Examiner only

Your task is to carry out an investigation to see how the amplitude, *A*, of vertical oscillation of a mass hanging from two springs in series varies with time, *t*.

Time allowed: You are **advised** to spend 15 minutes to answer parts *(a)* and *(b)* during which time you are allowed to set up and use the equipment for trial readings.

You are provided with the following equipment

500g hanger and masses
2 linked springs
pointer
split cork
2 clamps and stands
G-clamps
Metre rule
Stopwatch
Sticky tape

(a) The relationship between the amplitude of an oscillation, A, and the time t, can be expressed by:

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

where A_o = initial amplitude
and λ = an unknown constant

Rearrange this equation in the form of $y = mx + c$ and explain which graph you will draw to confirm this relationship and also determine the unknown constant λ. [2]

If you are unsure what to do, ask your supervisor for information sheet 1.
You will be deducted 2 marks for this information.

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For supervisor's use only [Tick one box (✓)]	
Yes information sheet **needed**	
No information sheet not **needed**	

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(b) Write a plan of how you will obtain sufficient readings to investigate this relationship. Include a labelled diagram with your plan, and justify all values chosen. [5]
[You are advised **not** to stop the timer as you record readings.]

If you are unsure what to do ask your supervisor for information sheet 2.
You will be deducted 2 marks for this information.

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For supervisor's use only [Tick one box (✓)]	
Yes information sheet **needed**	
No information sheet not **needed**	

Examiner only

(c) Obtain results and record them in a table. State the resolutions of all instruments used. [5]

(d) Draw a suitable graph to determine λ. Error bars are **not** required. [4]

Examiner only

(e) Does your graph confirm the relationship given in *(a)*?
Explain your answer. [3]

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(f) (i) Use your graph to determine a value for λ. Remember to include units with your answer. [3]

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(ii) What does the intercept on the y-axis of your graph represent? [1]

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(iii) From the graph, determine the time taken for the initial amplitude of oscillation, A_o, to halve. Show your working clearly. [2]

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Apparatus Required

Test 1

The task is to carry out an investigation of how the amplitude of vertical oscillation of a mass hanging from two springs in series varies with time.

The following apparatus is required for each candidate:

100 g mass holder with 4 × 100 g masses, taped together to produce a combined mass of 500 g
2 springs joined "in series", e.g. Nuffield No. 2 extension springs / expendable springs
1 optical pin
1 split cork
2 × clamp and stand
G-clamp
Metre rule
Stopwatch / timer of resolution 1 s – or a centisecond timer with the fractional second section of the display obscured, e.g. by masking tape
Sticky tape (to secure the optical pin).

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Test 2

The task is as in **Test 1**.
The apparatus required is as in **Test 1** except that the combined mass required is 400 g.

EXPERIMENTAL TASK

MARK SCHEME – TEST 1

Question		Marking details	Marks Available
(a)		$\ln A = -\lambda t + \ln A_0$ (1) Plot ln A (vertical axis) against t (horizontal axis) or equivalent stated - accept a sketch showing this. NB. No back-crediting from candidate's graph. (1) [Remember to indicate in the box whether the information sheet has been given and not to award the marks if it has been issued].	2
(b)		Labelled diagram – springs shown approx vertical, securely attached vertical rule, weight shown on spring. (1) Method to avoid parallax [or shown on diagram]. (1) Suitable range of time intervals used which allows the amplitude to decrease by at least 50% and at least 5 equally spaced readings. (1) Justification of the choice of range provided by a statement in the method not just implied from results. (1) e.g. I plan to take these readings because they will show the amplitude decaying by at least half. Suitable initial amplitude, A_0 - minimum 10 cm. (1) [Remember to indicate in the box whether the information sheet has been given and not to award the marks if it has been issued].	5
(c)		Single clear main table: titles with units: including time, amplitude readings and ln A [ignore additional summary tables, e.g. a table with only ln A and t columns]. (1) Resolutions correct ruler 1 mm (accept 0.5 mm), stopwatch 1 s. (1) ln A values correct. (1) Repeat readings and correct means. (1) All readings and means to resolution of instrument and ln A to 2 or 3 s.f. (1)	5
(d)		Axes labelled with units - correct orientation [e.c.f. from *(a)*]. (1) All points plotted correctly to within ½ small square division. (1) Good line of best fit consistent with the data. (1) Suitable scales (not involving awkward factors, e.g. 3 / over ½ each axis used). (1)	4
(e)		NB There is no mark for yes / no only – the marks are for the explanation, straight line / not a straight line. (1) Negative gradient [no e.c.f. on incorrect data]. (1) Points close to line of best fit or not [as appropriate]. (1)	3
(f)	(i)	Large triangle used (should be close to extremities of the line of best fit) [or 2 equivalent suitable points clearly indicated on the graph] and gradient calculated. (1) λ [identified as gradient] and given to 2 or 3 s.f. (1) Units s^{-1} or min^{-1}. (1)	3
	(ii)	ln (original amplitude) or ln A_0 [**not** A_0 on its own]. (1)	1
	(iii)	Calculation of ln (A_0 / 2) given or horizontal line at ln (A_0 / 2) on graph shown. (1) Time calculated consistent with graph [NB No s.f. penalty]. (1)	2
			[25]

MARK SCHEME – TEST 2

Same as TEST 1

Examiner only
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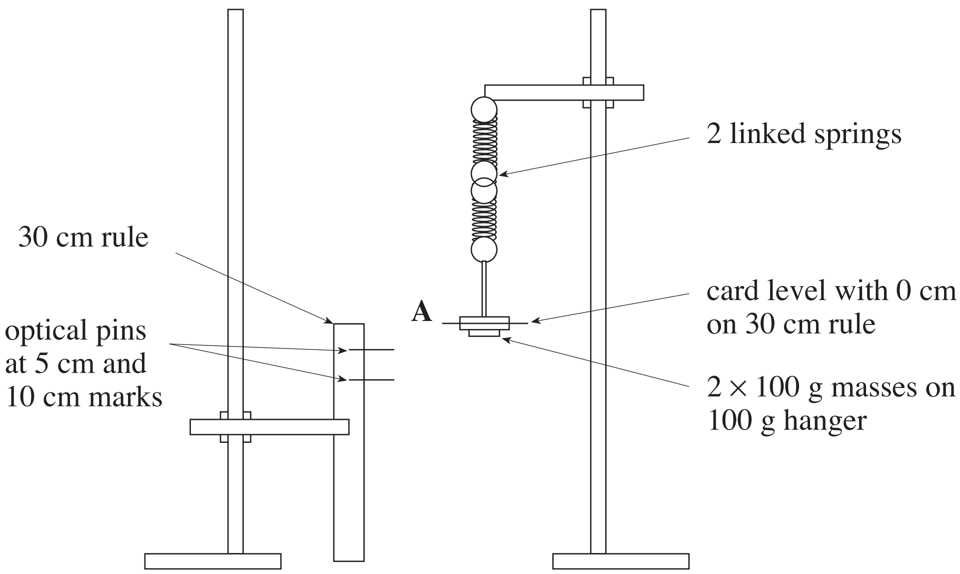
Question 1

In this experiment you are going to use a number of different size cards to investigate the effect of air resistance on the motion of a spring–mass system.

(a) You have been provided with four circles of cardboard all of different sizes. These are labelled **A**, **B**, **C**, & **D**. Find the area of **each** circle giving the appropriate unit. Ignore the small hole in the centre. [3]

CARDBOARD	AREA *(A)*
A	
B	
C	
D	

(b) Use the apparatus shown, with card **A** sandwiched between the two 100 g masses on a 100 g hanger.



Turn over.

Ensure that the card is initially level with the 0 cm mark on the 30 cm rule.
Pull down the weights until the card is level with the pin at the 10 cm mark.
Release the weight and count how many oscillations *(n)* it takes for the card, at its lowest point, to be level with the pin only 5 cm below its original position.
One oscillation is the distance the spring moves from when you release it to the top of its motion and back to the bottom again.

Repeat this for **each** of the cards and **record your results** in a suitable table below.

Include and complete a column headed 1/Area in your table. [6]

(c) A fellow Physics student suggests that the number of oscillations, n is inversely proportional to the area of the card, A. Plot a suitable graph to check if this suggestion is correct. [5]

(d) Using your results, explain whether or not the Physics student was correct. [3]

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(e) Determine the gradient of your graph and use it to state a mathematical relationship between n, the average number of oscillations, and A the area of card used. [3]

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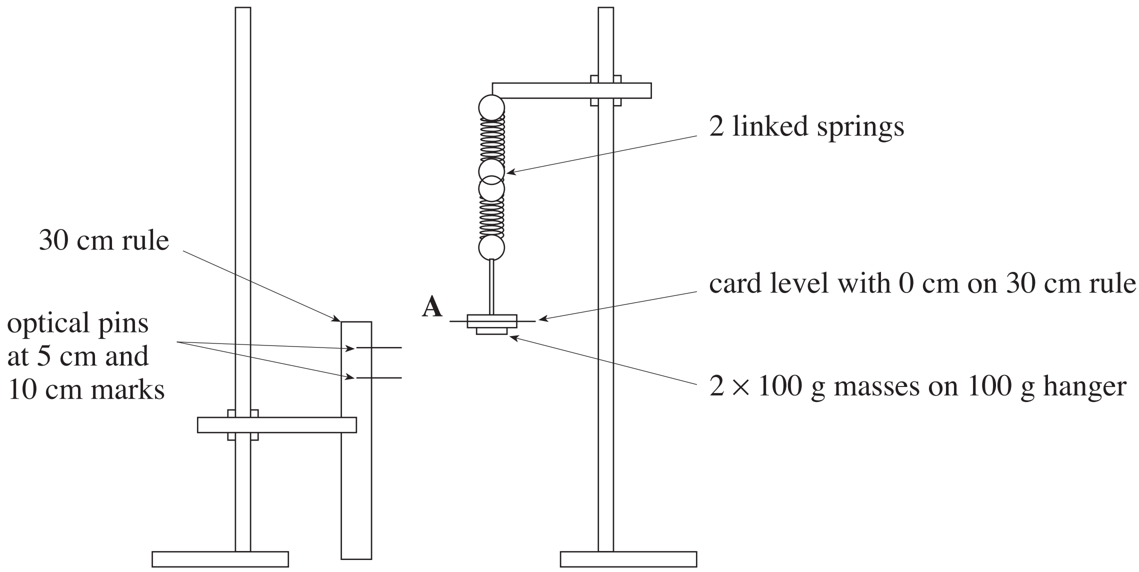
Experiment 1

Candidates will be expected to investigate the decay in oscillations of a spring and mass system. No previous knowledge of damping will be required.

Test 1

Apparatus required:

4 cardboard discs of radii, 0.050 m, 0.060 m, 0.070 m, and 0.080 m, labelled A, B, C and D, respectively with a hole punched in the centre of each, so that they can be mounted between the 100 g masses as shown in the diagram.
2 × 100 g masses and a 100 g holder
2 × expendable Springs (e.g. Philip Harris B6A41397)
2 × Clamp, boss and stand
1 × split cork to help clamp the springs
Metre rule
30 cm rule
2 × optical pins [or other markers] one attached to the 5cm mark and one attached to the 10cm mark of the 30 cm rule as shown.



The two springs should be linked together at the start of the experiment and suspended from one of the clamp stands. The optical pins should be firmly attached to the 30 cm rule. Card **A** and the masses should be mounted as shown, with the card level with the 0 cm mark on the 30 cm rule.

Test 2

The apparatus is as for **Test 1** except that **three** linked springs should be used and **one** 100 g mass on a 100 g hanger. Card A should be mounted below the 100 g mass and be level with the 0 cm mark on the 30 cm rule.

PH3 Mark Scheme – May 2007

Additional notes:

By the nature of a practical examination, the data are the candidates own and every attempt is made not to penalise candidates unduly for poor results, especially in the sections involving their analysis. The various sections of the questions are independent. e.c.f. stands for *error carried forward*, and indicates that the results of previous (incorrect) calculation or poor measurement will be treated as correct for the current section, i.e. the mistake will only be penalised once. This does not extend to errors of principle, for example inappropriately drawing a best-fit line through the origin and subsequently stating that the intercept is zero.

Experiment	Answers / Explanatory notes	Marks Available
1. *(a)*	A: 72·4 - 84·9 cm^2 B: 105·7 - 120·8 cm^2 C: 145·3 - 162·9 cm^2 D: 191·1 - 211·2 cm^2 Unit (1); 2-4 s.f.(1); calculations (1)	3
(b)	Table: Titles (1) Units (1) Repeat readings (1) 1/Area correct (1) consistent s.f. (1) Clear table **and** all cards used. (1)	6
(c)	Graph: Plot of *n* against 1/*A* [either orientation] (1) Axis labels and units [e.c.f.] (1) points correctly plotted (–1 per incorrect plot) (1) line of best fit [e.c.f.] Scales – reasonable use of graph paper, no multples of 3 (1)	5
(d)	Yes (1); straight line (1) through origin [all e.c.f.]	1
(e)	Gradient: Good sized Δ shown on graph (1) Calculations correct (1) [no readings from table] $n = \frac{\text{gradient}}{A}$ [+ c if appropriate] (1)	3
		[20]