Lesson 10

Momentum

We use the word "Momentum" often in our daily conversation, but can you imagine how many people really know the real definition of momentum? I can't emphasize enough to point out the importance of knowing English definitions of terms used in Physics, direct math translations, and relations between the terms.

Momentum – Ability to maintain moving (how difficult it is to stop) – ($\vec{p}$ - lower case)

What are the factors you can think of to calculate "momentum"?

$\therefore\ \vec{p} = m\vec{v}$

Relation between $\vec{F}$ and $\vec{p}$

$\vec{F} = m\vec{a}$

$\vec{p} = m\vec{v}$

How are they related (assuming that "m" remains the same)?

Conservation of Momentum

Knowing how "outside force" and "momentum" are related, when can we apply the idea of "conservation of momentum"?

The idea of "conservation of momentum" is heavily used in "collision cases". When you encounter a collision problem, it is important to check whether or not you can use "conservation of momentum" in WHICH direction since "momentum" is a vector (i.e. each momentum has to be broken into components according to the coordinate system you establish.).

Collisions

There are basically three types of collisions for physics. They are "Perfectly Elastic", "Perfectly Inelastic", and "Partially Elastic".

Perfectly Elastic

$\vec{p}$:

KE:

Perfectly Inelastic

$\vec{p}$:

KE:

Partially Elastic

$\vec{p}$:

KE:

Example (Perfectly Elastic)

The three balls in the overhead view of Fig. 9-83 are identical. Balls 2 and 3 touch each other and are aligned perpendicular to the path of ball 1. The velocity of all 1 has magnitude v_0 = 10m/sec and is directed at the contact point of balls 2 and 3. The collision is a perfectly elastic collision. After the collision, what are the speed and direction of each ball?

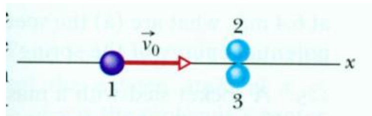

Fig. 9-83 Problem 130.

Example (Perfectly Inelastic and partially elastic)

In fig. 9-59a, a 3.5 g bullet is fired horizontally at two blocks at rest on a frictionless table. The bullet passes through block 1 (mass 1.20 kg) and embeds itself in block 2 (mass 1.8 kg). The blocks end up with speed v_1 = 6.30 m/sec and v_2= 1.40 m/sec (Fig. 9-59b). Neglecting the material removed from block 1 by the bullet, find the speed of the bullet as it (a) leaves and (b) enters block 1.

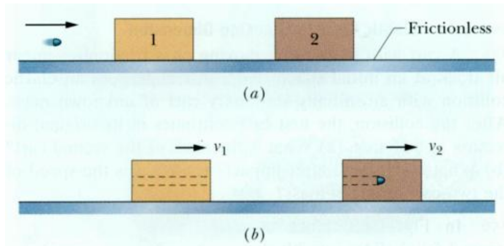

Fig. 9-59 Problem 49.

When can't you apply "conservation of momentum"?

When there is a non-zero net outside force, there is an acceleration, which causes velocity to change. Thus, there is a change of momentum (Impulse).

$$\Delta\vec{p} = \int \vec{F} \cdot dt \equiv \text{Impulse}$$

Show mathematically that this will turn into the change of momentum.

Example

A 0.25 kg puck is initially stationary on an ice surface with negligible friction. At time t = 0 sec, a horizontal force begins to move the puck. The force is given by $\vec{F} = (12.0 - 3.00t^2)\hat{\imath}$, with $\vec{F}$ in newtons t in seconds, and it acts until its magnitude is zero.

(a) What is the magnitude of the impulse on the puck from the force between t = 0.500 sec to t = 1.25 sec?
(b) What is the change in momentum of the puck between t = 0 and the instant at which F = 0?
(c) What is the final velocity of the puck?

It is very important to know when you can and can't apply "conservation of (kinetic) energy" and "conservation of momentum".

Example - Ballistic Pendulum