Student Guide: Metrology

Introduction (50-100 Words)

Metrology is the science of measurement. Measurements and measurement standards are found in the earliest written documents: The law code of Ur-Nammu (in ancient Sumeria, about 2000 BC) describes how the king Ur-Nammu established a volume standard (probably used for grain) and a weight measure. In this lesson, we will explore making good measurements of length and of force.

Discussion

(1) Discuss what are standards? A standard would include the width of a roll of toilet paper (4.5 inches). Why is that a standard? What does it mean to be "standard?" In your group, come up with examples of standards that are used in your home, or in your classroom.

(2) Discuss what is a physical property and quantity? Temperature is a physical property (quantity). Length is also a physical quantity. What would ***not*** be a physical quantity? Can you name other physical quantities besides length and temperature? Make a quick list of examples and non-examples.

(3) Decide as a group what makes a good a standard of measurement for a physical quantity (a "unit of measurement"). Make a quick list.

Lab one: length or linear measurements.

You have been given some paper rulers. You need to determine if you can use these for measuring the dimensions (length, width, thickness) of the chocolate that you will be breaking.

Supplies:

- Assorted paper rulers for your group
- Your teacher has a ruler, your teacher also has some US coins
- There is a table with the properties of US coins on the back of this handout

Activity:

Using information from your group discussion, devise a method to test whether or not your paper ruler is acceptable for use for measuring the dimensions (length, width, thickness) of the chocolate that you will break. Test your method, and report both your method and your results.

Use the following steps:

- Devise a procedure. What do you define as an "acceptable" ruler or an "unacceptable ruler"?
- Test the procedure
    - Does your procedure test different portions of the ruler or just one section? How many portions? Why is it important to consider this?
    - Does your procedure include different students in your group conducting this test? Why is it important to consider this?

    - Does your procedure use different sets of coins, or your teacher's ruler? Why do you care?
    - How does the procedure you designed establish "acceptable" from "unacceptable"?
- Conduct the procedure
    - Describe your quantitative observations in a table
- Could you improve your procedure?
    - Describe any improvements that can be made
- Checking your procedures for clarity: if you handed your procedure to a different team, would they be able to perform the procedure, and obtain the same results you did?

Coin Specifications

The following table gives specifications for The United States Mint legal tender coins presently in production for United States Mint Annual Sets.

Denomination	Cent	Nickel	Dime	Quarter Dollar	Half Dollar	Presidential $1	Native American $1 Coin
Composition	Copper Plated Zinc 2.5% Cu Balance Zn	Cupro-Nickel 25% Ni Balance Cu	Cupro-Nickel 8.33% Ni Balance Cu	Cupro-Nickel 8.33% Ni Balance Cu	Cupro-Nickel 8.33% Ni Balance Cu	Manganese-Brass 88.5% Cu 6% Zn 3.5% Mn 2% Ni	Manganese-Brass 88.5% Cu 6% Zn 3.5% Mn 2% Ni
Weight	2.500 g	5.000 g	2.268 g	5.670 g	11.340 g	8.1 g	8.1 g
Diameter	0.750 in. 19.05 mm	0.835 in. 21.21 mm	0.705 in. 17.91 mm	0.955 in. 24.26 mm	1.205 in. 30.61 mm	1.043 in. 26.49 mm	1.043 in. 26.49 mm
Thickness	1.52 mm	1.95 mm	1.35 mm	1.75 mm	2.15 mm	2.00mm	2.00 mm
Edge	Plain	Plain	Reeded	Reeded	Reeded	Edge-Lettering	Edge-Lettering
No. of Reeds	N/A	N/A	118	119	150	N/A	N/A

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https://www.usmint.gov/learn/coin-and-medal-programs/coin-specifications

Lab two: Testing a luggage scale to measure force.

Your teacher has a luggage scale, and would like to use it to measure the breaking strength of chocolate. You need to decide if the luggage scale is acceptable.

Supplies:

- Teacher's luggage scale
- Rolls of nickels (40 nickels in a roll)

Use the following steps:

- Devise a procedure. What do you define as "acceptable performance" for the luggage scale?
- Test the procedure
    - Does your procedure test different amounts of force? Over what span of force? Why is it important to test this?
    - Does your procedure include different students in your group conducting this test? Why is it important to consider this?
    - Use your data to make a graph to help you interpret the data.
    - How does your procedure establish "acceptable" from "unacceptable"?
- Implement the procedure
    - Describe your quantitative observations
- Could you improve your procedure?
    - Describe any improvements that can be made
- Checking your procedures for clarity: if you handed your procedure to a different team, would they be able to perform the procedure, and obtain the same results you did?