Impulse

Knowledge/Understanding Goals:
• what impulse is

Skills:
• calculate the impulse given to an object
• calculate the change in momentum as the result of an impulse

Notes:
impulse \( (J) \): a force applied to an object over an interval of time. Impulse is a vector quantity.

An impulse causes a change in momentum, and the amount of the impulse is equal to the change in momentum. The impulse also equals force times time:

\[
J = F \Delta t = \Delta p = p_{\text{final}} - p_{\text{initial}} = \Delta p
\]

Basically the Impulse is just a change in velocity. In terms of Momentum:

\[
J = m_1v_{\text{final}} - m_2v_{\text{initial}}
\]

Impulse is measured in the same unit as momentum (newton-seconds):

\[
1 \text{ N} \cdot \text{s} = 1 \text{ kg} \cdot \text{m/s}
\]

A way to think about Impulse is to imagine which would do more damage a karate chop across and arm or a tight squeeze across the arm with the same amount of force as the karate chop but a much larger time of contact. The Impulse is basically a force applied in a time interval \( \Delta t \). The shorter the \( \Delta t \) for the same amount of force does much more damage.

“The Impulse applied by the net Force on a system is equal to the Change of the Momentum of the system.”

Sample Problems:

Question: A baseball has a mass of 0.145 kg and is pitched with a velocity of \(-38.0\) m/s toward home plate. After the ball is hit, its velocity is \(+52.0\) m/s toward the outfield fence. If the impact between the ball and bat takes place over an interval of \(3.0\) millisec \((\text{milliseo}c = 10^{-3} \text{ sec})\), find the impulse given to the ball by the bat, and the force applied to the ball by the bat.

Answer: The impulse is:
\[ J = F \Delta t = \Delta p = p_{\text{final}} - p_{\text{initial}} = p_f - p_i \]
\[ J = m v_f - m v_i = m(v_f - v_i) \]
\[ J = (0.145 \, \text{kg})(52.0 \, \text{m/s} - (-38.0 \, \text{m/s})) = 13.05 \, \text{N} \cdot \text{s} \]

The collision takes place over a time interval of 3.0 millisec = 0.0030 sec.

The Force is: \[ J = F \Delta t \]
Solving for the Force gives: \[ f = \frac{j}{\Delta t} = \frac{13.05 \, \text{N} \cdot \text{s}}{0.003 \, \text{sec}} = 4350.0 \, \text{N} \]

**Question:**

In the picture a bird flies into the front of a plane. The plane is moving at 600 Mi/hr, how would you make a reasonable estimate of the impulse?

**Answer:** Some assumptions we could make are:
1. Assume that the bird is stopped immediately upon contact,
2. Assume that the bird and plane are approaching each other along a straight line which we can call the x-axis,
3. Assume that the time of impact is very small, say millisecs.

Then the \[ F_{\text{average}} = \frac{m \Delta v}{\Delta t} \]
And the Impulse would be
\[ J = F_{\text{average}} \Delta t = m \Delta v = (\text{mass of bird} + \text{mass of a typical jet})(\text{the change in velocity}). \]