Occasionally, there are questions about the Engineering and Physics of our Patent Pending moving weight cue designs.

So, here is the short version:

Momentum

The momentum of a system of particles is the vector sum of their momenta. If two particles have respective masses m_1 and m_2, and velocities v_1 and v_2, the total momentum is

$$p = \sum_i m_i v_i .$$

Momentum can be judged in a single particle (standard cue) or many particle (Moving Weight Cue, filled with ball bearings) situation. In a many particle situation the Center of Mass of the many particles is used to calculate momentum.

If all the particles are moving, the center of mass will generally be moving as well. If the center of mass is moving at velocity v_{cm}, the momentum is:

$$p = mv_{\mathrm{cm}} .$$

This is know as Eulmer's First Law:

Since the cue filled with ball bearings has "many particles" its momentum is the sum of the velocity of the particles times the mass of the total. Thus if the ball bearings are moving faster than the cue itself then the velocity of the center of mass is higher than the cue alone….thus an increase in the momentum for the "many particle" cue is greater than the "single particle" cue.

Most of this can be confirmed on wikipedia.org .

Relation to force

Since the cue tip stays in contact with the cue ball for a fraction of a second (longer with a softer tip) as the ball bearings move forward there is a change in the net force applied to the cue ball during that time.

For a standard cue the force is constant thus:

If the net force applied to a particle is a constant F, and is applied for a time interval Δt, the momentum of the particle changes by an amount

$$\Delta p = F \Delta t \, .$$

For a cue with a moving weight system the force changes during the stroke thus:

If the net force experienced by a particle changes as a function of time, $F(t)$, the change in momentum (or impulse J) between times t_1 and t_2 is

$$\Delta p = J = \int_{t_1}^{t_2} F(t) \, dt \, .$$

This discussion of Momentum and Relation to Force prove that the moving weight system produces a subtle improvement to the force provided from the cue tip to the cue ball. Our calculations show that the increased momentum is between 1.8 percent and 3.7 percent.