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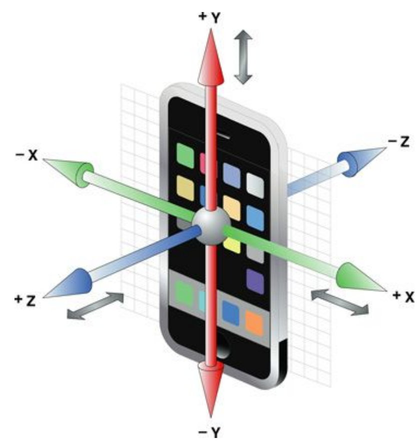
Scaling Down, Effects on Behavior

Nanotechnology is todays Industrial Revolution. Futurist predict it will change our way of life much like industrialization did back in the late 1700's to the mid 1800's. What is the big deal about Nanotechnology? It is incredibly small!

Nano mean 1 billionth of something. A billion is 1 000 000 000 of something and a billionth is .000 000 001 of something. Scientist are building with substances that are $1*10^{-9}$ in size! They are making things like tiny accelerometers that are found in your phone and Wii controllers. These structures detect motion (acceleration) in a specific direction. If you tip your phone to the side, the image "flips" to stay upright.



Scientist are also building structures one atomic layer at a time. This advance in technology will drastically impact the products of the future. Imagine a sensor on your carton of milk that indicates that milk has gone bad. Solar panels will become for efficient, batteries will become lighter and last longer, and medicine may enter the body like a magic bullet, targeting only the diseased tissues. Thinking small will have huge impacts on the future!

In this activity you will investigate two concepts, what is a billion and how does size affect the behavior of a substance.

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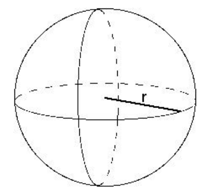
Activity 1 What does a billion look like?

Materials

3 different size styrofoam balls
length of string
container (box)
rabbit fur/wool/silk/plastic wrap
glass rod/ plexiglass rod
scale

Procedure:



Volume $= \frac{4}{3}\pi r^3$

1. *Devise a method to determine the volume, mass and density of each of the styrofoam balls, using the materials given. Record your results in Data table #1. (using cm)*
2. *Determine the volume of box in* cm^3*., record in Data table #1*
3. *Explain how you would predict how many styrofoam ball would fit into the box without actually filling the box up with styrofoam balls.*
4. *Write your prediction in Data table #1.*
5. *Test your prediction and record the actual number in the data table.*
6. *If there was a difference in number predicted explain why there was a difference. (note: mathematical error is not an acceptable response)*
7. *If you filled the box with each type of styrofoam balls, would the final mass for the box filled small styrofoam balls be the same the box filled with one of the others? Justify your answer.*

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RESULTS:
Volume of the Box: (Show calculations)

DATA table #1

styrofoam ball size	*mass in grams*	*Volume cm^3*	*Density g/cm^3*	*# of balls prediction*	*# of balls actual*	*Mass that would fill the box*
small						
medium						
large						

8. Which box filled with styrofoam balls would have the greatest density?

9. What conclusions can be made about very dense materials from this exercise?

10. Choose 1 of the values for the number of balls that filled the box.

example: 8 balls= 1 box

Predict how many balls would be in 10 boxes using either ratio or factor label method. Fill in the chart.

(ratio:) $\frac{8\text{balls}}{1\text{box}} = \frac{X}{10\text{ boxes}}$ $\qquad$ $\frac{10\text{ boxes}}{} \Big| \frac{8\text{ balls}}{1\text{ box}}$ *(factor label)*

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boxes	1									
Balls	8									
$1*10^x$ notation indicating units of boxes	$1*10^0$									
	one	ten	hundred	thousand	ten thousan d	hundred thousand	million	ten million	hundred million	billion
metric prefix	unit	deca	hecto	kilo			mega			giga

11. *If your box was 30 cm tall, how tall would _____ be?*

a. ten boxes ____________________
b. ten thousand boxes ____________________
c. 1 billion boxes ____________________

12. *The above exercise considers getting bigger by a factor of 10, what if we get smaller by a factor of 10 and go to a billionth? Fill in the following chart,*

boxes	1	1/10								
Balls	8	.8								
$1*10^x$ notation indicating units of boxes	$1*10^0$	$1*10^{-1}$								
	one	tenth	hundredth	thousandth	ten thousandth	hundred thousandth	millionth	ten millionth	hundred millionth	billionth
metric	unit	deci	centi	milli			micro			nano

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13. Just checking! Which box can hold more stuff? (circle the correct answer)

a. *10 decimeter*^{3} *or 10 micrometer*^{3}

b. *2 hectometer*^{3} *or 2 micrometer*^{3}

c. $1*10^{-7}$ cm^3 *or* $1*10^{-3}$ cm^3

A billionth is really small!!! Consider scientist working with substances that small. For example a single atom of aluminum has a diameter of approximately 0.25 nanometers! Scientists are able to make thin films only a few atoms thick. Does working with an atom of aluminum differ from working with a block of aluminum? In this next exercise we will investigate the effect of size on behavior.

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Activity #2: Behavior

Procedure:

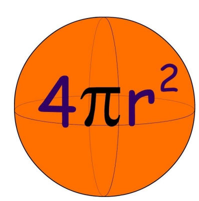
1. Predict which ball can be throw the furthest distance and record your prediction in Data table #2.
2. Explain why you think ball "x" can be thrown farther than the others. Place your explanation in the space provided on the chart.
3. Throw each ball horizontally from the line on the floor and record the distance in centimeters in your data chart.
4. Take the average of the three trials for each and record in your data table.

Prediction:	
Reason:	

Distance (cm)	Trial 1	Trial 2	Trial 3	Average
small				
medium				
large				

5. Compare your results with your predictions, are they the same why or why not?

6. What is the relationship between surface area and distance? Calculate the surface area of each using the following formula to the right. After calculating the surface area in centimeters, determine ratio of distance to surface area.



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	surface area (cm^3)	distance (cm)	ratio distance/surface area
small			
medium			
large			

Activity #3: Investigating Effect of Charge on Size

Procedure:

Does size influence response to accumulated charge? Styrofoam accumulates electrons (negative charge) from substances that give up electrons easily. Wool, silk or rabbit fur will give up electrons and become positive.

1. Place a large stryofoam ball and a small styrofoam ball in a ziplock bag with one of the materials. Shake the bag and rub the materials together. Place each ball on a dry smooth surface.
2. Charge a glass rod or plexiglass rod using rabbit fur, wool, silk or plastic wrap by rubbing the materials together. (balloon rubbed on hair will also work)
3. Place the charged rod (balloon) near the stryofoam record your observations.

	response	
large styrofoam ball		
small styrofoam ball		

8. Does size influence the response to accumulated charge?

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9. Predict which would dissolve faster in room temperature water; 3 gram sugar cube or 3 grams of granulated sugar. Explain your answer!

10. In nanotechnology, size does matter. Identify two different issues scientist may have when working at the nanoscale.