of the 6 marks in this part are available for the quality of your written communication.

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*(6 marks)*

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19

**END OF QUESTIONS**