Matlab Homework 5*a*

In the online book:

- Do the "Challenge Activities" of: 4.4,6-8
- Do the "Participation Activities" of: 2.8,9; 4.11; 5.6

Matlab Homework 5*b*

The same general requirements as for homework 4b apply. And you must study the posted lesson(s) and have done the online book part above before you can ask a TA or the instructor for help.

The same requirements as for homework 3c apply.

1. Continuing the previous homework, find the derivatives of the three fitted polynomials and plot them all three together, with the same colors as before. Also plot the exact derivative as a black broken line. Comment on the quality of each of the three approximations using again the `disp` command. Use appropriate title, labels, legend, and axis ranges. The vertical axis range should be a bit bigger than the vertical range of the exact derivative.

2. Your city is being attacked by a ship. You want to shoot cannon balls at it, but the ship may be too far away. Your cannon can shoot the cannon ball out at an initial total velocity V_0 of 100 m/s, and the acceleration of gravity g at your city happens to be 9.81 m/s^2. You know from basic physics that ignoring air resistance, your cannon ball will travel farthest when you shoot the ball out at 45 degrees from the horizontal. It will then travel 1,019 m in 14.42 seconds to a ship at the same height as the cannon. You would like to know how this changes in the presence of air resistance.

   To do so, the first step is identify the equations of motion of a canon ball in air, but without significant spin. They are:

$$\frac{\mathrm{d}x}{\mathrm{d}t} = u \tag{1}$$

$$\frac{\mathrm{d}y}{\mathrm{d}t} = v \tag{2}$$

$$\frac{\mathrm{d}u}{\mathrm{d}t} = (-F_{\text{air}}u/V)/m \tag{3}$$

$$\frac{\mathrm{d}v}{\mathrm{d}t} = (-F_{\text{gravity}} - F_{\text{air}}v/V)/m \tag{4}$$

   where x is the horizontal distance traveled from the canon, y the height above the canon, u the velocity component in the x-direction and v the one in the y-direction. Also m is the mass of the canon ball, which has radius r and is made of iron with a density ρ_{iron} equal to 7272 kg/m^3. Also

$$V = \sqrt{u^2 + v^2} \qquad F_{\text{gravity}} = mg \qquad F_{\text{air}} = C_d \pi r^2 \tfrac{1}{2} \rho_{\text{air}} V^2$$

where the drag coefficient C_d can be taken to be 0.5 and the density of air ρ_{air} to be 1.225 kg/m^3.

Write a well-documented Matlab function cannonBall that takes as inputs the time t from firing the cannon, a vector consisting of values of the four unknowns (x, y, u, v), and the cannon ball radius r, and that outputs the corresponding values of the derivatives of the unknowns in a column vector.

3. Use the function of the previous question to find the motion of a canon ball of 10 cm radius in 14.42 seconds using the data as described above. Let Matlab produce the solution at at least 100 times in that time range. Plot the path of the cannon ball as y versus x (not against time). To do so neatly, you will want to take the x and y values out of `unknownValues`. You can do that as

```
xValues=unknownValues(:,1);
yValues=unknownValues(:,2);
```

(If you have to know, the second number within the parentheses is the column number, 1 for unknown x and 2 for unknown y. The first number is the row number; putting a bare colon for that number produces all row numbers from 1 to end, i.e. all computed times.) Add an appropriate title and axis labels, of course.