Design Exercise #1. Trajectory Analysis

Assigned: 9/20/12, Due: 9/26/12

Part I.

1. Treat your potato as a point mass, m. Launch your potato from a height, h, with an initial speed, v_0, an an initial angle with the horizontal, θ. Acceleration due to gravity is g. What is the range, R in terms of m, h, v_0, θ, and g? What parameters affect range? What is the sensitivity to each parameter (NOTE: assume $R = R(m, h, v_0, \theta, g, ...)$ and compute e.g., $\frac{\partial R}{\partial h}$)?
2. Pick some values for the parameters that affect range (based on your potato measurements and some reasonable estimates of desired trajectory) and compute
   $\delta R = \sqrt{(\frac{\partial R}{\partial m}\delta m)^2 + (\frac{\partial R}{\partial h}\delta h)^2 + (\frac{\partial R}{\partial v_0}\delta v_0)^2 + (\frac{\partial R}{\partial \theta}\delta\theta)^2 + (\frac{\partial R}{\partial g}\delta g)^2 + \cdots}$ where
   $\delta m, \delta h, \delta v_0, \delta\theta, \delta g, ...$ are your estimates on the possible variation of these parameters.
3. Base on the above estimates, what parameters will cause the most variation in your range? Discuss how you might accommodate these variables in your design.

Part II

1. Repeat Part I but add the parameter, ϕ, the angular deviation of the initial velocity about the gravity axis.

Part III

1. Treat your potato as a rigid body, with mass, m, and moment of inertia (about the axis of travel), J and angular velocity, ω. Repeat the analysis of Part I. (NOTE: this is the same as saying, treat the potato as if it were a football thrown by a quarter back.)

Part IV

1. Treat your potato as a rigid body, with mass, m, and moment of inertia (about the axis perpendicular to the potato's trajectory), J and angular velocity, ω. Repeat the analysis of Part I. (NOTE: this is the same as saying, treat the potato as if it were a kicked football.)