General Certificate of Education
January 2003
Advanced Level Examination

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

to be conducted between 1 November 2002 and 3 February 2003

In addition to this paper you will require:

- an 8-page answer book;
- A4 graph paper;
- a calculator;
- a ruler.

Time allowed: 1 hour 30 minutes

Instructions

- Use blue or black ink or ball-point pen.
- Write the information required on the front of the answer book. The *Examining Body* for this unit is AQA. The *Unit Reference* is PHB6/1.
- Answer **all** questions. A separate sheet of graph paper is required.
- *Formulae Sheets* are produced on pages 3 and 4. Detach this perforated page at the start of the examination.
- All working must be shown. Do all rough work in the answer 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.

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 You are going to investigate the oscillations of a loaded metal strip and determine the thickness of the metal strip.

You have been provided with the apparatus shown in **Figure 1**, without any masses attached.

You should not unclamp the metal strip during the experiment.

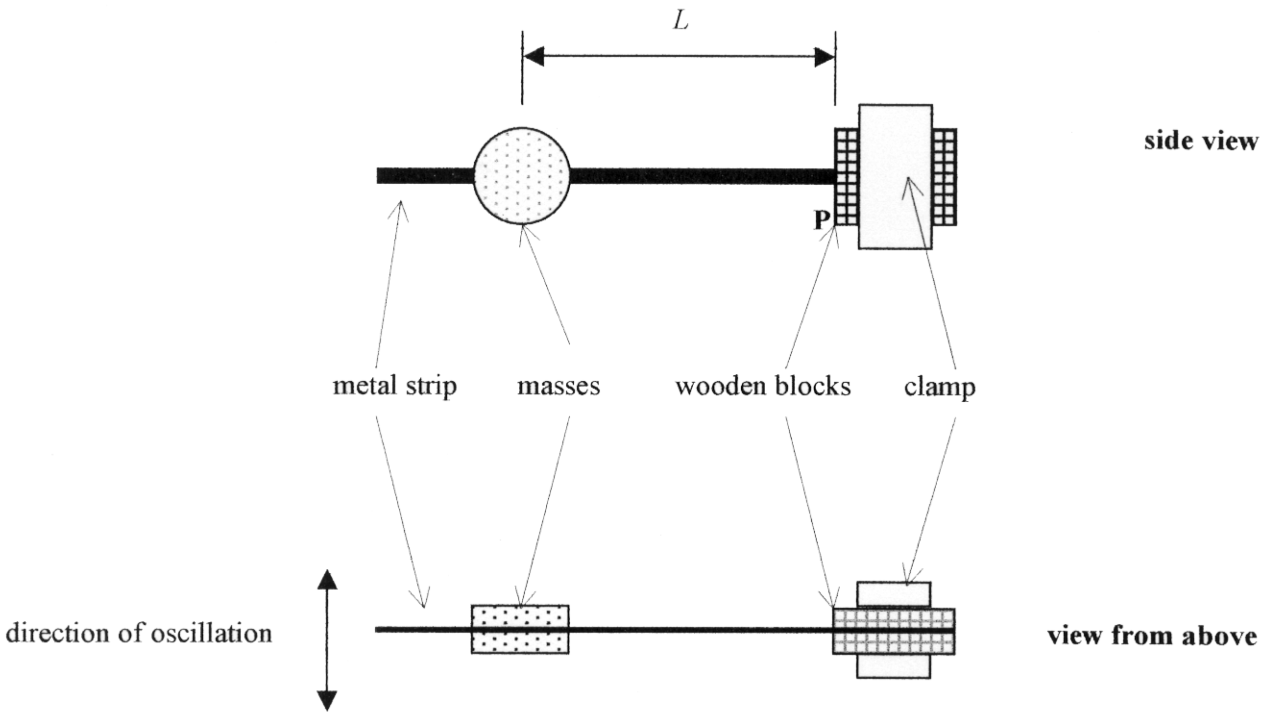


Figure 1

(a) Using the Blu-Tack, fix the two 0.050 kg masses to the metal strip about 0.2 m from **P**.

(i) L is the distance between **P**, the point where the metal strip leaves the wooden blocks, and the centre of the masses. Measure and record the distance L, in m.

(1 mark)

(ii) Set the strip oscillating with a small amplitude and determine the period of oscillation T.

(2 marks)

(iii) The strip performs simple harmonic motion. Why is there a restoring force when the strip is displaced?

(2 marks)

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

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

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, $\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3} + \ldots..$

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	$-\frac{1}{3}e$	$+\frac{1}{3}$
$\overline{\mathrm{u}}$	$-\frac{2}{3}e$	$-\frac{1}{3}$
$\overline{\mathrm{d}}$	$+\frac{1}{3}e$	$-\frac{1}{3}$

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

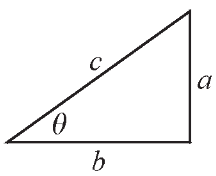
Geometrical and Trigonometrical Relationships

circumference of circle $= 2\pi r$

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

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

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



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

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

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

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

Turn over

Detach this perforated page at the start of the examination.

Circular Motion and Oscillations

$v = r\omega$

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

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

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

maximum $v = 2\pi f A$

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

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

Fields and their Applications

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

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

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

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

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

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

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

for a straight wire, $F = BIl$

for a moving charge, $F = BQv$

$\phi = BA$

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

$E = mc^2$

Temperature and Molecular Kinetic Theory

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

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

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

Heating and Working

$\Delta U = Q + W$

$Q = mc\Delta\theta$

$Q = ml$

$P = Fv$

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

work done on gas $= p\Delta V$

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

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

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

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

Capacitance and Exponential Change

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

in parallel, $C = C_1 + C_2$

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

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

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

time constant $= RC$

time to halve $= 0.69\, RC$

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

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

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

Momentum and Quantum Phenomena

$Ft = \Delta(mv)$

$E = hf$

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

$hf = E_2 - E_1$

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

(b) The period of oscillation of the strip is given by the equation

$$T = kL^n$$

where k and n are constants for the arrangement.

You are now to make measurements that will enable you to plot a graph of log (T/s) against log (L/m) and hence to determine values for n and k.

(i) Make rough measurements to determine an appropriate range, number and distribution of these measurements. State and explain your decisions. *(2 marks)*

(ii) State how the apparatus could be modified to enable you to make accurate measurements for very small values of L. *(2 marks)*

(iii) Make the measurements that you have decided to make in part (i) and calculate the data you need to plot the graph. *(13 marks)*

(iv) Plot the graph drawing the best straight line through your plotted points. *(5 marks)*

(v) By taking logs on both sides of the equation $T = kL^n$, write down the logarithmic relationship between T and L. *(1 mark)*

(vi) Determine a value for n. *(3 marks)*

(vii) Determine a value for k. (Do not attempt to give a unit for k) *(2 marks)*

(c) The value of k is given by

$$k^2 = \frac{c}{bt^3}$$

where t is the thickness of the strip
b is its width
and c is a constant with a value of $(8.0 \pm 0.1) \times 10^{-11}$ in SI units.

Use a ruler to determine a value for b and hence calculate a value for t.

(4 marks)

(d) State the greatest cause of uncertainty in your value for t and how you would proceed to reduce this uncertainty.

(2 marks)

END OF QUESTIONS

General Certificate of Education
January 2003
Advanced Level Examination

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

Monday 3 February 2003 Morning Session

In addition to this paper you will require:
• an 8-page answer book;
• a calculator;
• a ruler.

Time allowed: 1 hour 30 minutes

Instructions
- Use blue or black ink or ball-point pen.
- Write the information required on the front of the answer book. The *Examining Body* for this unit is AQA. The *Unit Reference* is PHB6/2.
- Answer **all** questions.
- *Formulae Sheeets* 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 the answer book. Cross through any work you do not want marked.

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Answer **all** questions.

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

1 You are to investigate the damping of the pendulum shown in **Figures 1 and 2.**

Do not make any adjustments to the pendulum during the experiment.

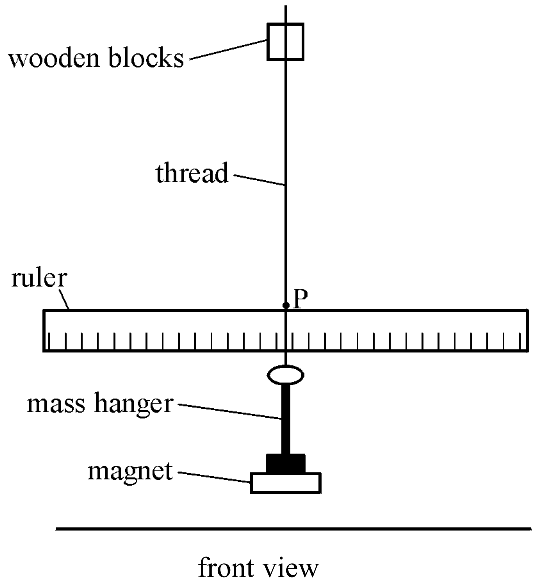

Figure 1

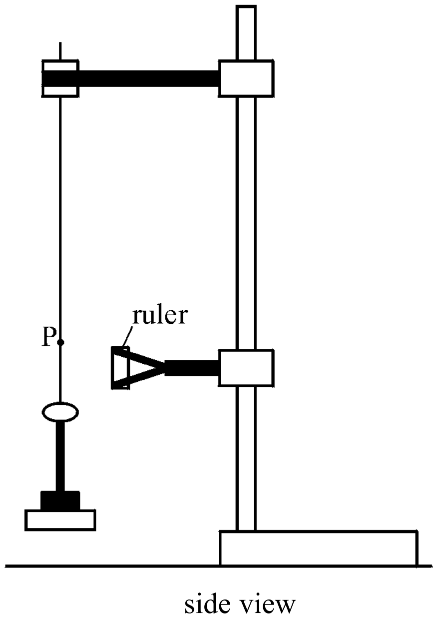

Figure 2

(a) (i) Record the scale reading on the ruler when the pendulum is in the rest position.

Displace the pendulum so that when released the initial amplitude of the oscillations of point **P** is 50 mm.

Determine the number of oscillations required for the amplitude to fall to 30 mm. *(2 marks)*

(ii) State the uncertainty in this measurement. Explain why the uncertainty arises and how you tried to reduce the uncertainty. *(2 marks)*

(iii) Determine the percentage of the original energy of the pendulum that is left when the amplitude falls to 30 mm. *(2 marks)*

(iv) State why energy is lost from the pendulum and state the form taken by the energy that is lost. *(2 marks)*

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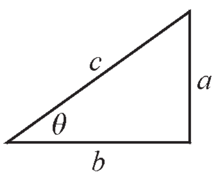

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Turn over ▸

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

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

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

Fields and their Applications

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

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

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

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

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

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

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

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$$\Delta U = Q + W$$

$$Q = mc\Delta\theta$$

$$Q = ml$$

$$P = Fv$$

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

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

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

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

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

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

$$Ft = \Delta(mv)$$

$$E = hf$$

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

$$hf = E_2 - E_1$$

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

(b) (i) Insert the metal foil provided between the bottom face of the magnet and the bench. Ensure that the foil does not touch the bottom face of the magnet.

Again starting with an initial amplitude of 50 mm, determine the new number of oscillations required for the amplitude to fall to 30 mm. *(1 mark)*

(ii) Explain why the presence of the foil makes a difference to the number of oscillations required for the amplitude to fall by the same amount. State the forms that the energy loss takes when the pendulum is oscillating with the foil in place.

Two of the 7 marks in this question are available for the quality of written communication. *(7 marks)*

(c) (i) State **two** factors, other than the initial amplitude, that affect the rate at which energy is lost from the oscillating pendulum when the foil is placed below the magnet. *(2 marks)*

(ii) For each of the factors you have given in (c)(i) state and explain how you would expect each of them to affect the rate at which energy is lost from the pendulum. *(2 marks)*

TURN OVER FOR THE NEXT QUESTION

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

2 You are first going to measure the resistance of a thermistor. You will then use this to determine the energy gap for the semiconductor and go on to describe how you would develop the experiment further.

(a) Set up the circuit shown in **Figure 3**.

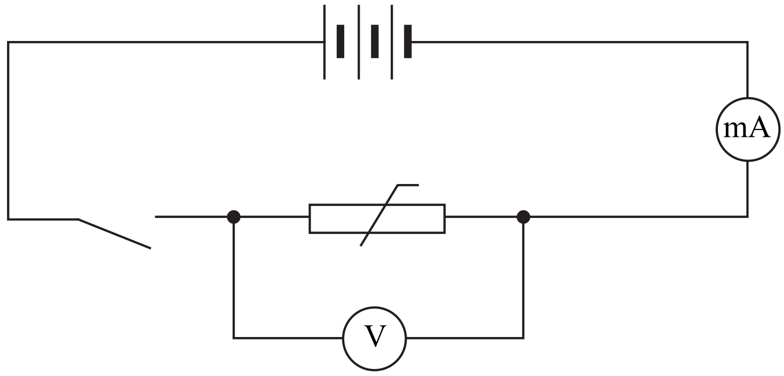

Figure 3

If you are unable to connect the circuit you should ask for help from the supervisor. This will be reported to the examiner who will deduct marks appropriately but you will then be able to gain credit for later parts of the question.

(i) Take voltmeter and ammeter readings and determine the resistance of the thermistor at room temperature.

Immerse the thermistor in the iced water and determine the new resistance. *(2 marks)*

(ii) Explain why the resistance changes when the thermistor is immersed in the iced water. *(3 marks)*

(b) The resistance of the thermistor is related to its thermodynamic (kelvin) temperature T by the equation

$$\ln\left(\frac{1}{R}\right) = \ln A - \frac{E}{kT}$$

where R is the resistance of the thermistor at temperature T
E is the energy gap for the semiconductor
k is the Boltzmann constant ($1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$)
and A is a constant for the thermistor, $740\,\Omega^{-1}$ in this case.

(i) Use your value for the resistance in the iced water to determine a value for E. *(2 marks)*

(ii) Showing your reasoning clearly determine:

- the percentage uncertainty in your value for the resistance R at room temperature
- the percentage uncertainty in the value of $\ln\left(\frac{1}{R}\right)$. *(3 marks)*

(c) The equation in (b) can also be written

$$\frac{1}{R} = A\,e^{-E/kT}$$

(i) Draw a sketch of the graph you would expect if $\frac{1}{R}$ were plotted against $\frac{1}{T}$.

(1 mark)

(ii) Describe clearly how you would obtain and use data to investigate whether this relationship holds for temperatures between 0 °C and 100 °C.

In your description include any extra apparatus you would need, the precautions you would take and a description of the procedure you would follow.

Two of the 8 marks in this question are available for the quality of written communication.

(8 marks)

END OF QUESTIONS