MATLAB Practical III: Graphics and Matrices

This practical concentrates on sparse matrices in MATLAB. Try some of the examples on the "MATLAB Practical III: Graphics and Matrices". In particular, consider the handle graphics and three dimensional graphics sections.

1. In the lecture, to plot the contours 1, 2, and 3 for the `peaks` data set, we typed

   ```
   contour(peaks, [1 2 3])
   ```

   Type `help contour` to learn more about plotting contour lines. Notice that if you only want to print *one* specific contour line, you need to do something special. What is the command to print only the 1 contour?

2. To practice constructing diagonal matrices using the `diag` command, build a 32×32 *Grcar matrix*, a matrix with constant diagonals of the form

   $$A = \begin{pmatrix} 1 & 1 & 1 & 1 & 0 & 0 \\ -1 & 1 & 1 & 1 & 1 & 0 \\ 0 & -1 & 1 & 1 & 1 & 1 \\ 0 & 0 & -1 & 1 & 1 & 1 \\ 0 & 0 & 0 & -1 & 1 & 1 \\ 0 & 0 & 0 & 0 & -1 & 1 \end{pmatrix}.$$

   (There are only five non-zero diagonals.)

   Plot the eigenvalues of the matrix in the complex plane, `plot(eig(A), 'r*')`. Superimpose on this plot the eigenvalues of a perturbed matrix, `plot(eig(A+1e-3*randn(32)), 'bx')`. Use a `for` loop to repeat this process for twenty more perturbed matrices. (Use `axis equal` to put the real and imaginary axes on the same scale.)

   Roughly how far do the eigenvalues move, relative to the size of the perturbation? (You can find the size of the perturbation using the `norm` command.)

3. Suppose a desktop computer has 128 MB of memory (1 MB = 1024 KB = 1024^2 bytes). Each of the N^2 entries in a MATLAB full matrix requires 8 bytes.

   How big is the largest matrix that can fit into memory?

   Some PDE discretizations yield matrices with no more than 5 non-zero entries per row.

   What is the largest such *sparse* matrix that will fit into memory?

   (Hint: Use the MATLAB command `whos` to investigate sparse matrix memory use.)

please turn over...

4. Use `help sparse` and `help speye` to describe the difference between the two commands

   ```
   I = sparse(eye(200));
   I = speye(200);
   ```

   N.B. “No difference” is not the right answer!

5. A two-dimensional discretization of the Laplacian operator $\nabla^2 u$ can be constructed using the following code (yielding a matrix of dimension $16^2 = 256$):

```
N = 16;
D = spdiags(ones(N,1)*[-1 4 -1], [-1 0 1], N, N);
L = spdiags(ones(N,1)*(-1), 0, N, N);
A = sparse(N*N, N*N)
for j=1:N,
   A((j-1)*N + (1:N), (j-1)*N + (1:N)) = D;
   if j>1,  A((j-1)*N + (1:N), (j-2)*N + (1:N)) = L; end;
   if j<N,  A((j-1)*N + (1:N), j*N + (1:N)) = L; end;
end
```

How many non-zero entries does this matrix have?