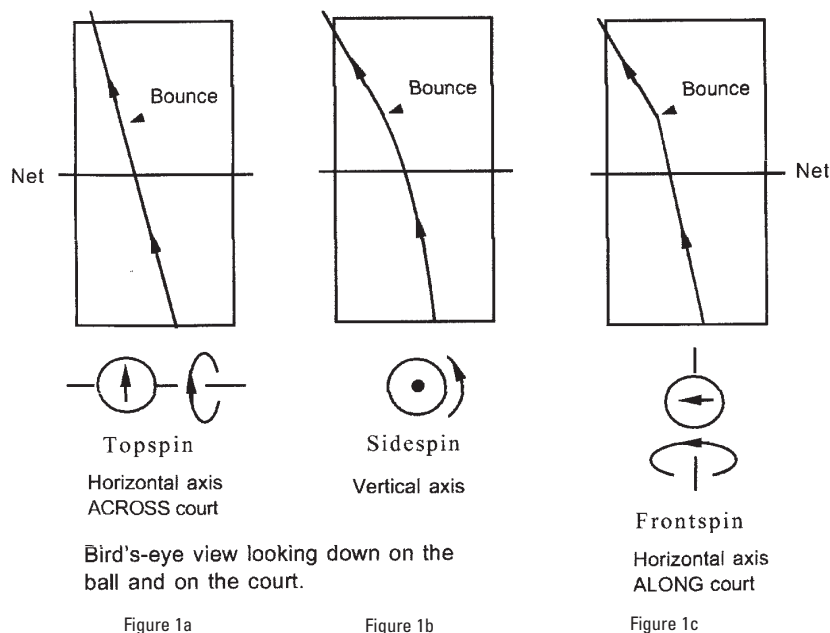


Six Different Ways to Spin a Ball



by Prof. Rod Cross

Rod Cross is a Professor of Physics at Sydney University, who has been working on tennis research since 1996. Dr. Howard Brody, Crawford Lindsey and Rod collaborated on the 2002 book [The Physics and Technology of Tennis](#), that describes in considerable detail the behavior of racquets and strings and the way that balls move through the air and bounce off the strings and the court. Rod has a laboratory full of scientific equipment that he uses to squeeze secrets out of the racquets, balls and courts used by tennis players.

Most players and coaches know all about topspin and backspin, and they also know something about sidespin, or slice. There is another way a ball can spin, which for want of a better word, I will call frontspin. I have never seen anything written about frontspin, which indicates either that no one knows about it or that I haven't read enough tennis magazines.

Spin means that the ball is rotating or spinning about a particular axis, either in a clockwise or a counter-clockwise direction. Logically, the opposite of "top" spin is "bottom" spin, but someone decided years ago to call it backspin. Topspin and backspin refer to rotation about an axis that runs horizontally through the middle of the ball. The direction of the axis is across the court, so the top of

the ball rotates away from the player who hit the ball or toward the player receiving the ball. Backspin is vice-versa.

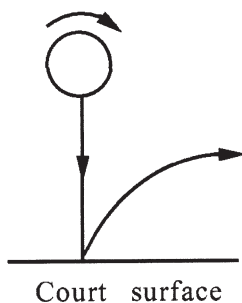
Sidespin refers to the rotation about a vertical axis pointing straight up to the sky or straight down to the court. The ball can spin clockwise or counter-clockwise, but no one has figured it is important enough to give the two directions of spin two separate names. But, it does make a difference to the way the ball curves through the air. If a ball is spinning about a vertical axis as it travels from one end of the court to the other, the ball will curve toward one side of the court or the other depending on the direction of spin. In golf, sidespin is called hook or slice, and players pay coaches to help them get rid of it.

Every object, including a tennis ball, has three main spin axes. The three axes are all at right angles to each other and are usually called the x, y and z axes. The third axis for a tennis ball, at right angles to the other two, is a horizontal axis pointing along the court rather than across the court. When a quarterback throws a football, he spins it about this third axis to make sure the ball doesn't wobble through the air. Similarly, when a bullet is fired, it is given spin around an axis that points along the same path as that followed by the bullet. That way, the bullet doesn't tumble and turn and hence, it doesn't get deflected by the air. A tennis ball cannot wobble since it is a sphere, but it can be made to spin in the same way as a football. Since the axis passes through the front of the ball, we can call this sort of spin frontspin. Counting the spin direction as being important, we therefore have a total of six different ways to spin a ball. Logically they should be called Top, Bottom, Left Side, Right Side, Front and Back spin.

Suppose that the y axis is vertical, the x axis is horizontal and the across the court, and the z axis is horizontal and along the court. A ball hit from one end of the court to the other down the middle travels in the z direction. If it has topspin, then the rotation axis is the x axis and the ball gets deflected by the air and downward (in the y direction). If the ball has backspin, the air exerts a force vertically upward, so it takes longer for the ball to fall and it will land closer to the baseline than a ball hit with topspin, unless the ball is hit at a lower speed or lower over the net.

A ball hit over the net (in the z direction) with sidespin (around the y axis) gets deflected sideways by the air (in the x direction). The spin axis, the direction of travel and the direction of the deflection are always at right angles. So what happens when the ball is traveling over the net in the z direction and is spinning around the z axis? The answer is that it doesn't get deflected by the air at all. It keeps going in the z direction until it hits the court. Then it gets deflected sideways, as shown in Figure 1c. There is no sideways deflection by the court if the ball has topspin or backspin or sidespin.

The effect of the court on a spinning ball can be seen most easily by dropping a spinning ball vertically, as shown in Figure 2. If the ball has sidespin, then the spin axis is also vertical. When a ball with sidespin hits the court, the bottom of the ball spins around on the court and the rotation speed slows down because of friction between the ball and the court. The ball then bounces vertically up off the court since it is still spinning about its vertical axis, but with less spin than before. However, if the ball is spinning about a horizontal axis when it hits the court, then the ball bounces upward and sideways. The direction of the sideways deflection is the direction in which the top of the ball is spinning. That's because the bottom of the ball slides backward on the court so the court acts by pushing the ball forward. It's like a sprinter pushing back on the starting blocks to accelerate forward.



Vertical drop

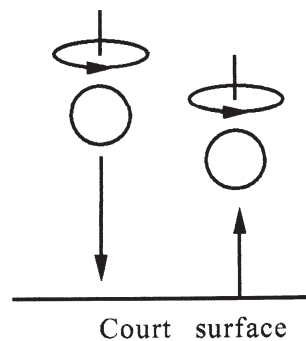


Figure 2

A ball hit over the net with topspin shoots forward when it lands. Hit with enough backspin, a ball can even bounce back over the net. Hit with sidespin, there is no deflection by the court at all either forward or sideways. Hit with frontspin, the ball will suddenly move sideways when it hits the court.

The easiest way to hit a ball with frontspin is to hit it underarm over the net, like a coach feeding balls to a beginner, with a right to left sideways chop of the racquet. The bigger the chop, the more spin on the ball and the bigger the sideways deflection when it lands. The same sort of thing happens when a player serves the ball or hits a groundstroke, unless it is a dead flat serve where the racquet face is moving exactly perpendicular to the eventual path of the ball. If the racquet face is not perpendicular, or is rising up to meet the ball or moving sideways across the ball, then the ball will acquire spin. It will generally spin about all three axes simultaneously, but not all at the same speed. It is the job of the coach to teach the player how to control the spin so the ball swerves through the air and/or kicks upward or sideways on command. Frontspin is generated when the racquet is moving across the face of the ball (upward, downward or sideways) in such a way that the strings make contact with the ball at any point that is not exactly at the back of the ball - that is, not coincident with the spin of axis. For example, when feeding a ball underarm, the strings contact the ball at a point underneath the back of the ball.

18 DIFFERENT WAYS TO HIT A BALL

Each of the six different spins requires a different hitting action. Figure 3 shows six different hitting actions. In each case, the racquet must move toward the net so that the ball travels over the net. At the same time, the racquet must move across the back of the ball to generate spin. The strings are quite slippery and have less friction than the court. When the strings first contact the ball, they start sliding across the back of the ball, but then they grip the ball. The sliding and gripping action drags the back of the ball in the same direction as the strings are moving, so the ball will spin in that direction.

Figure 3 shows views looking at the back of the ball, and the arrows indicate the direction of motion of the racquet as well as the position where the strings grip hold of the ball. The strings can drag along a line through the center of the ball (the three drawings on the left) or they can drag along a line off-center (the three drawings on the right). If the racquet head is rising upward as it strikes the ball, and if the racquet contacts the back of the ball along the center line, then the only spin that is generated is topspin. If the racquet head is moving downward when it strikes the ball, then the resulting spin is backspin. That action is not shown in Figure 3, since it is the same as topspin but with the arrow pointing the other way. In fact, all of the six arrows in Figure 3 can be reversed, so there are at least 12 different ways to hit a ball. Furthermore, the off-center arrows on the left side, or the top side of the ball, could equally well be drawn on the right side, or the bottom side of the ball. That makes at least 18 different ways to hit the ball. There are even more ways if the bottom two drawings have the arrows sloping upward at a different angle.

Hit through center	Hit off center
<p>Topspin only</p>	<p>Topspin & Frontspin</p>
<p>Sidespin only</p>	<p>Sidespin & Frontspin</p>
<p>Topspin & Sidespin</p>	<p>Topspin, Sidespin & Frontspin</p>

Figure 3