Boolean algebra, conditional statements, loops.

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Lecture 03

Notes

Boolean algebra

Variable of boolean type can have only two values

- true
- false

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$$\neg\text{true} = \text{false}$$
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$$A \wedge B = \begin{cases} \text{true, if A=true and B=true,} \\ \text{false, otherwise} \end{cases}$$

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- ∨ - logic **or**, Matlab `|`

$$A \vee B = \begin{cases} \text{false, if A=false and B=false,} \\ \text{true, otherwise} \end{cases}$$

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Boolean operators precedence in Matlab

If $A = false$, $B = true$, $C = true$

$$A|{\sim}B\&C$$

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Boolean logic examples

There is an island, which is populated by two kind of people: liars and truthlovers.

- Liars always lie and never speak a word of truth.
- Truthlovers always speak only truth.

Suppose, you are landed on this island and met a person. What will be the answer to your question "Who are you?"

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Now you see a person who answers to your question. "I am a liar."
Is it possible?

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Now you see a person who answers to your question. "I am a liar."
Is it possible?

- This makes a paradox and should not ever happen on this island.

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Matlab boolean logic examples

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- `~ 1232e-6 =`

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>> B=[1.22312, 0; 34.343, 12]
B =
1.2231     0
34.3430   12.0000
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"To be or not to be"
The answer is to be

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ans =
1      1
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>> B=[1.22312, 0; 34.343, 12]
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>> A=[56, 655; 0, 24.4]
A =
56.0000   655.0000
0         24.4000
```


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Comparison operators

Math	Matlab
$=$	== double equal sign!
$\neq$	~=
$<$	<
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```
x >= 3
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% choose such 'x' where x>=3
x(x >= 3)
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         3    4    5
```

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Comparison with matrices

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>> A=[1,2;3,4]
A =
1      2
3      4
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```
>> B=[33,11;53,42]
B =
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A(A>=2)
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B(A>=2)
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Choose such elements of B where elements of A≥2

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Choose such elements of B where elements of A≥2

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ans =
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if-else-end statement

`if` *expression*
this part is executed only if *expression* is true
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`if` *hungry*
buy some food
`else`
keep working
`end`

Notes

if-else-end statement

```
if expression
this part is executed
only if expression is
true
else
this part is executed
only if expression is
false
end
```

```
if hungry
buy some food
else
keep working
end
```

```
if (x>=0)
  y=sqrt(x);
else
  error('cannot do');
end
```


Notes

Common mistake in the 'if' statement

```
if (x=y)
  D=4;
  Z=45;
  C=12;
else
  D=2;
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someone used assignment operator (=) instead of comparison (==)

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Short form of 'if-end' statement

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```
if (deviation<=0)
  exit;
end
```


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The 'while' statement

`while` *expression*
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```
i=1;
while (i<=10)
  c=a+b;
  z=c*4+5;
  i=i+2;
end
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`while` loop is extremely useful but they are not guaranteed to finish. For a bit more complicated conditional statement and loop it is impossible to predict if the loop will finish.

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Yet another common mistake is

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not updating the term leading to fulfillment of the while condition

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for variable = *expression*
do something
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In this case variable is assigned consequently with columns of the *expression*, and then statements inside of the loop are executed

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sum=0;
x=[1,3,5,6]
for v=x
  sum=sum+v;
end
```

```
>> sum
sum =
  15
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The 'for' statement

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for loops are guaranteed to complete after predictable number of iterations (the amount of columns in *expression*).

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Example

$$S = \sum_{i=1}^{100} i = 1 + 2 + 3 + 4 + \cdots + 99 + 100$$

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```
S=0; i=1;
while(i<=100)
  S=S+i;
  i=i+1;
end
```


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Example

$$S = \sum_{i=1}^{100} i = 1 + 2 + 3 + 4 + \cdots + 99 + 100$$

```
S=0; i=1;
while(i<=100)
  S=S+i;
  i=i+1;
end
```

```
S=0;
for i=1:100
  S=S+i;
end
```


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Example

$$S = \sum_{k=1} a_k$$

While k<=100 and $a_k \geq 10^{-5}$, where $a_k = k^{-k}$.

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S=0; k=1;
while( (k<=100) & (k^-k >= 1e-5) )
  S=S+k^-k;
  k=k+1;
end
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```
S=0; k=1;
while( k<=100 )
  a_k=k^-k;
  if (a_k < 1e-5)
    break;
  end
  S=S+a_k;
  k=k+1;
end
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Same example with 'for' loop and use of matrix ops

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  if (a_k < 1e-5)
    break;
  end
  S=S+a_k;
end
```


```
>> S
S =
  1.2913
```

Often it is more elegant to use built in Matlab matrix operators

```
>> k=1:100;
>> a_k=k.^-k;
>> S=sum(a_k(a_k>=1e-5))
S =
   1.2913
```

Note

- use of the *choose elements* construct
- built in `sum` function

Notes

Interest rate related example

Suppose bank gave you 50% interest rate (let's call it 'x'), and you put one dollar in.
How much would you get at the end of the year?

- one payment at the end of the year

$$M_1 = 1 * (1 + x) = 1 * (1 + .5) = 1.5$$

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- interest payment every half a year

$$M_2 = 1 * (1 + x/2) * (1 + x/2) = 1 * (1 + .5/2)^2 = 1.5625$$

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$$M_2 = 1 * (1 + x/2) * (1 + x/2) = 1 * (1 + .5/2)^2 = 1.5625$$

- interest payment every month

$$M_{12} = 1 * (1 + x/12)^{12} = 1.6321$$

Notes

Interest rate related example

Now let's find how your return on investment (M_N) depends on the number of payments per year

```
x=.5; N_max=100; N=1:N_max;
M=0*(N); % since N is vector M will be a vector too
for i=N
    M(i)=(1+x/i)^i;
end
plot(N,M,'-'); set(gca,'FontSize',24);
xlabel('N, number of payments per year');
ylabel('M_n, return on investment'); % note M_n use
title('Return on investment vs number of payments');
```

Of course we do not need computer to show that $M_\infty = e^x = 1.6487$ but we need it to calculate something like
$M_{1001} - M_{1000} = 2.0572 \times 10^{-7}$

Notes

Interest rate related example

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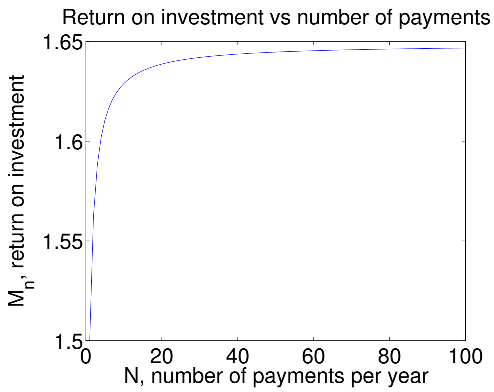
Bonus question: can you calculate `M` without use of loops?

Notes

Interest rate related example



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