**Momentum and Impulse**

We know from experience that there is more to describing the motion of an object than knowing its speed. It is very difficult to stop a massive object even if it is not moving very fast. Similarly, a small object that moves very fast (like a bullet) is also difficult to stop. The property that relates mass and velocity in describing the motion of an object is **momentum**:

 momentum = p = mass x velocity

 We also know from experience that there is more to applying a force than just pushing on (or getting pushed by) something. If we fall down and do not brace ourselves at all while falling we hurt a lot more than when we stick our arms and knees and legs out and “brace” our fall. In essence, we are extending the time over which the force acts by sticking our limbs out. This combination of force and the time over which the force acts is known as **impulse**. An applied force causes an object to accelerate. Acceleration is a change in velocity. A net force causes an object to change its **momentum**. Impulse is defined to be the product of the force times the time over which the force acts. It is also equal to the change in momentum while the force is acting.

 Impulse = force x time = change in momentum

Write this using symbols in the space below.

Solve:

Find the momentum of

a) a 10,000,000 kg boat which is at rest.

b) a 10, 000, 000 kg boat moving at 1 m/s.

c) a 0.005 kg bullet moving at 200 m/s.

d) a 1 ton car moving 40 m.p.h.

II) a) A force of 200 Newtons is applied to a 1000 kg car for 10 seconds. What is the impulse delivered to the car? What is the final speed of the car?

b) if the car in example a is initially moving at 30 m/s, and the direction of the applied force is opposite to the direction of the car’s velocity, how fast is the car moving after the force is applied?

c) Why do highway off-ramps have those yellow plastic bumper things in front of concrete poles?

d) Would you rather be in a car (going 30 mph) that collides with a wall and stops instantly, or in a car that bounces off of the wall relatively unscathed (assuming that the car is moving the same speed in each example prior to collision)? Use your understanding of impulse to explain your answer below.