Physics 263: MATLAB Cheatsheet VIII

This sheet summarizes some additional matrix manipulations in MATLAB beyond those described in “MATLAB Cheatsheet VII”.

1. Accessing Matrix Elements

Recall that matrices are specified by entries between [ ]’s with semicolons ; used to separate rows. So

\[
A = \begin{bmatrix}
1 & -2 & 1 \\
2 & -5 & 4 \\
-1 & 3 & -2
\end{bmatrix}
\quad
B = \begin{pmatrix}
3 \\
4 \\
5
\end{pmatrix}
\quad
C = \begin{pmatrix}
3 & 4 & 5
\end{pmatrix}
\]

are entered as

\[
>> A = \begin{bmatrix}
1 & -2 & 1 \\
2 & -5 & 4 \\
-1 & 3 & -2
\end{bmatrix};
\]

\[
>> B = [3; 4; 5];
\]

\[
>> C = [3 4 5];
\]

To get the \(ij\) matrix element of \(A\), use \(A(i,j)\). So

\[
>> A(1,2)
\]

\[
ans = -2
\]

\[
>> A(2,2)
\]

\[
ans = -5
\]

The \(n\)th row is \(A(n,:)\) and the \(m\)th column is \(A(:,m)\). So the 2nd row and 3rd columns are:

\[
>> A(2,:)
\]

\[
ans =
2
-5
4
\]

\[
>> A(:,3)
\]

\[
ans =
1
4
-2
\]

2. More Matrix Operations

a. Exponential of a matrix. The \texttt{expm} function returns the exponential of a matrix, as defined by its Taylor series. So \texttt{expm(A)} gives \(e^A\). [Note: if you use \texttt{exp(A)} by mistake (no \texttt{m} at the end of the name), you’ll get a matrix whose elements are each the exponential of the corresponding matrix element in \(A\).]

b. General matrix functions. To calculate the cosine, sine, or logarithm or a matrix \(A\), use \texttt{funm(A,’cos’)}, \texttt{funm(A,’sin’)}, or \texttt{funm(A,’log’)}.
c. **Trace of a matrix.** The sum of the diagonal matrix element of matrix $A$ is $\text{trace}(A)$.

d. **Adjoint and transpose of a matrix.** The adjoint of matrix $A$ (designated $A^\dagger$), which is the complex conjugate of the transpose, is found from $A'$ or the function $\text{ctranspose}(A)$. If you want just the transpose $A^T$ of $A$ and not the complex conjugate, use $A.'$ or $\text{transpose}(A)$.

e. **Determinant of a matrix.** The $\text{det}$ function returns the determinant of a square matrix. That is, $\text{det}(A)$ gives the determinant of the matrix $A$.

f. **Eigenvalues and eigenvectors of a matrix.** $E = \text{eig}(A)$ gives a vector with the eigenvalues of the matrix $A$. $[V,D] = \text{eig}(A)$ gives a diagonal matrix $D$ of eigenvalues and a matrix $V$ whose columns are the corresponding eigenvectors.

g. **Powers of Matrices.** To get $A^3$, just use $A^3$, and so on.

3. **More Special Matrices**

a. **Random matrices.** Use $\text{rand}(N)$ to generate an $N \times N$ matrix whose entries are random numbers uniformly distributed between 0 and 1. E.g.,

```
>> M = rand(3)
M =
0.1239  0.4238  0.0785
0.7745  0.1592  0.7084
0.1123  0.2949  0.0181
```

The numbers are really “pseudo-random” numbers. See help $\text{rand}$ for more info.

b. **Random complex matrix.** We can combine a real and an imaginary random matrix to get a complex one:

```
>> C = rand(3) + i * rand(3)
C =
0.8189 + 0.3162i  0.2035 + 0.3700i  0.3652 + 0.0847i
0.4283 + 0.5119i  0.5217 + 0.2280i  0.9393 + 0.6571i
0.3677 + 0.3355i  0.6054 + 0.9477i  0.4161 + 0.5234i
```

4. **Timing Matrix Operations**

The functions $\text{tic}$ and $\text{toc}$ can be used to time one or more MATLAB operations (not just matrix functions). A stopwatch is started with $\text{tic}$ and stopped with $\text{toc}$, which then displays the elapsed time. For example, to time how long it takes to calculate the determinant of a $100 \times 100$ matrix:

```
>> M = rand(100);
>> tic; det(M); toc
Elapsed time is 0.130749 seconds.
```