Stories of Other Worlds

Crater Diameter Prediction Lab—Walk Through

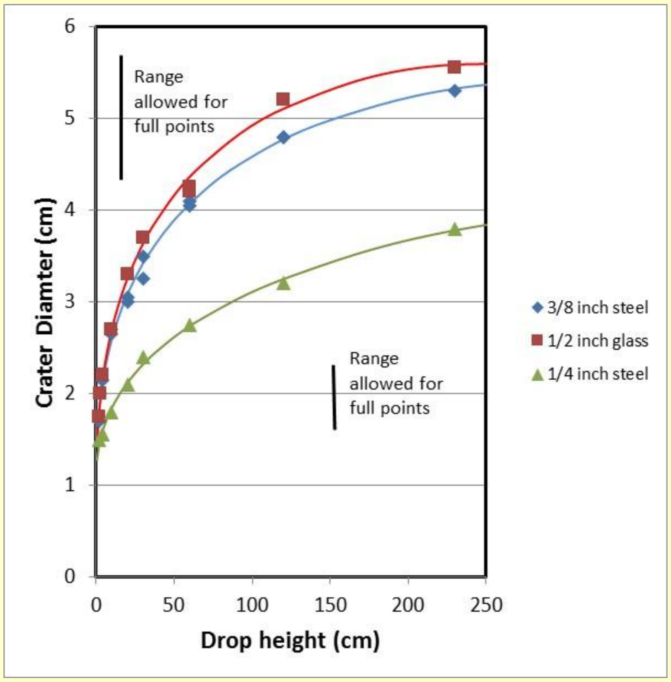
Earth Science Essentials-Advanced

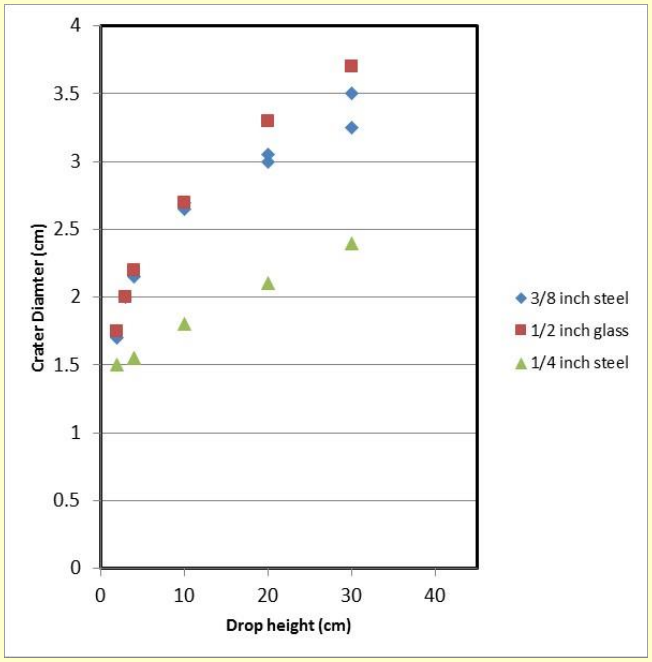
by Russ Colson

Part 1—Predicting crater diameters:

1 glass marble, 0.5" diameter, mass = 2.91g
smaller steel marble, 0.25" diameter, mass = 0.94g
larger steel marble, 0.375" diameter, mass = 3.31g

The easiest way to make the predictions of crater size on the short time frame that you are given is to make a graph that shows your experimental results. From this graph you can interpolate crater diameters for intermediate drop heights that you may not have experimentally determined. My data and graph are shown below, along with the range of variation allowable for full credit (±15%). The graph is shown at two different scales so that the variation in data at short drop heights can be seen and interpolations made.





Part 2—Does density have any effect on crater diameter that is different from mass and drop height?

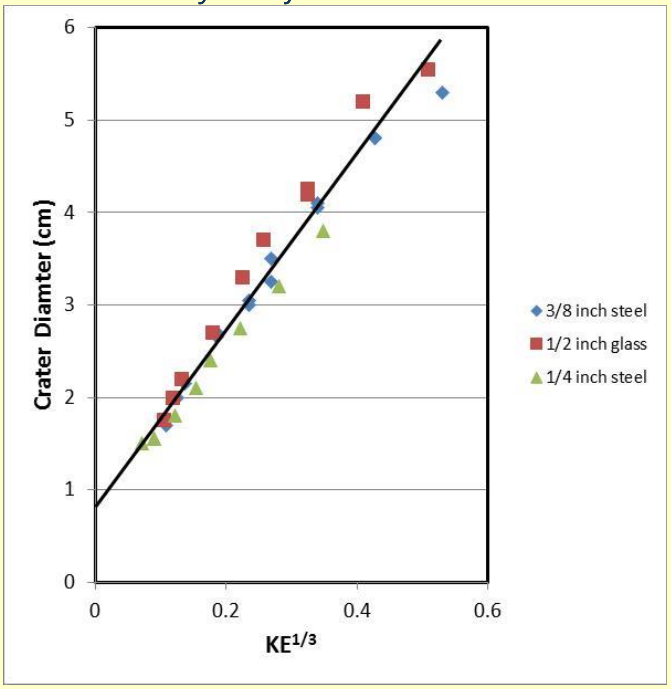
From the two experiments with different masses of steel but the same density, we can see that the effect of mass is to increase crater diameter for any given drop height.

The glass marble has a slightly *lower* mass than the 3/8" steel marble. Thus, we would expect that it would form smaller craters for any given drop height. However, it can be seen from the graph above that the opposite is true--the glass marble consistently makes a crater that is slightly bigger than the more massive 3/8" steel marble. That this difference is statistically significant can be inferred from the persistence of this trend over many different drop heights and for repeated experiments at single drop heights (most experiments were repeated 2-3 times—with many of the repeat experiments overlapping and thus not apparent in the graph above).

Thus, for any given drop height, the size of the crater formed by the glass marble is larger than what we would expect for a steel marble of the same mass. This difference must be due to the lower density of the glass marble (larger size for a given mass).

Part 3--Other thoughts
You can see from the graphs that the crater diameter does not vary in a linear fashion with drop height. The theoretical crater size expected for hypersonic impacts on planets is related to total kinetic energy of the impactor by the expression **crater diameter = k * KE$^{1/3}$** where k is a constant and KE is kinetic energy which equals ½ m*v^2 , where m = mass and v = velocity, and velocity is a function of drop height. This theoretical expression predicts a dependence of crater size on velocity and mass, but not density. The expression also predicts that the crater size passes through the origin, which it did not do in my experiments and probably didn't do in yours. So, the theoretical expression does not quite describe the situation for our sand and marble experiments.

If you're really ambitious, you might plot your data to show the relationship between crater diameter and **KE$^{1/3}$**. Is this relationship linear (making it consistent with the theoretical equation above)? My data are close, although the difference is greater than the uncertainty in my measurements!



Here are my tentative interpretations of the deviations of the subsonic sand craters from theoretical hypersonic impacts. Maybe you can test these ideas in your own classrooms!

1) Rather than pass through the origin, the subsonic impacts pass through the diameter of the impactor--thus, the 1/2" marble crater sizes average larger than the 3/8" steel, which average larger than the 1/4" steel.
2) There is a deviation from linearity at velocities below which the impactor is imbedded less than half way into the sand (that is, its maximum diameter is not experienced by the sand).
3) There is a deviation from linearity at velocities above which the impactor is completely below the sand surface after impact (explaining why the highest drops fall below the trend of the other drops).

Although different in detail and cause, these shifts in impact character with increasing velocity are analogous to changes in impact crater morphology with increasing size that we talked about in the text.

Last updated Oct 16, 2015.