Flipping Physics Lecture Notes:

Demonstrating Impulse is Area Under the Curve

Previously we derived Impulse from the force of impact equation:

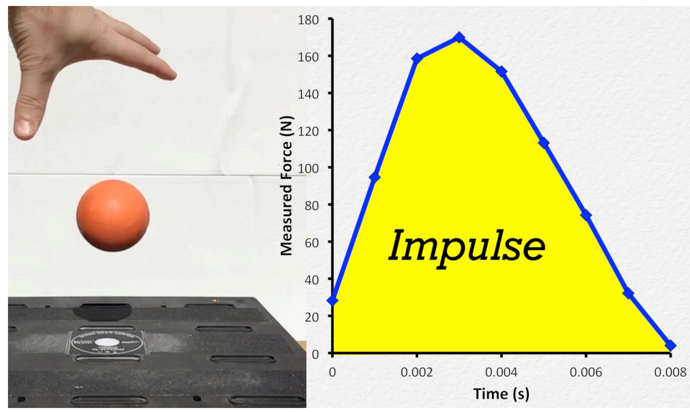
$$\sum \vec{F} = \frac{\Delta \vec{p}}{\Delta t} \Rightarrow \Delta \vec{p} = \sum \vec{F} \Delta t = Impulse$$

Now we need to do something similar, only using calculus:

$$\sum \vec{F} = \frac{d\vec{p}}{dt} \Rightarrow d\vec{p} = \sum \vec{F} dt \Rightarrow \int_{p_i}^{p_f} d\vec{p} = \int_{t_i}^{t_f} \sum \vec{F}\, dt \Rightarrow \Delta \vec{p} = \int_{t_i}^{t_f} \sum \vec{F}\, dt = Impulse$$

And the integral is the "Area Under the Curve".

In other words, if we drop a ball onto a force plate, we get a force curve that looks like this:



On a Force vs. Time graph, the area between the curve and the time axis is Impulse. In this particular case the impulse is 0.81 N·s

Note the force changes as a function of time. In an algebra based physics class like this one, we use the average force and the change in time to create a rectangle with the same area as under the curve.

$$Impulse = \vec{F}_{avg} \Delta t = (91.8)(0.008) = 0.7344 \approx 0.73 N \cdot s$$

Note: The two values for the Impulse, Area under Curve and $F_{average}$ times Δt, should be the same. However, the PASCO Force Platform does not quite show that correctly.

$\Delta \vec{p} = \vec{F}_{avg} \Delta t = Impulse$ (area under the force vs. time curve)