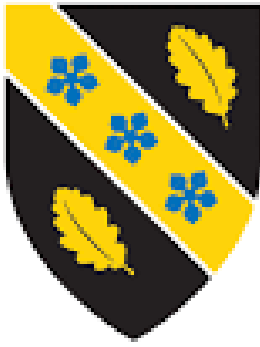


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Energy in a Fly Wheel

Further Science for Engineers (ACHA4007)

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Contents

1. Introduction.....	1
2. Experimental Procedure	2
3. Results.....	3
4. Analysis.....	4
5. Conclusion.....	6
6. Evaluation	7
7. Further Work.....	8
8. References	9

1. Introduction

The first aim of this experiment is to compare the potential energy (PE) applied to the potential energy (PE) loss. There should be more PE loss as the mass increases. The theory is that flywheels store energy. When an object has more mass, the angular / linear velocity will increase when dropped. This means more speed and more energy stored. The amount of energy the part can store depends on the speed and mass. Heavy objects have a bigger resistance to change in motion, meaning that there is more energy required. This resistance to change in motion is undesirable when initially starting to move, because it will need a larger amount of force. "Friction slows a flywheel down even when the bearing that it spins on has been lubricated. The other problem is that as a flywheel spins the air resistance (drag) slows it down. In automobiles, modern flywheels have got around this problem by using low-friction bearings and being contained in metal casing so that they don't lose as much energy from drag as traditional flywheels would have (Woodford, 2023)." Flywheels store energy for the non-power strokes of the engine. The kinetic energy (KE) is absorbed during the power stroke and then released during the non-power stroke, similar to the experiment. This creates a smoother engine and reduces vibrations.

The second aim is to compare the average value of inertia found from the data recorded to the actual value of inertia provided. This will show the accuracy of the test. "Moment of inertia, also known as rotational inertia or angular mass, is a physical quantity that resists a rigid body's rotational motion. It is analogous to mass in translational motion. It determines the torque required to rotate an object by a given angular acceleration. ("Moment of Inertia," 2023)"

2. Experimental Procedure

Equipment used to complete the test:

Weight hanger, 49 x 10g weights, magnetic rule, stopwatch, backplate, bearing block, flywheel, flywheel brake, cord or strings.

The flywheel assembly was constructed by attaching the cord and weight hanger. The ruler was positioned so that the weight hanger's lowest point was at zero to set the reference for all the measurements subsequently taken. Nine 10g free weights were added to the hanger to increase the weight to 100g. Before starting the experiment, a check was carried out to ensure that everything was working safely. Person 1 turned the flywheel so that the hanger was at its maximum height and held it in place. Person 2 recorded the time taken for the hanger to travel down and then back up. Good communication was necessary for exact recording of time. Person 1 counted down from three and let go of the flywheel. The stopwatch needed to be started at exactly the same time as the flywheel was dropped. Person 1 recorded the height that the hanger reached. This procedure was repeated with 200g, 300g, 400g and 500g.

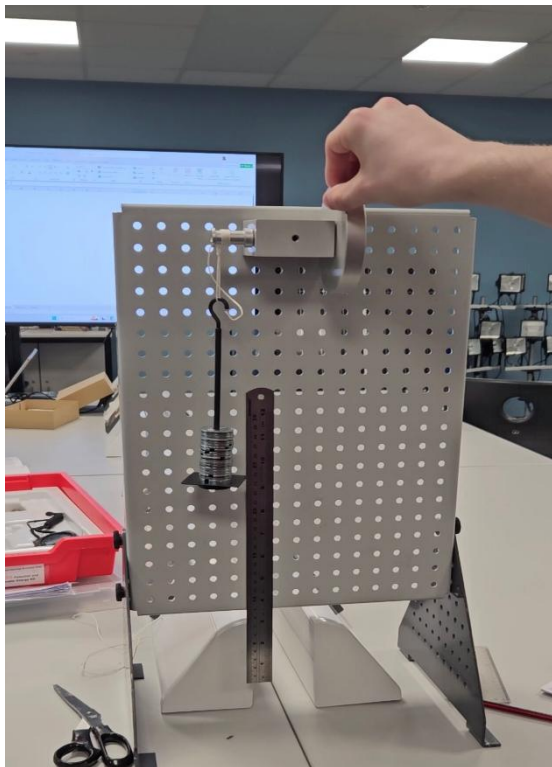


Figure 2 – Assembly

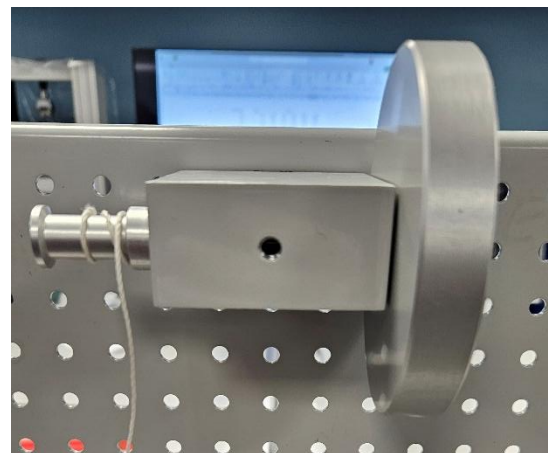


Figure 1 – Flywheel Block and Pulley

3. Results

MASS	DROP 1	DROP 2	DROP 3	AVERAGE	AVG TIME
0.1KG	0.23m	0.232m	0.236m	0.233m	4.39s
0.2KG	0.25m	0.253m	0.255m	0.253m	2.79s
0.3KG	0.253	0.255m	0.255m	0.254m	2.59s
0.4KG	0.258m	0.26m	0.255m	0.258m	2.04s
0.5KG	0.243m	0.245m	0.23	0.239m	1.85s

4. Analysis

The first part of analysing the data, was to calculate the values of the acceleration, kinetic energy and torque. These findings were then displayed a graph showing the moment of inertia.

Mass	Initial P	Tt	h2	mg	PE loss adjusted	Tf	Acceleration	v	ω	Torque	α	KE
kg	J	s	M	N	J	s	m/s ²	m/s	rad/s	Nm	rad/s	J
0	0	0	0	0	0	0	0	0	0	0	0	0
0.1	0.27468	4.39	0.233	0.981	0.025165614	2.396101	0.098037499	0.234907786	36.1757	0.00631	15.0827	0.32717
0.2	0.54936	2.79	0.253	1.962	0.027828743	1.46566	0.260688307	0.382080531	58.8403	0.01241	40.1059	0.86554
0.3	0.82404	2.59	0.254	2.943	0.040121798	1.358052	0.303637375	0.412355476	63.5026	0.01854	46.7134	1.00814
0.4	1.09872	2.04	0.258	3.924	0.044929071	1.06171	0.49679385	0.527451017	81.2273	0.02421	76.4298	1.64947
0.5	1.3734	1.85	0.239	4.905	0.108495954	0.998073	0.562164495	0.561081326	86.4063	0.03006	86.4868	1.86651

Figure 3- Results Table

Using the universal measurement of gravity the weight force was calculated ($m \cdot g$). Using the equations in the guidebook provided by TecQuipment, all the values given in the above table were calculated. The equation $a = \frac{2 \cdot h_1}{t_f^2}$ was used to work out linear acceleration of the weight hanger. In practice, it was particularly difficult to record just the time falling, so instead, the total time was measured. The time falling could then be worked out by using the equation $t_f = t_t \cdot \frac{h_1}{h_1 + h_2}$. These new values can be multiplied together ($a \cdot t_f$) to give the final velocity.

Inertia is equal to torque over angular acceleration (α). The angular velocity (ω) of the flywheel was calculated by using the equation $\frac{2\pi v}{c}$. c is (0.408m) is the diameter of the cord holding the mass. Torque is equal to the (mass*gravity + mass*acceleration) *the radius of the pulley. The radius of the pulley is half the diameter (0.013).

KE is equal to half of the moment of inertia total multiplied by the angular velocity squared. $KE = 0.5 I_t \omega^2$ The PE will be equal to the kinetic energy if the mass returns back to its original height.

The values of torque and angular acceleration were used to create a graph (shown below). In this graph, the gradient will equal the average value of inertia. The graph shows a value of 3.289×10^{-4} .

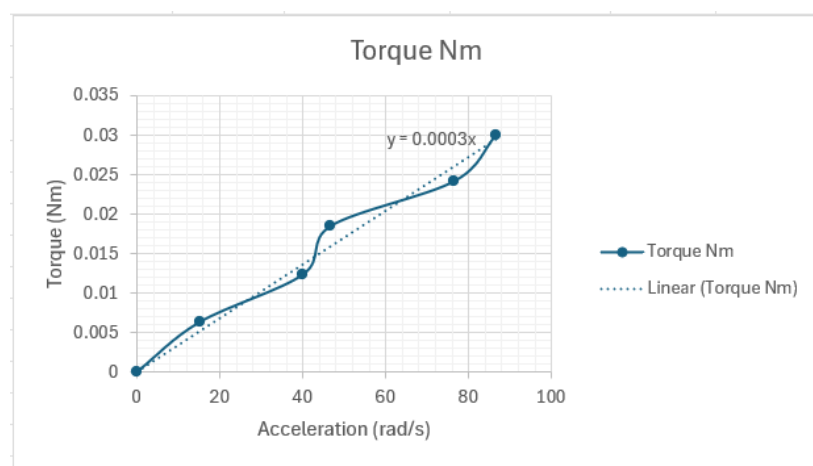


Table 1- Moment of inertia

The accuracy of the value (created by the gradient) is dependent on the accuracy of the results recorded. The nature of this experiment tends to include inaccuracies due to human error. The 500g measurement result was clearly incorrect because it did not fit with the pattern (see later). Therefore, it was discarded and wasn't used in the graph.

5. Conclusion

The aim of this experiment was to compare the average value to the theoretical value and to note the relationship of mass applies and PE loss.

While the average value found from the graph was 3.289×10^{-4} , the theoretical was 4.696×10^{-4} . The difference between the values suggests that there were inaccuracies in the measurements taken. This could be because the 500g measurement wasn't included in the graph. However, the gradient should be unaffected by this. External factors such as co-efficient of friction and are unaccounted for when working out the average value. It also is unaccounted for when looking at the pattern of potential energy loss. There is more energy lost for heavier masses because it takes more energy to raise the mass up. This means that the greater the mass the greater inertia. This assumption fits with the pattern shown in the graph.

There is a discrepancy in the equation $KE = PE + PE \text{ loss}$. For the first mass $PE + PE \text{ loss}$ is 0.22435 however the KE that was worked out using $KE = 0.5I_t\omega^2$ is 0.3727. This discrepancy is the similar to the discrepancy of the average inertia and the theoretical inertia. In this scenario it could be because it is the rotational KE and the linear KE. The data also shows that as a percentage of loss, it decreases according to the increase in mass.

6. Evaluation

On the 500g test the ruler was knocked causing it to misalign from the set scale. When it was realigned, it wasn't set the same. This meant that the 500g had inaccurate height measurements and was discarded. To minimize errors the flywheel brake was removed. When using the brake, it would get stuck and wouldn't release the flywheel at a consistent rate. So instead, the flywheel was held in position and released by hand. Having someone to count down from three allowed each person to synchronise their tasks. Recording data was the area that could have caused the most errors. This is because humans can get distracted, and their reaction times are inconsistent.

7. Further Work

With unlimited time and money, the test would have been repeated using recording equipment that would ensure measurements are consistent, removing human error. It would also be conducted in a closed environment so that no external factors could interfere with the process. They could also use an electronic brake to hold and release the flywheel. The experiment could be streamlined by using computer software to complete the test.

8. References

Moment of Inertia [WWW Document], 2023. URL <http://hyperphysics.phy-astr.gsu.edu/hbase/mi.html> (accessed 3.23.25).

Woodford, C., 2023. How do flywheels store energy? - Explain that Stuff [WWW Document]. URL <https://www.explainthatstuff.com/flywheels.html> (accessed 3.23.25).

Table 1- Moment of inertia	4
Figure 1 – Flywheel Block and Pulley	2
Figure 2 – Assembly	2
Figure 3- Results Table.....	4