- Previous Lecture:
  - 2-d array—matrix
- Today's Lecture:
  - More examples on matrices
  - Optional reading: contour plot (7.2, 7.3 in *Insight*)
- Announcements:
  - Prelim 1 to be returned at end of lecture. Unclaimed papers (and those on which student didn't indicate the lecture time) can be picked up after 5pm today during consulting hours (Su-R 5-10p) at ACCEL Green Rm (Carpenter Hall)
  - Prof. Fan away next week at a conference. *Lectures will be pre-recorded and posted online.* Discussions next week will be held in Upson B7 lab

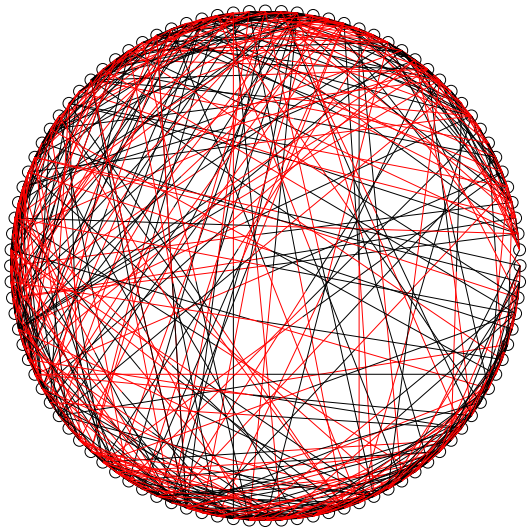
Storing and using data in *tables*

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

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
```

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

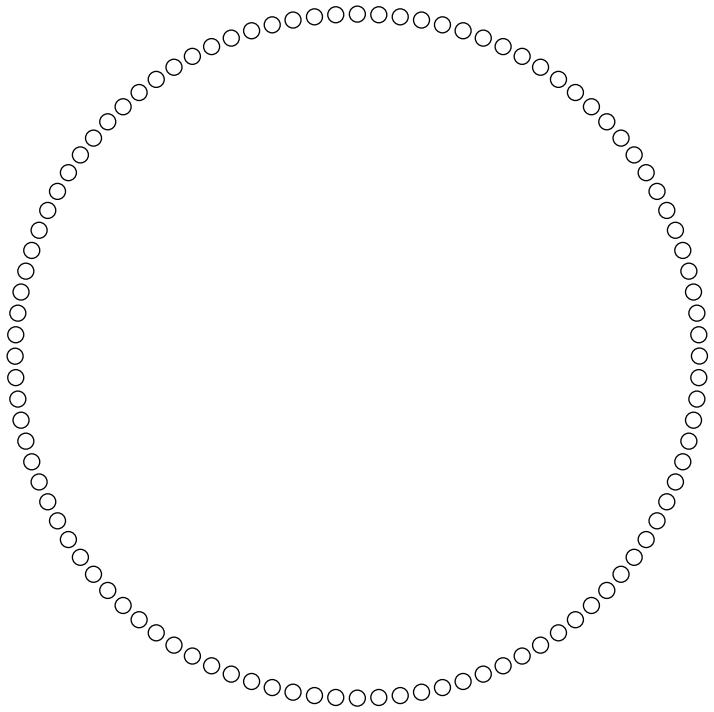
```
function A = RandomLinks(n)
% A is n-by-n matrix of 1s and 0s
% representing n webpages

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 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 0 0 1 0 1 0
```

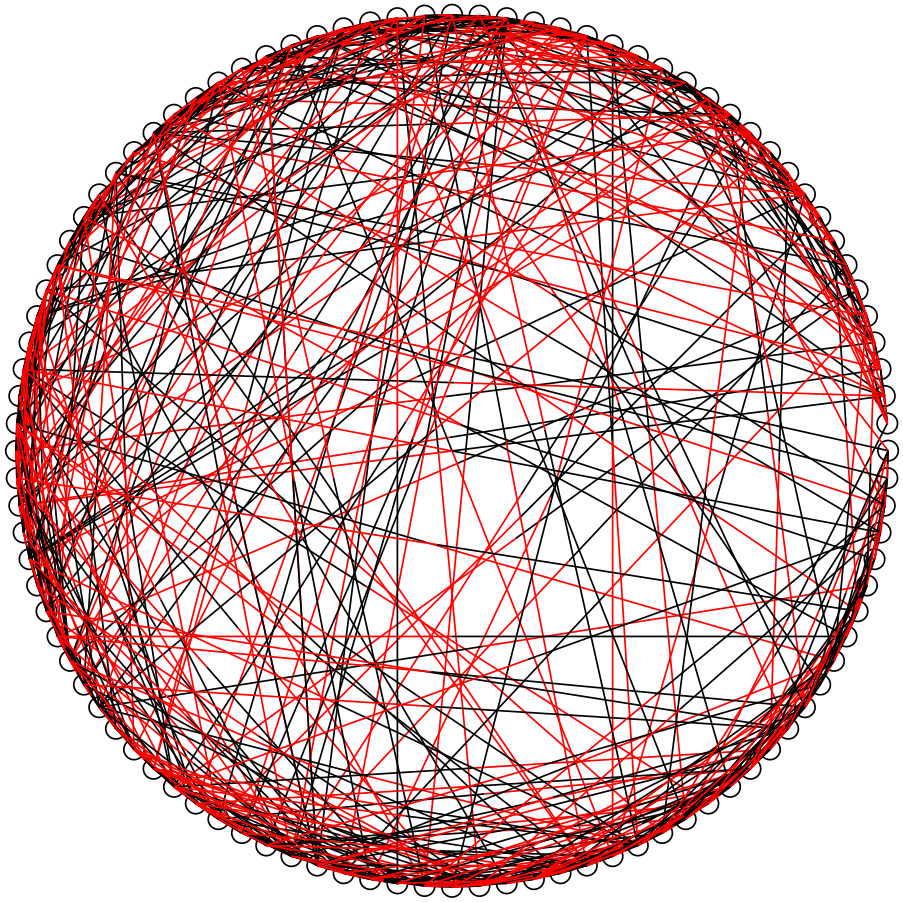
Represent the web pages graphically…



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

Represent the web pages graphically…

See
`ShowRandomLinks.m`



Line black as it leaves page j, red when it arrives at page i

```
% 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

```
% 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
```

M

0	3	2	5
4	13	20	6
11	26	9	1

A Cost/Inventory Problem

- A company has 3 factories that make 5 different products
- The cost of making a product varies from factory to factory
- The inventory/capacity varies from factory to factory

Problems

A customer submits a purchase order that is to be filled by a single factory.

1. How much would it cost a factory to fill the order?
2. Does a factory have enough inventory/capacity to fill the order?
3. Among the factories that can fill the order, who can do it most cheaply?

Cost Array

C

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

The value of `C(i,j)` is what it costs factory i to make product j.

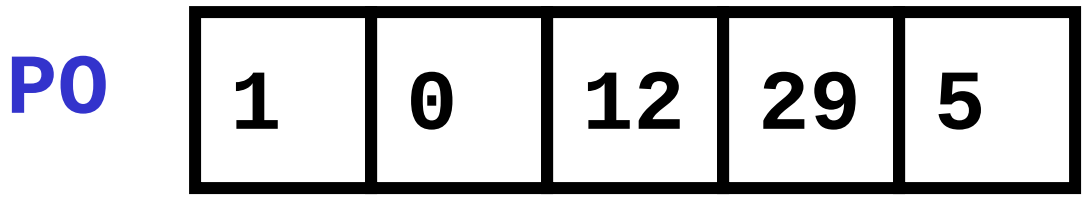
Inventory (or Capacity) Array

Inv

38	5	99	34	42
82	19	83	12	42
51	29	21	56	87

The value of **Inv(i,j)** is the inventory in factory i of product j.

Purchase Order



The value of `PO(j)` is the number of product j's that the customer wants

C

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

P0

1	0	12	29	5

Cost for factory 1:

1*10 + 0*36 + 12*22 + 29* 15 + 5*62

C

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

PO

1	0	12	29	5

Cost for factory 1:

```
s = 0;  %Sum of cost
for j=1:5
   s = s + C(1,j)*PO(j)
end
```

C

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

PO

1	0	12	29	5

Cost for factory 2:

```
s = 0;  %Sum of cost
for j=1:5
   s = s + C(2,j)*PO(j)
end
```

C

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

PO

1	0	12	29	5

Cost for factory i:

```
s = 0;  %Sum of cost
for j=1:5
   s = s + C(i,j)*PO(j)
end
```

Encapsulate…

```
function  TheBill = iCost(i,C,PO)
% The cost when factory i fills the
% purchase order

nProd = length(PO);
TheBill = 0;
for j=1:nProd
   TheBill = TheBill + C(i,j)*PO(j);
end
```

Finding the Cheapest

```
iBest = 0;  minBill = inf;
for i=1:nFact
    iBill = iCost(i,C,PO);
    if iBill < minBill
        % Found an Improvement
        iBest = i; minBill = iBill;
    end
end
```

`inf` – a special value that can be regarded as positive infinity

`x = 10/0`	assigns `inf` to `x`
`y = 1+x`	assigns `inf` to `y`
`z = 1/x`	assigns `0` to `z`
`w < inf`	is always true if `w` is numeric

Inventory/Capacity Considerations

What if a factory lacks the inventory/capacity to fill the purchase order?

Such a factory should be excluded from the find-the-cheapest computation.

Who Can Fill the Order?

Inv

38	5	99	34	42	Yes
82	19	83	12	42	No
51	29	21	56	87	Yes

PO

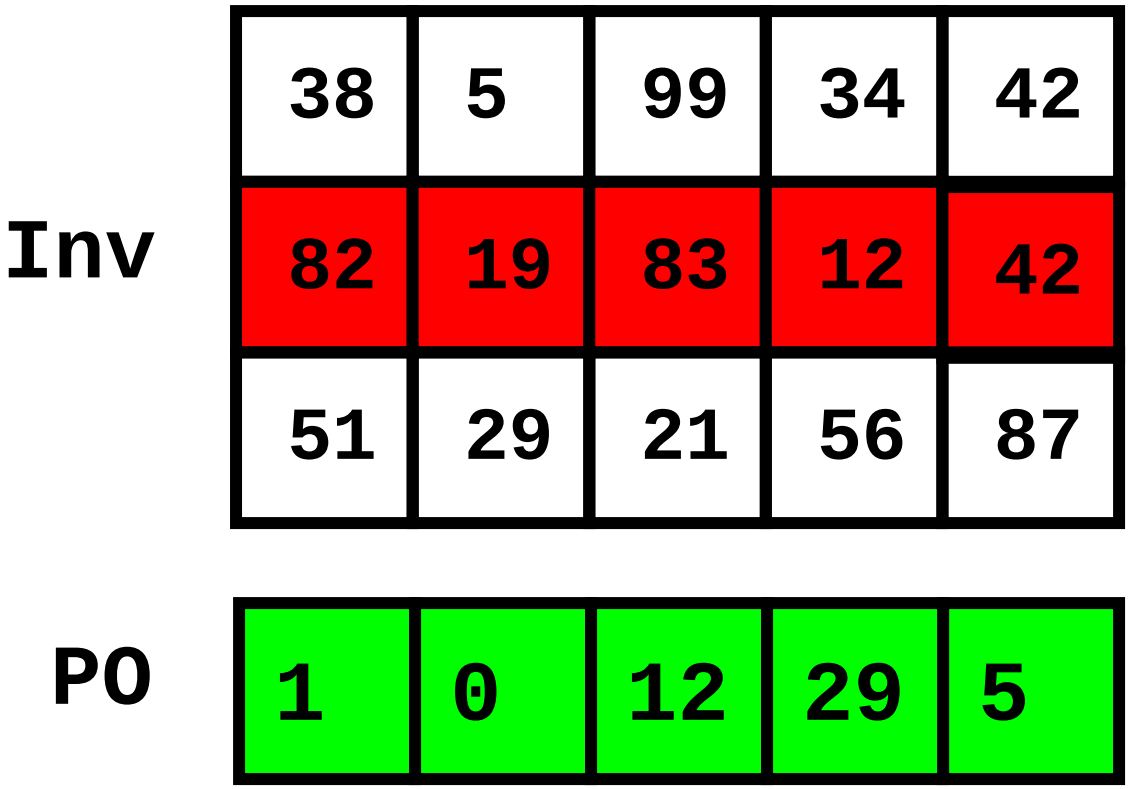
1	0	12	29	5

Wanted: A True/False Function

DO is "true" if factory i can fill the order.

DO is "false" if factory i cannot fill the order.

Example: Check inventory of factory 2



Method 1: check the inventory for every product

Initialization

Inv

38	5	99	34	42
82	19	83	12	42
51	29	21	56	87

DO 1

PO

1	0	12	29	5

Still True…

Inv

38	5	99	34	42
82	19	83	12	42
51	29	21	56	87

DO 1

PO

1	0	12	29	5

```
DO = DO && ( Inv(2,1) >= PO(1) )
```

Still True…

Inv

38	5	99	34	42
82	19	83	12	42
51	29	21	56	87

DO 1

PO

1	0	12	29	5

```
DO = DO && ( Inv(2,2) >= PO(2) )
```

Still True…

Inv

38	5	99	34	42
82	19	83	12	42
51	29	21	56	87

DO 1

PO

1	0	12	29	5

```
DO = DO && ( Inv(2,3) >= PO(3) )
```

No Longer True…

Inv

38	5	99	34	42
82	19	83	12	42
51	29	21	56	87

DO 0

PO

1	0	12	29	5

```
DO = DO && ( Inv(2,4) >= PO(4) )
```

Stay False…

Inv

38	5	99	34	42
82	19	83	12	42
51	29	21	56	87

DO 0

PO

1	0	12	29	5

```
DO = DO && ( Inv(2,5) >= PO(5) )
```

Encapsulate…

```
function  DO = iCanDo(i,Inv,PO)
% DO is true if factory i can fill
% the purchase order. Otherwise, false

nProd = length(PO);
DO = 1;
for j = 1:nProd
     DO = DO && ( Inv(i,j) >= PO(j) );
end
```

Encapsulate…

```
function  DO = iCanDo(i,Inv,PO)
% DO is true if factory i can fill
% the purchase order. Otherwise, false
nProd = length(PO);
j = 1;
while j<=nProd && Inv(i,j)>=PO(j)
   j = j+1;
end
DO = ________;
```

Encapsulate…

```
function  DO = iCanDo(i,Inv,PO)
% DO is true if factory i can fill
% the purchase order. Otherwise, false
nProd = length(PO);
j = 1;
while j<=nProd && Inv(i,j)>=PO(j)
    j = j+1;
end
DO = ___________;
```

DO should be true when…

A `j < nProd`

B `j == nProd`

C `j > nProd`

Encapsulate…

```
function  DO = iCanDo(i,Inv,PO)
% DO is true if factory i can fill
% the purchase order. Otherwise, false
nProd = length(PO);
j = 1;
while j<=nProd && Inv(i,j)>=PO(j)
   j = j+1;
end
DO = (j>nProd);
```

Back To Finding the Cheapest

```
iBest = 0; minBill = inf;
for i=1:nFact
    iBill = iCost(i,C,PO);
    if iBill < minBill
        % Found an Improvement
        iBest = i; minBill = iBill;
    end
end
```

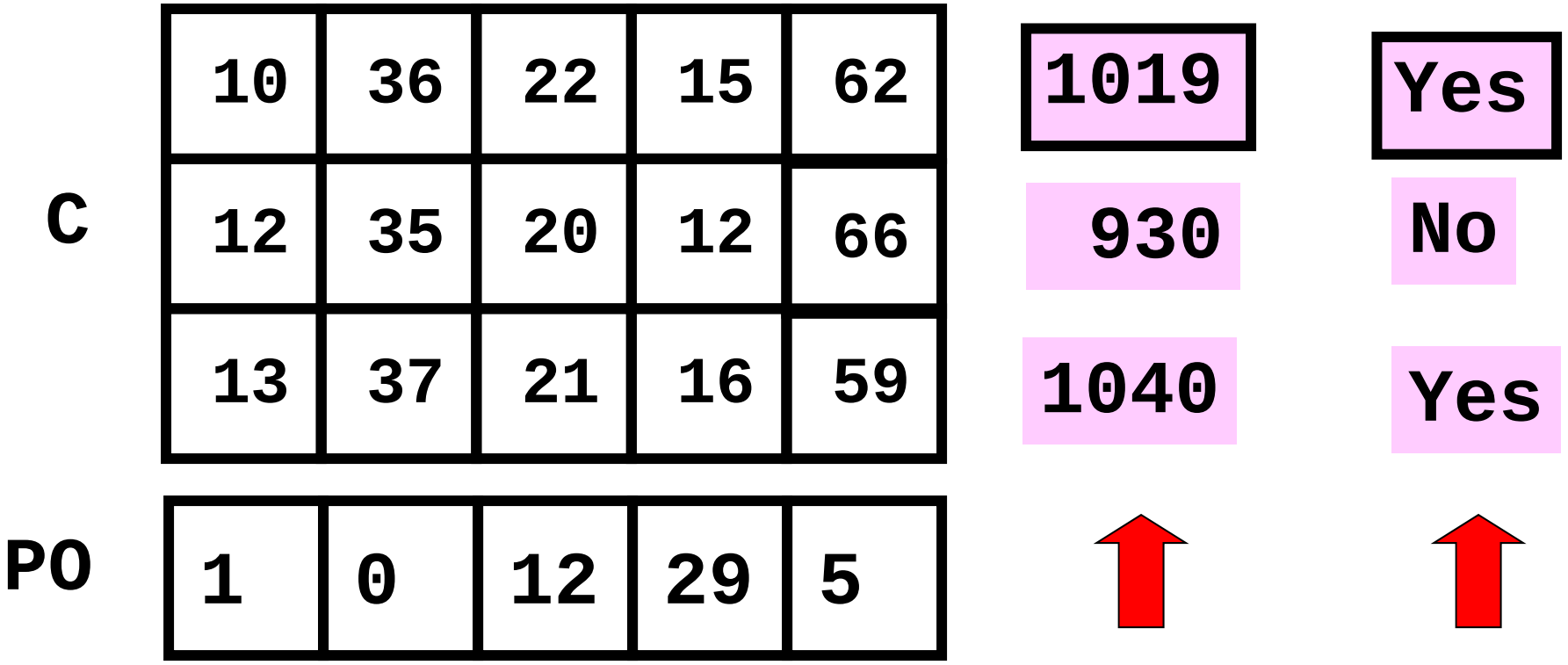
Don't bother with this unless there is sufficient inventory.

Back To Finding the Cheapest

```
iBest = 0; minBill = inf;
for i=1:nFact
    if iCanDo(i,Inv,PO)
        iBill = iCost(i,C,PO);
        if iBill < minBill
        % Found an Improvement
            iBest = i; minBill = iBill;
        end
    end
end
```

See **Cheapest.m**
for alternative implementation

Finding the Cheapest



Prelim 1

Median 86
Mean 82.0; Std. Dev. 14.6
Max 100 (×2)

- Q1: Program trace (nested loops) & functior
- Q2: if-construct; boolean expressions; creating vectors (colon expression) ☺
- Q3: function and function call, random numbers, if-construct, ☺☺
- Q4: nested loops; decomposing a problem and looking for patterns ☺☹
- Q5: while-loop (indefinite iteration), multiple stopping conditions, setting and keeping counters 😐☹

```
if score>80
    celebrate, look up solutions and learn from mistakes
elseif score>60
    re-do the open questions that you got wrong first; then read solutions
else
    see course staff one-on-one to re-do the questions; avoid the solutions!
end
```

If your paper isn't here, pick it up from Matlab consultants in ACCEL Green Rm during consulting hrs (starting today at 5pm)