Impulse

1 Program of Studies Checklist:

- explain, quantitatively, the concepts of impulse and change in momentum, using Newton's laws of motion
- analyze graphs that illustrate the relationship between force and time during a collision

2 Impulse: Not Just for Poor Spending Decisions Anymore!

Recall that Newton wrote his second law in terms of momentum. This could be rearranged as:

From this, we can see that the product of force and time is momentum! Let's apply this to a real-life situation.

2.1 Example

Assume we have an egg with mass m and initial velocity v_i, dropped from equal heights onto two different floors: one concrete floor, and one with padding on it.

The p_i in each trial is the same, as the mass and velocity of each egg is equal.

The p_f in are both 0, as the egg comes to a stop.

This means that the change in momentum is the same in each trial:

Now, just because the momentum is the same does not mean that the force and time are the same!

Force and time can vary, but as one goes up, the other goes down! (otherwise, the momentum changes as well)

In the first trial, the time the egg takes to stop is very fast. It hits the concrete and stops immediately. This means we have a small time and a large force to make up the momentum.

In the second trial, the egg stops over a longer period of time. This allows for the same momentum change, but with a ________________ acting on the egg.

In each of these trials, the change in ________________ is the same. We call the change in ________________ of an object the ________________.

Impulse is defined as the product of a __________________ and the __________________ interval that __________________ acts over. It is the __________________ in __________________ an object experiences. __________________ is a vector quantity.

Impulse does not receive a special symbol (other than Δp), but it does receive the units of Ns or kgm/s.

2.2 Example

A force of 14.0 N acts on a 6.00 kg bunny for 1.00 ms. What is the change in velocity of this object?

2.3 Example

A student is standing on a stationary 2.3 kg skateboard. If the student jumps at a velocity of 0.37 m/s forward, the velocity of the skateboard becomes 8.9 m/s backwards. What is the mass of the student?

BE CAREFUL WITH YOUR SIGNS, FOR GOODNESS' SAKE

The importance of momentum is that, like energy, it is conserved. This allows us to examine a very special type of situation in physics: *the collision*.

3 Collisions

There are two types of collisions we study:

1. __________________ Collision: objects collide and bounce back without deforming, and there is no energy lost. __________________ and __________________ are conserved.
2. __________________ Collision: objects collide but deform in some way, losing energy. Objects bounce back less, or not at all ("hit and stick"). ____________________________________ is conserved.

3.1 Hit and Rebound

Two objects collide and bounce back in the same directions that they travelled initially.

3.2 Example

A 0.25 kg volleyball is flying West at 2.0 m/s when it strikes a stationary 0.58 kg basketball, dead centre. The volleyball rebounds East at 0.79 m/s. What is the velocity of the basketball immediately after impact?

Step 1: Is the system isolated?

Step 2: Make a free body diagram.

Step 3: Write the conservation statement.

3.3 Example

A 125 kg bighorn ram butts heads with a younger 122 kg ram during mating season. The older ram is rushing North at 8.50 m/s immediately before the collision, and bounces back at 0.11 m/s [S]. If the younger ram moves at 0.22 m/s [N] immediately after sollision, what was its velocity just before impact?

Question: was this collision elastic, or inelastic?

If the collision was elastic, then there will be a conservation of energy.

$$\Sigma KE_i = \Sigma KE_f$$

$$\frac{1}{2}m_o v_{oi}^2 + \frac{1}{2}m_y v_{yi}^2 = \frac{1}{2}m_o v_{of}^2 + \frac{1}{2}m_y v_{yf}^2$$

where $o =$ old ram, $y =$ young ram