Salisbury University—Department of Physics

Bowling Ball Core Shape Dynamics

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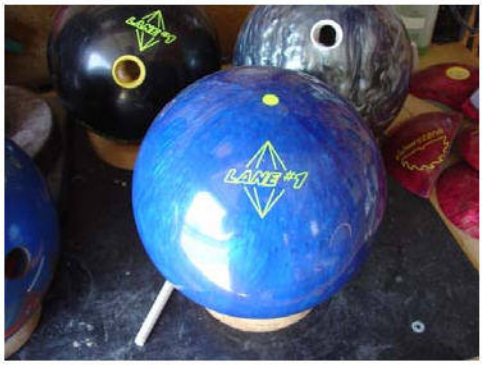
SU PHYSICS

BOWLING BALL CORE SHAPE DYNAMICS

AN INTRODUCTION:
THE BEGINNINGS OF A PHYSICS RESEARCH PROJECT

How does an astrophysicist start doing a research study on the motional dynamics of bowling balls? Specifically, an experimental and theoretical project about the core designs of the bowling balls produced by Lane #1 bowling. Sometimes the story of the evolution of an idea that instigated a scientific research inquiry is just as interesting as the research. Why and how did this line of physical concepts, calculations, experimental investigation, theoretical results, and scientific critique take place? Well, that is the story to start us off into the contained material in this bowling ball core research report.



First, I am an avid bowler. I like to bowl and have often thought of some of the physical concepts that must govern the behavior of a bowling ball while in use during a game at the local bowling alley. But, until recently, I only thought about what was going on in a superficial way without really investigating any aspect of the physics involved in any deep and thorough understanding way. I knew, for instance, that once a bowler releases a bowling ball that a few forces and concepts come into play that govern the behavior and performance of the ball such as gravity, friction, inertia, and energy. But, how exactly are these dynamics working and in play during a game was not something that I had researched or experimented with besides just throwing the ball at the pins.

A few forces are key to the game of bowling. Gravity, the force that is felt between massive objects, is always in play during the game. The large mass of the Earth exerts a force on the bowling ball and is always acting on the ball. Many bowlers use the force of gravity to begin the motion of a bowling ball, those who use a “free-armswing” without muscling the ball, to generate the speed of the ball down the lane. In addition, gravity is what ultimately sets up the friction that exists between the ball and the lane surface. The frictional force that the ball experiences between itself and the lane surface (whether in the oil or not) is dependent on the force of gravity as well. Frictional force depends, not only on the weight of the ball (force of gravity), but also in the properties of the ball and lane surface. The roughness, material composition, and even environmental conditions of the bowling center can affect the friction between the lane and ball. Why is friction important? Friction is the force a bowler will exploit to hook a ball across the boards of the lane surface. No friction on the lane, no hook is

possible. Finally, depending on the amount of revolutions the bowler creates, the fingers on the hand of the bowler will apply a force to the ball to get the ball spinning about an axis. This type of force, a force to change the rotation of an object, is called torque. In reality, most of the forces applied to the ball can create a torque, friction changes the ball's rotation and gravity acts on the spinning core in the ball to alter the path of the ball – both create torques on the ball.

Although not a force, there is an intrinsic property that moving objects (or stationary ones) display that also influence the motion of a bowling ball – inertia. The term "inertia" is solely a term that describes an object's resistance to a change in a linear straight line motion it already has OR if that object is at rest and stationary how much resistance it has to moving in a linear fashion from that state of rest. To quantify "inertia" of an object we measure the object's mass (in kilograms for the scientists in the room, or in pounds for the bowlers). However, a bowling ball is not only traveling down the lane, it is also spinning (revolving). Rotational Inertia is a spinning object's resistance to a change in the rotational motion it already has about a rotational axis OR if that object is at rest and stationary how much resistance it has to moving in a rotational fashion about an axis from that state of rest. To quantify "rotational inertia" of an object we measure the object's mass and its moment arm from the axis of rotation and calculate the object's moment of inertia. (Think mass in kilograms, with a distance measure - like mass of a sphere and its radius).

Here is where we encounter gravity and friction again. Gravity is a force applied by the armswing of a bowler to "change the bowling ball's state of rest" to motion down the lane. Gravity will also act on the core in the ball as it rotates. The core is very much like a "spinning top" of interesting shape often with a designed mass imbalance. Gravity will torque this spinning core causing the ball to change its axis of rotation ("flare") as it moves down the lane. Friction is the force that the ball coverstock experiences via its interaction with the lane surface and oil to "change the speed of the ball" and "change the direction of travel" as the ball "hooks" moving down the lane. The strength of all these forces is in response to the measure of straight line and rotational inertia of a specific ball in motion.

How can all of these forces and factors be analyzed in any meaningful way? It seems there is so much going on that there might not be an easy way to get an idea of the physics behind the "big picture" of rolling a bowling ball. Well, we can actually take all these concepts of forces, inertia, rotation, friction, & torques and lump them altogether into the physics of energy – specifically, kinetic energy of the bowling ball.

Who knew there are so many possible avenues of physical concepts to scientifically explore in what seems like the apparently relatively simple game of tenpin bowling?

Second, I have a physics background and sometimes inspiration to study the physics involved in things appears from unanticipated places. The idea came from Richie Sposato of Lane#1 Bowling via the following correspondence.

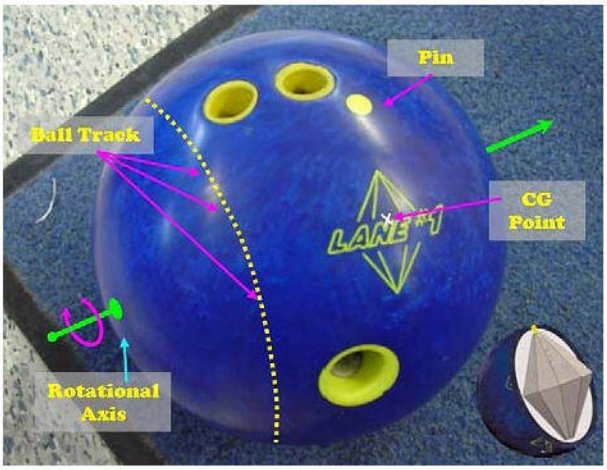
Dr. Joe,

Seeing as though you're a physics professor, would you be interested in doing a physics study for us, regarding our diamond core, vs. all other shapes (round, square, rectangle, etc...). Something that we can use for advertising, backed up by the laws of physics..?

The reason I'm asking is that we had one done before by my patent attorney's son, who was a physics major at Syracuse University. It showed that the diamond core generated 20% more inertia than any other shape. The test results were given to me informally on a piece of paper. I'm wondering if you could do a similar study for me that we can use for advertising? Something formal in writing that is presentable with maybe a picture also. Basically, if we took the diamond shape, same size and weight, vs. all other shapes, same size (volume) and weight, what would the numbers be..? How do these numbers translate to more effectiveness at the pins? Plus, how could we explain this benefit to the average bowler..?

Would you be interested in doing something like this? Let me know.

Sincerely,
Richie Sposato – President
Lane #1



So, the research idea began to take shape (so to speak). A look into the "inertia" of the core shape is a good way to begin to explore the dynamics of a given bowling ball and this step of looking at inertia could be used to investigate the "energy" of a moving and spinning bowling ball. We could derive theoretical formulae for the "moment of inertia" of a core, we could conduct experiments into some of the actual core shapes to determine the "moment of inertia" of a specific core, and we could then use this research to possibly make some conclusions about (or at least better hypothesis) the behavior of a bowling ball with different core designs. This could

be a great project because it involves some experimental and theoretical physics, uses a lot of mathematics, and applies to the sport of bowling. Plus, I had no idea were the research would lead. I might end up finding results that verified some of Lane#1's claims, or I might not. This is when science research is fun and challenging – "having no idea of the results beforehand and the possibility of surprising results."

This is where the actual Lane#1 Scientific Research Report begins. You will find in this notebook a collection of works that explores some of the physics and dynamics of some differing bowling ball core designs. The core, often called the weight block is the custom shaped inner mass of the bowling ball. A theoretical difference in core design in regards to ball performance makes sense. Manufacturers have discovered that the core shape, size, and mass can affect the ball roll and spin. Ball designers are trying to find and use different aspects of energy distribution among the various engineering aspects (cores, covers, etc) of the ball design in hopes of finding the magic combination. Thus, there is a rush in trying many different styles of core designs.

What happens when actual science, mathematics, and experiments are conducted? What can be concluded?

Keep going and see for yourself.

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