# The Ballistic Pendulum Post Lab

**Physics 203: Profs. Bean, Lu, & Martens Yaverbaum**
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## 1. The Epistemological Table

| Claim | Type of Knowledge |
|---|---|
| $\|W_{grav}\| = mgh$ (*Careful!*) | |
| Gravity did negative work on the bullet-ring system as it swung. | |
| Normal force did zero work on the bullet-ring system. | |
| $\Sigma W = \Delta KE$ | |
| Kinetic Energy = $\frac{1}{2}mv^2$ | |
| Linear momentum = mv | |
| The mass of the brass ball was 23.034 g. | |
| The pendulum attained a maximum height of 9.1 cm. | |
| Work done by gravity on the pendulum as it swung = -.0573 J | |
| Momentum of pendulum-sphere system after collision = 8.51 kg(cm/s) | |
| Momentum of pendulum-sphere system prior to collision = momentum of pendulum-sphere system after collision | |
| In the conservation of momentum equation, $\vec{p}_{ring,0} = 0$ | |
| The horizontal velocity of the brass sphere right before it hit the ring was 6.14m/s (based on pendulum). | |

## 2. The Research Design Chart

The first box in your research design chart should be the change in ***change in height*** of the ring from its initial position to its final position.

**3. The Counter Factual**

A. Imagine that the ***bullet*** had been made of lead and had ***twice the mass*** that it had in the actual lab BUT it had the same initial velocity as in the actual lab, and all other initial variables were the same: size and mass of brass ring, size of bullet, length of pendulum rod, etc. What would be different about the final state of the apparatus—i.e. the angle of the pendulum?

B. Now imagine that the ***brass ring*** was instead made of lead and had ***twice the mass*** that it had in the actual lab, BUT the bullet had its real mass from the lab and all other initial variables were the same: size, mass, length, initial velocity, etc. What would be different about the final state of the apparatus—i.e. the angle of the pendulum?

C. In 1-3 sentences, explain why changing the mass of the bullet has the opposite effect from changing the mass of the ring.

***Thoroughly EXPLAIN how you reached both of your answers and SHOW ALL WORK. Provide any diagrams you feel necessary. Equations & numbers are welcome.***

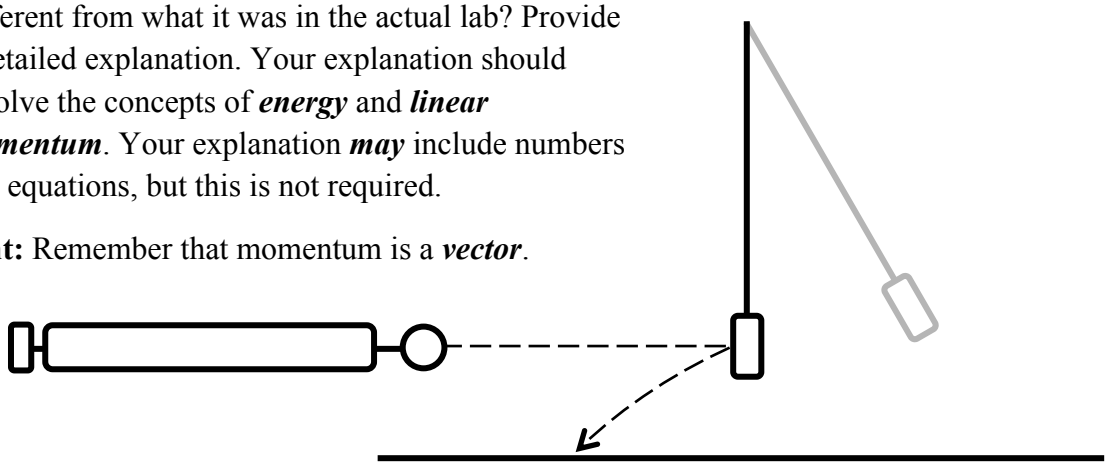
**4. Wild Card**

A. Compute the energy lost during the bullet-ring collision—that is, the total loss of energy of the system (the ring & the bullet) from before the collision to after. Use the numbers from your lab work. Show all work.

B. Imagine that everything about the experiment setup was exactly the same as in the lab: same initial velocity of the sphere, same length of the rod, same masses. ***BUT***, for some reason, the brass sphere did not stick in the ring. Instead it ***bounced off*** the ring, and was thrown back in the direction it had come, as shown in the diagram below.

How will the final height of the pendulum be different from what it was in the actual lab? Provide a detailed explanation. Your explanation should involve the concepts of ***energy*** and ***linear momentum***. Your explanation ***may*** include numbers and equations, but this is not required.

**Hint:** Remember that momentum is a ***vector***.



## The Formal Report

As always, the first step in writing your report should be coming up with a good research question. There are two reasonable approaches to this. One is to make the question about the muzzle velocity itself: "What is/was the muzzle velocity of a...." Another is to make the question about the technique: "How can the muzzle velocity of a… be calculated using…." The first approach is fine, but I think I prefer the second one. (Since you're going to compare your calculated velocity to a velocity calculated using photogates, you might want to add a second question that goes something like "How accurate is this method as compared to….")

Notice, though, that if you use the second method (which I recommend) then the answer to your RQ is more complicated. Because if the question is "How can the muzzle velocity be calculated?" the answer can't be 6.45 m/s, right? Both of your calculated muzzle-velocities (from the pendulum and from the light-gates) ***should*** still appear in both your Abstract and your Conclusion, along with uncertainty intervals, but you also need to ***answer your RQ***. And the answer to your RQ will have to be a very clear, concise summary of the method you used. That summary definitely should mention momentum, energy, and collisions.

Your lab report should, of course, clearly and thoroughly explain how you used the ballistic pendulum apparatus to predict the muzzle-velocity of the bullet. It should ***also*** clearly and thoroughly explain how you ***tested*** this prediction against a different method for calculating muzzle velocity. Be careful when writing about this: neither calculation of muzzle velocity is perfectly correct; both contain error ***and*** uncertainty. You may believe that the second method is ***more*** accurate than the first—and you should ***justify*** this claim—but it's not perfectly accurate. you are NOT comparing a PREDICTED value to an ACTUAL value. You are comparing two values that were both measured using different tools. The percent difference between them is just that: a percent ***difference***, NOT a percent ***error***.