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Energy in a Flywheel Report

ACHA4007 Further Science for Engineers

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1. Introduction

The flywheel is a device fitted to most engines for the purpose of storing rotational energy which is used to help keep the engine rotating between power strokes. It also smooths the power generated by the burning of the fuel/air mix in the engine (Briggs & Stratton, 2025).

Though most engines have a flywheel, they vary in design to suit the intended application. For example, a luxury car will be fitted with a flywheel which has considerable mass, while a race car will be fitted with a lightweight flywheel to allow the engine to be more reactive and accelerate more quickly (Cubespeed, 2025). Though, a light weight flywheel makes the engine more responsive, it does have drawbacks. One of these being that it makes it much easier to stall the engine when moving off from rest as it stores less energy due to the reduced mass. The luxury car will have the high mass flywheel as this allows it to store more rotational energy and deliver a smoother power delivery making it more comfortable for the occupants.

The aim of this experiment is, using the raw data measured during the experiment, to calculate the kinetic energy as well as the potential energy in the flywheel. Several other parameters need to be calculated to enable this.



Figure 1 - Flywheel on an engine, Shanghai Jianping Equilibrator Manufacturing Co., Ltd. (2022)

2. Experimental Procedure

The procedure for carrying out the experiment is as follows-:

1. Fit plastic guide to the bottom of the weight hanger.
2. Fit the weight hanger to the end of the cord and ensure it can travel vertically by 280mm.

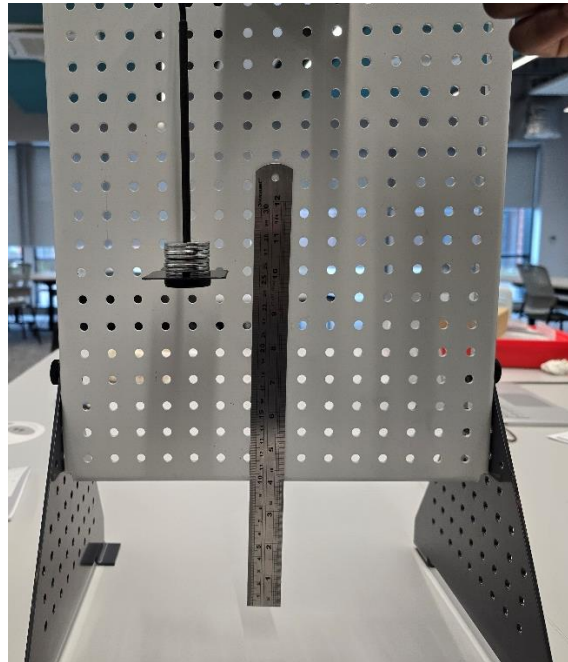


Figure 2 - Ensuring the weight hanger has enough vertical travel, (2025)

3. Place a magnetic rule on the metal board behind the weight hanger, so that when the cord is fully extended, the 0mm of the rule, aligns with the plastic guide.

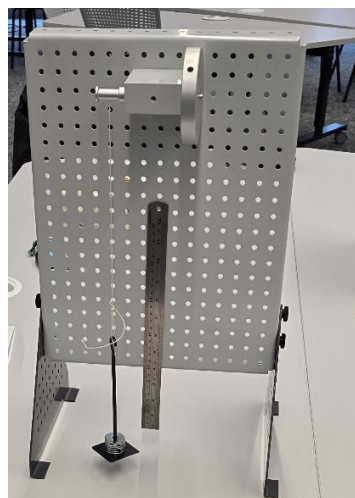


Figure 3 - Aligning the plastic guide with the rule, (2025)

4. As the weight hanger and guide weigh 10g, add 90g to the weight hanger to make 100g total. Mass is supplied in 10g plates.
5. Rotate the flywheel until the weight hanger is lifted to 280mm on the rule.

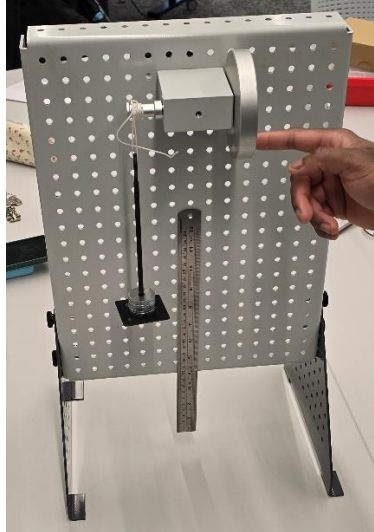


Figure 4 - Lifting weight hanger into position, (2025)

6. Use a stopwatch to time how many seconds it takes for the weight hanger to drop to 0mm and then rise up to its maximum height (h_2). Note: the timer should only be stopped when the weight hanger reaches h_2 .
7. Add 100g of extra mass and repeat the experiment as before. Do this until the experiment has been completed with 500g.

Now with that, the experiment has been completed and the raw data can be used to calculate various other values, such as PE, mg, PE loss, PE loss (adjusted). Acceleration, Torque, falling time, velocity and Angular Acceleration values can also be calculated.

3. Results

Below are the raw data measurements from each of the 3 runs of the experiment.

Table 1- Raw data for 1st run of experiment

Mass [m] (kg)	Time to fall and rise [t_t] (seconds)	h_2 (m)
0	0	0
0.1	4.16	0.2485
0.2	2.85	0.255
0.3	2.41	0.265
0.4	2.01	0.255
0.5	2.13	0.247

Table 2- Raw data for 2nd run of experiment

Mass [m] (kg)	Time to fall and rise [t_t] (seconds)	h_2 (m)
0	0	0
0.1	3.71	0.25
0.2	2.72	0.26
0.3	2.34	0.267
0.4	2.07	0.245
0.5	1.68	0.247

Table 3- Raw data for 3rd run of experiment

Mass [m] (kg)	Time to fall and rise [t_t] (seconds)	h_2 (m)
0	0	0
0.1	4.23	0.255
0.2	2.66	0.265
0.3	2.53	0.2605
0.4	2.27	0.255
0.5	2.2	0.24

4. Analysis

Having gathered the measurements in the experiment, the following values were calculated (as can be seen in the screenshots below)-:

- Potential Energy (PE)
- Weight (mg)
- PE Loss
- PE Loss (adjusted)
- Falling Time (t_f)
- Acceleration (a)
- Linear Velocity (of the weight hanger) (v)
- Angular Velocity (of the flywheel) (ω)
- Torque in the Cord (τ)
- Angular Acceleration (α)
- Moment of inertia (I_t)
- Kinetic Energy (KE)

The formulae for performing the calculations were supplied in the assessment specification handout.

The formulae are as follows (in the same order as the list of values above)-:

- $PE = m * g * h$
- $W = m * g$
- $PE_{loss} = m * g * (h_1 - h_2)$
- $PE_{loss (adjusted)} = PE_{loss} * [\frac{h_1}{(h_1 + h_2)}]$
- $t_f = t_t * \frac{h_1}{h_1 + h_2}$
- $a = \frac{2 * h_1}{t_f^2}$
- $v = a * t_f$
- $\omega = \frac{2 * \pi * v}{c}$
- $\tau = (m * g - m * a) * r$
- $\alpha = \frac{a}{r}$
- $y = mx + c$
- $KE = \frac{1}{2} * I_t * \omega^2$

For many of the values listed above, it was only possible to calculate them by first calculating the earlier values. Below are the screenshots of the completed tables for each of the 3 runs of the experiment.

The moment of Inertia (I_t) for each run was calculated using Excel's slope function, using the torque (τ) values for the y axis and the angular acceleration (α) values for the x axis. This was required so that the angular kinetic energy could be calculated.

t_{t1}													
Mass [m] (kg)	PE [mgh] (J)	Time to fall and rise [t_t] (seconds)	h_2 (m)	mg	PE Loss (J)	PE Loss Adjusted (J)	Falling Time [t_f] (seconds)	Acceleration [a] (m/s^2)	Velocity [v] (m/s)	Velocity [ω] (rad/s)	(mg-ma)r	a/r	KE (J)
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.1	0.27468	4.16	0.2485	0.981	0.030902	0.016372	2.2039735	0.115285659	0.254087	39.07109	0.980925064	17.73625523	44.59084166
0.2	0.54936	2.85	0.255	1.962	0.04905	0.025671	1.4915888	0.251703821	0.375439	57.7315	1.961672785	38.72366476	97.35543279
0.3	0.82404	2.41	0.265	2.943	0.044145	0.02268	1.2381651	0.365284197	0.452282	69.5478	2.942287696	56.19756872	141.2866953
0.4	1.09872	2.01	0.255	3.924	0.0981	0.051342	1.0519626	0.50604299	0.532338	81.85809	3.922684288	77.85276776	195.7301807
0.5	1.3734	2.13	0.247	4.905	0.161865	0.086	1.1316888	0.437254198	0.494836	76.09128	4.903578924	67.26987663	169.123661

Figure 5 - Screenshot of Spreadsheet for run 1, (2025)

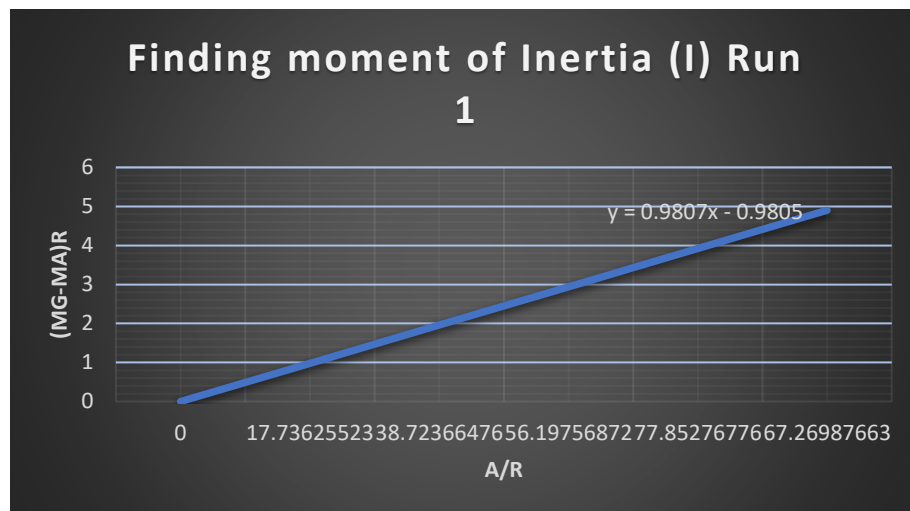


Figure 6 - Graph of torque vs angular acceleration for run 1, (2025)

The graphs show torque (y axis) and angular acceleration (x axis). The gradient of the line can be used to give a reasonable I_t value, though as mentioned earlier, the slope function was used to do this.

t ₂													
Mass [m] (kg)	PE [mgh] (J)	Time to fall and rise [t _f] (seconds)	h ₂ (m)	mg	PE Loss (J)	PE Loss Adjusted (J)	Falling Time [t _f] (seconds)	Acceleration [a] (m/s ²)	Velocity [v] (m/s)	Velocity [ω] (rad/s)	(mg-ma)r	a/r	KE (J)
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.1	0.27468	3.71	0.25	0.981	0.02943	0.015548	1.96	0.145772595	0.285714	43.93452	0.980905248	22.42655304	46.08338727
0.2	0.54936	2.72	0.26	1.962	0.03924	0.020347	1.4103704	0.281528052	0.397059	61.05606	1.961634014	43.31200806	89.00003658
0.3	0.82404	2.34	0.267	2.943	0.038259	0.019584	1.1978062	0.390314695	0.467521	71.89114	2.942238886	60.04841458	123.3909794
0.4	1.09872	2.07	0.245	3.924	0.13734	0.073248	1.104	0.459462298	0.507246	77.99969	3.922805398	70.68650736	145.250752
0.5	1.3734	1.68	0.247	4.905	0.161865	0.086	0.8925996	0.702869392	0.627381	96.47288	4.902715674	108.1337526	222.1995323

Figure 7 - Screenshot of spreadsheet for run 2, (2025)

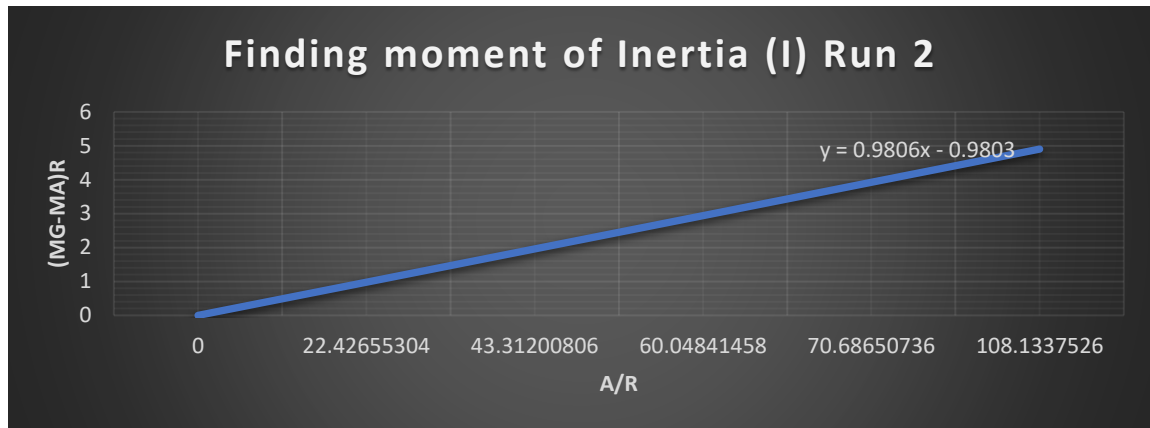


Figure 8 - Graph of Torque vs Angular Acceleration for run 2, (2025)

t ₃													
Mass [m] (kg)	PE [mgh] (J)	Time to fall and rise [t _f] (seconds)	h ₂ (m)	mg	PE Loss (J)	PE Loss Adjusted (J)	Falling Time [t _f] (seconds)	Acceleration [a] (m/s ²)	Velocity [v] (m/s)	Velocity [ω] (rad/s)	(mg-ma)r	a/r	KE (J)
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.1	0.27468	4.23	0.255	0.981	0.024525	0.012836	2.2138318	0.114261203	0.252955	38.89711	0.98092573	17.57864667	52.11931316
0.2	0.54936	2.66	0.265	1.962	0.02943	0.01512	1.3666055	0.299848372	0.409774	63.01135	1.961610197	46.13051881	136.773382
0.3	0.82404	2.53	0.2605	2.943	0.057389	0.029729	1.3106383	0.326003542	0.427273	65.70207	2.942364293	50.15439106	148.7038487
0.4	1.09872	2.27	0.255	3.924	0.0981	0.051342	1.1880374	0.396759938	0.471366	72.48228	3.922968424	61.0399905	180.9788
0.5	1.3734	2.2	0.24	4.905	0.1962	0.105646	1.1846154	0.39905549	0.472727	72.69166	4.90370307	61.3931523	182.0258971

Figure 9 - Screenshot of spreadsheet for run 3, (2025)

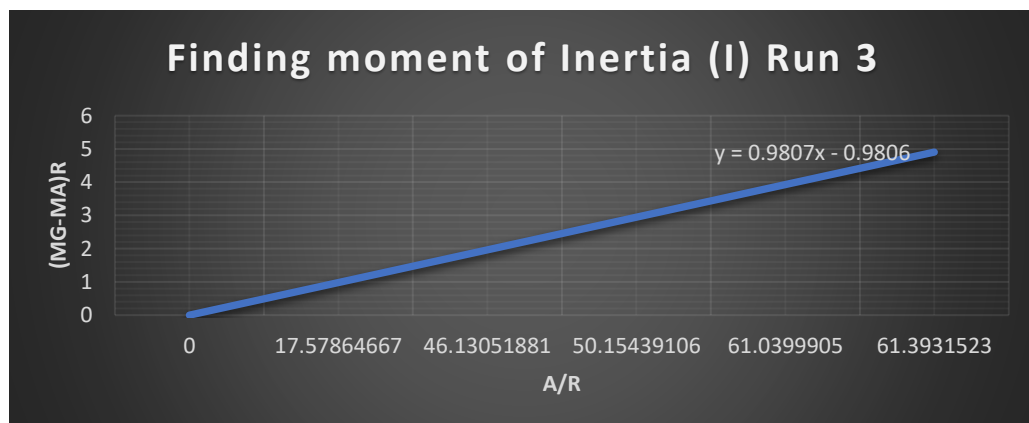


Figure 10 - Graph of Torque vs Angular Acceleration for run 3, (2025)

5. Conclusion

Over the course of all 3 runs of the experiment, it is seen that as the mass on the weight hanger is increased, the falling time reduces to around half of the initial falling time. Values like PE and KE increase as the mass is increased, which as expected leads to greater values for velocity and acceleration. PE and KE both increase by around 5 times the initial value, which makes sense as the mass is increased by 5 times the initial mass.

6. Evaluation

To minimise any errors, the group performing the experiment had members take on separate roles. One member took charge of the stopwatch, another winding and releasing the flywheel. Two members then worked together to read the h_2 value, ensuring they both agreed with the value that was recorded.

There were, however, possible errors as a result of it being conducted by humans and not measured by computer. These include getting inaccurate reading based on the angle the 2 members were at in relation to the rule and plastic guide. Another, variations in time between the timer being started and the flywheel being released, as well as, in the reaction time for the timer being stopped again when it reached its maximum h_2 height. As long as people are taking the measurements, errors like these are unavoidable.

7. Further Work

If money and time were no object, the experiment's accuracy would benefit from being measured by computer monitoring the rotation of the flywheel. The computer could record the data in relation to time, which would allow for very accurate and reliable timing as well as measurements for h_2 . This could be achieved with a tachometer or a magnetic sensor similar to those employed in ABS systems.

The tachometer would directly read the angular velocity of the flywheel, allowing the computer to read the velocity and if it were told the diameter of the flywheel, it could accurately calculate the distance the weight hanger had travelled (Compact Instruments Limited, 2025).

The magnetic ABS style sensor would work in a similar way only the flywheel would need to have a notch cut into it or a tooth added to it to create a magnetic anomaly for the sensor to pick up. The computer could then be programmed to recognise the anomaly as 1 rotation (TiePie engineering, 2025).

8. References

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