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| RESEARCH ARTICLE

Golf and Science

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| ABSTRACT

Golf is often seen as a leisurely sport and is considered to be the most popular outdoor sport. Most importantly, Golf is a remarkable fusion of art and science. This research explores the profound scientific understandings that govern the dynamics of golf, from the physics of ball flight to the biomechanics of the swing. It delves into the intricacies of golf equipment design, the influence of weather conditions, and the impact of golf on physical and mental well-being. Through a comprehensive analysis of existing literature and empirical studies, this research signifies the fusion of golf and science, offering a holistic understanding of this age-old game's modern facets. The paper concludes by shedding light on the potential of golf as a platform for understanding the dynamics behind the sport and its contributions to the wider domain of sports science.

| KEYWORDS

Golf, Science, Sports, Club Anatomy, Flex

| ARTICLE INFORMATION

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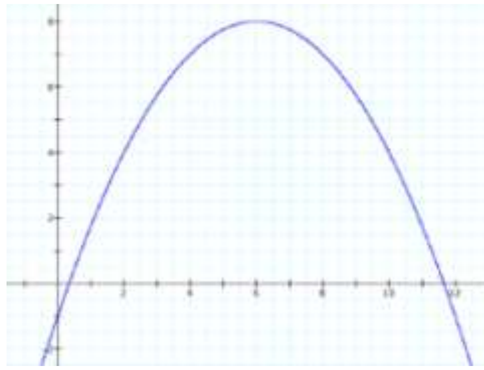
1. Introduction

Why do we study Science? It is a question I am sure most of us have asked ourselves at some point. What is the purpose of it all? Delving a little deeper, you will discover that Science can be found in the most unexpected places.

When I first started playing golf, I was always intrigued by how some shots ended well while others were a disaster. A lot goes behind a simple golf game that the average person never considers. Mathematicians can use equations to predict the trajectory of the ball and how it is affected by factors such as air temperature, the speed of the swing and the quality of the golf ball and the golf club.

2. Basics

A golf ball in flight is a perfect example of projectile motion because it follows a curved path called a parabola. The shape of the curve is affected by two main forces: gravity and air resistance. Let us assume that air resistance is negligible and consider gravity, as this is the easiest to analyze.



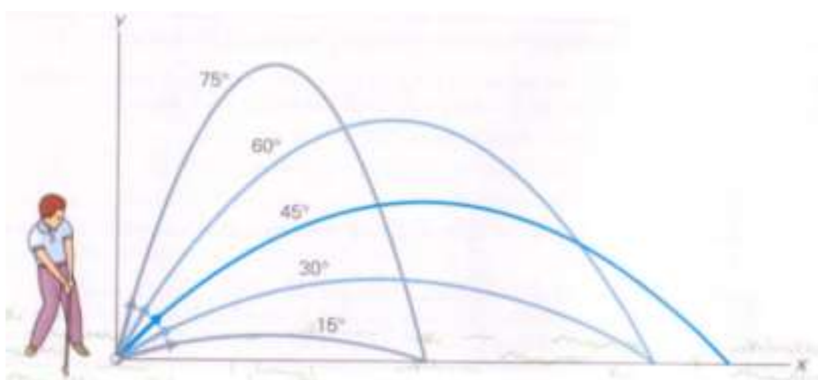
First, we will split the projectile motion of the ball into horizontal and vertical components. In the absence of air resistance, the horizontal velocity of the golf ball remains constant throughout the flight as no external forces are acting on it. The vertical velocity, however, is affected by gravity, so it changes over time.

Acceleration due to gravity g is equal to $9.8m/s^2$. This acts towards Earth, so the velocity of any object decreases by 9.8 m/s every second when the object travels upwards and increases when the object travels downwards.

For a golf ball, let us say it is initially hit at a vertical velocity of 49m/s. This will initially decrease as the ball travels upwards, reaching zero after 5 seconds (9.8 * 5 = 49). When the vertical velocity equals zero, the ball is at its peak height. This is because, after this point, the ball begins to travel downwards as g causes the velocity to increase back towards the ground. This means the greater the initial vertical velocity is, the higher the ball flies.

Due to differences between the horizontal and vertical components of velocity, the angle at which the ball is hit affects the shape of the trajectory. Suppose the golf ball is struck with velocity U at an angle θ to the horizontal direction. This can be resolved into horizontal and vertical components using trigonometry.

As you might expect, if the angle is small, the golf ball will have a large horizontal velocity and a small vertical velocity. This results in a path with a long range but a small height. If the angle is large, the opposite happens, and the trajectory has a large height and a small range. The golfer must decide which situation they need depending on the terrain and the type of shot they are performing. **The angle that gives the maximum height and range simultaneously is 45 degrees, which is often ideal.** The type of golf club used (discussed later in detail) usually determines the angle at which the ball travels. The figure below shows the flight paths of balls being hit at different angles.



Now, how do we measure the ball's height and velocity? The vertical velocity can be quite accurately measured using a set of equations referred to as the "equations of motion" or the SUVAT equations. They are derived from a velocity-time graph but are fairly easy to apply.

V = U + AT

V2 = U^2 + 2AS

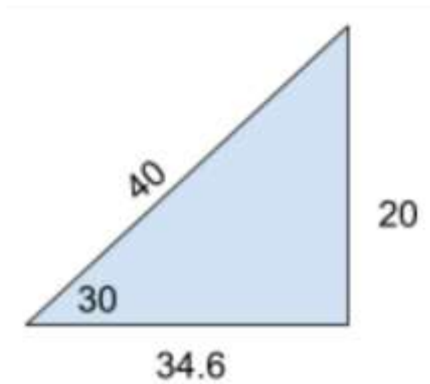
$S = UT + AT^2/2$

$S = (U + V) \times T/2$

where S = displacement; U = initial velocity of the object; V = final velocity of the object; A = acceleration (usually g); and T = time of flight. These equations hold true for both the vertical and horizontal components of the velocity.

When using the SUVAT equations in practice, you select an equation with one unknown and substitute in the other known values to solve for that unknown. To illustrate this, let us go through an example. Suppose a ball is hit with an initial velocity of 40m/s at an angle of 30 degrees from the horizontal. We want to determine its maximum height, range and time of flight.

First, let us determine the initial horizontal and vertical velocity. According to trigometry, the horizontal velocity is cos(30)*40 = 34.6 m/s. The vertical velocity is sin(30)*40 = 20 m/s.



For the height and time, we need to use the SUVAT equations. We know the initial vertical velocity U is 20 m/s; we know that at its peak height, the final velocity V must be 0 as it changes direction from going up to going down; we know the acceleration A is equal to -9.8 m/s^2 because it acts in the opposite direction to the motion of the ball; and we want to find the displacement S.

So, the equation we should use is $V^2 = U^2 + 2AS$. If we plug in our values,

$$\mathbf{0 = 20^2 + 2*(-9.8) * S \Rightarrow 19.6*S = 400 \Rightarrow S = 400/19.6 = 20.4\ m.}$$

So, the peak height of the ball in this situation is 20.4 m.

Now, we use the SUVAT equations again to find the time of flight. This time, we want to use the equation V = U + AT since T is the only unknown. Substituting in our values we have $0 = 20 - 9.8*T \Rightarrow T = 20/9.8 = 2.0$ seconds. However, this is the time it takes to reach its peak, **so the total flight time is 4.0 seconds.** Finally, we can use this time to work out the range using the equation speed = distance/time, so for the horizontal velocity, we have **distance = speed x time = 34.6 x 4.0 = 138.4 m.**

Having understood the basics, let us now get deeper and start with understanding the anatomy of golf clubs.

3. The Golf Club: The Club Anatomy

The club's main components are the grip, the shaft and the club face. However, there are a few more things to know about the golf club, for example, the types of shafts, what loft is, and what bounce is!

The shaft can be made of two different substances:

- Steel
- Graphite

The Steel shaft is much heavier, averaging about 130 grams in irons, while graphite averages about 55 grams. The Steel shaft is also much cheaper and more durable; it gives a more solid feel and control. The main advantage of using a Graphite shaft is its light weight; it is easier for beginners, and its lightweight allows for a much faster swing. It has much more flex, more torque, and feels more comfortable.

(flex = flexibility)

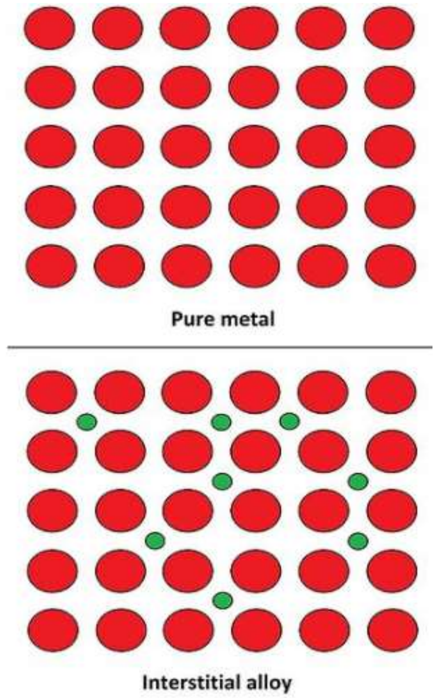
3.1 What is 'flex'?

'Flex refers to the ability of the golf shaft to bend as force is applied to it during the golf swing' - Golfburnaby.

It can be divided into five different ratings -

- Extra-stiff: swing speed of more than 93mph
- Stiff: swing speed of 84mph to 93mph
- Regular: swing speed of 75mph to 84mph
- Senior: swing speed of 60mph to 75mph
- Ladies: 60mph or less

The pattern we notice over here is that the faster the swing, the stiffer the shaft has to be. But why?



As you read above, the flex is simply the bending of the shaft during the swing. Why does this happen? Furthermore, how does it vary?

The shaft is made up of either (stainless) steel or graphite. Stainless Steel is an alloy made majorly of Iron, Chromium and Carbon. If you know a little more about stainless steel, you would know that it is an interstitial alloy, where the smaller atoms, in this case, C and Cr, sit in the hole in a metal lattice.

To answer the question as to why the shaft bends, we must think about speed and the composition of the metal.

3.2 Thought experiment and results:

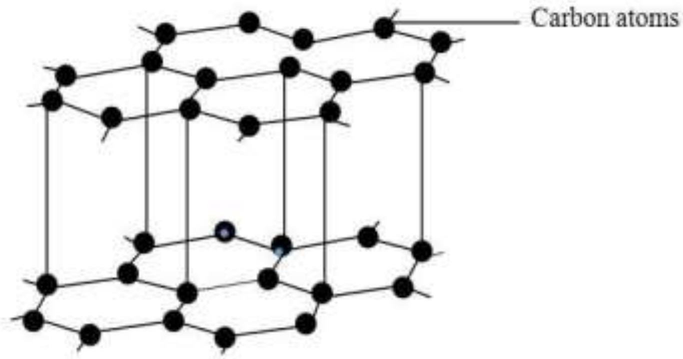
Imagine a machine which rotates a golf club along its grip, around in a circle, and then imagine it suddenly stops. Then, you will see the shaft continuing to move while the grip is stationary, and thus the shaft will be bending. The principle here is Newton's first law of motion: a moving object will continue to move even if the force being applied stops. The shaft in that thought experiment bent because it continued to move while the grip was now stationary, and because it cannot just throw away all that Kinetic energy, it has to bend to release it, to allow it to transform into some other form of energy.

3.3 So, why did I bring up the composition of the shaft?

The property of bending is similar to the metallic property of malleability. The atoms individually vibrate; thus, if there is more empty space in the lattice, there will be more overall bending because the atoms would have more space to move around. Thus, we can conclude that in steel, because there are atoms in the smallest regions in the lattice, there is less space for the atoms to move, so the steel shaft will be much stiffer.

Graphite, on the other hand, is an allotrope of Carbon. Instead of metallic bonding being used, there is covalent bonding.

The structure of graphite:



In this, the atoms are covalently bonded. Each carbon atom is covalently bonded with three others, which can be seen clearly in the diagram. However, these layers are only pulled together with much weaker intermolecular forces; thus, the graphite shaft will be much more flexible because of the weak intermolecular forces.

As the thought experiment above explains, the shaft will continue to move until all of its kinetic energy has been transformed. The fact that graphite is more flexible implies that the swing with such a shaft will lead to more bending.

Thus, a graphite shaft will have higher flex than a steel shaft, and to increase the stiffness of the shaft, we must reduce the malleability of the substance, which can be done by reducing the amount of space the atoms have to move.

3.4 Now, onto the first question that I asked

Why is there a linear relationship between the club speed and the stiffness of the shaft?

Firstly, I would like to clarify what this means. It is not trying to say that higher stiffness means higher club speed. It is not saying that higher speed equals higher stiffness, either. It is trying to say that a stiffer shaft is much better with a higher club speed - a stiffer shaft would handle a faster club speed better.

3.4.1 Now, let us begin answering it.

Steel is much denser than graphite, and this implies that to have the same volume of steel and graphite, we need more steel than graphite (density $\propto$ 1/volume), and in the end, the mass of the same size of a steel shaft will be heavier than that of the graphite shaft of the same size (density $\propto$ mass). So now we know why steel shafts are heavier, and we have also linked that steel shafts are less flexible.

We know that higher club speed equates to more distance, but what if the club is not solid enough to hold the force? What if the shaft is not strong enough to survive that immense force? Now, why would it not be strong enough?

3.5 Thought experiment:

Imagine performing a whole swing, but instead of a golf ball, we have a big rock. The idea we will be using here is momentum (momentum = mass * velocity).

The law of conservation of momentum states that momentum is preserved in a system. Thus, we can infer that the momentum before the collision of the club face with the ball (in this case, the rock) is equal to the momentum after it.

If you were to perform a fast swing on a big rock, you would observe that the shaft will almost definitely break, and with (p1=p2), we can find out the final speed at which the broken club flies. However, why does it break?

The club's swing speed is high, and thus, its initial momentum is going to be high. When it meets such a heavy obstacle, though, things change. To calculate the final momentum, we will have to use the mass of the rock.

Taking the average mass of a club (graphite) and the average swing speed for the initial momentum, we get:

p = 55g * 42m/s

p = 0.055kg * 42m/s

p = 2.31kgm/s

The value over here is tiny and has to equate to the final momentum.

Taking a rock's mass at about 5kg....

p1 = p2

2.31kgm/s = 5kg * x m/s

x = (2.31kgm/s / 5kg)

x = 0.462m/s

The change in velocity over here is:

Δv = 0.462m/s - 42m/s

Δv = - 41.538 m/s

(the minus sign means in the opposite direction - the resultant speed of the club face)

The reason why the shaft breaks is that the change in speed is too great, and it cannot convert the Kinetic energy that it has to other forms quickly enough, so the structure breaks.

We can also use another formula: F = ma. With this formula, we can find out the resultant force on the club after hitting. The resultant force can be too high for the club to bear, which could be another explanation.

Using the Force formula:

a = Δv / t

The stone was initially stationary, and thus:

a = (41.538m/s - 0m/s) / 400µs

a = 41.538m/s / (400x10^-6)s

a = 41.538m/s / 0.0004s

103845m/s^2

F = ma

F = 5kg * 103845m/s^2

F = 519225N

(This is obviously theoretical - these are not the actual values; they will be much lower, between 10000 and 20000N with an actual golf ball)

3.6 We are not hitting rocks in golf, so how does this analogy help?

With a higher club speed, even though the mass is still low, the initial momentum will be relatively higher, with the final mass being higher (ball + club, rather than just the club). With that, the final velocity will be lower, and the change in velocity will be higher. Thus, the resultant force will be higher.

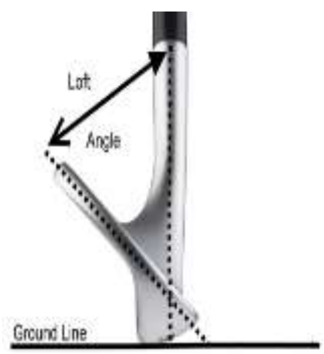
Thus, the relationship we see is that a higher club speed equates to a higher velocity change, consequently leading to a higher resultant force.

That resultant force may be enough to cause tension through the club, and thus, it may be wiser to use a heavier club, a steel shaft, which will, in turn, be stiffer.

The initial momentum is higher with a higher initial mass (steel shaft) and the same club speed. The final mass is again heavier (ball + club, rather than just the club), and thus the final velocity will be less. Thus, the change in velocity will be higher, and thus, a higher resultant force. However, the shaft is much stiffer, much less flexible, and can survive that force.

That is why a higher club speed can be better used with a stiffer club shaft because a stiffer shaft is stronger and more resistant to high amounts of force, and a greater speed leads to greater force.

Next, Loft. So, what is it?

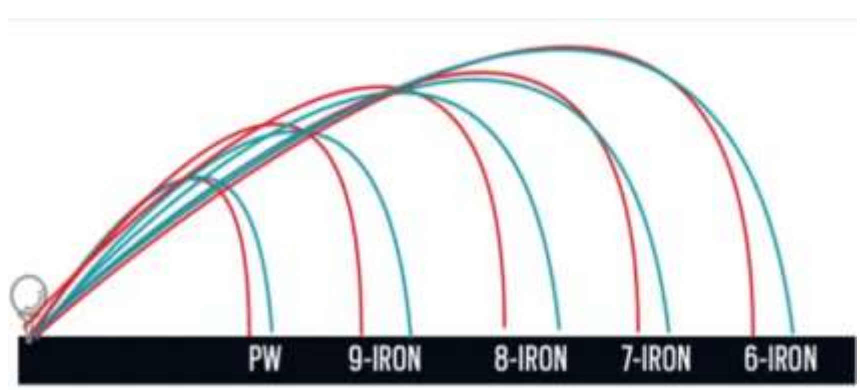


It is the angle between the shaft and the club face. All clubs have different lofts, which is the main difference between clubs. For example, a five-iron loft is much less than an 8 iron. That is because the smaller the number of iron, the less loft it has.

What a higher loft gives is a much higher ball flight. That can be understood with this:

Let us experiment with multiple clubs, each with a different loft. This is what the ball flights would look like:

What we see from this diagram is that the higher lofted clubs (9-iron, 8-iron) travel a lot less distance than lower lofted clubs (7-iron, 6-iron). This pattern continues up till the 1-iron.



When you get a higher lofted iron, the shot goes straight up, and thus, it covers less distance. On the other hand, with low lofted iron, the ball flight is much flatter and thus more distance. To go into more detail, we would have to look at how the ball flies through the air, with the different forces acting on it and the spin they give it, but let us leave that for another time.

3.7 Next, the shaft length.

The pattern for this - the less lofted a club, the longer the shaft. We know that the less lofted a club is, the further it is meant to travel, and that is because of the flatter ball flight. Thus, a longer shaft would be the best way to increase the distance. However, how does that help?

It helps by increasing the turning effect or the torque.

Torque or Moment (they are the same idea) = perpendicular distance from the pivot * Force applied

$$\tau = m*N$$

By simply increasing the perpendicular distance from the pivot, we can increase the torque, which will make the swing easier and multiply the final force applied in the swing.

However, a longer club has its downsides. It will be much heavier and also a lot more expensive. However, height is not something we can control.

3.8 And now, finally, the bounce.

'It is the angle between the ground and leading edge of the club where the sole is rested on the ground' - tgw, the sweetest spot in golf.

It is mainly found in wedges and helps by providing forgiveness and promoting ball spin. Lower bounce gives more accuracy. Mid-bounce helps achieve good distance control and trajectory control. High bounce generates a lot of spin, which helps with overall ball control once it has landed.

4. The basic Golf Swing:

4.1 The basic stance

Even though the stance is one of the many things in golf that are flexible and depend on the player, there are a few generally accepted rules. These include:

- The ball position depends on the shot and the club being used.
- The feet are arranged x inches apart depending on the following factors:
    - The centre of mass of the player, which depends on factors such as height
    - The swing
        - The speed of the swing can influence the flaring of the feet
        - The shot being attempted (such as a draw or fade) can also influence the alignment of the feet
    - Comfort
    - The flexibility of the player
- The shorter the club, the narrower the stance because the smaller clubs have a lower loft. Thus, the momentum the club gains, even at the same club speed as that of a driver, will be relatively lower, and a narrower stance should suffice the absorption of that much momentum. Secondly, if one uses a larger stance with a smaller club, their swing would also suffer, as the centre of mass is more likely to be harder to maintain. This is because a small club means the player is closer to the ball. Thus, a wider stance would implement the fact that the stance will be very uncomfortable. Another thing is the difficulty in shifting the centre of mass forward as the player reaches the downswing. To explain this, we can make use of geometry.

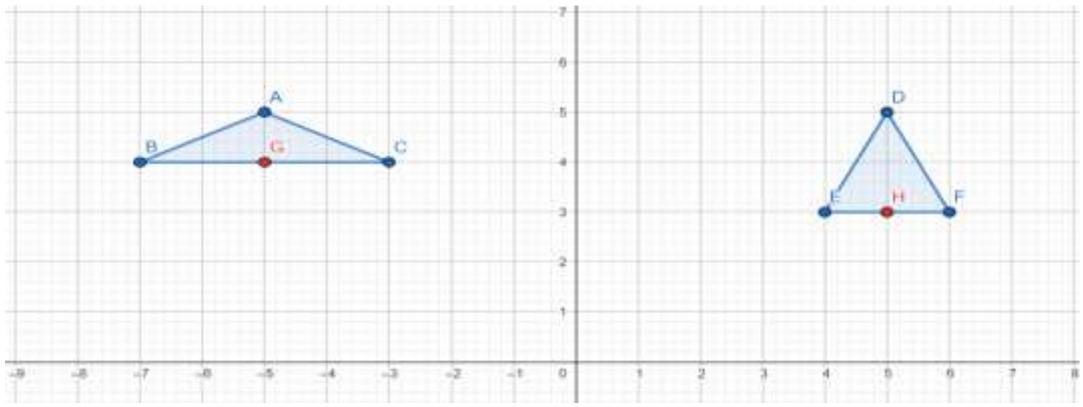


Image 1: △ABC represents a wide stance, while △DEF represents a narrower stance

One might be pondering a question: Why is the height of △ABC less than the height of the △DEF?

The reason?

As one's stance gets wider, the pelvis moves lower.

So, how does visualizing the stance as a triangle help us in any way? We can think of triangles as those formed by the legs and the pelvis, which can help us learn a few things.

Using simple mathematics, we can identify the lengths of the sides AC and DF. With the use of the Pythagorean theorem:

$AC^2 = GC^2 + AG^2$

Thus,

$AC = \sqrt{GC^2+AG^2}$

$AC = \sqrt{2^2 + 1^2}$

$AC = \sqrt{5}$

Similarly,

$DF^2 = HF^2+DH^2$

$DF = \sqrt{HF^2 + DH^2}$

$DF = \sqrt{1^2 + 2^2}$

$DF = \sqrt{5}$

We see that DF and AC are equal. However, as part of the downswing, we move forward; the entire body's weight moves forward. Thus, we can use this as the model:

Now, AC and DF are not equal.

$AC^2 = BC^2 + AB^2$

$AC = \sqrt{BC^2 + AB^2}$

$AC = \sqrt{4^2 + 1^2}$

$AC = \sqrt{17}$

And

$DF^2 = DE^2 + EF^2$

$DF = \sqrt{DE^2 + EF^2}$

$DE = \sqrt{2^2 + 2^2}$

$DE = \sqrt{8}$

Narrower stance: Wider stance:

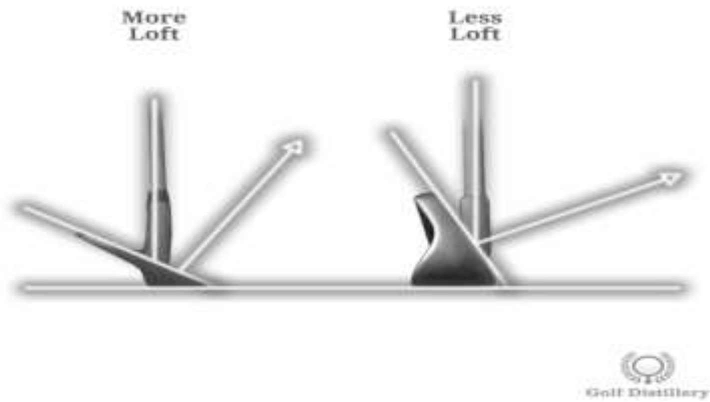
$\sqrt{8} - \sqrt{3}$ $\sqrt{17} - \sqrt{5}$

≈ 1.096 ≈ 1.887

Thus, as AC ≠ DF, the length of the back leg is more when a wider stance is used. Thus, we can imply that the distance to be moved forward in a wider stance is also greater. The fact is that these two things, the extension of the hind leg and the distance to be moved forward, are enough to make the swing far more challenging. This is why a narrower stance is used when using a smaller club. However, if we used a longer club, like a driver, the stance would have to get wider. This is because the force generated when a driver is used requires a wider stance to ensure the momentum does not topple you over!

Of course, these are not any measurements from real-life data but only hypothetical data values. However, the effect will be the same in real life. The fact that a person with a wider stance and a smaller club moves more distance forward in the downswing only makes their swing more challenging, uncomfortable and awkward. The fact is that either the body will not move forward enough, and the club will hit behind the ball, or the body will be so low that the club is too close to the ground and yet again hits the ground before the ball. To prevent that, the body might unconsciously try to reduce the distance moved forward, but that would disturb the swing path, with it ending higher than usual; instead of being parabolic, the swing would drift off that path.

4.2 Ball placement for different clubs:



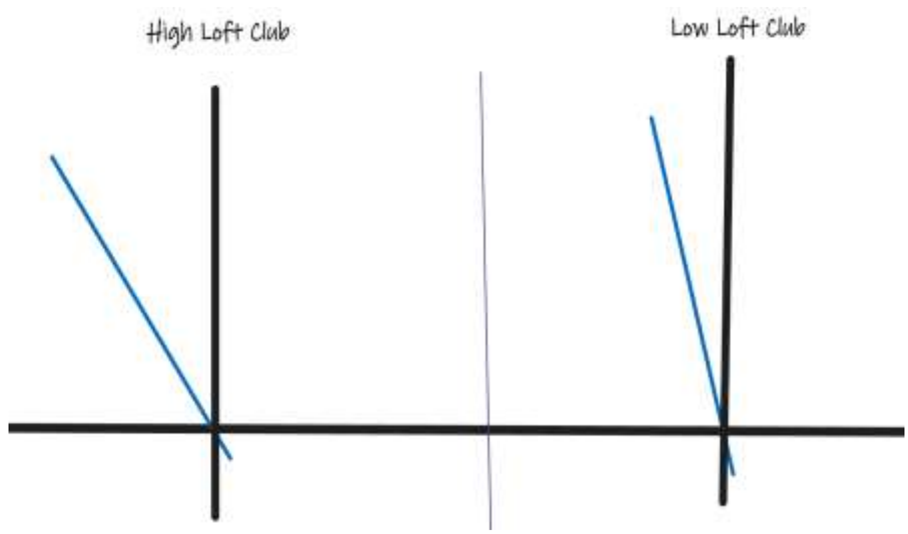
Firstly, ball placement refers to the alignment of the ball with respect to the feet, meaning it can be in the middle, closer to the front foot, or closer to the back foot. The factors which affect the ball placement are the loft of the club, the shot being attempted, and, of course, the natural feel, which is different for everyone. The natural feel is something that simply includes factors such as the forward movement of the body in the swing, which is different for everyone. This movement depends simply on the strength of one's legs and other things like the ratio between the mass of the upper body and the lower body; if the fraction ends up being less than 1, the legs are probably stronger and are capable of moving forward greater. Other factors, like flexibility, also play a big role, as do height and weight. Overall, it is simply what feels the most comfortable for the player and what they can repeat continuously.

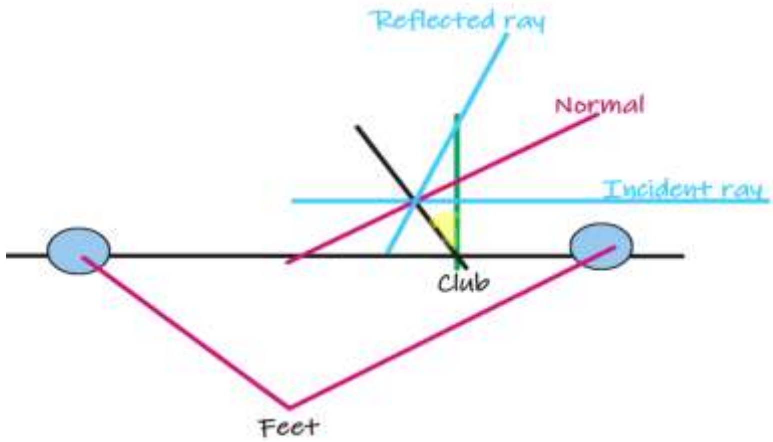
Why does ball placement differ for clubs? That has already been answered, and it is the loft.

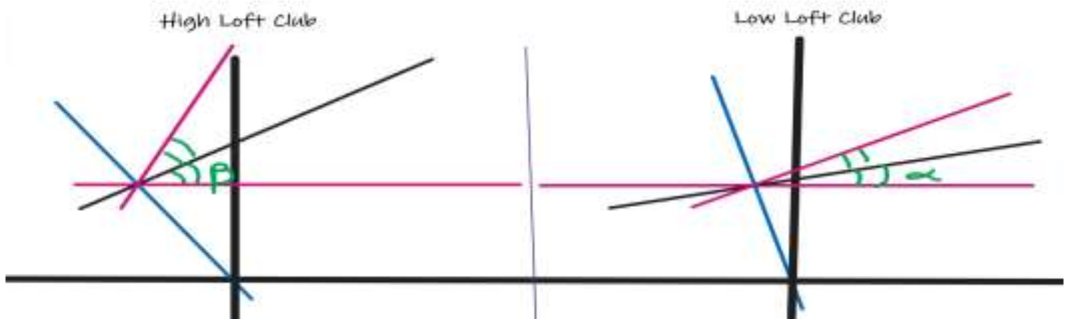
The idea is simple: the greater the loft, the higher the ball goes, and the higher the ball goes, the less the distance it travels.

To understand this, we can use the phenomena of reflection across clubs with different lofts, with the incident ray travelling parallel to the ground.

Note that the following diagrams feature the ball placed in the middle of the feet.







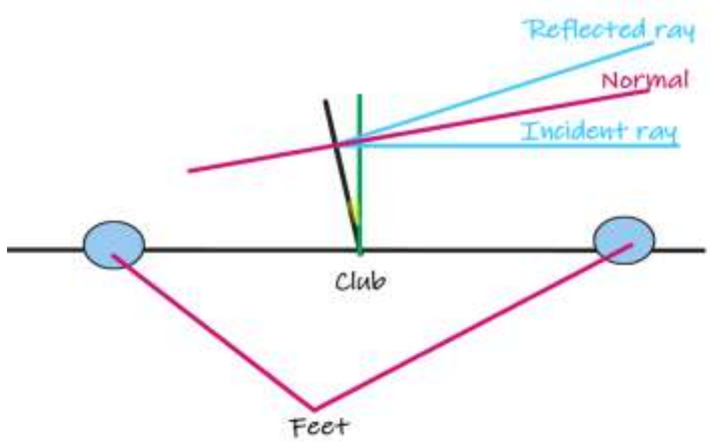
While using the phenomena of reflection, we must note that the angle of incidence must equal the angle of reflection, meaning the angle between the incident ray and the normal (the line perpendicular to the club) has to be the same as the angle between the reflected ray and the normal. This is shown in the above diagram. A thing to note is that the angles are definitely not equal but are as precise as they could be drawn without a protractor.

The observation to make is that the angle **β** > the angle **α**. This means that a shot being hit from a club with a higher loft will be launched at a higher angle than a similar shot with a lower lofted club.

Now that that is out of the way, we can understand how the loft affects the ball placement. For this, we will use a similar concept but involve the idea of a high loft club facing a ball at different alignments with the feet. To maintain the loft angle, I will make use of another normal.

4.3 Ball closer to the front foot:

Ball in the middle of the feet (approximately):



The main difference is the angle colored yellow; it is much smaller when the ball is in the middle of the feet than when the ball is closer to the front feet. The reason behind this is the fact that the body does not shift when the ball position changes. It instead opens up or closes depending on the ball placement; the closer the ball is to the front foot, the bigger the yellow angle. Because the club face opens closer to the front foot, the yellow angle increases, and we see the reflected ray traveling at a much higher trajectory.

Higher trajectory = Less distance

Therefore, when using high-lofted clubs, to get a decent distance, we must place the ball closer to the middle of the feet so that the yellow angle remains small and the trajectory remains lower. However, it is to note that in some instances, when distance is less important and higher trajectory is more important, for example, trying to hit the ball over a bunker, the club may be placed closer to the front foot.

Another thing to know is that low-lofted clubs, such as the 5-iron, already have a low loft, and if we were to place the ball in the middle of the feet while using the 5-iron, the club would be almost perpendicular to the ground. This will make it harder to hit the ball so that the reflected ray travels the same path as the incident ray, meaning that the ball, which lies on the ground, will be hit along the ground.

In most instances, having the ball travel along the ground is not the best, and that is why the low lofted clubs are hit nearer to the front foot, to allow the ball to have a better trajectory and carry it as far as it can.

Lastly, the ball placement depends also on the shot being attempted. If the shot being played is a stinger, a shot with a lower trajectory than normal, the ball will be placed closer to the middle to reduce the yellow angle.

If the shot needs a high trajectory, the ball must be placed closer to the front foot to increase the yellow angle.

5. Specific clubs:

5.1 Wedges:

These clubs have the greatest loft of all the other clubs. This implies that they are used to making shots where distance is not the most important aim and height is instead. This could be when you have to get the ball over a bunker or a tree, but they are also used around the green. The loft and bounce of these clubs work together to provide the ball height and a comfortable and soft landing. The bounce can provide additional spin as well, allowing for smarter plays.

If you do not want the ball to go straight up and land 10 yards away from you, you might want to place the ball closer to the middle or even closer to the back foot. However, it depends; for certain instances, like trying to get it over a tree after losing the fairway from a bad tee shot, height matters much more than distance, so placing it closer to the front foot is better.

Another critical situation is chipping when the ball is mere yards away from the green.

While chipping, distance is a factor. You should always know how far you are from the hole, the slope of the green, and the condition of the grass. If the grass is wet, it clumps together, and the ball will slide down slower. In these instances, you only have two choices if you are far from the hole. Play a lower shot using a lower lofted club or placing the ball closer to the back feet. This ball will have a worse landing but enough force to slide down and cover the distance.

The tips, point A and point D, represent the pelvis of the player, while the lower points, points B, C, E and F, represent the legs.

The second choice is to use the high loft but make it go higher, landing it closer to the hole to reduce the distance it has to slide. If the grass is dry, you can choose the higher shot, but keep the distance in mind. That is why we must practice knowing how far we can play the high loft shots to know when to use the low lofted shot. Taking the slope into consideration is important, as the curvature can often guide the ball away from the hole or towards the hole and can increase or decrease the speed of the ball.

Another thing to remember is that the main goal of the shot should not be to get the ball into the hole. For beginners, it would be better to get it close to the hole, around 3-5 feet away from the hole, so that the put is easier. Imagine a circle around the hole with a radius of 5 feet; getting the ball within that circle should be the primary goal. Once you master that, reduce the imaginary circle's radius and keep shrinking it until it reaches the hole.

Other instances in which wedges are used are simply when the hole is less than 100 yards from the hole, but that number depends on each individual.

5.2 Irons:

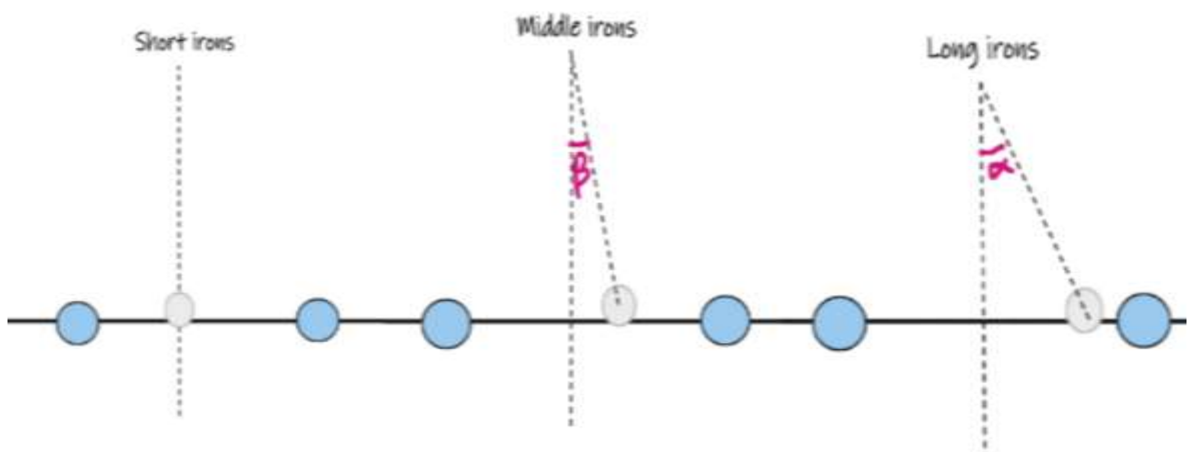
Irons are the most commonly used clubs, ranging from 9-iron to 1-iron; the larger the number, the greater the loft. They can be used off the tee or even on the fairway. The main goal when using irons is to get the ball on the fairway and as close to the green as possible.

The irons can further be divided into smaller categories,

- Short irons: the 8-iron and 9 iron
- Middle irons: 5 iron, 6 iron, 7 iron
- Long irons: 1 iron, 2 iron, 3 iron, 4 iron

A characteristic of irons is that as the loft decreases, the length of the club decreases. This is mainly to maximize distance. These clubs with lower lofts are optimized mainly to get distance, and increasing the length of the club only increases the toque and, therefore, helps to maximize distance.

As the loft is a big feature of these irons and helps distinguish between them, it should be noted that the ball placement nears the front foot as the iron number decreases.



In the image, we see the center of gravity perpendicular to the floor and the ball position with respect to the center of gravity.

5.3 Woods:

Woods are clubs normally used to hit off the tee and have the lowest lofts of all the clubs mentioned before. Thus, one can guess the ball placement for these clubs - close to the front foot. These clubs are categorized further with their loft.

- Driver ← 9° to 12.5°
- Woods ← 15° to 19°
- Hybrids ← 17° to 26°

The driver has the lowest loft of all, with the soft spot of the club head being in the middle. The club head is so big that it requires a tee to hit the ball effectively, as it may lead to bad contact otherwise.

These clubs are also the clubs with the longest shaft length, following the principle of torques to maximize the power output.

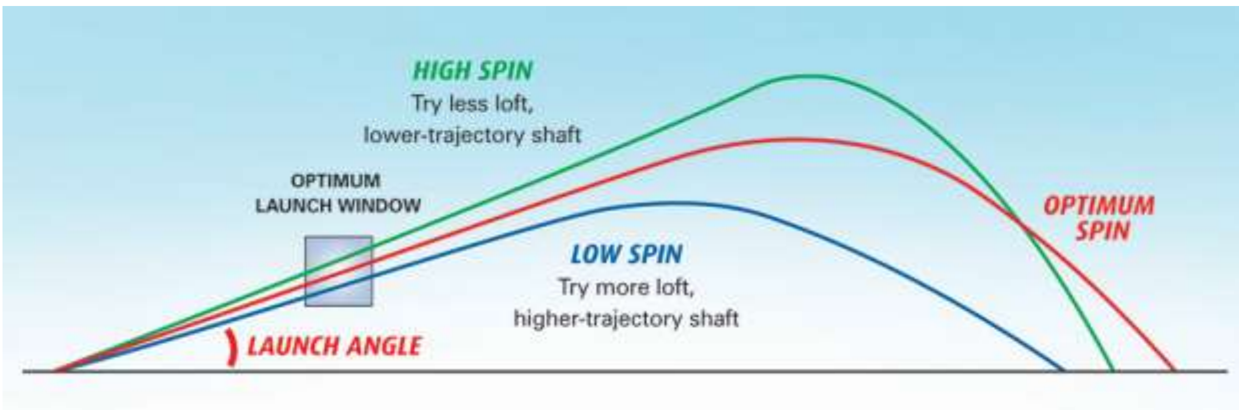
Talking about tees, how high should they be?

The tees are of multiple heights, and as the club face of the driver is the highest among the woods, the tee for it has to be the highest as well. Now, the tee has to, of course, have a solid foundation in the grass, and only then can it handle the weight of the ball. However, how should the ball be?

To know that, it is simply best to place the club head alongside the ball on the tee and adjust the height to the center of the club head. The tee height can affect several things: the trajectory, the apex height and the spin on the ball.

5.4 Impact on trajectory:

The trajectory of the shot is not parabolic, meaning it does not reach its apex point halfway through the shot.



As visible, different trajectories are possible, and this depends on two factors: the spin and the launch angle.

NOTE: When practicing, gripping the club from different lengths along the grip can help you hit different distances while using the same force.

Therefore, the factors affecting the distances hit from the club are the force being applied and the length of the club in play.

The greater the force, the greater the distance

The longer the length of play, the greater the distance, even when the force is unchanged.

5.5 How the length of the club in play affects the distance:

The moment of a force = The perpendicular distance from the pivot * The force applied

$\tau = F * d$

The longer the length of the club in play is, the greater the distance from the pivot and, therefore, the greater the moment of a force. This means that the turning effect is much greater, and thus the distance is greater.

6. Conclusion:

This research explores the profound scientific understandings that govern the dynamics of golf, from the physics of ball flight to the biomechanics of the swing. It delves into the intricacies of golf equipment design, the influence of weather conditions, and the impact of golf on physical and mental well-being. The basic understanding of science can go a long way in improving the game of golf. The principles of projectile motion, speed, altitude, placement of the clubs, use of various clubs, flex, bounce, and ball swing have been evaluated to assess their impact on the game. While many readers may have been playing the game of golf successfully, reading this study will help them understand the reasons for their success at the game and will also help them understand the ways in which they can further improve their game. The basic principles of science have been discussed, along with their impact on the outcomes of the game. The successful outcome depends on the understanding of the principles, their application while playing and regular practice. The user of this study should carefully understand the observations made in the report and their implications on the game and then measure the various outcomes by applying these principles and observations. The measurement, game-after-game, will help the user to assess the improvement and become more conscious of the principles at every stroke, thereby improving the performance and enhancing the love for the game of GOLF.

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