

Computer Science

MATLAB

Essential MATLAB for Scientists

Chap 3: Fundamentals (continued 2)

7. Repeating with for

- Avoid *for* loops by vectorising

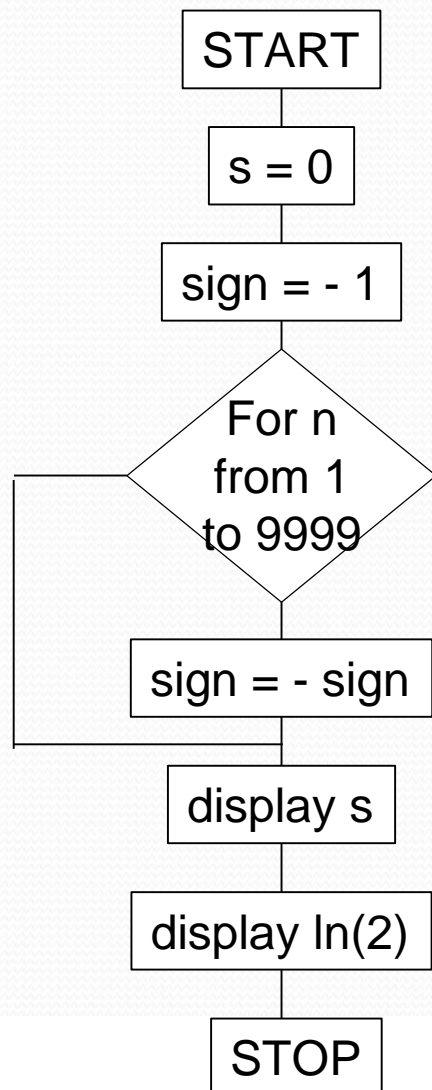
Series with alternating signs are a little more challenging.
The following series sums to $\ln(2)$.

$$1 - \frac{1}{2} + \frac{1}{3} - \frac{1}{4} + \frac{1}{5} - \dots$$

- Think of an algorithm that finds the sum of the first 9999 terms of that sequence/series using a *for* loop then vectorize the calculation.

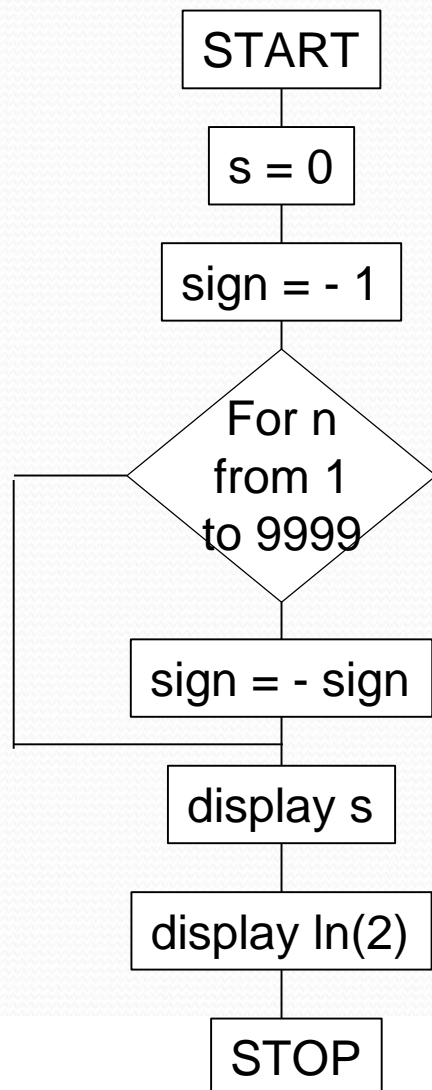
7. Repeating with for

- The series is $1 - \frac{1}{2} + \frac{1}{3} - \frac{1}{4} + \frac{1}{5} - \dots$



7. Repeating with for

- The series is $1 - \frac{1}{2} + \frac{1}{3} - \frac{1}{4} + \frac{1}{5} - \dots$



Program: Matlab code

- `sign = -1;`
- `s = 0;`
- `for n = 1 : 9999`
 - `sign = - sign; or sign = -(-1)^n`
 - `s = s + sign*1/n;`
- `end`
- `disp(s);`
- `disp (log(2));`

7. Repeating with for

- A common mistake: for less loops
 - A common mistake is to omit the word *for* from a *for* loop. Instead of reporting an error, MATLAB creates a vector, and executes the statements in the 'loop' only one. For example, run the program for square-rooting with Newton's method, leaving out the word *for*, i.e.
 - `a = 2;`
 - `x = a/2;`
 - `i= 1:6`
 - `x = (x + a / x) / 2;`
 - `disp(x);`
 - `end`
 - `i` is now a vector. Therefore, the loop is inexistent.

7. Repeating with for

- Exercises

Write algorithms and MATLAB programs to find the following sums

a) with for loops, and

b) by vectorization.

Time both versions in each case.

a) $1^2 + 2^2 + 3^2 + \dots + 1000^2$

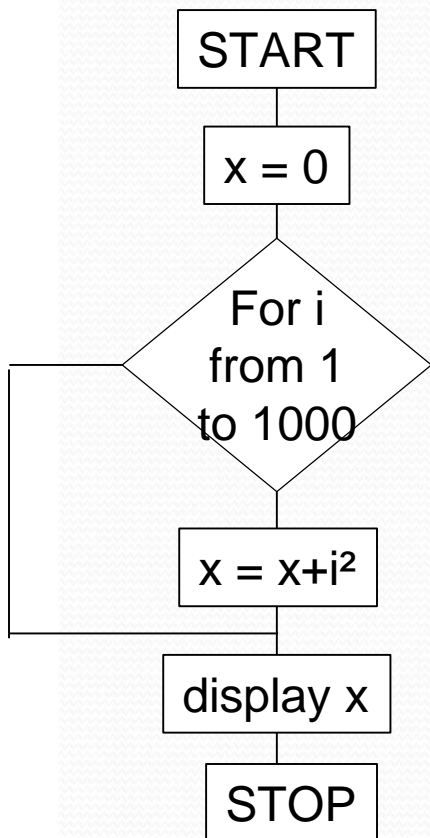
b) $-1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \frac{1}{9} - \dots - \frac{1}{1003}$

c) $\frac{1}{1^2 \cdot 3^2} + \frac{1}{3^2 \cdot 5^2} + \frac{1}{5^2 \cdot 7^2} + \dots + \frac{1}{999^2 \cdot 1001^2}$ (500 terms)

7. Repeating with for

a) $1^2 + 2^2 + 3^2 + \dots + 1000^2$

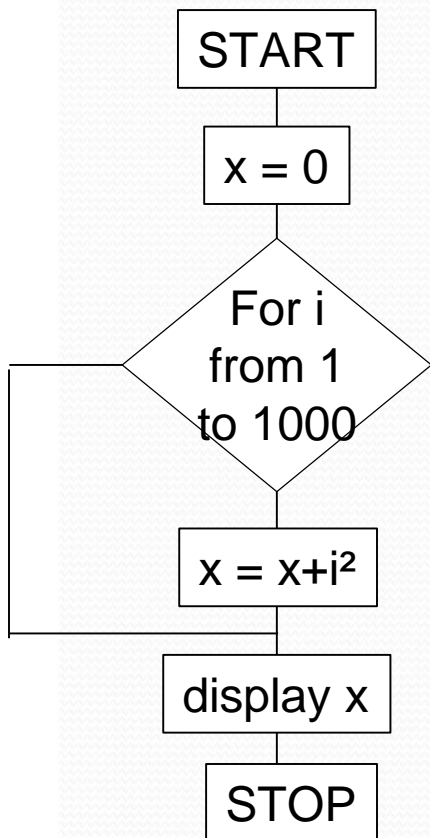
Algorithm with for
loop 1st way



7. Repeating with for

a) $1^2 + 2^2 + 3^2 + \dots + 1000^2$

Algorithm with for
loop 1st way



Program Matlab code

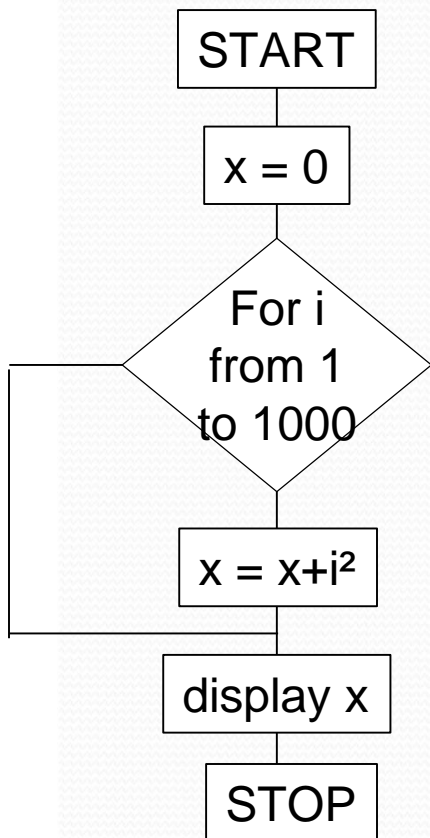
%With for loop, 1st way

```
x=0;  
for i=1:1000  
x=x+i^2;  
end
```

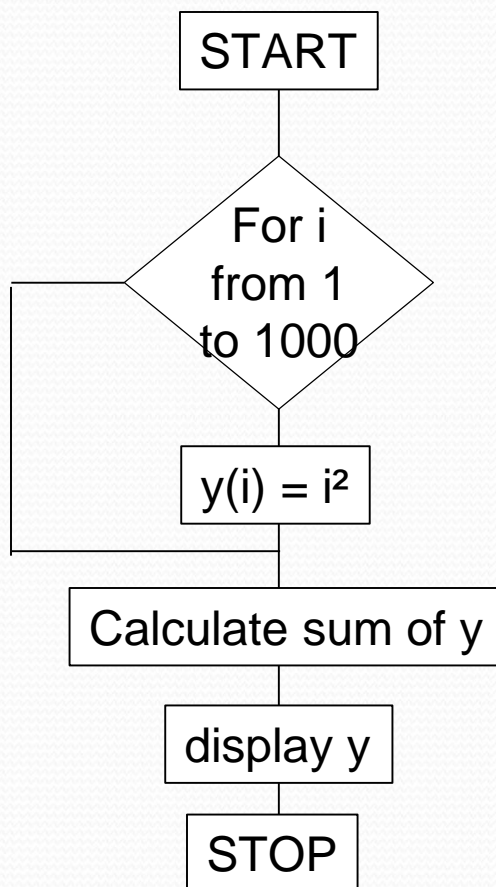

7. Repeating with for

a) $1^2 + 2^2 + 3^2 + \dots + 1000^2$

Algorithm with for
loop 1st way



Algorithm with for
loop 2nd way



Program Matlab code

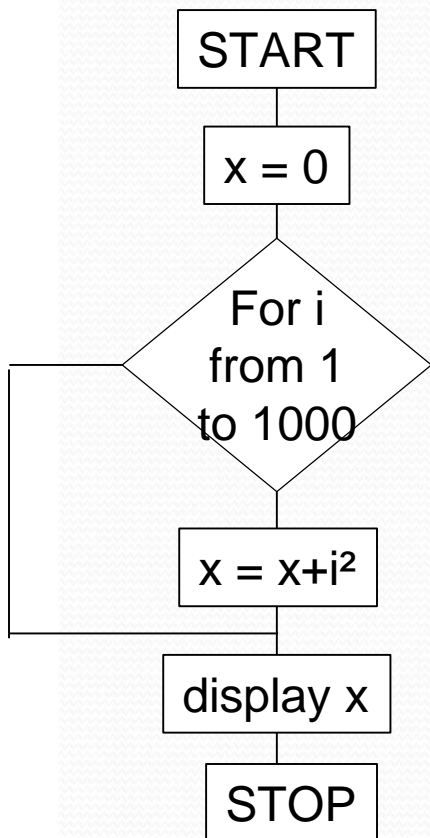
%With for loop, 1st way

```
x=0;  
for i=1:1000  
x=x+i^2;  
end
```

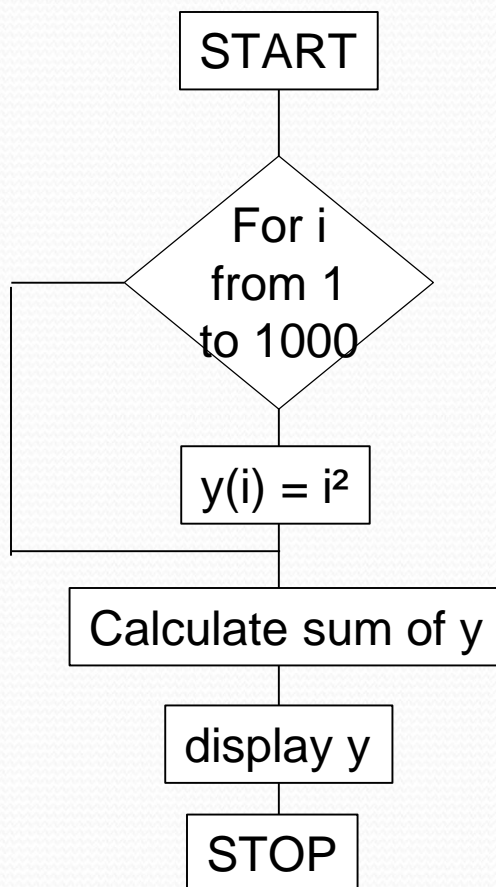
7. Repeating with for

a) $1^2 + 2^2 + 3^2 + \dots + 1000^2$

Algorithm with for
loop 1st way



Algorithm with for
loop 2nd way



Program Matlab code

%With for loop, 1st way

```
x=0;  
for i=1:1000  
x=x+i^2;  
end
```

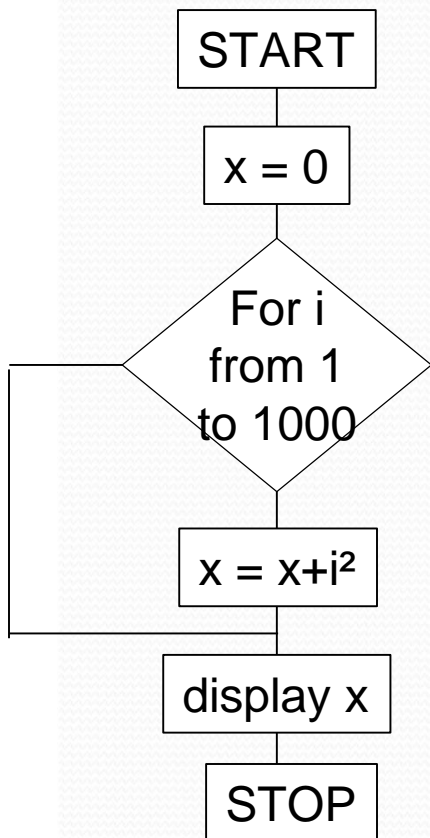
%With for loop, 2nd way

```
for i=1:1000  
y(i)=i^2;  
end  
sum(y)
```

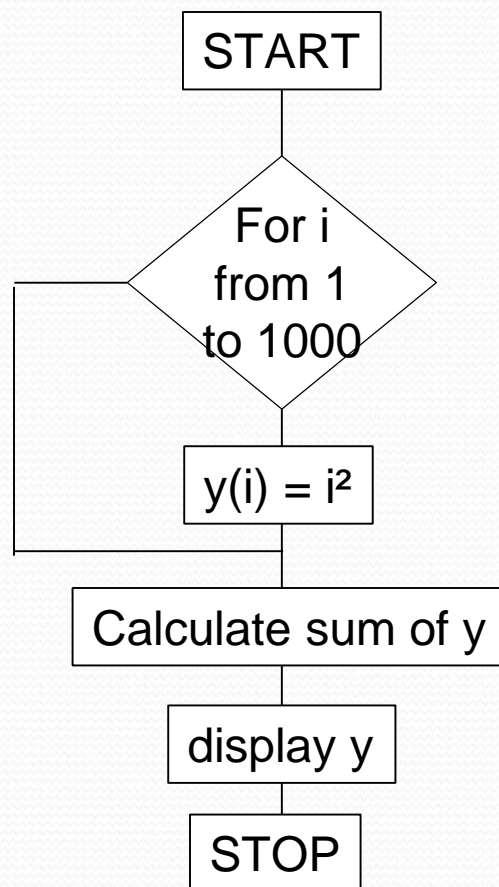

7. Repeating with for

a) $1^2 + 2^2 + 3^2 + \dots + 1000^2$

Algorithm with for
loop 1st way



Algorithm with for
loop 2nd way



Program Matlab code

%With for loop, 1st way

```
x=0;  
for i=1:1000  
x=x+i^2;  
end
```

%With for loop, 2nd way

```
for i=1:1000  
y(i)=i^2;  
end  
sum(y)
```

%With vectorization

```
z=[1:1:1000];  
sum(z.^2)
```

% x,sum(y) and sum(z.^2) have the same result

8. Decisions

- Now enter the following:
 - $2 > 0$
- Now enter the following:
 - $-1 > 0$
- MATLAB gives a value of 1 to a logical expression which is *true*, and 0 to one which is *false*.

8. Decisions

Exercises: The following statements all assign logical expressions to the variable x . See if you can correctly determine the value x in each case before checking your answer with MATLAB.

- $x = 3 > 2$
- $x = 2 > 3$
- $x = -4 \leq -3$
- $x = 1 < 1$

- $x = 2 \sim 2$
- $x = 3 == 3$
- $x = 0 < 1.5 + 1$

8. Decisions

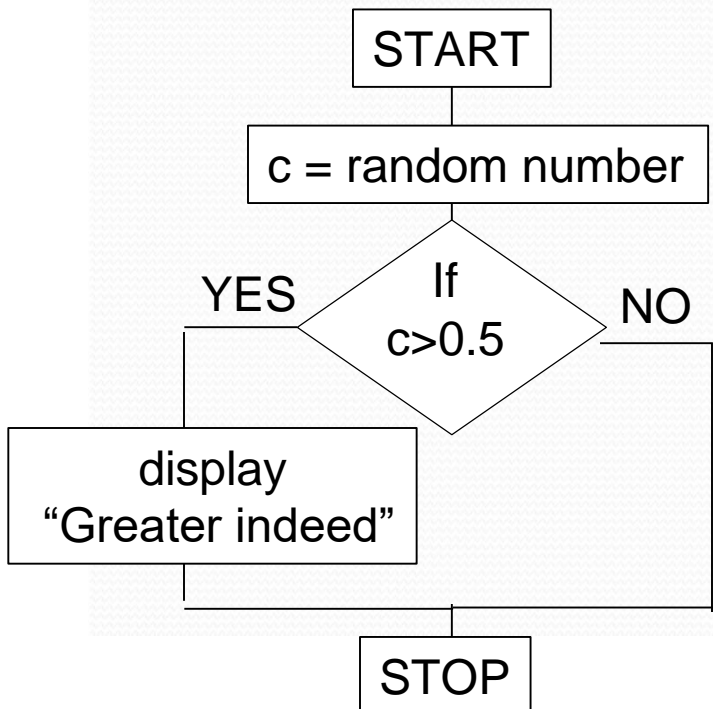
- The « if » structure

if *condition* is true, *statement* is executed. But if *condition* is false, nothing happens.

Example:

Would like to know if *c* (a random number) is greater than 0.5, display « greater indeed ».

Algorithm



8. Decisions

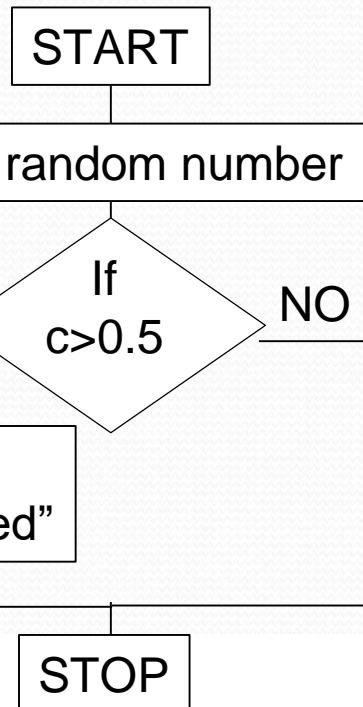
- The « if » structure

if *condition* is true, *statement* is executed. But if *condition* is false, nothing happens.

Example:

Would like to know if *c* (a random number) is greater than 0.5, display « greater indeed ».

Algorithm



Program Matlab code

```
if c > 0.5
    disp( 'greater indeed' )
end
```

8. Decisions

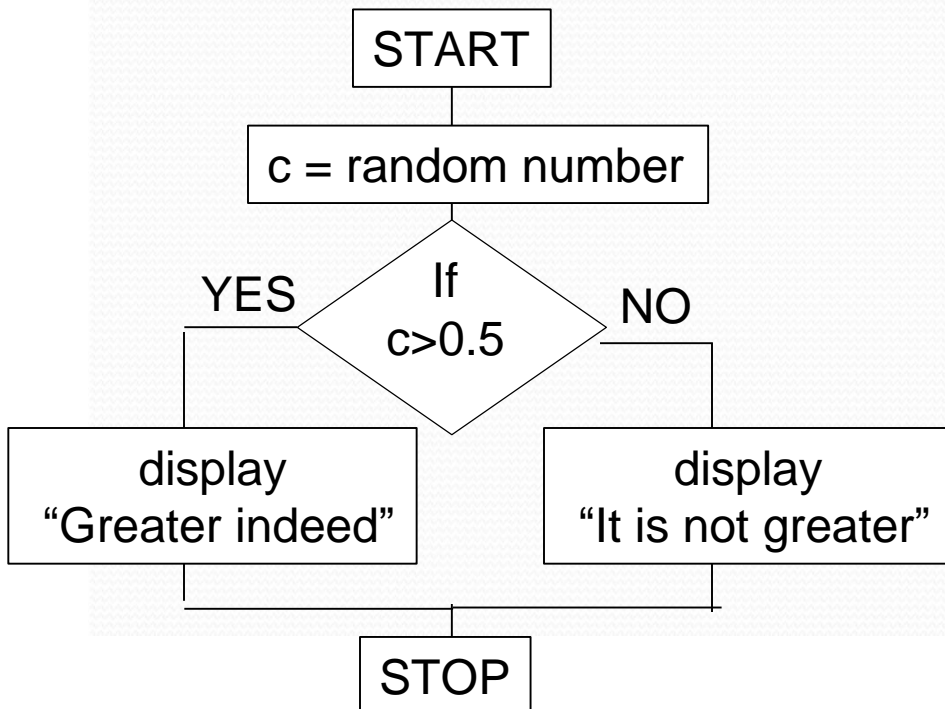
- The « if » structure

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Example:

Would like to know if *c* (a random number) is greater than 0.5, display « greater indeed », else display « It is not greater ».

Algorithm



8. Decisions

- The « if » structure

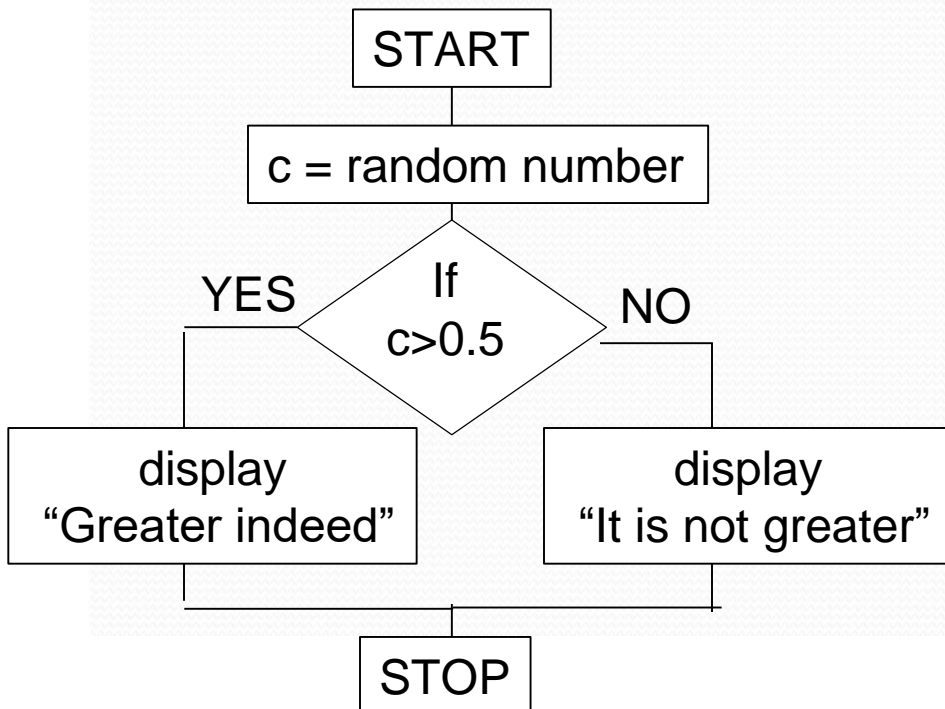
if *condition* is true, *statement* is executed. But if *condition* is false, nothing happens.

Example:

Would like to know if *c* (a random number) is greater than 0.5, display « greater indeed », else display « It is not greater ».

Algorithm

Program Matlab code



```
if c > 0.5
    disp( 'greater indeed' )
else
    disp( 'it is not greater' )
end
```

8. Decisions

- In the example of the previous slide, MATLAB has to make a decision depending on the value of c . The *if* construct, which is fundamental to all computing languages, is the basis of such decision-making.
- The simplest form of *if* in a single line is
 - if condition (*then*) statement, end

8. Decisions

- *condition* is usually a *logical expression*, i.e. an expression containing *relational operator*, and which is either *true* or *false*. The relational operators are shown in the following table.

Relational operator	Meaning
<	less than
<=	less than or equal
==	equal
~=	not equal
>	greater than
>=	greater than or equal

8. Decisions

- *condition* may be a vector or matrix, in which case it is true only if *all* its elements are non-zero. A single zero element in a vector or matrix renders it false.
- MATLAB allows you to use an arithmetic expression for *condition*. If the expression is false, then it evaluates to 0. Otherwise, it evaluates to 1.

8. Decisions

Exercise: $x = 2$;

```
if x < 0
disp( 'neg' )
else
disp( 'non-neg' )
end
```

- Now change the value of x to -1 and execute the *if* again.

8. Decisions

Exercise:

- Let us consider the following example. Banks offer differential interest rates. Suppose the rate is 9% if the amount in your savings account is less than \$5000, but 12% otherwise. The Random Bank goes one step further and gives you a random amount in your account to start with! Type and run the following program a few times.

8. Decisions

Algorithm

START

bal = random number

YES
If
bal < 5000
NO

rate=0.09

rate=0.12

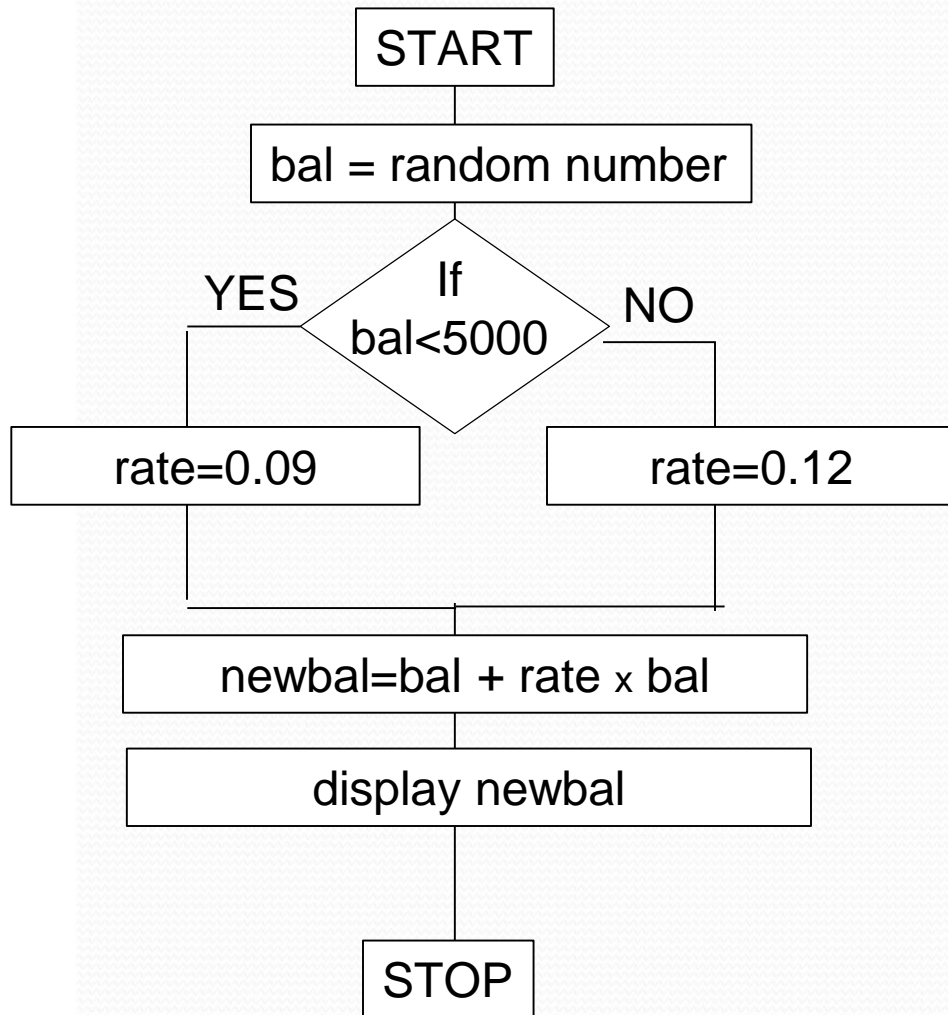
newbal=bal + rate x bal

display newbal

STOP

8. Decisions

Algorithm



Program Matlab code

- `bal = 10 000 * rand`
- `if bal < 5 000`
 - `rate = 0.09`
- `else`
 - `rate = 0.12`
- `end`
- `newbal = bal + rate * bal;`
- `disp('New balance after interest compounded is: ')`
- `format bank`
- `disp(newbal)`
- `format`

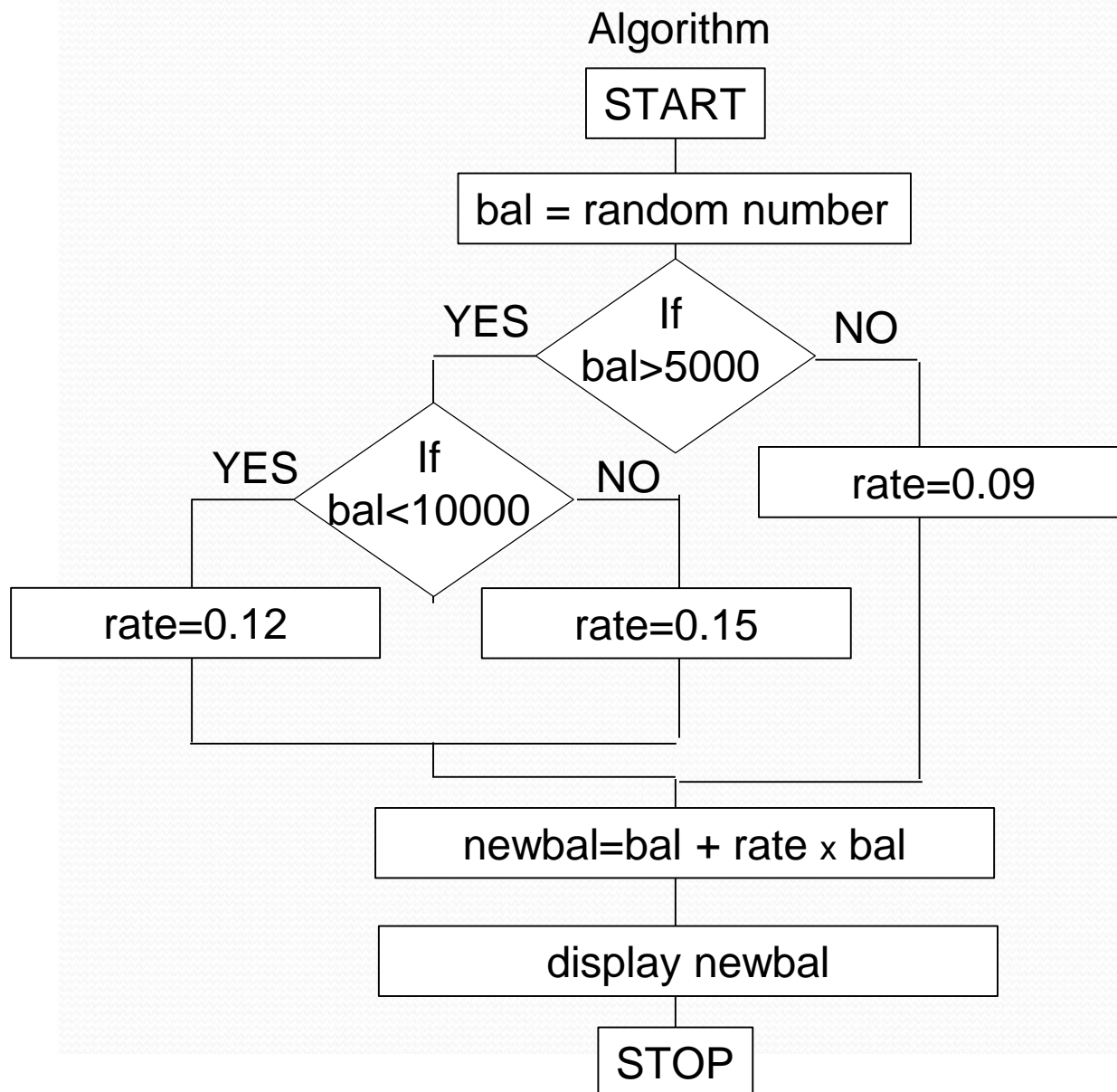
8. Decisions

- The one-line *if-else* statement
 - The simplest general form of *if-else* for use on one line is
 - if condition statements A, else statements B, end
 - Note
 - Commas (of semicolons) are essential between the various clauses.
 - The *else* part is optional.
 - Do not forget *end*, or MATLAB will wait forever.

8. Decisions

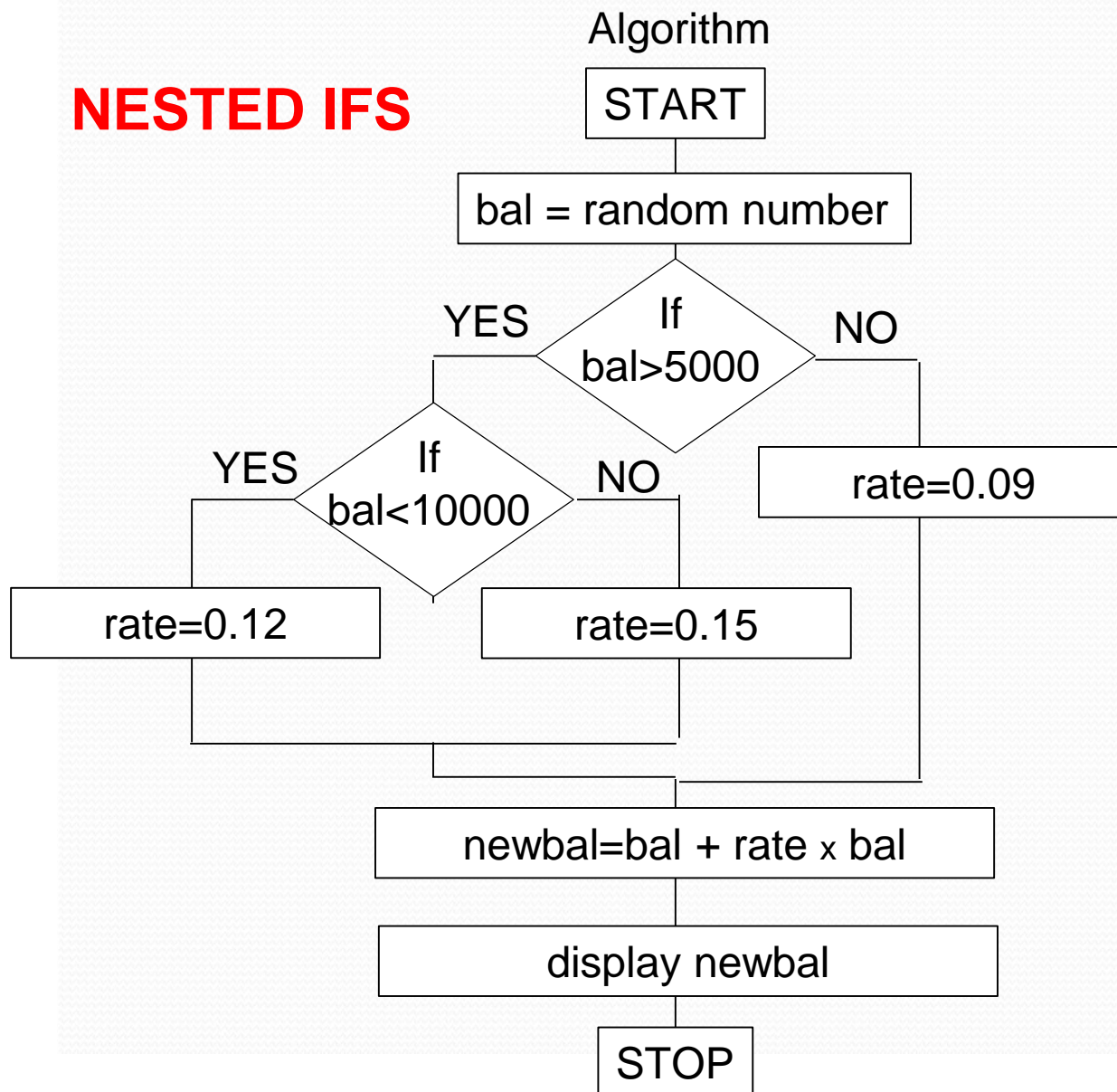
- Suppose the Random Bank now offers 9% on balances of less than \$5000, 12% for balances of \$5000 or more but less than \$10000, and 15% for balances of \$10000 or more.
- The following program calculates a customer's new balance after one year according to this scheme.

8. Decisions



8. Decisions

NESTED IFS



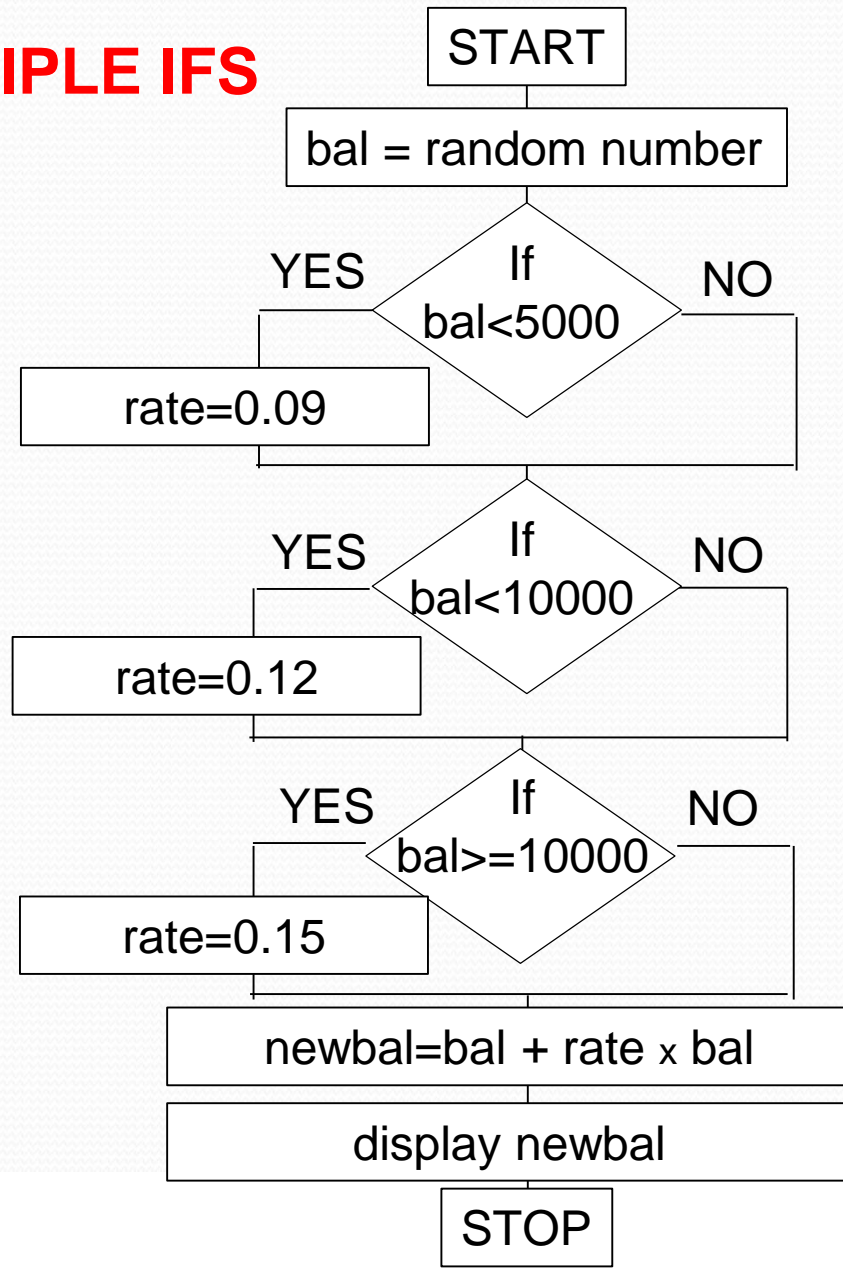
Program Matlab code

```
bal = 15000 * rand;  
if bal > 5000  
    if bal < 10000  
        rate = 0.09;  
    else  
        rate = 0.15;  
    end  
else  
    rate = 0.09;  
end  
newbal = bal + rate * bal;  
format bank  
disp( 'New balance is: ' )  
disp( newbal )
```


8. Decisions

Algorithm

MULTIPLE IFS



Program Matlab code

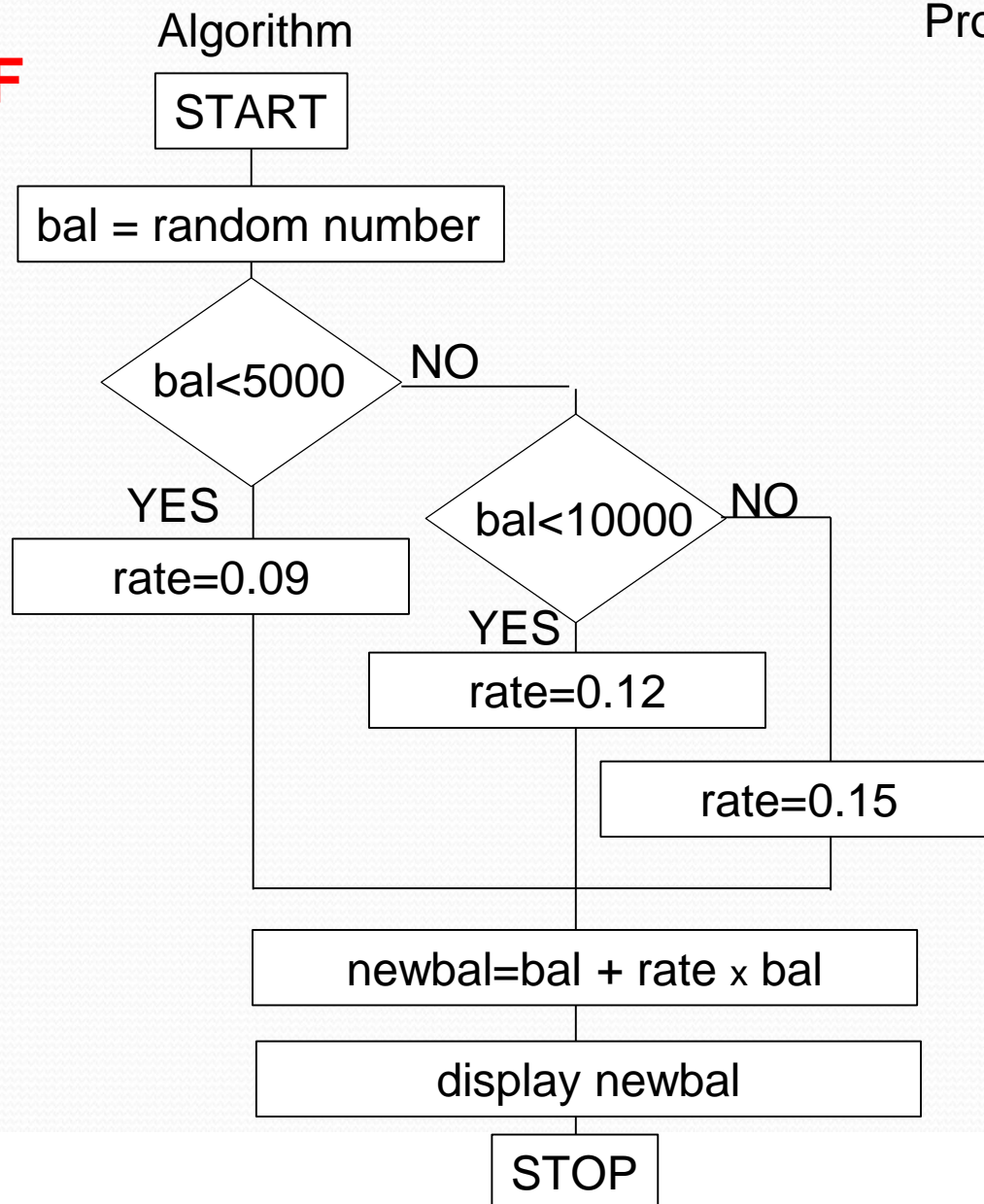
```
if bal < 5000
    rate = 0.09;
end
if bal < 10000
    rate = 0.12;
end
if bal >= 10000
    rate = 0.15;
end
disp( 'New balance is: ' )
disp( newbal )
```

8. Decisions

- Multiple *ifs* versus *elseif*
 - **Multiple *ifs* is inefficient** since each of the three conditions is always tested, even if the first one is true.
 - The mistake expressed in the following program is common. **You should always avoid it.**
- Nested *ifs* versus *elseif*
 - An *if* construct can contain further *ifs*, and so on. This is called *nesting* and should not be confused with *elseif* ladder.

8. Decisions

ELSEIF

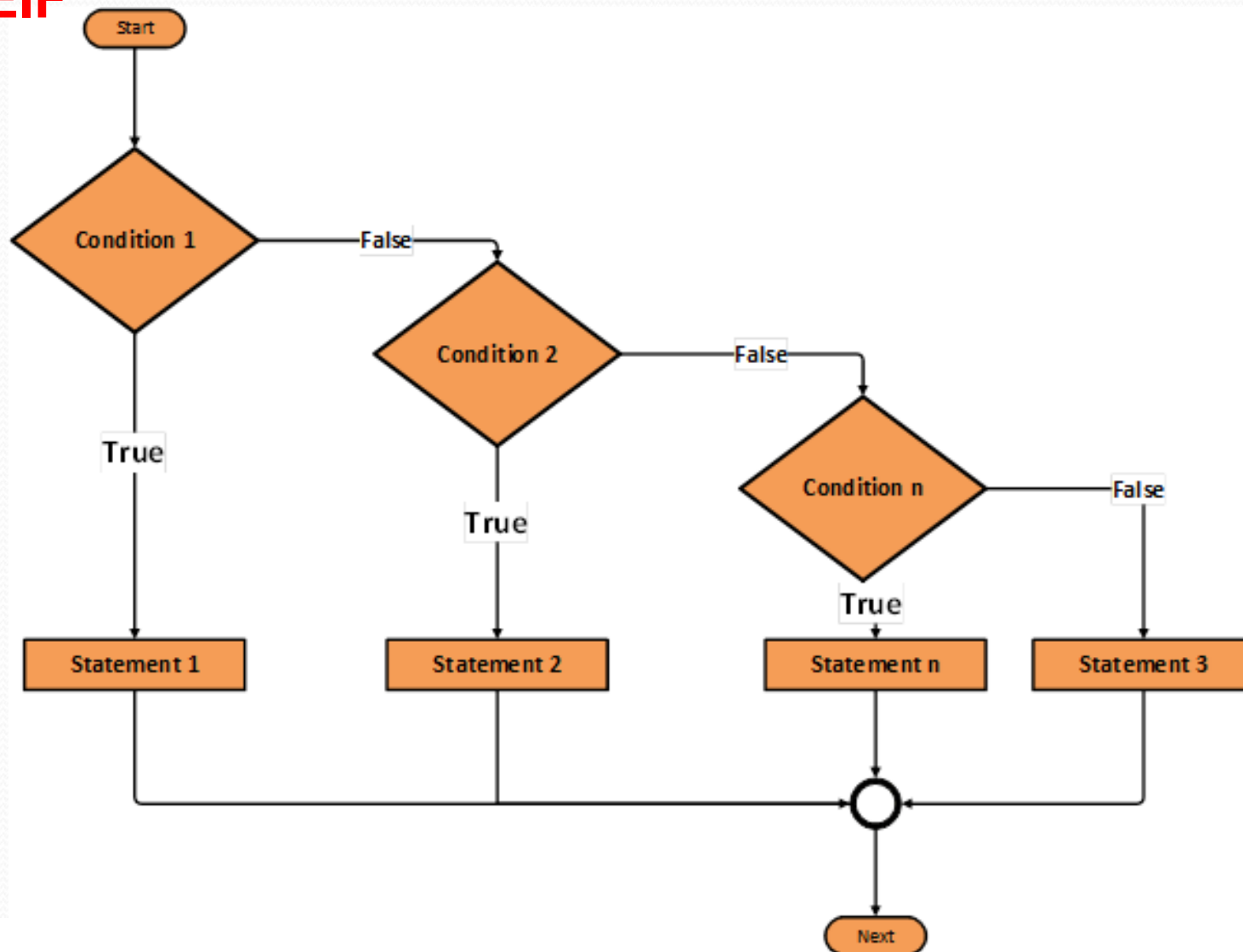


Program Matlab code

```
bal = 15000 * rand;  
if bal < 5000  
    rate = 0.09;  
elseif bal < 10000  
    rate = 0.12;  
else  
    rate = 0.15;  
end  
newbal = bal + rate * bal;  
format bank  
disp( 'New balance is: ' )  
disp( newbal )
```

8. Decisions

ELSEIF



8. Decisions

- elseif
 - Run the program a few times and display the values of *bal*, *rate*, and *newbal* to make sure MATLAB has chosen the correct interest rate.
 - In general, the *elseif* clause is used as follows:
 - if condition 1
 - statements A
 - elseif condition 2
 - statements B
 - elseif condition 3
 - statements C
 - ...
 - else
 - statements E
 - end
 - That is sometimes called an elseif ladder

8. Decisions

elseif

- The elseif ladder works as follows
 1. *condition 1* is tested. If it is true, then *statements A* are executed. MATLAB then moves to the next statement after *end*.
 2. if *condition 1* is false, MATLAB checks *condition 2*. If it is true, *statements B* are executed, followed by the statement after *end*.

8. Decisions

elseif

- The elseif ladder works as follows
 1. *condition 1* is tested. If it is true, then *statements A* are executed. MATLAB then moves to the next statement after *end*.
 2. if *condition 1* is false, MATLAB checks *condition 2*. If it is true, *statements B* are executed, followed by the statement after *end*.
 3. In this way, all the conditions are tested until a true condition is found. As soon as a true condition is found, no further *elseifs* are examined, and MATLAB jumps off the ladder.
 4. If none of the conditions is true, *statements E* after *else* are executed.

8. Decisions

elseif

- The elseif ladder works as follows
 1. *condition 1* is tested. If it is true, then *statements A* are executed. MATLAB then moves to the next statement after *end*.
 2. if *condition 1* is false, MATLAB checks *condition 2*. If it is true, *statements B* are executed, followed by the statement after *end*.
 3. In this way, all the conditions are tested until a true condition is found. As soon as a true condition is found, no further *elseifs* are examined, and MATLAB jumps off the ladder.
 4. If none of the conditions is true, *statements E* after *else* are executed.
 5. You should arrange the logic so that not more than one of the conditions is true.
 6. There can be any number of *elseifs*, but at most one *else*.
 7. *elseif* must be written as one word.
 8. It is good programming style to *indent* each group of statements as it is done automatically by MATLAB and shown in this presentation.

8. Decisions

- Logical operators
 - More complicated logical expressions can be constructed using the three *logical operators* & (and), | (or), ~ (not).
 - Example: the quadratic $ax^2 + bx + c = 0$ has equal roots, given by , provided that $b^2 - 4ac = 0$ and $a \neq 0$.

This translates to the following MATLAB statements:

- if (b^2 - 4*a*c == 0) & (a ~= 0)
 - x = -b / (2*a);
- end
- of course, a, b and c must be assigned values prior to reaching this set of statements. Note the double equal sign in the test for equality.

8. Decisions

Multiple *ifs* versus *elseif*

- Another mistake is common and illustrated in the following program.
 - Program
 - if 5000 <= bal < 10000
 - rate = 0.12;
 - end
 - In that case, whatever the value of *bal* is, this condition will always be true.

8. Decisions

- Nested *ifs*
 - Let us understand the concept of *nested ifs* through an example. Suppose you want to compute the solution of a quadratic equation. You may first want to check if $a = 0$ to prevent a division by zero.

8. Decisions

Nested *ifs*

- Program
 - $d = b^2 - 4*a*c;$
 - if $a \neq 0$
 - if $d < 0$
 - `disp('Complex Roots')`
 - else
 - $x1 = (-b + \text{sqrt}(d)) / (2*a) ;$
 - $x2 = (-b - \text{sqrt}(d)) / (2*a) ;$
 - end
 - end

8. Decisions

- *ifs*
 - Pay attention to where you write the *end*.
 - The first *end* belongs to the second *if* by default, as intended.
 - Now, move the first *end* up as follows:
 - $d = b^2 - 4*a*c;$
 - *if* $a \neq 0$
 - *if* $d < 0$
 - $\text{disp('Complex Roots')}$
 - *end*
 - *else*
 - $x1 = (-b + \text{sqrt}(d)) / (2*a) ;$
 - $x2 = (-b - \text{sqrt}(d)) / (2*a) ;$
 - *end*
 - Now, *else* belongs to the first *if*. Division by zero is therefore “forced” instead of prevented.

8. Decisions

- Switch
 - The *switch* statement executes certain statements based on the value of a variable or expression. In the following example, it is used to decide whether a random integer is 1, 2 or 3.
 - Program
 - `d = floor(3*rand) + 1`
 - `switch d`
 - `case 1`
 - `disp('That"s a 1!');`
 - `case 2`
 - `disp('That"s a 2!');`
 - `case 3`
 - `disp('Must be 3!');`
 - `end`

8. Decisions

Switch

- Multiple expressions can be handled in a single case statement by enclosing the case expression in a cell array. Try the following program.
 - Program
 - `d = floor(10*rand)`
 - `switch d`
 - `case { 2 , 4 , 6 , 8 }`
 - `disp('Even');`
 - `case { 1 , 3 , 5 , 7 , 9 }`
 - `disp('Odd');`
 - `otherwise`
 - `disp ('Zero');`
 - `end`