Plot the Dot: A Graphical Approach to Density

Materials

Glass marbles
Steel washers or nuts
Plastic bags
Balances
Wood pieces (ordinary pine shelving wood)
PVC pieces
Graduated cylinders and/or appropriately calibrated beakers or measuring cups -- NOTE: volumes of the samples will be determined by water displacement, so the samples must be able to fit into the containers or, conversely, the containers must be big enough to hold the samples!
Water
Large piece of graph paper for plotting group data
Labels -- 3/4 in. diameter circular labels of five different colors (for water, glass, steel, wood and PVC)

Procedure

1. Find the mass of the volume of water that is assigned to your group. Record the mass and volume in the spaces below:

mass: _____g volume: _____mL

2. Write the **mass** and the **volume** of the water on the appropriately colored label (color will be specified by your instructor), and stick the label at its appropriate mass-volume coordinates on the large graph.
3. Find the mass and volume of the contents of each of the four numbered bags of materials you are given.
   Use a balance to find the mass (in grams). You may consider the mass of the One-Zip quart bag to be 5 g, or you may use a more refined technique if you wish.
   Use water displacement to find the volume (in milliliters). **After you are finished with the water displacement for a material, please use the towels to dry the excess water from the sample as best you can (without taking a lot of time) and return it to it's original numbered bag.**
   Record data for your samples in the table below:

bag nr	substance	mass (g)	vol H2O initial (mL)	vol H2O final (mL)	vol of sample (mL)
	glass				
	steel				
	Wood				
	PVC				

4. For each of your four samples, write the **bag number**, the **mass** and the **volume** of the sample on the appropriately colored label (colors will be specified by your instructor), and stick the label at its appropriate mass-volume coordinates on the large graph.
5. Notice the regularities on the large graph after the entire group has finished placing their labels.
6. Using a straightedge, draw the best straight line for each of the four materials represented on graph. Use (0,0) as the starting point of each line (when mass is zero, volume is zero).

Questions/Conclusions

1. If you draw a slope triangle for any of the lines, what will be the **units** of its: rise_____ run_____.
The **units** for the slope of any of the lines will be _____

2. The physical quantity represented by the slope is _____. The larger the value of the slope (the steeper the line), the greater the _____.

3. Rank the materials, including water, 1-5 in order of density, with 1 being largest:
1_____ 2_____ 3_____ 4_____ 5_____

4. What is the special significance of the slope values for the four materials relative to the slope value for water?

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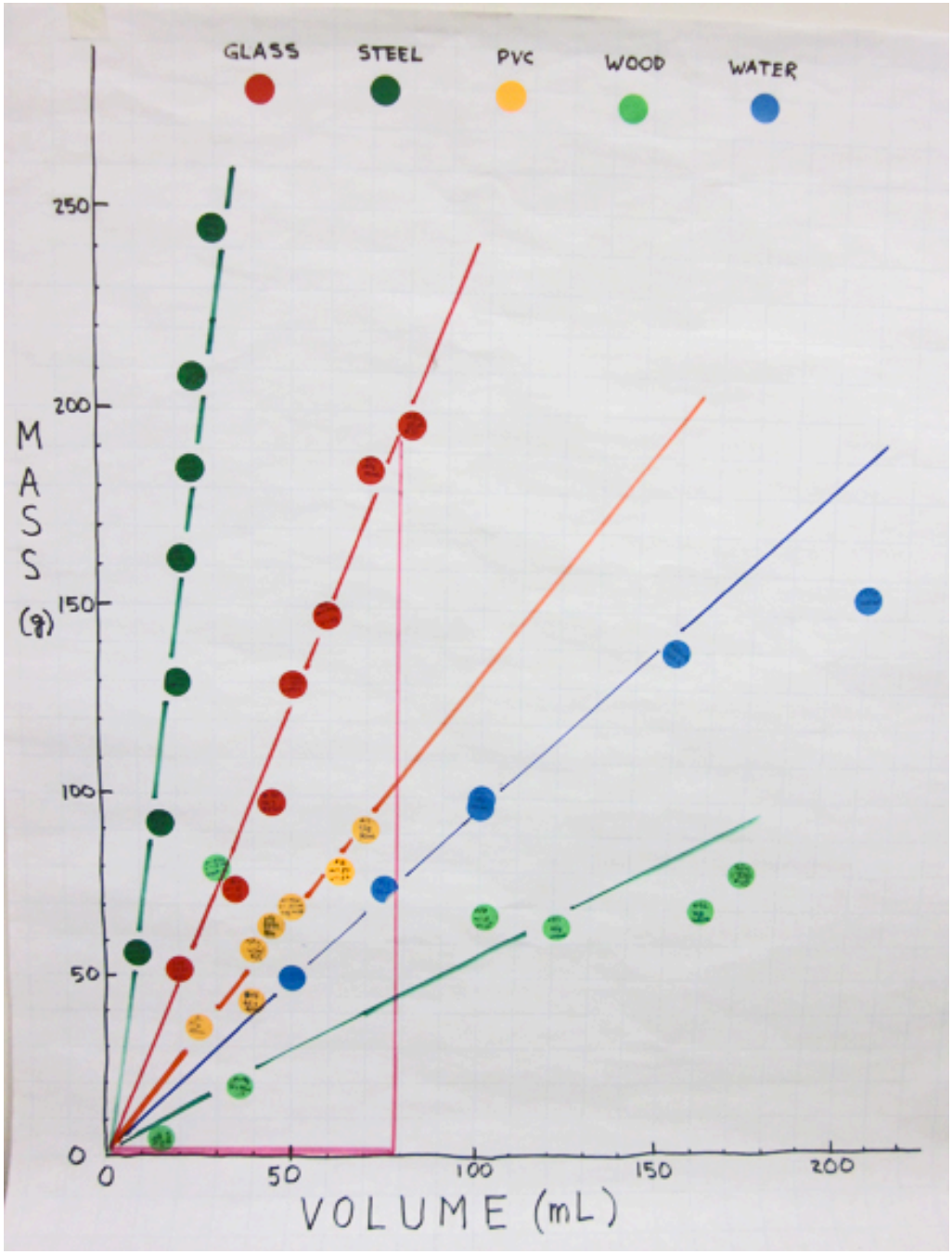
Going Further

Shown below is a class graph from 2012. Since colors do not show on a black and white image, it will be noted that the steepest line is steel, the next steepest is glass, the third is PVC, the fourth is water and the least steep is wood.

1. Draw a slope triangle for each straight line. The triangle for glass is drawn as an example.
2. Determine the rise and run values for each slope triangle, with appropriate units (g for rise, and mL for run). For the triangle shown for glass, the values would be approximately 192 g and 80 mL.
3. Calculate the slope for each line (rise/run), with units (g/mL), and state the values for the densities. The value for glass is shown as an example.

water: _____g/mL glass: 2.4 g/mL steel: _____g/mL wood: _____g/mL PVC: _____g/mL

4. Check these against accepted values. A web search showed 2.5 for common glass. The wood is pine.
5. A "best-fit" straight line has been drawn on the graph for each substance by subjective visual inspection. What is a likely explanation for points that lie significantly far away from a "best-fit" line?



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Plot-the-Dot Mass Values

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This page is included as a potential time-saver for teachers when preparing samples. There is nothing sacred about these exact values. The only real requirement is that the range of mass-volume points plotted for a particular substance are spread out enough on the graph so that a line is clearly defined.
For the mass values shown below, the graph axes used had maximum ranges of 250 g and 200 mL (see graph example).
All masses were determined using a 5g tare for the One-Zip quart bag (see Procedure step 3).
For teacher convenience, samples are shown sorted by bag number and also by mass.

	Bag #	Mass			Mass	Bag #
WOOD	41	36			4	44
	42	71			16	46
	43	65			24	45
	44	4			36	41
	45	24			49	47
	46	16			65	43
	47	49			71	42
	48	81			81	48
PVC	11	104			36	18
	12	79			42	17
	13	91			57	15
	14	71			65	16
	15	57			71	14
	16	65			79	12
	17	42			91	13
	18	36			104	11
GLASS	31	198			26	38
	32	184			52	37
	33	146			78	36
	34	125			98	35
	35	98			125	34
	36	78			146	33
	37	52			184	32
	38	26			198	31
STEEL	21	224			54	28
	22	244			91	27
	23	131			131	23
	24	186			162	26
	25	206			186	24
	26	162			206	25
	27	91			224	21
	28	54			244	22

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