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The Speed of Golf Ball after Impact with Golf Club

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Abstract

In the present article, an algorithm is obtained for calculating the speed of a golf ball that flies after being hit by the head of a golf club. First, the golf club moves at a given speed to hit the golf ball. Then, the head of the golf club moves forward in the same direction at a given speed. At this time, the speed of the golf ball flying upon impact of the golf ball with the club head is calculated. The purpose of the present article is to calculate the speed of the club head, the impact, the speed of flying ball after the impact, the moving directional pattern of the ball after impact, etc. Results of the study through experiments and implications as well are exhibited in details.

Keywords*: golf ball, golf club, club head, impact, speed of ball*

1. Introduction

These days, even the general public is fully immersed in the charm of golf. This may be in attributable particularly to the fact that Korean players are ranked high in the LPGA (Ladies Professional Golf Association). Anybody willing to pay the entrance fee to a golf course, which is around 100,000 won, is allowed access to enjoy the game.

In addition, screen golf, especially designed to allow people to play and enjoy golf indoors, is very widespread in Korea. This system is also known as golf simulator. Currently, a new venture item also known as golf room or screen golf course, which makes use of this system, is at the spotlight [1].

The screen golf course consists of a sensor, screen, projector, computer, swing plate, auto tee-up equipment, putting simulator, motion camera, *etc.* The most important of these is the sensor, which decodes trajectory, direction, distance, speed, rotation, *etc.* of the ball hit by the player for representation as numerical data.

Also, numerous books related to screen golf are in the market. Books such as Conquering Screen Golf [2], Bible of Screen Golf with More Fun Than Field [3], How to Play Good Golf Without Ever Losing in Wager [4], and Secret for Venture and Operation of Screen Golf For Achievement of 200% Sales [5], *etc*. may be considered as representative books related to the screen golf.

In this way, golf (screen golf) has been completely popularized and can be enjoyed by any contemporary, and anyone desiring to do business can be easily engaged in golf business as long as he/she has money.

The following Figure1 shows a scene for an actual golf shot. It is a swing scene with the iron of In-Gee Jeon among golf clubs.

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Figure 1. Iron Shot of In-Gee Chun

In the present article, the head of a golf club moves at a given speed for impact. After the impact, the head of the golf club moves in the same direction at a given speed. At this time, the speeds of the flying ball are obtained when the head hits the golf ball. Speeds of the golf ball will also be obtained respectively when speeds before striking the ball are varied. Related studies are introduced in Chapter 2 of the present article, while speeds of the golf ball after impact are considered in Chapter 3, speeds are measured through experiments in Chapter 4, and conclusions will be drawn in Chapter 5.

2. Related Studies

Although a driving distance is determined by the club head speed, it is difficult to explain by that alone. The saying that a driving distance is determined by the speed of the correctly applied club head is a more fitting expression. Also, the speed of the club head can be correctly applied when the technique is certain. Therefore, fast swings to hit the ball farther and to increase the speed of the club head is very foolish. This is because the accuracy and the driving distance both become poor since consistency and control are loosened with the fast swing. To hit the ball farther by increasing the speed of the club head, your swing will need further development.

Considering studies related to golf, improving golf players' game through an apparatus for golf swing was presented in [7]. This study aims to improve the relation between protection and configuration of golf apparatuses. Shown in [8] is the accuracy of presuming a center of mass trajectory in complicated motion operations for the wearing technique based on an inertia sensor (in golf swing, for instance). In [9] was the key to minimum rotation of body (the least amount of shift distance of the rotation center point) and reaction force from the ground of the left foot (the vertical peak ground reaction force). In [10] is a golf information system (GIF) by usefully modifying and improving Mix are, the augmented reality open source, for the sport of golf into an augmented reality-based system that can supply various information according to the real environment of the golf course and explain how to really use it for the golf course.

While there are many additional studies related to golf swing, no more of them will be considered here, since most of them are related to golf swing apparatuses, motion recognition sensor, and posture of body upon swing, *etc*.

3. Speed of Golf Ball

Momentum is a vector quantity involving directionality, and also shows the extent of motion of an object in comparison with the force ($F=ma$) of the moving

object. Momentum is defined as mass×velocity, and the direction of momentum becomes the velocity direction of the object, since velocity is a vector quantity while mass is a scalar quantity. Strictly speaking, what we express as the momentum means a linear momentum in linear motion. Circular motion and objects such as rotating earth are expressed by angular momentum rather than linear momentum.

Momentum provides very important information on the motion of the object when two objects having masses interact by collision, *etc.*. In other words, impact amount or impact time upon collision between two objects can be found when the two objects collide if masses of the objects and speeds before and after collision are known. The greatest utility when the concept of momentum is used is the establishment of the law of momentum conservation. The law of momentum conservation states that the sum of momentums before and after collision is conserved upon collision of the objects; it is also the base data for velocity analysis, which is useful when vehicles of similar weights are collided in reproduction of traffic accidents.

Object *X* with a mass of *M* and object *Y* with a mass of *m* are in motion at speeds of s_1, s_2. This is the case where objects *X and Y* are in motion on a straight line and continues motion on the same line after collision as well. If speed of the object *X* has become s_1', and that of the object *Y* s_2', it may be seen by considering the change in momentum.

When two objects collide, the two objects exert force on each other. When the short time between contact and separation of two objects is called *t* and the force exerted by *X on Y* is *F*, the force exerted by *Y on X* becomes *-F* with the same magnitude and the opposite direction according to the law of action and reaction. In this case, the impact amount experienced by the object *Y* is *Ft*, while the impact amount experienced by *X* s *-Ft*. Meanwhile, since the impact amount experienced by the object is the same as a change in the momentum for each of *X*, *Y*,

In the case of X :

$$Ms_1' - Ms_1 = -Ft \qquad \textit{Equation (1)}$$

In the case of Y *:*

$$ms_2' - ms_2 = Ft \qquad \text{Equation (2)}$$

Hold. Therefore, from these two equations,

$$-(M_{s1}' - M_{s1}) = m_{s2}' - m_{s2} \qquad \textit{Equation (3)}$$

Holds.

The part of $Ms_1' - Ms_1$ on the left side in this equation is a reduced amount of the momentum of *X* (since the momentum is reduced due to a reduction in the speed of *X* as a negative value after collision). And $ms_2' - ms_2$ on the right side is an increased amount of the momentum of *Y* (since the momentum is increased due to an increase in the speed of *Y* as a positive value after collision).

Namely, the momentum of *Y* is increased by as much as the momentum of *X* is reduced. That is, momentum is meant to be conserved as a whole. Rearranging this equation, one obtains $Ms_1 + Ms_1' = Ms_2 + Ms_2'$. Again, it can be seen that the total sum of momentum before and after collision is conserved to be constant. This is referred to as the conservation law of momentum.

Conservation law of momentum is applied to golf in the same way. The golf club head of P_1g was moving at speeds of S_{1x}m/s, S_{2x}m/s, S_{3x}m/s, S_{4x}m/s, S_{5x}m/s, S_{6x}m/s, respectively, before hitting the golf ball of Q_2g. After hitting the golf ball, the golf club head moved in the same direction at the speed of S_1'm/s. Now, speeds of the flying golf ball after hitting the golf ball are obtained.

According to the conservation law of momentum,

$$P_1S_1 + P_2S_2 = Q_1S_1' + Q_2S_2' \qquad \textit{Equation (4)}$$

Holds.

When this is expressed as an algorithm, it may be shown as follows.

(Algorithm 1) Velocity Measurement Algorithm for Golf Ball's
※ Parentheses can come to anything either speed or mass.
A. Before Hit
A.1 Understand (Mass) of P_1
A.2 Understand (Velocity) of P_1
A.3 Understand (Mass) of Q_1
A.4 Understand (Velocity) of Q_1
B. After Hit
B.1 The Mass of The Object P_1 and Q_1 after The Conflict is Constant
B.2 Understand (Velocity) of P_2 after Conflict
B.3 Understand (Velocity) of Q_2 after Conflict

4. Experiments

For experiments, Visual C++ 2011 in Windows Vista 7 was employed, and "Vision Sensor", the most advanced sensor independently developed by Golfzon, was used. Vision Sensor recognizes high-speed obstacles without marking by using a high-speed camera. Through sensing technology allowing real-time processing, swing speeds are obtained with a sensor capable of free impacts on the ball on a matte. In experiments, speed measurements when swung with each golf club held are made by using Vision Sensor. And mass of the golf club head is input after being weighed. Also, programming was prepared so that final result values were produced by weighing and putting in the weight of the golf ball. Figure 2 shows important components of Golfzon.

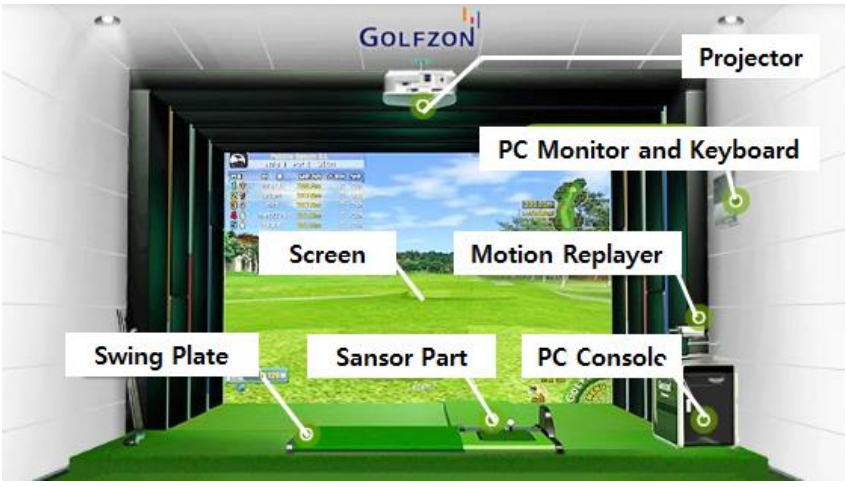

Figure 2. Architecture of GOLFZON

Experiments were conducted after the weight of No.7 iron as an object was weighed. In the experiment, P_1 refers to the mass of a golf club head of 200g. S_1 is a speed of the golf club head shown to be 40m/s, 42m/s, 44m/s, 48m/s, 50m/s, respectively. Q_2 represents the mass of a golf ball of 50g, showing the speed of 0, since Q_2 was lying before the golf ball was hit. S_1'shows 2 kinds of speeds at 20m/s and 40m/s for a golf club after the golf ball was hit. S_2'shows the flying speed after the golf ball is hit with the golf club head, *i.e.*, a value to be obtained.

When the value is substituted in Equation (4), the flying speed of Q_2 to be obtained after the golf ball is hit becomes 80m/s.

When the head mass of No.7 iron was 200g, head speeds of the golf club head were varied to be 40m/s, 42m/s, 44m/s, 46m/s, 48m/s, 50m/s, respectively. At this time for the mass of a golf ball of 50g, the head speed of the golf club head was reduced to 20m/s after golf ball was hit. Therefore, when the flying speeds were sought after the golf ball was hit with the golf club head, the results as shown in Table 1 could be obtained.

Table. 1. Flying Speed of Golf Ball after Collision (Head speed 20)

P_1	Q_2	S_1	S_2	S_1'	S_2'
200g	50g	40m/s	0m/s	20m/s	80m/s
		42m/s			88m/s
		44m/s			96m/s
		46m/s			104m/s
		48m/s			112m/s
		50m/s			120m/s

When the friction coefficient of air was multiplied by thus-obtained results, actual flying speeds were calculated. In the present article, only the direct flying speeds were obtained without calculating the friction coefficient of air. Although mentioned frequently, it can be seen that as the ball travels farther, the higher the head speed becomes.

It can be seen more clearly when the graph in the following Figure 3 is examined.

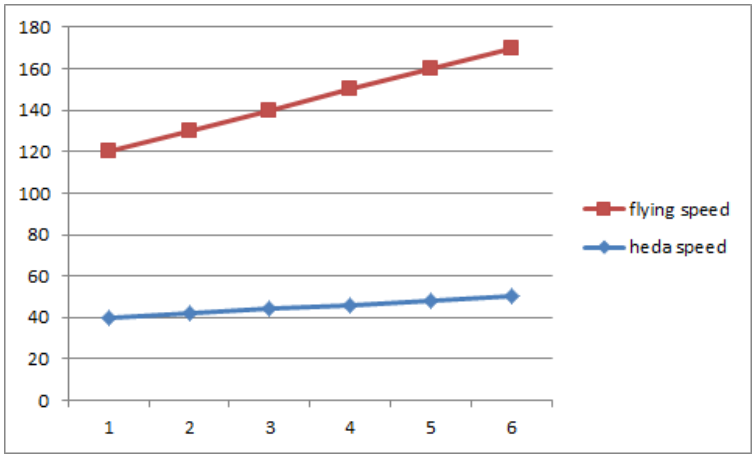

Figure 3. Graph of Flying Speed of Golf Ball

5. Conclusion

Golf has become a very fundamental and popular sport that everybody can easily talk about and experience nowadays. In the present article, the speed of the golf ball was calculated after the ball is hit by a golf club at a given speed. The speed when the mass of No.7 iron was 200g and that of the 50g golf ball were obtained. These were the speeds when the head speed of the golf club was 40~50m/s and increased by 2m/s at each time. After striking the golf ball, the speed of the golf club head determined by the the reduced speed of 20m/s. Here, the pure flying speed was obtained with the friction coefficient of the excluded air. As shown by the Table and the graph, when the flying speed of the ball increased, the higher the head speed also became.

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