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General Certificate of Education  
June 2005  
Advanced Level Examination



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

**PHB6/2**

Wednesday 25 May 2005 Morning Session

<p><b>In addition to this paper you will require:</b></p> <ul style="list-style-type: none"> <li>• a calculator;</li> <li>• a ruler.</li> </ul>
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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.

**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.

For Examiner's Use			
Number	Mark	Number	Mark
1			
2			
Total (Column 1)	→		
Total (Column 2)	→		
TOTAL			
Examiner's Initials			

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

**Total for this question: 20 marks**

- 1 You are to take some readings that will allow you to measure a modulus of elasticity,  $M$ , of a rubber band.  $M$  is defined by the equation

$$M = \frac{Tl}{eA}$$

where  $l$  is the effective length,  $e$  is the extension and  $A$  the cross-sectional area of the band.  $T$  is the tension in the band.

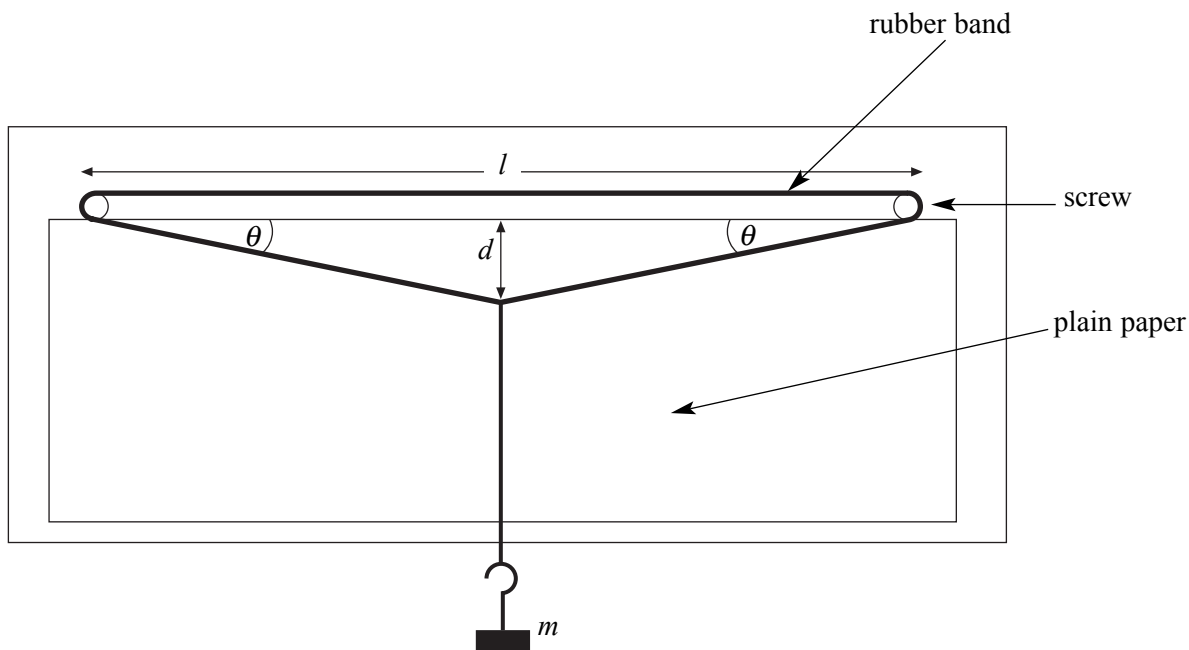
- (a) (i) State an appropriate unit for  $M$ .

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(1 mark)

- (ii) Suggest why you would not expect this modulus of elasticity to be constant for a rubber band even when it is maintained at a constant temperature.

.....  
.....  
(1 mark)

- (b) In order to measure a value for  $M$  the apparatus shown in **Figure 1** may be used.



**Figure 1**

Detach this perforated page at the start of the examination.

### Foundation Physics Mechanics Formulae

$$\text{moment of force} = Fd$$

$$v = u + at$$

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

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

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

$$\text{for a spring, } F = k\Delta l$$

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

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

### Foundation Physics Electricity Formulae

$$I = nAvq$$

$$\text{terminal p.d.} = E - Ir$$

$$\text{in series circuit, } R = R_1 + R_2 + R_3 + \dots$$

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

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

### Waves and Nuclear Physics Formulae

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

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

$$\text{diffraction grating } n\lambda = d \sin \theta$$

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

$$\text{Hubble law } v = Hd$$

$$\text{radioactive decay } A = \lambda N$$

### Properties of Quarks

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

### Lepton Numbers

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

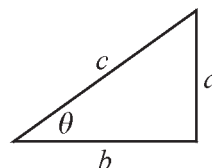
### Geometrical and Trigonometrical Relationships

$$\text{circumference of circle} = 2\pi r$$

$$\text{area of a circle} = \pi r^2$$

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

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



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

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

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

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

Detach this perforated page at the start of the examination.

### Circular Motion and Oscillations

$$v = r\omega$$

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

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

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

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

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

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

### Fields and their Applications

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

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

$$k = \frac{1}{4\pi\epsilon_0}$$

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

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

$$\text{for point masses, } \Delta E_p = GM_1 M_2 \left( \frac{1}{r_1} - \frac{1}{r_2} \right)$$

$$\text{for point charges, } \Delta E_p = kQ_1 Q_2 \left( \frac{1}{r_1} - \frac{1}{r_2} \right)$$

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

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

$$\phi = BA$$

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

$$E = mc^2$$

### Temperature and Molecular Kinetic Theory

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

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

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

### Heating and Working

$$\Delta U = Q + W$$

$$Q = mc\Delta\theta$$

$$Q = ml$$

$$P = Fv$$

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

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

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

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

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

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

### Capacitance and Exponential Change

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

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

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

$$\text{parallel plate capacitance, } C = \frac{\epsilon_0 \epsilon_r A}{d}$$

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

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

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

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

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

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

### Momentum and Quantum Phenomena

$$Ft = \Delta(mv)$$

$$E = hf$$

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

$$hf = E_2 - E_1$$

Explain how you would check that adding masses to the lower part of the rubber band, as shown in the diagram, does not extend the upper part of the loop (above the screws).

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(1 mark)

(c)  $T$  is related to the suspended mass,  $m$ , by the equation  $T = \frac{mg}{2\sin\theta}$

where  $g$  = gravitational field strength and  $\theta$  is the angle shown in **Figure 1**.

With the aid of a force diagram, show that this relationship is valid.

(3 marks)

(d) (i) Suspend a  $(50 \pm 5)$ g mass from the lower section of the rubber band.

Without using a protractor, take measurements to determine  $\theta$  and hence determine the value of  $T$ .

$$g = (9.8 \pm 0.2) \text{ N kg}^{-1}$$

(3 marks)

(ii) Showing your working clearly, estimate the percentage uncertainty in your value for  $T$ .

(4 marks)

(e) Describe how you would use the apparatus to investigate how  $M$  depends upon the mass suspended from the lower portion of the rubber band. You should make clear

- how each quantity is measured or calculated
- the range of values of  $m$  that you would use
- how you would display your results.

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

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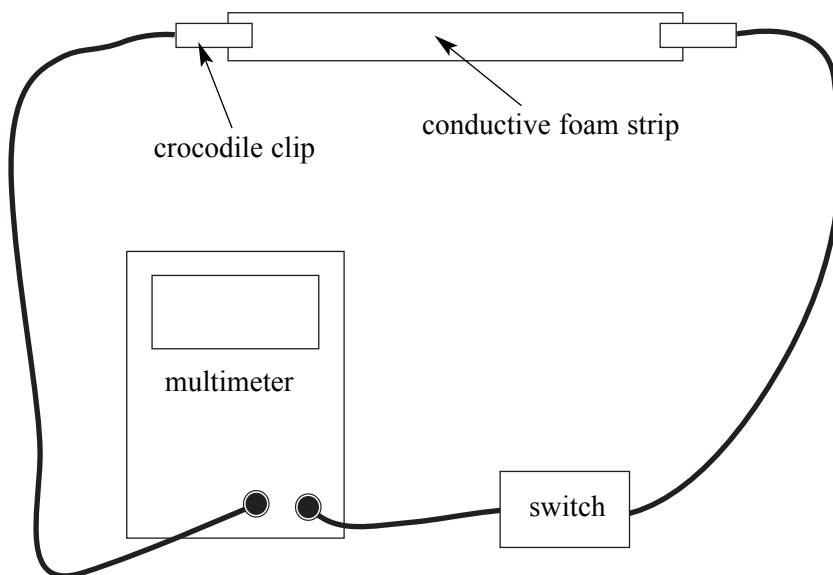
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(7 marks)

**Total for this question: 19 marks**

- 2 You are going to measure the resistance of a strip of electrostatic conductive foam.

Attach the two leads terminated by crocodile clips to the ends of the conductive foam strip as shown in **Figure 2**.



**Figure 2**

- (a) (i) Measure and record the resistance of the foam strip using the multimeter 60 s after connecting the circuit.  
**Do not repeat this reading.**

*(1 mark)*

- (ii) Explain how you were able to obtain the most precise value using the resistance scales on your multimeter.

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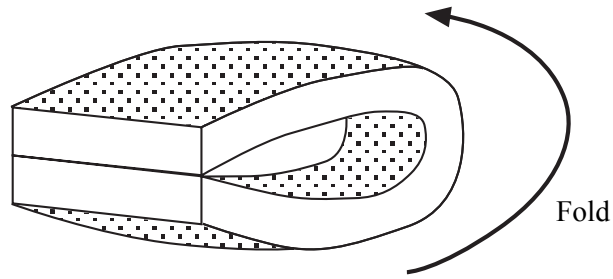
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*(2 marks)*

- (b) Now fold the foam strip in half so that the short ends come into contact, as shown in **Figure 3**.



**Figure 3**

- (i) Measure the resistance of the folded strip between the two joined ends and the fold 60 s after connecting the circuit.  
**Do not repeat this reading.**  
Record your value.

*(1 mark)*

- (ii) Without doing a detailed calculation, explain whether or not your measurement in part (b) (i) corresponds to the value you would expect for the resistance of the folded strip.

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*(3 marks)*

- (c) Make further measurements and use these to estimate a value for the resistivity of the conductive foam.

*(4 marks)*





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