Experimental Tasks A + B + C

Time : 3 hrs
Marks :40

Very Important Instructions

The first 15 minutes are to be used ONLY for reading the question paper and planning of the experimental tasks.

You MAY NOT write anything during this period, even on the Question Paper.

After 15 minutes, you will be given the answer sheets and a signal to start the experiments.

You will then have a further 3 hours to complete the examination.

Task: A Pendulum (14 marks for this task)

Examination Rules:

1. You are not allowed to bring any tools **except** any personal medicine or any personal medical equipment.
2. You must sit at your designated table.
3. Before the examination starts, you must check the stationery and any tools (pen, ruler, calculator) provided by the organizers.
4. You must check the question paper and answer sheet. Raise your hand, if you find any missing sheets. You may start only when given the signal by the organizers.
5. During the examination, you are not allowed to leave the examination room except in an emergency and for that the examination supervisor/volunteer/invigilator will accompany you.
6. You are not to disturb any other competitor or disrupt the examination. In case any assistance is needed, you may raise your hand and the nearest supervisor will come to help.
7. You may not question or discuss the examination problems with anyone other than your team members. You must stay at your table until the time allocated for the examination is over, even if you have finished the examination or you do not want to continue working.
8. A signal will indicate the end of the allotted time for the examination. You are not allowed to write anything on the answer sheet after the allocated time is over. You must leave the room quietly after all the answer sheets have been collected.

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Read the following instructions carefully:

1. While you are in the examination hall, you should wear safety spectacles at all times. While doing your experimental task, always wear your lab coat, safety goggles, and hand gloves.
2. Handle each and every apparatus and chemicals with care.
3. Do not try to taste or smell any chemical substance.
4. Chemicals are very safe if handled and disposed of properly.
5. Ensure that you keep the answer sheet and question paper away from liquids.
6. Place all waste papers and used material in the waste basket provided.
7. Immediately report all accidents, injuries, however minor they may be, to the invigilator/supervisor/volunteer present.
8. Eating of any kind of food is strictly prohibited during the experimental task.
9. You are expected to work safely, to behave socially, and to keep the equipment and work environment clean. When carrying out discussions with your teammates, keep your voice low.
10. Do not leave the examination hall until you have permission to do so. Ask an invigilator/supervisor/volunteer if you need to use the bathroom.
11. You may start working only when the start signal is given.
12. You have 3 hours to complete the experimental tasks and to record your results on the yellow answer sheets. You must stop your work immediately after the stop command is given.
13. Be sure that your team has a complete set of the question paper (3 copies) and 2 types of answer sheets (1 white copy for rough work and 1 yellow copy for final answers). **ONLY YELLOW ANSWER SHEETS WILL BE EVALUATED.**
14. Use only the pen and calculator provided.
15. ID code must be written on every page of the final (yellow) answer sheets. Each team member must sign on the front page of the final (yellow) answer sheets.

16. All results must be written in the designated boxes on the **yellow answer sheets**. **Data written elsewhere will not be evaluated.**
17. After completing the task, put all the equipment back to its original place. Make sure you clean your work place.
18. After the stop command is given, put all papers inside the envelope kept on the desk. Wait for the volunteer to check and collect it.

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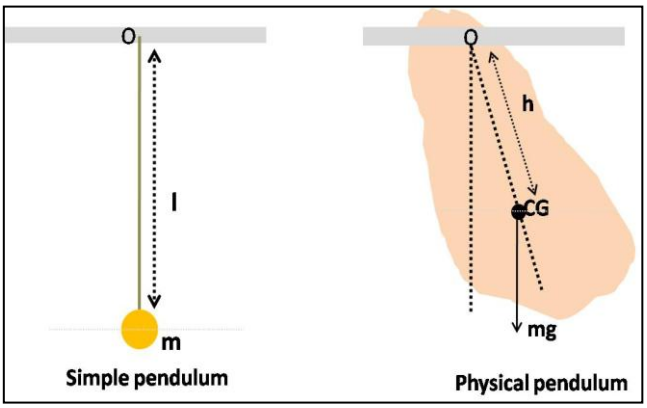
Task **A:** This task is divided into three parts:

A1: To determine the centre of gravity of a triangular plate, A.
A2: To record the time period of oscillation for different suspension points for the plate.
A3: To analyze the above data and results.

A *simple pendulum* consists of a point mass m suspended from a string of fixed length l and negligible mass, the other end of which is fixed to a rigid support O. For small displacements from the equilibrium position (shown in the figure below), the point mass m executes simple harmonic motion with time period, T (time taken for one oscillation):

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

where g is the acceleration due to gravity.



A much wider variety of situations that involve small oscillations may be described in terms of a *physical pendulum*, also called a "compound pendulum". Using this concept, we can describe the motion of a rigid body of mass m, of arbitrary shape and size. It is pivoted at O (called the "point of suspension", as shown in the above figure). For small displacements, such a physical pendulum executes simple harmonic motion, with time period

$$T = 2\pi\sqrt{\frac{I_0}{mgh}}$$

Here I_0 is the *moment of inertia* about an axis passing through the point of suspension, h is the distance of the point of suspension from the *centre of gravity* (CG)**,** and g is the acceleration due to gravity.

Moment of inertia (I_0) is a quantity measuring the resistance offered by a body against its rotational motion. It is always referred to with respect to an axis of rotation and it depends on the body's shape. For a point mass m**,** the moment of inertia I_0 is given by $I_0 = mr^2$, where r is the distance of the point mass from the axis of rotation.

In this experiment we consider a triangular plate of mass m which oscillates in its own plane. Its moment of inertia about an axis passing through its point of suspension O is given by:

$$I = m(K^2 + h^2)$$

where K is called the radius of gyration.

The time period of oscillation of the physical pendulum is therefore

$$T = 2\pi\sqrt{\frac{K^2 + h^2}{gh}}$$

The time period can also be written as $T = 2\pi\sqrt{\frac{L}{g}}$

where $L = \frac{K^2}{h} + h$ is called the length of an equivalent simple pendulum.

A point S, on the other side of the CG and at a distance of $h' = \frac{K^2}{h}$ from the CG (along the line joining O and CG) is called the "point of oscillation". The oscillations with the point of suspension O are then equivalent to having all the mass concentrated at S.

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You are supplied with the following:

	Quantity
Clamp Stand	1
Triangular plate	1
Fulcrum rod with knife edge for suspension	1
Plumb line	1
Ruler	1
Stop watch Same stopwatch to be used for Task B	1

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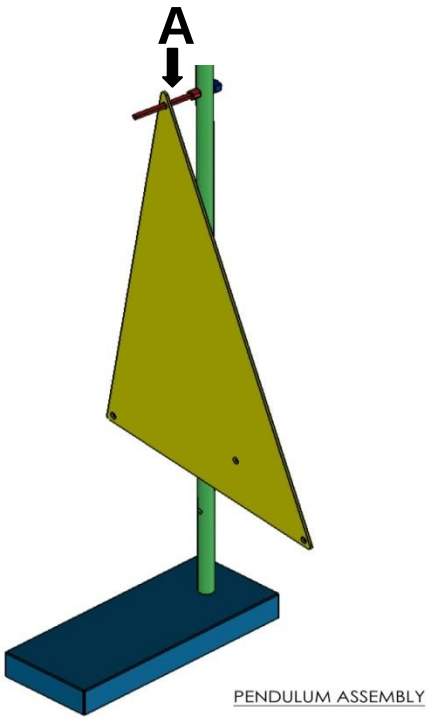
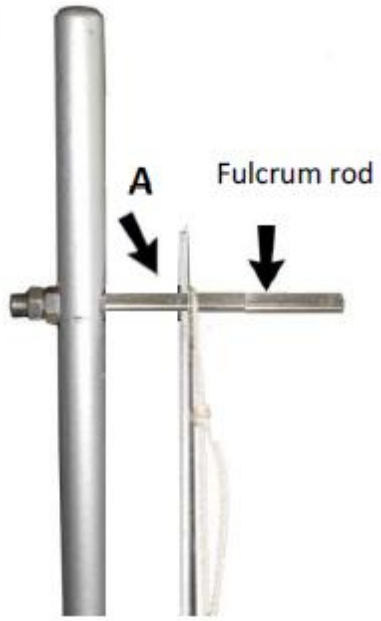
A1 To determine the centre of gravity (CG) of triangular plate, A.

Procedure:

1. Suspend the triangular plate **A** from the fulcrum rod (mounted on the clamp stand) by one of the three holes provided at the three corners of the triangle (see the figure below).



PENDULUM ASSEMBLY



2. Ensure that the suspended plate is stationary. Pass the loop of the string on the rod and hang the plumb line through the fulcrum rod (as shown in the figure above). Using a ruler and pencil, mark a straight line on the plate along the string.

3. Repeat the same procedure by suspending the plate through a different hole. The intersection of the two lines gives the CG. Use a pencil to mark it as 'X' on the plate.

   Mark the two lines and the point 'X' also on the large sized sheet of paper (provided to you) with a drawing of the triangular plate on it. Label it as **Sheet 1**.

   Please write ID codes of all team members and the Country Code on **Sheet 1**.

   [A.Q1: 1.0 mark]

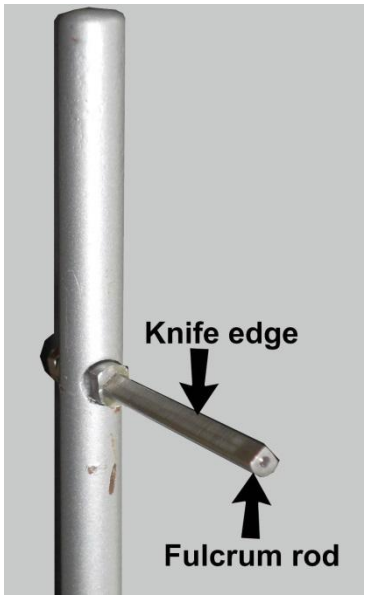
4. Suspend the plate through a different hole and repeat steps 1 and 2. This line should also pass through the CG. Show the line on **Sheet 1** also.

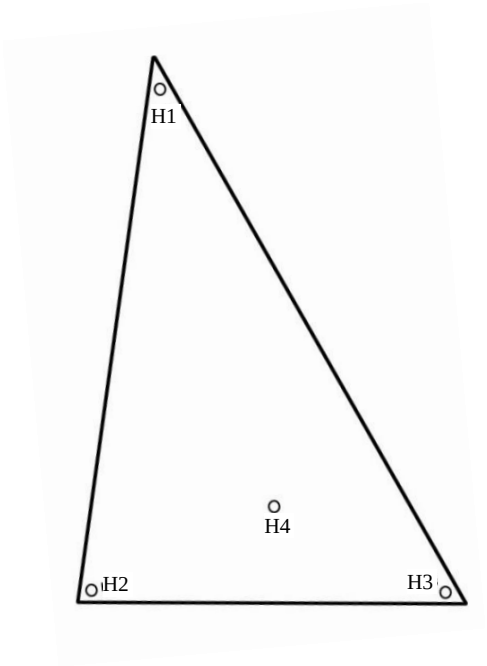
Note: The correct determination of CG is very important as any error here will introduce a corresponding error in the measurement of h, which will be used later.

A2 To record the time period of oscillation for different suspension points for the plate.

Procedure:

1. Suspend the plate from hole **H1** using the fulcrum rod. Ensure that the plate is almost at the centre of the fulcrum rod and resting on the knife edge (see the figure below). This is important to reduce damping of the oscillations and, hence, to minimize error in determining the time period of oscillations.





Note: Measure all distances from the top end of all the holes.

2. Measure the distance **h** between hole **H1** and the **CG** you marked in the previous part of the experiment. (Measure the distance from the top end of hole **H1**). Write it in **Table A.1 in the yellow answer sheet**.

3. Set the plate into oscillation (with small amplitude) and ensure that these oscillations occur mostly in the plane of the plate.

4. Using the stop watch, measure the time taken for 50 oscillations. Repeat three times and write each reading in **Table A.1 in the yellow answer sheet.**

5. Repeat the above steps for holes **H2**, **H3**, and **H4.**

[A.Q2: 4.0 marks]

A3 To analyze the above data and determine

a) the acceleration due to gravity
b) the radius of gyration of the plate about an axis passing through its CG normal to the plane of the triangle;
c) the positions of the corresponding points of oscillation from the CG for two points of suspension; and
d) the lengths of the equivalent simple pendulum for these two points of suspension.

Procedure:

1. Using the data in **Table A.1**, plot a graph of hT^2(y-axis in ms^2) versus h^2 (x-axis in m^2) on the grid provided in the answer sheet (**Grid 1**).

[A.Q3: 2.0 marks]

2. Draw a straight line through the points (best fit) and determine the slope s and the y-intercept c.

   Using these values of s and c, and the expression for the time period of a physical pendulum, determine the values of g in ms^{-2} and K in units of metres. Enter the values of s, c, g, and K in **Table A.2 in the yellow answer sheet.**

[A.Q4: 3.0 marks]

3. For holes **H1** and **H4**, calculate the positions of the corresponding points of oscillation from the CG (h'). Write it in **Table A.3 in the yellow answer sheet**. On the large sized sheet of paper (**Sheet 1**), mark the positions of the points of oscillation **J1** and **J4** corresponding to the holes **H1** and **H4, respectively.**

[A.Q5: 3.0 marks]

4. Determine the length (L) of the equivalent simple pendulum when the plate is suspended from **H1** and **H4**. Write your answer in **Table A.4 in the yellow answer sheet.**

[A.Q6: 1.0 mark]

Space for rough work