SPH4U UNIVERSITY PHYSICS

DYNAMICS

☞ Analyzing Uniform Circular Motion (P.136-137)

Circular Motion

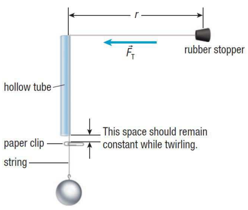
You have seen the derivation of the equations for circular motion and solved problems by using it. However, it is always hard to accept a theoretical concept until you test it yourself. In this investigation, you will obtain experimental data for uniform circular motion and compare your data to the theory.

$$F_c = ma_c$$
$$= \frac{mv^2}{r} \qquad \because\ a_c = \frac{v^2}{r}$$
$$= 4\pi^2 mrf^2 \qquad \because\ a_c = 4\pi^2 rf^2$$
$$= \frac{4\pi^2 mr}{T^2} \qquad \because\ a_c = \frac{4\pi^2 r}{T^2}$$

Activity: Circular Motion (Inv.9.4.1/P.136)

BACKGROUND

In this activity you will be looking at how well the equation $F_c = 4\pi^2 mrf^2$ describes actual experimental results for an object experiencing uniform circular motion.



NOTE!

You will varying 3 different variables:

- tension due to a hanging mass (F_g)
- radius of rotation (r)
- mass of stoppers (m)

Activity: Circular Motion (Inv.9.4.1/P.136)

INSTRUCTIONS

A. Follow procedure steps 1-13.

B. Record:
- the time and frequency to 2 decimal places
- the remaining values to 3 significant digits

NOTE!

To obtain reasonable values, you will need to make the measurements several times and take the average.

Activity: Circular Motion (Inv.9.4.1/P.136)

INSTRUCTIONS

C. Create a data table like the one below to record your data (you will need 9 rows in total – 3 sets each for changing the tension, the radius, and the mass). Recall: f = N/t

	Theoretical ($F_c=F_g$)		Experimental ($F_c=4\pi^2mrf^2$)				
radius r (m)	mass m (kg)	F_c (N)	stopper m (kg)	20 cycles t (s)	frequency f (Hz)	F_c (N)	% error

Activity: Circular Motion (Inv.9.4.1/P.136)

INSTRUCTIONS

D. Use the equation $4\pi^2mrf^2$ to calculate an experimental value of F_c for each radii.

E. Calculate the percentage error between the theoretical (accepted) and experimental (measured) centripetal forces.

Activity: Circular Motion (Inv.9.4.1/P.136)

QUESTIONS

1. What sources of error did you encounter? How did they affect your results? How did you minimize them? To improve your results, what would you do differently next time?
2. To obtain the best accuracy, the tension force acting on the stopper should be horizontal. What should happen to the accuracy as the frequency of revolution of the stopper(s) increases? Explain your reasoning.
3. Use the equation $F_c = 4\pi^2 mrf^2$ to answer the following questions.
   (a) Determine the relationship between $\mathbf{F_c}$ and (i) **m**, (ii) **r**, and (iii) **f**. Express your answer as a proportionality.
   (b) What happens to $\mathbf{F_c}$ when (i) **m**, (ii) **r**, and (iii) **f** are halved? Express your answer as a multiplier.
   (c) How can you keep $\mathbf{F_c}$ and **r** constant if **m** doubles? if **f** triples? Explain your reasoning with the aid of a proportionality statement.

Activity: Circular Motion (Inv.9.4.1/P.136)

QUESTIONS

4. A conical pendulum swings in a circle, as shown. Show that the form of the equation relating the angle that the string makes with the vertical to the speed of the bob is identical to the equation for the banking of curves. (i.e. $\tan\theta = v^2/rg$)

L = length of pendulum
θ = angle with vertical
F_T = tension in the string
mg = weight of bob (i.e. F_g)
r = radius of circular path
h = height of object from ceiling