Rewarding Learning

Centre Number

71	

Candidate Number

ADVANCED
General Certificate of Education
2009

Physics

Assessment Unit A2 3B

assessing

Module 6: Experimental and Investigative Skills
Session No. 2

[A2Y33]

WEDNESDAY 20 MAY

A2Y33

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Turn to page 2 for further Instructions and Information.

For Examiner's use only	
Question Number	Marks
1	
2	
3	
Total Marks	

Instructions to Candidates

Answer **all** the questions in this paper, using this booklet. Rough work and calculations must also be done in this booklet. Except where instructed, do **not** describe the apparatus or experimental procedures.

The Supervisor will tell you the order in which you are to answer the questions. Not more than 28 minutes are to be spent in answering each question, and after 26 minutes you must stop using the apparatus in Questions **1** and **2** so that it can be re-arranged for the next candidate. At the end of the 28-minute period you will be instructed to move to the area set aside for the next question. At the end of the Test a 6-minute period will be provided for you to complete the answer to any question, but you will not have access to the apparatus during this time.

Information for Candidates

The total mark for this paper is 70.

Quality of written communication will be assessed in Question **3(b)**.

Questions **1** and **2** carry 25 marks each, and Question **3** carries 20 marks.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each part question.

Question **3** contributes to the synoptic assessment of the Specification. In this question, you will need to make and use connections between different areas of physics and to use your knowledge and understanding of more than one area.

Before the Test begins, the Teacher/Supervisor will give a Health and Safety demonstration to show you how to manipulate the apparatus in Question 2. You must not start Question 2 unless you have seen this demonstration.

1 Introduction

An object is suspended by a vertical wire. If the object is twisted through an angle and then released, it will perform oscillations about the wire as an axis, the wire remaining vertical. These oscillations are called **torsional oscillations**. In this experiment you will investigate one of the quantities that affects the period of torsional oscillations of a mass suspended by a wire.

Aims

The aims of this experiment are:

(a) to determine the period of torsional oscillations of a mass suspended by a composite wire, for different numbers of strands in the composite wire;

(b) to plot a graph from the experimental results;

(c) to find the gradient and intercept of the graph;

(d) to determine the relationship between the number of strands in the composite wire and the period of torsional oscillation.

Apparatus

Fig. 1.1 shows the apparatus, which has already been set up for you.

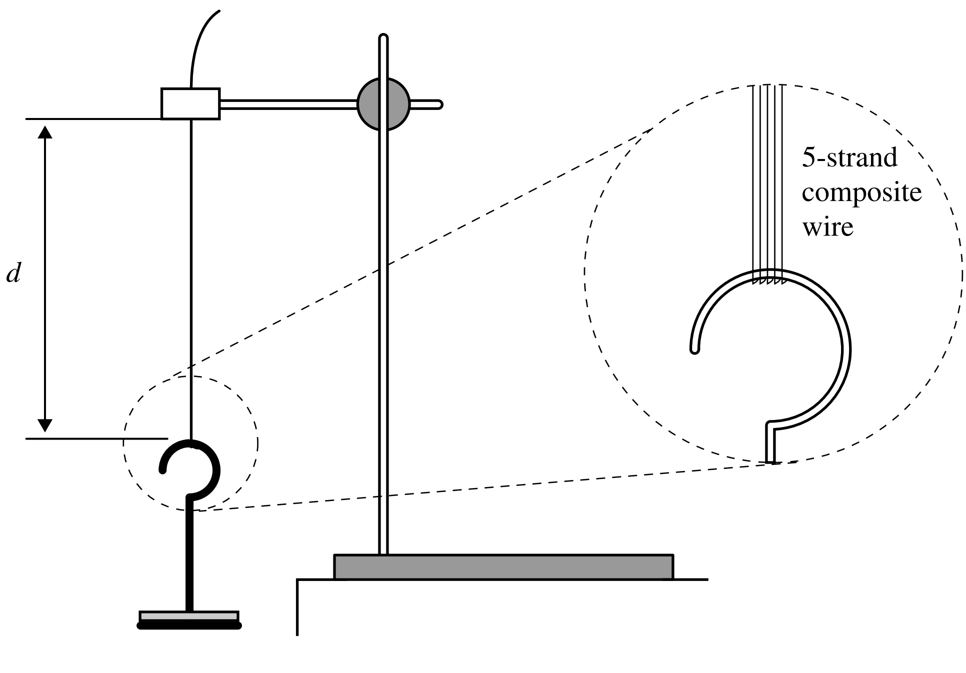

Fig. 1.1

A mass hanger carrying a 100 g mass is suspended from a composite wire, made up of five strands. The strands are gripped between two pieces of wood at the upper end. Each strand has a loop at the lower end through which the hook of the mass hanger is passed. This allows strands to be removed from the composite wire one at a time.

When the mass hanger is turned through an angle, and then released, it will perform torsional oscillations, as shown in **Fig. 1.2** on page 4. The wire should remain vertical.

Procedure

(a) The length of the strands has been set so that the distance *d* is approximately 0.6 m. **This is to remain constant throughout.** Do **not** attempt to adjust the length. Measure *d* accurately and record your answer below.

d = _______ mm [1]

Rotate the mass hanger so that the composite wire twists and the slit in the mass turns through an angle of about 180°, as shown in **Fig. 1.2**.

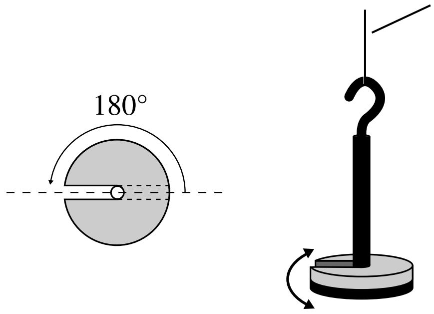

Fig. 1.2

Release the mass hanger so that the suspended mass hanger undergoes torsional oscillations.

Take suitable measurements to allow you to determine an accurate value of the period of oscillation *T*. Record all your results in **Table 1.1**.

Table 1.1

Number of strands *n*		*T*/s		
5				
4				
3				
2				
1				

[5]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

Remove one of the strands of the composite wire so that $n = 4$. This is achieved by taking the loop at the lower end of the wire off the hook of the mass hanger.

Repeat this procedure to obtain the period T of torsional oscillations for $n = 4$ strands. Record all your readings in **Table 1.1**.

Repeat for $n = 3$, 2 and 1. Record all your readings in **Table 1.1**.

(b) Use the micrometer screw gauge to obtain a single value of the diameter of one of the strands.

Diameter = _______ mm

This value will be subject to an uncertainty because of the reading error in the micrometer. Calculate the percentage uncertainty in your value of the diameter.

Percentage uncertainty = ______ % [3]

Analysis

The relationship between n and T is of the form

$$n = AT^B$$ **Equation 1.1**

where A and B are constants.

(c) Calculate values for $\log_{10} n$ and $\log_{10} T$ and record them in the two right-hand columns of **Table 1.1**. Label each column with appropriate headings and units. [3]

Examiner Only	
Marks	Remark

(d) (i) On the graph grid of **Fig. 1.3**, plot a graph of $\log_{10} n$ on the y-axis against $\log_{10} T$ on the x-axis. Label the axes of your graph and choose suitable scales. The scale of the $\log_{10} T$ axis should include $\log_{10} T = 0$. The scale of the $\log_{10} n$ axis should be such as to allow you to obtain the intercept of the best straight line, i.e. the value of $\log_{10} n$ when $\log_{10} T = 0$. Plot the points and draw the best straight line through them. [5]

(ii) Find the numerical value of the gradient of your graph.

Gradient = ____________________ [3]

(iii) Find the numerical value of the intercept of your graph.

Intercept = ____________________ [2]

(iv) Determine the numerical values of the constant A in **Equation 1.1**. Explain how you arrived at this value.

A = ________________________

Explanation:

____

____ [3]

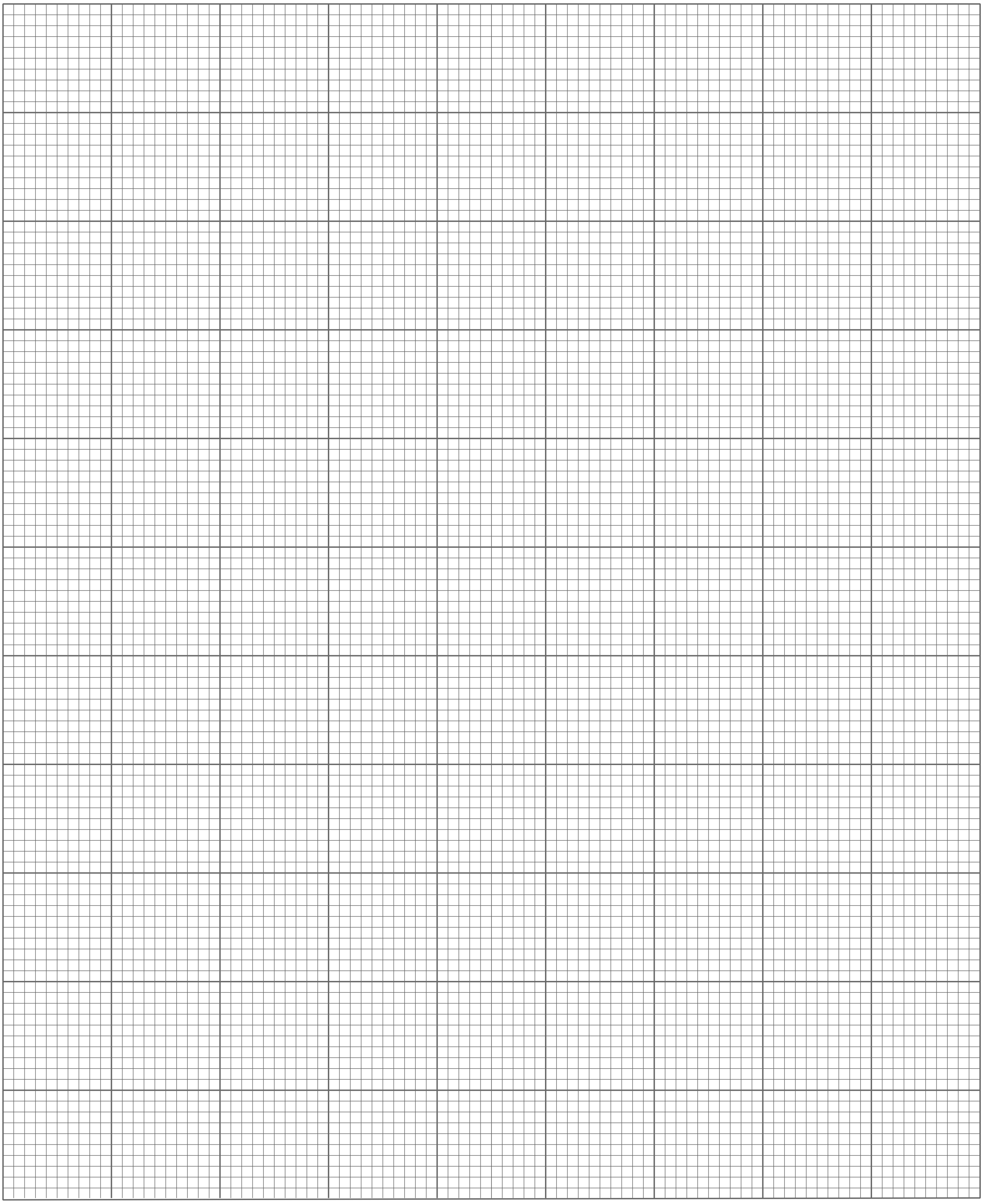

Fig. 1.3

2

You must not attempt this question unless you have seen the Health and Safety demonstration.

Introduction

In this experiment you will investigate one of the factors affecting the rate at which water flows from a burette.

Aims

The aims of the experiment are:

(a) to determine the average flow-rate of water from the burette for different angles of inclination of the burette;

(b) to use a non-graphical method to test a relationship between the flow-rate and the angle of inclination;

(c) to consider the uncertainties associated with the experiment.

Apparatus

Fig. 2.1 shows the apparatus, which has already been set up for you.

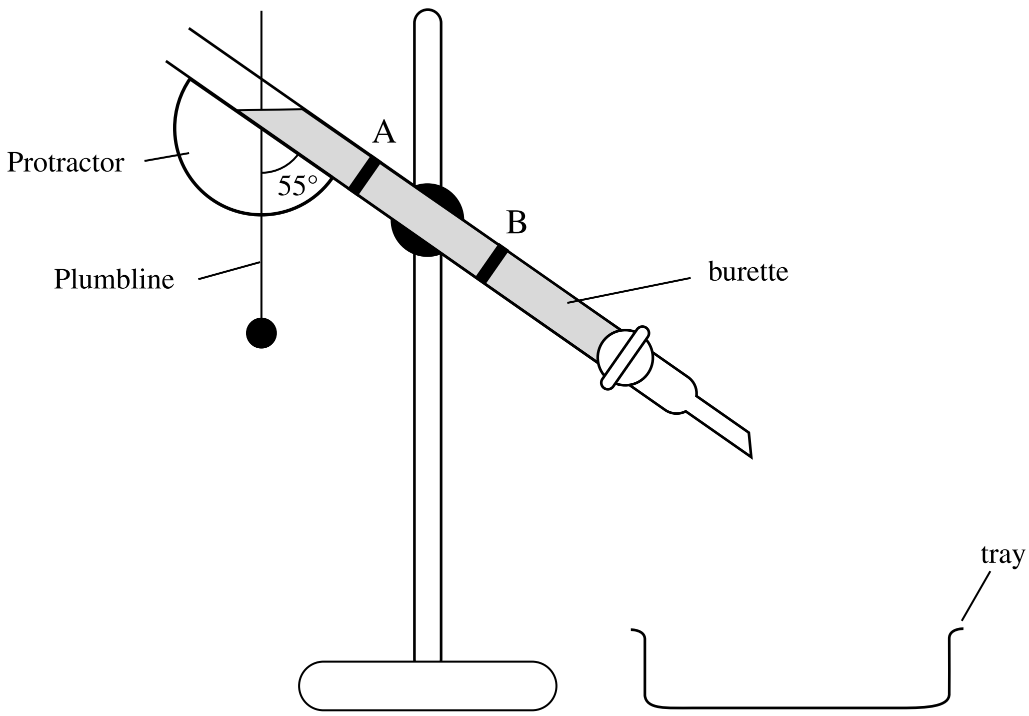

Fig. 2.1

The burette has been filled with water to above the marker A. The angle θ between the vertical plumb-line and the edge of the burette has been set at approximately 55°. The angle θ can be adjusted by **gently** turning the clamp in the retort stand, as demonstrated.

Procedure, results and uncertainty

Examiner Only	
Marks	Remark

(a) Measure the angle θ accurately with the protractor provided, by placing it as shown in **Fig. 2.1**. Record the value in **Table 2.1**.

Open the burette tap fully and start the stop clock or stopwatch as the water passes the top of marker A on the burette. Find the time t for the water to reach the top of marker B. Record the results in **Table 2.1**. Do not repeat the timing at this angle.

(b) Refill the burette carefully, as demonstrated. Obtain four further sets of results with the angle of inclination of the burette ranging from your first value of θ to a value of $\theta = 0°$, when the burette will be vertical. Record all five sets of results in **Table 2.1**. [5]

Table 2.1

$\theta/°$	t/s	T/s cm^{-1}	$\dfrac{1}{\cos(\theta/°)}$

(c) **(i)** Use the metre rule to measure the distance between the markers A and B. State the uncertainty in your measurement.

Distance between markers = _________ cm

Uncertainty in measurement = ± ______ cm [2]

(ii) The quantity T in **Table 2.1** is the time taken for a one-centimetre length of water to leave the burette. T is calculated by dividing the time taken for the water to move between the markers by the distance between the markers. The value of T will be different for each value of θ.

Calculate T for each angle θ and insert these values in the third column of **Table 2.1**. [1]

(iii) Explain why each of the values of T in **Table 2.1** is an **average**.

____

____

____

____ [2]

(iv) State the factors that may contribute to the overall uncertainty in the values calculated for T.

____

____

____

____

____ [3]

(v) Which value of T do you consider to have the higher percentage uncertainty, that when $\theta = 0°$ or that when $\theta = 55°$? Indicate your answer by placing a tick in the appropriate box. Explain your answer.

T has the higher percentage uncertainty when $\theta = 0°$ ☐

T has the higher percentage uncertainty when $\theta = 55°$ ☐

Explanation ____

____ [2]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

Analysis

The quantity T is thought to be **inversely** proportional to $\cos\theta$.

(d) **(i)** In the right-hand column of **Table 2.1**, tabulate values of $\frac{1}{(\cos\theta)}$.
Quote the values to an appropriate number of significant figures. [2]

(ii) Explain how you could use a **non-graphical** test to confirm whether or not the proposed relationship between T and $\cos\theta$ is correct.

____

____

____

Perform this test, showing all necessary calculations in the space below. State your conclusion.

Conclusion: ______________________________________ [3]

(iii) The proposed relationship could also be tested **graphically**. Describe how you could have done this. You may **sketch** a graph to help to explain your answer.

____

____

____

____ [3]

(iv) By considering the spread of values in **Table 2.1**, suggest why it would have been difficult to test the relationship graphically from your results.

____

____

____ [2]

Examiner Only	
Marks	Remark

BLANK PAGE

(Questions continue overleaf)

Where appropriate, your answer to this question should be in continuous prose. You will be assessed on the quality of your written communication in part (b).

3 Planning and design question

Introduction

A ball bearing is projected by the release of a compressed spring which is positioned near the end of a desk, as shown in **Fig. 3.1**.

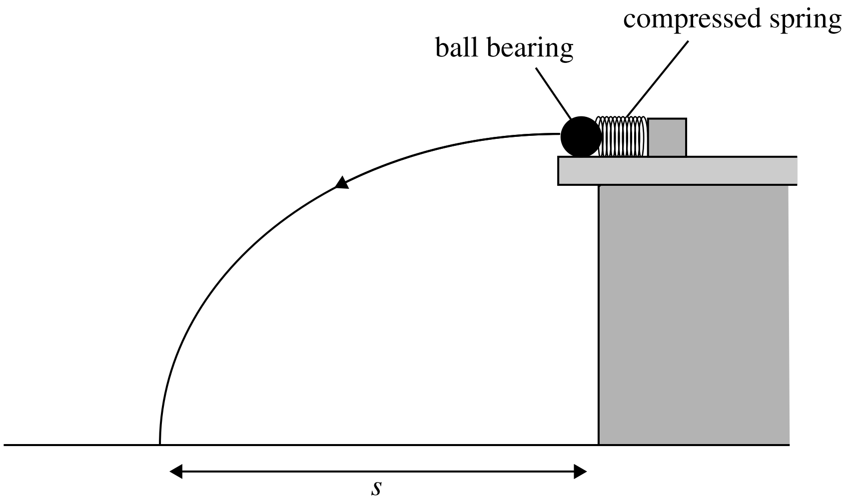

Fig. 3.1

In this question you are asked to plan an experiment to investigate how the horizontal range of the ball bearing changes with the compression of the spring.

A diagram of the *uncompressed* spring to be used in the experiment is shown in **Fig. 3.2**.

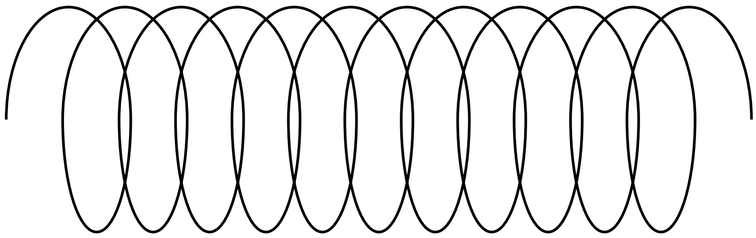

Fig. 3.2

The length of the uncompressed spring is 14.0 cm. The diameter of the wire used to make the spring has been measured using a micrometer screw gauge and has a value of 0.80 mm. The spring has twelve complete turns. When the spring is compressed, the coils are all touching.

(a) Calculate the length of the spring when it is fully compressed.

Length of spring = ___________ cm [2]

Examiner Only	
Marks	Remark

Examiner Only

Marks	Remark

The plan

(b) Describe a suitable method, based on the arrangement of **Fig. 3.1**, that will allow you to find the relationship between the distance x the spring has been compressed and the horizontal range s of the ball bearing.

You should include the following in your answer:

- the measurements you will take,
- the instruments you will use to take the measurements,
- a suitable range of values of x (consider your answer to **(a)**),
- how you will judge the position at which the ball bearing hits the ground,
- how you will ensure the reliability of your results. [6]

Examiner Only	
Marks	Remark

Quality of written communication [1]

Energy considerations and the spring constant

Examiner Only	
Marks	Remark

(c) The energy stored in a spring compressed by a distance x is $\frac{1}{2}kx^2$, where k is the spring constant. Use the principle of conservation of energy to show that the speed v at which the ball bearing leaves the compressed spring is given by

$$v = \left(\sqrt{\frac{k}{m}}\right)x \qquad \textbf{Equation 3.1}$$

where m is the mass of the ball bearing.

[2]

(d) The relation between the compression x of the spring and the range s of the ball bearing is

$$x = A\left(\sqrt{\frac{m}{k}}\right)s \qquad \textbf{Equation 3.2}$$

where A is a constant. In order to find the value for the constant A, the spring constant k and the mass m of the ball bearing must be known.

(i) Describe how you could obtain a value for the spring constant k of the compressible spring by experiment.

____

____

____

____

____

____

____ [3]

Examiner Only	
Marks	Remark

(ii) To measure the mass m of the ball bearing, scales reading to the nearest 1 g are used. When a single ball bearing is placed on the scales, the reading is 2 g.

Explain why it would not be good practice to use this value of m in the calculation of A in **Equation 3.2**.
Suggest how you could obtain a more accurate value, still using the same scales.

____

____

____

____

____ [3]

(iii) Assume that k and m are now known.
Describe how a value for the constant A in **Equation 3.2** could be found graphically from a set of results of s and x.

____

____

____

____

____

____ [3]

THIS IS THE END OF THE QUESTION PAPER