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Energy in a flywheel

Further Science for Engineers (ACHA4007)

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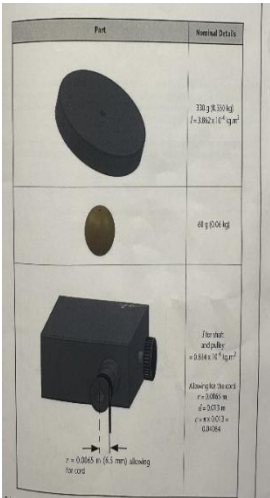
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1. Introduction

The aim and objective of this experiment is to reveal the validity of the theory behind the energy of a flywheel. Therefore, an experiment must be conducted, allowing the theory to be reinforced by scientific evidence.

2. Experimental Procedure



Initially, individuals were provided with guidance notes. This was essential as it provided key information such as nominal part values, these nominal part values refer to the parts that was utilized in the experiment. These nominal details are then used for later computations. Within this booklet a spare sheet is provided to write down all data that were observed.

Furthermore, an experimental setup must be constructed. This setup consists of a work back panel, pulley block, flywheel, an engineer's rule and lastly the weight hanger with a plastic guide at the bottom for precision. To ensure that the setup is constructed properly, in the booklets provided, an image portrays of how the setup must look like.

To begin constructing the setup, bolt the back panel onto the stand, then the pulley block must be correctly placed onto the back panel, to ensure that it's accurately placed, count the holes in the image ensuring its replicated how its constructed in figure 2.1 In addition to this, a cord must be cut to length allowing the bottom of the weight hanger to travel through a vertical drop of approximately 290mm.

Next, allow the weight hanger to hang and reach an equilibrium state therefore no movement. Then adjust the rule to its designated spot just behind the weight hangers so its measurement 0mm aligns with the plastic guide. Then add 90g onto the weight hanger giving the weight hanger at a total weight of 100g/0.1kg, ensuring that the rule's measurement 0mm is still aligned with the plastic guide.

After this step, rotate the flywheel to lift the weight hanger until the bottom of the weight hanger reaches the measurement 280mm on the rule. Ensure to have a stopwatch, measuring the duration of how long the weight hanger takes to fall from the original point of 280mm to 0mm then back up to its maximum height. Make certain to execute this multiple times to obtain a valid average value for the time and height.

After the first reading is executed, add 100g of weight for the second reading. The weight hanger must have a total weight of 200g/0.2kg. Then continue the process until the final reading, fifth reading. The weight hanger must have accumulated 500g at this point.

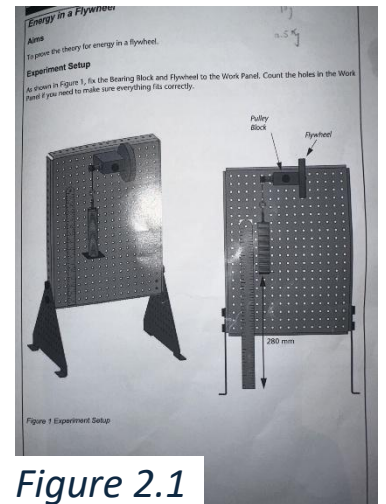


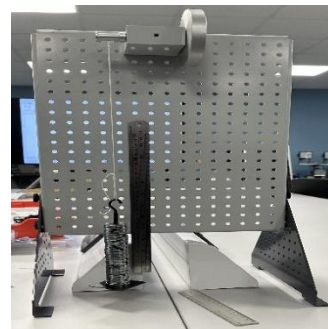
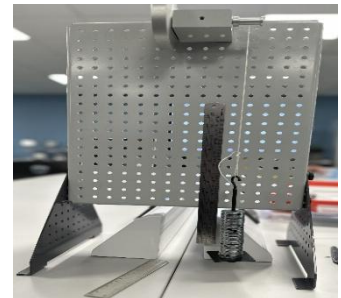
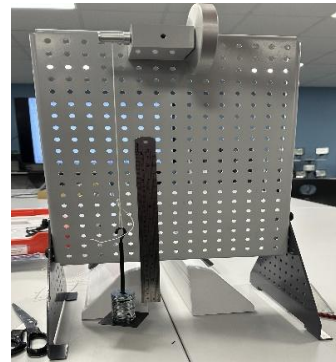
Figure 2.1

Without failure all data that has been observed must be recorded to obtain a valid evaluation.

3. Results

These following images are examples of expected values to be gathered during the experiment.

1st Reading			
	Mass (100g)	Time to fall & rise (s)	h2 (cm)
		4.17	23.2
		4.61	23.6
		4.54	23
AVERAGE=		4.44	23.2
2nd Reading			
	Mass (200g)	Time to fall & rise (s)	h2 (cm)
		2	25
		2.99	25.3
		3.23	25.5
AVERAGE=		2.74	25.2
3rd Reading			
	Mass (300g)	Time to fall & rise (s)	h2 (cm)
		2.98	25.3
		2.39	25.5
		2.38	25.5
AVERAGE=		2.58	25.43
4th Reading			
	Mass (400g)	Time to fall & rise (s)	h2 (cm)
		2.06	25.8
		2.09	26
		1.96	25.5
AVERAGE=		2.03	25.7



5th Reading			
	Mass (500g)	Time to fall & rise (s)	h2 (cm)
		1.86	24.3
		1.83	24.5
		1.74	24.5
AVERAGE=		1.81	24.4

4. Analysis

Mass	PE	Tt	h2	mg	PE loss adjusted	Tf	Acceleration	Velocity	Velocity (ω)	Torque	Alpha (α)	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	0	0	0	0	0	0
0.1	0.27468	4.44	0.232	0.981	0.02575125	2.428125	0.094983014	0.230631	35.5170341	0.006315	14.61277	0.296191
0.2	0.54936	2.74	0.252	1.962	0.028913684	1.442105	0.269273803	0.388321	59.80132	0.012403	41.42674	0.839691
0.3	0.82404	2.58	0.254	2.943	0.040121798	1.352809	0.305995519	0.413953	63.7486881	0.018533	47.07623	0.954203
0.4	1.09872	2.03	0.257	3.924	0.047058771	1.058473	0.499837067	0.529064	81.4756715	0.024206	76.89801	1.558669
0.5	1.3734	1.81	0.244	4.905	0.094355725	0.967176	0.598656068	0.579006	89.1666423	0.029937	92.10093	1.866822

In the booklet that was provided resides an empty table. In order to validate the theory of the energy in a flywheel, the table must be filled. This is deemed as a solid physical evidence of the experiment supporting the theory.

Firstly, PE referred to as (Potential energy) is stored energy waiting to do work measured in joules. PE can be converted and take other forms of different energies such as Kinetic energy, Thermal energy, Chemical energy etc. To calculate PE, utilize the formula given: $\text{mass} \times \text{gravity} \times h_1$ (which was given in the booklet as a predetermined value) with the measurement of 0.28m (Tecquipment Ltd 2012, 2012), as an example $0.1 \times 9.81 \times 0.28$.

The following column is Time to fall and rise, measured in seconds which links back to the experiment. This column is the data that was observed with a stopwatch, measuring how long it takes for the weight hanger to fall from the original position to the 0mm point and return up to its maximum height. This must be repeated multiple times to get a good average value, similar occasions to h_2 multiple readings portray a better average value. h_2 is the maximum height it can reach after falling from its original point. Weight is the force acting upon an object due to gravity, it is measured in newtons and can be calculated by $\text{mass} \times \text{gravity}$.

The next values are PE loss adjusted; to calculate PE loss adjusted you must first calculate the PE loss by implementing the use of the formula: $\text{mass} \times \text{gravity} \times (\text{predetermined height}(h_1) - \text{average height from experiment}(h_2))$ as an example $0.1 \times 9.81 \times (0.28 - 0.232)$ then after obtaining a value for PE loss. Calculate the PE loss adjusted by using the value for PE loss, the formula for PE loss adjusted is as follows: $\text{PE loss} \times \{h_1 / (h_1 + h_2)\}$ which then gives the value for PE loss adjusted ensure to convert the measurement of h_1 and h_2 into mm so

= $h_1(280\text{mm}) = h_2(232\text{mm})$ when calculating PE loss adjusted (Tecquipment ltd 2012, 2012).

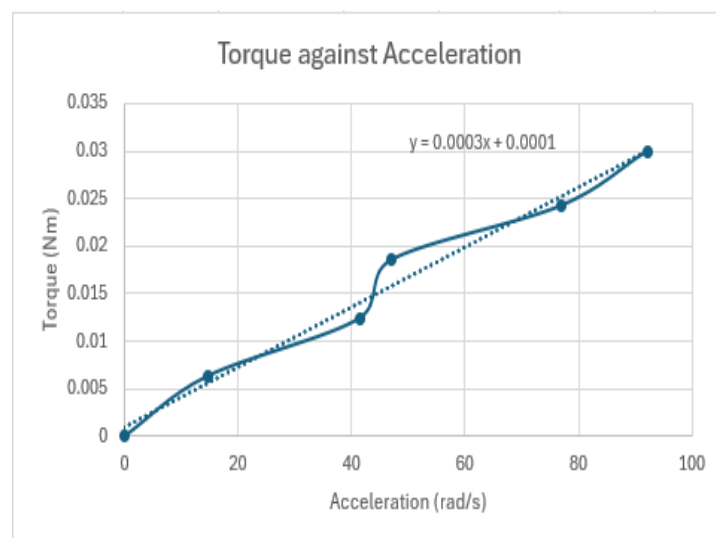
Falling time, to calculate the value for falling time multiply T_t , which was accumulated during the experiment, by the predetermined height(h_1) divided by $h_1 + h_2$. For example $4.44 \times 0.28 / (0.28 + 0.232)$.

To calculate the value of acceleration relating to the falling mass, use the formula: $2 \times (\text{predetermined height})$ divided by falling time² for example $2 \times 0.28 / 2.428^2$. Once the values of acceleration have been calculated they must then be used to find the linear terminal velocity of the falling mass by multiplying the acceleration by falling time.

After. Angular velocity must then be calculated, measured in rad/s. Linear velocity must be converted to Angular by using the circumference of the pulley, which was one of the nominal detail about the pulley, stated as (0.0408). The formula to calculate Angular velocity is as follows 2π multiplied by linear velocity then divided by the circumference.

In terms of torque, this is calculated by using the formula (mass*gravity- mass*acceleration) then divided by the radius provided as a nominal value in the booklet of (0.0065m). Then angular acceleration in the flywheel is calculated by Acceleration divided by the pulley radius.

Finally, the last column that must be filled is Angular motion kinetic energy referring to the energy of the flywheel. This form of kinetic energy is calculated by half multiplied by the total nominal value of the fly wheel and pulley block then multiplied again by angular



acceleration squared (Tecquipment ltd 2012, 2012). As an example of the formula: $0.5 \times 4.696 \times 10^{-4} \times 35.52^2$ This then gives the value of Angular motion Kinetic energy.

This graph portrays the torque values going against the values of angular acceleration. As it implies, the relations between the two variables move in unison as angular acceleration increases so does the torque value, revealing a positive

correlation.

5. Conclusion

In conclusion various figures have aligned; by utilizing the equation from the line, the 'I' value from the chart came to 3.9×10^{-4} which is quite similar to the theoretical nominal value given from the book, stated as 3.862×10^{-4} .

In addition to this, the relationship within the mass and PE loss implies that as mass increases the potential energy loss also increases, this could be due to varying factors such as energy being loss through heat by the friction within the bearing block.

(Tecquipment 2012, 2012)

6. Evaluation

When carrying out experiments, consider various errors that could occur impacting data collecting. For example, on this occasion there could be minor human errors such as reaction time, different individuals have varying reaction time therefore to minimize a negative impact on the data collecting, referring to time to fall and rise, only one person must take charge on the stopwatch. In addition to this, to further minimize other errors that could potentially have an impact within the experiment, thus referring to the 3-strand strings, this could have an impact as the string coils up with lesser weight therefore receiving inaccurate height value within lower weight.

7. Further work

To make this experiment the best version that it could be and provide a much more accurate outcome is to eliminate any form of human errors. The significant human error encountered is the stopwatch time value due to varying reaction times. This can be eliminated by implementing the use of high-speed slow-motion cameras. With the use of a high-speed camera, readings such as the time to fall and rise will have a definite accurate value (Academia, 2023).

8. References & Bibliography

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