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## The Physics Of Volleyball Playing

I have played volleyball my entire life, from playing with my brothers and sister, to playing throughout grade school and high school. It has always been the sport that I spend majority of my free time on and the sport my parents spent the most time watching because all of my siblings played. Even though I have spent so much time with this game, I never thought about the physics behind it. There are a lot of forces that act upon the player when he/she is on the court. There is the constant force of gravity that is acting on the player at all times. Also present, is the constant force of air particles hitting the players body from all directions and the force being exerted on them by the ground. While doing this research I came to realize a lot more about the game of volleyball than I initially anticipated. I also came to understand certain concepts of physics to a deeper degree than I would have thought.

The game of volleyball has a lot of different components to it, but one of the first actions a player must learn is how to serve the ball over the net. The serve is the area of the game where you can make it your own. The player can do an underhand serve, overhand serve, jump serve, top-spin jump serve, or a float jump serve. The top-spin jump serve is the most intimidating of all serves. It comes at the defenders with a great amount of power behind it; the faster the ball is spinning the quicker it dives toward the opposing team. Ed Chang, writer for Volleyball Magazine, spoke to Pete Heureux, who has a degree in physics from California Polytechnic State University and who is also an avid volleyball player, Heureux states, "The high-speed top-spin serve is daunting, but at least it is predictable". Due to physics the ball in a top-spin jump serve is destined to go straight forward toward the other team in the direction the player is facing while making contact with the ball.

Although the serve can change due to different cofactors the largest contributor is that of the effort put onto the ball by the player, which results in the balls speed. The concept of velocity plays a key role in the game of volleyball. Velocity is the speed of an object in a particular direction, and when it comes to the jump serve, especially the top-spin, it is important. After the player tosses their ball into the air they jump to gain momentum and then uses his/her force to hit the ball over the net. The ball tilting downwards allows for the player to put more power behind the ball without sending it way out of bounds. In addition to velocity affecting the top-spin so does the concept of pressure. Bernoulli's Principle states that the faster air has lower pressure. With that being said, there is more are pressure on top of the ball and less on the bottom, creating the forward spin that inevitably forces the ball down. The ball begins to drag due to their being higher pressure air underneath the ball, and this rotation creates that forceful and daunting serve that every team hates to receive.

Another serve that a player can master is the float jump serve. The float serve contrasts in many ways in comparison to the top-spin jump serve. The float jump serve leaves the opponents confused as to where the ball is going to land. This serve creates a ball that does not rotate while moving through the air. Pete Heureux goes into detail about this concept and explains as to how the ball is, "subject to the unpredictable interactions with other forces like drag, lift, and a narrow window of opportunity called the drag crisis". This ball that does not rotate has the ability to change direction, it is not predictable and hard to place unlike the top-spin serve.

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One of the reasons the float jump serve is so difficult to place is because the type of ball being used can really affect the players performance. The panels and seams on a volleyball have the ability to change the speed of the air surround it. The ball can accelerate or slow down depending on where the seams are in that when the player makes contact, which is the case for many sports and the equipment they use, especially baseball. It has been found that the volleyballs with a hexagonal or a dimpled pattern can change the serve and potentially increase the constancy of the serve. So, depending on the ball that the team decides to use it is possible that it greatly impact the game that is being played. If the team is using a ball that is panels peeling away and it is deflated the ball will not react in the same way to a float serve as a ball that has a dimple textured and is inflated. The two will not have the same outcome because the change in direction of the ball is directly contributed to the weight, shape, and texture said ball.

Another factor that contributes to the serve is the jump prior to the contact with the ball. The jump serves usually start with the player taking a few larger step and then bending their knees to prepare for the vertical jump. When the player descends into a momentary squatting position before the jump the force plate has forces that need to be lower than 981N so that they are able to resist the force of gravity, indicating that the player is in a downward movement. Next, the player needs to accelerate and switch from this downward acceleration into upward motion. This upward motion is a shift of the players center of mass up and finally the player extends his/her arm forward and serves the ball. The act of the jump add momentum and thus adds additional force to the ball that is about to be hit.

Volleyball is a complex game that has been a part of my life for years. I have always admired the sport, but after researching about all of the physics behind the serve I am even more intrigued than before. From the constant forces acting on the player to the difference the drag crisis plays on the float serve, physics adds complexity to the already complex game.

The forces acting upon the player and on the ball are constant and powerful which makes the game what it is today.