Dissecting the Launch Monitor Data

MIZUNO
GOLF SCHOOL

Ball Flights

<u>Understanding Ball Flights:</u>

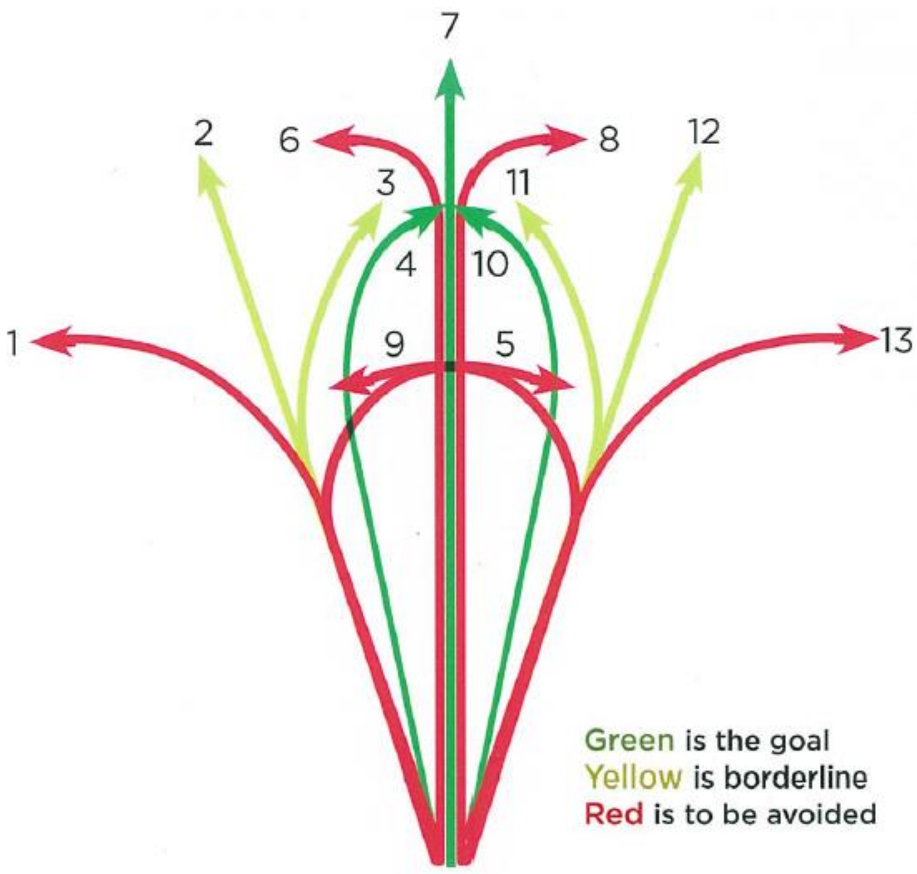
When it comes to being a great Golf Mechanic, having a detailed knowledge of how ball flight is created and manipulated is a must. If you are going to try and change the ball flight of a player, we think it is imperative that you first understand what is creating their current ball flight. The problem is, there has been a lot of debate and misinformation on ball flight for many years. The good news is, with today's technology, we now have a better understanding of what creates a ball flight than any other time in history. To really master this topic you just need to understand all the information that is now possible to collect.

To try and simplify this potentially complicated discussion, we think it helps to think in simple terms. You can call yourself an expert on understanding ball flights if you can answer these three simple questions:

1. Why did the ball start there?
2. Why did the ball curve that way?
3. What made the ball go that far?

To answer these three simple questions we are going to have to review some basic physics and mathematics and discuss some simple equipment design and engineering. With that said, once you can answer these three questions, you can take you level of teaching to a whole new level.

Before we begin breaking out each of these questions in detail, let's review all the possible ball flights that may occur. Taking away the occasional shank, skull, fat and topped shots we have identified 13 possible ball flights. These are categories of flights based on thousands of players being analysed on launch monitors all over the world.



<u>13 Major Ball Flights:</u>

Let's make sure we define all the basic shot patterns the same way, so that we can communicate better amongst ourselves. MGS uses the following terminology:

1. **PULL HOOK** – Starts left, curves left and ends left of the target
2. PULL – Starts left, goes straight and ends left of the target
3. PULL FADE – Starts left, curves right and ends left of the target
4. **FADE** – Starts left, curves right and ends at the target
5. **PULL SLICE** – Starts left, curves right and ends right of the target
6. **HOOK** – Starts straight, curves left and ends left of the target
7. STRAIGHT – Starts straight and goes straight and ends at target
8. **SLICE** – Starts straight, curves right and ends right of the target
9. **PUSH HOOK** – Starts right, curves left and ends left of the target
10. **DRAW** – Starts right, curves left and end at the target
11. PUSH DRAW – Starts right, curves left and ends right of the target
12. PUSH – Starts right, goes straight and ends right of the target
13. **PUSH SLICE** – Starts right, curves right and end right of the target

Why Did the Ball Start There (Face vs. Path)?

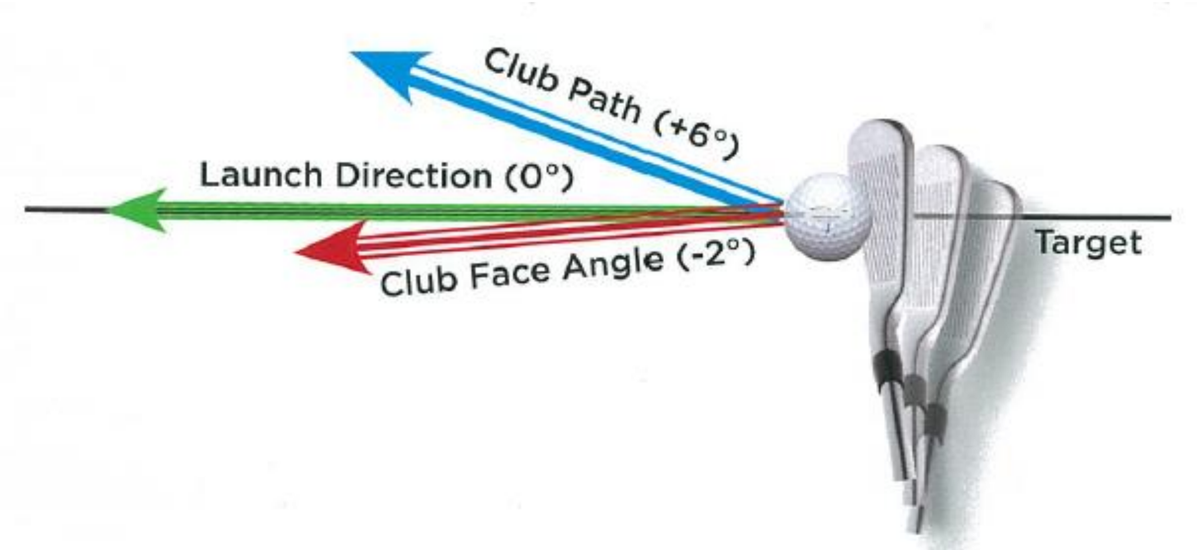
To begin to understand ball flight, let's discuss ***LAUNCH DIRECTION*** first. Launch direction is defined by the launch monitor as the horizontal direction of movement of the golf ball's centre of gravity immediately after leaving the club face. Two major factors influence launch direction, let's discuss club face angle and club path first.

Influence of Face vs. Path on Launch Directions:

We now know that the club face angle will have approximately four times greater influence on the launch direction than the club path. According to data collected by the launch monitors, the face orientation (face angle) represents approximately 75% of the initial launch direction for irons and 85% for most drivers. Therefore, the path only accounts for 25% of initial launch direction for irons and 15% for drivers.

Therefore, let's review an example. Let's say you had a club face angle of -2 degrees and a club path of +6 degrees. Because the face influences the launch direction by 75%, then to figure out the resulting launch direction you would have to perform the following math:

- The Face Angle: (-2 x .75 = -1.5) so the face will want to make the ball go left -1.5 degrees
- The Club Path: (+6 x .25 = +1.5) so the path will want to make the ball go right +1.5 degrees
- So to determine the resulting launch direction all you do is add those two together (-1.5 + +1.5) which equals to 0. So the resulting launch direction will be straight!



*** Don't forget this important face, just because the launch direction is straight doesn't mean the ball will not curve off that line. Curvature is due to spin axis tilt, and if there is a difference in the club face orientation to the club path direction (like above), there will be a tilted spin axis. So for the above example, the ball would start straight and curve to the left (drawing motion) assuming this was a centre face contact (more on this later).

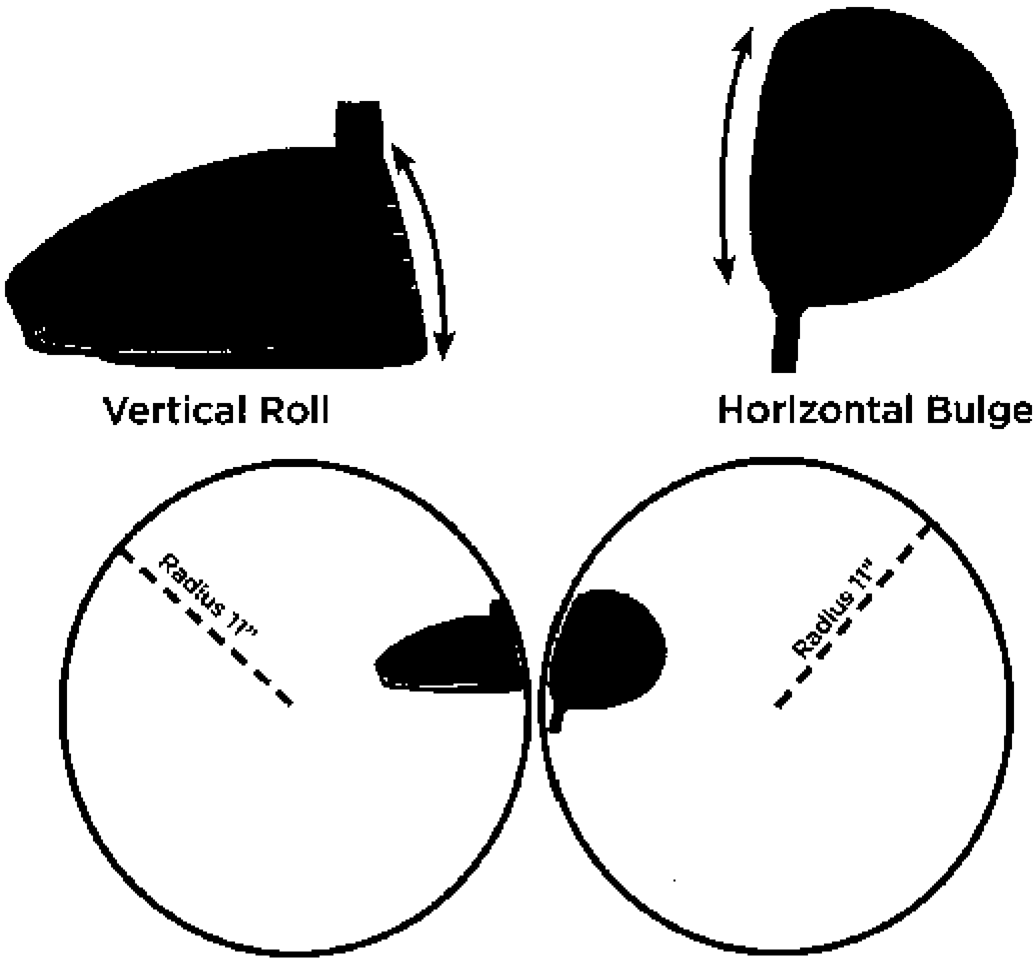
Club Face Angle:

So now that we know club face angle is the most critical factor influencing launch direction, we should discuss all the factors that influence the orientation of the club face.

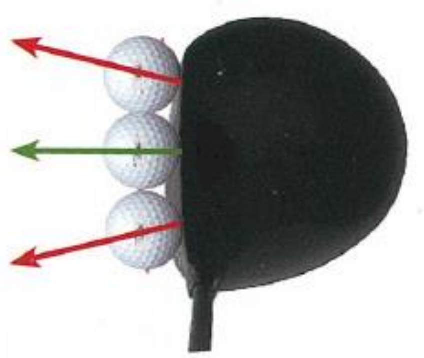
Impact Point:

The CLUB FACE ANGLE is defined by the launch monitor as the horizontal club face orientation at the centre of contact between club face and golf ball at the maximum compression of the golf ball. So to put this in layman terms, it is where the club face is pointing at the point of impact between the ball and club face For a driver, fairway wood or hybrid this is significant since the face is not flat, it actually has two curvatures calls “Horizontal Bulge” and “Vertical Roll”. They are commonly referred to as Bulge and Roll.

Bulge and Roll are curved surfaces that are typically measures in inches. Industry standard is around 11 inches of bulge and roll. This simply means the surface of the driver would equal the same curve of a circle that has a radius on 11inches (see diagrams below).



Because of the horizontal bulge, impact point will directly change the resultant club face angle. A ball hit on the toe of the club will have a club face angle pointing more to the right (positive). Whereas a ball hit more on the heel of the club will have a club face angle pointing more to the left (negative). Fore a bulge of 11" the face will be +2.6 degrees open for a contact that is ½ inch towards the toe.



Face Direction:

The next critical factor influencing club face angle is Club Face Direction. Club face direction is defined by the launch monitor as the horizontal club face orientation of the centre of the club face at impact.

So a toe shot on a driver may start the ball on the target line if the club face direction offsets the club face angle at impact (see below).

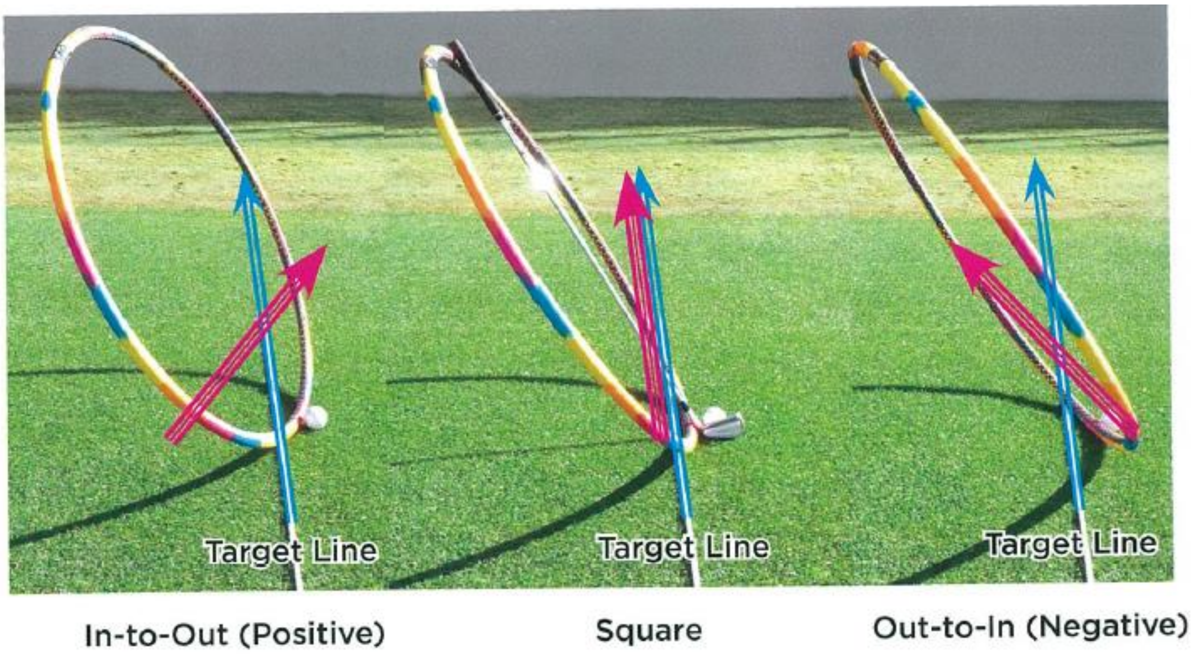
Club Path:

So let's now examine the factors that influence club path. There are three major factors that influence the club path:

1. Swing Direction
2. Attack Angle
3. Vertical Swing Plane

Swing Direction:

SWING DIRECTION is defined by the launch monitor as the horizontal direction of the plane defined by the club head's centre of gravity movement prior to impacting the ball. I think it is not hard to imagine that the swing direction will alter the club path. In other words, if we swing from in-to-out the club path will typically go more in-to-out as well. And vice –versa, and out-to-in swing direction will make the club path go more out-to-in.



Many people used to think that swing direction was the only factor that determined club path (at least that is what it looks like on a video camera). Unfortunately, there are a few more factors that can influence the true club path.

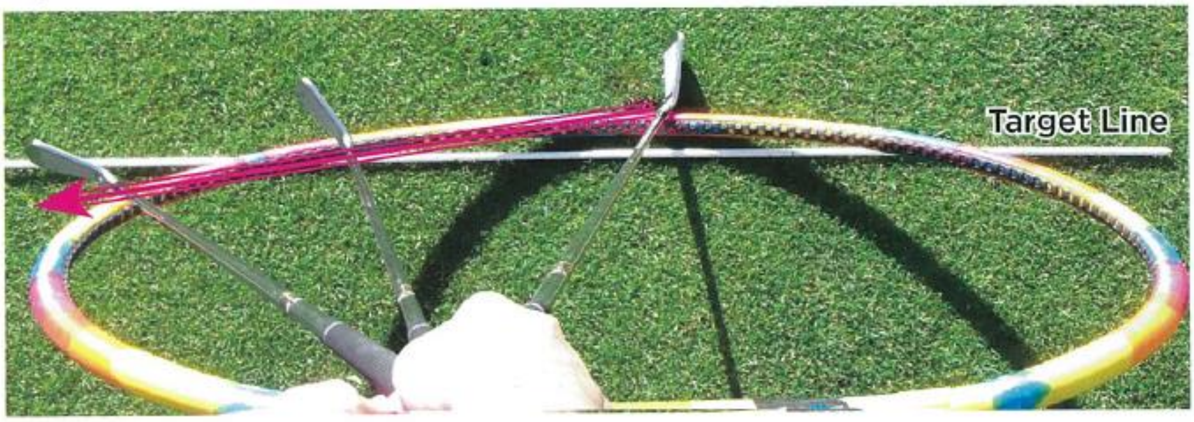
Attack Angle:

ATTACK ANGLE is defined by the launch monitor as the vertical direction of the club head's centre of gravity movement at maximum compression of the golf ball. This measurement is a bit harder to see than swing direction. To see why attack angle matters, look at the two pictures below. These pictures represent a downward attack angle. In other words, this is what happens when you are hitting down on a ball, like most iron shots. Notice that the club is actually travelling from in-to-out due to the downward attack angle.

So we can always assume that a downward attack angle will influence the club path in-to-out (or positive). Therefore, if you are hitting an iron, and hitting down on the ball, you must have a swing direction that goes out-to-in (negative) to balance out the positive attack angle and create a straight launch direction.

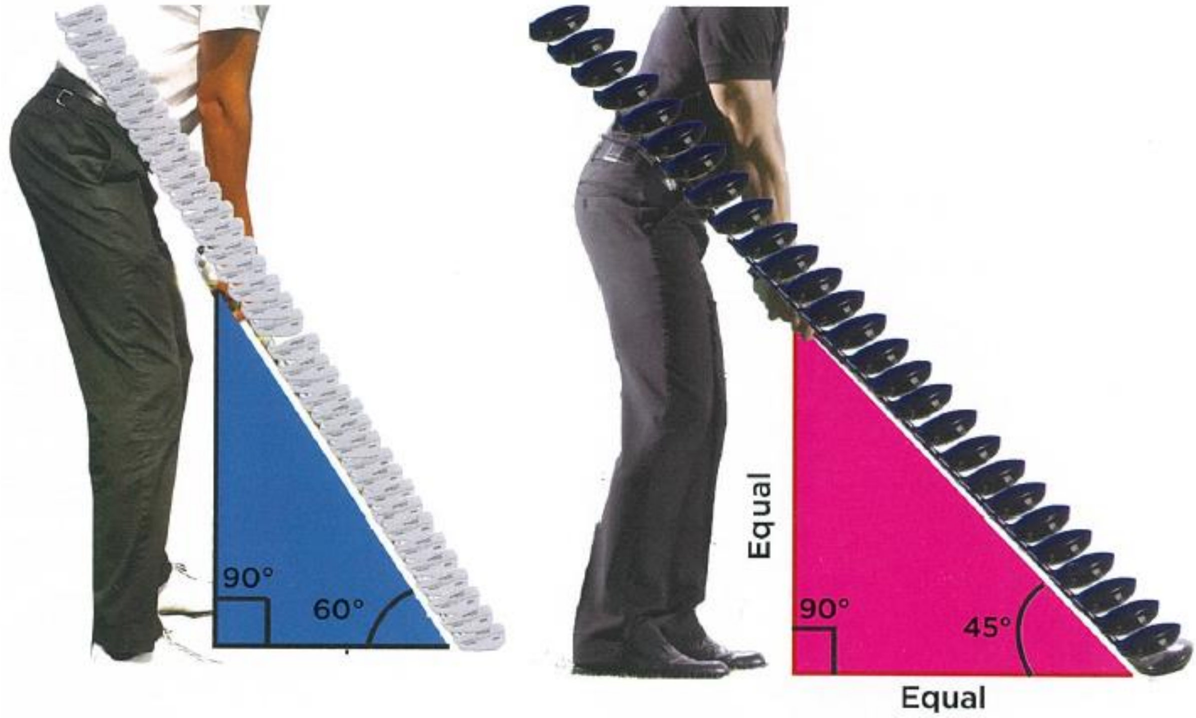
In case you were wondering the magnitude of in-to-out or out-to-in that is needed to compensate for a downward attack angle is dependent on the Vertical Swing Plane.

The pictures below represent an upward attack angle. In other words, this is what happens when you are hitting up on a ball, like a driver hitting a ball on a tee. Notice that the club is actually travelling from out-to-in due to the upward attack angle. So we can always assume that an upward attack angle will influence the club path out-to-in (or negative). Therefore, if you are hitting a driver, and hitting up on the ball, you must have a swing direction that goes in-to-out (positive) to balance out the negative attack angle and create a straight launch direction. As stated on the previous page, Vertical Swing Plane will determine the magnitude of compensation needed to counterbalance an upward attack angle.



Vertical Swing Plane (VSP)

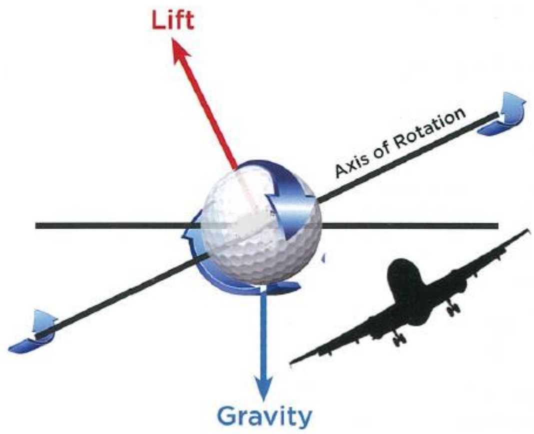
VERTICAL SWING PLANE is defined in simple terms as the inclined plane that the club head swings on during the downswing. For an iron VSP averages 60 degrees and for a driver VSP averages 45 degrees.



The important thing to understand about VSP is the geometry of the plane. Since the driver plane is usually angled at approximately 45 degrees, you ca see from the diagram above that we get a perfect right isosceles triangle (pink triangle above) – which basically means that two side of the triangle are equal. SO we can start to see that for every inch of attack angle we would get an equal corresponding inch of club path. So for an attack angle of +3 with a driver, you would need a swing direction of +3 to make a straight launch direction.

For an iron, it's a completely different story. Since the VSP for most irons is closer to 60 degrees, we don't have a one-to-one relationship (the blue triangle above is not an isosceles triangle). If you apply a bit of trigonometry you could determine that for 1 degree of negative attack angle you would get a corresponding positive .57 of club path.

What Makes the Ball Curve?



Spin Axis:

The only thing that causes a ball to curve is a tilt in its Axis of Rotation (the axis in which the ball is back spinning around). When a golf ball is struck, the only spin that occurs is backspin (it will only rotate around one axis). Many people believe there is side spin combined with backspin, but that is not true.

For a right handed golfer, if the spin axis is tilted to the right (positive), the ball will fade or slice. If the spin axis is tilted to the left (negative) as shown above, the ball will draw or hook. This is due to the interaction between gravity (pulling the ball down) and the lift force (pulling the ball up created by the tilted axis of rotation.

Launch monitor has shown that for every 5 degrees of tilt in the spin axis the ball will curve approximately 3.5 yards to the side per every 100 yards of carry (each degree of axis tilt equals .7% curvature).

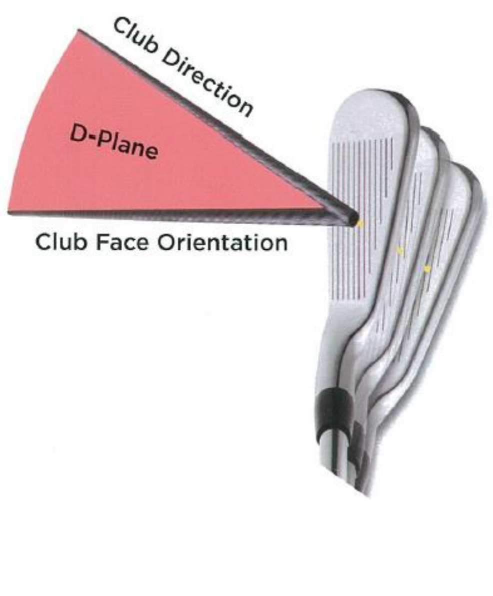
To complete understand curvature of the ball, one would have to know what factors influence or create spin axis. There are three basic factors that determine spin axis:

1. Club Face Orientation (First part of the D-Plane)
2. Club Direction (Second part of the D-Plane)
3. Impact Location on the Club Face

Spin axis tilt is created by a difference between the club face angle and the club path (Face to Path). If the face is open relative to the path, the spin axis will tilt to the right (positive) resulting in a fading shot. Whereas a face that is closed relative to the path will tilt the axis left (negative) and result in a drawing shot. Impact location is also a major influence on spin axis. Heel impacts will tilt the spin axis to the right (positive), while toe impacts will tilt the spin axis to the left (negative). Therefore, heel impacts will create a fading shot, while toe impacts will create a drawing shot.

Influence of the D-Plane on Spin Axis Tilt:

The D-Plane stands for Descriptive Plane. The simplest way to describe the D-Plane is the plane that contains the initial flight of the golf ball. It is parallel to the lift axis and is perpendicular to the axis of rotation (or spin axis) of the ball. The D-Plane is formed by two simple vectors, the club path direction (the direction the club is moving at impact) and the club face orientation (the direction the club face is pointing at impact).



The D-Plane shows us exactly how the ball is going to curve. Since the spin axis of rotation is perpendicular to the D-Plane, imagine the wings of an airplane perpendicular to the D-Plane (it would turn the same way as the ball.)

Centre of Gravity and the Gear Effect:

As stated earlier, impact location on the face will have a direct influence on spin axis and curvature of the ball. This is due to something called the ***Gear Effect***. To understand the gear effect we must first discuss how the ***Centre of Gravity (CG)*** effects rotation. A driver will rotate around its CG, not its hosel or shaft's axis.

So if the ball impacts the face directly in-line with the clubs CG, there will be no resultant face rotation or twisting of the club due to contact collision. If the ball hits more towards the toe than the drier's CG, then the driver will react by rotating open and vice versa for a heel contact.

Gear effect is the counter rotation inflicted on the golf ball due to the interaction of the rotating face on the golf ball. As seen below, the ball and the club act like gears in a machine connected by friction and induce opposite rotation on each other. This causes a tilt in the spin axis and therefore affects curvature of the ball.

Gear Effect with Drivers vs. Irons:

The last thing that effects the influence of the gear effect is the location of the CG in relationship to the face. The difference between irons and drivers is significant when it comes to gear effect. In a nutshell, irons only exhibit a minor amount of a gear effect. This is due to one main reason, the location of the centre of gravity. The farther the centre of gravity is behind the face of the club, the more the gear effect comes into play. For irons, the CG is in line with the face so there will be minimal gear effect. This is due to the movement of the face after off-centre contact. Notice on the driver that the point of contact actually moves down and to the right after contact, whereas the iron point of contact moves down and left. It is that movement to the right that imparts the gear effect on the golf ball and that is what is missing on an iron.

How Much Spin Axis Tilt Does the Gear Effect Create? :

According to data recorded from the launch monitor, a driver will impart 20^{o} of spin axis tilt for an impact that is ½" off centre. That is so significant that it is easy to see how off centeredness of contact is a major cause of curvature of the golf ball.

Why Did the Ball Go That Far (Spin Rate)?

Distance the Ball Travels:

There are several outside factors that influence the distance a golf ball travels (due to air resistance and flight aerodynamics), but are outside the control of a golfer. Those factors include: Wind, Humidity, Moisture, Temperature and Air Pressure.

There are also club and ball fitting parameters that will influence how far a ball travels including: Golf Ball Design (material composition, compression and dimple patterns) and Golf Club Design (club head design, club length, shaft flex and weight).

Lastly, there are a three basic parameters (that a golfer can control) that effect the distance a ball travels. Those factors are based merely on physics and are:

1. Spin Rate
2. Launch Angle
3. Ball Speed

In general, maximum distance is produced with a higher ball speed, a higher launch angle and a lower spin rate. The problem is the trade-off between these three factors. Typically, as launch angel increases, spin rate increases and ball speed decreases. So the effects can counteract each other.

To better understand how these factors influence each other and total distance, we must look at each factor a little closer. The good news is, most of these factors can be altered by modifying swing mechanics or physical conditioning. Let's take a closer look at all the parameters that effect each of these three factors.

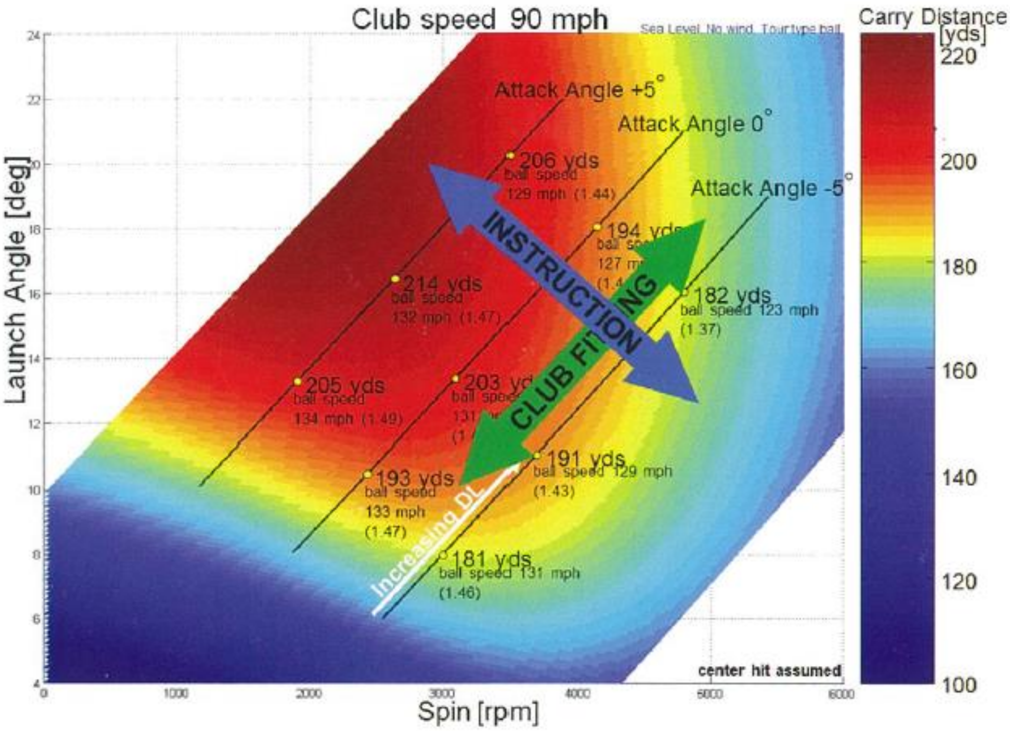
Spin Rate:

There are five key factors that will affect the overall spin rate of a golf ball. Those factors include:

1. Dynamic Loft
2. Attack Angle
3. Club Speed
4. Impact Position
5. Friction between Club Face and Ball

These factors can all influence each other and it is the combined effects of each of these that will result in the total spin produced on the ball.

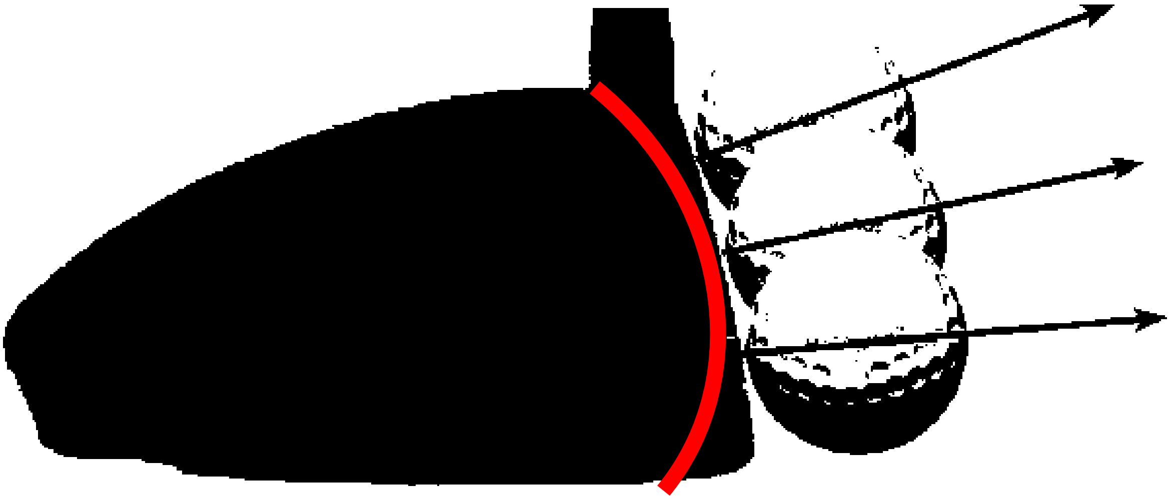
An important fact to note is almost all Spin will be backspin. This is due to the golf club having loft. The second thing you must understand is in general – backspin is a good thing. Backspin can help improve aerodynamics, vertical lift and total carry distance. But just like all good things, too much or too little can also be a problem.



As you can see from the data provided by the launch monitor there is an ideal range of backspin to produce the longest carry distance. Another key point is the idea spin rate changes as a player works from the driver down to the wedge. A higher spin rate is preferred for wedge play, because player's can use that spin to maximizing control around the green. Less spin is preferred with most drivers because the objective off the tee is to promote distance and roll. Players with slower club head speeds need a higher spin rate to help increase the overall flight time of the golf ball, keeping it in the air longer. The backspin essentially provides the vertical lift force or energy needed to keep the ball airborne.

Dynamic Loft

Dynamic Loft is a term used in launch monitors to describe the vertical club face orientation at the centre point of contact between club face and golf ball at the maximum compression of the golf ball. In other words, the loft of the club at the impact point of the face. As discussed earlier, the loft can change due to vertical roll. Just for a reminder, **Vertical Roll** is the curvature of the face in the vertical direction. Because of this vertical roll, I think it is easy to see how a ball hit higher on the face will have a higher dynamic loft than a ball hit lower on the face.



Dynamic Loft due to Vertical Roll

It is important to remember that the loft that is written on the bottom of a driver is only the average loft of the face of the driver. Vertical roll makes the loft of a metal wood variable across the face.

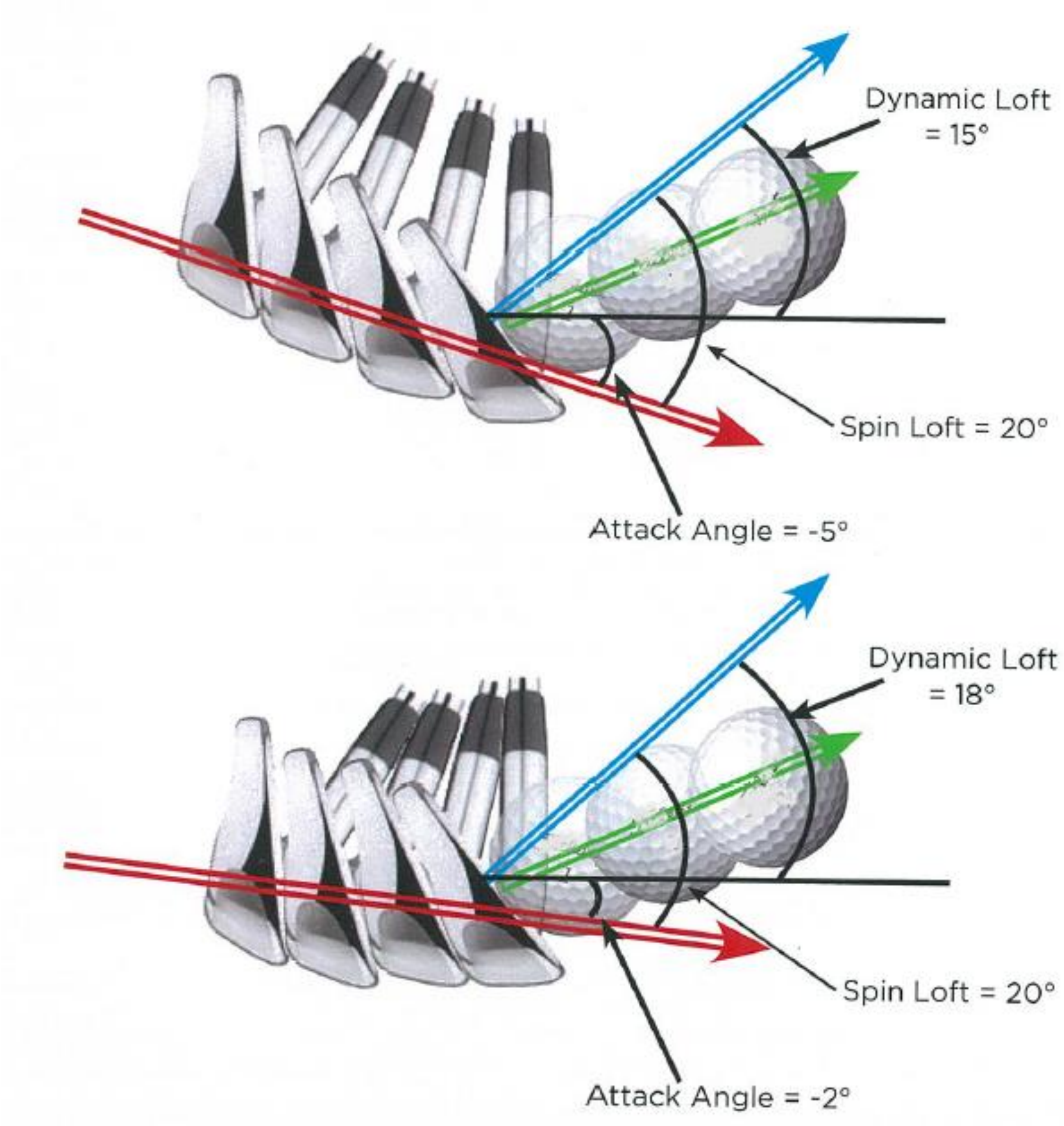
In general, the more dynamic loft at impact, the more potential there is to create higher spin. This phenomenon can be negated by two things though, loss of friction and attack angle. Let's discuss those two factors next.

Attack Angle

As discussed earlier, attack angle is the vertical direction of the club head's centre of gravity movement at maximum compression of the golf ball. This will also have an influence on the total spin produced on a golf ball. With a lower (negative) attack angle, there is more potential to create a lower spin rate. We use the word "potential" because it has been shown that attack angle and dynamic loft can directly influence each other. Let's take a closer look at that relationship.

Spin Loft

Spin loft is defined by the launch monitor as the angle between the direction of the club head's centre of gravity movement (attack angle and club path) and the club face orientation at the centre point of contact between club and ball (dynamic loft and face angle) at the maximum compression of the golf ball. In other words, it is the difference between dynamic loft and attack angle. This measurement will help explain the total spin rate produced on the golf ball. You can see from the two examples below that hitting more down (-attack angle) can be offset by a lower dynamic loft and produce the same spin rate.



Impact Position

As discussed earlier, the impact position on the face can influence the spin that is produced on the golf ball. We discussed how to gear effect can influence the spin axis tilt, but there is also **a Vertical Gear Effect** that comes into play. Since the club head will rotate around its centre of gravity (CG), a ball that strikes above the CG will create an effective top spin gear effect. So it effectively reduces the total backspin normally created.

The complete opposite holds true for a ball that strikes below the CG on a driver face. This will create a backspin gear effect and create more backspin as a result.

Friction

The amount of friction between the ball and the face of the club will also affect the total spin produced. For example, if there is water or grass between the ball and the club, the effect of the grooves is reduced and in-turn reduces friction. This will result in less effective backspin and produce the low spin “flier” so many golfers have experienced.

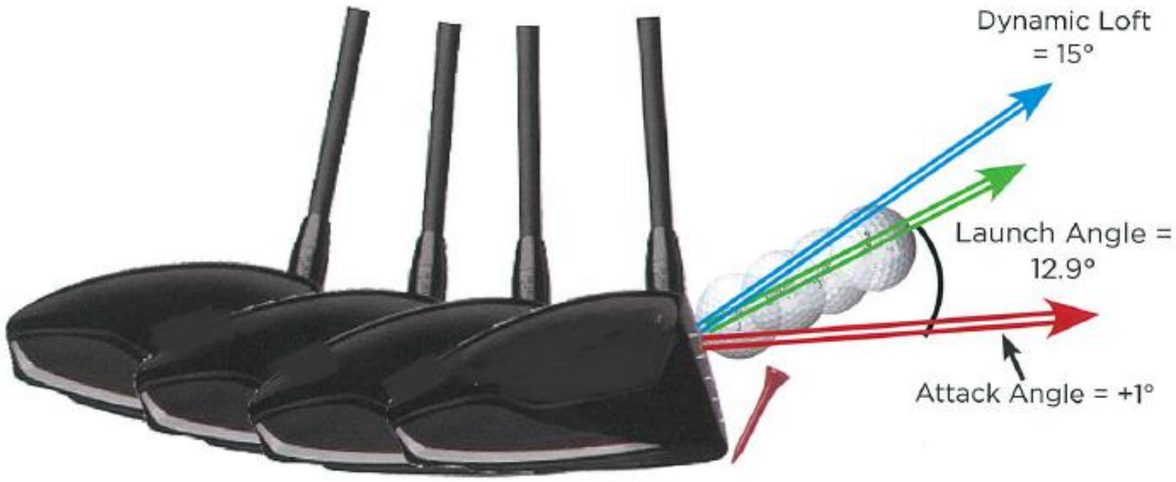
Why Did the Ball Go That Far (Club Speed)?

This is probably obvious but overall club speed will help determine that spin rate produced on a golf ball. The higher the speed, the higher the potential to generate spin. This is why many low speed players, need golf balls that help produce more spin and high speed players like balls that can reduce their spin.

Launch Angle:

Let's discuss the next factor that determines how far a ball will travel and it is called **Launch Angle**. For any given ball speed and spin rate, there is a corresponding launch angle that will maximize distance that is just based on pure physics. According to the launch monitors, launch angle will always fall between the dynamic loft and the attack angle of the club. The dynamic loft will have a much greater influence on launch angle than attack angle. For drivers, the dynamic loft will account for 85% of the launch angle, while for irons it will account for 75% of the launch angle.

If the friction between the face and the ball is reduced (like when the ball and club are wet), the dynamic loft will influence the launch angle even more than 85% for a driver. This can help explain why some fliers may carry farther (it produces a higher launch angle with reduced spin).



Ball Speed:

The last parameter that affects how far the ball will travel is total ball speed. There is obviously a relationship between club head speed and ball speed but it is not a one-to-one relationship. The efficiency of speed transferred to the ball is called **Smash Factor**. The higher the smash factor the better the transfer of speed to the ball. The best players in the world have a smash factor of 1.47 or higher. For example, if a player smash factor is 1.5 and their club head speed is 100mph, then the ball speed would be 150mph.

The most important factor in increasing the smash factor, is centre face contact. For that reason, the best way to improve someone's overall ball speed is to focus on centre face contact.