



## Pitching Science

Standing on the mound, a major league baseball pitcher has 60 feet and 6 inches of air to get each pitch to sizzle before it crosses the plate. But it's their arsenal of throws that separates a good pitcher from a great one. Two-fingered fastball, four-fingered fastball, slider, curve, cutter, knuckleball—each option spins differently to achieve a unique motion. Speed and rate of spin influence how much a ball moves in the air.

As a baseball rotates, air moves around it and is deflected off one side of the sphere. The axis it spins around and the rate of that spin determines where the air is released and with how much force. A ball that spins counter-clockwise (to the left) on a vertical axis—like a disco ball—will move towards the left, because the rotation pushes air off towards the right.

This flow creates a low-pressure zone on the left side, and the ball moves towards the area of vacuum, says Bauer. That force—the Magnus force—creates the bending effect. Pitches like a breaking ball take full advantage of the Magnus force to arc the baseball's path as it travels towards the batter.

Not all pitches are trying to bend so dramatically, though. Four-seam fastballs implement the Magnus force to fight gravity instead. "To throw a ball as fast as you can, you want your fingers and your hand behind the ball when you release it," says Eric Goff, professor of physics at the University of Lynchburg. "When you do, your fingers are going to roll on the back of the ball and that will put backspin on it." This upward rotation causes the Magnus force to exert the equivalent of about a quarter of the weight of the ball, Goff says. While it doesn't prevent gravity from acting on the ball, it gives these pitches a little more lift or "hop" in baseball parlance.

The breaking ball is where the drama of the Magnus force really comes into effect. A breaking ball appears to come in level with the top of the strike zone (roughly the middle of the batter's abdomen) and drops down to a batter's knees as it crosses the plate. "There are some very neat illusions that are associated with a breaking ball," says Goff. "It will look like it's just straight on a string and at the very last second it drops." Pitchers need a wide variety of movement in their arsenal because pitching is all about disrupting the batter's timing. There is about a tenth of a second after the ball is released before a batter has to decide to swing, he says.

