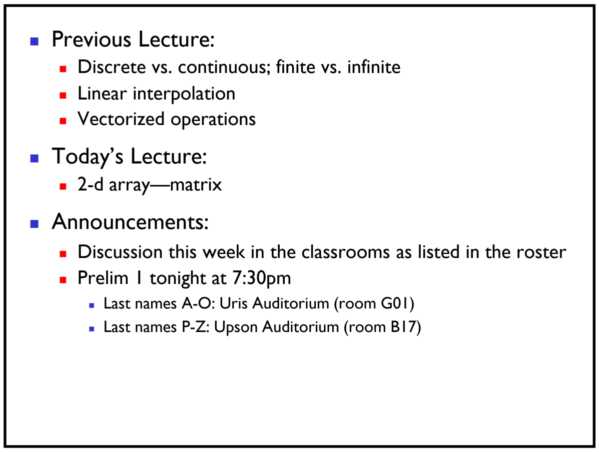
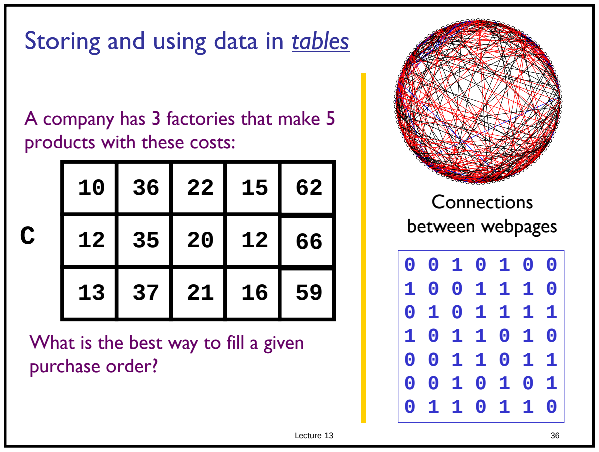


- Previous Lecture:
  - Discrete vs. continuous; finite vs. infinite
  - Linear interpolation
  - Vectorized operations
- Today's Lecture:
  - 2-d array—matrix
- Announcements:
  - Discussion this week in the classrooms as listed in the roster
  - Prelim I tonight at 7:30pm
    - Last names A-O: Uris Auditorium (room G01)
    - Last names P-Z: Upson Auditorium (room B17)



Storing and using data in *tables*

A company has 3 factories that make 5 products with these costs:

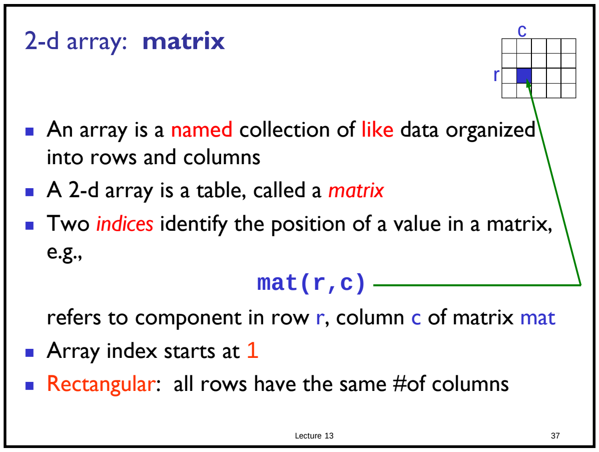
C

10	36	22	15	62
12	35	20	12	66
13	37	21	16	59

What is the best way to fill a given purchase order?

Connections between webpages

0	0	1	0	1	0	0
1	0	0	1	1	1	0
0	1	0	1	1	1	1
1	0	1	1	0	1	0
0	0	1	1	0	1	1
0	0	1	0	1	0	1
0	1	1	0	1	1	0

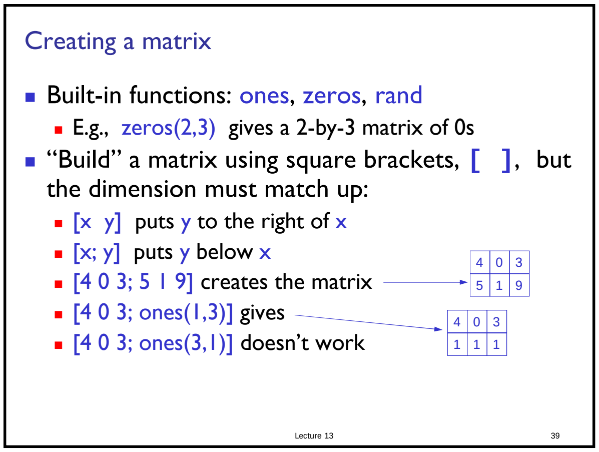


2-d array: **matrix**

- An array is a named collection of like data organized into rows and columns
- A 2-d array is a table, called a *matrix*
- Two *indices* identify the position of a value in a matrix, e.g.,

```
mat(r,c)
```

  refers to component in row r, column c of matrix mat
- Array index starts at 1
- Rectangular: all rows have the same #of columns

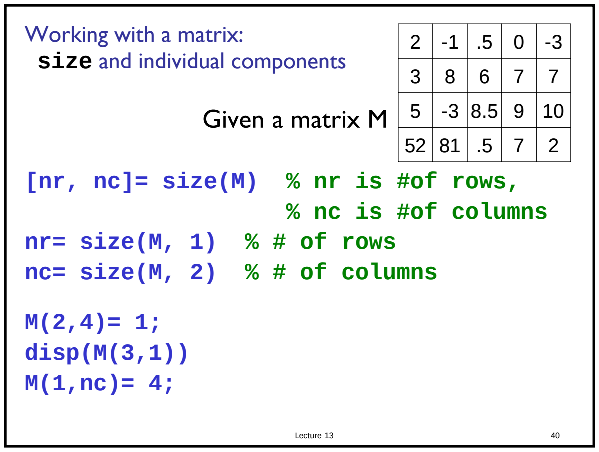


Creating a matrix

- Built-in functions: ones, zeros, rand
  - E.g., zeros(2,3) gives a 2-by-3 matrix of 0s
- "Build" a matrix using square brackets, **[ ]**, but the dimension must match up:
  - [x y] puts y to the right of x
  - [x; y] puts y below x
  - [4 0 3; 5 1 9] creates the matrix
  - [4 0 3; ones(1,3)] gives
  - [4 0 3; ones(3,1)] doesn't work

4	0	3
5	1	9

4	0	3
1	1	1

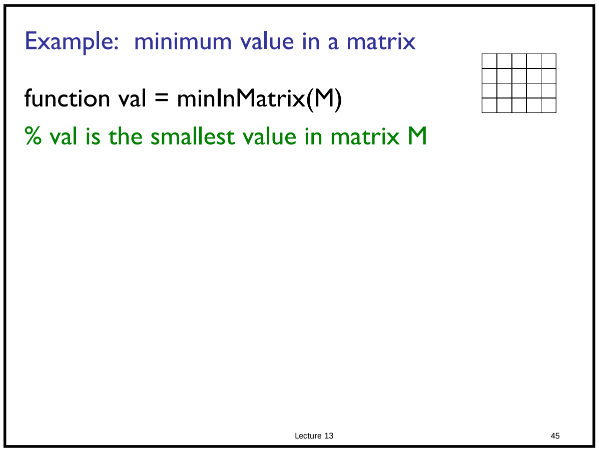


Working with a matrix: **size** and individual components

Given a matrix M

2	-1	.5	0	-3
3	8	6	7	7
5	-3	8.5	9	10
52	81	.5	7	2

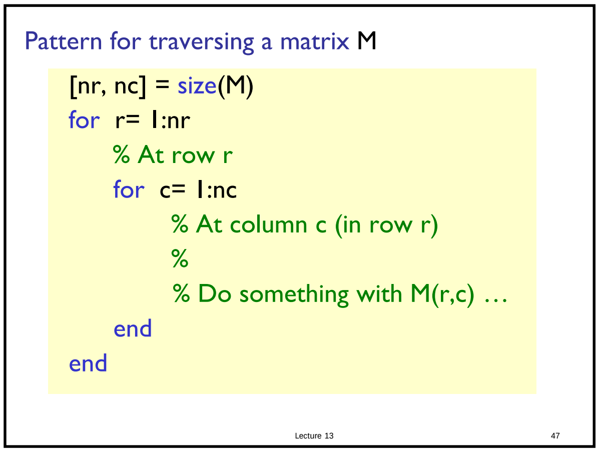
```
[nr, nc]= size(M)  % nr is #of rows,
                   % nc is #of columns
nr= size(M, 1)  % # of rows
nc= size(M, 2)  % # of columns

M(2,4)= 1;
disp(M(3,1))
M(1,nc)= 4;
```



Example: minimum value in a matrix

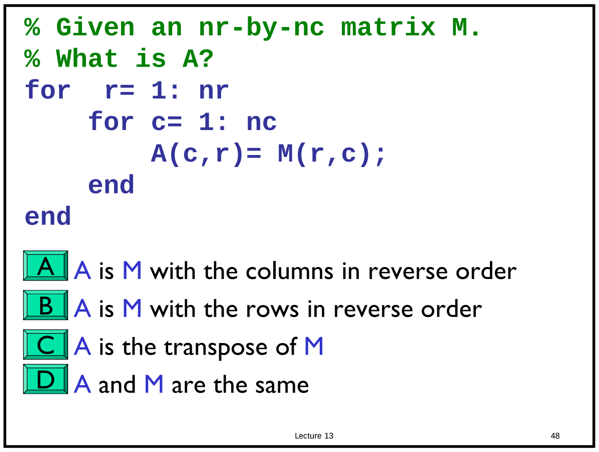
function val = minInMatrix(M)

% val is the smallest value in matrix M



Pattern for traversing a matrix M

```
[nr, nc] = size(M)
for  r= 1:nr
     % At row r
     for  c= 1:nc
            % At column c (in row r)
            %
            % Do something with M(r,c) …
     end
end
```



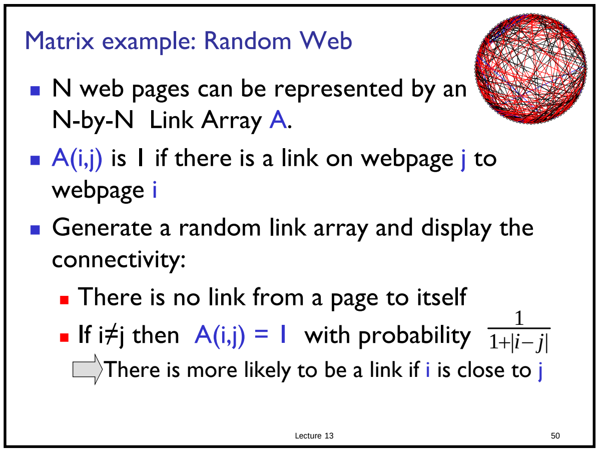
```
% Given an nr-by-nc matrix M.
% What is A?
for  r= 1: nr
    for c= 1: nc
        A(c,r)= M(r,c);
    end
end
```

A A is M with the columns in reverse order

B A is M with the rows in reverse order

C A is the transpose of M

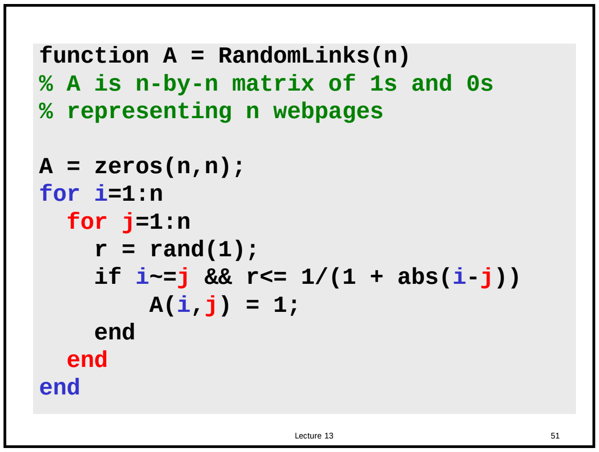
D A and M are the same



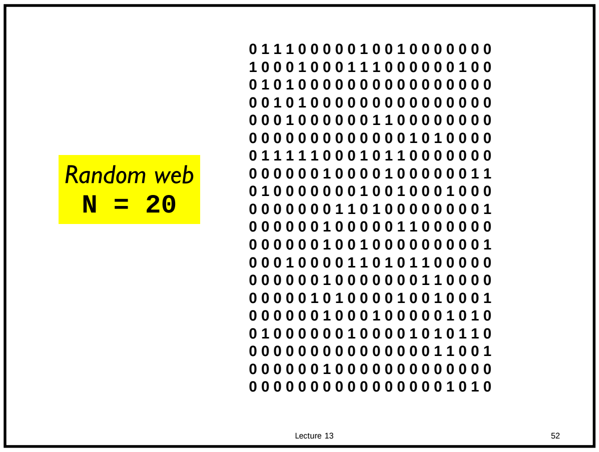
Matrix example: Random Web

- N web pages can be represented by an N-by-N Link Array A.
- A(i,j) is 1 if there is a link on webpage j to webpage i
- Generate a random link array and display the connectivity:
  - There is no link from a page to itself
  - If i≠j then A(i,j) = 1 with probability $\frac{1}{1+|i-j|}$

⇨There is more likely to be a link if i is close to j

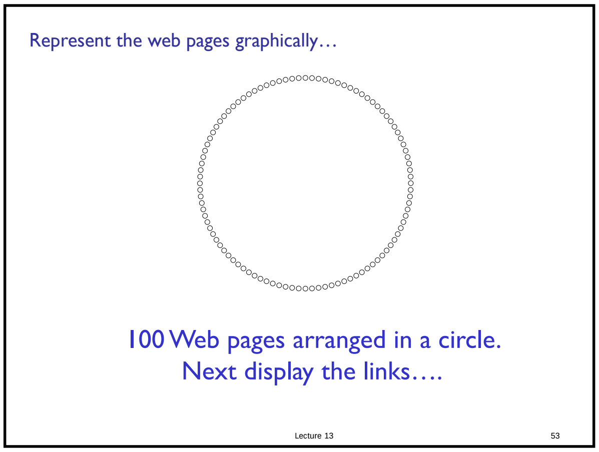


```
function A = RandomLinks(n)
% A is n-by-n matrix of 1s and 0s
% representing n webpages

A = zeros(n,n);
for i=1:n
  for j=1:n
    r = rand(1);
    if i~=j && r<= 1/(1 + abs(i-j))
        A(i,j) = 1;
    end
  end
end
```



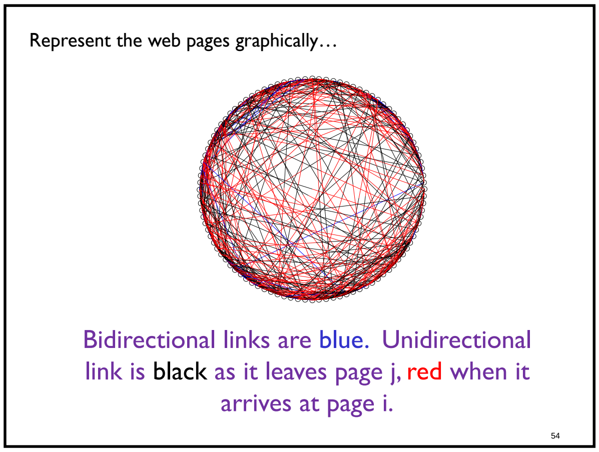
Random web
N = 20

```
0 1 1 1 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0
1 0 0 0 1 0 0 0 1 1 1 0 0 0 0 0 0 1 0 0
0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0
0 1 1 1 1 1 0 0 0 1 0 1 1 0 0 0 0 0 0 0
0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 1 1
0 1 0 0 0 0 0 0 0 1 0 0 1 0 0 0 1 0 0 0
0 0 0 0 0 0 0 1 1 0 1 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0 0 0
0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 1
0 0 0 1 0 0 0 0 1 1 0 1 0 1 1 0 0 0 0 0
0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 1 0 0 0 0
0 0 0 0 0 1 0 1 0 0 0 0 1 0 0 1 0 0 0 1
0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 1 0 1 0
0 1 0 0 0 0 0 0 1 0 0 0 0 1 0 1 0 1 1 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 1
0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0
```



Represent the web pages graphically…

100 Web pages arranged in a circle.
Next display the links….



Represent the web pages graphically…

Bidirectional links are blue. Unidirectional link is black as it leaves page j, red when it arrives at page i.

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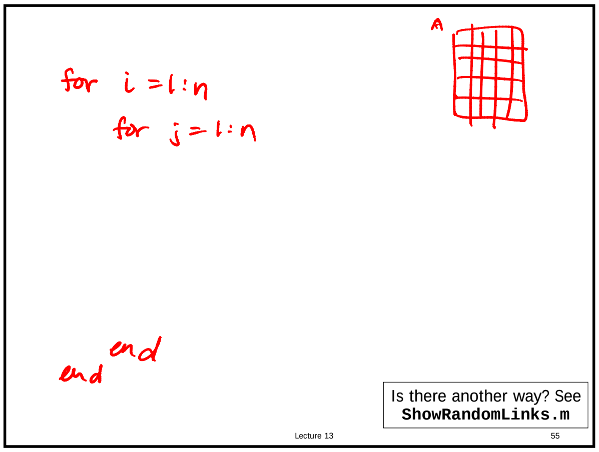

```
for i = 1:n
    for j = 1:n



    end
end
```

Is there another way? See **`ShowRandomLinks.m`**

Lecture 13

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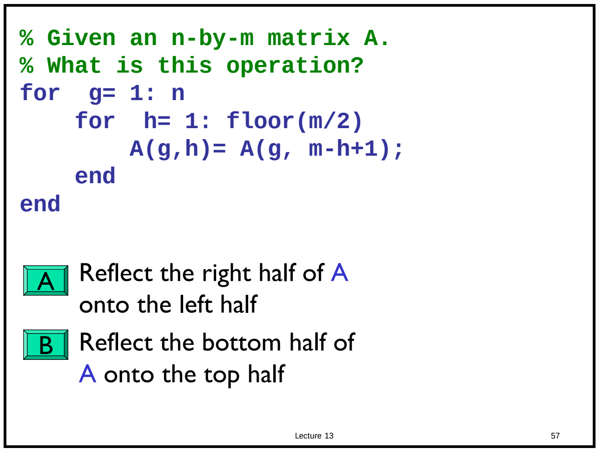

```
% Given an n-by-m matrix A.
% What is this operation?
for  g= 1: n
    for  h= 1: floor(m/2)
        A(g,h)= A(g, m-h+1);
    end
end
```

A Reflect the right half of A onto the left half

B Reflect the bottom half of A onto the top half

Lecture 13

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