General Certificate of Education
June 2008
Advanced Level Examination

PHYSICS (SPECIFICATION B) **PHB6/1**
Unit 6 Exercise 1

To be conducted between Monday 3 March 2008 and Monday 19 May 2008

For this paper you must have:
- an 8-page answer book
- A4 graph paper
- a calculator
- a ruler
- a formulae sheet insert.

Time allowed: 1 hour 30 minutes

Instructions
- Use black ink or black ball-point pen.
- Write the information required on the front of your answer book. The *Examining Body* for this paper is AQA. The *Paper Reference* is PHB6/1.
- Answer **all** questions.
- A separate sheet of graph paper is required.
- Show all your working. Do all rough work in the answer book. Cross through any work you do not want to be marked.

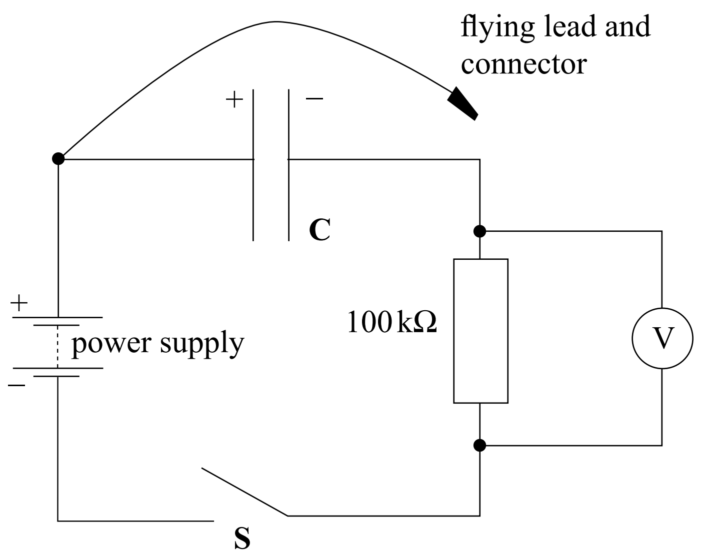
Information
- The maximum mark for this paper is 38.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- The *Formulae Sheet* is provided as a loose insert to this question paper.

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.

1 This question is about the process of charging capacitors in series.

Figure 1



(a) (i) The circuit shown in **Figure 1** has been set up for you and can be used to charge the unknown capacitor **C**.
Use the flying lead to fully discharge **C**.
With the flying lead disconnected, close switch **S** and, by taking readings every ten seconds, plot a graph of the potential difference, *V*, against time over a period of 100 s.
You are not required to take repeat readings for this part of the exercise.

(ii) Use your graph to find, as accurately as possible, the time taken for *V* to halve.
Hence calculate a value for the capacitance of **C**.

(iii) Explain why the potential difference across the 100 kΩ resistor decreases after the switch is closed.

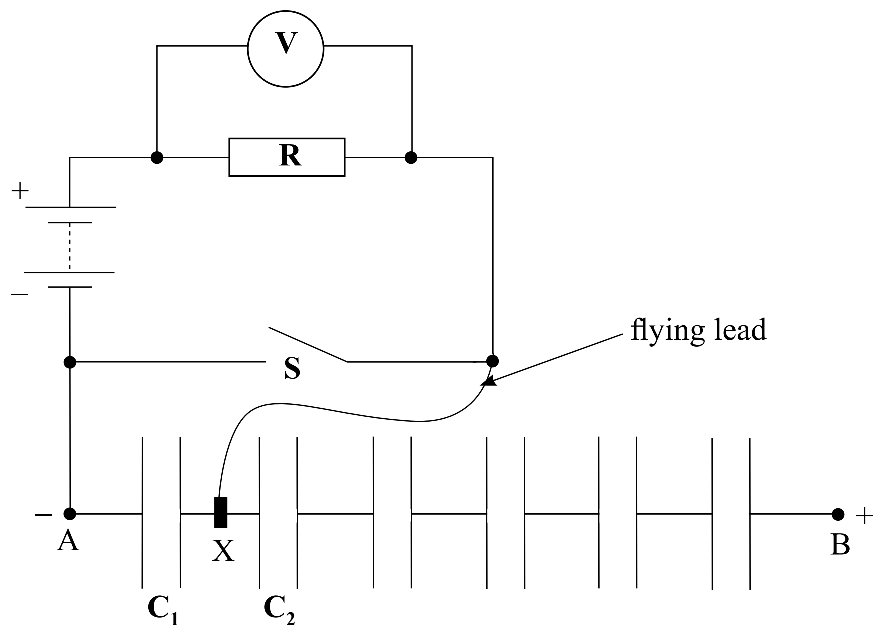
(12 marks)

(b) Fully dismantle your circuit and then connect the new circuit shown in **Figure 2**. **AB** is a row of six 100 μF capacitors connected in series. Use a crocodile clip for the connection at **A**.

Make sure that A is connected to the negative terminal of the supply.

X is a crocodile clip connection between $\mathbf{C_1}$ and $\mathbf{C_2}$, the first two capacitors in the row.

Figure 2



(i) Close switch **S**. With **S** closed, $\mathbf{C_1}$ remains fully discharged.
Record V_0, the reading on the voltmeter.
Open **S** and observe that the voltmeter reading decreases with time.
If your voltmeter reading does not decrease quite quickly when S is opened, ask your supervisor for help.

(ii) Close **S** to discharge $\mathbf{C_1}$.
When the voltmeter reads V_0 again, open **S** and start the stopclock.
Record V, the voltmeter reading after 10 seconds. *(2 marks)*

(c) Close **S**.
Attach the crocodile clip **X** between the second and third capacitors in the row **AB** so that $\mathbf{C_1}$ and $\mathbf{C_2}$ are charged in series when **S** is opened.

(i) Calculate the total capacitance of $\mathbf{C_1}$ and $\mathbf{C_2}$ connected in series.

(ii) Having first discharged $\mathbf{C_1}$ and $\mathbf{C_2}$, measure and record V, the voltmeter reading after 10 seconds, for $\mathbf{C_1}$ and $\mathbf{C_2}$ in series.

(iii) Measure V for 3, 4, 5 and 6 capacitors in series.
Record **all** of your readings for V in a table. Include in your table a column for n, the number of capacitors in series, and also a column for ln (V/V).
Complete the table. *(11 marks)*

(d) Plot a graph of ln (V/V) (y-axis) against n (x-axis).

(5 marks)

(e) Theory predicts that

$$V = V_0 e^{\frac{-nT}{RC}}$$

R is the resistance of the resistor shown in **Figure 2**, $C = 100\,\mu F$ and $T = 10\,s$.

(i) Use your graph to find R.

(ii) Use your graph to find a value for V_0 and compare it with your answer to part (b)(i).

(iii) Suggest and explain **two** sources of uncertainty in your value of R.

(8 marks)

END OF QUESTIONS

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PHYSICS (SPECIFICATION B) **PHB6**
Unit 6

ASSESSMENT and QUALIFICATIONS ALLIANCE

Formulae Sheet

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 $= \frac{1}{2}F\Delta l = \frac{1}{2}k(\Delta l)^2$

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

Foundation Physics Electricity Formulae

$I = nAvq$

terminal p.d. $= E - Ir$

in series circuit, $R = R_1 + R_2 + R_3 + ...$

in parallel circuit, $\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3} + ...$

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

Waves and Nuclear Physics Formulae

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

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

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

Doppler shift $\dfrac{\Delta f}{f} = \dfrac{v}{c}$ 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	$-\frac{1}{3}e$	$+\frac{1}{3}$
$\overline{u}$	$-\frac{2}{3}e$	$-\frac{1}{3}$
$\overline{d}$	$+\frac{1}{3}e$	$-\frac{1}{3}$

Lepton Numbers

Particle	Lepton number L		
	L_e	L_μ	L_τ
e^-	1		
e^+	−1		
ν_e	1		
$\overline{\nu}_e$	−1		
μ^-		1	
μ^+		−1	
ν_μ		1	
$\overline{\nu}_\mu$		−1	
τ^-			1
τ^+			−1
ν_τ			1
$\overline{\nu}_\tau$			−1

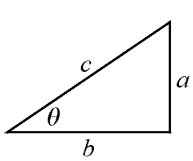
Geometrical and Trigonometrical Relationships

circumference of circle $= 2\pi r$

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

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

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



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

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

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

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

This insert page should **not** be sent to the examiner

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

$$\Delta U = Q + W$$

$$Q = mc\Delta\theta$$

$$Q = ml$$

$$P = Fv$$

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

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

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

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

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

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

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

$$Ft = \Delta(mv)$$

$$E = hf$$

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

$$hf = E_2 - E_1$$

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