

University Of Wales Trinity Saint David

Wales Institute of Science & Art



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

Energy in a Flywheel

Energy in a Flywheel – Further Science for Engineering (ACHA4007)

Joe Dashwood

2404498

Date (03/2025)

Contents

1. Introduction.....	3
2. Experimental procedure.....	4
3. Results and analysis.....	5
4. Conclusion.....	7
5. Evaluation.....	7
6. References and Bibliography.....	8

Introduction

This Technical report covers the observations made in an experiment that was carried out to observe how adding different masses to a flywheel of known parameters affects the transfer of gravitational potential energy to kinetic energy, when subjected to gravitational acceleration, rotating the flywheel. This experiment aims to compare the real world recorded values of the energy transfer in the flywheel, with the expected values. The experiment demonstrates how energy can be “stored” in a flywheel through conservation of energy.

A Flywheel, by definition, is a heavy wheel for opposing and moderating by its inertia any fluctuation of speed in the machinery with which it revolves.[1]

As the mass drops, it spins the flywheel, converting gravitational potential energy to rotational energy, in the form of kinetic energy. Upon reaching the lowest point, the spinning flywheel then starts to rewind the apparatus, lifting the mass back up, demonstrating the law of conservation of energy, which states that energy cannot be created or destroyed, it can only be transformed from one form to another.[2]

2. Experimental Procedure

To conduct the experiment the Potential and Kinetic Energy Kit ES9 [3] was used and set up according to the guidance notes booklet provided, to ensure that the equipment was all securely assembled, on a level surface to minimise any margins for error.

The length of string was pre cut and measured using a steel rule so that it allowed the weight hanger to reach 0.29m from the pulley axle at rest, ensuring the hanger is centred and was straight and inline with the centre of the axle.

The magnetic steel rule was placed on the apparatus so that it measured 0mm from the point where the weight hanger rests with no weight attached to the hanger. The data recorded was from adding extra weights to the hanger between 0.1kg and 0.5kg, increasing by 0.1kg increments each time for a total of 5 data points. To reach the first measurement of 0.1kg, 0.09kg was added to the hanger as its base weight was 0.01kg.

To record the data, the flywheel was rotated to wind the string around the axle until the bottom of the hanger was at the drop height of 0.28m (h_1). The next step was to record the total time taken for the weight set to drop from h_1 , using a stopwatch, until it went on to reach 0, and return up to its maximum height (h_2), making notes of the distance it reached on return, as well as the time taken to reach this height. This was repeated three times with each weight set, for a total of 15 drops to gain an average between each set. Any results that were affected measurably by human error were then retaken and discarded from the average. All the recorded data was noted down and input to a spreadsheet to calculate further values.

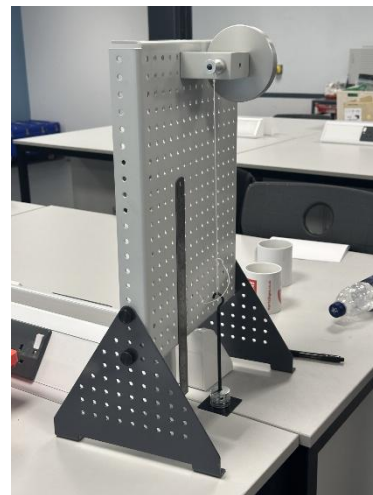


Figure 1 - assembled apparatus

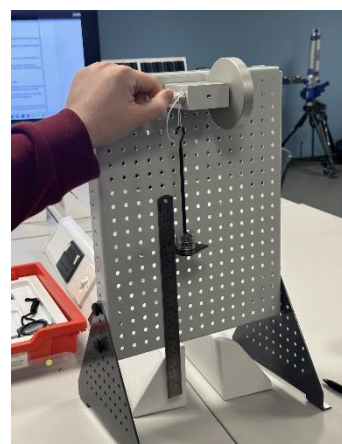


Figure 2 - hanger at maximum height

3. Results and Analysis

Handwritten raw data from the lab showing calculations for different masses and heights. The data is organized into groups for 100g, 200g, 300g, 400g, and 500g. Each group lists height (h2) and time taken (Tt) for multiple trials, with some values circled to indicate averages or specific results.

The data collected in the lab (see figure 3) shows the time taken for each weight set to reach h2 in cm.

Mass	Average Height Reached (h2)	Average Time Taken
0.1kg	0.238m	4.55s
0.2kg	0.254m	3.10s
0.3kg	0.255m	2.75s
0.4kg	0.251m	2.30s
0.5kg	0.227m	2.03s

Figures 3 and 4 - raw data collected in the lab.

Mass	Initial PE	Tt	h2	mg	PE loss adjusted	Tt	Acceleration	v	w	Torque	a	KE
kg	J	s	m	N	J	s	m/s ²	m/s	rad/s	Nm	rad/s ²	J
0	0		0	0	0	0						
0.1	0.27468	4.55	0.238	0.981	0.022271351	2.459459	0.092578191	0.227692		35.06453339	0.007121	0.30738
0.2	0.54936	3.1	0.254	1.962	0.026747865	1.625468	0.211948863	0.344516		53.0553598	0.016304	0.703718
0.3	0.82404	2.75	0.255	2.943	0.038506542	1.439252	0.270342385	0.389091		59.91985988	0.020796	0.897597
0.4	1.09872	2.3	0.251	3.924	0.060005424	1.212806	0.380719687	0.461739		71.10765981	0.029286	1.264075
0.5	1.3734	2.03	0.227	4.905	0.143570414	1.121105	0.445549343	0.499507		76.92395805	0.034273	1.479324
h1 (m)	0.28											
g (m/s ²)	9.81											
c (m)	0.0408											
r (m)	0.0065											
I (kgm ²)	0.0005											

Figure 5 - Table of results from data collected, and

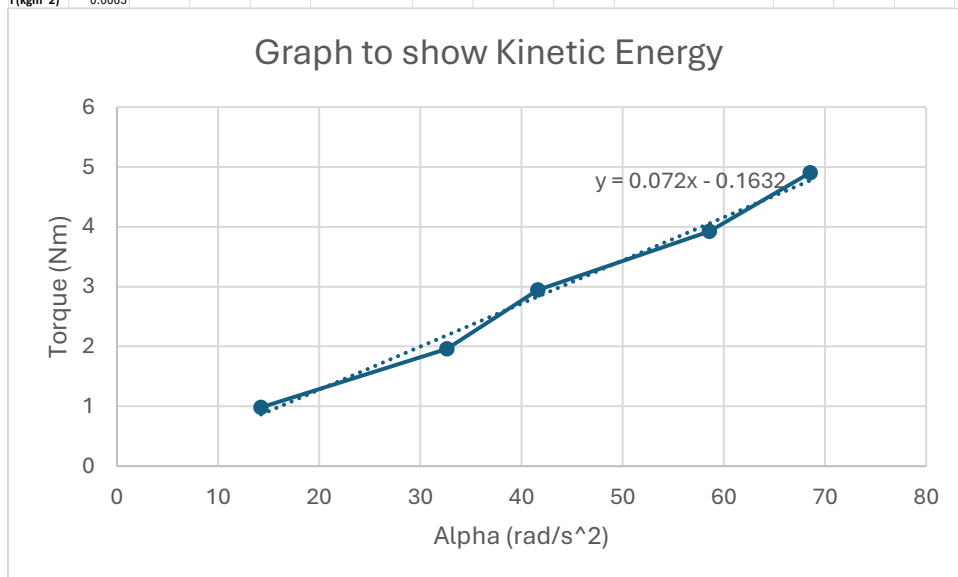


Figure 6 - Graph showing Kinetic Energy

The data shown in figure 5 was calculated using the following formulas:

Initial Potential energy is calculated with the formula $m \times g \times h$ (mass $\times$ gravity constant $\times$ the initial height).

Potential energy (loss adjusted) is calculated by using $[mg(h_1-h_2)]$.

Tf, or time to fall (falling time) is the total time (tt) multiplied by the initial height over the initial height added to the second recorded height ($h_1/(h_1+h_2)$). This means that the written formula is: $[tf = tt(h_1/(h_1+h_2))]$.

The formula for Acceleration is the initial height (x_2), divided by the falling time squared (tf^2): $[a = 2(h_1)/tf^2]$.

The formula for velocity is acceleration multiplied by the falling time: $[v = a(tf)]$

To calculate omega, use the formula $[(2 \times \pi \times v) / c]$.

Torque uses the formula $[T = (mg-ma)r]$.

Alpha uses the formula $[a/r]$.

Kinetic energy uses the formula $[1/2 \times \text{Inertia} \times \text{Omega}^2]$, which can be seen in figure 6.

4. Conclusion

To conclude, this experiment demonstrates the effectiveness of the law of conservation of energy, from gravitational potential energy into kinetic energy through the rotation of a flywheel. This can be seen in the graph shown in figure 6, demonstrating a mostly straight line graph with no real anomalies. The observations made show how the results are affected by the varied masses attached to the pulley. As the data in figure 5 shows, the greater the mass that is added to the pulley, more potential energy is lost, increasing in a seemingly exponential manner, increasing significantly with the two heavier masses. This is likely due to factors such as the flywheel's mass not exceeding that of the mass on the pulley, making it more difficult to lift up the mass to its second height when gravity is in effect. This could also be due to certain elements not accounted for in the experiment such as friction between the different parts of the kit, as well as other factors, mainly human error in recording results.

5. Evaluation

While recording data for this experiment, actions were taken to minimise any erroneous results, such as assigning single tasks to one individual, such as one person recording the time using the same stop watch, another person recording the height reached for each run of the experiment, person releasing the weight set after a countdown each time, to retain continuity and keep the experiment as accurate as possible. Every run of the experiment was recorded on the exact same apparatus and equipment throughout without any modifications made, apart from the mass added to the hanger.

If this experiment was repeated, given unlimited time and money, there are a few ways in which it could be repeated more accurately. For example, if, when the weight hanger is released, a computer was able to control and measure the time taken for the hanger to fall, and return up to its second height, as well as measure the distance it reached at that second height to a more accurate height than the human eye can measure.

Furthermore, each experiment could be repeated more than three times, with smaller

steps in the amount of weight added (smaller than 0.1 kg intervals). The experiment could also be repeated with different flywheels of varying masses, and diameters, to see how the resulting graphs would be different to each other recording the values for Kinetic Energy and Inertia. Similarly if the experiment was repeated with a different material for the string holding the weight hanger, as the elasticity was not taken into account during the experiment.

6. References and Bibliography

[1] – Merriam-Webster – *Definition of a flywheel* - <https://www.merriam-webster.com/dictionary/flywheel>

[2] – University of Leipzig *Energy Fundamentals – the history of the word “Energy”*. Available at: <https://home.uni-leipzig.de/energy/energy-fundamentals/01.htm#:~:text=Between%201842%20and%201847%2C%20Julius,from%20one%20form%20to%20> (accessed on 19/03/2025)

[3] – TecQuipment LTD - *Potential and Kinetic Energy Kit ES9* - <https://www.tecquipment.com/potential-kinetic-energy-kit> (accessed on 20/03/2025)