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The Physics of Beyblades:

Application In Competitive Play

Beyblades are a popular children's toy originating from Japan. The game is played by spinning tops called beyblades in a stadium using a launcher with the objective being to spin longer than the opponent or to knock the other beyblade out of the stadium. There are many different kinds of beyblades with each part being interchangeable with one another in order to create the best combination. Knowing the competitive and strategic nature of this game it begs the question: can we use the knowledge of physics in order to optimize the gameplay meta? The answer to this is yes, but in order to be better in competitive play we must know some of the basic physics of a beyblade top.

A top is able to stay upright while spinning due to angular momentum. Angular momentum is the momentum of rotating object whose direction is by which direction it spins and is along its axis which the body is rotating. For a top the direction of the angular momentum will be vertical. Just like regular momentum, angular momentum must be conserved due to the law of conservation of momentum and the change in the direction of momentum, from vertical to horizontal violates this law in an isolated system. Entropy due to friction with the ground and air however, eventually causes the top to slowly stop spinning. What is interesting about a top is that because the base of a top is able to move independently (as opposed to a gyroscope) it causes the top to be self-correcting. This is similar to how a moving bicycle can self-correct itself and stay upright even when no one is riding it.

One thing that sets apart beyblades from ordinary tops is that they are used in a stadium. A beyblade stadium is usually a wide, shallow bowl with several pockets around the outside for the beyblade to be hit into. What is interesting about this is how beyblades move inside the stadium. While some beyblades barely move and stay near the center, some will move quickly around the stadium in circles. This circumvention of the beyblade is caused by many factors, one of which is the stadium itself. If a beyblade were to be moving on a flat surface the direction of the beyblade would be in a straight line, like a coin rolling across the floor. In a stadium however, the beyblade is constantly changing direction. Because of newton's first law of motion we know that this change in direction is caused by the normal force acting upon the beyblade by the stadium. This inward force is also known as a centripetal force.

The width of the circle which a beyblade spins in the stadium is dependant on two main factors: The slope of the stadium and the velocity at which at which a beyblade’s tip is spinning. The slope of a beyblade stadium increases as you get farther from its center. An increase in the slope of an inclined plane means that there will be a greater net force acting upon the beyblade as it moves farther out from the stadium’s center as gravity has more of an impact on the net force. This means that as a beyblade moves farther out from the center of the stadium it will experience a greater net force pushing it back towards the center, slowly decreasing the radius of its path as the beyblade loses momentum. Because gravity affects all objects equally, a faster moving beyblade will move farther from the center of the stadium and take more time to decelerate. The

movement speed of a beyblade is largely dependant on the velocity at which the tip is spinning. The velocity at which the tip is spinning depends on the the radius of the tip and the rotations per minute of the beyblade. A beyblade tip with a larger radius means the tip will have a larger circumference which means that the outside of the tip will have to travel a farther distance in a single rotation as opposed to a tip with a smaller circumference. The faster a beyblade rotates, the more distance the circumference of the tip can travel in a minute.

Knowing how physics affects beyblades can help determine how to improve gameplay strategy. There are three main types of beyblades, each countering one another like a game of rock, paper, scissors. First, there are Attack type beyblades which are able to move fast around the stadium to attack the other beyblade. Second, there are Defense type beyblade that are slower but more sturdy and are able to withstand attacks. Last, there are Stamina type beyblade which have bad defence but are able to spin longer than defence types. These types create a triangle where Attack beats Stamina, Stamina beats Defense, and Defense beats Attack. While having a type that counters your opponent gives you a better chance at winning it is not a sure fire way to win. This is why having a well optimized beyblade based on physics can turn the tide in a beyblade battle.

In general, having a beyblade with more mass will always be superior to a beyblade with less mass. A more massive beyblade has more momentum that it can transfer to other beyblades with attacks and also has more inertia to allow for longer spin times and for preventing stadium knock outs. Being able to spin a beyblade faster will also be more beneficial in battle. In order

to spin a beyblade fast you need to apply a sufficient enough torque. A torque is a force that causes objects to spin and the torque that causes a beyblade to spin comes from a linear force being applied to a beyblade launcher through a ripcord. This linear force is turned into a torque using a gear system attached to prongs on the launcher. A launcher with a higher gear ratio will cause a beyblade to spin faster than one with a lower gear ratio. A launcher with a longer ripcord will also spin a beyblade faster because the linear force is applied over a longer amount of time.

For Attack types it is important to have a flat tip and a ring with some slopes or protrusions. As previously stated, a wider tip will have more velocity around the stadium than one that is narrower. This, along with the protrusions on the ring, allow an Attack type to transfer its linear and angular momentum into the opposing beyblade and reduce its angular momentum and even knock it out of the stadium. Attack types also work best using a tip that has a high friction coefficient such as a tip made out of rubber.

Defense types work best with a ball shaped tip and a thick, bulky, sloped ring. The dynamics of a ball shaped tip allow for a Defense type to have a higher grip on the stadium the farther from the center the beyblade becomes. Defense type rings typically weigh more to give the beyblade more inertia and are sloped down to redirect the force of an attacking beyblade downward instead of up and out.

A good Stamina type is one with a sharp tip and a wide, round ring. Just like how an Attack type moves fast using a wide, flat tip, a Stamina type barely moves due to its narrow,

sharp tip. This tip reduces friction with the stadium which in turn reduces entropy and allows for a longer spin time. Stamina types also have round and smooth rings which reduces friction with the air and rings whose weight distribution is toward the outside of the ring. This weight distribution creates a greater centripetal force because the outside of the ring has a greater initial acceleration than the inside of the ring.

Using any of these strategies in a competitive match can help you to win, but even with these benefits, the randomness of beyblade battles can cause an unforeseen loss or victory. That is why applying the knowledge of physics to beyblade battles is crucial to the competitive meta. Even with the importance of this meta, the most important part of any beyblade battle is have fun. Knowledge is useless without the drive and determination to use it. That, in a certain sense, can even show how beyblades are important to physics education.

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