Let us first start in general with the idea of momentum P. Momentum is the product of the mass of an object and its velocity-- it is a vector. This velocity can only change if there is a force acting upon this. If I write this down as dp dt-- take the derivative-- equals m times dv dt plus dm dt times v. If the mass of the object is not changing, then the mt is 0, and what you see here equals ma-- dv dt equals the acceleration.

We know that the [UNINTELLIGIBLE] ma is the force on the object-- let's call it the external force. You'll see later why I want to make that distinction. This tells you that immediately that the dp dt change in momentum per unit time equals the force-- the external force-- on the object. If there is no external force on the object, if this is 0, then dp dt is 0, and we call that the conservation of momentum.

Of course, we use [UNINTELLIGIBLE PHRASE] when we have one object, but when we have more than one-- two, three, or four-- these objects interact with each other. The internal forces between them, since action equals minus reaction, exactly cancel each other out. If we have a collection of objects, and if the sum of the total external forces is 0, then the sum of the momentum of all these individual objects is conserved, and that is very important rule when we dealing with collisions-- it always holds as long as there's no external force. Conservation of momentum always holds as long as there's no net external force on the system.

If we write these down in general form: p 1 plus p 2 equals p 1 prime-- that is after a collision-- plus p 2 prime. We'll dealing here with two objects, and you can write this down as m 1 v 1, which is a vector, plus m 2 v 2 vector equals m 1 v 1 prime, which is a vector, plus m 2 v 2 prime, which is a vector. That is the conservation of momentum as long as there's no external force.

It always holds: it always holds, regardless of whether kinetic energy is conserved, or it is not conserved. If kinetic energy decreases, we call that's an inelastic collision. Kinetic energy can even increase when there is an impact right away-- think about that. If kinetic energy does not change during the impact, we call it an elastic collision, but the conversation of momentum always holds as long the net sum of all the external forces equals 0.

A small example: suppose you have a marble here, and you have a piece of putty here. There are no external forces, so there is no friction. We have to do this somewhere in outer space. I give the marble a speed, it hits the putty, and it gets stuck to the putty. Kinetic energy is nowhere nearly conserved; it's a very inelastic collision.

The two get together and clump together, but since there's no external force, only internal forces-- action equals minus reaction-- the putty pushes on the marble, the marble pushes on the body, and they cancel out. One is in this direction and one is in the other direction, and therefore in this case, momentum is conserved.

That is very important that you are aware of that, and we'll use that to our advantage many times.