BOOMERANG SOCCER BALL
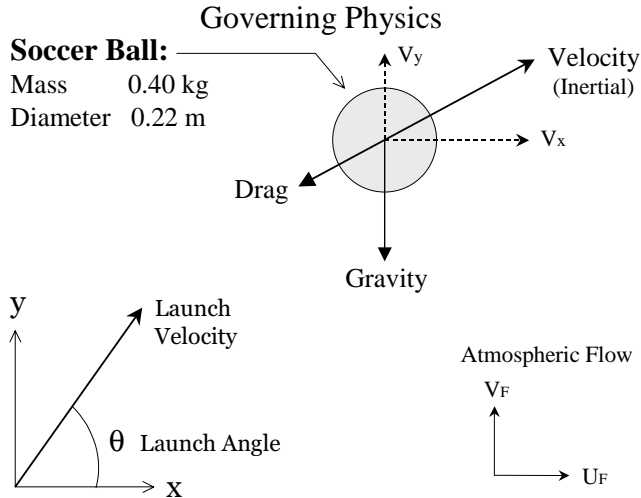
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PROBLEM DEFINITION
The goal is to determine possible Soccer ball launch configurations that result in the ball returning to the launch site.

Governing Physics

Soccer Ball:
Mass   0.40 kg
Diameter   0.22 m

MATHEMATICAL DESCRIPTIONS
The problem is modeled with Newton's Law in two dimensions applied to a sphere. Drag and buoyancy effects are considered.

$$\frac{d^2 x}{dt^2} = \frac{3\rho}{4D} C_D (U_F - u) w_r \bigg/ \left(1 + \tfrac{1}{2}\rho\right)$$

$$\frac{d^2 y}{dt^2} = \left(-(1-\rho)g + \frac{3\rho}{4D} C_D (U_F - u) w_r\right) \bigg/ \left(1 + \tfrac{1}{2}\rho\right)$$
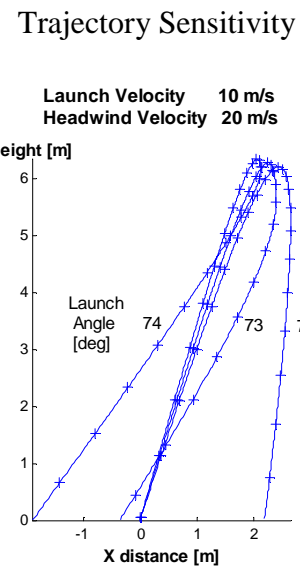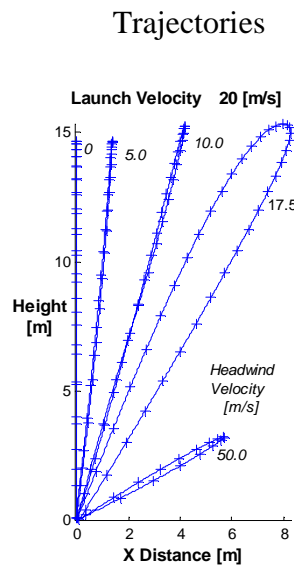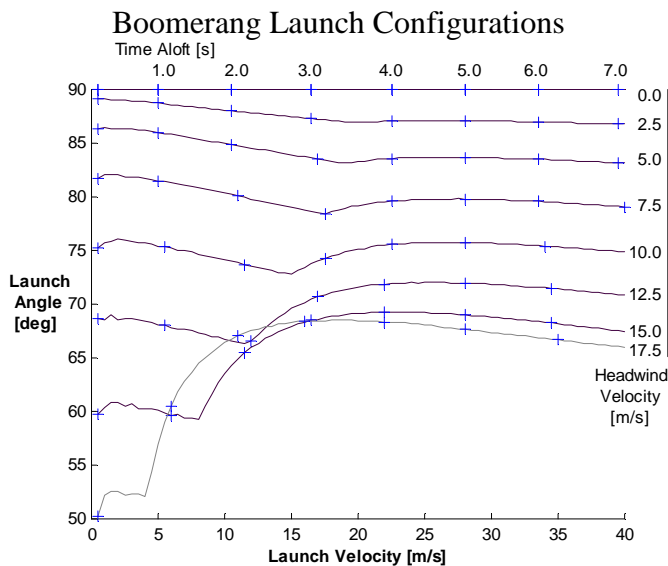
$$C_D = f(Re)$$

SOLUTION TECHNIQUE
Individual trajectories are time marched forward with a Runge Kutta 4th order ODE Solver

Return trajectories are found by iterating launch angles with a half interval search routine.

RESULTS

Boomerang Launch Configurations   Trajectories   Trajectory Sensitivity

DISCUSSION
A returning soccer ball is possible with the proper launch angle and velocity. A headwind is required except for the purely vertical case.

Trajectories with long free fall times are extremely sensitive to their initial conditions. These critical trajectories have outgoing and incoming paths that are vastly different.

Flow regimes and the resulting drag coefficients clearly dominate the launch configurations. The transition to fully turbulent flow increases the required launch angle. Higher headwinds quicken the appearance of the turbulent regime. As such, drag modeling is critical.

CONCLUSION
Soccer ball launch configurations for a returning ball exist. Critical influence parameters were identified.