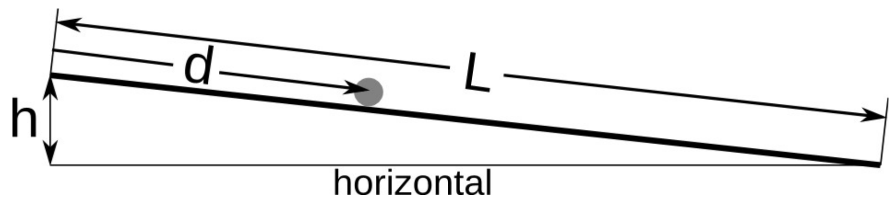
Rolling Objects

Falling objects are difficult to measure accurately without analyzing video cameras or using automatic timing devices. In a separate handout the video method is used, but here is how simple rolling measurements can gain nearly the same information.

When something falls, all the gravitational energy mgh is converted to kinetic energy $\frac{1}{2}mv^2$, and the following simple formula connects the distance below the release point with the square of the time since the object was released:

Falling, not rolling: $d=\frac{1}{2}gt^2$ where $g=9.8\,\mathrm{m/s^2}$ near the surface of the earth

However, when things roll, some energy also goes into a rotational kinetic energy which depends on the shape of the rolling object and the slope along which it is rolling. This figure shows the height of the slope and the distance along the slope



For a solid ball, the formula for distance rolled vs. time is $d=\frac{1}{2}gt^2\cdot\left(\frac{5}{7}\frac{h}{L}\right)$

For a hollow ball, the formula for distance rolled vs. time is $d=\frac{1}{2}gt^2\cdot\left(\frac{3}{5}\frac{h}{L}\right)$

For a solid cylinder, the formula for distance rolled vs. time is $d=\frac{1}{2}gt^2\cdot\left(\frac{2}{3}\frac{h}{L}\right)$

For a hollow cylinder, the formula for distance rolled vs. time is $d=\frac{1}{2}gt^2\cdot\left(\frac{1}{2}\frac{h}{L}\right)$

We will check these formulas in the lab. If they are correct, we should get a value for g that is close to 9.8 m/s^2.

In all cases, we are neglecting the air resistance and rolling resistance. Using Nerf balls would not work! Styrofoam balls and tennis balls might not work as well as hard, smooth objects.

Moments of Inertia for Rolling Round Objects

Solid sphere	$I=2/5\ MR^2$	rolls fastest
Solid cylinder	$I=1/2\ MR^2$	rolls 2nd fastest
Hollow sphere	$I=2/3\ MR^2$	rolls 2nd slowest
Hollow cylinder	$I=MR^2$	rolls slowest