- Previous Lecture:
  - 2-d array—matrix
- Today's Lecture:
  - More examples on matrices
  - Contour plot (see 7.2, 7.3 in *Insight*)
- Announcements:
  - Project 3 due tonight at 11pm
  - See website for announcement on review session
  - Prelim 2 on Thurs, Oct 21st, 7:30-9pm. Email Randy Hess (rbhess@cs.cornell.edu) NOW if you have an exam conflict

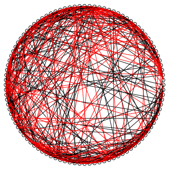
## Storing and using data in *tables*

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 |

```
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
```

## 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?

C

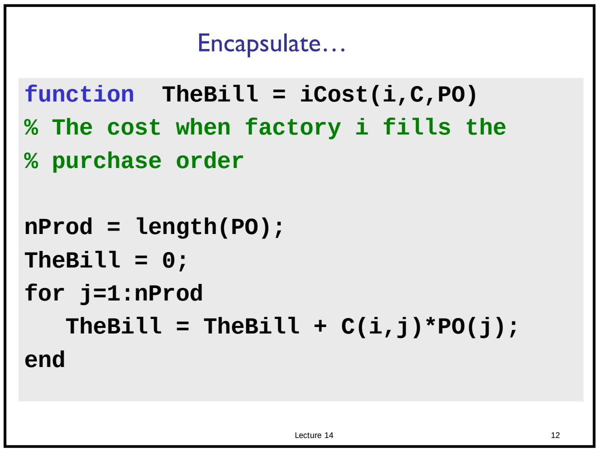
| | | | | |
|---|---|---|---|---|
| 10 | 36 | 22 | 15 | 62 |
| 12 | 35 | 20 | 12 | 66 |
| 13 | 37 | 21 | 16 | 59 |

PO

| | | | | |
|---|---|---|---|---|
| 1 | 0 | 12 | 29 | 5 |

Cost for factory i:

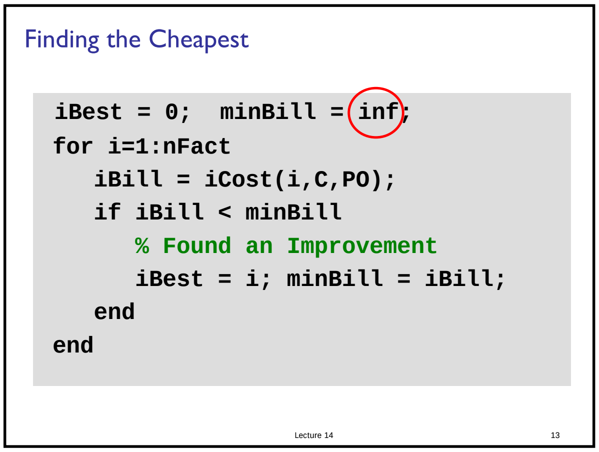
```
s = 0;  %Sum of cost
for j=1:5
  s = s + C(i,j)*PO(j)
end
```



## Encapsulate…

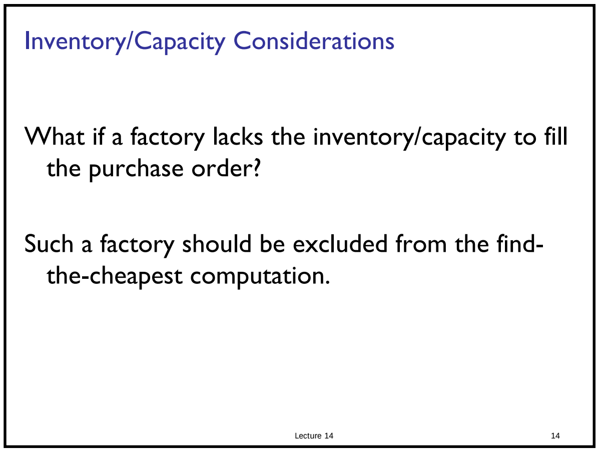
```
function  TheBill = iCost(i,C,PO)
% The cost when factory i fills the
% purchase order

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



## Finding the Cheapest

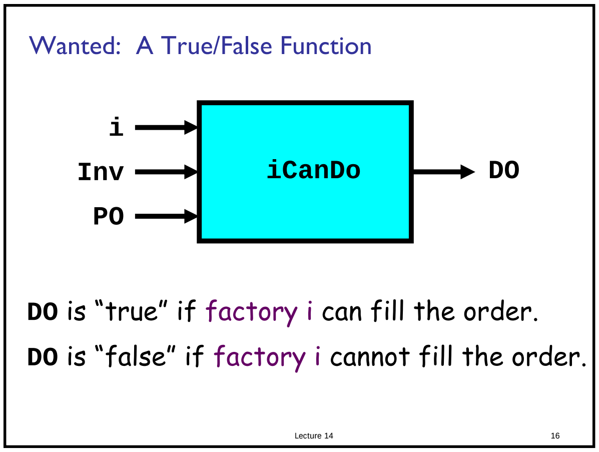
```
iBest = 0;  minBill = inf;
for i=1:nFact
   iBill = iCost(i,C,PO);
   if iBill < minBill
      % Found an Improvement
      iBest = i; minBill = iBill;
   end
end
```



## Inventory/Capacity Considerations

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

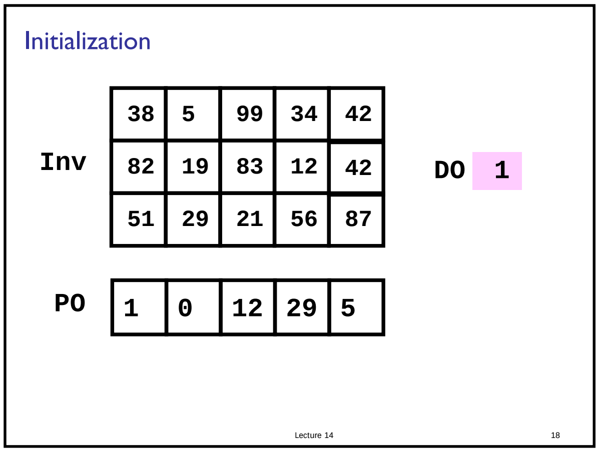
Such a factory should be excluded from the find-the-cheapest computation.



## 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.



## Initialization

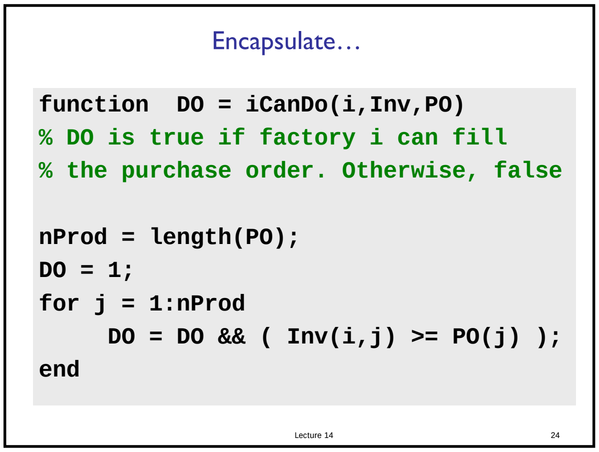
Inv

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

PO

| | | | | |
|---|---|---|---|---|
| 1 | 0 | 12 | 29 | 5 |

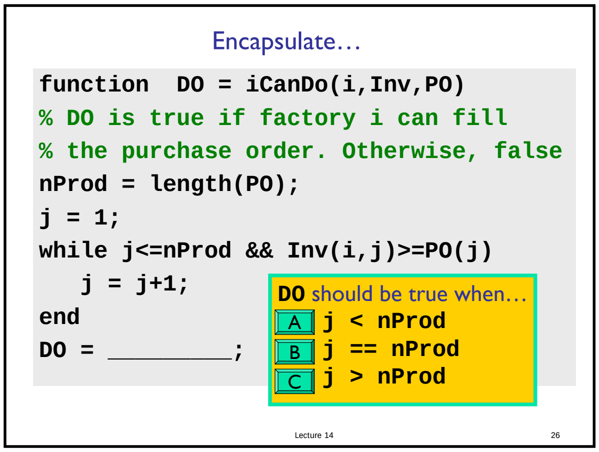
DO 1



## 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…

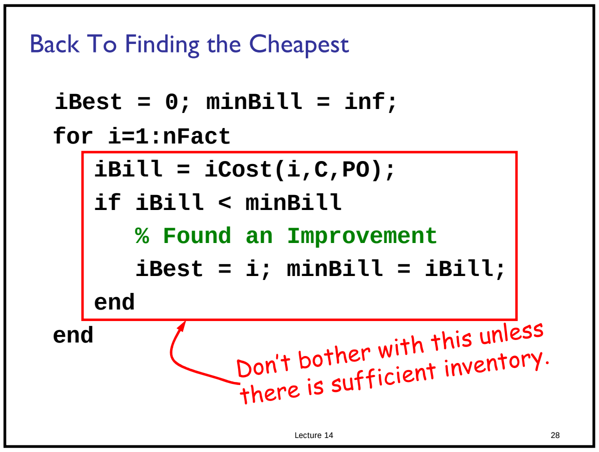
```
function  DO = iCanDo(i,Inv,PO)
% DO is true if factory i can fill
% the purchase order. Otherwise, false
nProd = length(PO);
j = 1;
while j<=nProd && Inv(i,j)>=PO(j)
   j = j+1;
end
DO = _________;
```

DO should be true when…

A `j < nProd`

B `j == nProd`

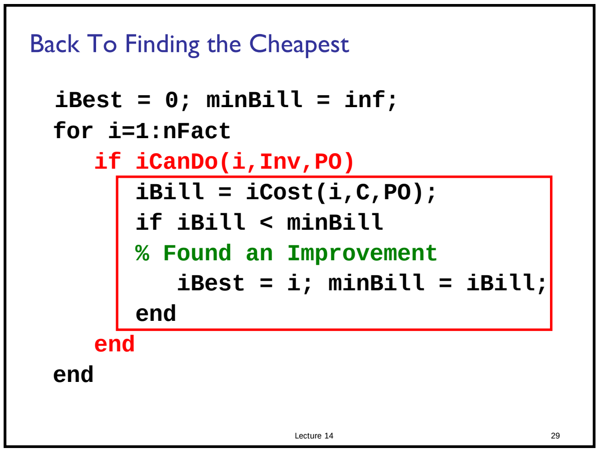
C `j > nProd`



## Back To Finding the Cheapest

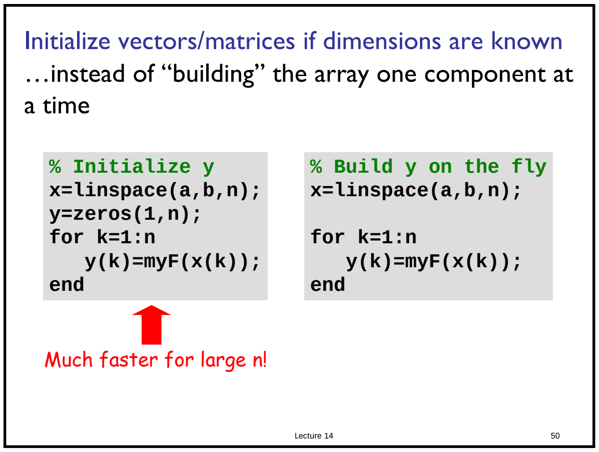
```
iBest = 0; minBill = inf;
for i=1:nFact
   iBill = iCost(i,C,PO);
   if iBill < minBill
      % Found an Improvement
      iBest = i; minBill = iBill;
   end
end
```

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
```



## Initialize vectors/matrices if dimensions are known

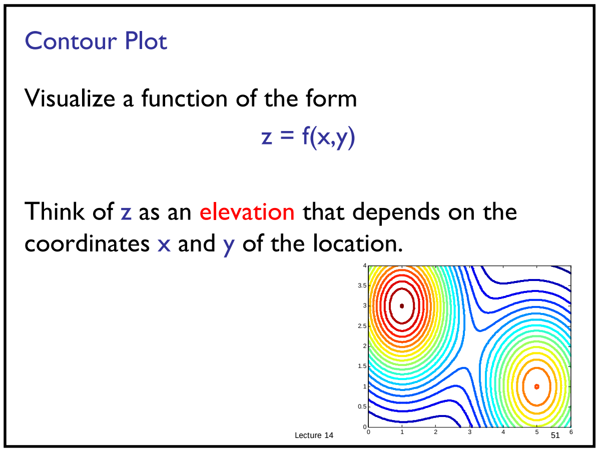
…instead of “building” the array one component at a time

```
% 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!



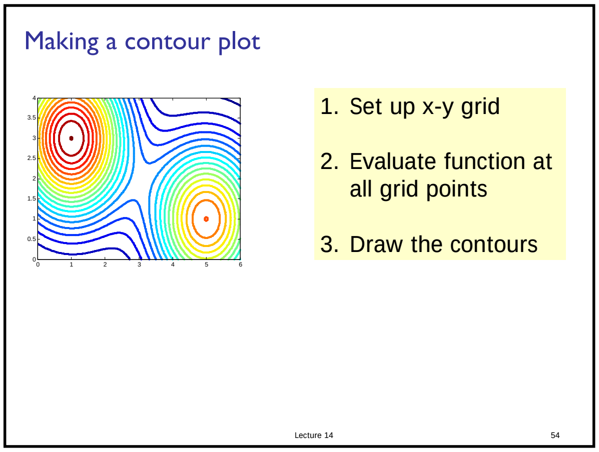
## Contour Plot

Visualize a function of the form

z = f(x,y)

Think of z as an elevation that depends on the coordinates x and y of the location.

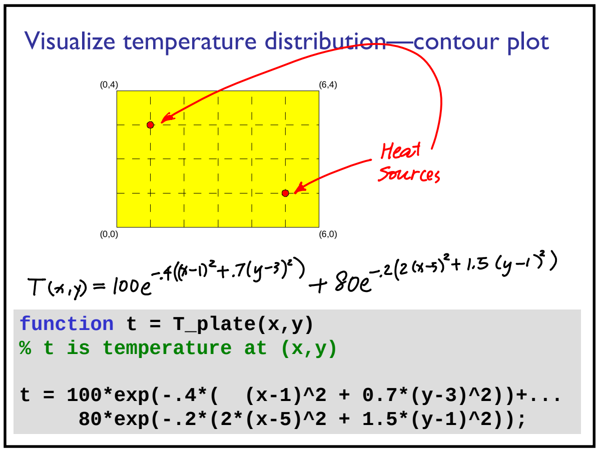
4
3.5
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6



## Making a contour plot

1. Set up x-y grid
2. Evaluate function at all grid points
3. Draw the contours

4
3.5
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6



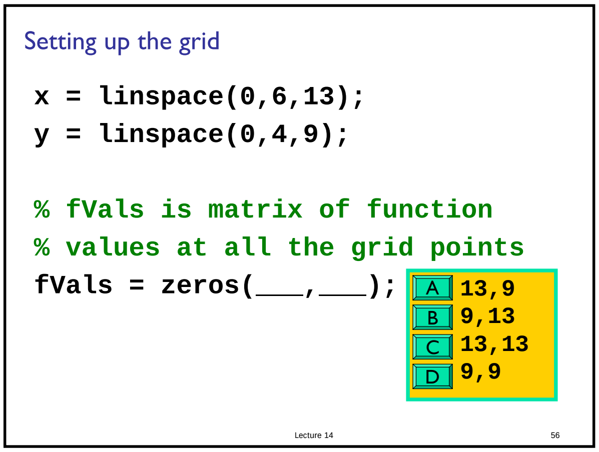
## Visualize temperature distribution—contour plot

(0,4)
(6,4)
(0,0)
(6,0)
Heat Sources

$$T(x,y) = 100e^{-.4((x-1)^2+.7(y-3)^2)} + 80e^{-.2(2(x-5)^2+1.5(y-1)^2)}$$

```
function t = T_plate(x,y)
% t is temperature at (x,y)

t = 100*exp(-.4*(  (x-1)^2 + 0.7*(y-3)^2))+...
     80*exp(-.2*(2*(x-5)^2 + 1.5*(y-1)^2));
```

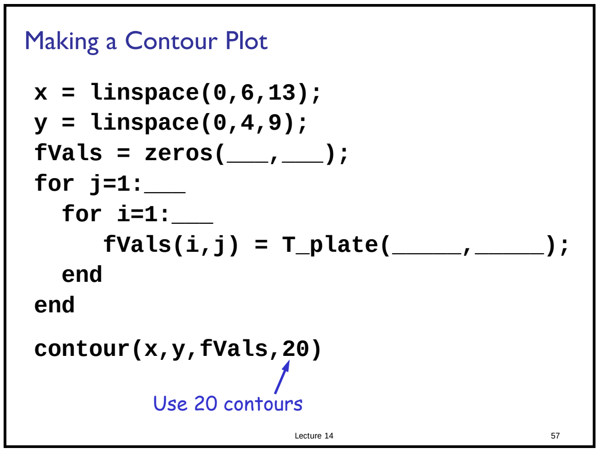


## Setting up the grid

```
x = linspace(0,6,13);
y = linspace(0,4,9);

% fVals is matrix of function
% values at all the grid points
fVals = zeros(___,___);
```

A 13,9
B 9,13
C 13,13
D 9,9

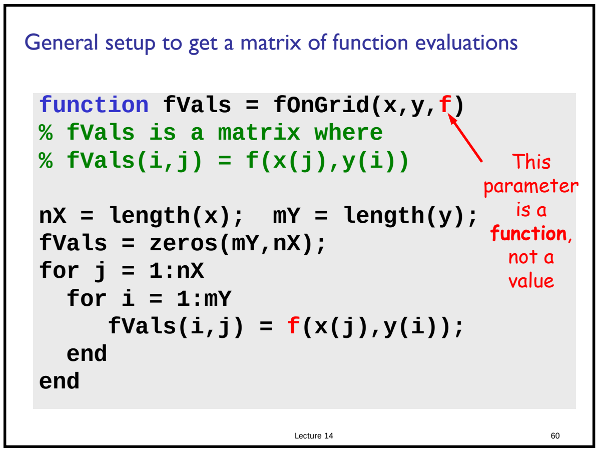


## Making a Contour Plot

```
x = linspace(0,6,13);
y = linspace(0,4,9);
fVals = zeros(___,___);
for j=1:___
  for i=1:___
     fVals(i,j) = T_plate(_____,_____);
  end
end

contour(x,y,fVals,20)
```

Use 20 contours

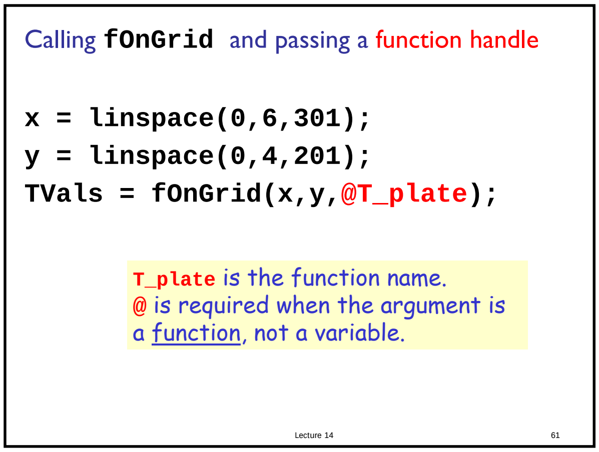


## General setup to get a matrix of function evaluations

```
function fVals = fOnGrid(x,y,f)
% fVals is a matrix where
% fVals(i,j) = f(x(j),y(i))

nX = length(x);  mY = length(y);
fVals = zeros(mY,nX);
for j = 1:nX
  for i = 1:mY
     fVals(i,j) = f(x(j),y(i));
  end
end
```

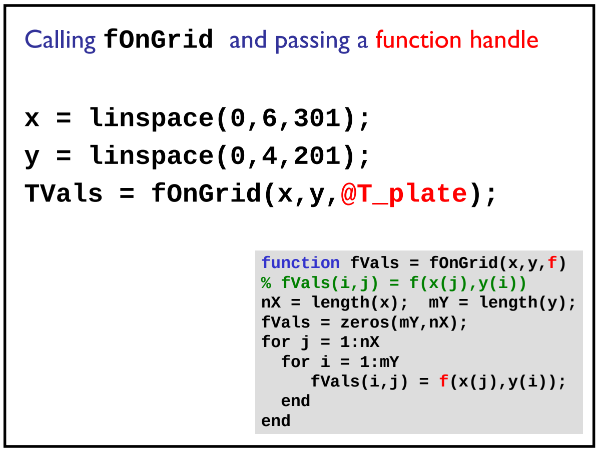
This parameter is a **function**, not a value



## Calling fOnGrid and passing a function handle

```
x = linspace(0,6,301);
y = linspace(0,4,201);
TVals = fOnGrid(x,y,@T_plate);
```

T_plate is the function name.
@ is required when the argument is a function, not a variable.



## Calling fOnGrid and passing a function handle

```
x = linspace(0,6,301);
y = linspace(0,4,201);
TVals = fOnGrid(x,y,@T_plate);
```

```
function fVals = fOnGrid(x,y,f)
% fVals(i,j) = f(x(j),y(i))
nX = length(x);  mY = length(y);
fVals = zeros(mY,nX);
for j = 1:nX
  for i = 1:mY
     fVals(i,j) = f(x(j),y(i));
  end
end
```