| Surname | | Other Names | |
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| Centre Number | | Candidate Number | |
| Candidate Signature | | | |

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General Certificate of Education
June 2002
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

# PHYSICS (SPECIFICATION B) PHB3
## Unit 3

Thursday 16 May 2002 Morning Session

**In addition to this paper you will require:**
- a calculator;
- A4 graph paper;
- a ruler.

Time allowed: 2 hours

| For Examiner's Use | | | |
|---|---|---|---|
| Number | Mark | Number | Mark |
| 1 | | | |
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### Instructions
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions in the spaces provided. A separate sheet of graph paper is required for question 3.
- 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 78.
- 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.
- You are allowed 30 minutes for each of Questions 1 and 2, and 1 hour for Question 3.

### 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.

**NO QUESTIONS APPEAR ON THIS PAGE**

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

*30 minutes are allowed for this question.*

In this question you are to collect a small set of data. You will then be expected to estimate the errors in your measurements and to suggest reasons for these errors.

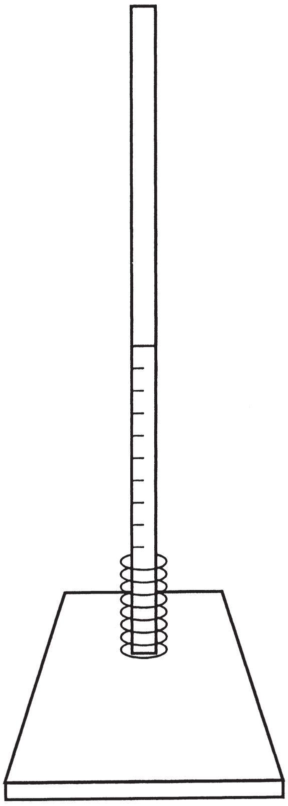

**Figure 1**

You are provided with a compression spring on a retort stand as shown in **Figure 1**.

(a) (i) Press the top of the spring down by 1 cm. Release the spring cleanly and observe its subsequent motion as it jumps up the rod.

Describe the energy changes that take place from the moment you release the spring until it hits the base of the retort stand again.

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*(3 marks)*

**QUESTION 1 CONTINUES ON THE NEXT PAGE**

**Turn over ►**

(ii) A scale is provided on the retort stand to enable you to record the maximum height reached by the **top** of the spring.

Press the top of the spring down by 1 cm and release it as before. Determine the maximum height reached by the **top** of the spring after release. Record all raw and derived data in the table.

Press the top of the spring down by 2 cm and repeat the experiment.

| **Distance through which top of spring depressed before release/cm** | **Maximum height reached by top of spring/cm** | | | |
|---|---|---|---|---|
| | | | | **Average** |
| 1 | | | | |
| 2 | | | | |

*(2 marks)*

(b) (i) Write down the equation that relates the gain in gravitational potential energy of a body to its mass ($m$), the height through which its centre of gravity rises ($h$), and the gravitational field strength ($g$).

*(1 mark)*

(ii) The energy stored in the compressed spring is equal to $\frac{1}{2}kx^2$, where $k$ is the spring stiffness and $x$ is the distance through which the spring is compressed. Assuming that all the energy stored in the spring is transferred to gravitational potential energy at the top of the motion, show that $\frac{h}{x^2}$ is a constant for the system.

*(2 marks)*

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(c) Assume that $h$ is equal to the average maximum height reached by the top of the spring.

(i) State the absolute uncertainty in your measurement of $h$.

*(1 mark)*

(ii) State the absolute uncertainty in your measurement of $x$.

*(1 mark)*

(iii) Calculate the percentage uncertainty in $\frac{h}{x^2}$ when $x$ is 2 cm.

*(2 marks)*

(iv) Use your data obtained in part (a)(ii) to calculate the values of $\frac{h}{x^2}$ for **both** compression distances of your spring. Why is it unlikely that your data will confirm that $\frac{h}{x^2}$ is constant for this system?

*(2 marks)*

(d) State **two** factors in this experiment that are sources of error in the measurements. Explain whether these factors will increase, decrease or act randomly on the values of the measured data as $x$ is increased. Two of the 6 marks in this question are available for the quality of your written communication.

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*(6 marks)*

20

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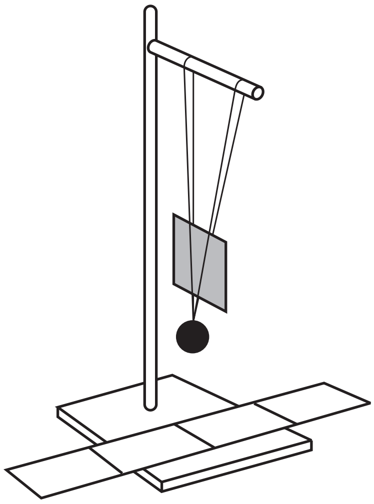
**2** **Total for this question:** ***20 marks***

*30 minutes are allowed for this question.*

In this question you are to carry out a rough test and then develop a more refined method.

**You will not be expected to carry out this refined method.**

You are provided with a pendulum, the oscillations of which can be damped by a piece of card. The larger of two damping cards is already inserted into the supporting strings.



(a) Pull the mass to one side through the distance indicated by the paper scale on the bench. Release the mass and count the number of oscillations ($n$) it takes for the amplitude to halve (this distance is also indicated on the paper scale).

**Use only the apparatus provided in order to make this measurement.**

Record your results in the table below. The area of the card is printed on it.

| **Card** | **Area $A$/cm$^2$** | $n_1$ | $n_2$ | $n_3$ | **Average** |
|---|---|---|---|---|---|
| **Large** | | | | | |
| **Small** | | | | | |

Replace the large card with the small card. Repeat the experiment, again recording your results in the table. Use the Sellotape or Blu-Tack provided to hold the card in place.

*(2 marks)*

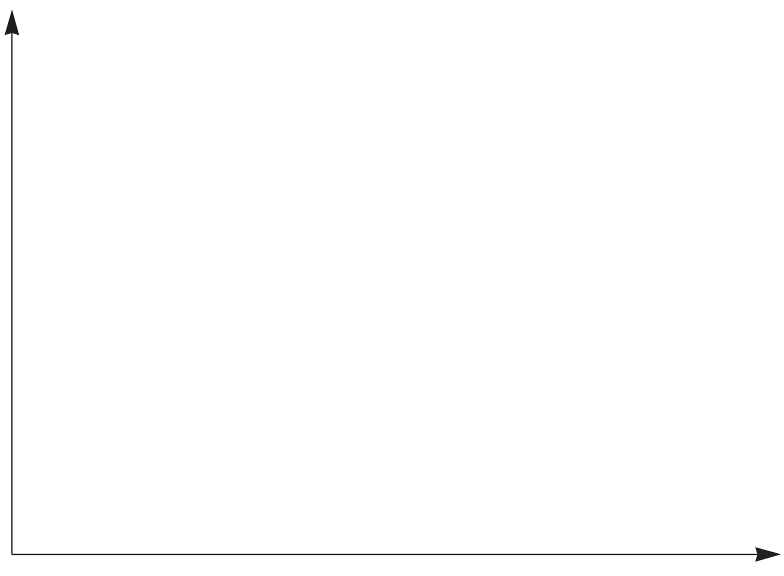
*LEAVE MARGIN BLANK*

(b) **Without drawing a graph**, use your results to test the suggestion that the number of oscillations ($n$) required to halve the amplitude is inversely proportional to the area of the damping card ($A$).

Explain how you tested the suggestion.

*(4 marks)*

(c) Sketch on the axes below the graph you would expect to obtain if the suggestion that $n$ is inversely proportional to $A$ is correct. Label the axes.



*(3 marks)*

**QUESTION 2 CONTINUES ON THE NEXT PAGE**

**Turn over ►**

(d) Describe how you would obtain the data to enable you to plot the graph you sketched in part (c). **Do not attempt to carry out your method.**

In your account you should give full details of your procedure and include a description of the ways in which you might attempt to reduce errors in your measurements.

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

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*(7 marks)*

(e) Describe and explain the way in which the damping force on the card varies throughout one cycle of the oscillation.

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*(4 marks)*

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**3** **Total for this question:** ***38 marks***

*One hour is allowed for this question.*

You are going to investigate the position and mass of the load required to keep a heavy beam horizontal. You will also determine the mass of the beam. You should consider this mass to be concentrated at the centre of the beam.

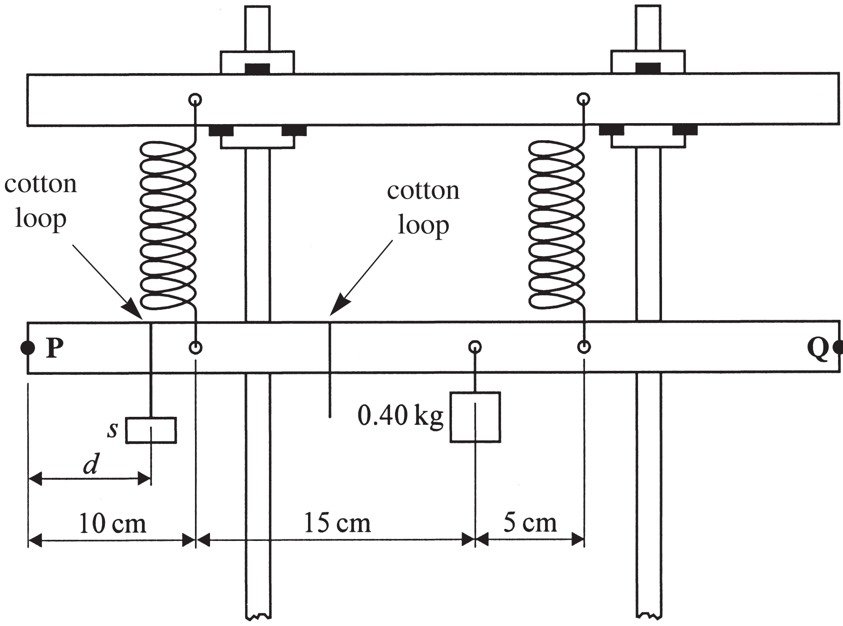


**Figure 2**

(a) (i) Using the mass hanger and masses provided, determine the **smallest** value of the mass ($s$) which, when placed near to **P**, will make the beam **PQ** horizontal. You may need to change the distance ($d$) by moving the loop along the beam.

Record the value of $s$ in kg.

*(1 mark)*

**QUESTION 3 CONTINUES ON THE NEXT PAGE**

(ii) Describe how you ensured that the beam **PQ** was horizontal. You may sketch a diagram if it helps you to explain.

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*(2 marks)*

(iii) Measure and record the distance $d$ **(measured in cm)** from **P** at which the smallest mass $s$ must be placed to make the beam **PQ** horizontal.

*(2 marks)*

(b) (i) State the **two** conditions that must be satisfied to keep the beam **PQ** in equilibrium.

*Condition 1* ..........................................................................................................................

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*Condition 2* ..........................................................................................................................

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*(2 marks)*

(ii) The springs exert equal upward forces ($F$) on the beam when the beam is horizontal.

By taking moments about **P**, write down an equation that relates: $F$, $s$, $d$ , the 0.40 kg mass, the mass of the beam ($M$), the distances marked on **Figure 2**, and the acceleration due to gravity ($g$).

The moment of a force about a point is equal to the magnitude of the force multiplied by its perpendicular distance from the point.

*(2 marks)*

(c) You are going to measure the positions at which a further **five** values of $s$ (measured in kg) must be placed in order to make the beam **PQ** horizontal. You will then calculate values of $\frac{1}{s}$.

(i) In the space below, draw a table for recording all of the measurements you will make.

Include spaces for your initial measurements of $s$ and $d$, and for values of $\frac{1}{s}$. *(1 mark)*

(ii) Measure and record values of $d$ **(measured in cm)** for **five** further values of $s$. Note that for some of the measurements you will need to use the second loop between the spring and the 0.40 kg mass.

Calculate and record the corresponding values of $\frac{1}{s}$. All measured and derived data should be entered in your table.

*(11 marks)*

**QUESTION 3 CONTINUES ON THE NEXT PAGE**

**Turn over ►**

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(d) On a separate sheet of graph paper, plot a graph with $\frac{1}{s}$ along the $y$-axis and $d$ along the $x$-axis. Draw the best straight line through your plotted points. *(7 marks)*

(e) The equation of the straight line you have drawn is:

$$\frac{1}{s} = \left(\frac{-1}{5(M + 0.40)}\right) d + \frac{4}{(M + 0.40)}$$

The general equation for a straight line is:

$$y = mx + c$$

(i) Determine the gradient of your graph.

*(3 marks)*

(ii) Calculate a value for $M$.

*(3 marks)*

(iii) Read from the graph and record below, the intercept on the $\frac{1}{s}$ axis.

*(2 marks)*

(iv) Calculate a second value for $M$.

*(2 marks)*

**END OF QUESTIONS**

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