

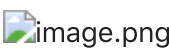
Linear momentum in more than one dimension

Inelastic collisions

A [bullet hitting an object](#) is a good example of an **inelastic** collision.

Ballistic Pendulum

We can however use conservation of momentum for the collision and conservation of energy for the **subsequent motion** in a [ballistic pendulum](#) to find the velocity of a bullet fired in to a block from the height that the bullet and block rises to.



$$mv = (M + m)v'$$

$$\frac{1}{2}mv^2 \neq \frac{1}{2}(M + m)v'^2$$

$$\text{but } \frac{1}{2}(M + m)v'^2 = (M + m)gh \rightarrow \frac{1}{2}v'^2 = gh$$

$$\text{so } v = \frac{M+m}{m}\sqrt{2gh}$$

Multidimensional collisions

The equation of conservation of momentum is a vector equation.

$$m_A\vec{v}_A + m_B\vec{v}_B = m_A\vec{v}'_A + m_B\vec{v}'_B$$

Therefore if we have a collision involving more than one dimension we need to consider conservation of each component of momentum, for example in 2 dimensions

$$m_Av_{Ax} + m_Bv_{Bx} = m_Av'_{Ax} + m_Bv'_{Bx}$$

$$m_Av_{Ay} + m_Bv_{By} = m_Av'_{Ay} + m_Bv'_{By}$$

Perfectly Elastic Collisions in 2 dimensions

If a collision is perfectly elastic we can add a 3rd equation

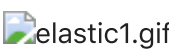
$$m_Av_{Ax} + m_Bv_{Bx} = m_Av'_{Ax} + m_Bv'_{Bx}$$

$$m_Av_{Ay} + m_Bv_{By} = m_Av'_{Ay} + m_Bv'_{By}$$

$$\frac{1}{2}m_Av_A^2 + \frac{1}{2}m_Bv_B^2 = \frac{1}{2}m_Av_A'^2 + \frac{1}{2}m_Bv_B'^2$$

Billiards Question

When we hit a billiard ball straight on all the momentum of the incident ball should be transferred to the 2nd ball.



However we know already from experience that if we hit a billiard ball at an angle this does not happen. Can we use our conservation of momentum principle to predict the trajectories of billiard balls after a collision? If one ball hits another head on, it should come to rest. **But if it comes in at a small angle where should it go?**

Bil (oi pu	Co of mc v _A + 0 : + 	v' _B v' _B	Billia (con	Perfe Inela Colli: in 2D	Compa between the two collisio	Perfe Inela Colli: (con	Cen of Mas	The Useful of Cente of Mass	Cer of Ma: (co	Center of Mass for Contin Object	COM of contin object (cont.	Snooke Video	In []:
			Squan the conse of mome equati	 In a perfec inelast collisic	All real collisions lie somewhe between the extremes we have looked at, but let's consider now the two extreme cases for a collision of 2 objects of equal mass colliding at right angles with equal velocities	For an inelast collisic	We have looke at two quite differ 2 dime: collis Howe there is one way of lookir at them whic make them look more simile If we consi the motic of the cente of mass of the objec instea of the motic of the indivi mass we can see that from this persp the motic is identi	We can actually consider the motion of any extende mass to be composi of different kinds of motion with respect to the center of mass. So far we have dealt with translati motion, and we can now make explicit our implicit assumpt till now that we consider the translati motion of an object's center of mass. We will now also see in the coming lectures that we can add to this translati motion other motions of the mass around the center of mass, for example rotation: or vibratio motion.	so we have obta a new form of New Secc Law that work for a systi of parti	$\vec{r}_{CM} = \frac{\sum_i m_i \vec{r}_i}{M}$ can be expresse in integral form $\vec{r}_{CM} = \frac{1}{M} \int \vec{r} dm$ image.pr We can consider a uniform rod to be a one dimensio object. If we want to find the COM we could place the origin of our coordina system at the center of the rod and then	On the other hand if we were to place the origin at the left end of the rod then we could show that $\vec{r}_{CM} = \frac{1}{M} \int \vec{r} dm = \frac{1}{M} \int_0^l \lambda x dx = \frac{1}{M} \frac{\lambda}{2} l$ and as $\vec{r}_{CM} = \frac{l}{2} \hat{i}$	Clearly there is more to this game than we discussed above! To understan better the way we can manipulat the path of a billiard ball we will need to study rotational motion..	