Uniform Circular Motion

Concepts and keywords

An object moving on a circular track at a constant speed is called uniform circular motion. Although it is a constant speed, the velocity is always changing due to centripetal acceleration directed to center of the motion.

Objective

To find the relationship between the period and centripetal force of circular motions

Theory behind the experiment

In a uniform circular motion, the object experiences a centripetal acceleration and hence a centripetal force. For an object of mass m, moving in a circle of fixed radius r and with a constant speed v, the centripetal force is the mass times the centripetal acceleration.

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

The average speed of circular motion is given as

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

where T is the period of the motion, and r is the radius of the circle. Therefore, the centripetal force can be rewritten as

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

The plot between F vs. $4\pi^2 r/T^2$ gives a slope which is the mass of the object.

Procedure

1. Weigh the rubber bob with a balance.
2. Fasten the rubber bob securely to the end of the string.
3. Determine the radius, r, from 0.20 m to 0.50 m. Measure it of string from the center of the stopper and make a pen to mark at that point.
4. Thread the string through the tube and suspend a hanging mass to the free end of the string. (See the figure for the detailed set up.)
5. Hold the string slightly above the suspended weight with your one hand. Then, rotate the rubber bob with your other hand by holding

r

Rubber bob

m

Take r from the center of the rubber bob.

Tube

Do not hold the string while measuring T.

Hanging mass M
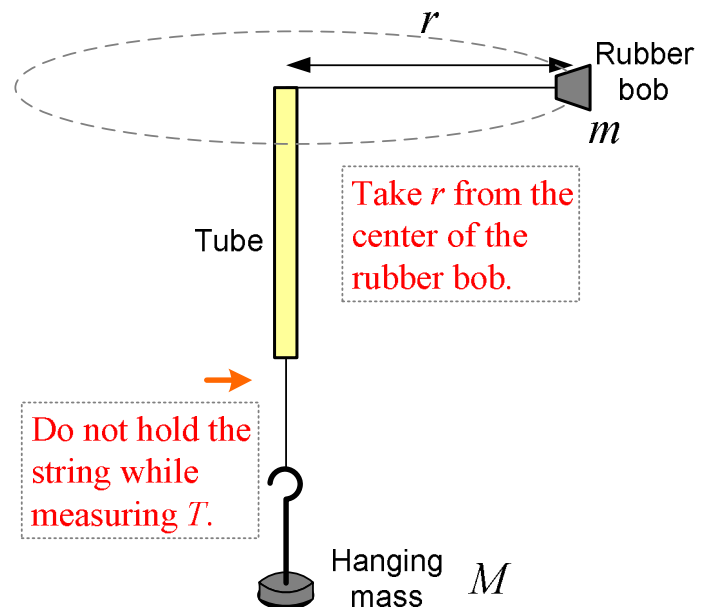
the tube.

6. Increase the speed gradually to adjust the rotational radius.

7. Make a horizontal circular motion above your head with the constant radius you mark on the string.

8. Use a stop watch to measure the time for 10 revolutions.

9. The average period is the time measured divided by 10.

10. Change the mass of the hanging weight as indicated in the table. Then, repeat the experiment to obtain the period.

11. After filling out all data, obtain the slope with Excel by following the next instruction:
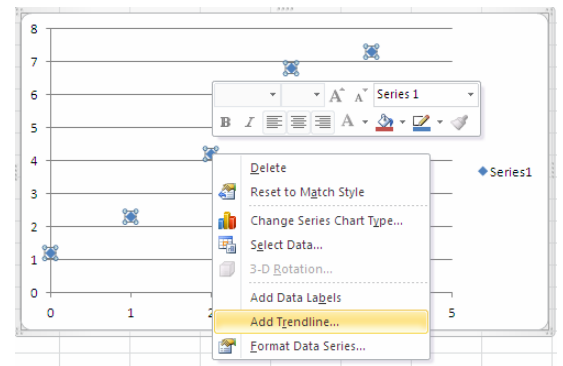
① ⇐Type in the x ($4\pi^2 r/T^2$) and y (F) values as follows:

② ⇒Select the x and y values; click "Insert" tab to choose "Scatter."; and then, select "Scatter with only Markers."
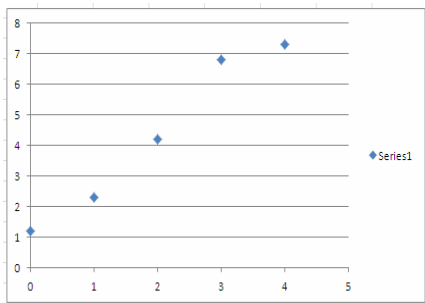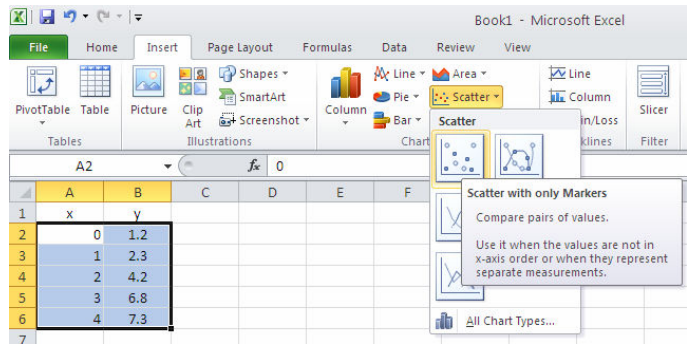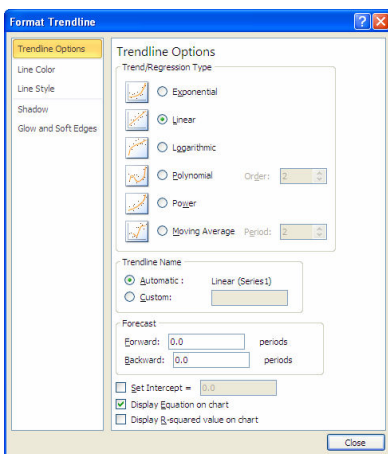

③ ⇐The plotted graph is popped up. Make sure it expresses the numbers you input.

④ ⇒Right click 'exactly' on the plotted point. Any one of them works in the same way. Then, select "Add Trendline."

⑤ ⇐"Format Trendline" is popped up. Make sure "Linear" is selected, and check for "Display Equation on chart" at the bottom of this.

⑥ ⇒After closing it, you will see the equation on the plot. The coefficient of x is the slope of the line.
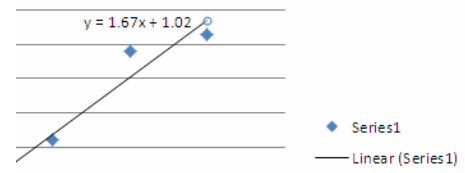
For the lab report: Write the title, introduction, discussions, conclusions and answers to the questions. Then, attach the data sheet and Excel graph (with the slope) to your report.

Data Sheet for Uniform Circular Motion

Name _____ Instructor's signature _____

◆ **Use the SI units.**

Mass of the rubber bob, *m* _____ (   ) ⇐ units

Radius of the motion, *r* _____ (   ) ⇐ units

Note that *M* and *m* are different. Do not mix them up for the calculation.

M (Hanging mass) Use 6 different masses.	*T* (Period) [Time measured (10 revolutions) divided by10]	*v* (Speed of circular motion) = $\dfrac{2\pi r}{T}$	*F* (Force due to hanging mass) = *Mg* Equivalent with the centripetal force	Calculate $\dfrac{4\pi^2 r}{T^2}$
Hanger (0.05 kg + 0.05-kg mass)				
Hanger (0.05 kg + 0.10-kg mass)				
Hanger (0.05 kg + 0.15-kg mass)				
Hanger (0.05 kg + 0.20-kg mass)				
Hanger (0.05 kg + 0.25-kg mass)				
Hanger (0.05 kg + 0.30-kg mass)				

Find the slope of *F* vs. $4\pi^2 r/T^2$ using the above data and Excel: Slope = _____

↰**You must show this before leaving.**

Question 1: Does the slope agree with the mass of the rubber bob? _____

Find the percentage error of the mass of the bob between the slope and the weighed mass:

$\dfrac{\left| m - slope \right|}{m} \times 100$ = _____ %

Question 2: How does the speed change by varying with the hanging mass? Is your result reasonable?