

Physics 101 Fall 2009 Lab 4:

a-Acceleration in Uniform Circular motion

b-Free Fall and Weightlessness

Part a-Uniform Circular motion

Goals

Motion in a circle is an important example of acceleration as a change in direction. Examples of (almost) uniform motion include the planets orbiting the Sun, satellites in orbit around Earth and cars traveling on curved roads. In the first part of this lab we will study the relationships between **radius**, **rotational speed** and the **force** necessary to maintain uniform circular motion. (Text pp150-154) In the second part we will examine laboratory demonstration related to weightlessness.

Materials (Part one)

Glass tube, string, Otto the orange, masses, paper clips, stop watch.

Activity

An object in uniform circular motion (UCM) maintains a constant speed but is continuously changing direction. It is constantly accelerating at a rate of $a = v^2/r$. A force

$F=ma=mv^2/r$ must be applied to the object in order to maintain its motion.

Draw a picture of a particle in UCM and clearly indicate the radius, the direction of the acceleration, the speed and the value of the **angular** velocity ω . What is the acceleration in terms of ω ?

Hook the 200gm weight onto the string and practice twirling Otto the Orange around your head. What is the tension T in the string? Make sure you will not hit anyone or anything. Now choose a length of the radius of revolution between 25-35cm and place a paper clip on the string near the bottom of the glass tube. Measure the radius (from what two points do you measure?) You will be able to maintain constant radius by keeping the paper clip at a constant distance below the end of the glass tube. Twirl Otto in UCM and time ten revolutions. Calculate ω .

On graph paper plot T vs. ω^2 .

Now repeat the process for weights of 100, 300 and 400 gm. What shape do you expect the plot of T vs. ω^2 to have? Do your results agree with this expectation?

Increase the radius 40% from its previous value. Record this new value of r and repeat the experiment with masses of 200 and 300gm. Compare the values of ω with the previous results. Compare the values of the speed of Otto in the two cases.

Part b

Free Fall

Purpose

To observe the effects of gravity on objects in free fall.

Required Equipment and Supplies

2 Styrofoam or paper cups
2 long rubber bands
2 washers or other small masses
masking tape
large paper clip
water

Discussion

It is commonly believed that *since* astronauts aboard an orbiting space vehicle *appear* to be weightless, the pull of gravity upon them is *zero*. This condition is commonly referred to as "zero — g ". While it is true that they *feel* weightless, gravity *is* acting upon them (Chapter 8 in *Conceptual Physics*). Gravity at space shuttle heights is in fact only about 10% less than at the earth's surface.

The key to understanding this condition is realizing that both the astronauts and the space vehicle are in free fall. It is very similar to how you would feel inside an elevator with a snapped cable! The primary difference between the runaway elevator and the space vehicle is that the runaway elevator has no *horizontal velocity* (relative to the earth's surface) as it falls toward the earth, so it eventually hits the earth. The horizontal velocity of the space vehicle ensures that as it falls *toward* the earth it also moves *around* the earth. The combination of motions (tangential and downward) results in it falling without getting closer to the earth's surface. Both the runaway elevator and the orbiting space vehicle are in free fall.

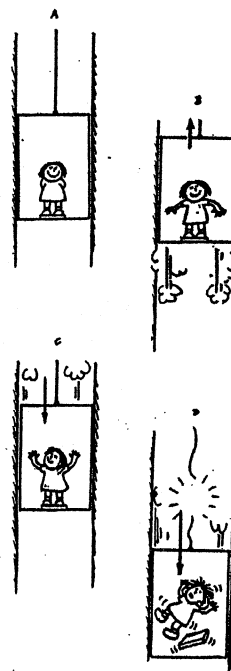
Procedure

Step 1: Elevators, especially those in tall buildings, are capable of changing the weight you feel or your *apparent* weight. When an elevator first starts to move up or down, your body senses the change in speed. Shortly afterwards, it moves at more or less constant speed until it begins to slow down to a stop. Weigh yourself on a bathroom scale in a motionless elevator. Observe what happens to the reading on the scale (your apparent weight) as the elevator:

a) accelerates upward.

b) accelerates downward.

c) moves upward at a constant speed.

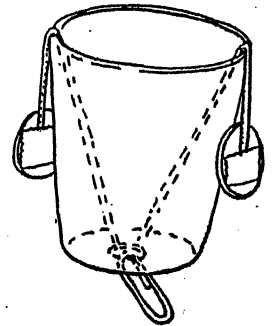


d) moves downward at a constant speed.

1. What would the scale reading be if the elevator cable(s) broke?

Step 2: Knot together two rubber bands to make one long rubber band. Knot each end around a small steel washer, and tape the washers to the ends. Poke or bore a small hole about the diameter of a pencil through the bottom of a Styrofoam or paper cup. Fit the rubber bands through the hole from the inside. Use a paper clip to hold the rubber bands in place under the bottom of the cup (see Figure A). Hang the washers over the lip of the cup. The rubber bands should be under enough tension to keep the bands taut but not so much as to flip them into the cup.

Fig. A

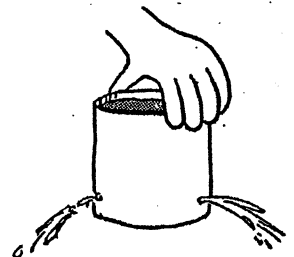


Step 3: Drop the cup from a height of about 2 m.

2. What happens to the washers?

Step 4: Remove the rubber bands from the cup and fill the cup half-full with water, using your finger as a stopper over the hole. Hold the cup directly over a sink or waste basket. Drop the cup into a sink or waste basket. What happens to the water as the cup falls?

Fig. B



Step 5: Repeat Step 3 for a second cup half-filled with water with two holes poked through its sides (Figure B).

Summing Up

3. Explain why the washers acted as they did in Step 2.

4. Explain why the draining water acted as it did in Steps 3 and 4.

