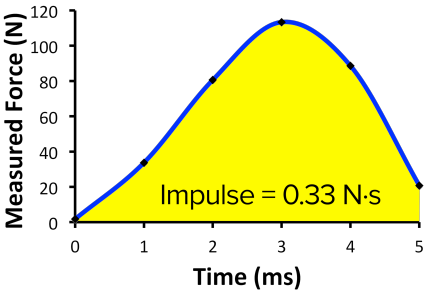
Flipping Physics Lecture Notes:
Using Impulse to Calculate Initial Height

Example Problem: A 66 g beanbag is dropped and stops upon impact with the ground. If the impulse measured during the collision is 0.33 N·s, from what height above the ground was the beanbag dropped?



It is important to recognize there are two parts to this problem:

- Part 1, when the beanbag is in free fall.
- Part 2, when the beanbag is colliding with the ground.

Knowns: $mass = 66g \times \frac{1kg}{1000g} = 0.066kg;\ Impulse = 0.33N \cdot s;\ \vec{v}_{2f} = 0;\ \vec{v}_{1f} = \vec{v}_{2i};\ h_{1i} = ?$

Part 2: $Impulse_2 = \Delta\vec{p}_2 = m\vec{v}_{2f} - m\vec{v}_{2i} = 0 - m\vec{v}_{2i} \Rightarrow \vec{v}_{2i} = -\frac{Impulse_2}{m} = -\frac{0.33}{0.066} = -5\frac{m}{s} = \vec{v}_{1f}$

Part 1: Use conservation of mechanical energy. Set the initial point where the beanbag is dropped, the final point where the beanbag strikes the ground and the zero line at the final point.

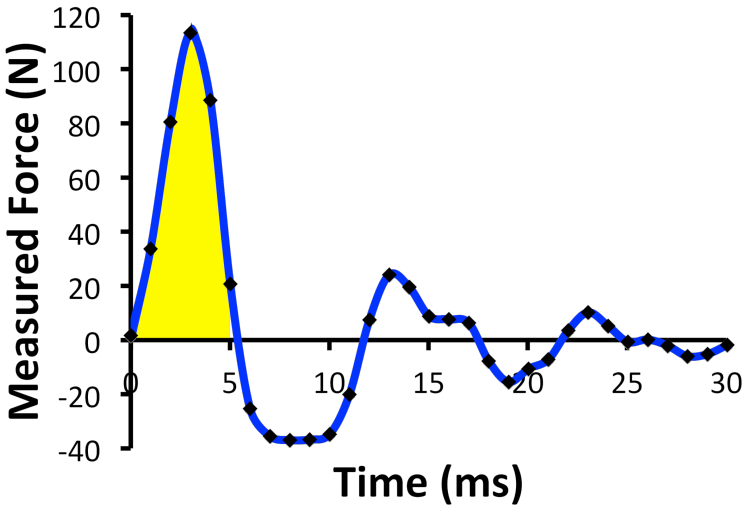
$$ME_{1i} = ME_{1f} \Rightarrow mgh_{1i} = \frac{1}{2}mv_{1f}^{\ 2} \Rightarrow gh_{1i} = \frac{1}{2}v_{1f}^{\ 2} \Rightarrow h_{1i} = \frac{v_{1f}^{\ 2}}{2g} = \frac{(-5)^2}{(2)(9.81)} = 1.27421 \approx \boxed{1.3m}$$

But the actual measured height was 0.50 m.

Therefore our prediction is way, way off.

$$E_r = \frac{O - A}{A} \times 100 = \frac{1.27421 - 0.50}{0.50} \times 100 = 154.842 \approx 150\%$$

We can understand this error if we look at the data from the force sensor *after* the collision. You can see the force measured has a damped oscillation around zero. It goes negative, then positive and continues that pattern, lessening in magnitude each time until it settles down to zero.



A negative force measurement on the force platform makes no sense because the beanbag does not pull upward on the force platform. My best guess is the collision between the beanbag and the force platform causes the force platform itself to enter into simple harmonic motion and therefore causes the force platform to register a larger impulse than it should. I don't think the force platform is intended for such dynamic measurements; it is instead intended for more static measurements.