

# UNDERSTANDING THE TENNIS BALL SPIN

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## 1. Why I made this article

This article was created following my personal struggle with the American twist serve (the struggle still continues). It seems like my coach's instructions didn't result in considerable improvement. I'm an amateur but I still feel like the following popular minded elaboration could bring help for other amateurs in a similar situation.

I appreciate any correction proposals from readers; there may simply be mistakes in the elaboration. I'm not a physicist but have been attracted a bit into some basic physics in this question of tennis.

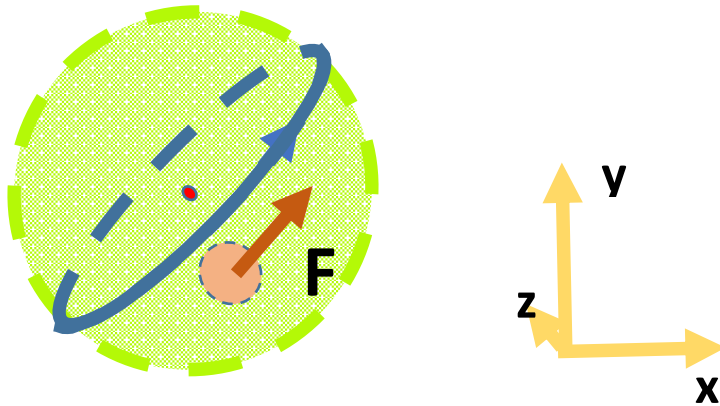
I've done this article on my own, without any connections to education establishments, study projects or anything; I'm not even a tennis coach. As of now, this presentation does not list references to existing articles and other material on the subject. This is because most of the substance is general in nature. If I receive feedback which I can use for improving this presentation, I'll make reference to the contributors.

## 2. Definitions and basic approach

The American twist serve, in some places called the kick serve, experiences at the ball bounce an abrupt sideways change of trajectory, which is somewhat mysterious for many people including myself.

In physics terminology, spin is a form of angular momentum. Let's observe how a given point on the surface of the tennis ball moves in the coordinate

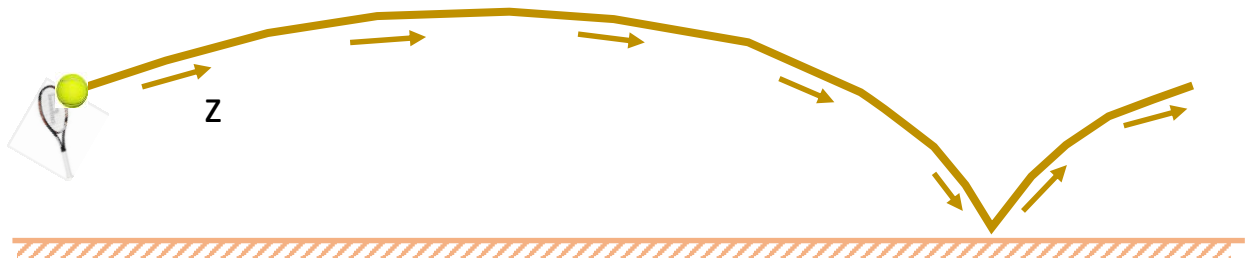
system from behind. Let's select a point on the ball equator since it probably is the most helpful in understanding the spin types.



**Figure 1 Definitions**

In the following figures the blue line shows the position of the selected point during a ball revolution. The dotted portion of the line represents the path on the opposite (non-visible) side of the ball. The red dot represents the ball center point. The brownish label shows the ground contact or bounce point. An arrow with " $F_b$ " signifies the force caused by ground contact and the force's direction. The Magnus force which is an important factor in the ball trajectory is well known and is here left out of the discussion.

The  $x, y, z$  coordinate system that is used as a reference for the spin components is selected to follow the trajectory (ball airway path), all the way down to the bounce point and even after it. E.g. see Figure 2; it shows the point revolving like on a horizontal plane. Let's assume that initially this horizontal system is planar with respect to ground surface, meaning that the ball momentarily seems to keep a constant altitude; however, if the ball's altitude increases or decreases, the trajectory is not planar against the ground any more; the coordinate system must also be pointing somewhat upward or downward. Therefore the revolving point still exhibits a straight line in the figure. For comparison, if the viewing angle is held constant, the point revolving path would exhibit an ellipse.



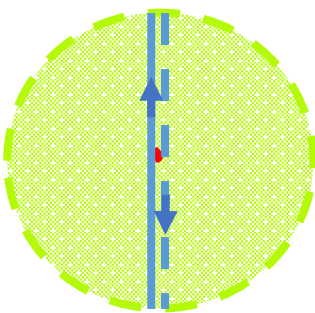
**Figure 2 Aerial path and coordinate system**

Especially Figures 3-4 and 3-8 below have been selected in such a way that they represent the spins typically involved for a right hander's serve.

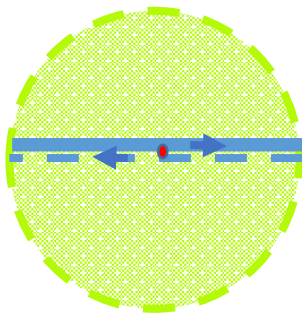
Besides serve aerial path, some of these illustrations may be helpful in understanding about groundstrokes as well.

The spins in Figures 3-1 and 3-3 are not typical for tennis serves, but they have been included here for the sake of completeness.

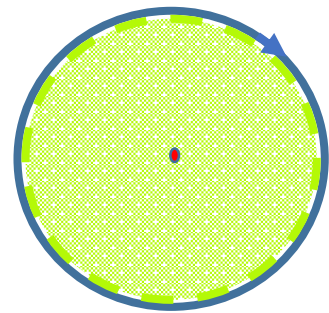
Note that even if we speak of x-axis spin (top spin), y-axis spin (side spin) and z-axis spin (spiral spin, corkscrew spin), the actual ball intrinsic spin axle is a single one and is roughly speaking maintained the same throughout the ball aerial path section. The axis terminology is used in order to make a link to the ball trajectory as well as with the coordinate system and what the observer sees from behind.



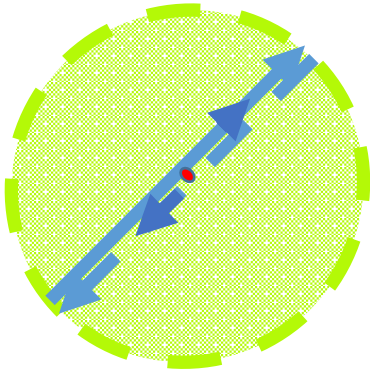
**1 - Top spin only**



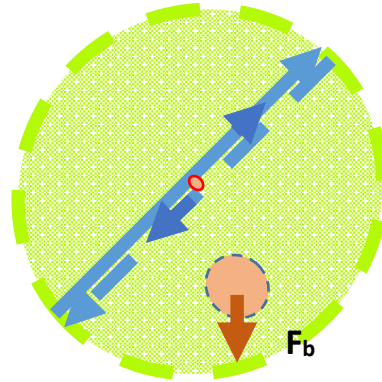
**2 - Side spin only**



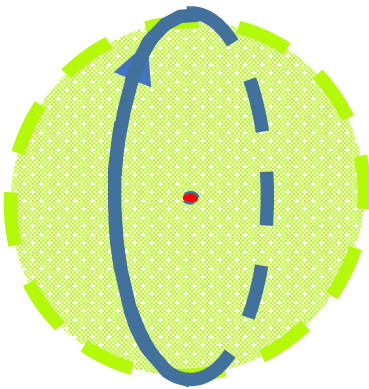
**3 - Spiral spin only**



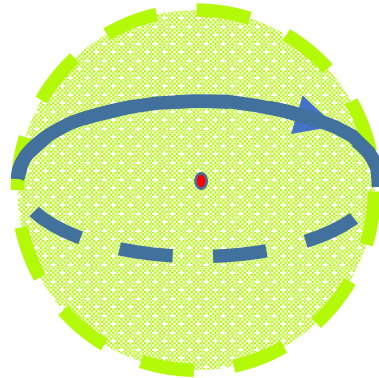
4 - Top spin + Side spin



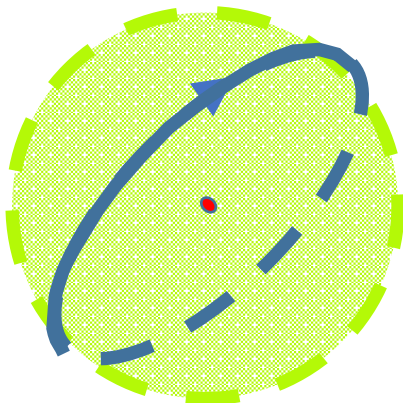
5 - Top spin + Side spin, at bounce.  
Note: Direction of  $F_b$  cannot be drawn accurately since view angle is not perpendicular to ground.



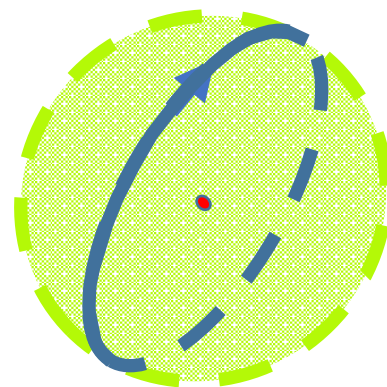
6 - Top spin + Spiral spin



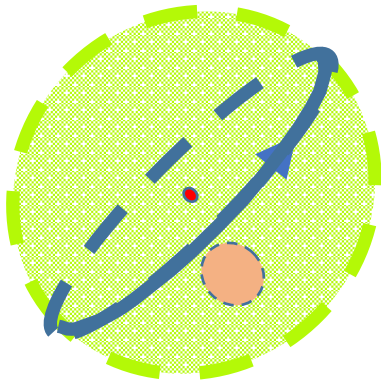
7 - Side spin + Spiral spin



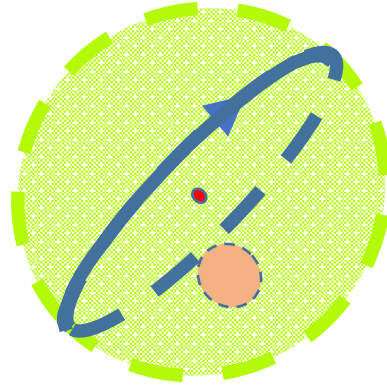
8 - Top spin + Side spin + Spiral spin



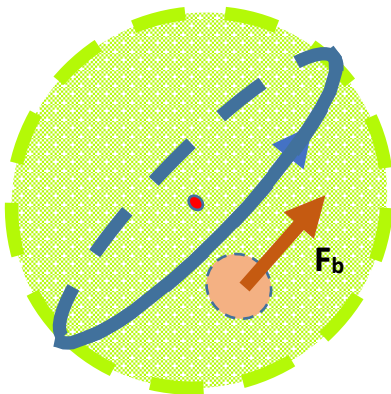
9 - Top spin + Side spin + *weak* Spiral spin



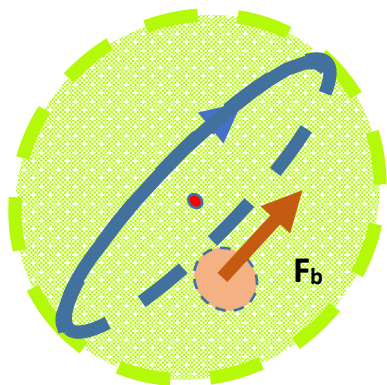
**10 - Top spin + Side spin + Spiral spin, just before bounce**



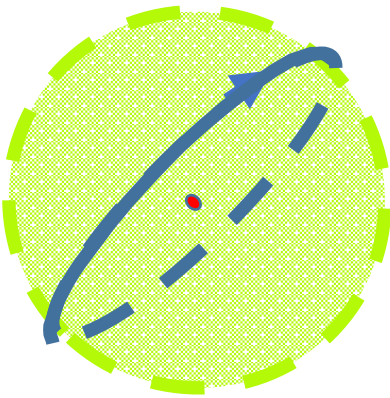
**11 - Top spin + Side spin + *weak* Spiral spin, just before bounce. Note: Direction of  $F_b$  cannot be drawn accurately since view angle is not perpendicular to the ground.**



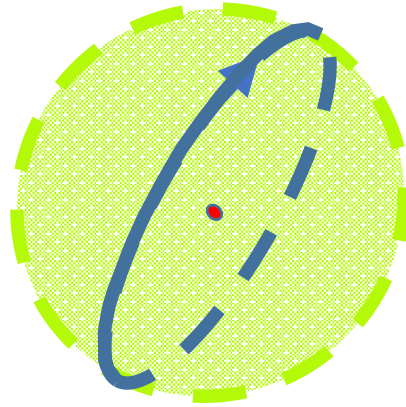
**12 - Top spin + Side spin + Spiral spin, at bounce point. Note: Direction of  $F_b$  cannot be drawn accurately since view angle is not perpendicular to the ground.**



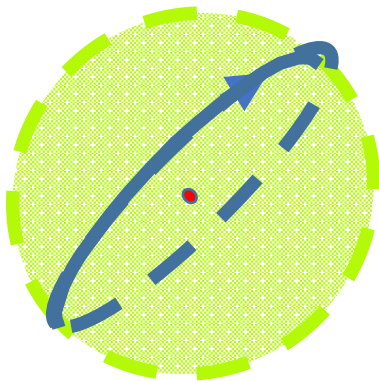
**13 - Top spin + *weak* Side spin + Spiral spin, at bounce point**



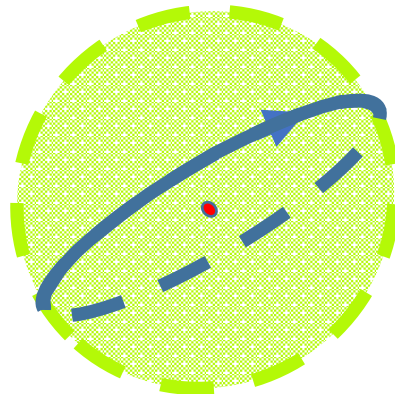
**13 - Top spin + Side spin + Spiral spin, just after bounce, view from bounce point**



**14 - Top spin + *weak* Side spin + Spiral spin, just after bounce, view from bounce point**



**15 - Top spin + Side spin + Spiral spin, just after bounce, view horizontally from launch point**



**16 - Top spin + *weak* Side spin + Spiral spin, just after bounce, view horizontally from launch point**

**Figure 3      Various spin types illustrated**

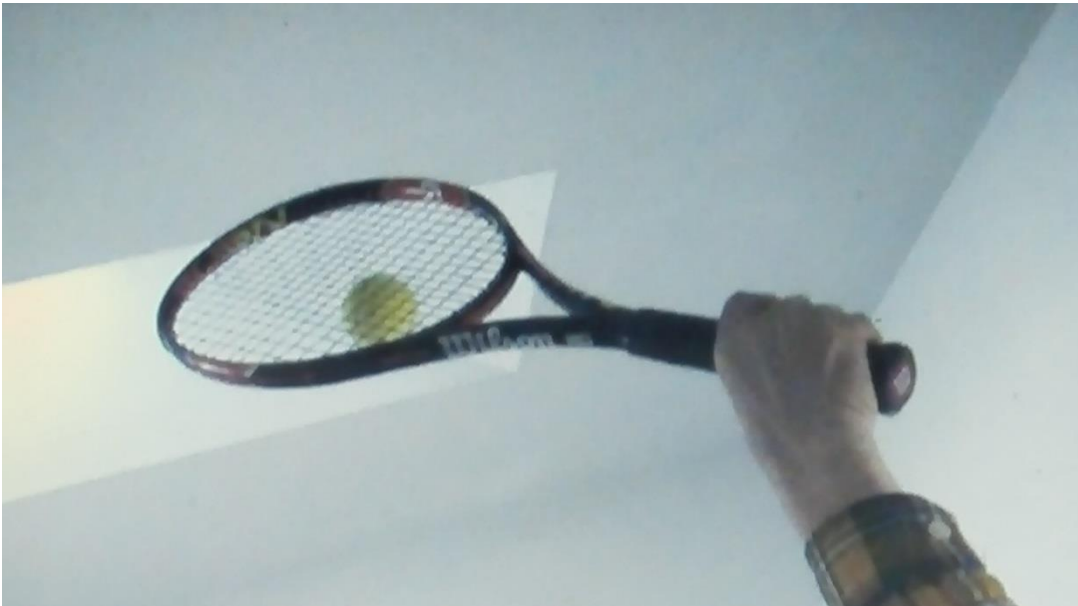
### 3. Speculations about the more complex spin questions

In order to achieve the desired spins and their combinations, there are the common factors such as ball toss, movements of arm, wrist, racket swing, brushing etc. For the American twist serve, especially the required spiral spin poses a challenge. A common advice is to brush the ball “from 7 to 1 o’clock”; however, this may be ambiguous or even misleading. Many instructions even lack a definition of the viewing angle toward the “clock”. E.g. this video <https://www.youtube.com/watch?v=tNz4cXtYUuo> instructs about the wall clock, but fails to state the viewing angle for the clock.

In fact, the viewing angle is not obvious partly since the ball trajectory is not evident yet at the moment of racket hit. In order to be explicit the viewing angle must be defined by all the three axes of the coordinate system and tied to the layout of the court and intended serve direction. Figures 4a ... 4c illustrate this point, but not being a coach and not knowing what should be the “official” position (a, b or c) looking at the “clock” I cannot give clear guidance with these figures as to what is the correct touch the racket should have against the ball.



**Figure 4a** (A possible?) twist serve ball hit point, horizontal view, perpendicular to baseline



**Figure 4b** (A possible?) twist serve ball hit point, slightly tilted view from downward, perpendicular to baseline



**Figure 4c** (A possible?) twist serve ball hit point, player's eye view



According to my coach, the pronation (winding down the thumb) with the American twist serve should be pronounced and be applied until the very end of racket swing. Obviously in this case there occurs a strong ball contact to the racket frame (see Figure 5); depending if it occurs at the racket head part, mid part, or the tip part (the last one is the most obvious), it can deviate the trajectory significantly, which in itself probably creates a spiral spin component. I'm not sure if this pronation is what first and foremost causes the spiral spin, or if it is the brushing alone.

The brushing contact is bound to occur along the equator of the ball in any case (when thinking of the equator as determined by the racket touch itself). However, if the ball imparts along a trajectory not aligning with the ball equator immediately at launch, one can claim, retrospectively, that the brushing occurred above the equator, or maybe below the equator.



**Figure 5                  Brushing with the racket frame**

A possible third explanation for the spiral spin is that the ball makes a curve due to Magnus force, which causes that whereas in the beginning the ball only had top spin + side spin (wrt the trajectory immediately following the launch), at the bounce it has all these: top spin + side spin + spiral spin; the last one of these being created by the fact that the trajectory is curvy and that the ball spin components stay the same wrt a stationary coordinate system,

but experience a change in the coordinate system based on ball trajectory. See Figure 6.

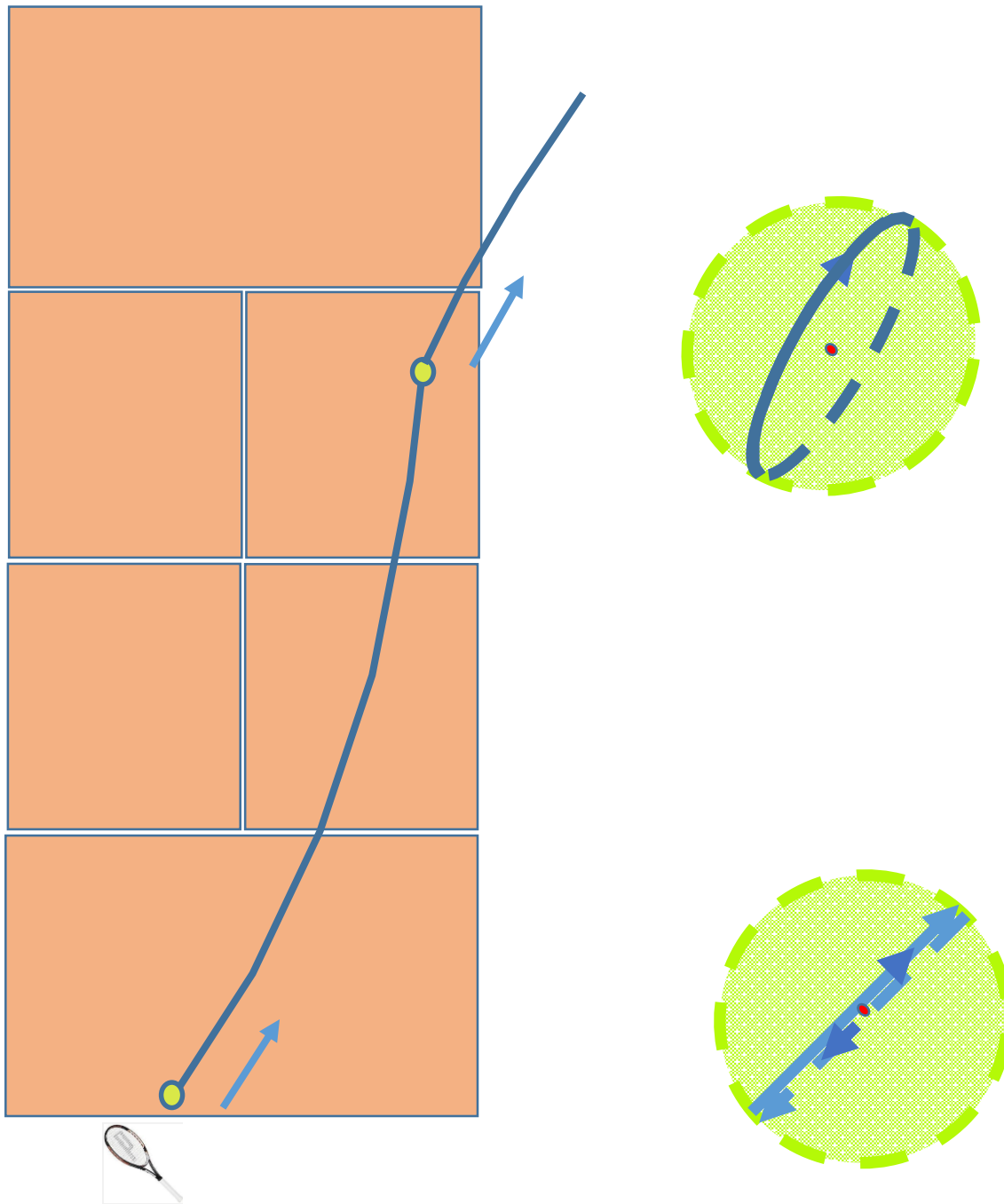


Figure 6

Effect caused by a curvy trajectory

## 4. Feedback is appreciated

As a conclusion, I see some bits and pieces are missing in those instructions that are available in the Internet, for example. There may be some more scientific and elaborate articles, but not everybody is equipped to read them through. If I receive feedback on this article, I could go on and make this presentation more complete and explicit especially regarding the twist serve.

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Thanks for reading.