Problem 9.4

A .145 kg baseball moving 45.0 m/s in the horizontal is hit by a bat and leaves the bat with 55.0 m/s velocity magnitude straight upward. If the time of impact is 2.00 milliseconds, what is the average force vector acting during the collision?

The *Impulse* relationship relates *applied force* during a collision, *time* of contact during the collision and a body's *change of momentum* due to the collision. Having been derived from N.S.L., its most succinct form is $\vec{F}\Delta t = \Delta\vec{p}$. Being incredibly anal about notation (for the sake of clarity), this yields:

$$\vec{F}_{avg,ball} = \frac{\vec{p}_2 - \vec{p}_1}{\Delta t}$$

$$= \frac{\left(m\left|\vec{v}_2\right|\right)\hat{j} - \left(m\left|\vec{v}_1\right|\right)\hat{i}}{\Delta t}$$

$$= \frac{(.145 \text{ kg})(55.0 \text{ m/s})\hat{j} - (.145 \text{ kg})(45.0 \text{ m/s})\hat{i}}{\left(2.00\text{x}10^{-3} \text{ s}\right)}$$

$$= \left(3.99\text{x}10^{4} \text{ N}\right)\hat{j} - \left(3.26\text{x}10^{4} \text{ N}\right)\hat{i}$$

This is the force the bat exerts on the ball. Put it in more conventional form with the x-component first, we get:

$$\vec{F}_{avg,ball} = -\left(3.26\text{x}10^{4} \text{ N}\right)\hat{i} + \left(3.99\text{x}10^{4} \text{ N}\right)\hat{j}$$

(Interestingly, the textbook's Solution Manual is off by a factor of 1000!) In any case, this is the force exerted on the ball. The force exerted on the bat will be, by Newton's Third Law (N.T.L.), *minus* that, or:

$$\vec{F}_{avg,bat} = \left(3.26\text{x}10^{4} \text{ N}\right)\hat{i} - \left(3.99\text{x}10^{4} \text{ N}\right)\hat{j}$$