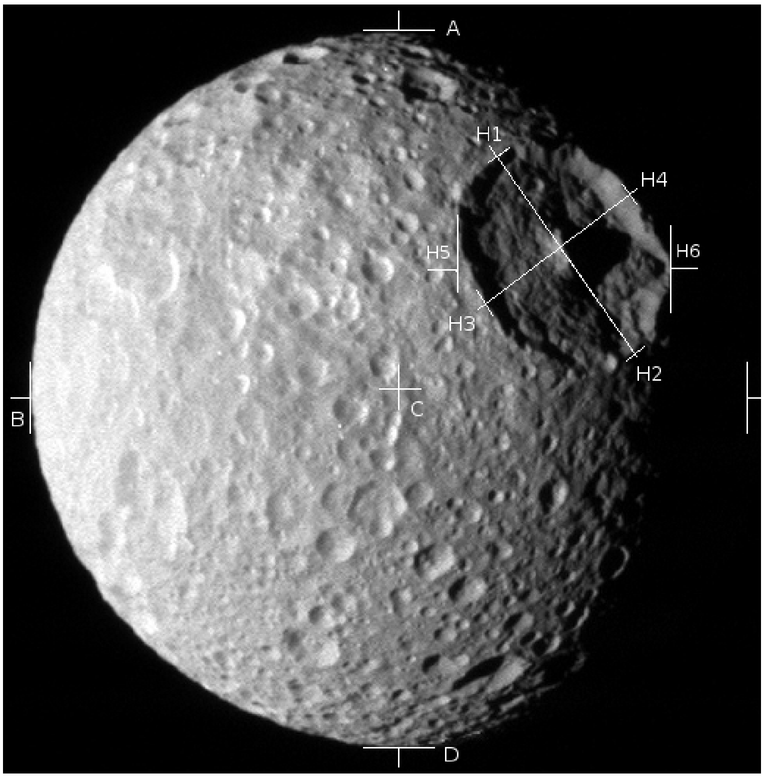
CRATERS in the SOLAR SYSTEM

1) Click the mouse button anywhere inside the image; this will cause the coordinates of the pixel on which the cross hair lies to be displayed at the left-hand side of the screen. Now move the cross hair to your best estimate of the "north pole" of Mimas. Then click the mouse button, and move the mouse so that the cross hair is on your best estimate of the "south pole" of Mimas. Determine the diameter of Mimas in pixels:

diameter of Mimas = (See Below)



2) We know from measurements taken by Voyager that the actual diameter of Mimas is 390 km. Now we can find the scale of this image in km/pixel:

scale = (diam. in km)/(diam. in pixels) = km/pixel (See Below)

Measured							
Data Points	**A**		**B**		**C**	**D**	
x	270		19		270	270	
y	506		261		261	16	
Conversion to							
C = 0/0							
x	0		251	W	0	0	
y	245	N	0		0	245	S
Using y axis	**AC+CD(Q1)**		**2D Px/Km(Q2a)**		**3D Px/Km(Q2b)**		
for Diameter	490	px	0.80		1.25		

Notes:
1) In an on going effort to increase accuracy I have located an image of Mimas that is 4x the area resolution of the given one and converted it to a FIT and used that for measurements.
2) Q2a uses the given 390 km Diameter to make the calculation.
3) Q2b uses half the calculated circumference to derive the answer to take account of the fact that Mimas is a three dimensional sphere.

3) Notice that the crater is not oriented north-south; find the widest part of the crater, and measure the diameter in the same manner as you measured the diameter of the whole moon.

diameter of crater = (See below)

4) Now multiply by the scale factor to find the diameter of Herschel crater in kilometres:

diam.(pix) x scale (km/pix) = diam. = km (See below)

Hershel Crater Dimensions						
	H5(x)	H6(x)	Diameter(Px)			
Distance	309	454	145			
	2D	3D				
	115.41	181.28	Km			
	H1/H2	H3/H4		Average	Actual	
Angular	143.2	136.98	Km	140.09	140	solarviews.com

Notes:
1) The *distance* data in the above table represents the required method for finding the diameter of the Herschel Crater. I have calculated it taking into account a flat *2D* representation together with the spherical 3D version.
2) Being unhappy with the accuracy of the my findings I went on to derive the angular positions of H1 - H4 using the formula from the last assignment. Reducing the data to simple right angled triangles I calculated the hypotenuse of each, thus determining the angular distance between H1/H2 and H3/H4. From the given diameter of Mimas (390km) I calculated the circumference from which I was able to determine the actual distance of H1/H2 and H3/H4. Averaging them both out produced a figure I was more happy with.

5) What fraction of the diameter of Mimas is the diameter of Herschel crater?

	Crater as a fraction of the diameter		
	Fraction	%	
2D	0.2959	29.59	
3D	0.4648	46.4827	
Angular	0.3592	35.92	

6) Try to find the centre of Dione from the image. Get as accurate an estimate of the radius of Dione in pixels as you can. One method to estimate the radius is to go to a 'zoom' of 200% and adjust the image so that you are viewing one 1/4 of the image.

radius in pixels = See below

7) The actual radius of Dione is about 560 km. Now you can estimate the scale factor for this image in the same way you did for the image of Mimas.

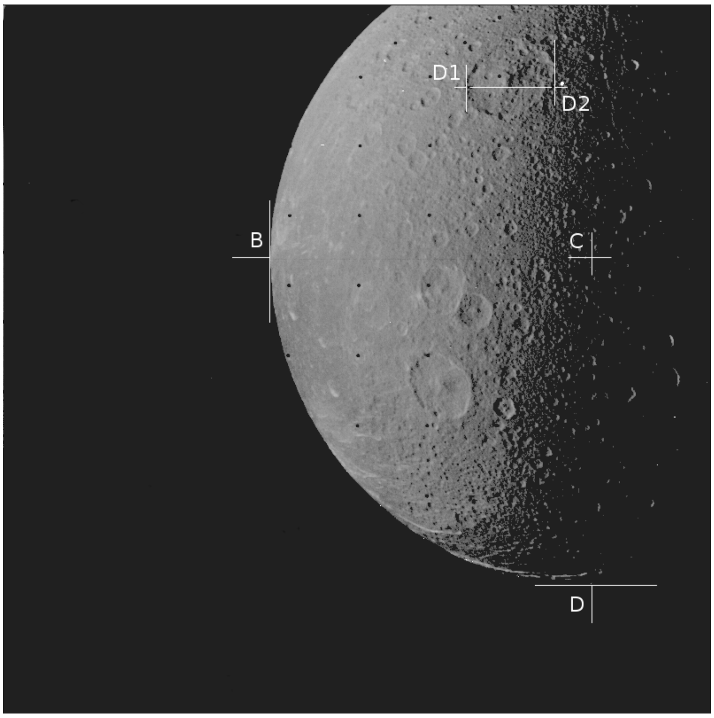
scale factor = (radius in km)/(radius in pixels) = See Below

Data					RadiusCalc.		
	B	C	D		BC	DC	Average(Px)
x	301	665	665		364	370	367
y	515	515	145			2D	
					Scale Km/Px	1.53	

8) Scroll up the image as far as it will go. Look for the largest crater you can find, and estimate its diameter in the same way you did for Herschel crater on Mimas.

diameter of crater in pixels = See Below

	D1	D2	
x	523	624	
	Px	x Scale	
	101	154.11	Km



9) Which crater is larger, this one on Dione, or Herschel on Mimas?

A) Dione

Which crater is larger IN PROPORTION TO THE BODY IT IS ON?

A) Herschel on Mimas (Data Below)

Relative Crater Sizes (2D)					
	Diameter	Crater Size	Proportion	%	
Mimas	390	115.41	0.296	29.59	
Dion	734	154.11	0.210	21.00	

A closer look at some craters...

10) Is there a difference in the appearance of the inside floor of a crater and the ground surrounding the crater?

Dione Crater

Moon Crater

Both of the above craters were selected for their similarity in size (About 60 Km across) and for their position with respect to the terminator so that lighting conditions were constant. The floors of these craters are markedly different Dione's being rough and granular whereas the Moon is much smoother. On the outside of the Dione crater little deformity of the surrounding surface from the crater's formation can be seen. On the Moon however surface disruption is evident at the 7 and 9 o'clock positions. Along the eastern edge the ground seems to rise appreciably towards the crater rim.

11) From what you know or suspect about the way impact craters form, would you expect there to be a difference? Why?

There are many considerations that need to be taken into account when examining a crater. I have listed some of them with their implications.

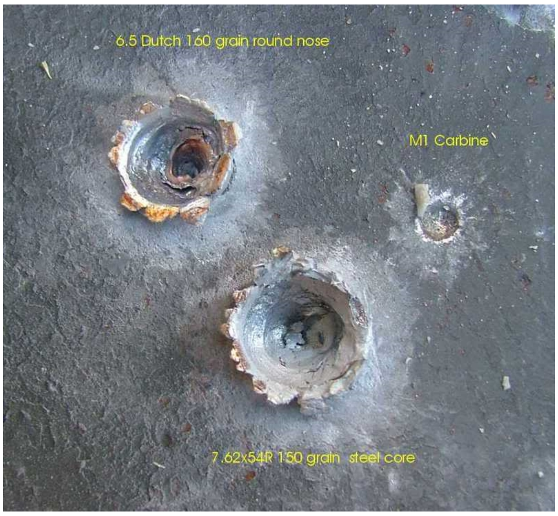
- Impacted body mass. Large mass bodies like our Moon have a higher gravity which causes higher energy impacts. More massive bodies are more likely to retain ejector from the crater formation.
- Impacted surface type and density. Where the impacted surface is rocky (similar to the Earth) then the vaporisation point is high meaning that for a given impact energy level more of the ejector is retained. Conversely a surface where the material is say, frozen water then much of the ejector is lost as steam. The density of the impacted material also plays a roll for an impact into bedrock will be quite different from one into a sandy surface which again will be quite different into a liquid.

Nature of Impactor. In general terms they come in two flavours, namely Asteroids and Comets. In turn Asteroids and their fragments can be subdivided into classes; Iron, Stony Iron and Stony. The iron meteorites are perhaps the most dense with the highest energy level for a given size and velocity. There is one other class of impactor that needs to be part of this list and has quite different effects on the impacted surface. Comets with their high water content, large size and high velocity (can be in the region of 1.6 million km/h at perigee) also contain huge amounts of kinetic energy and have the ability of causing massive disruption to an impacted surface. It is suspected that most of the water on planet Earth was shipped in aboard comets.
In the case of the above images the Moon's mean density of 3,346.4 kg/m and, from the findings of the Apollo missions, surface rock not unlike the Earth, means that its vaporisation point is very high. The conclusion is that much of the kinetic energy of the impact is held in the liquefied rock and as cooling takes a relatively long period as it radiates back into space and into the surround

ing surface, time is available for the rock on the inside of the crater to self level and produce a smooth terrain. A coherent, high density surface will want to resist deformation from the impact an will try to *push back.* This will cause the ground on the outside of the crater near the rim to compress and elevate, building noticeable slopes away from the rim.

Dione on the other hand with a mean density of 1.095 Kg/m^2 and a surface of mainly water ice has a low vaporisation point. The implications are that when a surface like this is impacted the kinetic energy is quickly dissipated into space as water vapour leaving little time for the surface to recover and self level. The chaos of the boiling slurry is almost instantly frozen leaving a rough and uneven terrain. The lower density surface also fails to *push back* and uplift of the surrounding area adjacent to the rim is much reduced.

12) Have you observed any examples of impact craters of any kind? What were they, and how were they formed? (Craters can be formed by a variety of falling objects, not only meteorites!)

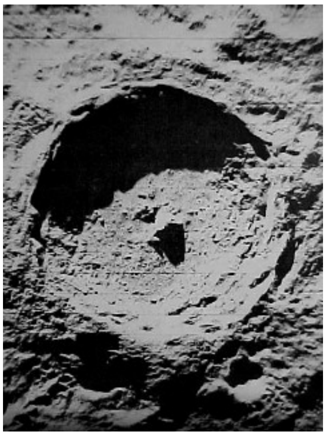


These images demonstrate cratering in every day life. Top left is of bullets impacting metal and although the kinetic energy is insufficient to melt the metal for anything but a very short period, it clearly demonstrates *push back* with the outside surface appreciably rising towards the cater rim. The bottom middle image is of rain drops on a sandy surface. In the realm of geology a question has long been asked about the patterns found in some sedimentary rocks. One of the main contenders to answer this is the fossilisation of ancient rain drop impacts. We may have many more craters on the earth than we thought! The short lived crater in the bottom left image caused by a water drop into water demonstrates surface rebound, a cause of central peaks in some craters. For the bottom right image cause and effect are well known!

13) Why do you think so few meteorite craters are observed on Earth compared with other bodies in the solar system?

Several causes conspire to erase the geological record of craters here on earth and perhaps the most insidious is that of erosion. After an impact wind, rain and the cyclic freezing and thawing of the seasons are quick, in a geological time scale, to remove every trace of all but the largest craters. Life itself can also have an eroding effect as many smaller impacts are covered in vegetation. Another cause, this time it stops the formation of craters in the first place, is our atmosphere. Many impactors fail to make it to the surface and are burnt up as they hurtle through it. Most meteors are an example of wanabe crater builders failing in their mission and burning up as they go. One very obvious cause is the fact that our earth's surface is 70% water and impacts into an ocean environment, while devastating with the subsequent massive tsunamis etc, mean that the resulting crater if one is formed is under the ocean surface and hidden from view. By far the most final of all causes is plate tectonics. Where the surface crust is recycled at subduction zones. Craters on continental crust that experience this are propelled under overlaying crust and are forced into the mantle where they are melted and form an indistinguishable part of the make up of the planet.

14) Many large impact craters have peaks in their centres. How do you think these central peaks formed?



The kinetic energy in a large impact is truly vast and orders of magnitude greater than the initial resistance of the impacted rock. It ceases to have any strength and behaves like a fluid. At the moment of impact the main pit of the crater is excavated. Almost instantly the the material on the inside of the crater walls begins to slump and move down towards the centre of the depression. As it comes together at the centre it has no other place to go but up and the ground rebounds forming a central mass that solidifies into the central peak. A graphic illustration of this happening is in the image on the previous page of a water droplet into water where the central rebound can be clearly seen. All that is missing from this example is a method of instantly freezing the example to make it permanent. The image on the left is of perhaps one of the youngest of the Moon's carters - Tycho with its central peak easily seen in the low attitude sunlight .

Power of Impacts

Question	Given	Units	Answer	Units
15) Convert density in g/cm3 to density in kg/m^3 :	3	g/cm^3	3000	kg/m^3
16) find the volume (V) in m^3 for a spherical body from V = (4 x pi x r^3)/3	1000	m (D)	523333333.33	m^3
17) Mass = (volume) x (density)			1570000000000	kg
18) convert velocity to m/sec :	10	km/sec	10000	m/sec
19) Now, let's consider how much kinetic energy is dissipated as heat and other forms of energy when this body K.E. = 1/2 mv^2			7.85E+019	Joules
20) How many megatons of TNT are equivalent to the energy released by our typical hypothetical impacting body?	4.20E+015	Joules	18690.48	Megatons

Coursework Submission Title Exploring the Universe - Assignment 6

Tutor this work is for Stacey Harbergham

Student Registration Number 467830

Student Name (BLOCK CAPITALS) ROGER CHAPRONIERE

I confirm that I am aware of the University Modular Framework Assessment Regulations (Section D Appendix C) regarding academic impropriety and that the work submitted conforms with those Regulations. I confirm that the coursework is my own and that all sources consulted have been appropriately acknowledged. I am aware that, in case of doubt, I may be required to take a viva voce examination.

Signature of Student: [signature]

Date: 21st June 2010