Flipping Physics Lecture Notes:

Force of Impact Equation Derivation

Newton's Second Law is $\sum \vec{F} = m\vec{a}$.

The equation for acceleration is $\vec{a} = \frac{\Delta\vec{v}}{\Delta t} = \frac{\vec{v}_f - \vec{v}_i}{\Delta t}$ which we can substitute into Newton's Second Law.

And knowing the equation for momentum is $\vec{p} = m\vec{v}$. Therefore:

$$\sum \vec{F} = m\vec{a} = m\left(\frac{\vec{v}_f - \vec{v}_i}{\Delta t}\right) = \frac{m\vec{v}_f - m\vec{v}_i}{\Delta t} = \frac{\vec{p}_f - \vec{p}_i}{\Delta t} = \frac{\Delta\vec{p}}{\Delta t} \Rightarrow \boxed{\sum \vec{F} = \frac{\Delta\vec{p}}{\Delta t}}$$

This is the equation for the force of impact during a collision. The net force acting on an object equals the change in momentum of the object divided by the change in time while that net force is acting on the object. Both force and momentum are vectors.

This gets us closer to Newton's original second law which is $\sum \vec{F} = \frac{d\vec{p}}{dt}$. The net force acting on an object equals the derivative of the momentum of that object with respect to time. If you ever take a calculus based physics course, like AP Physics C, you will get an opportunity to work with this equation.

Note: This equation for the force of impact acting on an object during a collision marks a paradigm shift in our physics learning. Before we had this equation, we only looked at objects before they ran into one another. Now, using this equation, we can determine forces during collisions. Which means dropping the medicine ball onto the ground actually has two parts. Part 1, when the medicine ball is in free fall and part 2, when the medicine ball strikes the ground.