Momentum and Impulse

$$\vec{F} = ma = m\frac{\Delta\vec{v}}{\Delta t},$$

$$\Delta\vec{p} = \vec{F}\Delta t$$

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

$\vec{F}\Delta t$ called Impulse

If ***F*** changes with time, Impulse is time integral of Force:

$$\Delta\vec{p} = \int_{t_1}^{t_2} \vec{F}\,dt$$

Conservation of Momentum

2nd Newton's Law for ***n*** objects:

$$\Delta\vec{p}_1 = \vec{F}_1\Delta t$$

$$\Delta\vec{p}_2 = \vec{F}_2\Delta t$$

$$\ldots\ldots$$

$$\Delta\vec{p}_n = \vec{F}_n\Delta t$$

3rd Newton's Law, no external forces!

$$\vec{F}_1 + \vec{F}_2 + \ldots + \vec{F}_n = 0$$

$$\Delta\left(\vec{p}_1 + \vec{p}_2 + \ldots + \vec{p}_n\right) = 0$$

$$\vec{p}_1 + \vec{p}_2 + \ldots + \vec{p}_n = const$$

Total Momentum of Isolated System is Conserved

Homework

Problem 1

A tennis ball of mass ***m=57 g*** with initial velocity ***v=30 m/s***, directed towards the wall bounces off it elastically. Using high-speed camera, it was determined that the collision time was about ***t=1ms*** (1 millisecond). Estimate the maximum force between the wall and the ball.

Problem 2

A block of mass ***M=100g*** moves with speed of ***v=10m/s*** on a frictionless flat surface. A bullet of mass m=8g that moves with speed ***u=700 m/s*** in the opposite direction, hits the block and gets stuck in it. What will be the velocity of the block after this collision (include direction in your response)?