Gravitational Well

Apparatus

plastic or foam parabolic well, marbles

A parabolic well can be simply made using a swimming cap stretched over the opening of a suitable container, such as a plant pot, and weighed down in the middle with a heavy weight.

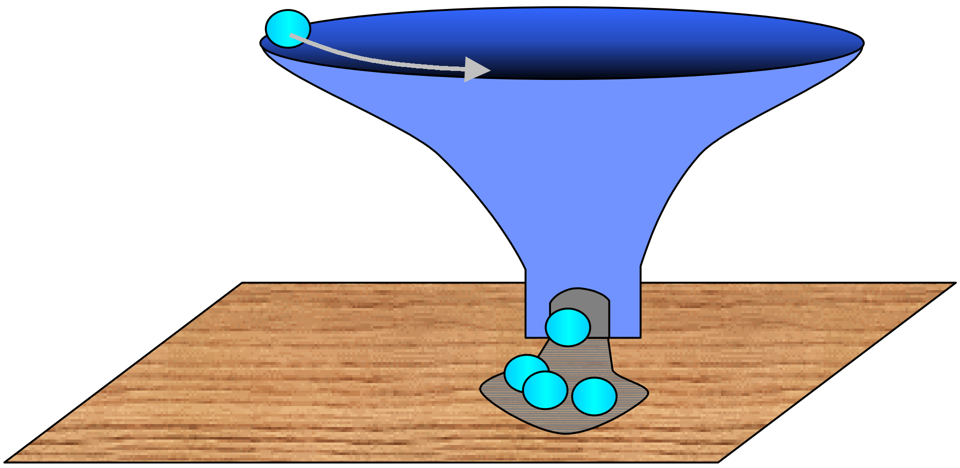
Action

The students roll the marbles around the well, observing how the velocity increases as they spiral inwards and downwards.

The Physics

The force acting to keep any object in a circular path is $F = mv^2/r$ where r is the radius of curvature, m is the mass of the object and v is its velocity. For a satellite this force is the gravitational force, $F = GMm/r^2$, where G is the gravitational constant, M is the mass of one body (e.g. the Earth) and m is the mass of the other (e.g. the satellite). These forces must be equal, $F = mv^2/r = GMm/r^2$, so $v^2 = GM/r$. As G and M are fixed, the velocity varies inversely with the square root of the radius, so the greater the radius the smaller the velocity.

(The model is slightly more complicated in that the marble has a vertical and horizontal component to its motion, however it does show this effect.)



Accompanying sheet

Gravitational Well

Drop a marble into the well.

What happens to the "orbital distance" of the marble as it sinks in the well?
What happens to the velocity of the marble?

How does the velocity of a satellite vary with orbit radius? Why?