General Certificate of Education
January 2004
Advanced Level Examination

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

to be conducted between 1 November 2003 and 2 February 2004

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 provided 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** parts of this question.

Total for this question: ***39 marks***

1 You are to investigate the oscillations of a metre rule swinging in a vertical plane.

(a) Start the rule swinging in a vertical plane about the horizontal pivot. Observe the motion of the pendulum for about 20 oscillations.

The amplitude of oscillation decreases with time.

(i) Explain why this occurs. *(2 marks)*

(ii) Suggest why the number of swings necessary for the amplitude to decrease to half of its initial amplitude is independent of the size of the initial amplitude. *(2 marks)*

(b) Remove the rule from its suspension and detach the pin and the Blu-Tack from the rule. Balance the rule, graduated face upwards, on the triangular prism.

Take and record data that will enable you to measure the distance of the centre of mass from the zero end of the rule. *(2 marks)*

Detach this perforated page at the start of the examination.

Foundation Physics Mechanics Formulae

moment of force $= Fd$

$$v = u + at$$

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

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

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

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

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

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

Foundation Physics Electricity Formulae

$$I = nAvq$$

terminal p.d. $= E - Ir$

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

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

Lepton Numbers

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

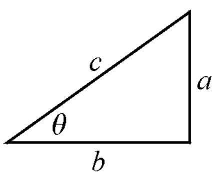
Geometrical and Trigonometrical Relationships

circumference of circle $= 2\pi r$

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

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

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



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

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

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

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

Turn over ▶

Detach this perforated page at the start of the examination.

Circular Motion and Oscillations

$$v = r\omega$$

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

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

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

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

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

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

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

$$Ft = \Delta(mv)$$

$$E = hf$$

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

$$hf = E_2 - E_1$$

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

Re-assemble the suspension system as it was when you found it, see **Figure 1.** Fix the pin to the rule with Blu-Tack so that the metre rule pivots about the 0.60 m mark. The rule should swing freely in a vertical plane. It may not hang vertically when at rest; this will not affect your results.

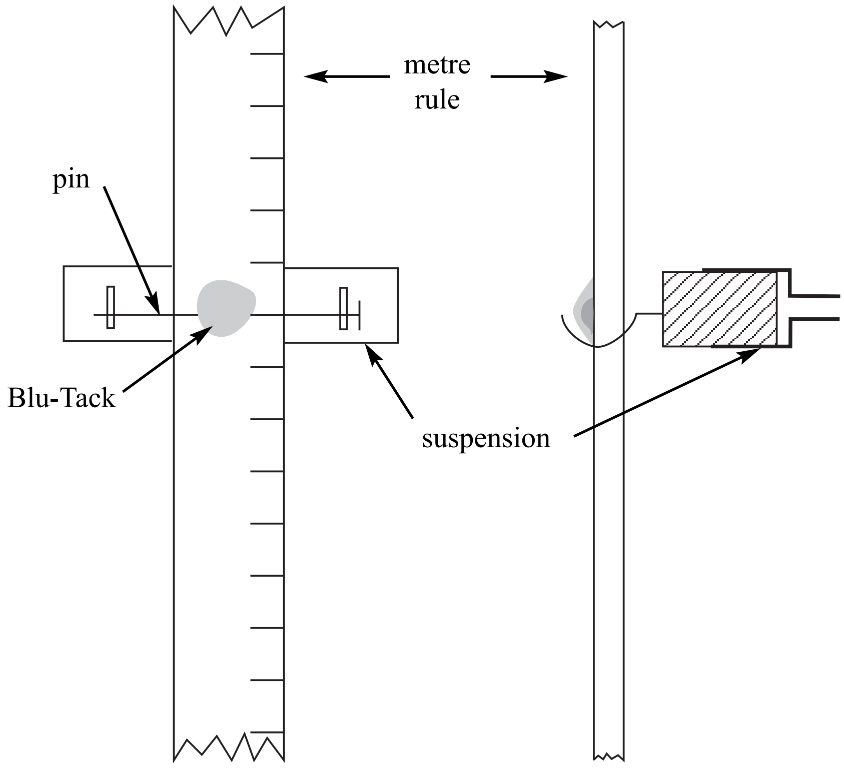


Figure 1

(c) Theory suggests that, for small angles of swing, the time period, T, of oscillation of the rule depends on the distance, x, from the point of suspension to the centre of mass as

$$T = 2\pi\sqrt{\frac{k^2 + x^2}{gx}}$$

where g is the acceleration due to gravity and k is a constant.

(i) Show that this equation can be re-written as

$$xT^2 = \frac{4\pi^2 k^2}{g} + \frac{4\pi^2 x^2}{g}$$

Explain how a graph of xT^2 against x^2 will enable you to determine

(ii) a value for g,

(iii) a value for k. *(4 marks)*

(d) Measure and record in a table corresponding values of x and T that will enable you to test the suggestion made in part (c). Include in your table values for xT^2 and x^2.

State all measurements of T in seconds and all measurements of x in metres. *(9 marks)*

(e) State and explain **two** steps you took in order to make your determinations of T as accurate as possible. *(4 marks)*

(f) Plot a graph of xT^2 against x^2. *(7 marks)*

(g) Comment on the extent to which the equation in part (c) is confirmed by your graph. *(2 marks)*

(h) Using your graph, determine g and k. *(6 marks)*

(i) The equation for the time period T_{sp} of a simple pendulum is

$$T_{sp} = 2\pi\sqrt{\frac{l}{g}}$$

where l is the length of the pendulum.

Suggest why this equation does **not** apply to the motion of the swinging rule. *(1 mark)*

END OF QUESTION