Matrices in MATLAB

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Vector

- Entering a vector

  The elements of vectors in MATLAB are enclosed by square brackets and are separated by spaces. For example, to enter a row vector, v, type

```
>> v = [1 4 7 10 13]
v =
1 4 7 10 13
```

- semicolon (;) must separate the components of a column vector,

```
>> w = [1;4;7;10;13]
w =
1
4
7
10
13
```

transpose

- The operation is denoted by an apostrophe or a single quote (').

```
>> w = v'
w =
1
4
7
10
13
```

Element of Vector

- v(1) is the first element of vector v, v(2) its second element, and so forth.
- to access *blocks* of elements, we use (:). For example,

```
>> v(1:3)
ans =
1 4 7
```

- Or, all elements from the third through the last elements,

```
>> v(3,end)
ans =
7 10 13
```

- If v is a vector, writing

```
>> v(:)    produces a column vector, whereas writing
>> v(1:end)    produces a row vector.
```

Matrix

- A matrix is an array of numbers. To type a matrix into MATLAB you must
  - begin with a square bracket, [
  - separate elements in a row with spaces or commas (,)
  - use a semicolon (;) to separate rows
  - end the matrix with another square bracket,]

Matrix

```
>> A = [1 2 3; 4 5 6; 7 8 9]
A =
1 2 3
4 5 6
7 8 9

>> A(2,1)
ans =
4
```

Matrix indexing

- We select elements in a matrix just as we did for vectors, but now we need two indices.
- The element of row *i* and column *j* of the matrix A is denoted by A(i,j).

```
>> A(3,3) = 0
A =
1 2 3
4 5 6
7 8 0
```

Colon operator

- The colon operator will prove very useful and understanding how it works is the key to efficient and convenient usage of MATLAB. For example, suppose we want to enter a vector *x* consisting of points

(0; 0.1; 0.2; 0.3; … ; 5)

```
>> x = 0:0.1:5;
```

Colon Operator

A =
1 2 3
4 5 6
7 8 0

- The colon operator can also be used to pick out a certain row or column.

>> A(2,:)
ans =
4 5 6

Null-ing vector

A =
1 2 3
4 5 6
7 8 0

- A row or a column of a matrix can be deleted by setting it to a *null* vector, [ ].

```
>> A(:,2)=[]
ans =
1 3
4 6
7 0
```

Creating a sub-matrix

A =
1 2 3
4 5 6
7 8 0

- To extract a *submatrix* B consisting of rows 2 and 3 and columns 1 and 2 of the matrix A, do the following

```
>> B = A([2 3],[1 2])
B =
4 5
7 8
```

sub-matrix

```
A =
1 2 3
4 5 6
7 8 0

>> C = A([2 1 3],:)
C =
4 5 6
1 2 3
7 8 0
```

```
>> A(:)
ans =
1
2
3
4
5
6
7
8
0
```

Deleting row or column

- To delete a row or column of a matrix, use the *empty vector* operator, [ ].

```
>> A(3,:) = []
A =
1 2 3
4 5 6
>> A = [A(1,:);A(2,:);[7 8 0]]
A =
1 2 3
4 5 6
7 8 0
```

Dimension

- To determine the *dimensions* of a matrix or vector, use the command size. For example,

```
>> size(A)
ans =
3 3
```

- means 3 rows and 3 columns. Or more explicitly with,

```
>> [m,n]=size(A)
```

Transposing a matrix

- The *transpose* operation is denoted by an apostrophe or a single quote (').

```
A =
1 2 3
4 5 6
7 8 0

>> A'
ans =
1 4 7
2 5 8
3 6 0
```

Matrix generators

`eye(m,n)`	Returns an m-by-n matrix with 1 on the main diagonal
`eye(n)`	Returns an n-by-n square identity matrix
`zeros(m,n)`	Returns an m-by-n matrix of zeros
`ones(m,n)`	Returns an m-by-n matrix of ones
`diag(A)`	Extracts the diagonal of matrix A
`rand(m,n)`	Returns an m-by-n matrix of random numbers

Matrix generators

```
>> b=ones(3,1)
b =
1
1
1
>> eye(3)
ans =
1 0 0
0 1 0
0 0 1
```

```
>> c=zeros(2,3)
c =
0 0 0
0 0 0
```

Matrix generators

```
>> D = [C zeros(2); ones(2) eye(2)]
D =
1 2 0 0
3 4 0 0
1 1 1 0
1 1 0 1
```

Matrix arithmetic operations

- A+B or B+A is valid if A and B are of the same size
- A*B is valid if A's number of column equals B's number of rows
- A^2 is valid if A is square and equals A*A
- *K**A or A**K* multiplies each element of A by *K*

Array operations

Operation	Matrix	Array
Addition	+	+
Subtraction	–	–
Multiplication	*	.*
Division	/	./
Left division	\	.\
Exponentiation	^	.^

Array operations

A =
1 2 3
4 5 6
7 8 9
B =
10 20 30
40 50 60
70 80 90

>> C = A.*B
C =
10 40 90
160 250 360
490 640 810
>> A.^2
ans =
1 4 9
16 25 36
49 64 81

linear equations

- $Ax = b$

  $x + 2y + 3z = 1$
  $4x + 5y + 6z = 1$
  $7x + 8y = 1$
- The coe±cient matrix A is

  A =
  1 2 3
  4 5 6
  7 8 0
  b =
  1
  1
  1

linear equations

```
>> A = [1 2 3; 4 5 6; 7 8 0];
>> b = [1; 1; 1];
>> x = inv(A)*b
x =
-1.0000
1.0000
-0.0000
```

Matrix inverse

- Let's consider the same matrix *A*.

  A =

  1 2 3

  4 5 6

  7 8 0

$$A^{-1} = \frac{1}{9}\begin{bmatrix} -16 & 8 & -1 \\ 14 & -7 & 2 \\ -1 & 2 & -1 \end{bmatrix}$$

Matrix inverse

```
>> A = [1 2 3; 4 5 6; 7 8 0];
>> inv(A)
ans =
-1.7778 0.8889 -0.1111
1.5556 -0.7778 0.2222
-0.1111 0.2222 -0.1111
```

Matrix functions

det	Determinant
diag	Diagonal matrices and diagonals of a matrix
eig	Eigenvalues and eigenvectors
inv	Matrix inverse
norm	Matrix and vector norms
rank	Number of linearly independent rows or columns