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A2 3 Did Altitude Help England at the World Cup?

A. Hawkins, R. McElroy, F. Stacey, S. Dias and M. Robertson

Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH

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Abstract

In this paper we model the goal kick that led to England being awarded the deciding penalty in the Round of 16 of the 2026 FIFA World Cup. We model the same kick as if the game had been played at home in London. We find that the ball would not reach the attacking players in this case. Hence, the altitude at the Azteca could have been the deciding factor that won the game for England.

Introduction

Media coverage ahead of England's 2026 FIFA World Cup Round of 16 match against Mexico suggested that England would be disadvantaged due to the altitude of the Azteca Stadium in Mexico City [1]. England won the game by scoring a deciding penalty in the 60th minute [2]. This penalty was given following a long goal kick to the striker, Harry Kane. Using the Python modelling package `ModSimPy` [3], we have modelled the goal kick that lead up to this penalty call. We also modelled the trajectory of the ball, from the same kick, had the game had been played at home at Wembley Stadium, in London.

Theory

For simplicity this model assumes that the ball from the goal kick has no spin. This removes the Magnus effect on the ball and allows us to model the trajectory in two dimensions [4]. After the initial kick the two forces acting on the ball are the weight and the drag force. These forces are given by

$$F = mg, \tag{1}$$

$$F_d = \frac{1}{2}\rho v^2 C_d A \tag{2}$$

respectively [5, 6]. In these equations m is the mass of the football, g is the acceleration due to gravity, ρ is the air density, v is the velocity of the ball, C_d is the coefficient of drag of the ball and A is the cross-sectional area of the ball. The vertical and horizontal components of forces are resolved using the angle that the ball is kicked, θ. The air density is given by the following equation [6].

$$\rho = \frac{P}{R \cdot T}, \tag{3}$$

Where R is the specific gas constant, T is the absolute temperature and P is the absolute pressure given by the following equation [6].

$$P = P_0 \cdot \left(1 - \frac{\delta T}{T_0} \cdot h\right)^{g/(R\delta T)}, \tag{4}$$

Where P_0 is the standard air pressure at sea level, δT is the lapse rate, T_0 is the standard temperature at sea level and h is the stadium altitude.

Modelling

We model the trajectory of the football using an edited version of the `ModSimPy` model for the flight of a baseball [7]. The model defines the

Parameter	Value
A	$\pi r^2 = \pi \cdot \left(\frac{0.22}{2}\right)^2 = 0.0378$ m^2[8]
m	0.431 kg [8]
C_d	0.24 [8]
T_{Azteca}	19 °C [9]
h_{Azteca}	2240 m [1]
δT	0.0065 Km^{-1} [6]
P_0	101325 Pa [6]
T_0	288.15 K [6]
v	35 ms^{-1}
θ	40° from horizontal axis

Table 1: Initial parameters used to model the trajectory of the ball.

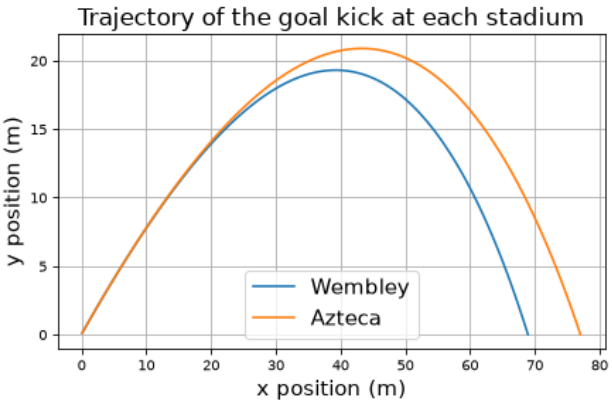


Figure 1: The modelled trajectory of the football from a goal kick taken at Wembley Stadium and the Azteca Stadium.

system using a set of initial conditions, an end time and a set of parameters. A slope function is also defined to calculate the x and y position of the ball and the x and y components of acceleration of the ball. The `run\_solve\_ivp()` function uses the resolved accelerations to estimate the next ball positions [3]. This repeats until the full trajectory of the ball is mapped. We first modelled the trajectory of the ball at the Azteca using the parameters shown in table 1. The kick angle and velocity are estimates based on video footage [10]. The model predicted the ball to travel a horizontal distance of 70 m before bouncing. From the video footage, we believe the ball travelled approximately 77 m horizontally before reaching Harry Kane. The initial kick velocity is increased to 37.8 ms^{-1} to match this distance.

The model was rerun using the altitude and temperature at Wembley on the day of the game. These parameters are 29 °C and 60 m respectively [11, 12]. The model predicted the ball would only travel a horizontal distance of 69 m at Wembley. The trajectories of the goal kick at both stadiums are shown in figure 1.

Validity of the Model

We have assumed that the coefficient of drag, C_d, is constant. This value however is dependent on the orientation [8] and velocity of the ball [6]. The model could be improved by calculating the coefficient of drag as a function of velocity.

We also assumed that the ball is not spinning. By making this assumption we remove the Magnus effect. This means our model ignores the Magnus effect and fails to account for any motion into a third plane [4]. The model could be improved by factoring in the rotation of the ball.

Conclusion

Overall, we believe this model provides a good comparison between the ball trajectory at the Azteca and at Wembley. We have predicted that if the same kick from the Azteca was taken at Wembley, the ball would have fallen 8 m short of Harry Kane. Had this happened in the game, Anthony Gordon may not have received the next pass and won the deciding penalty to win the game for England.

The change in temperature between the venues only accounts for 1 m of this distance, which Harry Kane could reasonably have covered. It is unreasonable to believe that the extra 7 m of difference, due to the altitude, could be covered in the few seconds that the ball was descending. This means the deciding factor between whether or not Harry Kane received the ball comes down to the altitude of the stadium.

Supporting Material

Claude Sonnet 5 and OpenAI GPT-5.6 Luna were used as python debugging aids [13, 14].

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