- Previous Lecture:
  - 2-d array—matrix
- Today's Lecture:
  - More examples on matrices
  - Optional reading: contour plot (7.2, 7.3 in *Insight*)
- Announcement:
  - Review your prelim and **re-do** the questions on which you didn't do well, perhaps with the help of a member of the course staff. Do not just read the solutions!

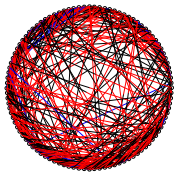
Storing and using data in *tables*

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
```


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

PO

1	0	12	29	5

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

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

Inv	38	5	99	34	42
	82	19	83	12	42
	51	29	21	56	87
PO	1	0	12	29	5

Method 1: check the inventory for every product

Still True…

Inv	38	5	99	34	42
	82	19	83	12	42
	51	29	21	56	87
PO	1	0	12	29	5

DO 1

```
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
PO	1	0	12	29	5

DO 1

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

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 = _________;
```

DO should be true when…

A `j < nProd`

B `j == nProd`

C `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

C	10	36	22	15	62	1019	Yes
	12	35	20	12	66	930	No
	13	37	21	16	59	1040	Yes
PO	1	0	12	29	5	↑	↑

As computed by **iCost**

As computed by **iCanDo**

Initialize vectors/matrices if dimensions are known

…instead of "building" the array one component at a time

```
% Initialize y
x=linspace(a,b,n);
y=zeros(1,n);
for k=1:n
   y(k)=myF(x(k));
end
```

```
% Build y on the fly
x=linspace(a,b,n);

for k=1:n
   y(k)=myF(x(k));
end
```

Much faster for large n!

Concatenating 2 vectors—copy 2 vectors into a new one

```
% given row vectors x and y
v= zeros(1,length(x)+length(y));
for k=1:length(x)
   v(k)= x(k);
end
for k=1:length(y)
   v(length(x)+k)= y(k);
end
```

This is **non-vectorized code**—operations are performed on one component (scalar) at a time

Concatenating 2 vectors—copy 2 vectors into a new one

```
% given row vectors x and y
v= zeros(1,length(x)+length(y));
for k=1:length(x)
   v(k)= x(k);
end
for k=1:length(y)
   v(length(x)+k)= y(k);
end
```

Below is **vectorized code**—ops are performed on multiple components (a vector) at the same time:

```
v = [x y];
```


Split a vector in 2—copy values into 2 vectors

```
% given row vector v
s= ceil(rand*length(v));  % split pt
x= zeros(1,s);
y= zeros(1,length(v)-s);
for k=1:s
   x(k)= v(k);
end
for k=1:length(y)
   y(k)= v(s+k);
end
```

This is **non-vectorized code**—operations are performed on one component (scalar) at a time

Accessing a submatrix

M

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

- `M` refers to the whole matrix
- `M(3,5)` refers to one component of `M`

Accessing a submatrix

M

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

- `M` refers to the whole matrix
- `M(3,5)` refers to one component of `M`
- `M(2:3,3:5)` refers to a submatrix of `M`

row indices

column indices

Split a vector in 2—copy values into 2 vectors

```
% given row vector v
s= ceil(rand*length(v));  % split pt
x= zeros(1,s);
y= zeros(1,length(v)-s);
for k=1:s
   x(k)= v(k);
end
for k=1:length(y)
   y(k)= v(s+k);
end
```

Below is **vectorized code**: multiple components (subvectors) are accessed at the same time:

```
x= v(1:s);
y= v(s+1:length(v));
```