

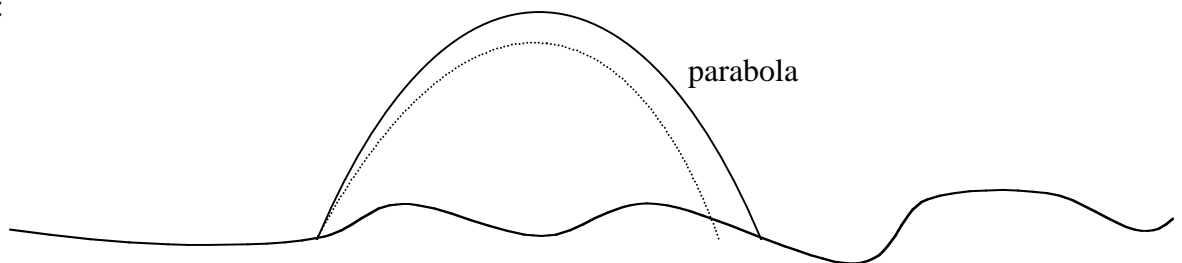
#### Activity 4: Conservation of E with objects launched straight up.

Try this: Take a small ball or equivalent object and toss it straight up. Catch it again as it comes down. Do the same thing, but toss it harder. Do you notice that it comes down faster when you toss it up faster? If the weather will let you be outdoors and you have access to a bat, you might try hitting it straight up harder than you can toss it. Careful, though; it may come down rather hard!

If you want to get scientific, you can arrange to measure the impact as it comes down using a big bucket of gelatin, Crisco, a bucket of sand, or some other relatively thick substance that won't splash too much. Toss the ball up and let it fall into the container. Measure how deep it goes and repeat with different initial speed.

What is happening here? When you throw it (or bat it) upwards, you give it some kinetic energy  $K = (1/2)mv^2$  where  $v$  is the speed. Toss it twice as hard and you give it 4 times the energy. As it rises, more and more of that energy goes into gravitational potential energy, until when all of  $1/2 mv^2$  has gone into potential energy, it can go no higher. It slowly falls, with more and more of the GPE turning into KE until, when it gets back to your hand (or the bucket) it is going nearly as fast as when it left, but in the opposite direction. (On the moon, it would be going exactly as fast, but here on Earth it runs into air resistance which steals a little energy away on both the upward and the downward part of the motion.)

What would happen if you didn't throw it straight up? You would give it the same KE but only part of that would be upwards, and only the upwards part of the KE would turn into GPE. When it came down it would again be moving at nearly the same speed, but the direction would have changed. The path that the ball takes would be approximately a parabola:



I say "approximately" because (a) even without air resistance, the correct shape is one end of a very skinny ellipse and (b) with air resistance it actually does something more like the dotted line in the picture.