Centripetal Force Experiment

General Physics Lab

Class Code : PHYS1010AE

Group : B

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Purpose:

The main purpose for this experiment is to study the effect of varying the mass of the object, the radius of the rotation, and the centripetal force on an object rotating in a circular path.

Introduction:

A centripetal force is the force experienced by rotating objects. The centripetal force keeps an object moving in a circle and is always pointed toward the center of that circle. The unit of centripetal force is Newton. When an object of mass *m*, attached to a string of length *r*, is rotated in a horizontal plane, then the centripetal force experienced by object is given by:

$$F = \frac{mv^2}{r} = mr\omega^2$$

Where, *v* is the tangential velocity (linear velocity of the object at that point)

and is the angular velocity (*v = r*). The tangential velocity of the rotating

object can be measured, if one knows the period of rotation (T) of the object and it

is given by:

$$v = \frac{2\pi r}{T}$$

Therefore, the centripetal force can be expressed as:

$$F = \frac{4\pi^2 mr}{T^2}$$

Where, m is mass of rotating object having period of rotation T.

Materials/methods:

The materials used for the experiment include rotating platform (base, rotating arm, stabilizer bars, heavy rod, pulley), motor, weight lifting plate set, springs, balance indicators, power supplies, photoelectric timers, light sensors, vernier, and a fine rope.

Method:

For fixed F and m observe the effect of change in r:

In this experiment we will keep the centripetal force (F) and the mass (m) at some fixed value.

(1) Measure the weight of the object. Hang the object from the side post and connect the string from the spring to the object. The string must pass under the pulley on the center post.

(2) Fix the 'clamp-on pulley' to the end of the track where we are going to hang the known mass. To establish the constant centripetal force on the object, attach a string to the hanging object and hang a known mass over the clamp on pulley. Record this mass in observation. The weight of the mass hanging over the pulley is equal to the centripetal force applied by the spring. Calculate this force by multiplying the mass hung over the pulley by "g" and record this force in the observation.

(3) Select a radius by aligning the line on the 'side post' with any desired

position on the measuring tape (Note: While pressing down on the ‘side post’ to assure that it is vertical, tighten the thumb screw must be at secure position on the on the side post)

(4) On the center post, adjust the spring bracket vertically in such a way that the

string from which the object hangs on the side post is aligned with the vertical line on the side post.

(5) Align the indicator bracket on the center post with the orange indicator.

(6) Remove the mass that is hanging over the pulley and remove the pulley.

(7) Rotate the apparatus, increasing the speed until the orange indicator is centered in the indicator bracket on the center post. This indicates that the string supporting the hanging object is once again vertical and thus the hanging object is at the desired radius.

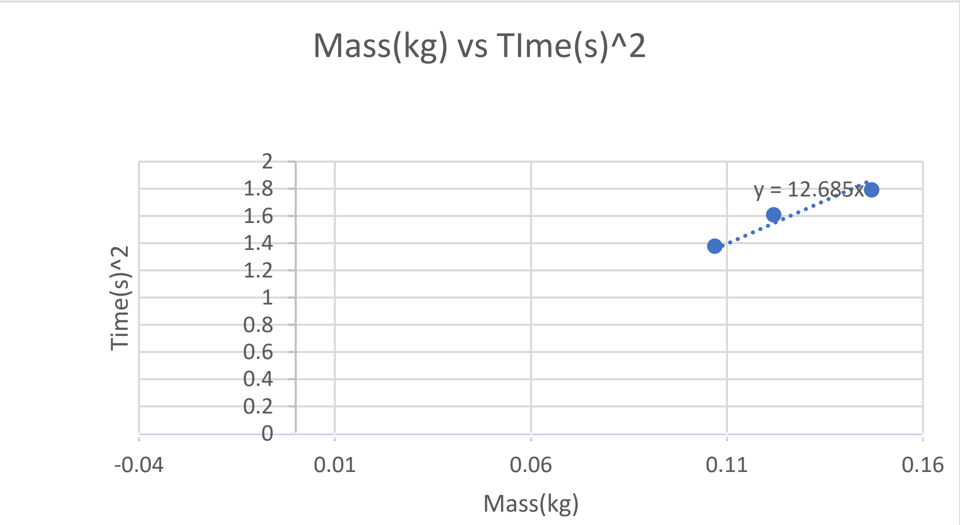
(8) Maintaining this speed, use a stopwatch to time ten revolutions. Divide the time by ten and record the period in Table 1.

(9) Move the side post to a new radius and repeat the procedure. Do this for a total of three radii.

(10) Plot r vs T2 and fit the points on the graph with straight line and calculate the slope of the line.

Results

Column1	m(g)	m(kg)	t(s)	T(s)2	Delta T(s)	T(s)^2)
1	106.94	0.10694	11.9131	1.19131	1.17437	1.379144897
			11.9045	1.19045		
			11.4135	1.14135		
2	121.94	0.12194	12.0656	1.20656	1.269099333	1.610613118
			12.7593	1.27593		
			13.24808	1.324808		
3	146.94	0.14694	13.37676	1.337676	1.339558	1.794415635
			13.53662	1.353662		
			13.27336	1.327336		



f theory	0.638176
f experiment	0.652902168
error(%)	2.31%

Discussion

There are multiple forces acting on the mass, to allow movement to outward direction. As from theory, there should have been only 2 forces which cancels each other, the centripetal and the centrifugal force. We can see that there exists a third force present which is the T, or Tension force. Which has the condition, “tension = centripetal force”. This causes the overall movement of the mass as the total amount of force is not in equilibrium. That is why, when there is no more centripetal acceleration, the mass could stay in the same place and valid data could be measured.

With an experiment that has multiple variables, there is a room for errors to occur. That is why, at the end of each experiment percentage error is calculated using the formula (measured value – expected value) / expected value * 100%. This gives a maximum value of error occurring in the experiment. In the case of this experiment, an error of 2.31% is obtained. There are multiple cases of where either systematic or human error could be made during the experiment of measuring centripetal force.

Possible errors:

(i) Parallax error: An error could be induced by the bad viewing angle towards the balance indicator disk and indicator bracket when assuming the balanced position of the mass. This will cause an effect of either increasing or decreasing the measured value depending on the direction of the error.

(ii) Unstable voltage: As this experiment uses a motor, it is advised to pre-test the output of the motor relative to the voltage given, as sometimes the force output of the motor is not stable which causes an inaccuracy in the period measurement. Which again could either increase or decrease the measured value relying to the magnitude of the force output, either increase or decrease.

(iii)Inconsistent figures: There is rounding occurring during the calculation part of the experiment, this causes a loss of data which leads to inaccuracy of the measured value. Despite the errors, from the experiment it can be established that the relation of centripetal is definitely valid. T 2 = 4π 2mr $Fcentripetal$

As can be seen from the graph, when m increases the value of T2 increases as well proportionally, proving the equation to be valid.

Conclusion .

In conclusion, the result were positive because we kept the mass of force and radius constant thus we could find the F theory and the F exp. That made the experiment positive. As per the hypothesis regarding the relationship between period and mass is correct. As derived from the equation, according to theory the relationship between period and mass is proportional which means when one is increased, the significant other is also added on, proving the relationship between both. We can also conclude that the increase in mass while the other factors are kept constant influences the centripetal force of the object in a circular part. That relation tells us that the centripetal force is proportional to the mass and to the radius and proportional to the square of the frequency. An acceptable percentage error was also found in this experiment below the endpoint. A lower percentage could be achieved if mitigation is done towards the possible errors.

References

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