An Experiment on Measuring Volumes

Learning Physics From the Crow and the Pitcher Story

Figure 1: Borrowed from The Aesop for Children, by Aesop, illustrated by Milo Winter, Project Gutenberg etext 1994

Do you remember the childhood fable of the crow and the pitcher? If you have forgotten, this may jog your memory.

In this unit, we will imitate the crow in the story and use the scientific principle that a body submerged in water displaces an amount of water equivalent to its volume to carry out some measurements. The last task is actually very closely related to the tale– and you may reach a surprising conclusion at the end of it!

Materials Required

- A narrow transparent cylinder (or a transparent 500 mL water bottle with the top cut off).
- Similar sized glass marbles (~40)
- Small irregular stone which can fit into cylinder comfortably (see note in task 4)
- Ruler
- Marker pen that draws thin mark
- Straight edge (like another ruler or edge of a notebook)

Are you familiar with these ideas?

•Volume:

• Displacement of fluids by solid objects:

• Average/ Mean:

Task 1: Creating Your Own Volume Measuring Instrument (a Graduated Cylinder)

1) Use the beaker to carefully measure 50 ml water and transfer it to the transparent cylinder. Mark the height of the water on the cylinder using a marker pen.
2) Repeat this till the cylinder is almost full, marking successive heights at steps of 50 ml.
3) Label the markings with appropriate multiples of 50 ml. (50,100, 150,...)

Now, you have a graduated cylinder which can measure volume. You will notice that we can use this cylinder to measure volume only in multiples of 50 ml. Hence 50 ml is the least count of this graduated cylinder.

Maximum volume your graduated cylinder can measure _____
(Highest marking on the cylinder)

Task 2: Measuring the average volume of marbles

1) Take the empty cylinder and fill it up to 200 ml mark.
2) Drop marbles in the transparent cylinder one by one while counting them, until the water level rises up to the next mark. The water level rises because each marble displaces an amount of water equal to its own volume.
   Volume of water before adding marbles _____
   Volume of water after adding marbles _____
   Number of marbles required to raise the water level to the next mark _____
   Thus, _____ marbles displace _____ volume of water.
3) Use this result to estimate the average volume of one marble. (V_{exp})
   Average volume of one marble _____

Task 3: Comparing the measured volume of marble with that obtained by using formula

1) Keep 10 marbles in a straight line touching each other (You can create a long narrow channel by a straight edge on one side and ruler on other side).
2) Measure the end to end length of the line of marbles.
   End to end length of marbles _____
3) Use this measurement to estimate the average radius of the marbles.
   Average radius of one marble _____
4) Calculate the volume of a sphere $\left(V_{math}=\frac{4}{3}\pi r^3\right)$ using the radius you have obtained.
   Volume of one marble _____
5) Estimate the percentage error using the formula: $\frac{|V_{math}-V_{exp}|}{V_{math}}\times 100\,\%$
   Percentage error =_____

Task 4: Measuring the Volume of an Irregular Stone

1) Fill the cylinder to 200 ml mark with water.
2) Put an irregular stone in the water (The stone should be completely immersed inside the water with the water level at least 2-3 cm above the upper surface of the stone).
3) Estimate the volume of the stone by observing the amount of water displaced. Unlesso the water level matches with one of the markings, this will only be approximate measurement.
4) Now, immerse enough marbles to bring the water level up to the next marking.
   Volume of water before adding the stone _____
   Number of marbles required to raise the water level to the next mark
   _____

The irregular stone + _____ marbles displaced _____ volume of water.

Final volume f stone + marbles + water _____

5) Use the mean volume of marbles, V_{exp} obtained in task 2 to determine the volume of the stone more precisely.

Volume of the irregular stone _____

Task 5: A challenge

1) Fill up the cylinder to 50 ml mark.
2) By adding enough marbles, try to raise the **water level** to the top of the cylinder.
3) If you do not succeed in raising the water level to the top, can you estimate the maximum marking to which the water level rises?

Maximum marking to which the water level rises _____

Number of marbles required to raise the volume by that much amount _____

4) Can you think of an explanation for this?

_____

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_____

5) Do you think the thirsty crow would have succeeded in quenching its thirst?

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