

A background image of a golfer in mid-swing, wearing a white cap and a dark shirt, with a golf club visible. The image is faded and serves as a background for the title.

# Application Training Resources



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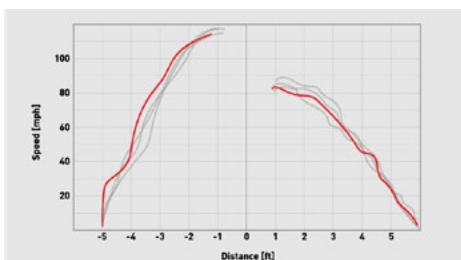
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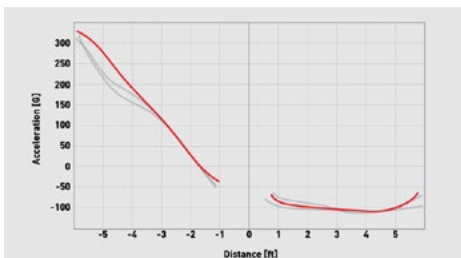
## Club speed

The speed of the geometric center of the club, measured at impact. Club speed has a direct influence on the ball speed.



## Club speed profile

Speed of the club head's geometric center away from the radar, measured pre and post impact with the ball. From the speed profile, a player can determine swing speed consistency and efficient energy transfer.



## Club acceleration profile

Acceleration of the club head's geometric center away from the radar, measured pre- and post-impact with the ball. The acceleration profile will indicate the rate of closure due to shaft bend and club release by the golfer.



## Face to target

Direction of the club face relative to the radar's target line, measured at impact. Face angle will influence the direction in which the ball starts relative to the radar's target line.



## Face to path

Direction of the club face relative to the club path, measured at impact. The angular difference between the face angle and the club path will tilt the spin axis.

**\*Off center hits will impart gear effect.**



## Dynamic loft

Loft of the club at impact. Dynamic loft can be influenced by shaft bend, forward press, and many other variables.



## Angle of attack

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The angle at which the geometric center of the club approaches the ball, measured just before impact. Can also be referred to as arch location strike or angle of approach.



## Club path

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The direction of the geometric center of the club relative to the radar's target line, measured at impact. Club path is influenced by angle of attack, horizontal swing plane, and vertical swing plane.



## Spin loft

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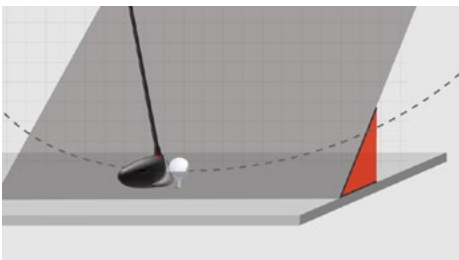
The contribution to ball spin as a result of the effective loft on the club face presented to the ball during impact, which is approximately defined by the difference between the 3D angle of attack and 3D dynamic loft of the club at impact.



## Horizontal swing plane

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The angle of the club's geometric center relative to the ground, measured at the lowest point of the swing.



## Vertical swing plane

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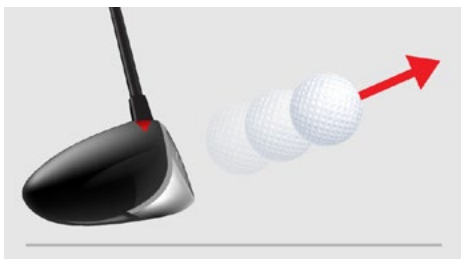
Vertical angle described by the trajectory of the clubhead relative to the ground.



## Low point

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The horizontal distance from the location of ball strike, to the point where the club trajectory bottoms out (lowest point in the arc).



## Ball speed

Launch speed of the golf ball. Ball speed has the biggest affect on carry distance. Centeredness of impact and an increase in club speed will ensure a higher ball speed.



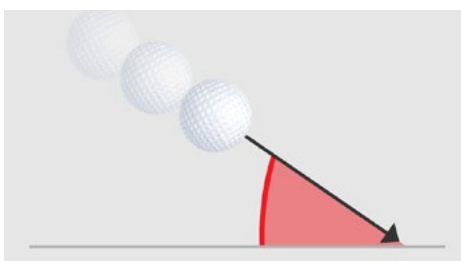
## Vertical launch angle

Angle at which the golf ball is launched relative to the horizon of the radar. Launch angle will influence the shot height and is mostly determined by the dynamic loft and angle of attack.



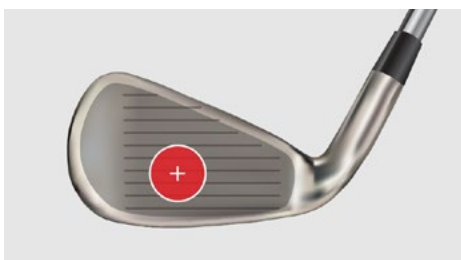
## Horizontal launch angle

Direction in which the golf ball gets launched relative to the radar's target line. Club face angle will have the biggest affect on the horizontal launch angle of the ball.



## Vertical descent angle

Angle at which the ball approaches the landing area. A lower descent angle will increase distance with a driver, and a steeper descent angle will give a player more stopping power on the green with an iron.



## Smash factor

### Ball Speed ÷ Club Speed

The energy transfer ratio from club to ball as a result of impact position on the club face. Centered impact will improve smash factor for optimal ball speeds.



## Spin rate

Number of rotations per minute of the ball at launch. A higher spin loft and higher friction will increase the spin rate of the ball.

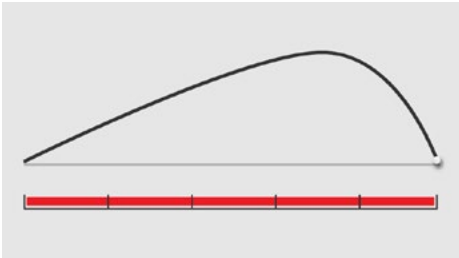


## Spin axis

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The axis tilt on the ball to determine the direction of curvature in the ball flight. A function of the delta between club face angle and club path.

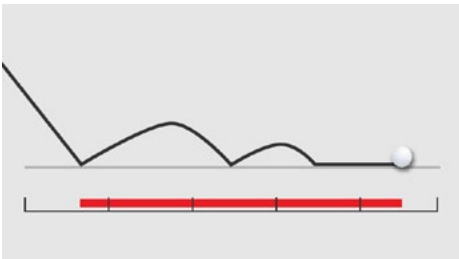
The amount of curvature in the ball flight is governed by  $(\text{ball speed})^2$  as a result of aerodynamic forces on the ball.



## Carry distance

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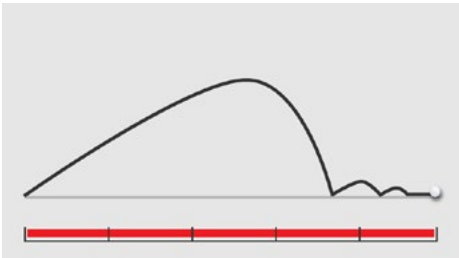
Landing distance of the ball from the tee. Ball speed, spin rate, spin axis, and vertical launch angle are all factors that will determine the carry distance.



## Roll distance

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Amount of roll from carry distance to final position of the ball. Lower spin rate and lower effective angle of descent will increase the amount of roll on the surface.



## Total distance

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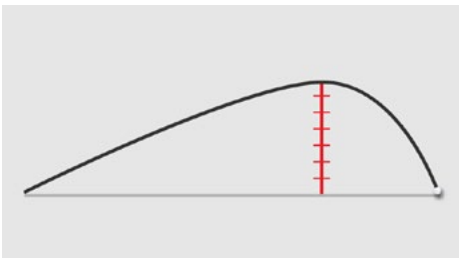
Final position of the ball on the ground from the tee.



## Lateral landing

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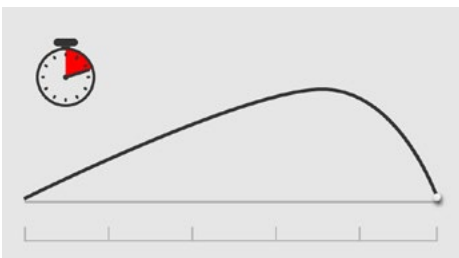
Distance of the ball's impact point measured perpendicular to the target line.



## Apex height

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Maximum height of the ball trajectory.



## Flight time

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Amount of time the ball spends in the air from time of club impact to initial ground impact, measured in seconds.



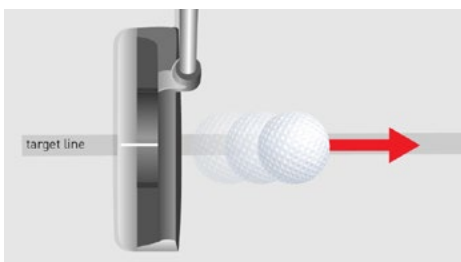
## Shot dispersion

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Grouping of the landing positions of shots with the selected club showing forward and lateral deviation of that cluster of shots.



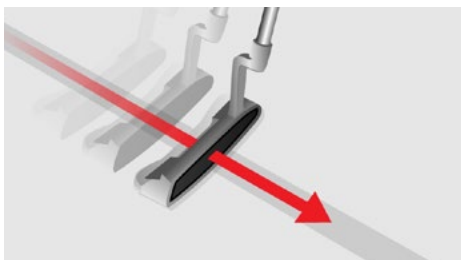
# Putting Data



## Putt speed

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Speed of the golf ball coming off the putter face.



## Putter head speed

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Speed of the putter head, reported at impact.

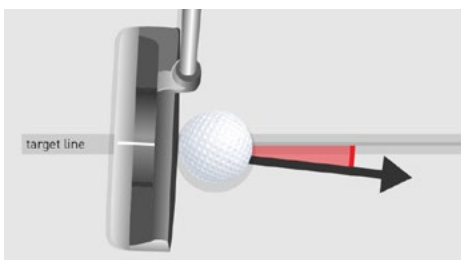


## Smash factor

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### Ball Speed ÷ Club Speed

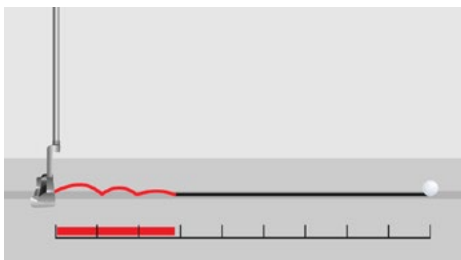
The energy transfer ratio from putter to ball as a result of impact position on the putter face. Describes efficiency of the energy transfer from the putter to the ball.



## Launch direction

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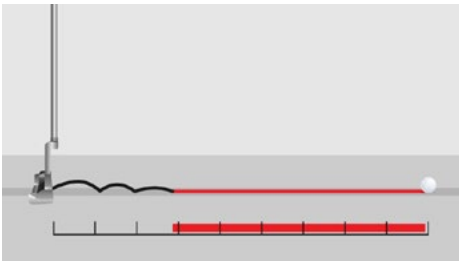
Initial direction of the golf ball in degrees (left or right), relative to the target line.



## Skid distance

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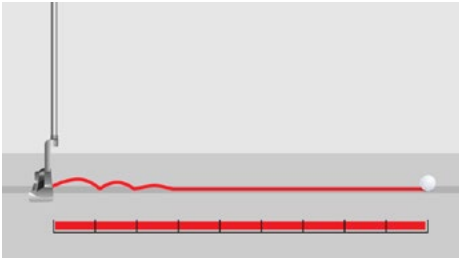
Distance the golf ball is sliding or bouncing after its initial launch off the putter face and before it begins rolling.



## Roll distance

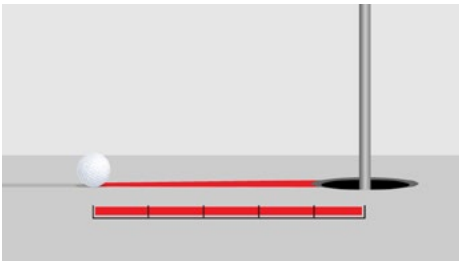
Distance the golf ball travels after it's initial launch and skid bounce.

Note: the golf ball shows linear deceleration until approximately 18" from its final resting position.



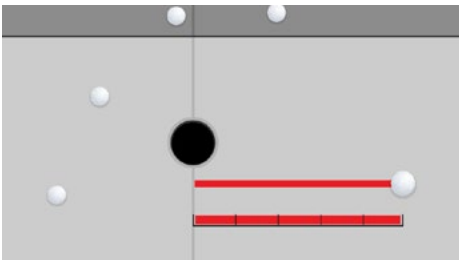
## Total distance

Distance the golf ball travels from impact to its final resting position.



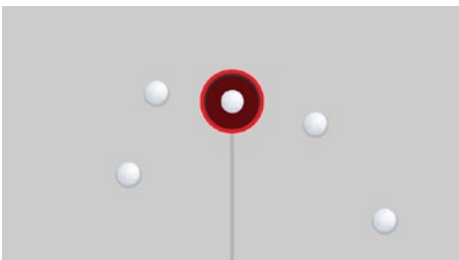
## Distance to pin

Distance from the golf ball's final resting position to the pin.



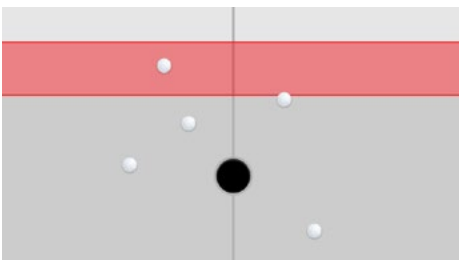
## Lateral position

Distance to the left or right of the target line after the golf ball reaches its final resting position.



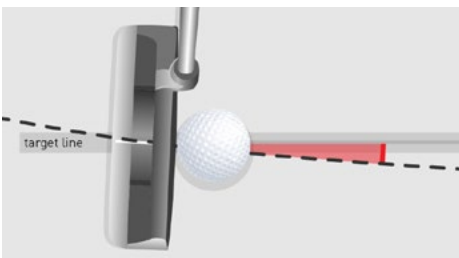
## Holed

Click parameter if ball entered hole (Y). This parameter will be set to no (N) by default.



## In miss range

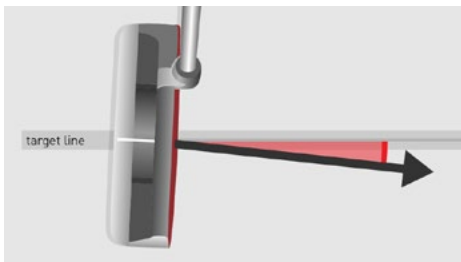
The ideal distance to miss a putt past the hole, if the putt is not holed, as determined by the user.



## Club path

The direction of the putter head, in degrees, relative to the target line (left or right).

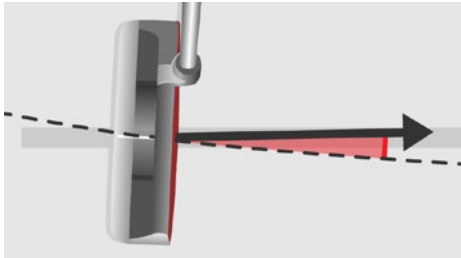




## Face to target

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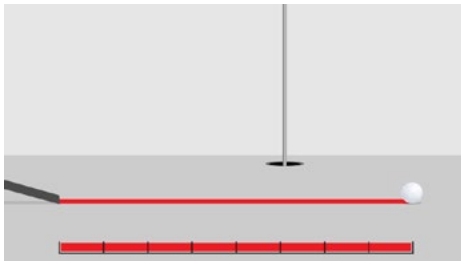
The direction of the putter face relative to the target line (left or right).



## Face to path

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The direction of the putter face relative to the path of the putter head (left or right).



## Stimp distance

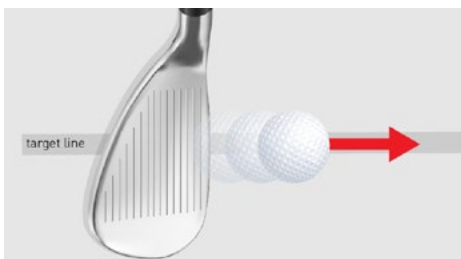
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Numerical value that represents how fast the golf ball is rolling on the putting surface. The higher the number, the faster the putting surface. Refer to "stimp meter" in the USGA guidelines.



 FlightScope

# Chipping Data



## Ball speed

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Speed of the golf ball coming off the club face.



## Club speed

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Speed of the club head, reported at impact.



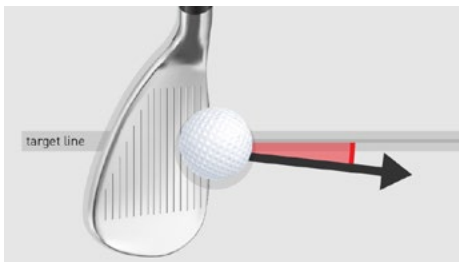
## Smash factor

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### Ball Speed ÷ Club Speed

The energy transfer ratio from putter to ball as a result of impact position on the club face. Describes efficiency of the energy transfer from the club to the ball.

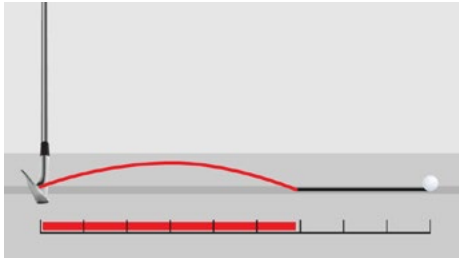




## Launch direction

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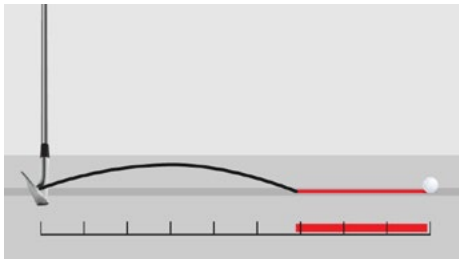
Initial direction of the golf ball in degrees (left or right), relative to the target line of the unit.



## Fly distance

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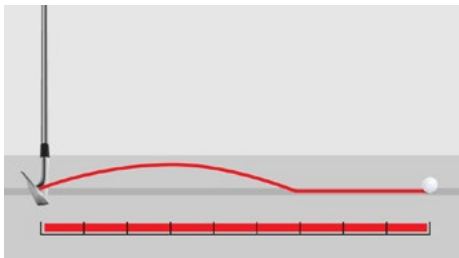
Distance traveled in the air from launch to first land, prior to roll.



## Roll distance

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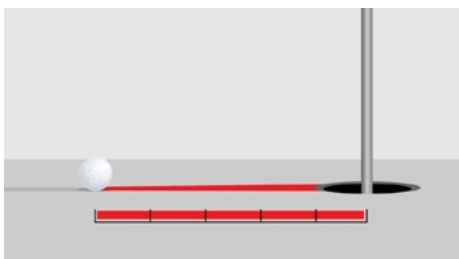
Distance traveled from first landing to final resting position.



## Total distance

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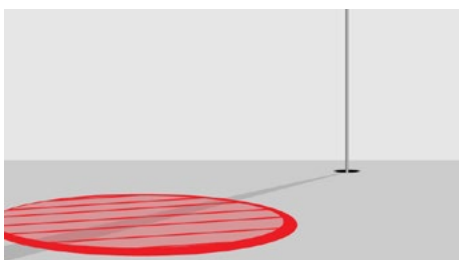
Distance traveled from launch to final resting position (fly distance + roll distance).



## Distance to pin

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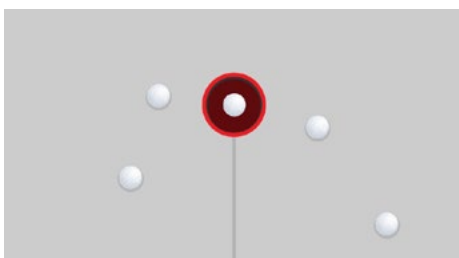
Distance between final resting position and the hole.



## Within landing area

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Distance select by the user in the "General" tab of the settings page. This distance is where the user wants the ball to first land.



## Holed

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Click parameter if ball entered hole (Y). This parameter will be set to no (N) by default.



	Club Speed (mph/meters)	Attack Angle (degrees)	Ball Speed (mph/meters)	Smash Factor	Launch Angle (degrees)	Spin Rate (rpm)	Apex Height (yds/meters)	Descent Angle (degrees)	Carry Distance (yards)
<b>Driver</b>	113 / 50.5	-1.3°	167 / 74.7	1.48	10.9°	2686	32 / 29.3	38°	275
<b>3-wood</b>	107 / 47.8	-2.9°	158 / 70.6	1.48	9.2°	3655	30 / 27.4	43°	243
<b>5-wood</b>	103 / 46	-3.3°	152 / 68	1.47	9.4°	4350	31 / 28.4	47°	230
<b>15-18° HB</b>	100 / 44.7	-3.5°	146 / 65.3	1.46	10.2°	4437	29 / 26.5	47°	225
<b>3-iron</b>	98 / 43.8	-3.1°	142 / 63.5	1.45	10.4°	4630	27 / 24.7	46°	212
<b>4-iron</b>	96 / 42.9	-3.4°	137 / 61.2	1.43	11°	4836	28 / 25.6	48°	203
<b>5-iron</b>	94 / 42	-3.7°	132 / 59	1.41	12.1°	5361	31 / 28.3	49°	194
<b>6-iron</b>	92 / 41.1	-4.1°	127 / 56.8	1.38	14.1°	6231	30 / 27.4	50°	183
<b>7-iron</b>	90 / 42.2	-4.5°	120 / 53.6	1.33	16.3°	7097	32 / 29.3	50°	172
<b>8-iron</b>	87 / 38.9	-4.5°	115 / 51.4	1.32	18.1°	7998	31 / 28.3	50°	160
<b>9-iron</b>	85 / 38	-4.7°	109 / 48.7	1.28	20.4°	8647	30 / 27.4	51°	148
<b>PW</b>	83 / 37.1	-5.0°	102 / 45.6	1.23	24.2°	9304	29 / 26.5	52°	136



	Club Speed (mph/meters)	Attack Angle (degrees)	Ball Speed (mph/meters)	Smash Factor	Launch Angle (degrees)	Spin Rate (rpm)	Apex Height (yds/meters)	Descent Angle (degrees)	Carry Distance (yards)
<b>Driver</b>	94 / 42	3.0°	140 / 62.6	1.48	13.2°	2611	25 / 22.9	37°	218
<b>3-wood</b>	90 / 40.2	-0.9°	132 / 59	1.47	11.2°	2704	23 / 21	39°	195
<b>5-wood</b>	88 / 39.3	-1.8°	128 / 57.2	1.47	12.1°	4501	26 / 23.8	43°	185
<b>3-iron</b>	85 / 38	-3.0°	123 / 55	1.45	12.7°	4693	25 / 22.89	46°	174
<b>4-iron</b>	80 / 35.8	-1.7°	116 / 51.9	1.45	14.3°	4801	24 / 21.9	43°	169
<b>5-iron</b>	79 / 35.3	-1.9°	112 / 50.1	1.42	14.8°	5081	23 / 21.03	45°	161
<b>6-iron</b>	78 / 34.9	-2.3°	109 / 48.7	1.39	17.1°	5943	25 / 22.9	46°	152
<b>7-iron</b>	76 / 34	-2.3°	104 / 46.5	1.37	19°	6699	26 / 23.8	47°	141
<b>8-iron</b>	74 / 33.1	-3.1°	100 / 44.7	1.35	20.8°	7494	25 / 22.9	47°	130
<b>9-iron</b>	72 / 32.2	-3.1°	93 / 41.6	1.28	23.9°	7589	26 / 23.8	47°	119
<b>PW</b>	70 / 31.3	-2.8°	86 / 38.4	1.23	25.6°	8403	23 / 21	48°	107

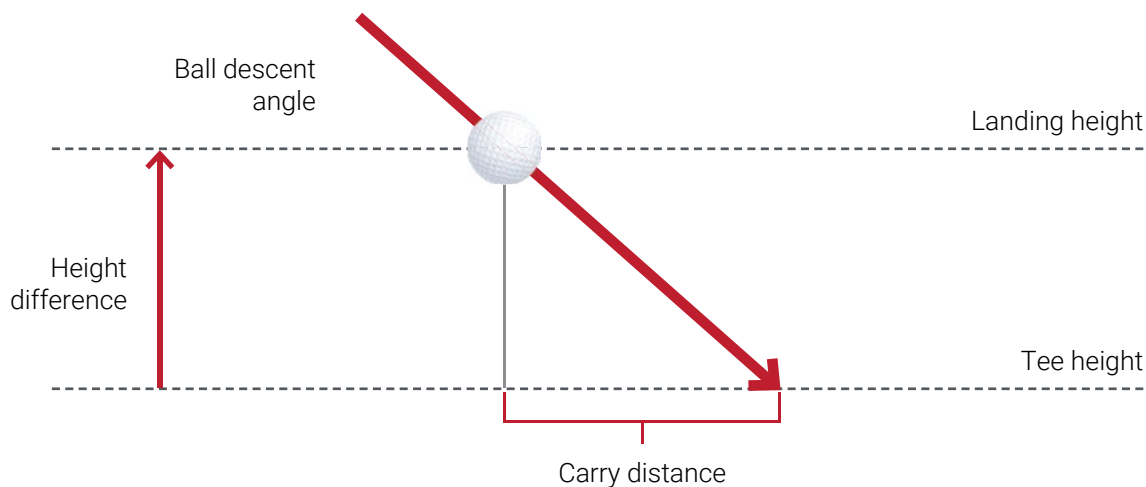
\* Altitude and environmental conditions were not taken into account for the data collected. Nonetheless, the data is based on a large sample size and is a fine representation of average data for tour professionals.

	Driver	13F	15F	19HB	22HB	3i	4i	5i	6i	7i	8i	9i	PW
<b>PGA Tour</b>													
Club MPH	109	106.1	104.8	101.2	98.5	96.2	94	91.9	90	87.6	85.5	83.3	82.2
Ball MPH	168	157	155.4	147	145.3	142.2	137.2	132.2	127.2	121.6	115.5	109.7	105.4
V. Launch Angle	12.8	10.1	9.8	8.9	10.6	9.8	11.3	12.8	14.6	16.6	18.6	20.5	22.5
Spin RPM	2430	3350	3750	3925	4225	4053	4659	5265	5972	6820	7765	8396	9024
Carry YDS	290	258	252.7	231.3	229.5	222	210.2	198.2	186.2	173.2	159.9	149.1	141.2
<b>0-10 Handicap</b>													
Club MPH	102					90.2	88.1	86	84	81.7	79.5	77.4	76.3
Ball MPH	157					134.6	129.8	124.8	119.7	113.8	108.1	102.4	98
V. Launch Angle	13.9					10.8	12	13.5	15.2	17.2	19.2	21.2	23.2
Spin RPM	2620					3773	4379	4985	5692	6500	7308	8116	8924
Carry YDS	267.1					206.7	195.8	184.4	172.4	159.8	148.1	137.5	129.6
<b>11-20 Handicap</b>													
Club MPH	90					82.3	80.2	78.1	76	73.8	71.6	69.5	68.4
Ball MPH	139					124.9	119.8	115	109.7	103.9	98.2	92.5	88.1
V. Launch Angle	16.8					11.3	12.8	14.3	16.1	18.1	20.3	22.1	24.3
Spin RPM	2560					3399	4005	4611	5318	6126	6934	7742	8550
Carry YDS	228.8					183.2	174.7	164.2	152.7	140.9	130.3	120.7	113.8
<b>Junior / Senior</b>													
Club MPH	78						69.3	67.2	65	62.9	60.8	58.6	57.6
Ball MPH	128						106.4	101.4	96	90.4	84.6	78.9	74.5
V. Launch Angle	18.9						14	15.5	17.2	19.2	21.2	23.2	25.2
Spin RPM	2990						3492	4098	4805	5613	6412	7229	8037
Carry YDS	203.8						143.3	133.5	123.5	114.3	105.2	97.2	91.4

Smash factor is the energy transfer ratio from club to ball as a result of impact position on the club face. Centered impact will improve smash factor for optimal ball speeds.

Club type	Smash factor
<b>Driver</b>	1.50
<b>3-wood</b>	1.49
<b>5-wood</b>	1.48
<b>3-iron</b>	1.46
<b>4-iron</b>	1.43
<b>5-iron</b>	1.43
<b>6-iron</b>	1.40
<b>7-iron</b>	1.38
<b>8-iron</b>	1.36
<b>9-iron</b>	1.32
<b>PW</b>	1.28
<b>SW</b>	1.15
<b>LW</b>	1.05

## Ball carry yards (flat vs. actual)



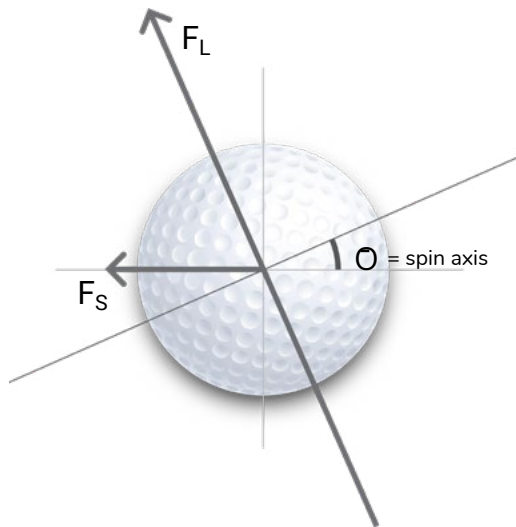
		Ball Descent Angle (°)			
		15°	30°	45°	60°
Height Difference (ft)	0	0	0	0	0
	5 ft	6.2 yds	2.9 yds	1.7 yds	1.7 yds
	10 ft	12.4 yds	5.8 yds	3.3 yds	3.3 yds
	15 ft	18.7 yds	8.7 yds	5.0 yds	5.0 yds
	20 ft	24.9 yds	11.5 yds	6.7 yds	6.7 yds

## Lateral movement of the ball due to spin axis

(assuming a ball speed to produce the distance below)

		Spin Axis (°)			
		5°	10°	15°	20°
Distance (yards)	100 yds	3.6 yds	7.2 yds	10.9 yds	14.3 yds
	200 yds	7.3 yds	14.3 yds	21.8 yds	28.7 yds
	300 yds	10.9 yds	21.5 yds	32.7 yds	43.0 yds

## Lift forces acting upon a golf ball during flight



$$F_S \text{ (side lift-force)} = F_L \cdot \sin(\text{spin axis})$$

$$F_L = (1/2) \cdot \sigma \cdot A_S \cdot V^2 \cdot C_L$$

$A_S$  = cross surface area of ball

$\sigma$  = the density of the air, which depends amongst other things on:

- height above sea level
- humidity
- air temperature

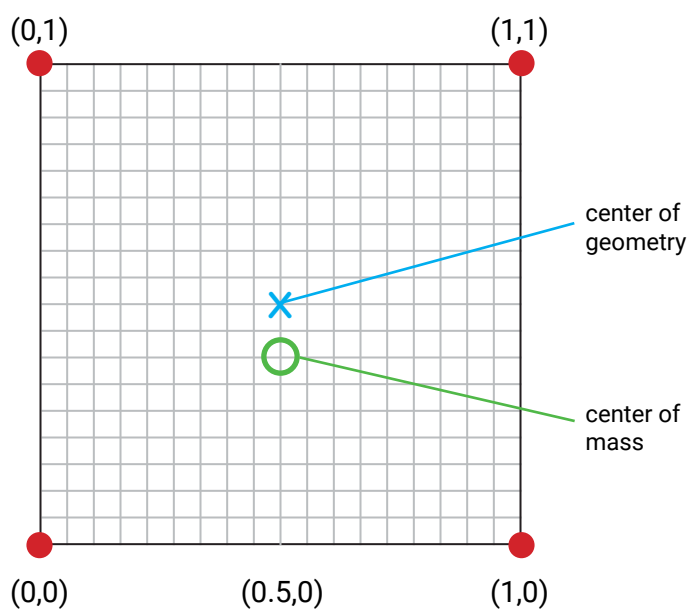
$V$  = speed at which the ball travels

$C_L$  = coefficient of lift from spin

- Possibly the most important aspect of the lift force,  $F_L$ , is the fact that it is directly proportional to the square of the ball speed.
- The lift force is, on the other hand, directly related to the lift coefficient, as well as the air density, which is merely a linear relationship compared to a quadratic relationship to ball speed.
- The lift coefficient typically varies between 0.23 @ 5,000 RPM to 0.26 @ 8,000 RPM. That is merely a range of 0.03, or proportionally an increase of 13% in the resultant Lift Force.
- On the other hand, if the ball speed doubles, then the lift force will increase by 400% in the resultant Lift Force.

With the speed and acceleration profiles we are able to see what affect the acceleration of the golfers swing has on the shaft. This information can be used to find solutions to any problems, or better equip the golfer.

## Which part of the club is measured



The clubhead is measured as a single, reflective mass where the geometric center is tracked.

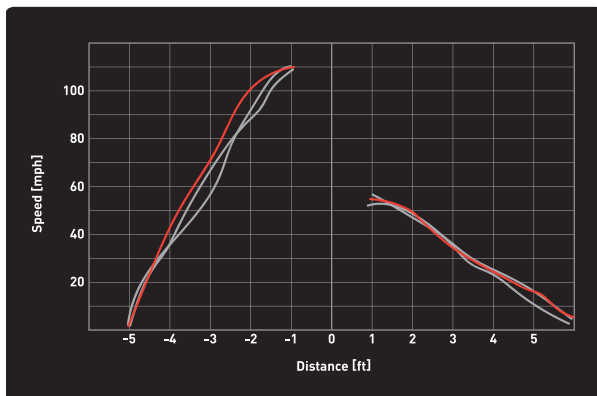
## Where is the club measured?

The speed profile is a continuous measurement through the strike zone.

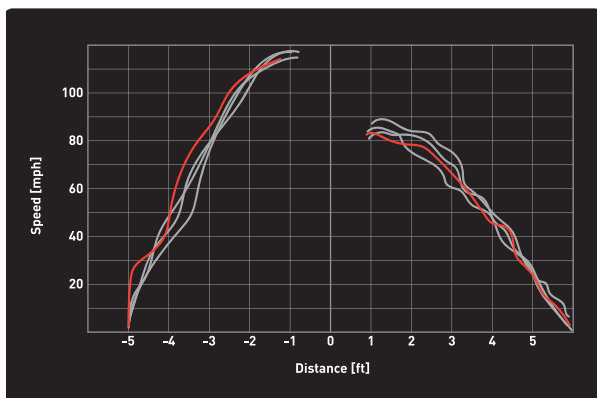




## Speed profile



- » Shows the apparent speed (speed directly away from the radar)
- » Shows build up of club speed before and after impact

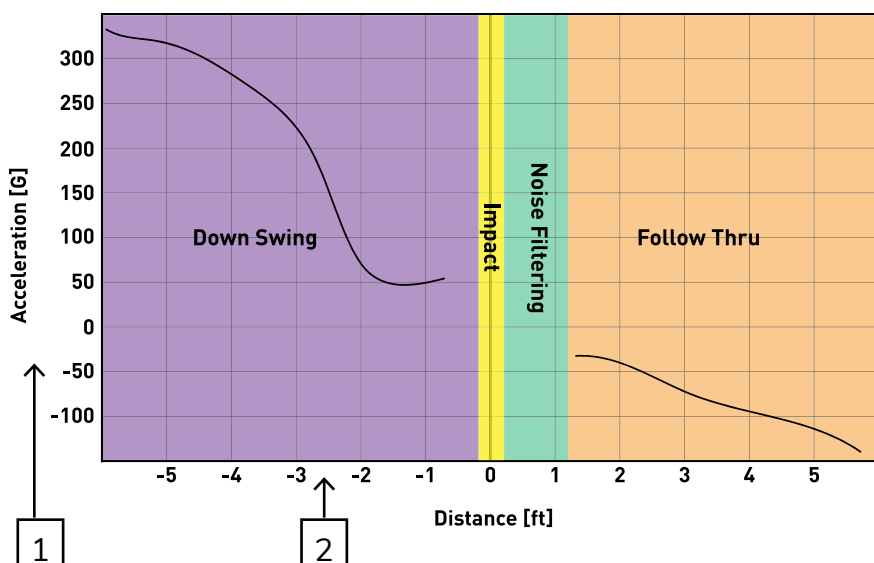


### Smooth curve

- » For a perfect fit, the speed profile prior to impact should be as smooth as possible with the least amount of kinks
- » Kinks show an incremental movement of the clubhead during the motion of the swing plane

## Acceleration profile

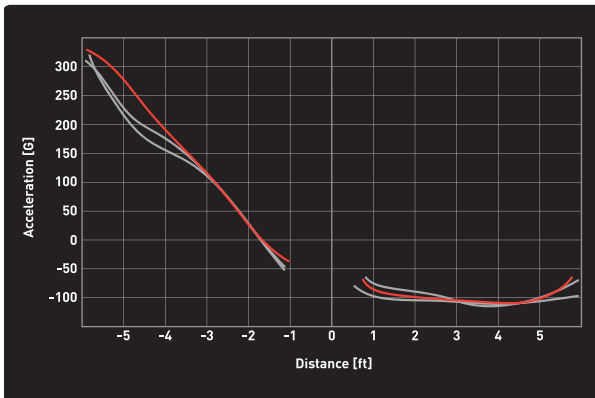
The acceleration profile graph shows the G-forces over the distance of the downswing. G-force is a force acting on a body as the result of acceleration or gravity, informally described in units of acceleration equal to one G.



1. Acceleration of the club in G-forces
2. Distance (in feet) showing where the downswing measurement takes place.

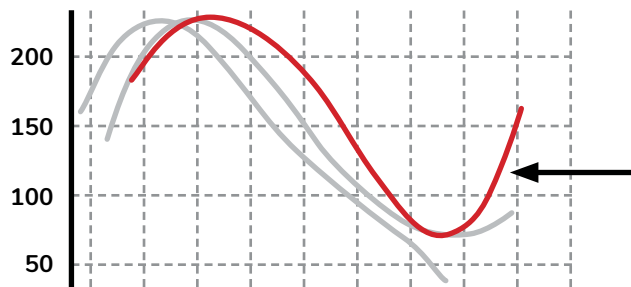
You can see on this graph the distance begins at 35 inches before impact. The gap in the data a few inches after impact is due to the radar filtering noise from the collision of the club and ball.

## Acceleration profile (cont'd)



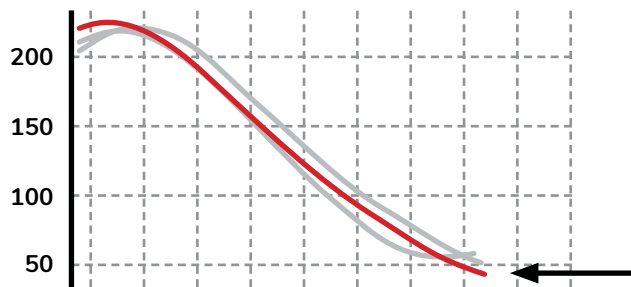
- » Shows the rate at which the clubhead is changing speed (away from the radar)
- » Shows the rate at which the club is gaining speed before and after impact
- » Declining acceleration profile  $< 0$ 
  - The club is still gaining speed, but the rate of speed gain is decreasing
- » Zero acceleration means that the speed remains constant
- » Positive acceleration means that the club is still gaining speed
- » Negative acceleration means the club is losing speed

## Shaft fitting



This image represents the downswing shot data from a player with a high club speed using the incorrect shaft type. We can assume the shaft is not correct due to the high g-force and the “fishhook” at the end of the profile. This can cause excessive lead deflection.

This type of profile is not ideal for higher club head speeds. However, this can be beneficial to players with low club head speed.

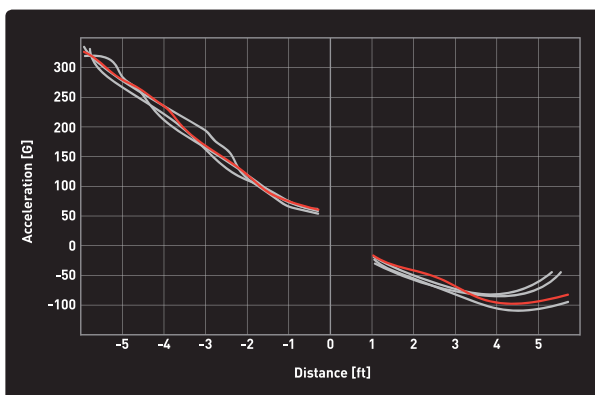


This image represents the downswing shot data of the acceleration profile created by a shaft which is very stable and would allow for a stable club head at impact.

Generally this should be what you see with tour players and would want with players with high club speeds. There is no fishhook at the end of the profile.

This type of profile is best for high club speeds. A lower club speed with this profile may have trouble generating higher ball speed.

## Acceleration profile during a fitting



- » Shows even the smallest change in the speed of the clubhead, and can see shaft behavior that's not possible to deduce from ball flight only
- » Is a fingerprint of the shaft's behavior in the hands of the player
  - Technique has a definite influence on the shaft's behavior
  - Study the entire swing sequence to make the most of the information in the speed and acceleration profiles

## Acceleration profile during a fitting (cont'd)

To demonstrate, two clubs were selected and provided to a player with a slower swing speed.

BACK

?

Armed

Demo Player

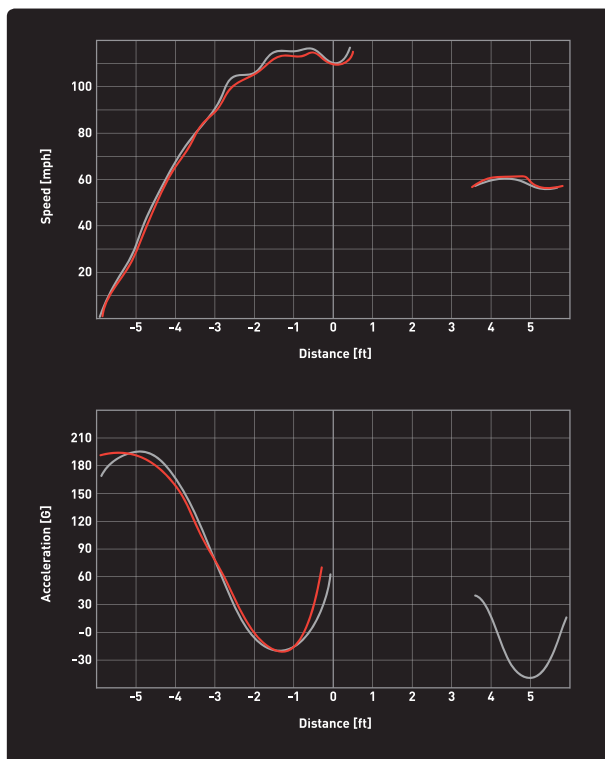
Driver 1

Standard Ball

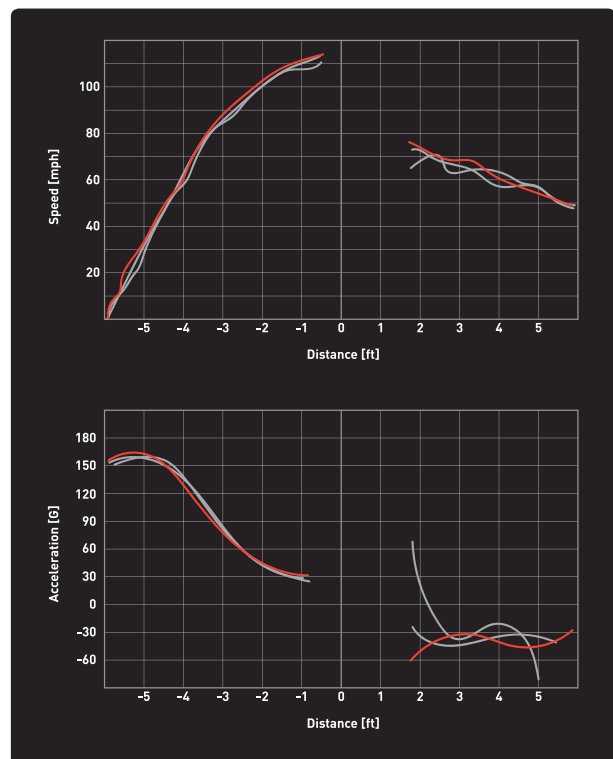
Club	Carry <small>[yds]</small>	Total <small>[yds]</small>	Lateral <small>[yds]</small>	Club <small>[mph]</small>	Ball <small>[mph]</small>	Smash	Spin <small>[rpm]</small>	Side Spin <small>[rpm]</small>	V Launch <small>[°]</small>	H Launch <small>[°]</small>	Descent V <small>[°]</small>	Height <small>[feet]</small>	Time <small>[s]</small>	Type
Driver 1	189.4	303.9	10.3 L	89.9	125.8	1.40	2792	-148	13.3	2.5 L	26.7	55.7	4.9	Straight
Driver 2	157.0	264.1	4.8 L	91.3	120.3	1.32	3170	318	8.8	3.2 L	18.4	31.5	4.0	Draw

The correct choice seems to be the stiff flex shaft, but the results table indicates the flex shaft is best.

Regular Flex Shaft



Stiff Flex Shaft




**In the results, we see the following:**

1. Even though the club speeds are very similar, the ball speed with the regular shaft assisting the player is greater.
2. The effect of the shaft has allowed the player to launch the ball higher and therefore have a better carry distance.
3. The shaft is allowing the player to hit the ball straighter.



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