EE 389 Homework 5 Due March 18, 2008

1. In an experiment, you measure the velocity and acceleration of an object with a mass of 0.5 kg falling in a fluid. You find the following data:

v	a
0.00	9.69
1.38	9.65
1.99	9.18
2.20	9.22
2.51	9.03
3.06	8.61
3.77	8.03
4.09	8.02
4.65	7.50
5.51	6.95
6.21	6.30
7.22	5.40
7.88	4.58
8.53	3.71
9.79	2.26
10.31	1.44
10.93	0.70
11.21	0.30
11.37	0.08

You think the data will fit one of the following functions:

$$a = g - \frac{1}{m}B_1 v - \frac{1}{m}B_2 v^2 \tag{1}$$

or

$$a = g - \frac{1}{m}b_1 v^{b_2} \tag{2}$$

1. Write two MATLAB `m` files which will calculate the acceleration a from the velocity data and the parameters B (or b). For example, if the function for the first equation is called `nls1.m`, it should be called as

```
nls1(b,v)
```

   where b is a two-element vector with the values of the two parameters, and v is the velocity data from the table.

2. Write a function to find the values of the parameters which minimizes the following:

$$\sum_{i=1}^{N} (a_{mi} - a_{ci})^2 \tag{3}$$

   where a_{mi} is the i^{th} measured acceleration from the table, and a_{ci} is the i^{th} acceleration calculated from Equation 1 or 2. You should assume some reasonable initial value for the parameters, and then search for the values of the parameters which give the minimum value for Equation 3. You should be able to find the best values for B_1 and B_2 by calling the function which implements Equation 1. You should then be able to find the best values for b_1 and b_2 by calling the function which implements Equation 2 instead. You can implement a grid search (try different values of the parameters until you find the "best" ones), or a gradient search (take the derivative of Equation 3 with respect to the parameters to find out which direction to move the parameters to get to the bottom of the bowl).

3. Which equation fits the data best — i.e., which function gives the smallest value for Equation 2? From this equation, estimate the variance of the measurement of the acceleration — i.e., find the value for σ^2 such that

$$\chi_\nu{}^2 = \sum_{i=1}^{N} \frac{\left(a_{mi} - a_{ci}\right)^2}{(N-2)\sigma^2} \tag{4}$$

   equals about 1.