Introduction to MATLAB

Practice Problem Solutions

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1 Basics

1.1 Find 3 different ways to create the vector $x = \begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix}$.

>> x = (1:3)’;
>> x = [1 2 3]’;
>> x = [1;2;3];
>> x = [1
2
3];

1.2 Let $x = \begin{bmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 \end{bmatrix}^T$ and $y = \begin{bmatrix} 171 & 53 \end{bmatrix}$.

(a) Find $A = xy$.

>> x = (1:8)’;
>> y = [171 53];
>> A = x*y

A =

\[
\begin{bmatrix}
171 & 53 \\
342 & 106 \\
513 & 159 \\
684 & 212 \\
855 & 265 \\
1026 & 318 \\
1197 & 371 \\
1368 & 424
\end{bmatrix}
\]
(b) What are the dimensions of $A$? $8 \times 2$
(c) Does $A$ have an inverse? NO
(d) What is the size of $A^T A$? $2 \times 2$
(e) What is the size of $AA^T$? $8 \times 8$
(f) Do $A^T A$ and $AA^T$ have inverses? YES

2 Programming in MATLAB

2.1 Write a function which takes inputs $x$, $a$, $b$, $c$, where $x$ is a vector and $a$, $b$, $c$ are scalars, and returns the values of

$$f(x) = ax^2 + bx + c$$

and

$$f'(x) = 2ax + b.$$

```matlab
function [f,fp] = ffp(x,a,b,c)
    f = a*x.^2+b*x+c;
    fp = 2*a*x+b;
end
```

2.2 Write a script that calls the previous function for 3 different sets of parameters $a$, $b$, $c$, over the range $-1 \leq x \leq 1$.

```matlab
x = linspace(-1,1,101);
[f1,fp1] = ffp(x,1,0,0);
[f2,fp2] = ffp(x,1,4,4);
[f3,fp3] = ffp(x,0,3,1);
```

3 MATLAB Functions

3.1 Create a 300 element column vector where the even entries are 2 and the odd entries are 1.

```matlab
>> x = ones(300,1);
>> x(2:2:300) = 2;
```
3.2 Create a $7 \times 7$ identity matrix and then change the $4^{th}$ column to 

$$
\begin{bmatrix}
1 \\
2 \\
3 \\
4 \\
5 \\
6 \\
7
\end{bmatrix}.
$$

```matlab
>> M = eye(7);
>> M(:,4) = (1:7)';
>> M
```

$$
M = 
\begin{bmatrix}
1 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 1 & 0 & 2 & 0 & 0 & 0 \\
0 & 0 & 1 & 3 & 0 & 0 & 0 \\
0 & 0 & 0 & 4 & 0 & 0 & 0 \\
0 & 0 & 0 & 5 & 1 & 0 & 0 \\
0 & 0 & 0 & 6 & 0 & 1 & 0 \\
0 & 0 & 0 & 7 & 0 & 0 & 1
\end{bmatrix}
$$

3.3 Let $A = 
\begin{bmatrix}
1 & 0 & 1 \\
1 & 1 & 0 \\
0 & 1 & 1
\end{bmatrix}$.

(a) Find $A^{-1}$.

```matlab
>> A = [1 0 1; 1 1 0; 0 1 1];
>> Ainv = inv(A)
```

$$
Ainv = 
\begin{bmatrix}
0.5000 & 0.5000 & -0.5000 \\
-0.5000 & 0.5000 & 0.5000 \\
0.5000 & -0.5000 & 0.5000
\end{bmatrix}
$$
(b) Find $A^{-1}A$ and $AA^{-1}$.

```matlab
>> A*inv
ans =
    1     0     0
    0     1     0
    0     0     1
```

```matlab
>> inv*A
ans =
    1     0     0
    0     1     0
    0     0     1
```

3.4 Write a function which defines the ODE

$$y'' = -y$$

```matlab
function dy = f(t,y)
    M = [ 0 1
          -1 0 ];
dy = M*y;
```

3.5 Write a script to solve the following IVP for times $0 \leq t \leq 2\pi$.  

$$\begin{align*}
y'' &= -y \\
y(0) &= 0 \\
y'(0) &= 1
\end{align*}$$

```matlab
[t,y] = ode45(@f,[0 2*pi],[0;1])
```
4 Other Useful Stuff

4.1 Plot the results from (2.2). Be sure to include a title, axis labels, and a legend.

```matlab
>> plot(t,y(:,1),t,y(:,2))
>> plot(x,f1,x,f2,x,f3)
>> title('Results from Script 1')
>> xlabel('x')
>> ylabel('f')
>> legend('a = 1, b = 0, c = 0','a = 1, b = 4, c = 4','a = 0, b = 3, c = 1')
```

4.2 Plot the results from (3.5). Be sure to include a title, axis labels, and a legend.

```matlab
>> plot(t,y(:,1),t,y(:,2))
>> title('Solution to IVP')
>> xlabel('x')
>> ylabel('y')
>> legend('y(x)','y''(x)')
```
4.3 Save all variables currently in memory.

```matlab
>> save mydata
```

4.4 Clear all variables currently in memory.

```matlab
>> clear
```

4.5 Load the variables from the file you just saved.

```matlab
>> load mydata
```