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Energy In a Fly Wheel Report

Further Science for Engineers (ACHA 4007)

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1. Introduction

The aim of this experiment is to understand the moment of inertia and how kinetic and potential energy is stored and lost within a fly wheel when small increments of weight are added to it. This is done by measuring the height that the weight hangar bounces back up to while consistently timing it. This experiment was conducted within a small group of 5 across a 2-hour time slot. Flywheels have many uses when it comes to engineering and are most used within a combustion engine, therefore it is important to understand how the energy is used within the flywheel and finding the moment of inertia to maximise efficiency. The fly wheel has many uses when it comes to an engine, one of those being the 'limitation of the effects of friction, enabling gear changing and overall vehicle functionality' (Wayken, 2024).

2. Experimental Procedure

This experiment had multiple steps, and each one had to be taken with precaution to ensure a fair test and all variables are met. The first step of this experiment was reading and understanding the guidance notes. This step ensures that the procedure was understood and could be carried out confidently. The next step was assembling the equipment. This consisted of a work panel, multiple 10g weights, string, the flywheel, weight hangar, pulley block and a magnetic ruler. When assembling the equipment, it is vital that the measurement of 280mm is correct, as if it was incorrect, the data would be inconsistent, and the experiment would be void. This would be the height that the weight would drop from. Therefore, allowing the data to be more reliable as each test was under the same conditions. The measurements were completed with the ruler provided and following the booklets instructions of 'ensuring the weight hangar is correct at eye level' (TecQuipment, 2012) . Once the weight hangar had been applied to the string, the measurement must be double checked that it was at the correct height of

280mm. Because the weight hanger weighs 10g, the first experiment only needed 9 of the 10g weights to be added to it. Every test after 0.1kg needed 10 of the 10g weights.

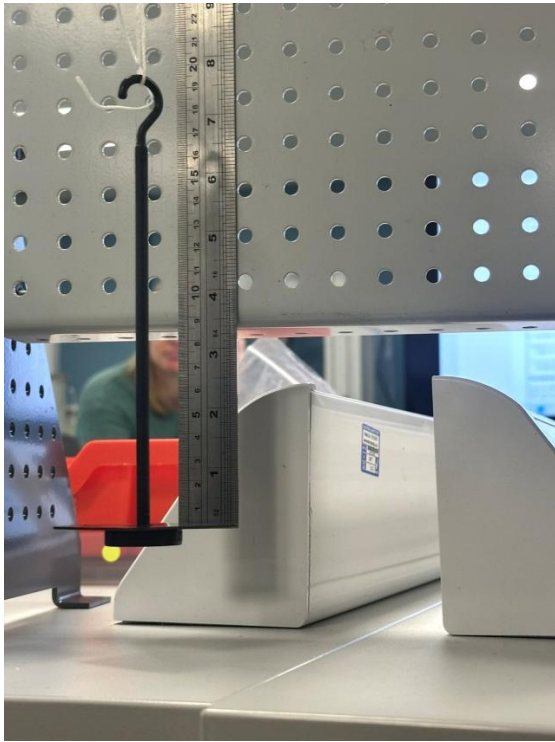


Figure 1 - The Weight Hanger Being Measured.

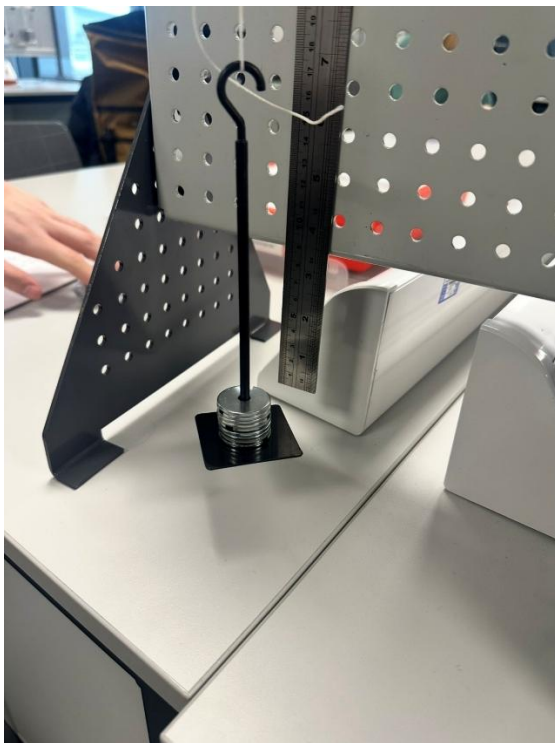


Figure 2 - An image of the weight hangar with multiple 10g weights on it.

The weight hangar was observed to be dropped from 280mm to 0mm, while one member of the team records the height that the weight bounces back up to. The other team member records the duration of the experiment. This was repeated 3 times and closely observed to ensure all the data is correct. The data is then recorded and written into a table. The next step was adding 10 of the 10g weights onto the weight hangar and checking the measurement again, then dropping from 280mm. This step was repeated 3 times to ensure a fair test and to calculate an average. After this, 10 of the 10g weights were added consistently after 3 drops with all the data being recorded. This was done all the way up to a total weight of 0.5kg on the fly wheel. Throughout the process it was important that photos were taken to document the experiment.

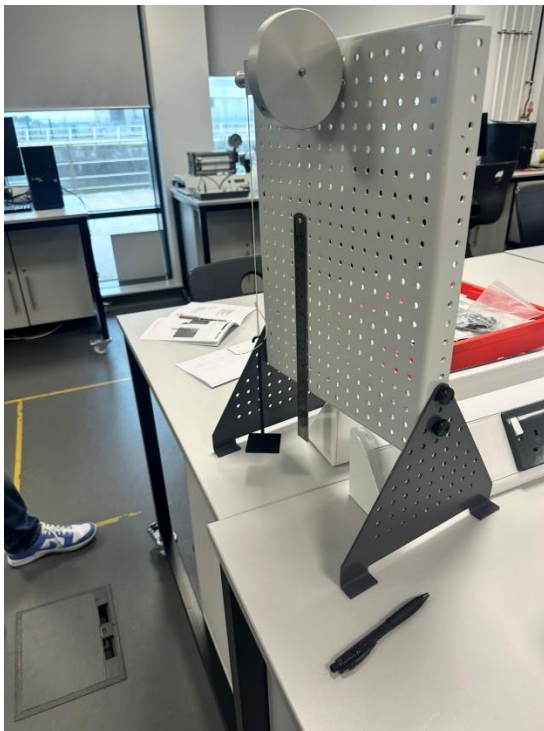


Figure 3 - A Full Image of The Correct and final Setup.

3. Results

Below are the results taken directly from the lab that were written down onto the back of the provided booklet and later converted into a table.

Table 1 - Raw results collected from the lab

Mass	Total Time	Height
KG	S	M
0.1	5.05	0.24
	4.55	0.237
	4.45	0.238
0.2	3.01	0.255
	3.15	0.255
	3.15	0.253
0.3	2.83	0.255
	2.86	0.255
	2.55	0.255
0.4	2.53	0.252
	2.36	0.248
	2.2	0.254
0.5	2.03	0.227
	2.06	0.225
	2.01	0.23

4. Analysis

During the experiment we had many anomalies that didn't fit the pattern. When one of these anomalies appeared, it was decided that the test would be repeated. The results from the anomalies were written down but not acknowledged during the data calculations on excel. All the data that was taken from the lab were calculated into

averages. Those were the data numbers that were used on the final excel table to calculate all the required data.

4.1 Calculations

The calculations needed for this experiment were in the ES9 guidance booklet (TecQuipment, 2012). The first calculation required was initial potential energy. The calculation for this is $(Mass \times Initial Height \times Gravity)$. Initial Potential energy is calculated to see how much energy can be converted into other forms of energy. The potential energy calculations made sense in terms of this experiment as they gradually increased with the weight. This shows that with increased weight, more energy can be created. The next calculation was mg . Mg is a simple calculation and is done by multiplying mass with gravity.

Then Potential energy loss adjusted was calculated. The calculation for this is $(Mass \times Gravity) \times (Height1 - Height2) \times (Height1 \div (Height1 + Height2))$. My results for this calculation were very close to the original potential energy calculation.

The next calculation was falling time. The calculation for this consists of $(Total Time \times Height1) \div (Height1 + Height2)$. As the weight was added on, the time taken to fall decreased majorly from 2.5s with 0.1kg of weight to 1.12s with 0.5kg of weight. This is due to the increased force acting on the weight.

The next calculation was acceleration. The formula for this is $(2 \times Height1) \div (Falling Time^2)$. Acceleration is one of the most important calculations required for this experiment as it allows the ability to calculate alpha and velocity.

The next calculation was the calculation of velocity. This is a simple formula that consists of $(Acceleration \times Falling Time)$. This calculation led to the calculation of Omega (radians per second).

To calculate omega, you first need to calculate 'C'. The formula for 'C' is $(2 \times \pi \times \text{Radius})$. Once 'C' is calculated, it is possible to use the formula for omega. The formula for this is $((2 \times \pi \times \text{Velocity}) \div C)$. The results for this calculation increased as the weight rose from 34.09 rad/s to 76.9 rad/s. This means that the flywheel had an increase in radians of 2.25x.

The next calculation was for torque. The formula for this calculation is the $(\text{Moment of Inertia} \times (\text{Acceleration} \div r))$. Torque can be applied to a flywheel 'to cause it to spin, increasing its rotational momentum' (al, 2024).

The next calculation was alpha. The formula for this calculation is $(\text{Acceleration} \div r)$. The unit for this is radians/s² and is the rate of change of angular velocity.

The final calculation required for this experiment was the calculation of kinetic energy. The formula for this calculation is $(0.5 \times (It \times \omega))$. The calculation for 'It' is the result gained from the graphs equation. Kinetic energy is used for 'maintaining energy during acceleration' (Muro, 2023).

4.2 Table analysis

The table needed to be organised and easy to understand. To do this, everything was clear and well-spaced, meaning the table is professional and well organised. It was important to import the data from the lab correctly into the data table to ensure all the calculations are relevant to our exact experiment.

Here is my completed table.

Table 2- Fully completed table

Mass KG	Initial PE J	Tt s	h2 m	mg N	PE loss adjusted J	Tf s	Acceleration m/s ²	v m/s	ω rad/s	Torque Nm	α rad/s ²	KE J
0	0	0	0	0	0	0	0	0	0	0	0	0
0.1	0.27468	4.68	0.238	0.981	0.022271351	2.52973	0.087506392	0.221368	34.09052	0.00632	13.46252	0.257181
0.2	0.54936	3.1	0.25	1.962	0.031095849	1.637736	0.208785491	0.341935	52.65794	0.012482	32.12084	0.61362
0.3	0.82404	2.74	0.255	2.943	0.038506542	1.434019	0.272319288	0.390511	60.13855	0.018598	41.89528	0.800345
0.4	1.09872	2.36	0.251	3.924	0.060005424	1.244444	0.361607143	0.45	69.29984	0.024566	55.63187	1.062762
0.5	1.3734	2.03	0.227	4.905	0.143570414	1.121105	0.445549343	0.499507	76.92396	0.030434	68.54605	1.309468

The table shows that when weight is added it speeds up and gains energy. It also shows that there are more radians per second, when there is more weight added. From this table its possible to pick up many trends and patterns. For example, as the acceleration increases, so does the number of radians per second. After creating the data table, it is possible to create a graph based on the calculations.

4.3 Graph analysis

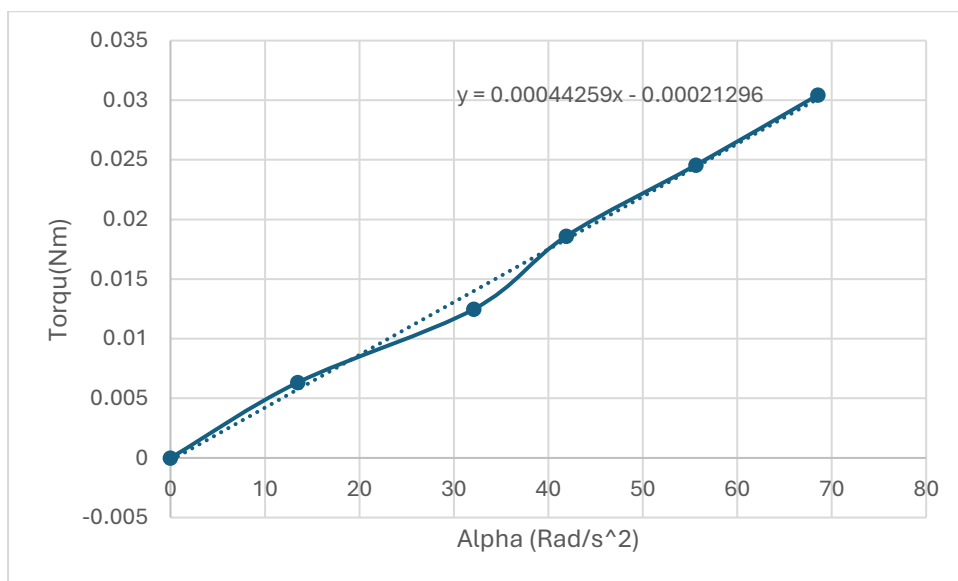


Figure 4 - The completed graph with all the calculations and the linear equation.

This graph shows torque (on the x axis), by the acceleration (on the y axis). The graph shows that that when Torque increases, so does the acceleration at the same rate. The calculation for the linear line is $0.00044259x$. This means that my value of inertia is

0.00044259. This can then be compared to the Inertia value gained from the pulley block and the wheel.

5. Conclusions

In this experiment, the moment of inertia, potential energy and kinetic energy were analysed and how a fly wheel uses them. Based on the analysis, the experiment was a success and the data that was collected was accurate. To validate this, all the formulas were compared to the formulas in the booklet to ensure they were entered correctly into excel. To ensure the moment of inertia was correct, the equation from the graph was compared to the Inertia for the pulley block and the wheel equalled to 0.0004696kgm^2 . Whereas the equation from my graph equalled to 0.00044259kgm^2 . This validates the experiment as they are very similar and only extremely small difference between the numbers. They could be slightly different due to human error which cannot be accounted for on this level.

6. Evaluation

There are many different procedures to be followed that ensure that errors are minimised. One of those is to ensure that the height and the weight was being dropped from the same height, before every test. This ensures that data will be consistent resulting in less anomalies. It's important that all variables are accounted for, and the experiment is carried out correctly. Another precaution taken was that unscrewing the brake for one full turn. This allows the fly wheel to fully rotate and not get stuck, meaning it wasn't dropped from a consistent height. The last major precaution that was taken was that everything was double checked by another member of the team. This lowers the chance of human error and during a practical experiment, everything should be checked twice to ensure correctness.

7. Further Work

If given the ability to conduct this test with unlimited time and money, there would be many possible changes to make. One of those changes would be that the test could be conducted with heavier objects. For example, the test could be conducted with 1–10-ton object giving much higher data and a higher understanding of energy and the moment of inertia at an extreme level. Another possibility would be changing the string after each drop. This would ensure the string hasn't withered and weakened, making the test much fairer and more accurate. Another change that is possible to make, would be to use a slow-motion camera. This would allow the ability to get each measurement down to the exact millimetre and millisecond. This would mean that all data is completely accurate as it removes reaction time. The experiment could also be conducted without friction and air resistance. This would make the experiment as accurate as possible as friction and air resistance lead to lower amounts of kinetic energy.

8. References

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