Teacher Resource Bank

GCE Physics B: Physics in Context

Sample A2 ISA: Damped Harmonic Motion

- Question Paper

AQA Physics Sample A2 ISA, Damped Harmonic Motion

Centre Instructions

In this ISA, candidates will be investigating how the amplitude of oscillation of a mass on a spring varies with time.

Candidates will require

- two 100 g masses on a 100 g mass holder
- a square card of side 10 cm
- a spring with a force constant of about 25 N m^{-1}
- a metre ruler, a clamp and stand
- a stopclock or stopwatch which measures to 0.01 s

The card should have a slit cut into it so that it can be slotted onto the mass holder and held in place between the two masses.

Information for centres

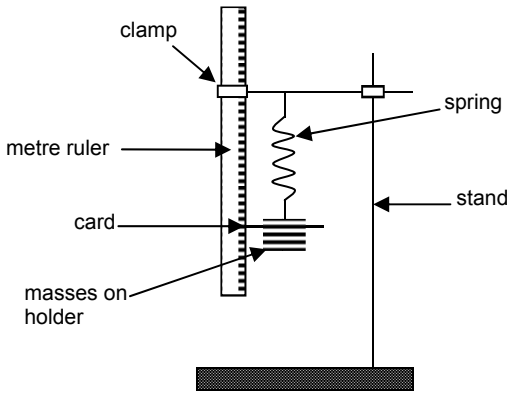
Candidates can be told approximately one week before undertaking Stage 1 of the ISA that the investigation will be about the damping of oscillations and the exponential decay of the amplitude.

Stage 2 of the ISA (the written tests; Section A & B) should be given as soon as possible after the practical investigation.

Task Sheet

Stage 1: Investigation

You are going to carry out an experiment to investigate the relationship between amplitude and time for a mass oscillating on a vertical spring.



- Set up the apparatus as shown in the diagram.
- Pull down the mass holder a few centimetres and release it so that it oscillates vertically. Take suitable measurements to determine accurately the period of the oscillations.
- Note the scale reading opposite the card when the masses are at rest. Pull down the mass holder vertically a distance of 5.0 cm and release it. Record the scale reading after 10, 20, 30, 40, 50 and 60 oscillations.
- Make a table to record the scale reading and the amplitude, A, of the oscillations every ten oscillations after the mass holder is displaced vertically a distance of 5.0 cm and released. Your table should also include columns for $\ln A$ and the time t calculated from the number of oscillations and the period.
- Plot a graph of $\ln A$ against t.

At the end of the investigation, hand the following to your supervisor

- Your completed answer sheet(s) which should include all your measurements, results table and calculations
- A piece of graph paper with your graph of $\ln A$ against t.

This documentation will be required for Stage 2 of the ISA. Please ensure that you have entered your centre details, candidate number and name on all the sheets you have completed.

Surname		Other Names	
Centre Number			Candidate Number				
Candidate Signature									

Leave blank

ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Advanced Level Examination

PHYSICS
Investigative and Practical Skills in A2 Physics

Sample Unit 6 ISA
Written Test

For Examiner's Use		
		Mark
Stage 1		
Section A	1	
Section B	2	
	3	
	4	
Total (Sec A)		
Total (Sec B)		
TOTAL		
Examiner's Initials		

For this paper you must have:
- a calculator
- a ruler
- a protractor
- your completed documentation from Stage 1.

Time allowed: 1 hour

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Answer the questions in the spaces provided.
- Attach your completed documentation from Stage 1 to this book before handing it to the invigilator at the end of the examination.
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for the questions are shown in brackets.
- The maximum mark for this paper and the practical task is 41.

SECTION A

Answer **all** questions in the spaces provided.
You should refer to your documentation from Stage 1 as necessary.

1 (a) What was the *dependent variable* in your experiment?

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(1 mark)

1 (b) What factors in the system affect the period of the oscillation?

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(1 mark)

1 (c) Identify two sources of error in determining the period.

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(2 marks)

1 (d) Estimate the uncertainty in your time measurements.

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(1 mark)

1 (e) Calculate the percentage uncertainty in your longest time measurement.

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(1 mark)

1 (f) Theory predicts that the amplitude of the oscillations should vary according to equation, $A = A_0 \exp(-\lambda t)$, where A_0 is the amplitude when $t = 0$ and λ is a constant referred to as the decay constant.

1 (f) (i) Use this equation to show that $\ln A = a + bt$, where a and b are constants.

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(2 marks)

1 (f) (ii) What physical quantity does the gradient of the graph represent?

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(1 mark)

1 (f) (iii) Discuss how well your data fits the relationship ln $A = a + bt$.

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(1 mark)

1 (g) Suggest a more accurate way of measuring the amplitude.

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(1 mark)

SECTION B

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

2 A student performs an experiment similar to the one you have just done and finds the value of λ for square cards of different sizes. The student also finds the time, $t_{1/2}$, for the amplitude to halve in each case.

$t_{1/2}$/s				λ/s^{-1}	λ^{-1}/s
1st value	2nd value	3rd value	mean		
4.3	4.5	4.4		1.61×10^{-1}	
12.2	12.3	12.1		5.71×10^{-2}	
22.6	22.8	22.4		3.07×10^{-2}	
34.9	34.7	34.6		2.00×10^{-2}	
42.4	42.0	42.2		1.64×10^{-2}	

2 (a) Complete the table by entering the mean $t_{1/2}$ and λ^{-1} values.

(3 marks)

2 (b) Plot a graph of the mean value of $t_{1/2}$ against λ^{-1}.

(3 marks)

2 (c) Find the gradient of the graph.

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(3 marks)

2 (d) Theory predicts that the gradient of the graph should be ln 2. Calculate the percentage difference between your value and the accepted value and comment on the quality of the student's measurements.

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(2 marks)

3 (a) Estimate the uncertainty in the largest measurement of $t_{1/2}$.

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(1 mark)

3 (b) What is the general name given to this type of error?

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(1 mark)

3 (c) By reference to the tabulated results, comment on the reliability of the results.

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(1 mark)

3 (d) The student estimates that the uncertainty on the smallest value of λ is 0.2%.

3 (d) (i) What is the percentage uncertainty in λ^{-1}?

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(1 mark)

3 (d) (ii) From your answer to 3 (a), calculate the percentage uncertainty in $t_{1/2}$.

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(1 mark)

3 (d) (iii) The student uses these values to calculate a value for ln 2. What is the percentage uncertainty of this value?

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(1 mark)

3 **(e)** What does the graph suggest about the relationship between $t_{1/2}$ and λ?

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(1 mark)

4 Describe briefly what difficulties are likely to be encountered when measuring the smaller values of $t_{1/2}$, which will require the use of a card with larger area.

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(4 marks)