Regis University – Physics 305A – Fall 2019
Lab 3: Force Table

Part I: Forces on a Force Table

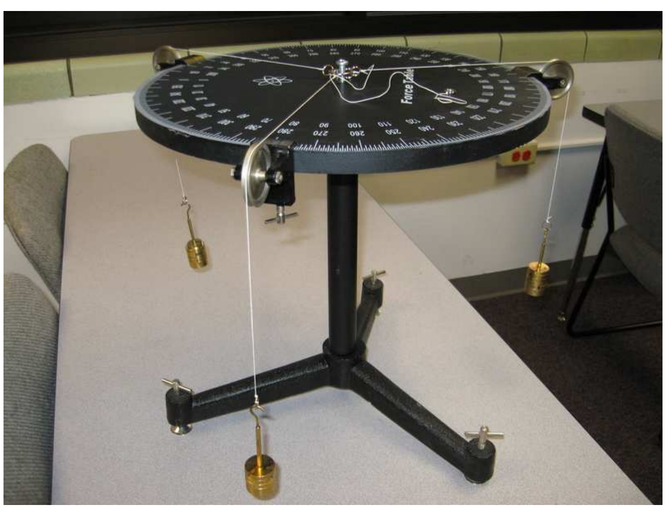
In this lab, you will begin to build your physical intuition about forces and improve your ability to calculate with vectors.

You probably have some intuition about forces from your everyday experience. For example, you probably have a rough idea that they are the interactions that cause objects tol accelerate – if you push on a shopping cart (i.e., apply a force), the shopping cart starts accelerating. In lecture, you will soon start studying forces in more formal detail. For now, we will simply make note of the fact that forces are **vectors**: they have a magnitude and direction. When the sum of forces on an object (the "net force") is equal to zero, the object will not accelerate. We will explore this fact today as a means for practicing vector math. You will try to balance the forces (i.e., make them sum to zero) due to gravity acting on small masses by using a force table.

There is one important fact that you will likely need to being to set up this experiment: The gravitational force on a mass within Earth's gravitational influence near the planet's surface can be calculated as

$$\vec{F} = m\vec{g}, \tag{1}$$

where m is the object's mass and $|\vec{g}| = 9.8\ \mathrm{m/s^2}$ is the gravitational acceleration due to Earth. This simple relation ship allows you to relate an object's mass to its weight (i.e., force) if it is near Earth's surface. In our experiment, this force acts on each small mass and is transmitted to a small metal ring via tension in a string.



The force table is shown "in action" in the photographs above; we have a number of models that look somewhat different, but the basic principle is the same. It is marked with an angular scale. Pulleys can be clamped onto it at any position around the circumference, allowing you to hang masses on strings from any angle. These strings are linked together by a ring; your goal is to find a configuration in which the net force on the ring is zero (well, at least very small) so that it remains balanced, in static equilibrium.

The table below specifies the magnitude and direction of two forces for various force table "problems":

Problem	Force 1	Angle 1	Force 2	Angle 2
A	1.22 N	0°	1.47 N	85°
B	0.88 N	75°	1.76 N	165°
C	1.47 N	30°	1.47 N	118°
D	1.96 N	0°	2.16 N	120°

For each of the problems:

1. Compute the magnitude and direction of a third force that would counterbalance the given pair, giving a net force $\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 = \vec{0}$. Remember that, to add vectors, you must break them into their Cartesian components and add those components.
2. Determine how much mass to hang at each position to create each of these three forces: two that were given, and one that you just calculated.
3. Set up the force table as you have calculated. Is the system balanced in static equilibrium, with the ring stationary at the center of the table?
4. If not, you should first double-check your calculations. If they are correct, then you should be able to make it balance with a small adjustment to one of the forces. How large was this adjustment, as a percentage of the force itself?

Part II: Computational Activity 2

Do not begin this part until you have completed all calculations in Part I. Handheld calculators are horribly inefficient for doing repetitious calculations, like you did in Part I. By writing a small computer program, you can do multiple complex calculations quickly. In this part, you will write a Python function to automate what you did manually in Part I.

Problem	Force 1	Angle 1	Force 2	Angle 2
E	1.47 N	0°	1.22 N	85°

Your job is to use the Python skills that you began to learn in Lab 1 to write a program that solves Problem E below in the same way that you solved the above problems manually. I've given you a skeleton of the code below; you must finish and adapt it. In doing so, you will definitely want to make use of the functions `math.pi`, `math.sin()`, `math.cos()`, and `math.atan()`, all of which you can google if you have questions about them. (Hint: Do these trig functions accept degrees or radians as input?) Also remember that lines that begin with # are comments; Python **ignores** them entirely. You need to uncomment a line if you want Python to use it. My skeleton of code below is just a suggestion; feel free to modify and experiment. However, you should obtain working code before you turn in your lab report, and you lab report should contain all of the code you wrote. If you do not finish it in lab, you should finish it before next lab.

As we discussed in Lab 1, you can run Python natively on your computer, but most of you probably don't have it installed, so we'll use a website that runs your code online for you. If you happen to have Python installed or prefer a different online implementation, feel free to use those. Regarless, please go to `https://trinket.io/python3/12950deb2c` to get my skeleton code.

If you feel confused by this exercise, please don't worry. Everyone makes a mess of programming the first time they attempt it. Try to enjoy the experimentation, failure, and learning!

When you are finished, please take a moment to appreciate what you have done. Though it was hard to code, you have now solved **all possible** three-vector problems. If you did it right, you could change the input values to any others and **instantly** get the answer!