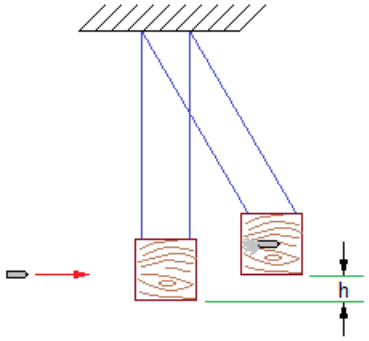
# Physics I

## Collisions

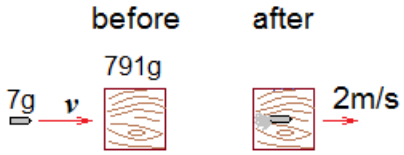
Conservation of momentum in collisions: $m_1 v_1 + m_2 v_2 = m_1 v'_1 + m_2 v'_2$

Conservation of energy in 1-dimensional collisions: $v_1 + v'_1 = v_2 + v'_2$

**Problem 1.-** A 7-gram bullet with an initial velocity of 250m/s impacts a 693-gram block of wood that was at rest hanging from strings. The bullet and block of wood stay together after the impact and swing upwards. What is the maximum height reached in the swing?



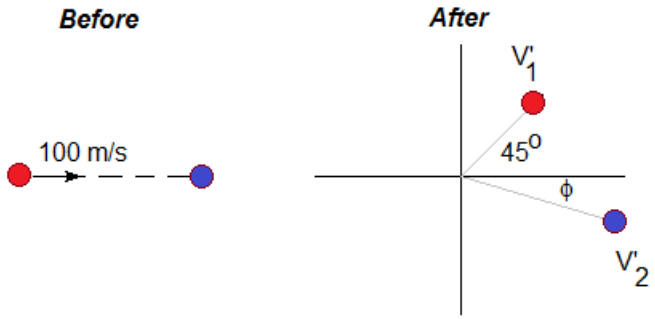

**Problem 2.-** A bullet of mass 7g with velocity ***v*** hits a block of wood of mass 791g initially at rest. After the collision the bullet remains embedded in the block and they move together with a final velocity of 2m/s, what was the initial velocity ***v***?



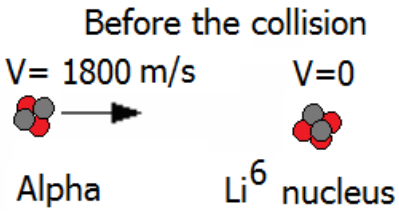

**Problem 3.-** A particle of mass 1kg with an initial velocity of 100 m/s collides elastically with a second particle of mass $m_2$ that was initially at rest.

After the collision the first particle has a velocity that makes an angle of 45 degrees with respect to its initial velocity as shown in the figure.

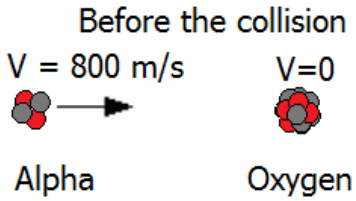
Calculate the velocity of the two particles after the collision for masses $m_2$ =2kg, 3kg, … 7kg.



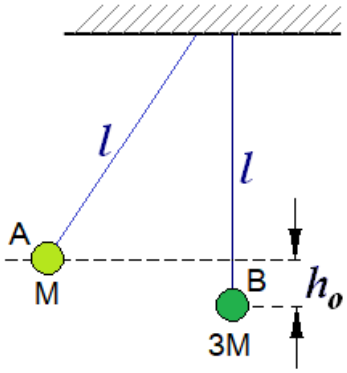
**Problem 4.-** An alpha particle (mass = 4u) with an initial velocity of 1800 m/s collides head on and elastically with a lithium nucleus (mass = 6u) initially at rest. Find the velocity of the lithium nucleus after the collision.



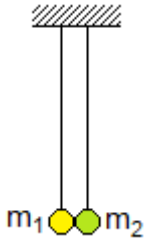

**Problem 4a.-** An alpha particle (mass=4u) with an initial velocity of 800 m/s collides head on and **elastically** with an oxygen nucleus (mass=16u) initially at rest. Find the velocity of the oxygen nucleus after the collision.




**Problem 5.-** Two small spheres of soft, malleable clay, A and B, of mass M and 3M, respectively, hang from the ceiling on strings of equal length *l*. Sphere A is drawn aside so that it is at a height $h_o$=1m, as shown in the figure, and then released. It collides with sphere B, they stick together and swing to a maximum height *h*. Calculate *h*.



**Problem 5a**.- Two spheres made of soft clay are suspended side by side by 1-m long strings. Their masses are $m_1$ = 5 g and $m_2$ = 20 g. If $m_1$ is pulled 53º off the vertical and released, find their velocities after they collide in a completely inelastic collision.




**Problem 6.-** An alpha particle (mass = 4*u*) has an elastic collision at $t = 0$ with another nucleus that was initially at rest and bounces straight back with 2/3 of its original speed. Calculate the mass of the second particle.


**Problem 6a.-** A 4kg-ball collides elastically with another ball, which is initially at rest. It rebounds in the opposite direction with a speed equal to one third of its original speed. What is the mass of the second ball?

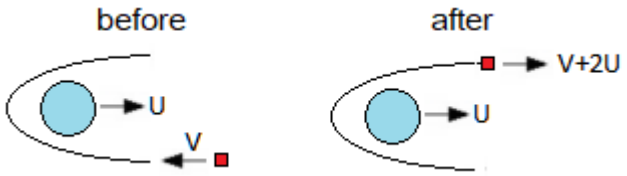
**Problem 7.-** A proton at rest is hit head on by an alpha particle moving at a speed v. If the collision is elastic, what speed will the proton have after the collision?
Consider the mass of the alpha particle to be 4 times the mass of the proton.

**Problem 8.-** In a one-dimensional collision, a particle of mass ***m*** with velocity ***v*** collides with a particle of mass 3***m*** at rest. If the particles stick together after the collision, what will be the final velocity of the two particles?

**Problem 9.-** A wooden duck of mass 0.80 kg floating quietly on a pond is hit by a 1g-pellet traveling at 350 m/s that buries itself in the wood. Calculate the speed of the duck just after the hit.

**Problem 10.-** A 4g projectile traveling at 450 m/s hits a 1kg block embedding itself in the material. If the block was resting on a smooth surface, find the final velocity of the block and how much kinetic energy was lost.

**Problem 11**.- In the technique called gravitational assistance (slingshot effect), a spacecraft approaches a planet to accelerate. One example is the Cassini probe when it approached the Earth in 1999 on its way to Saturn.
The figure below indicates schematically, how this is accomplished.
Explain why the spacecraft acquires a higher speed and where the extra kinetic energy comes from.




**Problem 12**.- When shooting a hunting rifle, the bullet and the rifle must have identical linear momenta just after the shot, however the bullet takes away more kinetic energy. If the mass of the rifle is 1kg and the bullet 5g, what approximate percent of the total kinetic energy is taken by the rifle?

(A) 0.1%
(B) 0.5%
(C) 1%
(D) 5%
(E) 25%

**Problem 13**.- If a large truck and a small car collide in an accident, which vehicle experiments the largest force?

**Problem 13a**.- If a large truck and a small car collide in an accident, which vehicle experiments the largest acceleration?