**Fall 2020 Physics Individual Investigation Exploration Planning**

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| **Topic Investigating (what do you want to find out . . . if the idea came from a source online, include a citation):**  I want to investigate the strength of lead in mechanical pencils and how much force different sizes of lead can withstand.  **Why it is interesting to you:**  Whether for math scratch paper or for my physical diary, I use mechanical pencils quite a bit. It’s always annoying when a bit too much pressure is applied and the lead snaps. I hence want to investigate how well different sizes of lead can withstand force. |
| **Investigative Question (how does \_\_\_\_ affect \_\_\_)?**  How does the diameter of a piece of lead from a mechanical pencil affect the force needed to snap it? |

**Background Research Pages:**

1. **What terms or Concepts are important to define or explain to fully understand your lab? List each Question/term and the explanations for each one.**

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| **Terms / Concepts / Questions** | **Definition / Explanation / Answer** | **Source Citation** |
| Pressure | The pressure is the force applied divided by area of application: | <https://www.school-for-champions.com/science/pressure.htm#.X7XldWhKjIU> |
| Weight Force | The downward force due to gravity exerted by any object with a mass in kilograms on the Earth’s surface is , where | <https://www.school-for-champions.com/science/gravity_overview.htm#.X7XjyWhKjIU>  (there are a multitude of sources for this) |

1. **Is there qualitative answer to your lab question? (EXAMPLE: With the Question how does Voltage affect current a qualitative answer would be  "as the voltage increase the current increases because…)**

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| **Qualitative Answer to lab question** | **Source Citation** |
| The greater the diameter of the lead, the more force is needed to snap it. | (can’t find a force from this, it’s more or less just common perception & experience?) |

1. **Is there mathematical or quantitative answer to your lab question? (EXAMPLE:  With the Question how does Voltage affect current a mathematical or quantitative answer would be that Voltage should be proportional to the current.)**

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| **Quantitated / mathematical Answer to lab question** | **Source Citation** |
| Can’t find quantitative answer online |  |

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| **Independent Variable (must be quantifiable):**  Diameter of the lead (in mm)  **How will you change the independent variable?**  By purchasing different thicknesses of lead.  **How will you measure your independent variable?**  The property should come labeled in the purchase. | **Dependent Variable (must be quantifiable):**  Force needed to snap the pencil lead  **How will you measure your dependent variable?**  I will hang increasingly heavy masses on the lead until the lead snaps; playdoh can be a good adjustable mass | **Possible Control Variables:**  Length of lead  Positioning of the point on the lead where force is applied  Room temperature |

**Hypotheses:** What do you think will happen? Why?

I think that the greater the diameter of lead, the thicker it will be, and because there are more bonds with the material to break, a greater force will be needed to snap it. When quantified, I think there will be an square relationship, because diameter has a square relationship with cross-sectional area.

**Materials:** What objects will you need to carry out your investigation? Where will these materials come from?

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| **Material** | **How will you use the item . . . why do you need it?** | **Where will this item come from?** |
| Lead | The lead will be snapped to measure force | Stores – Target, Amazon, etc. |
| Paper clip | Used to hand masses on the lead | Home |
| Playdoh (or other masses) | Exerts a variable, measurable weight force | Online purchases |
| Computer | To record data | Home |
| Scale | To measure the masses of the playdoh as I adjust it | Online purchases? Can I borrow from Interlake? |

**Procedure:** What steps will you do to collect data for your experiment. *Ideally this is specific with enough detail that someone else can replicate it.* You can revise your plan later, but we need an initial idea of what you will do.

1. Obtain needed materials (lead, paper clip, playdoh/mass, scale, computer)
2. Mass the paper clip
3. Put the 0.3mm pencil lead between two high ledges and hang the paper clip from it with a 0.2kg mass
4. Keep adding mass in increments of 0.1kg until the lead snaps
5. Record the mass (paper clip mass + hanging mass) needed to snap the lead, as well as the thickness of the lead itself
6. Repeat steps 3-5 with 0.4mm, 0.5mm, and all the other different diameters
7. Plot and analyze the data

**What problems do you foresee in implementation of your investigation?**

One problem may be figuring out how to obtain the different leads. 0.3mm, 0.5mm, and 0.7mm are readily sold commercially, but I will need 5 data points. 0.2m, 0.4mm, 0.6mm, 0.8mm, 0.9mm, etc. also exist, but I might need to figure out how to get them. (currently I’m eyeing 0.4mm and 0.9mm in addition to 0.3, 0.5, and 0.7, because they can be found easily on Amazon)

Additionally, figuring out how to mass properly may be a challenge; my house currently doesn’t have suitable equipment, so I’ll have to find it online (if I can’t borrow massing equipment from Interlake).