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Energy in a Flywheel

Motor Vehicle Engineering Science (ACHA4036)

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29th March 2026

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Introduction

The aim of this assignment is to carry out a practical experiment for Energy in a Flywheel, using a potential and kinetic energy kit ES9 in the university engineering science laboratory. By conducting this practical experiment, the aim was to find the relationship between potential and kinetic energy in a flywheel.

The aim of this experiment is to validate the Inertia value for the flywheel and pulley assembly combined.

What is a flywheel?

A flywheel is a rotating mechanical component that stores energy in the form of motion. It is usually a metal circular disc connected to a rotating shaft, where it spins to retain energy and release it when needed. The amount of energy stored depends on how fast the flywheel rotates and how its mass is distributed, meaning heavier or faster-spinning flywheels can store more energy.

In mechanical systems such as engines, the flywheel helps maintain a steady rotational speed. Since engines do not produce power continuously, the flywheel absorbs excess energy when more power is generated and releases it when less power is available. This reduces fluctuations and allows the system to run more smoothly.

In vehicles with manual transmissions, the flywheel also assists in transferring power between the engine and the gearbox. It provides a surface for the clutch to engage, allowing gradual and controlled movement. Different designs of flywheels exist depending on their application, but all serve the same main purpose of storing and regulating energy within a system.



Figure 1: Flywheel diagram (Adenwala, 2022)

Experimental procedure and setup

Before beginning the experiment, all necessary equipment for the investigation was gathered. This included a weight hanger, work panel, bearing block, flywheel, magnetic engineer's rule, 10 g increment weights, stopwatch, and 3-strand string.

Firstly, the equipment was set up. The work panel was placed on a flat horizontal surface. In science labs equipped with on-desk plug sockets, using the edge of these sockets ensures a level surface. Following this, the flywheel was attached to the workbench, with the holes counted to

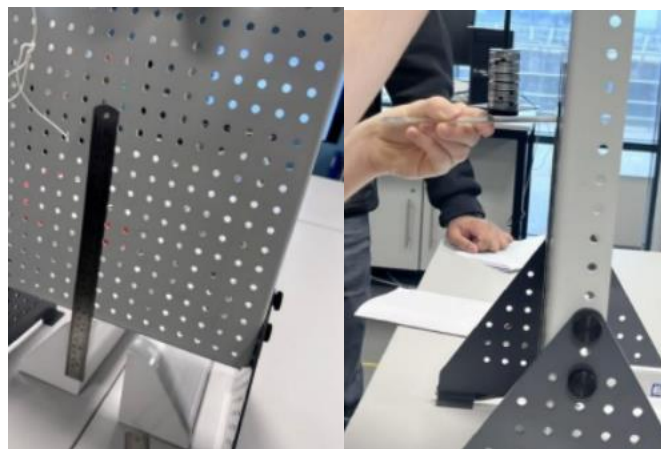
ensure the flywheel was centered. Three thumb screws were used to secure the flywheel, ensuring they were tightened to prevent any movement that could lead to inaccurate results.



Figure 2: (Shand, 2026)

The 3-strand string was gathered and carefully cut so that the bottom of the weight hanger could travel through a vertical drop of just under 290 mm. A small loop was created at the end of the string to attach the weight hanger. The weight hanger was then attached to the string, allowing it to fall freely to the bottom of its travel. Following this, nine 10 g increment weights were added to the weight hanger, giving a total mass of 100 g, with the hanger containing 10 g.

The magnetic engineer's rule was placed behind the weight hanger on the work panel, with its 0 mm edge aligned with the bottom of the weight hanger. Being magnetic, this allowed for more accurate readings than holding it manually. A plastic ruler was also positioned against the bottom of the weight hanger to ensure additional precision.



Figures 3: (Shand, 2026) Figure 4: (Shand, 2026)

The flywheel was then slowly rotated by hand, lifting the hanger until it reached 280 mm on the steel rule. By visually inspecting this at eye level, accuracy was ensured.



Figure 5: (Shand, 2026)

A digital stopwatch was used to measure the time it took for the weight hanger to fall from 280 mm to 0 mm and then return to its maximum height. This process was repeated three times to calculate an average time and height. The entire procedure was conducted five times, with the measurement repeated three times each, to obtain reliable average values. Additional nine 10 g weights were added to the hanger to increase its mass incrementally.

Results

Table 1: Raw data of fall and rise time (Shand, 2026)

Weight (g)	Time to fall and rise (seconds)	Fall (m)
100g	4.18	23
	4.09	24
	4.24	24
200g	3.02	25
	3.01	25.5
	2.9	25
300g	2.64	24.9
	2.60	25.5
	2.57	25
400g	2.22	24
	2.26	24.5
	2.69	24.5
500g	1.99	23.9

	1.97	23.8
	1.95	23.7

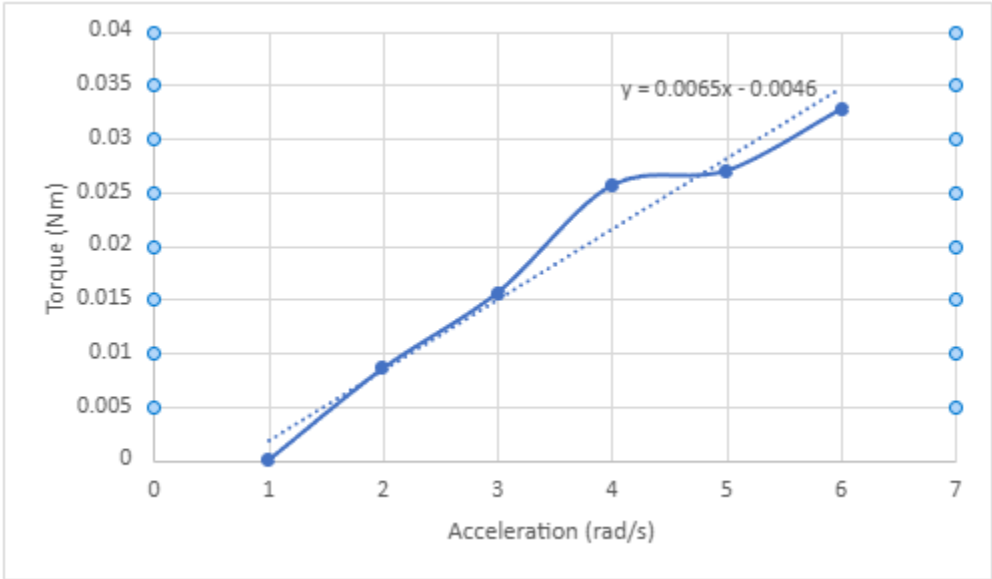
Analysis

The aim of this practical experiment was to find the relationship between potential and kinetic energy in a flywheel. Below is a table of results gathered from the experiment.

Table 2: Results table (Shand, 2026)

Mass	Initial PE	Tt	h2	mg	PE loss adjusted
<i>kg</i>	<i>J</i>	<i>s</i>	<i>m</i>	<i>N</i>	<i>J</i>
0	0	0	0	0	0
0.1	0.00784	4.17	0.241	0.981	0.020561459
0.2	0.54936	3.06	0.236	1.962	0.046844651
0.3	0.82404	2.43	0.245	2.943	0.054936
0.4	1.09872	2.35	0.241	3.924	0.082245835
0.5	1.3734	2.13	0.24	4.905	0.105646154

Tf	Acceleration	Velocity	Velocity2	Acceleration3	Torque	KE
<i>s</i>	<i>m/s2</i>	<i>velocity</i>	<i>w</i>	<i>rad/s^2</i>	<i>Nm</i>	<i>J</i>
0	0	0	0	0	0	0
2.241074856	0.111500111	0.464955464	0.068286876	17.15386328	0.008576932	0.028401459
1.660465116	0.203108694	0.621512605	0.005935686	31.24749146	0.015623746	0.596204651
1.296	0.333409541	0.810185185	2.181781046	51.29377557	0.025646888	0.878976
1.262955854	0.351084524	0.825048632	20.87901957	54.01300375	0.027006502	1.180965835
1.146923077	0.425715482	0.906773977	383.1887324	65.49468958	0.032747345	1.479046154



Conclusion

In conclusion, the experiment successfully investigated the relationship between potential energy and kinetic energy in a flywheel system. As the mass on the weight hanger increased, the time taken for the system to fall and rise decreased. This indicates that a greater mass produced more gravitational potential energy, which was then converted into a higher level of rotational kinetic energy in the flywheel.

The results support the principle of conservation of energy, as the gravitational potential energy lost by the falling mass was transferred into kinetic energy of the rotating flywheel and then partially converted back as the system rose again. Although some energy losses were inevitable due to friction in the bearings, air resistance, and slight inconsistencies in measurement, the overall trend in the data remained consistent with theoretical expectations.

The experiment also allowed validation of the inertia value of the flywheel and pulley system. While minor experimental errors may have affected the precision of the calculated values, the repeated trials and averaging results improved reliability and confidence in the findings.

Overall, the experiment demonstrated that increasing mass leads to increased energy transfer within the system, reinforcing the relationship between potential and kinetic energy. The findings align with theoretical predictions, confirming that a flywheel effectively stores and transfers energy through rotational motion.

Evaluation

During this experiment, several precautions were taken to minimize errors and ensure accuracy and reliability. A spirit level was used to confirm that all surfaces were flat. The 3-strand string was measured precisely by laying it alongside a ruler. The workspace was kept clean and organized to reduce procedural mistakes or obstructions.

To ensure accurate results, a student positioned themselves at eye level with the bottom of the ruler. A countdown was performed before starting the stopwatch to ensure all participants were ready. Two stopwatches were used to verify that the measured times for the weight hanger's fall and rise were correct.

A 3-strand string was selected for the experiment due to its strength and weight tolerance, as opposed to alternatives such as wire or rope. Using wire or rope could have introduced inaccuracies due to their weight and rigidity. The lightweight and flexible nature of the string made it particularly suitable for this investigation.

Further work

Comparing the value of ' I ' from the chart with that of the nominal values.

The experimental value of the moment of inertia was found to be **$0.0572 \text{ kg}\cdot\text{m}^2$** , compared to the nominal value of **$0.0596 \text{ kg}\cdot\text{m}^2$** .

This gives a percentage difference of approximately **4.03%**, indicating a good agreement between experimental and theoretical values.

The small discrepancy may be due to friction in the flywheel, air resistance, and measurement uncertainties in time and radius.

Since these values are close, the experimental result aligns well with the nominal values, suggesting the experiment was fairly accurate. Why does PE loss increase with mass? PE depends directly on the mass; increasing the applied mass leads to a larger initial potential energy. As the mass falls, this energy is converted into Rotational energy of the flywheel, Translational kinetic energy of the mass, and some energy is lost to air resistance and friction. The heavier the mass, it should lead to greater PE losses, resulting in a higher angular

acceleration and torque. As mass increases, frictional losses become more significant, reducing energy transfer efficiency. For example: in the bearings, air resistance, and string slippage. If the string starts slipping, not all potential energy is converted into rotational energy. The flywheel's moment of Inertia may not be able to accelerate proportionally at very high torques, due to its moment of Inertia acting as resistance. This experiment can be advanced further with the use of a high-speed camera, enhancing precision, data collection, and analysis. A high-speed camera has many beneficial features, such as capturing detailed motion, track flywheel interactions, and data synchronization. The camera can be used to record the flywheel's motion in detail, allowing for the capture of the flywheel's rotational speed, acceleration, and deceleration over time. A high-speed camera can also observe any vibrations, wobbling, or other inconsistencies in the flywheel's motion that might indicate energy losses due to friction or air resistance. By using the camera, high-quality footage can be created, providing a clearer, more detailed view of the flywheel's dynamics. This enables the identification of errors, refinement of calculations, and improvement in the overall accuracy of the experiment.

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Figure 1: Flywheel diagram (Adenwala, 2022)

Figure 2: Experimental setup (Shand, 2026)

Figure 3: Measurement setup (Shand, 2026)

Figure 4: Ruler alignment (Shand, 2026)

Figure 5: Flywheel position (Shand, 2026)

Table 1: Raw data of fall and rise time (Shand, 2026)

Table 2: Processed results (Shand, 2026)

Table 3: Results graph (Shand, 2026)