

# Effects of wind resistance on the distance of a drive in golf

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## Introduction

Gravity and air produce considerable forces on golf balls. Due to the relatively low mass and high speeds of golf balls, air resistance alters the path the ball will travel dramatically. Drag, lift, and gravity have major effects upon the path the ball will travel. Various atmospheric conditions will affect the drag and lift forces. The purpose of this study was to determine how headwinds and tailwinds affect the path of a professional's drive and what differences occur according to location.

## Methods

A computer simulation modeled the flight of a golf ball under various wind conditions: -4 m/s, -2 m/s, 0 m/s, 2 m/s, and 4 m/s. The typical air densities and gravitational effects at the 2003 Professional Golf Association Tour locations and Gunnison, CO were used in the model. The model used initial conditions of 80 m/s at 10 degrees which are typical drives of professional golfers.



## The Simulation

A step-by-step numerical integration determined the instantaneous position, velocity, and acceleration of the golf ball. Lift and drag forces were based upon previously established coefficients. Atmospheric conditions were taken from weather almanacs.

$$s = s_0 + v_i t + 0.5at^2$$

Projectile motion equation used in the simulation. Acceleration values were changed at small time intervals based upon drag and lift forces and gravitational accelerations.

### Flight distance of golf ball (m) with various windspeeds (m/s)

	-4	-2	0	2	4
Sandwich, England	228	243	259	275	292
Bloomfield, MI	230	244	260	276	294
Rochester, NY	231	245	261	278	295
Olympia Fields, IL	231	246	261	278	295
Augusta, GA	234	249	264	281	299
Gunnison, CO	274	289	304	320	337

Table 1: Distances a ball would fly under various conditions being released at 80 m/s at 10 deg.

## Results

Flight distances increased dramatically with increasing windspeeds with the greatest differences appearing in Augusta, GA (234m to 299m). Relatively small increases were observed between locations with the greatest differences with no wind observed between Augusta, GA and Sandwich, ENG of 264m and 259m respectively.

## Conclusion

Wind velocity has a large effect upon the distance a golf ball will travel. Locations with the smallest air density appear to have similar changes in distance due to wind and have the longest distances when no wind is present. The lower drag and slightly lower gravitational acceleration lead the greater distances at higher altitudes. Combining the data from this study, fluid mechanics, and projectile motion, it can be determined that the hitting angle should be slightly increased with a tailwind and decreased when hitting into a headwind.