# Momentum & Impulse

Pre-Lecture Questions

Problem Set #16 (due next time)

Lecture Outline

1. The Definition of Momentum
2. The Impulse-Momentum Theorem

# Pre-Class Summary:

Newton's Original Second Law $\Sigma\vec{F} = \frac{d\vec{p}}{dt}$

The Original Second Law requires a new concept called "linear momentum."

The Definition of Linear Momentum $\vec{p} \equiv m\vec{v}$

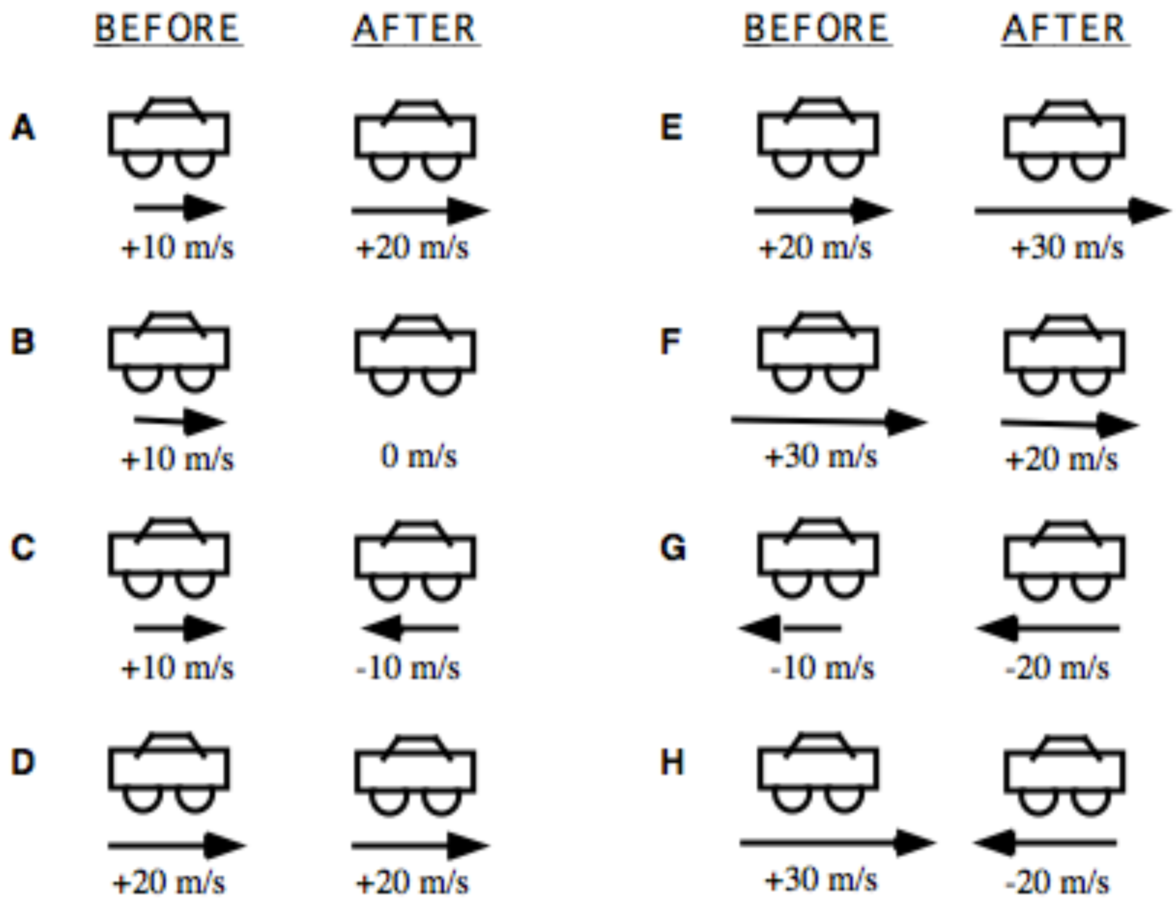
Rearranging the Original Second Law led us to define the concept of impulse,

The Definition of Impulse $\vec{J} \equiv \int_{t_o}^{t} \vec{F}\,dt$ ,

to establish the Impulse-Linear Momentum Theorem $\Delta\vec{p} = \vec{J}$ .

The idea is that momentum is changed by a force acting over a time. A large force acting over a short time can produce the same effect as a small force acting over a larger time.

The eight situations below show *before* and *after* "snapshots" of a car's velocity. Rank these situations, in terms of the change in momentum of these cars, from most positive to most negative. All cars have the same mass. Negative numbers, if any, rank lower than positive ones (-20 m/s < -10 m/s < 0 < 5).

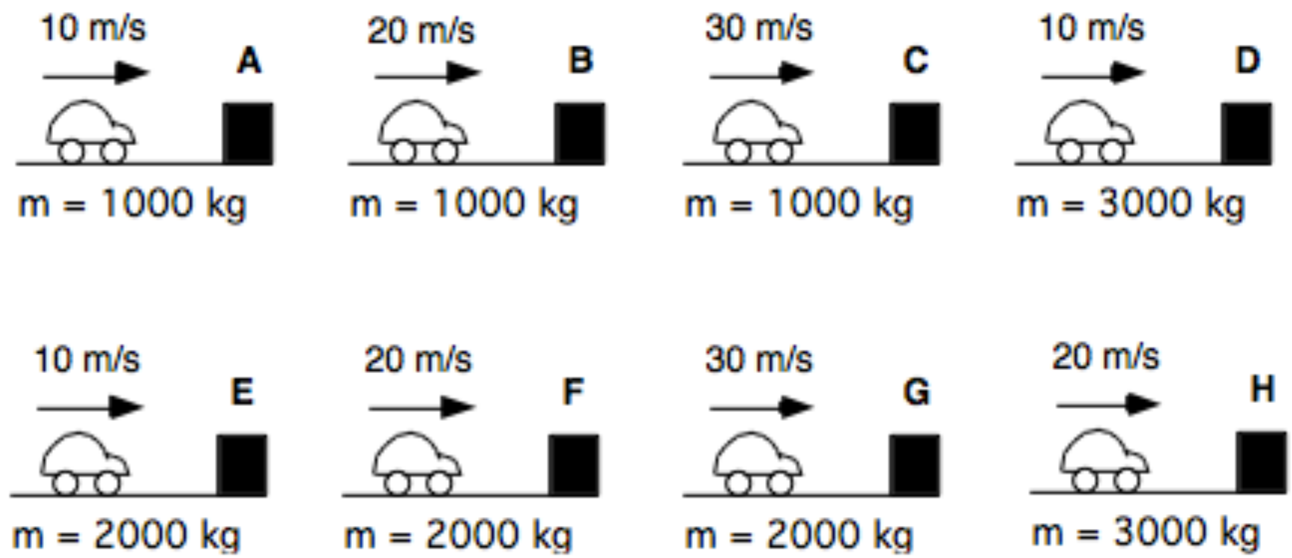


http://www.youtube.com/watch?v=CJHpUO-S0i8

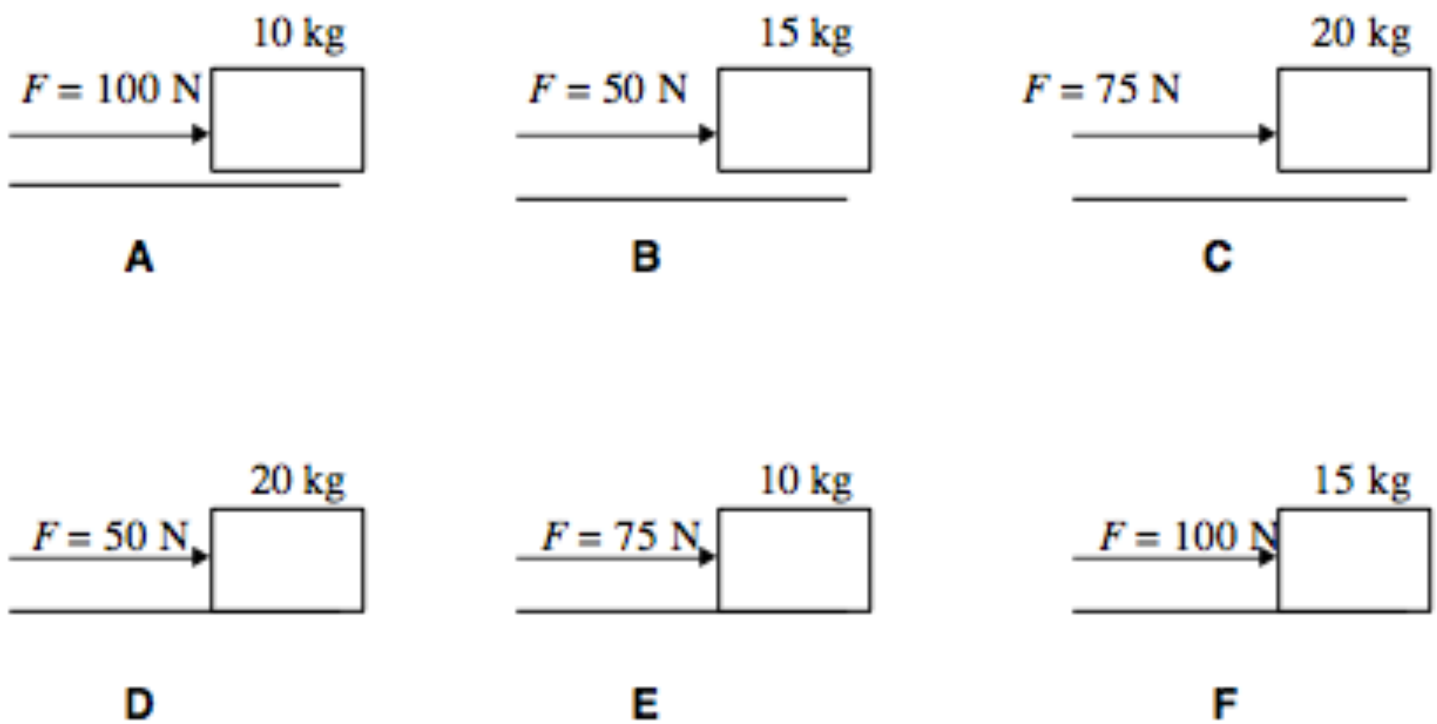
*Example 1: The 730kg Smart Car goes from 70mph to rest in 1.0s. Find (a)the initial momentum, (b)the final momentum and (c)the average force on the car.*

Shown below are eight cars that are moving along horizontal roads at specified speeds. Also given are the masses of the cars. All of the cars are the same size and shape, but they are carrying loads with different masses. All of these cars are going to be stopped by plowing into identical barriers. All of the cars are going to be stopped by the same constant force by the barrier.

Rank these situations from greatest to least on the basis of the stopping time that will be needed to stop the cars with the same force. That is, put first the car that requires the longest time and put last the car that requires the shortest time to stop the car with the same force.

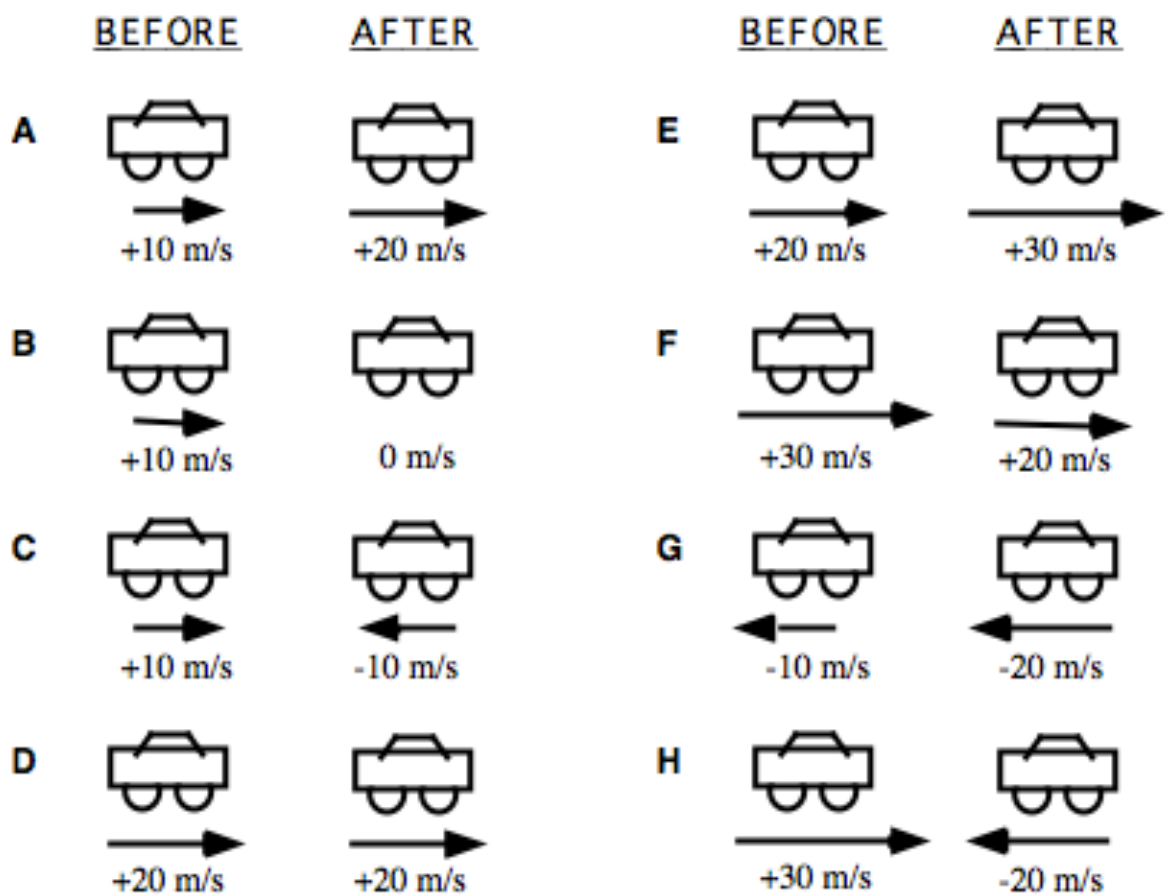


Similar boxes are pushed for 10 seconds across a floor by a net horizontal force as shown below. The mass of each box is indicated. Rank the boxes from greatest to least based upon the impulse imparted by the force.



*Example 2: A 0.50kg soccer ball is kicked with a constant force 300N that lasts for one-twentieth of a second. Find (a)the impulse imparted to the ball and (b) the impulse imparted to the foot of the soccer player.*

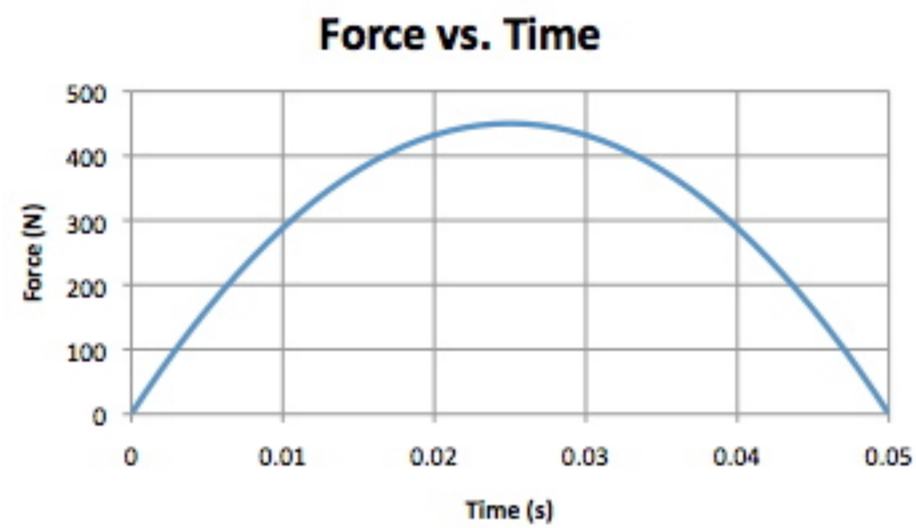
The eight situations below show *before* and *after* "snapshots" of a car's velocity. Rank these situations, in terms of impulse on these cars, from most positive to most negative, to create these changes in velocity. All cars have the same mass. Negative numbers, if any, rank lower than positive ones (-20 m/s < -10 m/s < 0 < 5).



*Example 3: A more careful analysis of the kicked soccer ball (0.50kg) reveals that the force is not constant but instead varies with time as shown at the right. The equation for the force as a function of time is,*

$F = -(7.2x10^5)t^2 + (3.6x10^4)t,$

*where t is in seconds and F in in Newton's. Find (a)the impulse imparted to the ball and (b)the final speed of the ball assuming it started at rest.*



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