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Programme: Beng Engineering Programmes

Module: Engineering Science 1

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Assignment title: Energy in a flywheel

1.0 Introduction

What is energy? Energy is the capacity to do work. There are many different types of energy, this assignment will discuss potential and kinetic energy. Kinetic energy is the energy of an object that possesses by virtue of its motion. By recalling Newton's second law of motion states 'that the acceleration of an object is dependent upon two variables - the net force acting upon the object and the mass of the object. The acceleration of an object depends directly upon the net force acting upon the object, and inversely upon the mass of the object. As the force acting upon an object is increased, the acceleration of the object is increased. As the mass of an object is increased, the acceleration of the object is decreased.' (Physicsclassroom.com, 2019)

To experience constant acceleration of an object the kinematic equation ($v_f^2 = v_i^2 + 2ad$) must be used. To discover the value of Kinetic energy you must use the equation $K.E = \frac{1}{2}mv^2$. The mass in the equation this means that two objects with different masses when falling from a distance. The object with the greater mass will necessarily will have more kinetic energy.



(Physicsclassroom.com, 2019)

Potential energy is forever intertwined with kinetic energy. It is the energy of an object which possesses by virtue of its position in a field, whether that's in a gravitation field, an electromagnetic field or any other type of field. If a ball is being lifted up in the air it is increasing the potential energy of the ball. If the ball is released that potential energy is converted into kinetic energy of motion as it falls. The closer an object is to the centre of gravity of the earth the less potential energy it has. If an object is pulled away and up from the centre of gravity it gains potential energy, because it has an increasing potential as it falls to the ground $PE = mgh$. There are other factors of potential energy example elastic potential energy. This energy is used in objects such as bows and arrow or springs.



1.1 Theory

(Physicsclassroom.com, 2019)

The theory was that kinetic energy was stored in the flywheel. They used the flywheel as an example of a moving part of a machine. To create more kinetic energy, they needed more mass or speed of the moving object. Therefore, the moment of inertia and its angular velocity is squared for the flywheel this means that the kinetic energy is equal to half the product. (Moodle.uwtsd.ac.uk, 2019)

2.0 Experimental Procedure

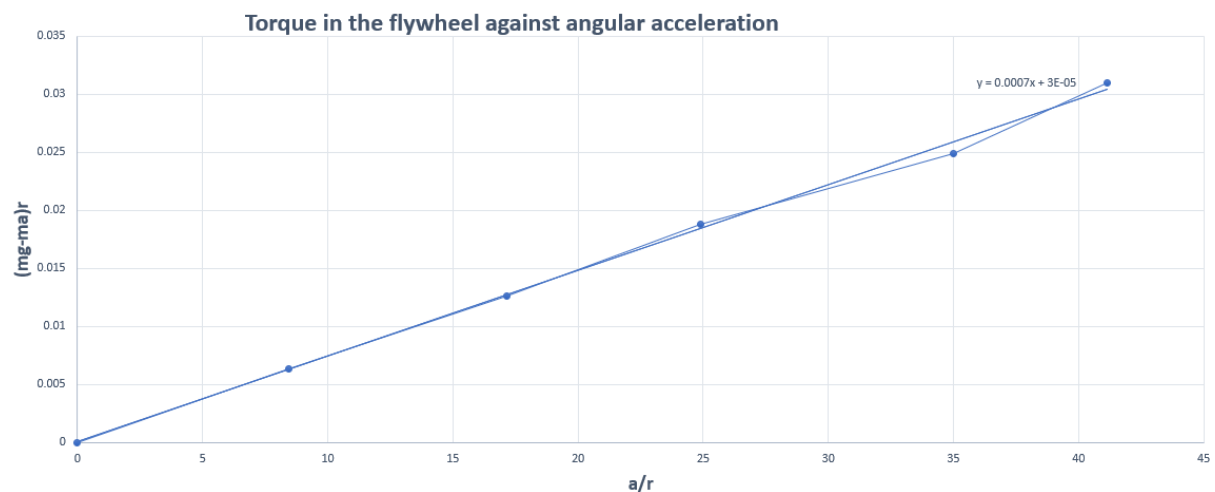
First the group would read the guidance notes that are supplied to understand the experiment and what is the aim of the experiment which is to prove the theory for energy in a flywheel. Second step is to put the experiment together, the experimentalist was given a diagram showing how to experiment looks. They must fit the plastic guide correctly to the bottom of the weight hanging. The lecturer cut the cord to the length needed to allow the weight hanger travel 280mm in a vertical downwards direction. Allow the weight hanger to travel to the end of travel so it reaches the bottom, next he/she had to line the weight hanger up with 0mm on the magnetic ruler. This step is very important to insure the experiment is accurate. The weight hanger weighs 10g therefore they had to add 90g to bring it up to a total of 100g. Next, they had to wind up the flywheel so the weight hanger read 280mm on the magnetic ruler. Each member of the group had different roles. One person had the role to wind and release the fly wheel from the height of 280mm and add weight onto the weight hanger. Two people read to measurement of the weight hanger maximum height reached after bouncing back up and had to say the word 'stop' to allow the two to me keepers to stop the clock. Record the data in a table. And repeat the experiment three times with the same weight. Record the data and work out and average for time and height for that weight. Add 100g to the weight hanger and they repeated the process until they reached 500g.

2.1 Calculations

Once the experiment was finished the group went on their own to do calculations and make an able on excel and calculate potential energy mgh , mg and Potential energy lost values. After calculation the doing this they had to also calculate the falling time, velocity, acceleration, $(mg-ma)r$ and a/r values. The group had to add the nominal I values for the flywheel and the pulley in to find the nominal I value for the flywheel. The group would then calculate kinetic energy value for the flywheel for each result. Once made the table the experimentalist had to make a graph comparing $(mg-ma)r$ against a/r . If the experiment was done correctly the graph should show two reasonable straight line with little bit of separation between the two lines.

3.0 Results

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Mass m (kg)	mgh_1 PE (J)	mgh_2 (J)	Time to fall and rise t (seconds)	h1 (m)	h2 (m)	mg	PE Loss (J)	PE loss adjusted (J)	Falling time tf (seconds)	Acceleration a ($m.s^{-2}$)	Velocity v ($m.s^{-1}$)	Velocity ω $rad.s^{-1}$	$(mg-ma)r$	a/r	KE
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0.1	0.27468	0.23544	4.2	0.28	0.24	0.981	0.03924	0.021129231	2.2615385	0.054745708	0.1238095	19.0479476	0.00634092	8.422417	0.12698851
4	0.2	0.54936	0.4905	3	0.28	0.25	1.962	0.05886	0.031095849	1.5849057	0.111468254	0.1766667	27.179956	0.01260809	17.14896	0.2585625
5	0.3	0.82404	0.741636	2.5	0.28	0.252	2.943	0.082404	0.043370526	1.3157895	0.161728	0.2128	32.7390263	0.01881413	24.88123	0.37514534
6	0.4	1.09872	0.981	2.1	0.28	0.25	3.924	0.11772	0.062191698	1.109434	0.227486233	0.252381	38.8285086	0.02491454	34.99788	0.52767858
7	0.5	1.3734	1.1772	1.9	0.28	0.24	4.905	0.1962	0.105646154	1.0230769	0.267510882	0.2736842	42.1059895	0.03101309	41.15552	0.62052002



4.0 Analysis

The graph and table showed above is the entire calculations done from the data received from the experiment. Thus including "Time to fall and rise", "h2" and "Mass". By knowing the results of these three factors a person is able to calculate many different factors such as the falling time, acceleration of each line of results and many more.

Mass m (kg)	mgh_1 PE (J)	mgh_2 (J)	Time to fall and rise t (seconds)	h1 (m)	h2 (m)
0	0	0	0	0	0
0.1	0.27468	0.23544	4.2	0.28	0.24
0.2	0.54936	0.4905	3	0.28	0.25
0.3	0.82404	0.741636	2.5	0.28	0.252
0.4	1.09872	0.981	2.1	0.28	0.25
0.5	1.3734	1.1772	1.9	0.28	0.24

From looking at the data given from the experiment the pattern shows that more mass, faster the weight hanger took to fall and rise. However, the time difference between 0.1kg and 0.2kg was larger than the time difference between 0.4kg and 0.5kg. This is due to many factors, example of this is when the weight hanger bounce reached 280mm the cord stretches exceeding the limit of 280mm. Also, the weight hanger bounce with more velocity having a harder impact causing the weight hanger to wobble losing momentum. This theory is backed by results of the height showing no difference from the results of 0.1kg and 0.5kg.

By gathering the results for the weight, height and time to fall and rise, an individual is able to calculate more factors to further his/her knowledge of energy the flywheel. An individual of the group is able to find the potential energy, potential energy loss potential energy loss adjusted.

To find potential energy a group member would use SUM on excel (SUM(A3)*9.81*0.28)). Using the value of gravity times weight used for that run and then times by height the object started at. This equation gave the individual 0.1kg potential energy. Using excel it is simple to calculate the potential energy for all the other masses. To calculate potential energy loss, the equation (PE)- MGH" (=SUM(B3)-C3) is used. A member of the group will then calculate potential energy loss times by the starting height of the weight hanger and then divided by the value of the height, add the height of the weight hanger peaked after the bounce and close brackets SUM(H3*(E3/(E3+F3))) this will give the factor for potential energy loss adjusted.

Acceleration a (m.s ⁻²)	Velocity v (m.s ⁻¹)	Velocity ω rad.s ⁻¹
0	0	0
0.054745708	0.1238095	19.0479476
0.111468254	0.1766667	27.179956
0.161728	0.2128	32.7390263
0.227486233	0.252381	38.8285086
0.267510882	0.2736842	42.1059895

The acceleration of the falling mass is calculated by using the factors "h1" this factor is then over square of "time taken to fall and rise t_f". In this experiment it is difficult to have an accurate time for the 'falling time' with the equipment given. Therefore, the group measured the total time taken to fall from rest to rise back up to optimum height and then multiply by the ratio h1/(h1+h2) therefore to use the equation =SUM(D3*(E3/(E3+F3))) is used.

Maximum acceleration and time are the products of maximum linear velocity of the falling mass. Example, =SUM(K3)/0.0065.

A group member would then covert angular velocity to linear velocity which are equal for the perimeter of the pulley.

$$\omega = \frac{2\pi v}{c}$$

Acceleration mass (ma) is taken away from gravity on the mass (mg). Due to gravity the difference between the force created by the acceleration is equal to the force of the cord of the flywheel at any given time. =SUM((G3)-(K3*A3))*0.0065

$$F = mg - ma$$

Angular acceleration is and moment of inertia equal to torque of the fly wheel.

$$\tau = I\alpha$$

=SUM(K3)/0.0065 is the result given by the table for angular acceleration of the mass divided by the pulley radius

$$\alpha = \frac{a}{r}$$

$$\text{From this: } \tau = I \frac{a}{r}$$

$$(mg - ma)r = I \frac{a}{r}$$

Using this equation above the indivial group member is able to plot a gradient line on a graph. If the experiment was done correctly the graph should show two reasonable straight line with little bit of separation between the two lines due to systematic errors. The result show that the from the experiment matches the theory thus proving the experiment was done correctly.

(Moodle.uwtsd.ac.uk, 2019)

5.0 Conclusion

To conclude this group experiment using the results gathered by performing this experiment proves that the kinetic energy in a flywheel is stored once the weight hanger at step 1 ready to drop. By having more mass on the flywheel increases the speed however, the moment of inertia and its angular velocity is squared for the flywheel this means that the kinetic energy is equal to half the product. The experiment proves Newton's second law of motion that an object with a larger mass than another will accelerate faster over the same distance.

6.0 Evaluation

According to the data proven results are accurate. We know this because the results are similar that of the hypothesis. But the result isn't perfect there was a slight spread on the graph due to systematic errors with better time keeping devices the spread of the two lines plotted on the graph. Also, when resetting the weight hanger to 280mm it might not have been a bit over or under 280mm. With the weight in the experiment each weight should be weighed on a scientific scale to make sure each one weighed the correct weight. However, from looking at the results the experiment is successful thus proving the hypothesis.

7.0 Further work

Weights that are added on the weight hanger may vary in weight due to manufacturing error. A way to solve this problem is to weigh each and every weight on a scientific weighing scale before adding the weights onto the weight hanger. During the experiment the group had to shorten the cord because I was reaching the bottom of its travel and hitting the desk. This is due to the cord stretching, therefore making the results inaccurate. This can be resolved by using a braided nylon cord or 30lb-50lb nylon fishing line to reduce the stretching. To receive more accurate results the best solution is to have a better timekeeping system. In the experiment the group had one person the say 'stop' once the weight hanger has reached maximum height, to inform the person with the stopwatch to stop the time. During the experiment the two time keepers used two different phones, this produces another factor causing inconsistent results across the experiment. To have the most accurate results the best way to time the experiment is to use a laser stop clock. The weight hanger will reach its peak to laser clock will read within millimetre of a second, thus replacing human reaction time. Also, to know where the exact height of the weight hanger reaches the group can use light gates. The weight hanger would bounce and wobble with 0.5kg, the weight many different weights cause the hanger to move in different directions, by using different materials or one solid piece it reduces the sway therefore the hanger will bounce up with all its momentum and give an accurate reading.

8.0 References and Bibliography

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