Year 12 Practical/Process Assessment Task 1

Student I.D. ______________________

Teacher: ☐ Coombes ☐ Pitt ☐ Robson

Task Weighting: 15 %

Time Allowed: 45 minutes

This task is marked out of 25 marks

Mark obtained ____ / ___

INSTRUCTIONS: There are **two** parts **A** and **B** in this task. There is one question in part A, which requires you to carry out a first-hand investigation. You will need to go to where the apparatus is set up in the lab to conduct this investigation. Several stations have been set up for you to do this. Record which station you used to conduct the investigation. You must watch for when the apparatus is free and quietly move to the vacant station to conduct the investigation. It should take you less than 4 minutes to conduct the investigation.

Part B requires you to apply some knowledge and skills to answer the questions without carrying out any first-hand gathering of data.

Read the whole of each question before commencing it, and then record your answers in the spaces provided.

Part A: Calculating the Acceleration due to Gravity

The following equation may be required:

$$\mathbf{T} = 2\pi\sqrt{\frac{l}{g}}$$

in which

T = period of pendulum (time for one complete backwards and forwards swing)

l = length of pendulum

g = acceleration due to gravity

1. The purpose of this task is to calculate the **period** of a pendulum of fixed length **experimentally** and to use the value and the equation below to calculate the **acceleration due to gravity**.

   You have been provided with a simple pendulum consisting of a mass suspended beneath a light string that is attached to a clamp.

   (a) Using the ruler provided, measure and record the length of the pendulum in metres.

   .... 1 M

   (b) Using the stopwatch provided, collect measurements that can be used to calculate the period. **(Do not spend more than 4 minutes collecting this data)**.
   Present these measurements in an appropriate format in the space below and determine the period, showing the procedure used.

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(c) Draw a scientific diagram of the pendulum that clearly shows the length of the pendulum.

2 M

(d) Calculate the acceleration due to gravity, using your results.

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(e) Identify one variable you kept constant and outline the strategy used to ensure it remained the same throughout the investigation.

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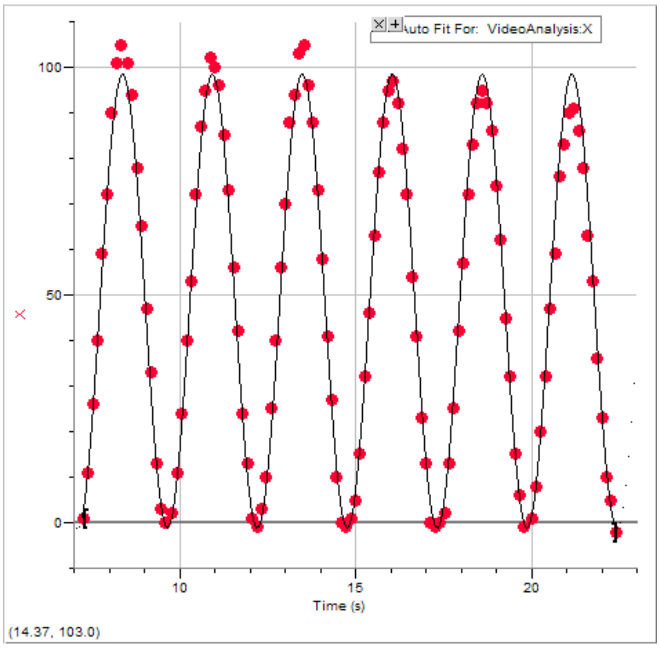
2. The pictures below show three frames in a movie taken of a basketball supported from a rigid support by a string. The basketball was pulled to one side, and released so that it was swinging backwards and forwards at a small angle to the vertical, thus behaving as a simple pendulum.

The movie was analysed using the LoggerPro computer program, from which the following graph of the ball's horizontal motion was produced. The vertical axis of the graph below, labelled 'X' is the horizontal displacement of the basketball measured in centimetres.



(a) Use the graph to calculate the period of the pendulum. Show all working.

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(b) The length of the pendulum was carefully measured and found to be 1.6 metres. Calculate the acceleration due to gravity using the appropriate formula.

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3. In questions 1 and 2, two methods of calculating the period of a pendulum and hence the acceleration due to gravity have been used.

(a) Propose which of these method is more appropriate and justify your answer with reference to the reliability and validity of the data collected in each experiment.

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(b) Outline, with the aid of a suitable diagram, an alternative method to the ones already described that could be used to determine the period of a simple pendulum such as a basketball hanging on a string.

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Part B

4. The table below shows the value of g at various locations from Earth's centre.

Location	Distance from Earth's centre (m)	Acceleration due to gravity (m s^2)	
At the Earth's surface	6.38×10^6	9.8	
1000 km above surface	7.38×10^6	7.33	
2000 km above surface	8.38×10^6	5.68	
3000 km above surface	9.38×10^6	4.53	
4000 km above surface	1.04×10^7	3.70	
5000 km above surface	1.14×10^7	3.08	
10000 km above surface	1.64×10^7	1.49	
50000 km above surface	5.64×10^7	0.13	

(a) Describe qualitatively the relationship between the value of g and the distance above the Earth's surface. 2 M

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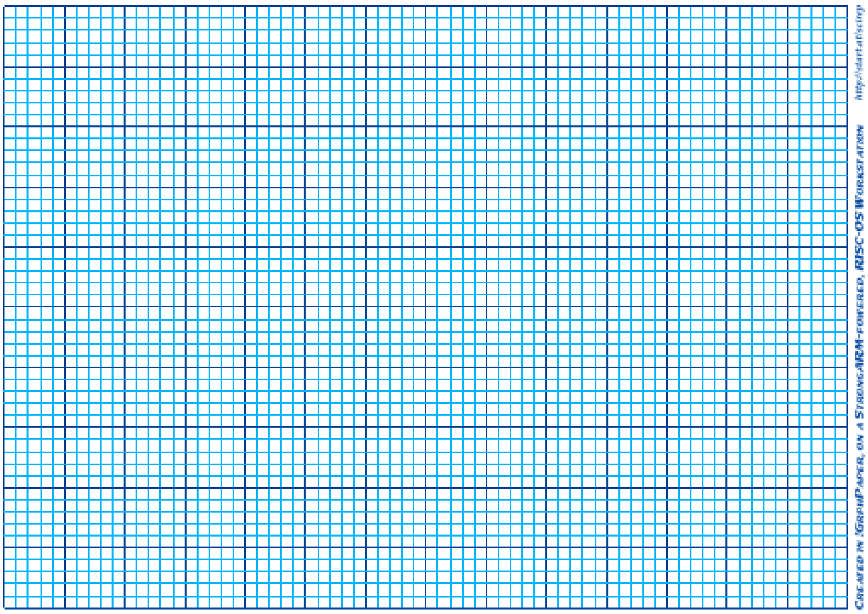
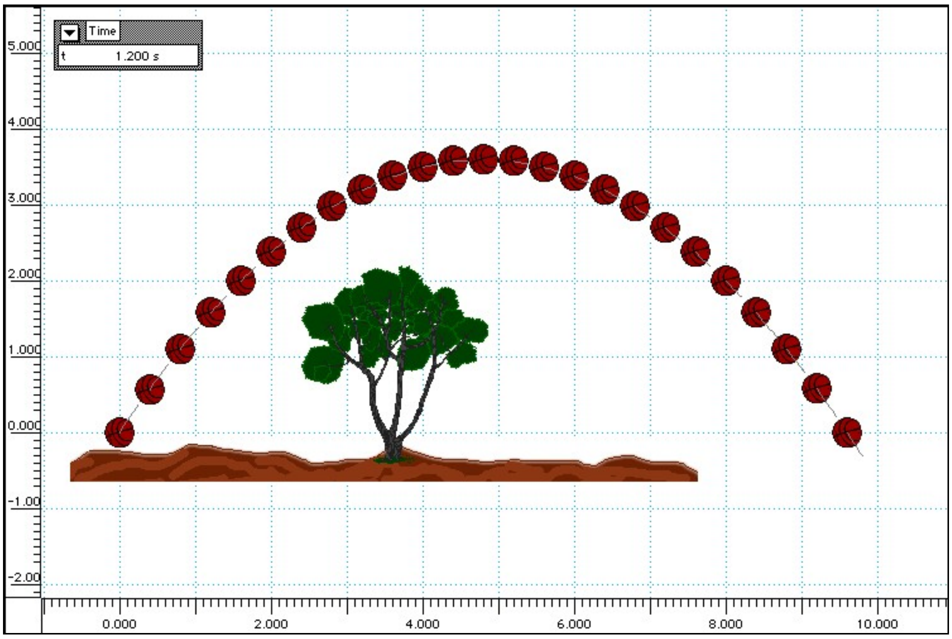
(b) A hypothesis was made that the acceleration due to gravity shown here obeys an inverse square law. Draw an appropriate graph using only three of the tabulated data pairs that could be used to test this hypothesis. 5 M



5. Examine the following image shows the successive positions of a ball thrown at an angle to the horizontal. The ball reaches its highest point at t = 1.2 s and the time between successive images is constant. The vertical and horizontal scales show distances in metres.



(a) Use this information to label the image of the ball at the highest point reached and deduce the time between successive images.

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(b) On the image, label the range of the projectile and state the value of the range in the space below.

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(c) Use this image to describe the horizontal motion of the projectile, supporting your description with appropriate evidence from the image.

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(d) On the axes below, sketch a qualitative graph of the vertical velocity of the projectile against time.

[Question continues on next page] 2 M

(e) Assess the role of first-hand investigations (i.e. experiments) in testing and validating mathematical models such as the one below.

$$\mathbf{T} = 2\pi\sqrt{\frac{l}{g}}$$

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END OF PAPER

Part A: Calculating the Acceleration due to Gravity

1a.

Criteria	Marks
Records the length of the pendulum in metres	1
Records length of pendulum in cm	1/2

1b.

Criteria	Marks
Tabulates results including column headings with units and closed cells A set of reasonable results recorded and a clear indication of repetition Correct calculation of the period using appropriate measurements of time.	5
Mark deducted for each part of the above that is missing (eg no units in headings but all other parts correctly completed will be worth 4 marks etc)	1- 4

1c.

Criteria	Marks
Ruled, labelled, pencil diagram with length correctly shown to centre of mass	2
Diagram correct but length wrong OR Diagram deficient and length correct	1

1d.

Criteria	Marks
Correct answer using data and equation	2
Correct equation identified	1

1e.

Criteria	Marks
Identifies a variable (angle of swing, mass, …) and presents an acceptable strategy for keeping it constant	2
Identifies a variable but does not present an acceptable strategy for keeping it constant	1

2a.

Criteria	Marks
Correctly calculates the period (2.54 s) using more than 1 cycle	2
Calculates the period using one cycle OR uses the correct process and gets wrong answer OR correct principle but misreads scale (does not commence at zero) OR Records one other significant factor used in calculating the period (scale, number of periods)	1

Sample answer: 5 cycles occurs over the time interval 8.5 s to 21.2 s (difference = 12.7 s)

Period (time for one cycle) = 12.7/5 = 2.54 s

2b.

Criteria	Marks
Calculates the acceleration due to gravity correctly (9.8 ms^{-1}) from the figure in part (a) and the length measured.	2
Correct formula written OR correct mathematical manipulation of data in formula	1

Sample answer: $T = 2\pi\sqrt{\frac{l}{g}}$ $\quad g = \frac{4\pi^2 l}{T^2}$ $\quad g = \frac{4\pi^2 \times 1.6}{2.54^2} = 9.8\,m\,s^{-2}$

3a.

Criteria	Marks
Demonstrates a clear understanding of **reliability** **validity** and Makes a **proposition** and Supports the proposition with a **justification** related to an aspect of the data collected	4-5 (mark for each if clearly expressed)
One or more of the above	1-3

Sample answer: The first method is more appropriate. This can be justified because in the first method, the investigation was repeated several times and the same value for the period was consistently obtained (e.g. to within +/- 0.2 s) thereby establishing that the procedure was reliable. The second method was carried out only once, so no conclusion can be made about its reliability.

In both investigations, the length of the pendulum was determined in a valid manner, and hence could be substituted into the formula used to calculate "g". Validity in this context refers to the fact that was intended to be measured was in fact what was measured i.e. the length of the pendulum from the support to the centre of mass.

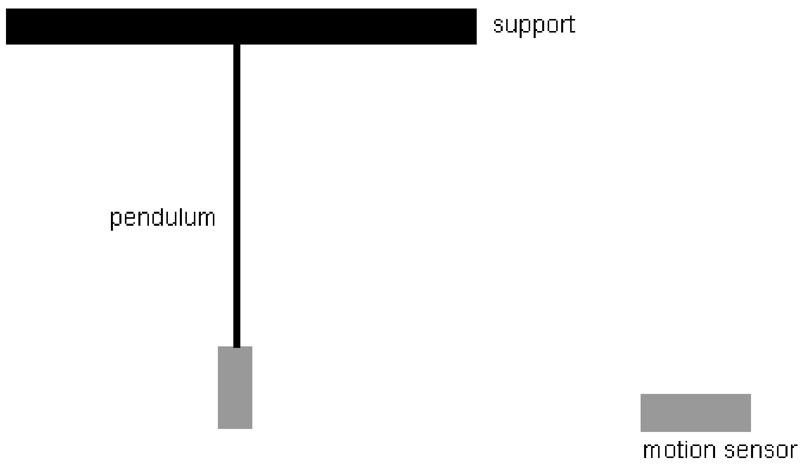
Both investigations involved human judgement that may result in random errors, however in both cases the use of an appropriate strategy to deal with these errors resulted in the measurements being valid. In the first case, variations resulting from judging when the pendulum had completed an oscillation and variations in human reaction time in starting and stopping the stopwatch produced random errors. Conducting several trials and taking an average is likely to produce a mean value close to the actual value if the variations are truly random. In the second case, human judgement was involved in estimating exactly where to click the mouse to record the data from the movie using Logger Pro. In this case, the computer software produced a line of best fit that effectively removed the irregularities in the measurements, enabling the period to be determined with a reasonable expected accuracy.

Some additional points: repeating an investigation does not make it any more accurate. If there are random variations in the measurements (as opposed to systematic ones), then taking the average of many trials tends to produce a value closer to the actual value than a single randomly chosen result. It is not true to say that the use of technology makes a procedure more accurate – potentially it may have this effect, but it depends how the technology is used, and in this case, despite the accuracy of the technology, human judgement was still involved in deciding exactly where to click the mouse on each movie frame to collect the data.

3b.

Criteria	Marks
Diagram + Outline of method	3
Good verbal outline OR Diagram + poor verbal outline	2
Diagram or poor verbal outline	1

Sample answer: A motion sensor could be used to measure the displacement of the basketball against time, and from this data a graph could be produced and from this the period could be determined. The following diagram shows how this could be set up. The motion sensor would be connected to a data logger to record the displacement.



An alternative would be to hang the pendulum from a force sensor. Variations in the tension in the string would result in a pattern from which the period could be measured.

Part B

1. The table below shows the value of g at various locations from Earth's centre.

Location	Distance from Earth's centre (m)	Acceleration due to gravity ($m\ s^2$)	$1/d^2$ (m^{-2})
At the Earth's surface	6.38×10^6	9.8	4.07×10^{13}
5000 km above surface	1.14×10^7	3.08	1.23×10^{14}
50000 km above surface	5.64×10^7	0.13	3.18×10^{15}

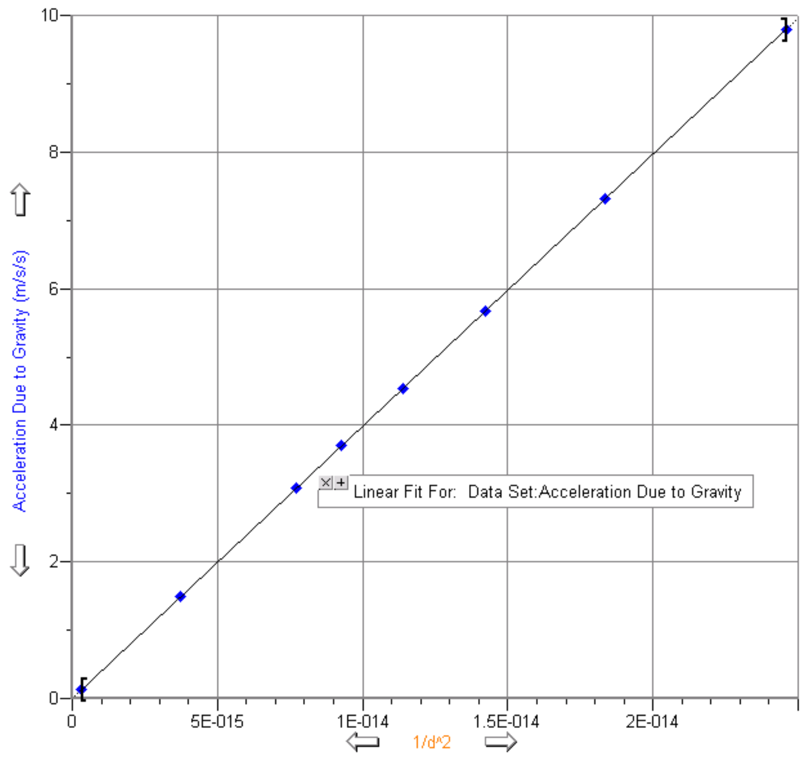
4a.

Criteria	Marks
As the distance above the Earth increases, the acceleration decreases at a decreasing rate	2
As the distance above the Earth increases, the acceleration decreases Or The acceleration due to gravity is inversely proportional to the distance above the Earth squared	1

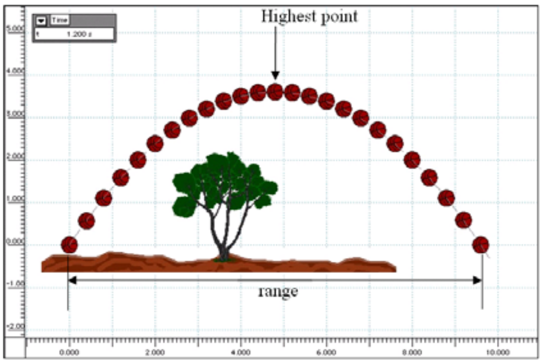
Comment: The fact that the acceleration is decreasing at a decreasing rate can be deduced because for equal increments in the increase in the height, there are successively smaller decreases in the value of g.

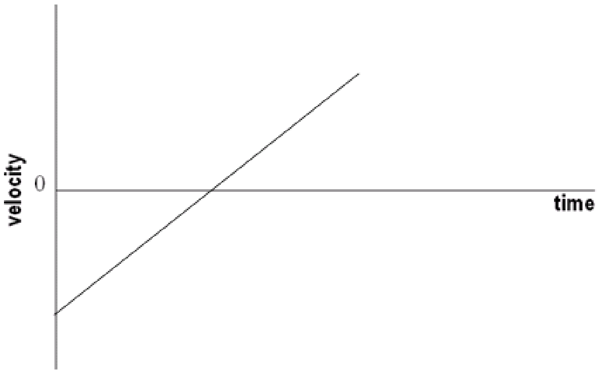
4b.

Criteria	Marks
A graph of Acceleration due to gravity vs $1/d^2$ Three points used to plot a straight line of best fit. Axes labelled correctly	5
Correct graph with a straight line of best fit but incorrect labelling of axes	4
Incorrect graph but axes labelled correctly and three points used.	2
Incorrect graph but axes labelled correctly or three points used.	1



5a.





Criteria	Marks
Labels the highest point and deduces that the time between images is 0.1 s	2
Labels the highest point OR deduces that the time between images is ~0.1 s	1

5b.

Criteria	Marks
Labels the range correctly and states its value in the range 9.5-9.8 metres	2
Labels the range correctly OR states the range.	1

5c.

Criteria	Marks
Describes the horizontal motion as being uniform velocity (or constant speed) and relates this to the equal horizontal spacing between the images of the ball.	2
Describes the horizontal motion as being uniform velocity (or constant speed) but does not provide adequate observational evidence.	1

5d.

Criteria	Marks
Draws a straight line that crosses the zero velocity axis. Velocity at t = 0 can be positive or negative.	2
Draws a straight line (or two sections, both straight) that is not constant velocity Or demonstrates that the direction of the velocity changes	1

Sample answer: (see above right)

5e.

Criteria	Marks
Makes a clear statement/judgement of the value of first-hand investigations and outlines at least 2 relevant ways in which such investigations can be used to test and validate mathematical models. Response must be well structured and written.	4
Makes a clear statement/judgement of the value of first-hand investigations and outlines 1 relevant way in which such investigations can be used to test and validate mathematical models OR outlines at least 2 relevant ways in which such investigations can be used to test and validate mathematical models. Response must be well structured and written.	3
Makes a clear statement/judgement of the value of first-hand investigations and outlines one relevant way in which such investigations can be used to test and validate mathematical models OR outlines 2 relevant ways in which such investigations can be used to test and validate mathematical models	2
Makes a clear statement/judgement of the value of first-hand investigations or outlines one relevant way in which such investigations can be used to test and validate mathematical models	1