PHYS 240 homework #4 – due Feb 5 2013, 1:25pm, upload to Canvas

Football trajectory and Euler's method

Solve the computational problems below. Write up your findings (including plots) in a LaTeX file. Submit your Python source code and your PDF report.

1. Write a Python script, `balle.py`, to solve for the trajectory of a football, where the goal is to create a plot showing $y(x)$. There should be two curves shown on the same plot: the analytical and numerical models. Use axis labels (with units) and legends.

An overall algorithm for this program is as follows (see class notes for equations of motion and for Euler's method):

- set physical parameters
  ($m \sim 0.43$ kg, $C_\mathrm{d} \sim 0.05$, $\rho \sim 1.2\ \mathrm{kg\,m^{-3}}$, $A \sim 0.013\ \mathrm{m}^2$,
  for a football thrown in a perfect spiral)
- set initial v_0, θ_0, Δt (all from user input)
- loop until ball hits ground
  - compute acceleration
  - calculate new position and velocity (r_{n+1},v_{n+1}) using Euler's method
  - record the position and velocity as needed for plotting
  - if ball reaches ground ($y < 0$), break out of the loop
- print maximum range and time of flight, both analytical and numerical
- plot the trajectory

2. (a) Assume a typical football throw of $20\,\mathrm{m\,s^{-1}}$ and a 45° angle. What is the range, with and without air resistance?

(b) Assume a typical field goal kick of $30\,\mathrm{m\,s^{-1}}$ and a 30° angle. Again, what is the range, with and without air resistance? The maximum range in reality is ~ 55 m (for clearing the goal post at a height of ~ 3 m). What could account for the difference between this number and your calculation?