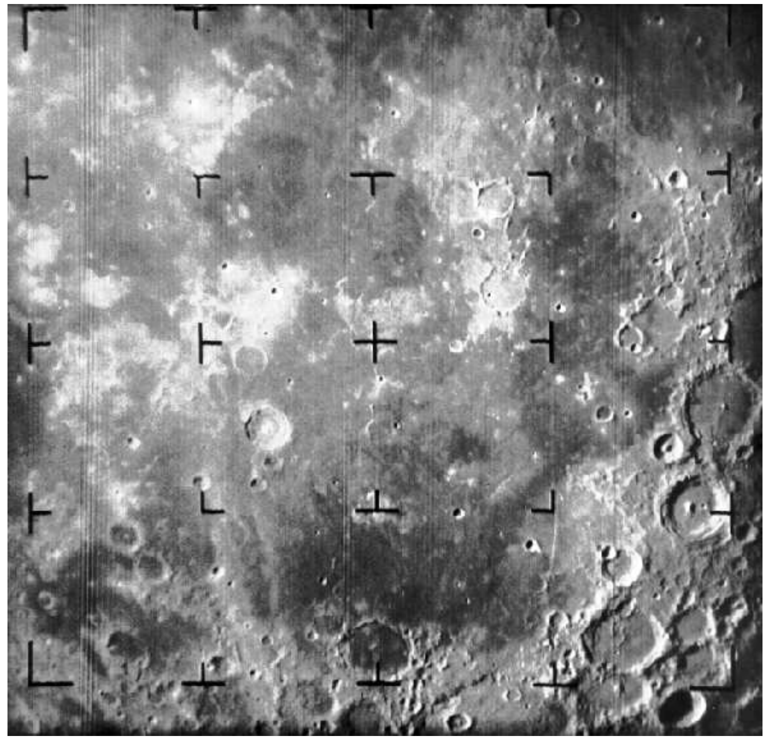
Craters

When a meteoroid (called the "impactor") hits the surface of a planet or moon, it creates an impact crater. As the impactor's kinetic energy is dissipated, the resulting explosive energy release carves out a crater.

This picture of our Moon's Mare Nubium and surrounding hills, shows some of the Moon's surface is quite smooth while other regions are covered in craters. By measuring the sizes and number of craters, astronomers can learn about the impactors that struck the surface and also about the ages of various regions on the planet's surface.

Keep in mind that plantary impact craters are caused by hypervelocity impacts (the projectile is moving faster than the speed of sound); this makes almost all craters circular. In this lab you will be doing subsonic impacts, so the craters are not as large as they would be if the projectile was moving several kilometers per second!



This photograph of the Moon's Mare Nubium was taken by the Ranger 9 spacecraft in 1965. *(NASA Image ID number: Ranger 9 A001)*

Part 1: What should we measure?

From what you observed when you made craters in the bucket of sand, write down as many factors as possible:

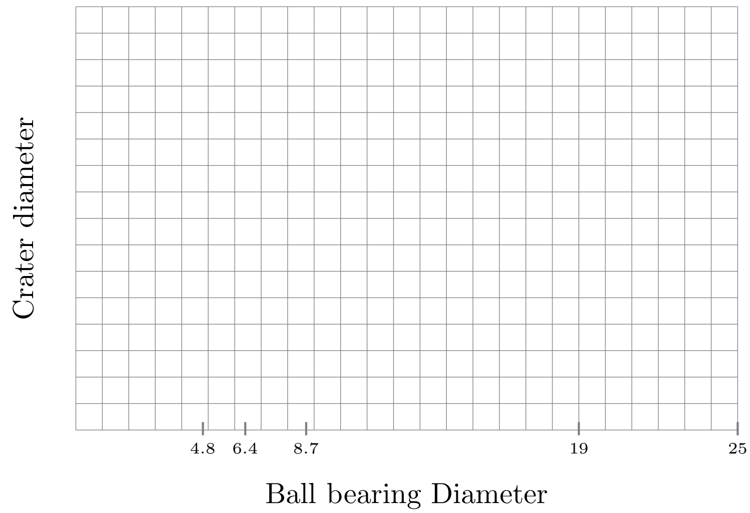
The appearance of a crater depends on these factors
Characteristics that describe a crater

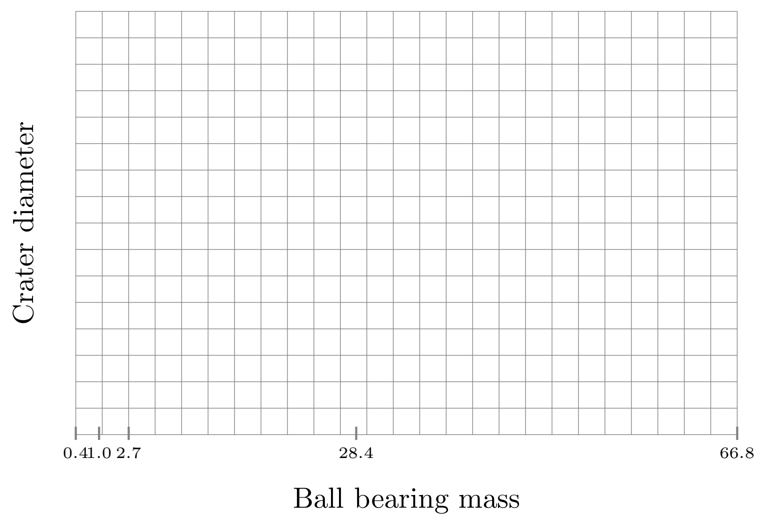
Part 2: Explore, discover and predict

The appearance of a crater depends on many factors. Here, you will use steel ball bearings dropped from a constant height, told to you by your TA. Each time, measure the diameter of the crater and record your results. Shine a flashlight across the surface of the sand to make the crater easier to see.

> **Goal:** Use the data to make 2 graphs that you can use to predict the size of a crater that forms when you drop a steel ball bearing with a certain diameter from the same height.

Drop height:		
Ball Bearing		Crater
Diameter	Mass	Diameter
$4.8mm$	$0.4gr$	
$6.4mm$	$1.0gr$	
$8.7mm$	$2.7gr$	
$19.0mm$	$28.4gr$	
$25.4mm$	$66.8gr$	





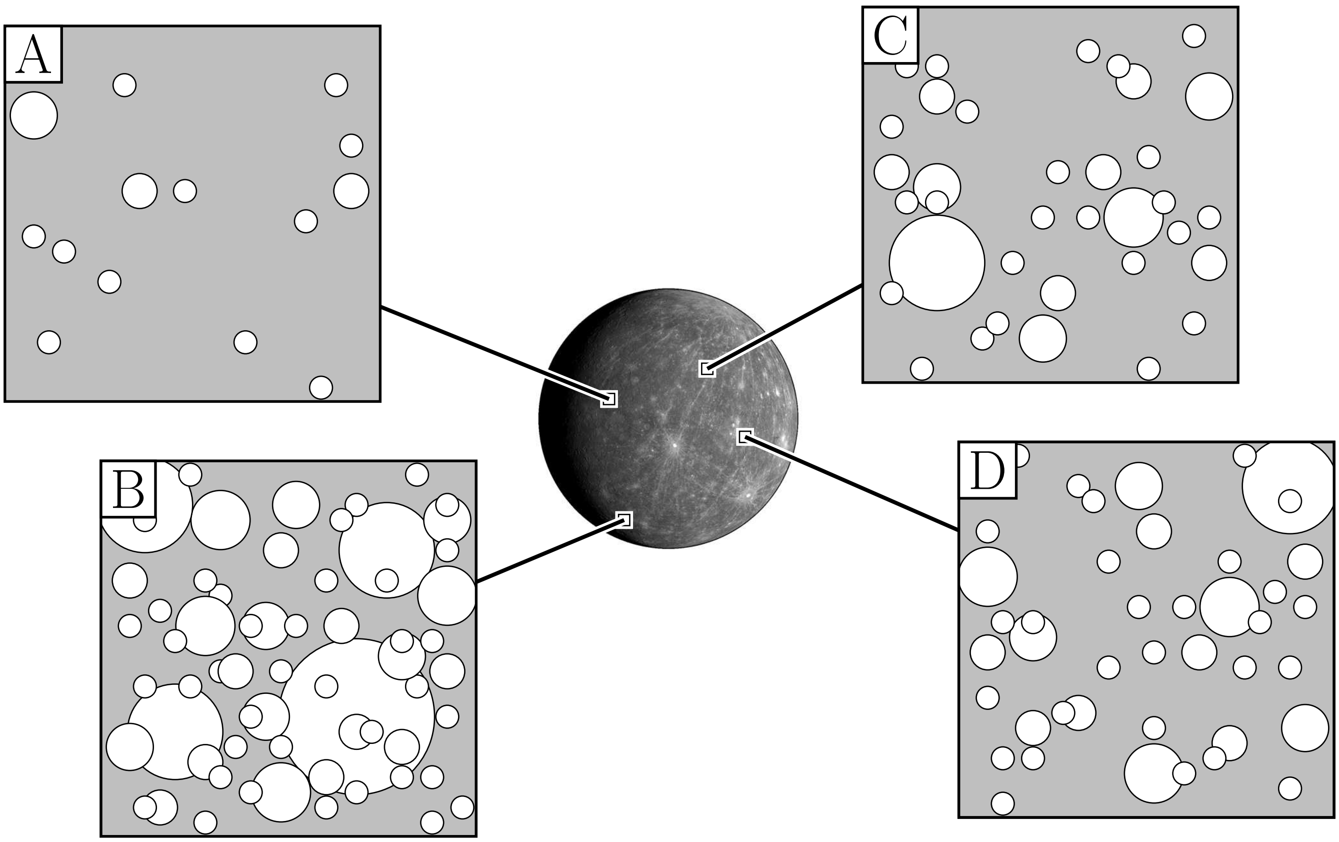
Based on your graphs, what is the diameter of the crater that forms when you drop a steel ball bearing with diameter 12.7 mm and mass 8.4 g into the sand from the same height you dropped the other ball bearings? Make your predictions in boxes below and then **show them to your instructor**, who will give you the $12.7mm$ ball bearing for you to do the experiment.

prediction from diameter *vs* diameter	prediction from diameter *vs* mass	Experimental result
best prediction		

Part 3: Surface Chronology

Impactors have been hitting the planets and moons in the Solar System since they formed 4.5 billion years ago. Volcanoes, floods, weather and other physical processes that smooth out the surfaces have erased some of those craters, though. By counting the number of craters in a region of a planet or moon, astronomers can estimate the age of the surface, that is, how long craters have been forming on the surface **since it was last smoothed out.** This is called the surface resetting age.

Four different regions of the same planet, as they appear today, are shown in the pictures below. Only craters larger than 1 km are shown.

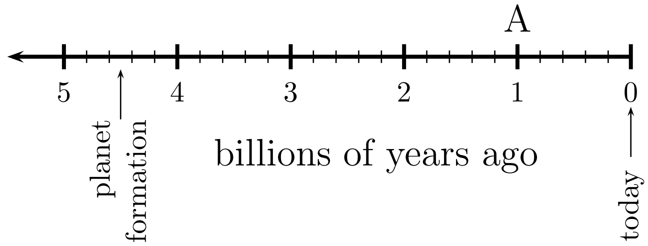


Write the letters A, B, C, D in the boxes below to arrange the four surfaces from oldest to youngest.

oldest youngest

For this hypothetical plant, assume that impactors big enough to create the illustrated craters arrive at an average rate of 14 impacts per billion years, for the amount of planetary surface area shown (since the rate is per unit area). We can use this average rate to estimate the surface resetting ages for different regions.

This time line runs from today (time 0) back into the past to planet formation (4.5 billion years ago.) **Write the letters A, B, C, D** on this time axis at the locations which show their ages. For example, region A has only 14 craters, so its surface 1 billion years old.



Name ______________________ ID No. ____________ Tutorial Day/Time ____________

Part 4: Questions

Please hand in this worksheet when you're done.

1. Copy your crater diameter data from Part 2 into this Table. Then calculate the ratio of the crater diameter to the impactor diameter.

   You should find the ratio is about the same for all ball bearings. Approximately what is the ratio? ______________________

   Which height did you drop from? __________

   Talk to a group who dropped from the other height. What is their ratio? ____________

Crater Diameter (mm)	Impactor Diameter (mm)	Ratio: $\left(\frac{\text{Crater Diameter}}{\text{Impactor Diameter}}\right)$
	4.8	
	6.4	
	8.7	
	12.7	
	19.0	
	25.4	

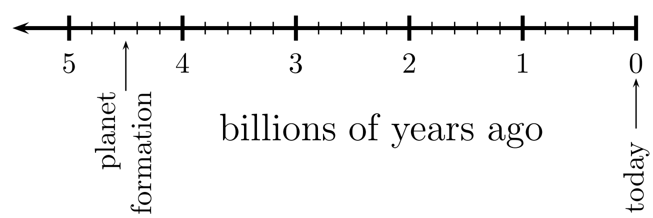
   How do you think the ratio will change if you drop the ball bearings from 10 meters high?

   smaller ratio   no change   larger ratio

2. Two rocks, a and b, hit the Moon and form craters. The rocks are made of the same material and hit the surface at the same speed but the diameter of rock b is 2 times larger than the diameter of rock a. What can you say about the craters formed by these two rocks? Check one:

   - ☐ crater b is about 8 times wider than crater a
   - ☐ crater b is about 4 times wider than crater a
   - ☐ crater b is about 2 times wider than crater a
   - ☐ crater b is about $\sqrt{2}$ times wider than crater a

3. Copy your chronology from Part 3 onto this time axis.

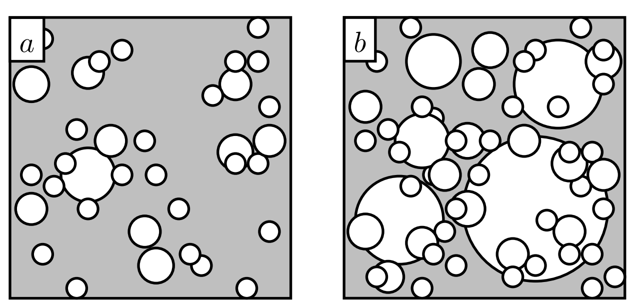


   Suppose it was a flood that smoothed out Region C. How many years ago did that flood occur?

   Over what **interval of time** (from when to when) did the impact craters in Region C form?

   Shade the box above the timeline over the entire time period when impact craters were forming on Region C.

4. The pictures show two cratered regions, a and b, of the same size on the planet Mercury.

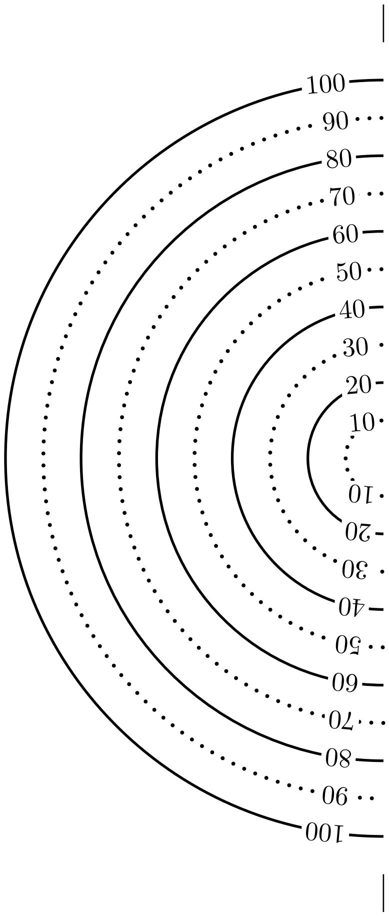


   What can you tell about the relative resetting ages of the surfaces of the two regions? Check one:

   - ☐ surface a is younger than surface b because surface a has had recent floods and/or volcanic eruptions
   - ☐ surface a and surface b are the same age, the age of Mercury
   - ☐ surface a is older than surface b because surface a has had many floods and/or volcanic eruptions
   - ☐ surface a shows a region of Mercury that receives less impacts than surface b so you can't tell from these pictures which surface is older

The appearance of a crater depends on these factors:

Characteristics that describe a crater: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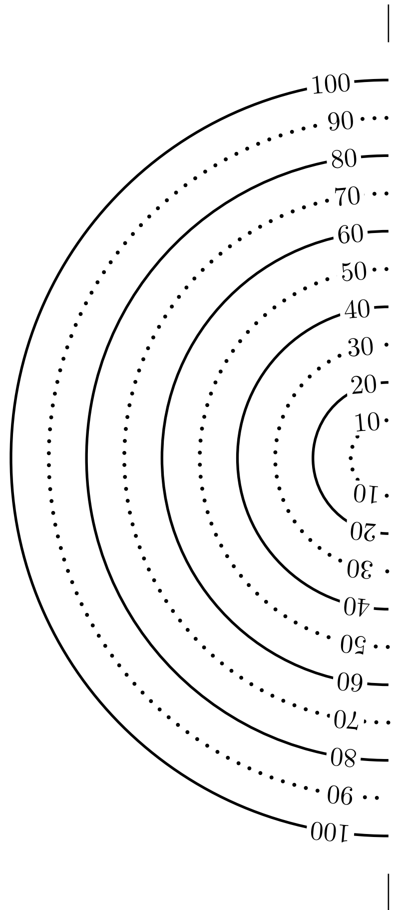
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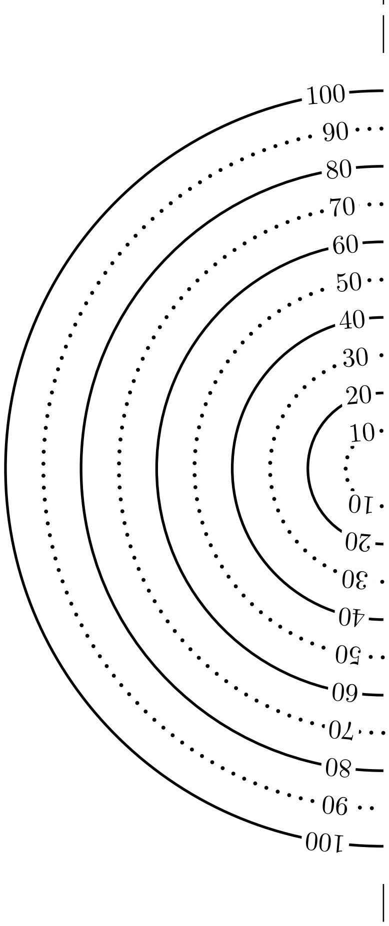
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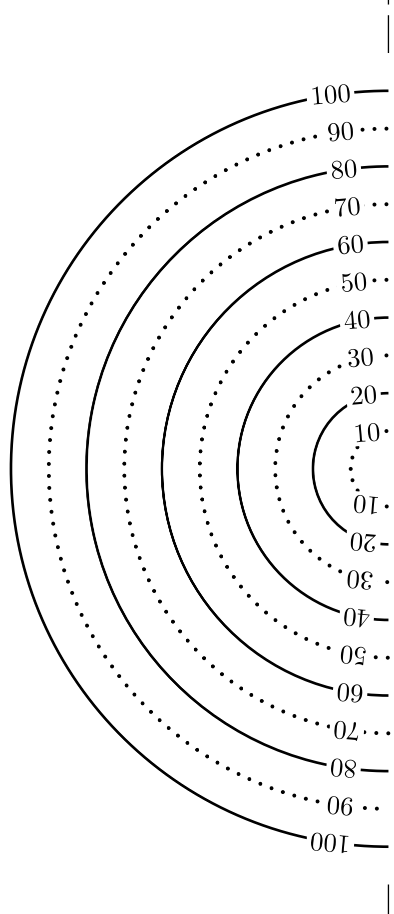
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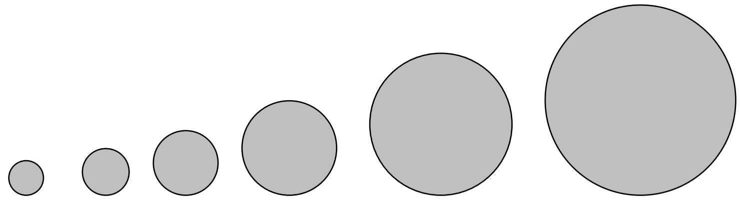
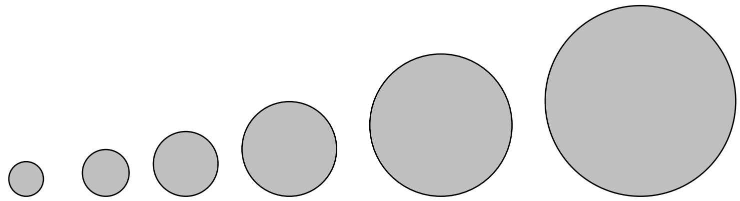


Steel Ball Bearings						
Diameter (mm)	4.8	6.4	8.7	12.7	19.0	25.4
Mass (g)	0.4	1.0	2.7	8.4	28.4	66.8



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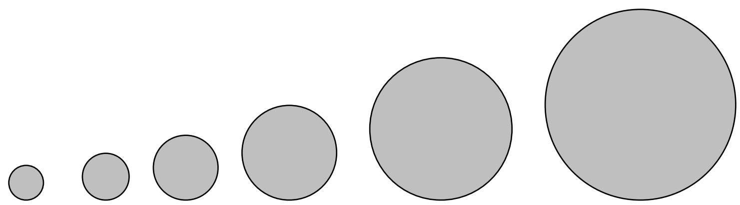

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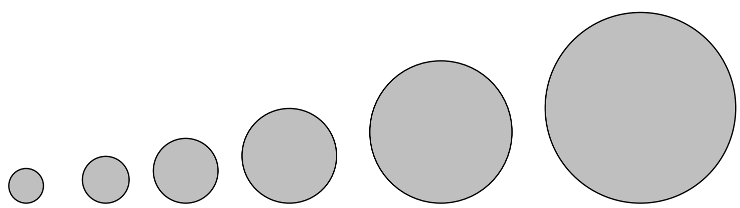

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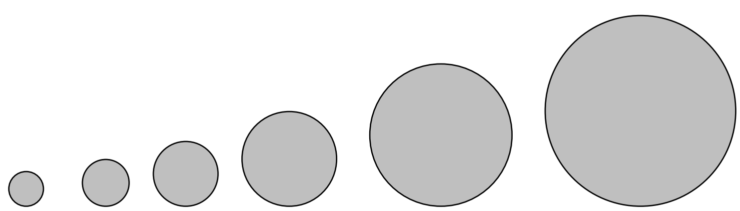

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