Knuckleball - (1% of the total pitches thrown in MLB)

Hit/Strike Rate For 2016 = 9.12%

The "Knuckleballer" is a category of its own

Oh, the knuckleball. It dives and darts every which way. Up, down, side to side and all angles in between. It confounds everyone, mathematical geniuses, physicists, engineers, and all who try to describe or especially to quantify it. Of course, I have never seen a mathematical formula put to an inflated balloon having been released with the valve open, either.

So, How Does a Knuckleball Dive and Dart?

I'll attempt to describe the knuckleball from a layman's perspective. The best knuckleballs I've seen personally and attempted to catch regularly have been on a fastpitch softball in the 60 mph ranges, but I've also been victim to line drives in the outfield that knuckleballed off the bat at a much higher speed. And I've seen soccer balls and volleyballs knuckle in flight, as well. I'm quite sure you have experienced many of these too.

Unfortunately, aerospace engineers and physics professors are in a certain amount of disagreement regarding projectiles flying through the air. So, until someone puts this together better than the real world observations and experiential understandings of those of us who have thrown, hit, caught, observed, missed, been hit in the nose by, been made a fool of, explained a black eye, and studied them in flight, then the following is my understanding of how this phenomenon most likely works in the real world.

Dr. Adair in his book, The Physics of Baseball, describes baseball this way; "Some people have asked, 'Well, baseball isn't rocket science, is it?' to which Dr. Adair replies, "No, it's a lot harder!" The reason, as he explained in his book, is that a cone at the nose of the rocket is pointed and smooth, whereas the baseball has sort of a yin-yang pattern of stitching surrounded by a smooth leather skin stretched around the ball. It makes it difficult if not impossible to put a mathematical formula to its flight.

I like to say it this way--along the path even a fastball takes, pressure builds up on the front of the ball caused by molecule displacement. As the air attempts to equalize, pressure builds and pushes the ball off course. This phenomenon is akin to the reason that airplane wings slant backward to afford a "wiping" effect of air molecules off the leading edges, and the reason rockets are built with cone-shaped noses. A knuckleball, however, moves two or more different directions (sometimes upward) in a "hopping" fashion from the same cause, i.e. air pressure buildup.

Now, did that explanation convince you? Well, let me try again after explaining a couple of things we already know about the air from other industries that the engineers, physicists, medical professionals, aeronautics professionals, meteorologists, and scientists have known for centuries--and have helped these industries to adjust to conditions all over the world.

Air pressure is caused by all the weight of the air stacking up on the earth due to gravity, just like the weight of anything else. Naturally, the lower elevations of the earth, then, have

more air molecules stacked up. Denver, Colorado has 5,280 feet **less** air stacked upon it than a sea-level city; a 16,000 foot elevation mountaintop has 16,000 feet less air stacked upon it. The weight of the air above pushes down ***and out*** upon the air below creating a pressurization that surrounds the whole earth. Air molecules repel each other vigorously, so that they stay evenly spaced and they create substantial power when pushed together, as you know from other industries such as the air compressor industry.

This evenly spaced air is the cause of all kinds of events such as wind, which pulls cold air into conformity with hot air. This results in tornados, sandstorms, hurricanes, typhoons, and any kind of weather event you can think of. It also is the cause of tiny things we don't think of very often, such as humid air pushing into dry air.

So, to help this discussion about the knuckleball, let me repeat an explanation of the air I read from a column in a Denver newspaper by Mike Nelson, a local meteorologist. **He said something like this:**

Humidity does not create heavy air, as most people think. Since Nitrogen is heavier than Hydrogen, then two molecules of Hydrogen attached to Oxygen (to begin to create H2O) humid air is lighter (not heavier) than dry air, here's why. Imagine a one cubit foot of air floating in front of you. Air molecules are made up of: mostly Oxygen, Nitrogen and Hydrogen. Nitrogen is attracted to Oxygen and Hydrogen is attracted to Oxygen, but Hydrogen and Nitrogen repel each other even as they are attached to the Oxygen. Since the block of air must remain in a state of equalized pressure within its geographic elevation, if one new molecule of Hydrogen enters that block of air in order to create humidity, a molecule of Nitrogen must be kicked out of the block. So the magnetism between Oxygen and Hydrogen allows the lighter Hydrogen in, and the extra repelling pressurization kicks out an equal number of heavier Nitrogen molecules.

With that equalization concept in mind, consider what would happen if a baseball entered that same block of air. As the baseball enters the block, it displaces a huge number of molecules (into the quintillions in number). As it pushes through the air, it knocks molecules straight back from the center of the nose of the ball and into adjacent molecules, which push back. It knocks some molecules back at a slight angle to the side. Some molecules that are further from center of the nose of the ball are swept around the ball on all sides by the adjacent equalized air within the block. Then, when the ball passes by these molecules, they snap back together behind the ball, equalizing to their natural distance. So, it is the molecules which get pushed straight back into the other air molecules that create the extra pressurization in front of the nose that build up on the non-spinning, free-flying knuckleball. The "Yin-Yang" stitch pattern, which is really in an "S" pattern of four circles and one open section on each, creates a parachute of sorts, holding some of those molecules in front of the moving ball. When the molecules collect together enough to create more pressure than the weight and momentum of the 6 oz. ball, then the ball slides around this bank of pressure in the direction the open section allows. The baseball is then turned slightly by this action and another pressure bank builds, but now the open section of the seams is faced in a different direction (sometimes) allowing the air to push the ball in a different direction--even upward--but sometimes a double, or triple push in the same direction causes the ball to float or fall off--***totally weird***.

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