**Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_ Period\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Investigating Barycenter**

**Lab GRADE**

Points Earned: \_\_\_\_\_\_\_\_\_\_

Points Possible: 50

**Objectives:**

* **EEn.1.1.2.E.** Demonstrate how objects that orbit each other at their barycenter.
* **100S.SI.1.C.3.** Compose a hypothesis using the “if…, then…” format.
* **100S.SI.1.C.4.** Determine the result that would support a hypothesis.
* **100S.SI.1.C.5.** Determine the result that would refute a hypothesis.
* **100S.EMR.1.A.3.** Summarize the key ideas of a model.

**Background Information**

**Barycenter** is the point between two objects where they balance each other. For example, it is the center of mass where two or more celestial bodies orbit each other. When a moon orbits a planet, or a planet orbits a star, both bodies are actually orbiting around a point that lies outside the center of the primary (the larger body).

Our solar system consists of the Sun and the many millions of celestial bodies, including large planets and microscopic dust particles, which orbit around it. As a unit, the solar system has a center of mass, its balancing point. At this point, the system would balance like a spinning plate on top of a circus performer's balancing stick. This point, called the **barycenter,** is the exact point about which all the bodies in the solar system orbit.

 Since the Sun is vastly larger and heavier than all the other bodies combined, *the solar system's barycenter is very close to the Sun—but not at the Sun's center.* Thus, while all the other solar system bodies seem to orbit the Sun, they, including the Sun, are actually orbiting a point in space just beyond the Sun's outer layer.

Likewise, the moon does not orbit the exact center of the Earth, but a point on a line between the Earth and the Moon approximately 1,710 km below the surface of the Earth, where their respective masses balance. This is the point about which the Earth and Moon orbit as they travel around the Sun.

**Binary bodies** are two celestial bodies held together by mutual gravitational attraction. In this project, you will learn how mass affects the location of their barycenter

**Materials** (2 pts)

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
6. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
7. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Procedure:**

1. Use the paper punch to make a hole in each end of the index card. Bend the paper to bring the holes together. Thread one end of the cord through the holes. Tie a knot to hold the holes together. You have made a paper sling for the dowel. **(*Steps 1-2 may be completed ahead of time by the teacher*)**
2. Tie the other end of the cord to another supporting object. Adjust the length of the cord so that the paper sling hangs about chest high. (***If there is no supporting object, students could tape the end of the string to the edge of their desk)***
3. Using the scale, measure two 40 g pieces. Shape each piece into a ball.
4. Stick one end of the dowel into the first clay ball – this is **binary body #1**. The dowel should be inserted to a depth equal to the radius of the ball.
5. Slide the free end of the dowel through the paper sling.
6. Repeat step 5 using the remaining clay ball on the other end of the dowel – this is **binary body #2.**
7. Determine the balancing point by moving the dowel back and forth in the sling until it balances (see Figure 11.1).
8. Measure the distance between the center of **binary body #**1 and the center of the paper sling. This center of the paper sling is the **barycenter** between binary body 1 & 2.
9. Gently push one of the balls so that the dowel turns. Observe the motion of the clay balls.
10. For trials 2 -5 you will add mass to **binary body #2** and record the new mass of binary body #2 only in Data Table 1.
11. Each time you add mass, you will determine the **barycenter** by measuring the distance between the center of **binary body #**1 and the center of the paper sling to complete Data Table 1.

**Pre-Lab Questions:**

1. What do the balls of clay represent? (2 pts) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. What does the dowel represent? (2 pts) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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| --- | --- |
| **1. Independent Variable:**  | **Dependent Variable:**  |
| **2. Hypothesis:** |
| **3. Determine the result that will support this hypothesis is…** | **4. Determine the result that will refute (reject) this hypothesis is….** |

3. Complete the hypothesis table below: (4 pts)

**Data:** (10 pts)

**Table 1:** Table of the distance of barycenter from Binary Body #1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Trial #** | **Mass of Binary Body #1 (g) (smaller)** | **Mass of Binary Body #2 (g) (larger)** | **Distance of barycenter from Binary Body #1 (cm)** | **Change Observed****( or)** |
| 1 |  |  |  |  |
| 2 |  |  |  |  |
| 3 |  |  |  |  |
| 4 |  |  |  |  |
| 5 |  |  |  |  |

**Analysis:** (10 pts)

**Figure 1:** Graph of the **distance of the barycenter** from binary body #1 as the **mass of binary body #2 increases**



**Results:**

1. Describe what happened to the distance from binary body 1 as the mass of binary body 2 increased. (5 pts)

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**Conclusion:**

2. Determine whether your results supported or refuted your hypothesis **and explain why**. (5 pts)

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3. If the mass of binary body 1 is 56,700 kg and the mass of binary body 2 is 678 kg, draw a picture of where you think the barycenter of will be located between these two objects **and explain why**. (5 pts)

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4. If the mass of binary body 1 is 795,008 kg and the mass of binary body 2 is 778,000 kg, draw a picture of where you think the barycenter will be located between these objects **and explain why**. (5 pts)

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| **Graphing** | **100S.ID.2.** **Presenting Data.** Translate quantitative or technical information into visual form (e.g., in a flowchart, diagram, graph, or table). (RST.6-8.7) |
| **Skill Standard** | **Advanced Proficient - 4** | **Proficient - 3** | **Partially Proficient - 2** | **Not Proficient- 1** |
| **100S.ID.2.A**. Translate information into a simple table, graph, or diagram. (IOD 403) | Graph meets ALL of the following criteria:1. Correctly assign variables to the X and Y axes, labeling both axes and the variable plotted on each
2. Create a consistent, logical scale on both axes
3. Plot data accurately and legibly on the graph
4. Create a key that allows for the easy differentiation of different data series
5. Create an appropriate title for the graph
 | Graph meets 4 of the criteria for an Advanced Proficient response. | Graph meets 3 of the criteria for an Advanced Proficient response. | Graph meets less than 3 of the criteria for an Advanced Proficient response. |
| **Composing Hypotheses** | **100S.SI.1. Experiments**. Design and conduct simple scientific investigations (SIS2) |
| **Skill Standard** | **Advanced Proficient - 4** | **Proficient - 3** | **Partially Proficient- 2** | **Not Proficient - 1** |
| **100S.SI.1.C.** Create a testable hypothesis. | Hypothesis meets all of the following criteria:1. Be in the IF…THEN … BECAUSE format
2. Select a **plausible independent variable** in the IF… part of the hypothesis
3. Select an **observable dependent variable** in the THEN… part of the hypothesis
4. Demonstrate the hypothesis is based on a prior observation or knowledge in the BECAUSE part
 | Response meets 3 of the criteria of an Advanced Proficient response.  | Response meets 2 of the criteria of an Advanced Proficient response. | Response meets less than 2 of the criteria of an Advanced Proficient response. |

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| --- | --- |
| **Hypotheses: Support or Refute?** | **100S.SI.1. Experiments**. Design and conduct simple scientific investigations  |
| **Skill Standard** | **Advanced Proficient - 4** | **Proficient - 3** | **Partially Proficient- 2** | **Not Proficient - 1** |
| **100S.SI.1.H.** Determine whether experimental results support or refute a hypothes | Response meets ALL of the following criteria:1. Written in complete sentences
2. Response begins by echoing the prompt
3. Accurately determines if the data supports or refutes the hypothesis.
4. Provides evidence from the data to support claim
 | Response meets 3 of the criteria of an Advanced Proficient response.  | Response meets 2 of the criteria of an Advanced Proficient response. | Response meets less than 2 of the criteria of an Advanced Proficient response |