Momentum

It's the LAW!

In physics we don't get very many laws, so when we do they are important. One of those laws is the Law of Conservation of Momentum.

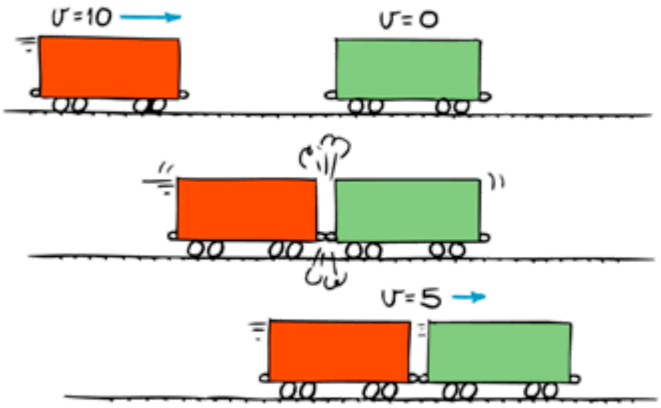
This law simply states that the total momentum of a system is always the same. The total momentum of the entire universe is the same today as it was yesterday, and that is the same as it will be tomorrow.

For the confines of this class we will think of it in terms of collisions.

The total momentum before a collision is the same as the total momentum after a collision.

$$P_{before} = P_{after}$$

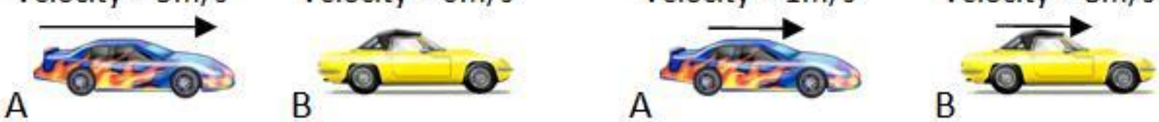
before



$Ft = p = mv$

after

Before		After	
Mass = 200kg Velocity = 5m/s	Mass = 100kg Velocity = 0m/s	Mass = 200kg Velocity = 1m/s	Mass = 100kg Velocity = 8m/s



Momentum Before = Momentum After

Momentum of Car A Before + Momentum of Car B Before	=	Momentum of Car A After + Momentum of B Car After
(Mass A x Velocity A) + (Mass B x Velocity B)	=	(Mass A x Velocity A) + (Mass B x Velocity B)
(200 x 5) + (100 x 0)	=	(200 x 1) + (100 x 8)
(1000) + (0)	=	(200) + (800)
1000 kg m/s	=	1000 kg m/s

I saw this image in an old physics textbook. I think we should try something similar tomorrow.

Let's throw some stuff$_1$ at stuff$_2$! And by stuff$_2$ I mean you!

Who can bring in a skateboard tomorrow? Sadly I have not had a skateboard for the last 30 years…
Names! We'll need about ½ of you to bring one… Who can do it, and who can bring more than one?

or rollerblades?
on ice?

Ex: A lion can weigh up to 200kg and can run 22m/s. A rhinoceros can weigh up to 2,300Kg. The lion is extra hungry and runs full speed into the rhino for a snack. What is the velocity of the lion/rhino after the lion hops on?

$$P_{before} = P_{after}$$

$$m_b v_b = m_a v_a$$

$$(mv)_b = (mv)_a$$

$$m_{lb} v_{lb} + m_{rb} v_{rb} = m_{la} v_{la} + m_{ra} v_{ra}$$

$$(200)(22) + 2300(0) = (200 + 2300) v_{rl}$$

$$\frac{200(22)}{200+2300} = V_{rl}$$

$$1.76\ m/s = V_{rl}$$

Another example: Remember that momentum is a vector, and direction matters. Hint: large negative numbers are still LARGE!

To Haille ↗

A tow truck of mass 3,000kg is traveling down a street at 2m/s. A fire truck is in a hurry and is heading straight for the tow truck at a velocity of 12m/s. If the fire truck weighs 5,000kg, what will the velocity be after impact?

$$P_b = P_a$$

$$(P_{tt} + P_{Ft})_b = (P_{tt+Ft})$$

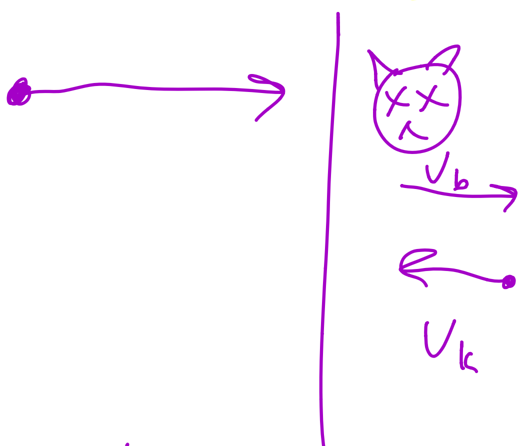
$$(3000)(2) + 5000(-12) = V(5000 + 3000)$$

$$\frac{(3000)2 - 5000(12)}{5000 + 3000} = V$$

$$-6.75\ m/s = V$$

A kid of mass 60kg runs at 5.0m/s toward a dead bobcat of mass 20kg at rest. After the collision the bobcat is moving at 20m/s in the original direction, what is the final velocity of the kid?

Hint: v_f=-1.7m/s



$$m_k V_k + m_b V_b = m_k V_k + m_b V_b$$

$$60(5) + 20(0) = 60 V_k + 20(20)$$

$$\frac{60(5) + 0 - 20(20)}{60} = V_k$$

$-1.67\,m/s = V_k$

A stupid zombie thinks it can attack Fraser. Fraser throws a grenade right down the zombie's throat. The zombie breaks into two pieces. The zombie originally weighed 75kg. After the grenade blew up, one piece of the zombie flew off to the east with a velocity of 15m/s and a mass of 50kg. What was the velocity of the other piece?

$m_z = 75kg$

$P_b = P_a$

$0 = 15(50) + V(25)$

$\frac{-15(50)}{25} = V$

$-30.0\,m/s = V$

Evan told us that he was sick last week, but I suspect he was practicing his *sick* BMX skillz! Evan (66kg) was riding his BMX (10kg) at 20m/s when he jumped backwards off of the bike. If the bike kept going at 22m/s how fast is Evan going?

$P_b = P_a$

$(m_E + m_b)V_b = m_E V_E + m_b V_b$

$(66+10)20 = 66V_E + 10(22)$

$\frac{(66+10)20 - 10(22)}{66} = V_E$

$19.7\,m/s = V_E$

Equal and opposite. There are a ton of amusing videos on the intertoobs about people firing a gun poorly.

We talked about a .50cal sniper rifle the other day. It fires a bullet of 50g at 850m/s. That gun weighs roughly 15kg. What is the recoil? Why don't we see this happen?

hint: $-2.8\ m/s$

$$p_b = p_a$$

$$(.05+15)0 = (.05)(850) + 15V_f$$

$$\frac{-.05(850)}{15} = V_f$$

$$-2.8\ m/s = V_f$$

Here's a tricky one: I'll have something like this on the test. A school bus of mass 12,000kg plus 40 kids who on average weigh 60kg, is travelling down the road when it hits a fire truck travelling head on. The velocity of the truck was 50km/hr. After the collision the fire truck/bus combo was brought to a stop. What was the original mass of the fire truck? Hint: 13,000kg.

$$\frac{50\ km}{hr} \cdot \frac{1000\ m}{1\ km} \cdot \frac{1\ hr}{3600} = 13.9\ m/s$$

$V = 12.6$

$$p_b = p_a$$

$$[12000 + 60(40)]V + (-13.9)m = 0$$

$$\frac{(12000 + 60(40))12.6}{13.9} = m$$

1 5 . 7

$$12.6\,\frac{m}{s} \cdot \frac{3600\,s}{1\,hr} \cdot \frac{1\,km}{1000\,m}$$

$$45.36\,\frac{km}{hr}$$