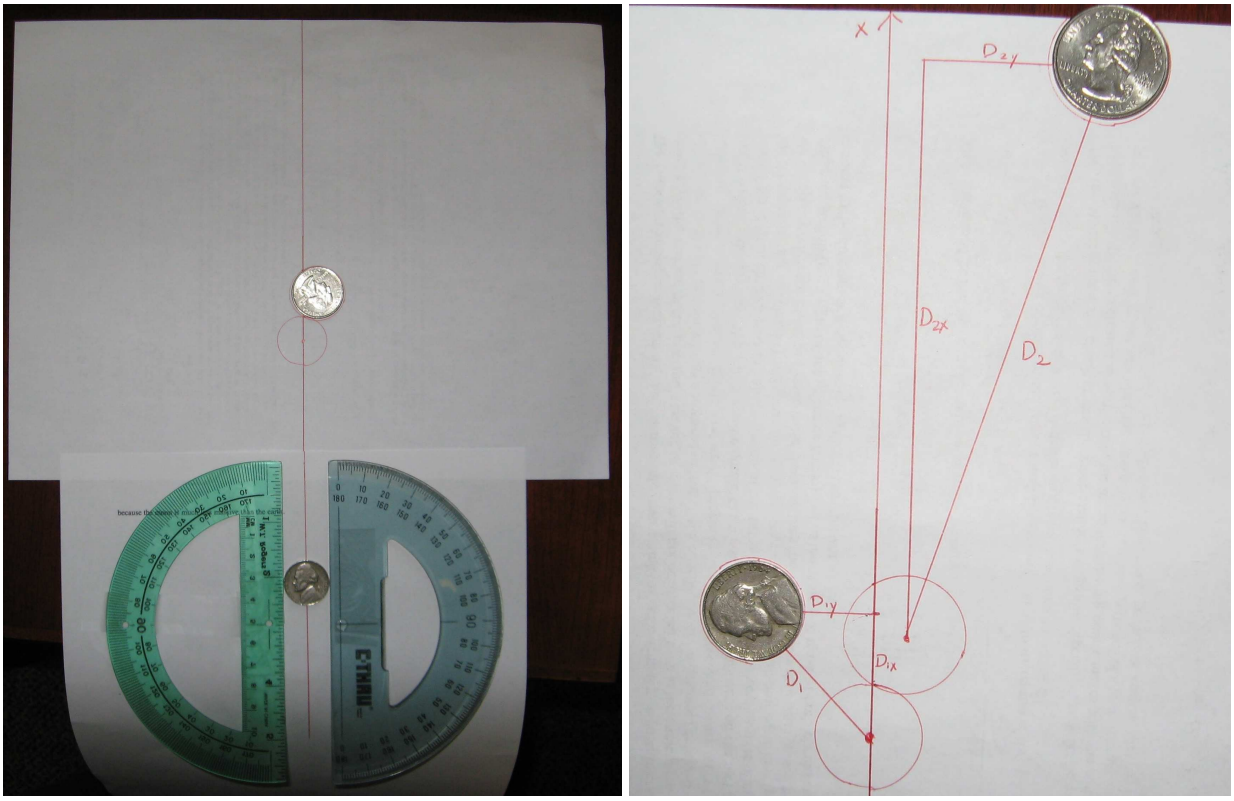
Regis University – Physics 305A – Fall 2017
Lab 7: Coin Collisions

In this lab, you will devise a method to measure the ratio of the masses of two coins by observing what happens after they collide and applying basic physical principles. You will first test your procedure by colliding two nickels; in this case, you know the correct answer (1 nickel = 1 nickel). If your procedure passes this test, you can go on to measure the masses of a quarter and a dollar coin (in units of nickels). It happens that the mass of a nickel is 5.000 grams, a fact that should be easy to remember, so you are also effectively measuring the masses of these coins in more conventional units.

You should begin by considering the pre-lab questions at the end. They will tell you what you need to measure. You should then build a nickel launcher that lets you control the initial direction of a "projectile" nickel's motion when you flick it with your finger. I did this by taping two protractors to a piece of paper, separated by a channel whose width equals that of a nickel.

Position your "target" coin on another piece of paper. Trace around the edge of the target coin and around the position that the projectile nickel will have at the moment of the collision. Then, launch your projectile, and trace around the edges of the final positions of the coins. Draw an x coordinate axis along the direction of motion of the projectile and a y coordinate axis perpendicular to it. Label and measure the distance that the center of mass of each coin traveled from the interaction point to its final position. Then label and measure the x and y components of the vector from the initial to the final position. These dimensions are illustrated in the "before" and "after" pictures of a nickel-quarter collision below (the "after" image is magnified relative to the "before"):



Use your results from the pre-lab questions to determine the ratio of the masses of the two coins. First, collide two nickels with each other, a case where you really should believe that the mass ratio ought to equal 1. Fortunately, these should be easy measurements to repeat for many trials. You can measure the mass ratio about five times (that is, $N = 5$), and calculate the mean and standard deviation (σ) of the distribution of results. The statistical uncertainty of the mean value is $\delta m = \sigma/\sqrt{N}$. You would expect that the mean should fall within $\pm\delta m$ of the true value about two-thirds (actually, closer to 68%) of the time, within $\pm 2 \cdot \delta m$ about 95% of the time, and within $\pm 3 \cdot \delta m$ about 99.7% of the time. So, does the mass ratio agree with the expectation of 1 to within a reasonable multiple of its uncertainty?

Next, collide nickels with quarters and with dollar coins. In each case, perform enough trials to be able to estimate the uncertainties of your measurements of the mass ratio. The nominal mass of a quarter is 5.670 grams, and the nominal mass of a dollar coin is 8.100 grams. Do your measurements agree with the expected mass ratios at the level that your calculated uncertainties suggest?

Pre-lab questions

(Try to start these questions before coming to lab, but plan to work together with your group to finish them in the lab.)

1. Use the principle of conservation of momentum to relate the mass ratio m_1/m_2 of the two coins to the y components of their velocities immediately after the collision, v_{1y} and v_{2y}.

2. To a good approximation, the magnitude of the frictional force between the coin and the paper is $F_f = \mu mg$, where μ (the Greek letter mu) is a constant that is approximately the same for all coins. Use this fact, together with what you know about the *work* done by the force, to relate a coin's speed v immediately after the collision to the distance D that it travels across the paper before stopping.

3. Explain why $v_{1y}/v_1 = D_{1y}/D_1$ and $v_{2y}/v_2 = D_{2y}/D_2$.

4. Put together your answers to the previous three questions to compute the mass ratio m_1/m_2 in terms of the distances that you will measure on your paper after a collision.