

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

PHB6/1

to be conducted between 1 March 2002 and 23 May 2002

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 *Paper 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** questions.

This paper carries 39 marks.

- 1** You are to investigate the behaviour of a strip of hardboard that is supported as shown in **Figure 1**.

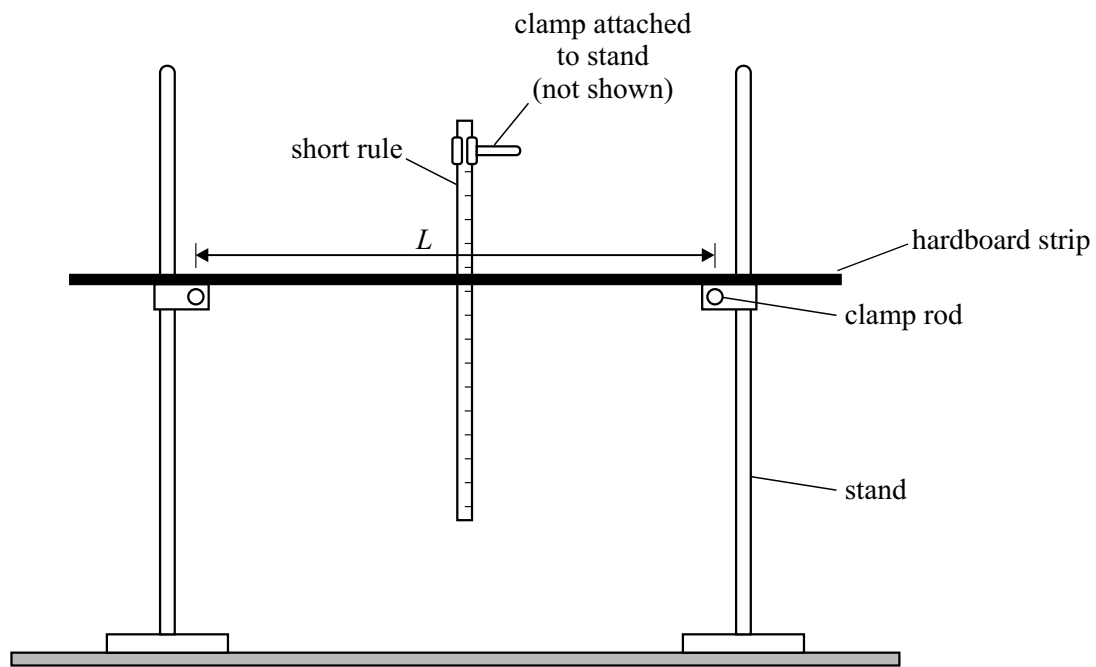


Figure 1

- (a) (i) Arrange the apparatus as shown in **Figure 1**. The smooth side of the hardboard strip should be at the bottom.

Adjust the supports so that the distance L is approximately 0.5 m. Measure and record the distance L , in mm. Record the scale reading on the short rule that corresponds to the position of the centre of the strip when no load is supported from it. (1 mark)

Detach this perforated page at the start of the examination.

Foundation Physics Mechanics Formulae

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

$$v = u + at$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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_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 |

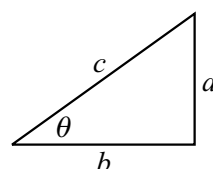
Geometrical and Trigonometrical Relationships

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

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

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

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



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

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

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

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

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

$$Ft = \Delta(mv)$$

$$E = hf$$

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

$$hf = E_2 - E_1$$

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

- (ii) Support a load of 0.50 kg from the centre of the strip as shown in **Figure 2** and record the new scale reading. Determine the depression d , in mm, of the centre of the strip when the load is added. (3 marks)

Remove the load.

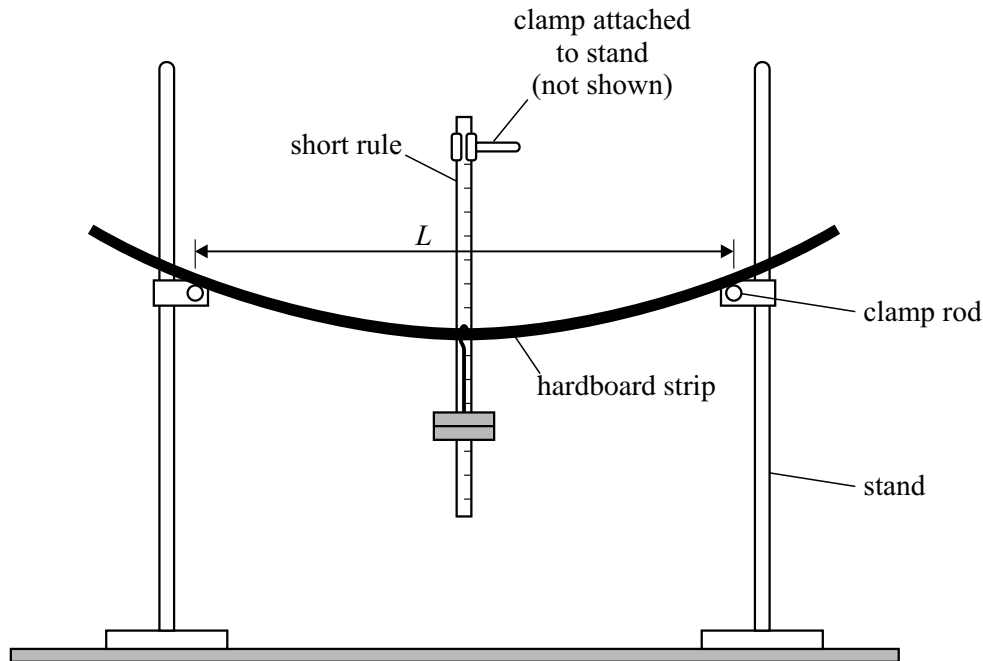


Figure 2

- (b) It is thought that, when the load is constant, the depression d is given by

$$d = kL^n$$

where k and n are constants.

- (i) Explain how a graph of $\log_{10}(d/\text{mm})$ against $\log_{10}(L/\text{mm})$ will enable you
- to test the relationship
 - to determine the values of k and n . (4 marks)
- (ii) Obtain measurements of corresponding values of d and L that will enable you to perform a graphical test of this relationship. Give all measurements in mm. (12 marks)
- (iii) State and explain one way in which the apparatus or procedure might be improved. (2 marks)
- (c) (i) Plot a suitable graph, drawing the best straight line through your plotted points. (5 marks)
- (ii) Suggest whether your data supports the relationship stated in part (b). (1 mark)
- (iii) Determine the value of n . (2 marks)
- (iv) Determine the value of k . (2 marks)

Turn over ►

(d) The magnitude of k is given by

$$k = \frac{(1.23 \pm 0.01) \times 10^6}{bt^3E}$$

where b is the breadth of the strip in mm

t is the thickness of the strip in mm

and E is the Young modulus of hardboard in Pa.

- (i) State how the Young modulus of the material affects the depression of the loaded strip. *(1 mark)*
- (ii) Explain why the Young modulus of the material affects the depression of the loaded strip. *(3 marks)*

(iii) The breadth of the strip is 30 ± 1 mm.

The thickness is 3.0 ± 0.2 mm.

Calculate a value for the Young modulus E of hardboard. *(2 marks)*

(iv) Ignoring any uncertainty in your value for k , calculate the percentage uncertainty in your value of E . *(1 mark)*

END OF QUESTIONS

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