1.1 Momentum:

- The more momentum a body has, the harder it is to stop.
- One body can give momentum to another body through a force between the two.
- Momentum is conserved: The total momentum for an <u>*isolated*</u> group of masses doesn't change.

Figure 1, The more momentum player #7 has, the further he will travel before the others stop him. (Credit: Ozzzie, Flickr)

If something has momentum it is hard to stop or make it change course. We use the term in every day English, such as "Jenny's business has gained so much momentum this year that it is certain to succeed." We also use it in terms of a moving object, such as, "John ran into a player from the other team, but John had enough momentum to carry the two of them over the goal line!" Momentum is about speed and mass. Thus, we could make an ordering of increasing momentum: a child walking, an adult walking, a bicyclist at high speed, a speeding car, a speeding truck, a speeding train, a full cargo ship, another planet.
We define momentum: $p = mv$, where
p is momentum,
m is mass, a measure of how much matter is in an object, measured in kilograms (kg),
v is velocity, how fast an object is moving, measured in m/s.

Thus, the unit of momentum is (kg m/s).
Momentum is important because it is conserved: the total momentum of an isolated system doesn't change. Only a few physical quantities are conserved in nature, including mass, momentum, energy, and angular momentum.

Momentum can be transferred from one object to another by a force between the two objects. For example, through a collision or some other force including springs, magnets, friction, etc.

Consider what happens when a car bumps into a truck, as shown in Figure 2. There is a repulsive force between the two vehicles pushing the car backwards and the truck forwards. The momentum that the car loses in the collision is equal to the momentum that the truck gains in the collision. So, the total change in momentum of the system is zero: yes, momentum is conserved.

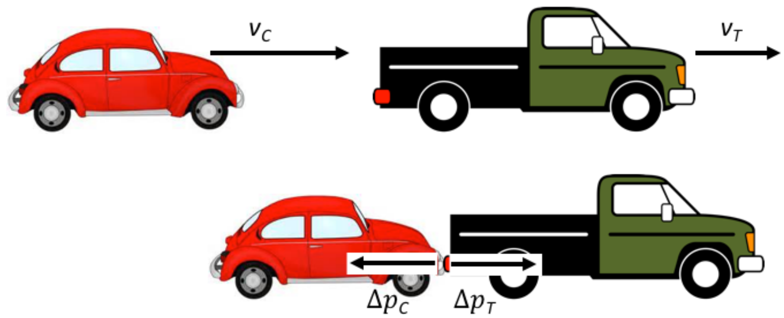

Figure 2, The faster car hits the slower truck. During the collision, the repulsive force between the two increases the momentum of the truck by (Δp), and reduces the momentum of the car by the same amount. Thus, the total momentum of the car/truck system remains constant.

We can say that the total momentum of the system (the two cars) is conserved if there is no outside force. In reality, there are outside forces such as wind friction, which would reduce the total momentum of the system. However, it is reasonable to neglect these outside forces because in the moment of the collision, the forces provided by the engines and friction are small compared to the forces of the impact between the vehicles.

Have you ever seen a small child learn about momentum? They might reach out and try to stop an adult on a swing. The adult on the swing does lose momentum, but the child is surprised to find that they gain this same amount of momentum when they are knocked over. So, if you see something change momentum, you can be sure that it happened through *force*: an interaction with another body (or bodies). And that the force produced an opposite change in momentum in the other body, ensuring that the total momentum of the system is conserved; it didn't change.

Exercise 1

A fly smashes into your windshield as you are driving. Between the car and the fly,

1. which one has the greater change in momentum, or are they the same?
2. which one has the greater change in velocity, or are they the same?
3. are both of the above answers the same? If not, how can that be?