Introduction to Flowcharting

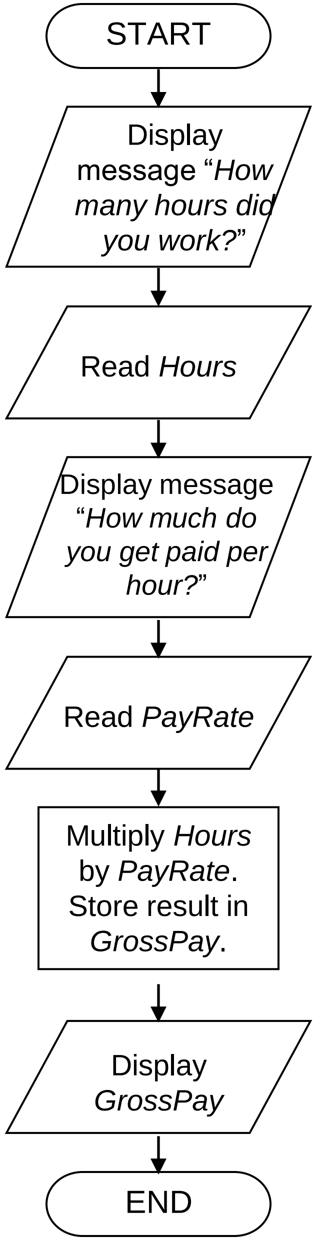
This slide is based upon Appendix C from *Starting Out with C++: From Control Structures to Objects* (5th Edition), Tony Gaddis 2007, Published by Addison-Wesley

Contents

- Flowchart
- Basic flowchart symbols
- Stepping through the flowchart
- Three flowchart structures
- Examples
- Exercises

What is a Flowchart?

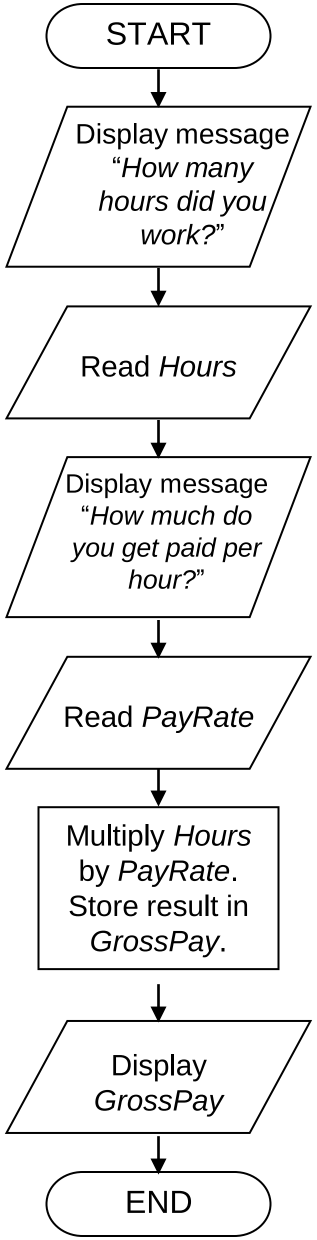
- A flowchart is a diagram that depicts the "flow of control" of a program.


START
Display message "*How many hours did you work?*"
Read *Hours*
Display message "*How much do you get paid per hour?*"
Read *PayRate*
Multiply *Hours* by *PayRate*. Store result in *GrossPay*.
Display *GrossPay*
END

What is a Flowchart?

- A flowchart
  - shows logic of an algorithm
  - emphasizes individual steps and their interconnections

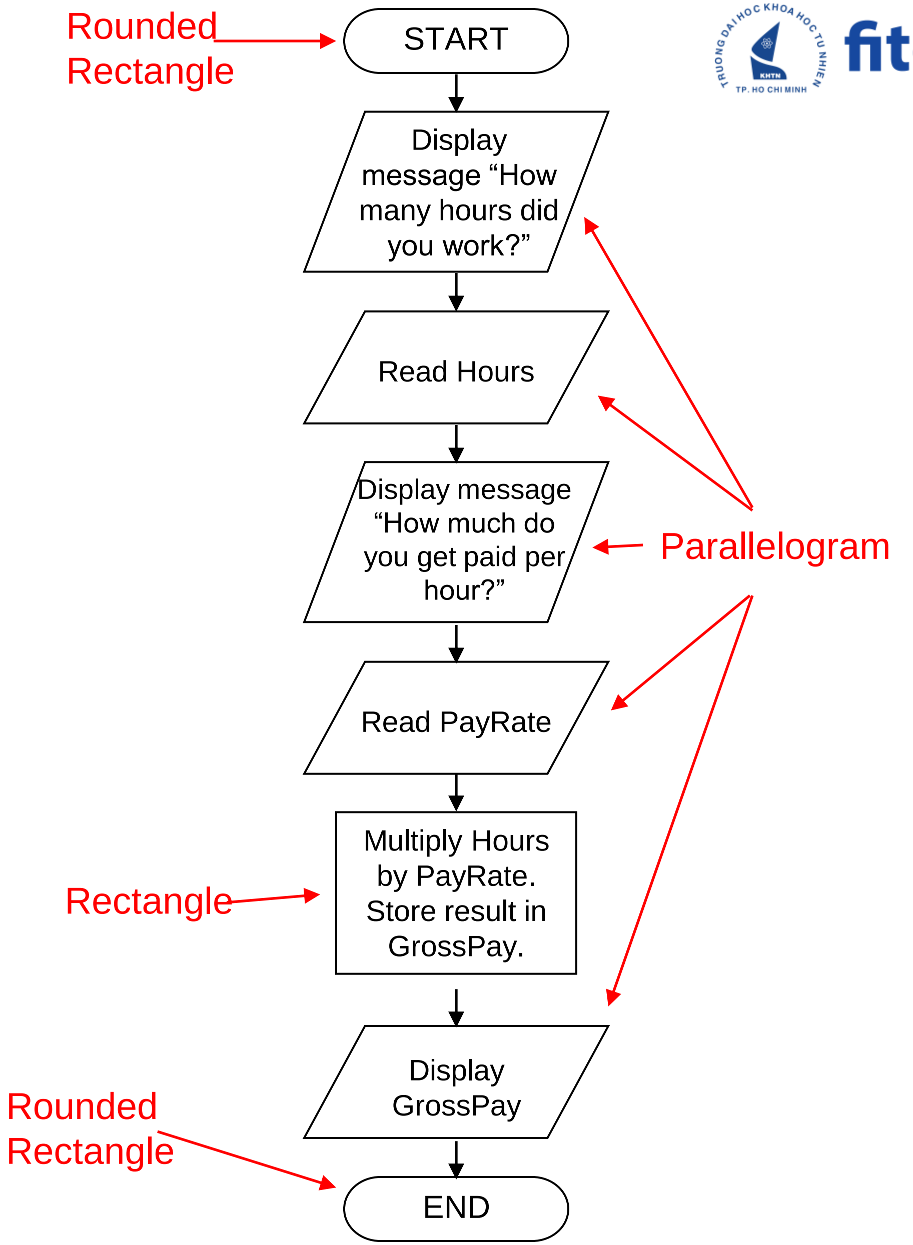
  e.g. control flow from one action to the next


START
Display message "How many hours did you work?"
Read Hours
Display message "How much do you get paid per hour?"
Read PayRate
Multiply Hours by PayRate. Store result in GrossPay.
Display GrossPay
END

Basic Flowchart Symbols

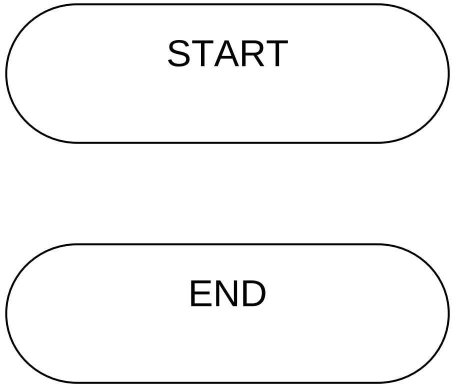
- Three types of symbols in this flowchart:
  - rounded rectangle
  - parallelogram
  - rectangle

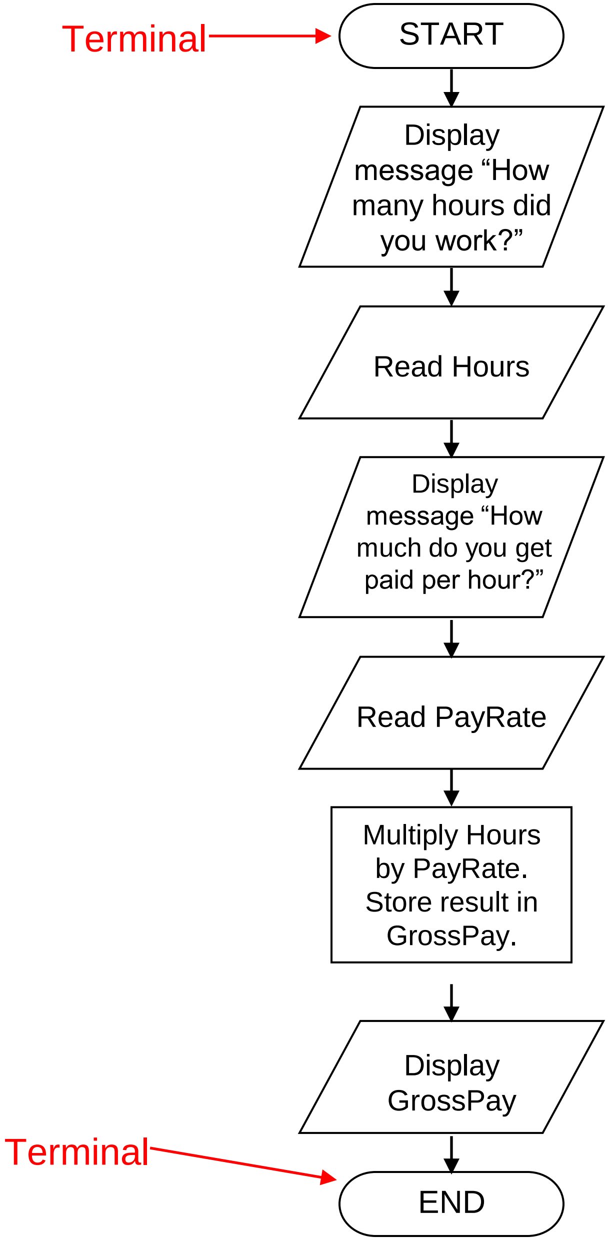
- Each symbol represents a different type of operation.


Rounded Rectangle
START
Display message “How many hours did you work?”
Read Hours
Display message “How much do you get paid per hour?”
Parallelogram
Read PayRate
Rectangle
Multiply Hours by PayRate. Store result in GrossPay.
Display GrossPay
Rounded Rectangle
END

Basic Flowchart Symbols

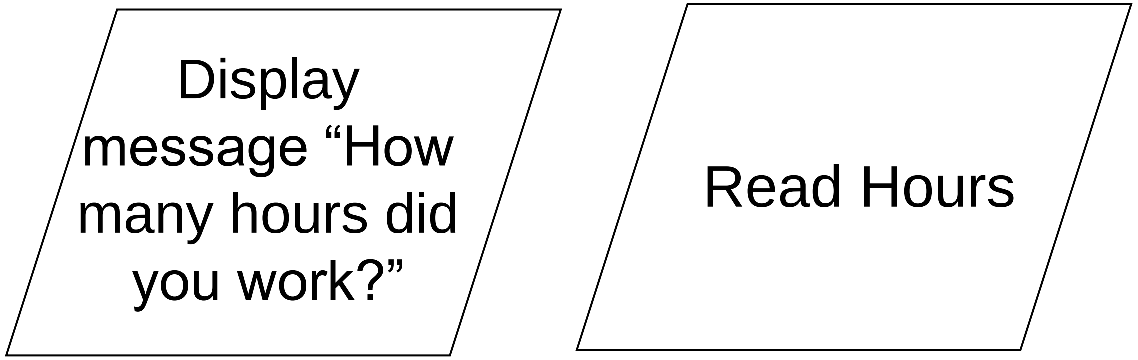
- Terminals
  - represented by rounded rectangles
  - indicate a starting or ending point

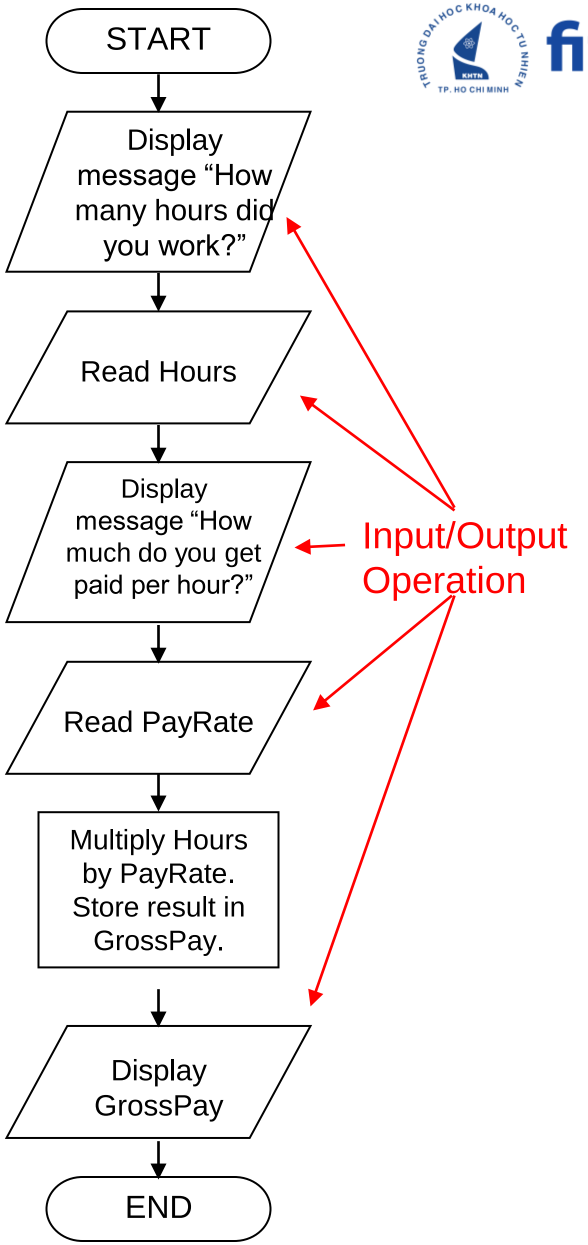



Terminal
START
Display message “How many hours did you work?”
Read Hours
Display message “How much do you get paid per hour?”
Read PayRate
Multiply Hours by PayRate. Store result in GrossPay.
Display GrossPay
Terminal
END

Basic Flowchart Symbols

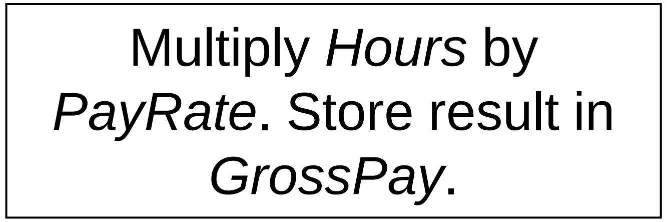
- ○ Input/Output Operations
  - represented by parallelograms
  - indicate an input or output operation

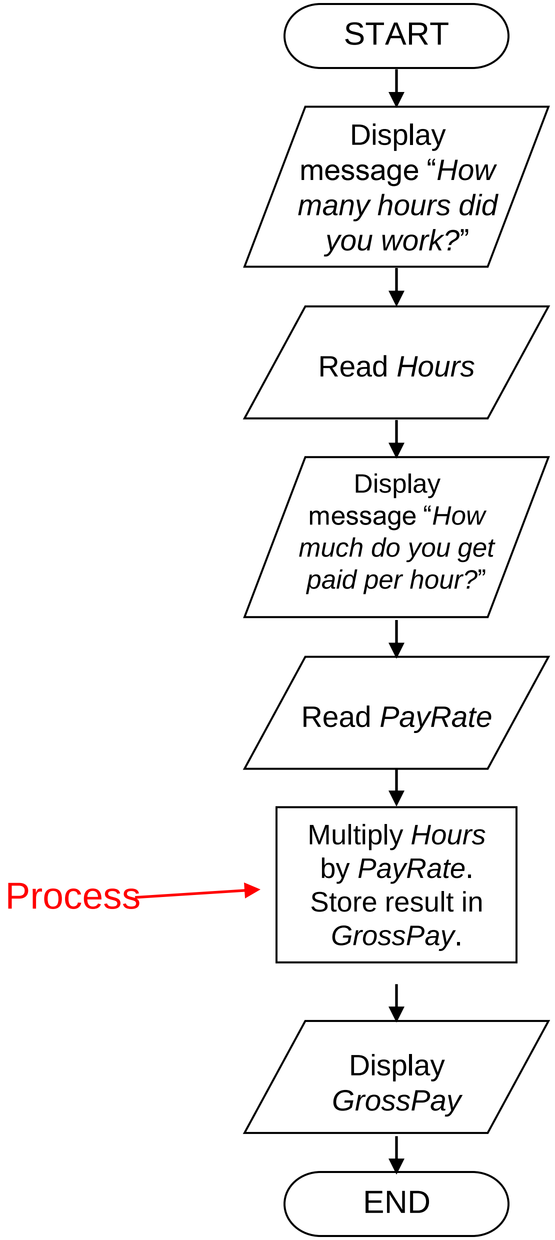



START
Display message “How many hours did you work?”
Read Hours
Display message “How much do you get paid per hour?”
Read PayRate
Multiply Hours by PayRate. Store result in GrossPay.
Display GrossPay
END
Input/Output Operation

Basic Flowchart Symbols

- Processes
  - represented by rectangles
  - indicates a process such as a mathematical computation or variable assignment





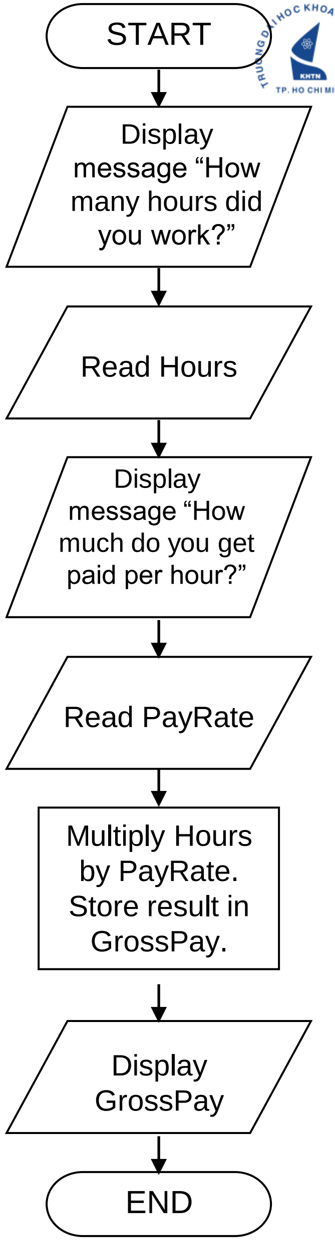
START
Display message "*How many hours did you work?*"
Read *Hours*
Display message "*How much do you get paid per hour?*"
Read *PayRate*
Process
Multiply *Hours* by *PayRate*. Store result in *GrossPay*.
Display *GrossPay*
END

Stepping Through the Flowchart

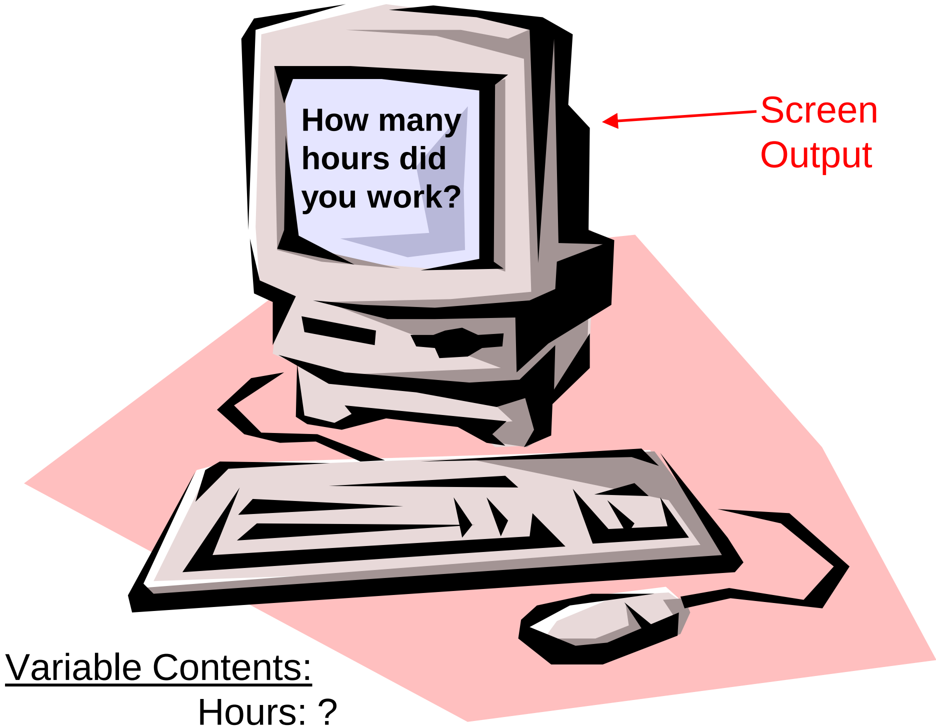
We will step through each symbol in the flowchart. We will show the program output and the contents of the variables.

Variable Contents:

Hours: ?
PayRate: ?
GrossPay: ?


START
Display message “How many hours did you work?”
Read Hours
Display message “How much do you get paid per hour?”
Read PayRate
Multiply Hours by PayRate. Store result in GrossPay.
Display GrossPay
END

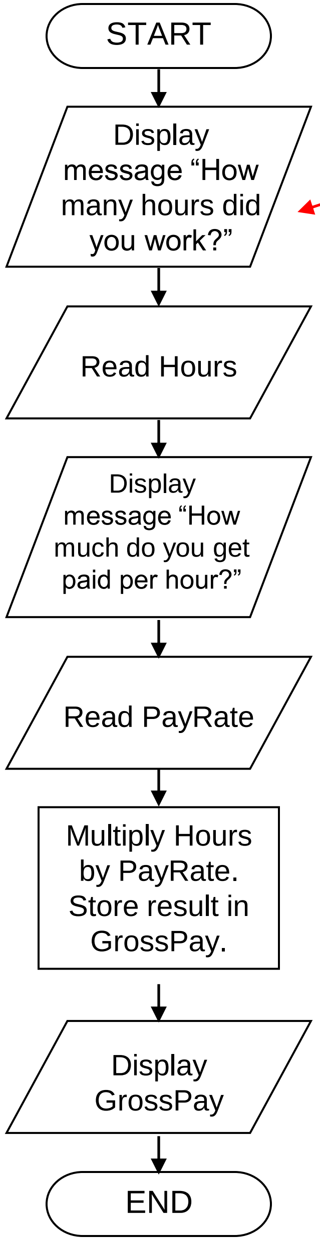
Stepping Through the Flowchart



Screen Output

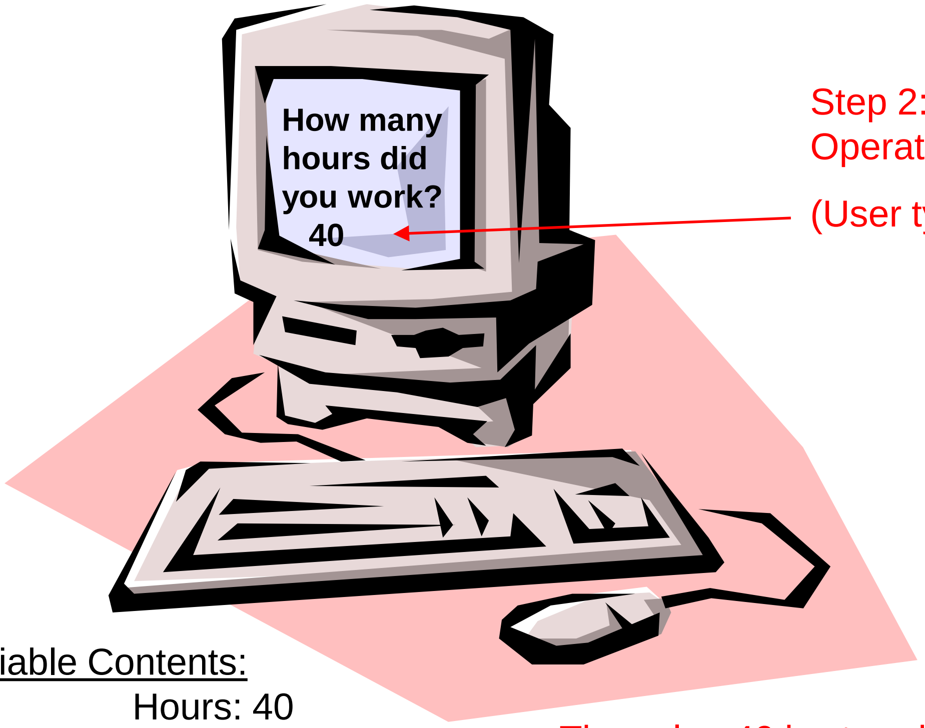
Variable Contents:

Hours: ?
PayRate: ?
GrossPay: ?


START
Display message “How many hours did you work?”
Read Hours
Display message “How much do you get paid per hour?”
Read PayRate
Multiply Hours by PayRate. Store result in GrossPay.
Display GrossPay
END

Step 1: An Output Operation

Stepping Through the Flowchart



Step 2: An Input Operation

(User types 40)

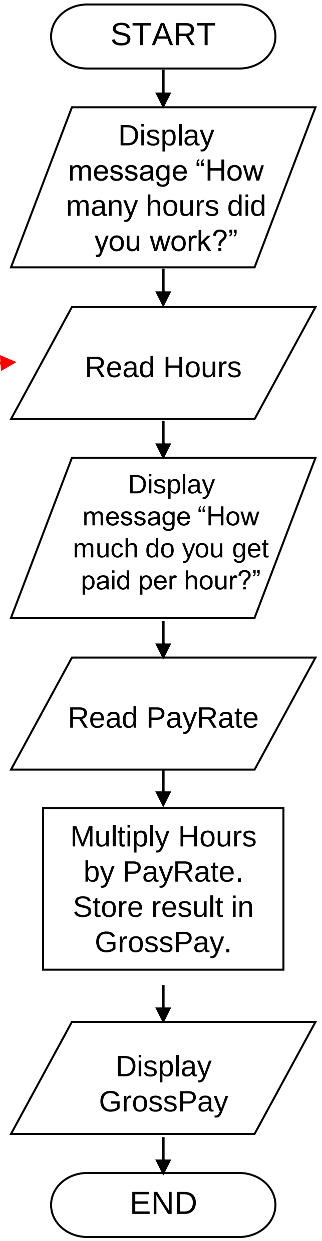
Variable Contents:

Hours: 40

PayRate: ?

GrossPay: ?

The value 40 is stored in Hours.



START

Display message “How many hours did you work?”

Read Hours

Display message “How much do you get paid per hour?”

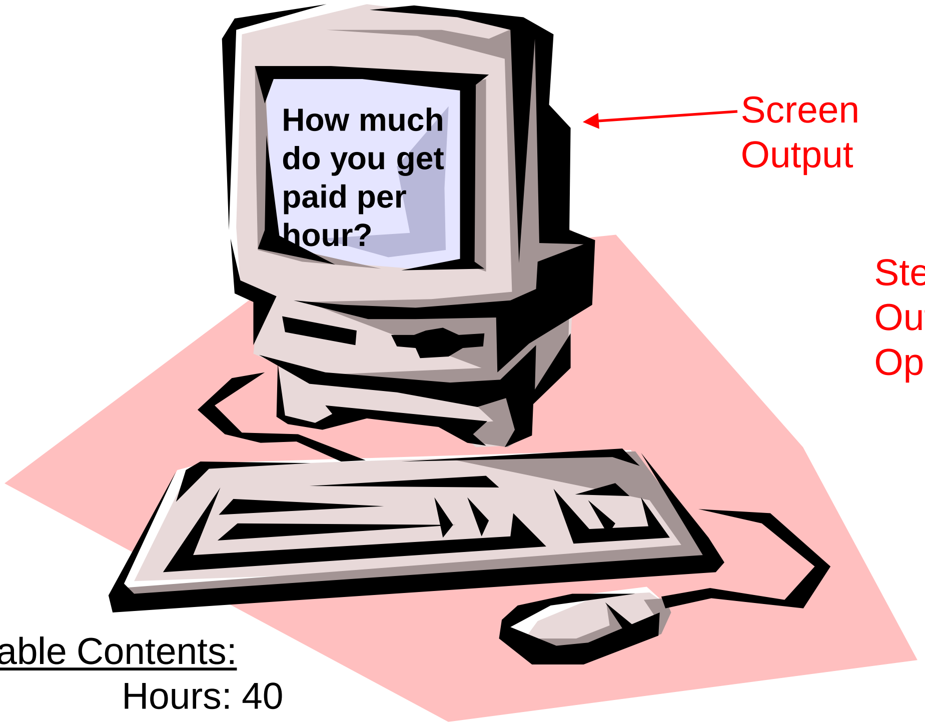
Read PayRate

Multiply Hours by PayRate. Store result in GrossPay.

Display GrossPay

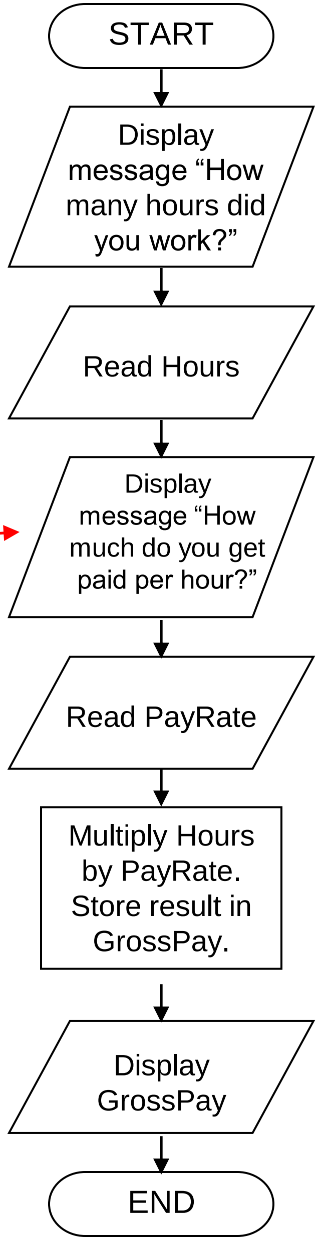
END

Stepping Through the Flowchart



Screen Output

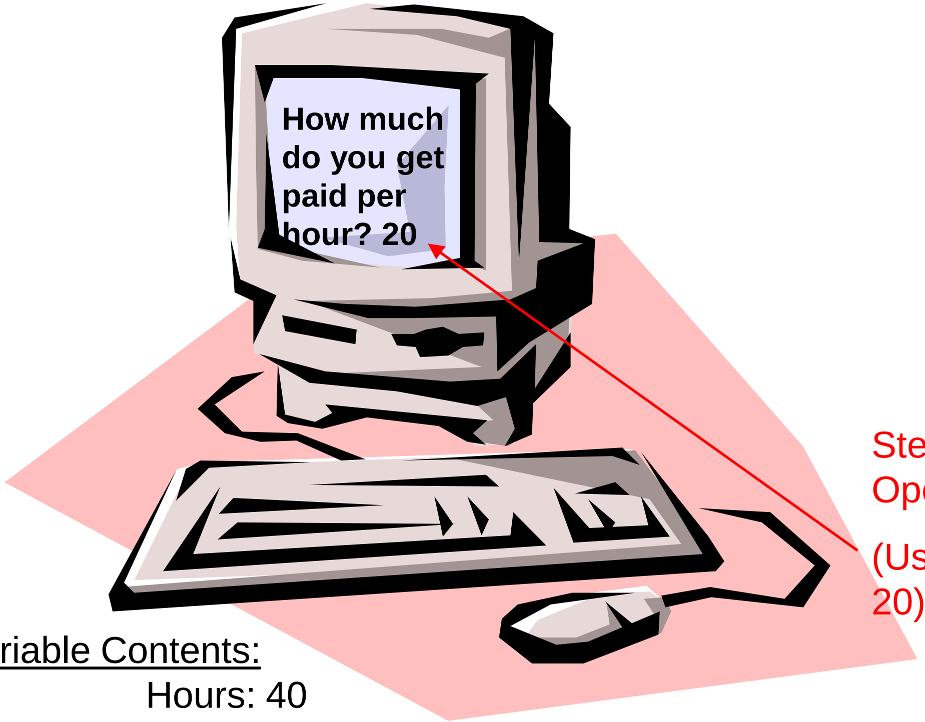
Step 3: An Output Operation


START
Display message “How many hours did you work?”
Read Hours
Display message “How much do you get paid per hour?”
Read PayRate
Multiply Hours by PayRate. Store result in GrossPay.
Display GrossPay
END

Variable Contents:

Hours: 40
PayRate: ?
GrossPay: ?

Stepping Through the Flowchart



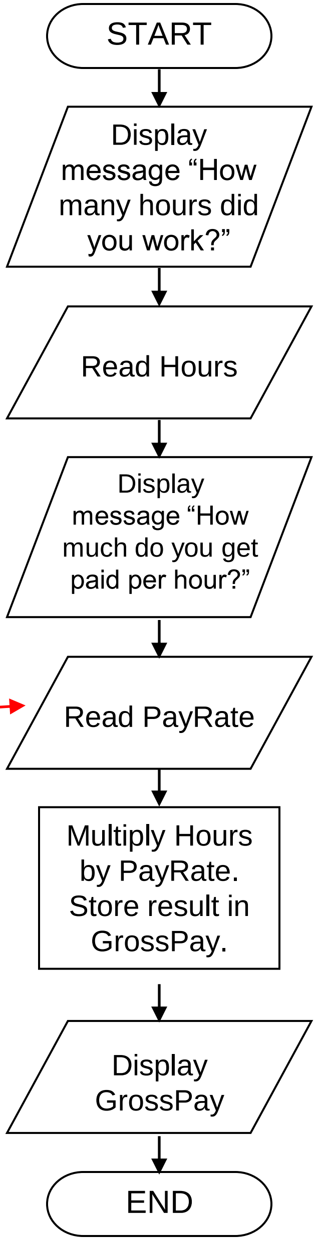
Step 4: Input Operation

(User types 20)

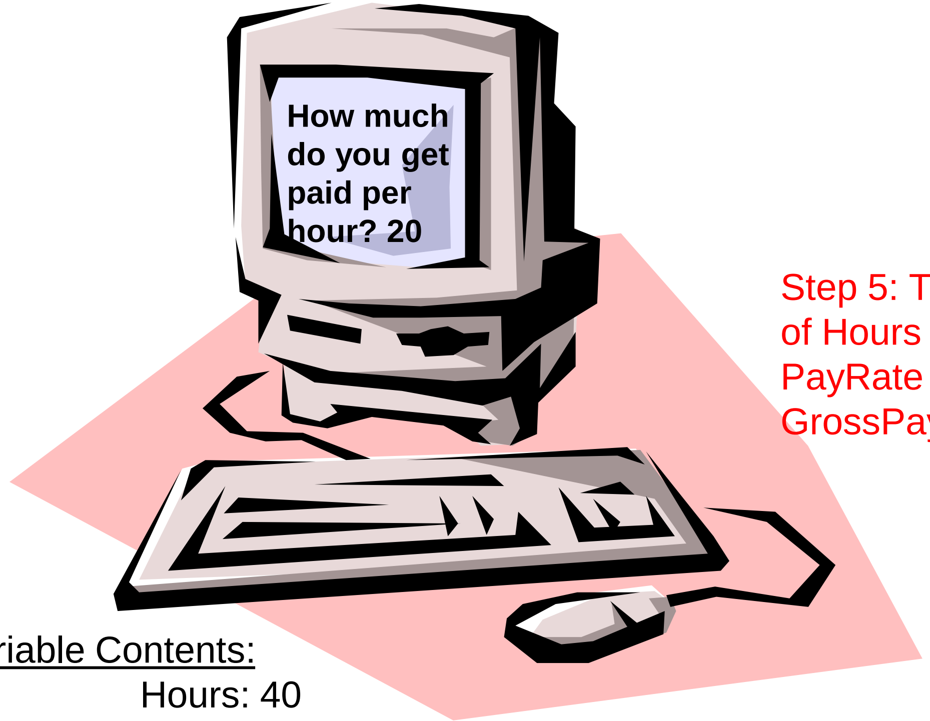
Variable Contents:

Hours: 40
PayRate: 20
GrossPay: ?

The value 20 is stored in PayRate.


START
Display message “How many hours did you work?”
Read Hours
Display message “How much do you get paid per hour?”
Read PayRate
Multiply Hours by PayRate. Store result in GrossPay.
Display GrossPay
END

Stepping Through the Flowchart

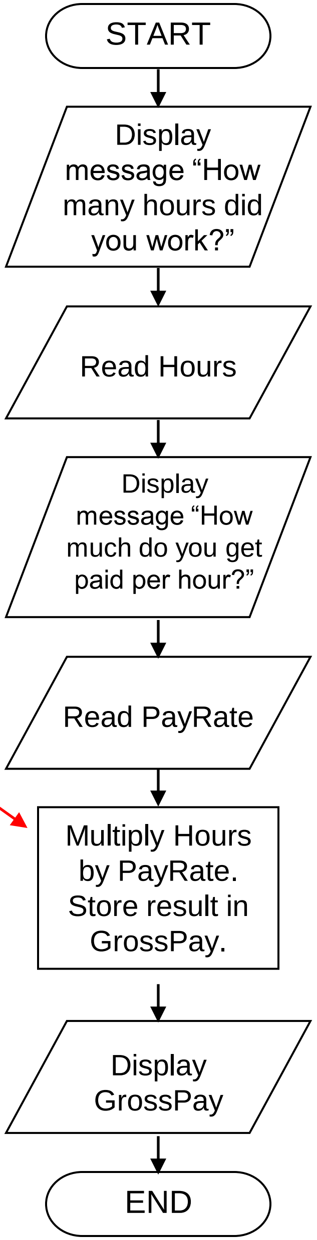


Variable Contents:

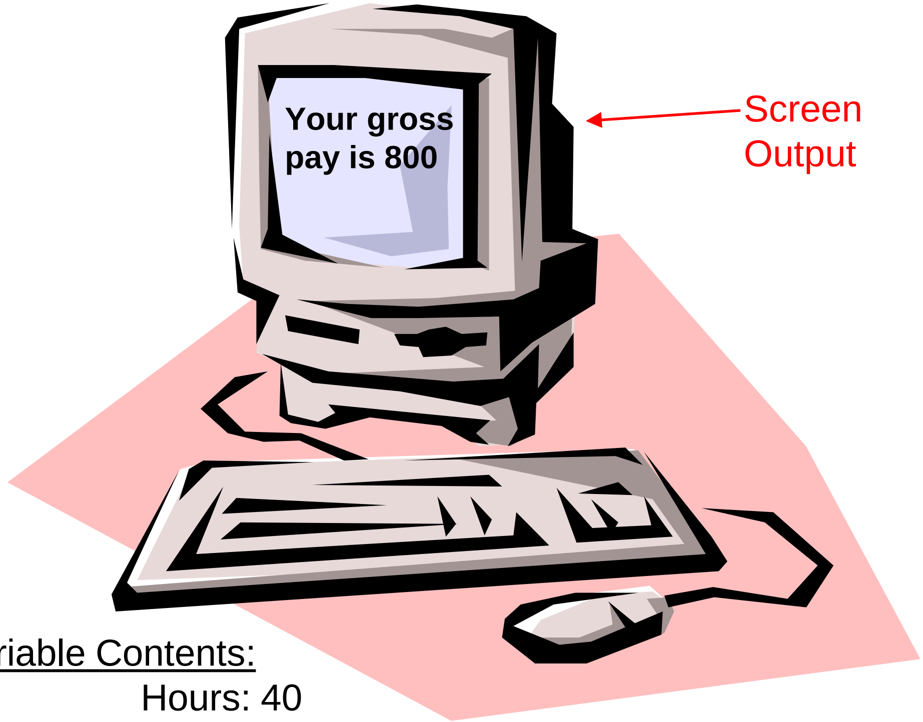
Hours: 40
PayRate: 20
GrossPay: 800

Step 5: The product of Hours times PayRate is stored in GrossPay

The value 800 is stored in GrossPay.


START
Display message "How many hours did you work?"
Read Hours
Display message "How much do you get paid per hour?"
Read PayRate
Multiply Hours by PayRate. Store result in GrossPay.
Display GrossPay
END

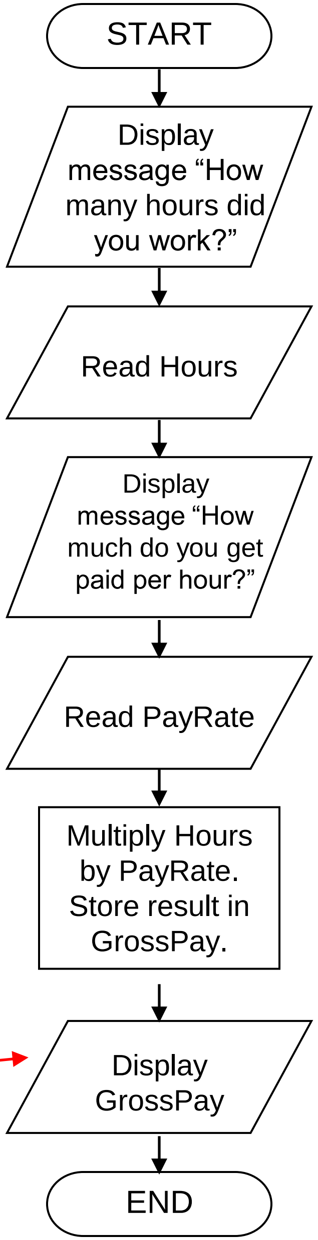
Stepping Through the Flowchart



Screen Output

Variable Contents:

Hours: 40
PayRate: 20
GrossPay: 800


START
Display message "How many hours did you work?"
Read Hours
Display message "How much do you get paid per hour?"
Read PayRate
Multiply Hours by PayRate. Store result in GrossPay.
Display GrossPay
END

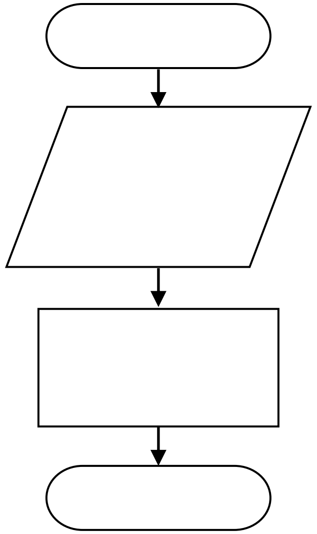
Step 6: An Output Operation

Three Flowchart Structures

- Sequence
- Selection
- Iteration

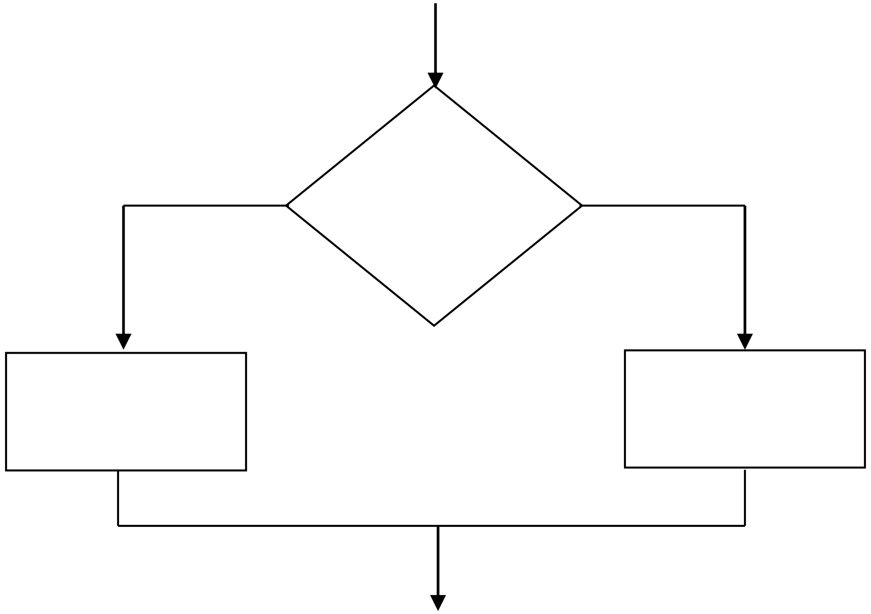
Sequence Structure

- A series of actions are performed in sequence
- The pay-calculating example was a sequence flowchart.



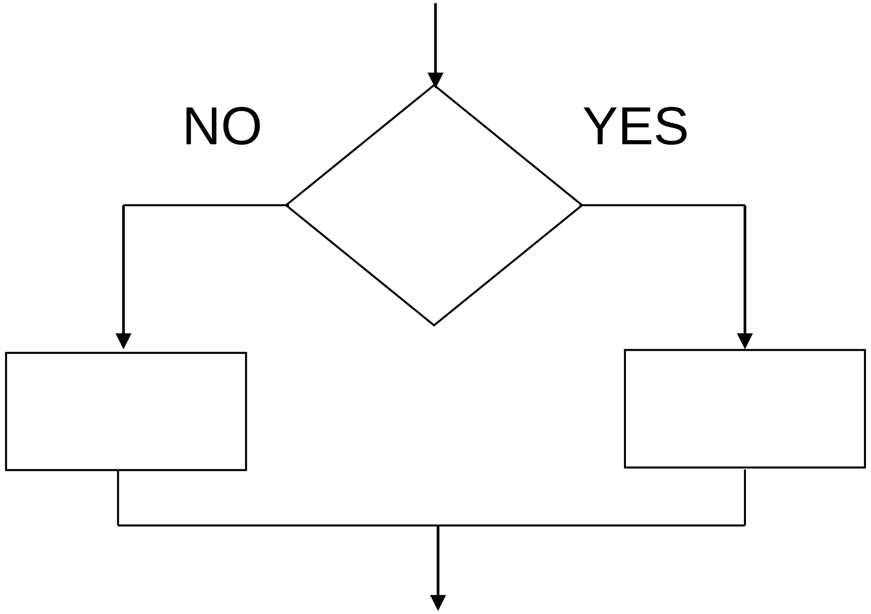
Selection Structure

- One of two possible actions is taken, depending on a condition.



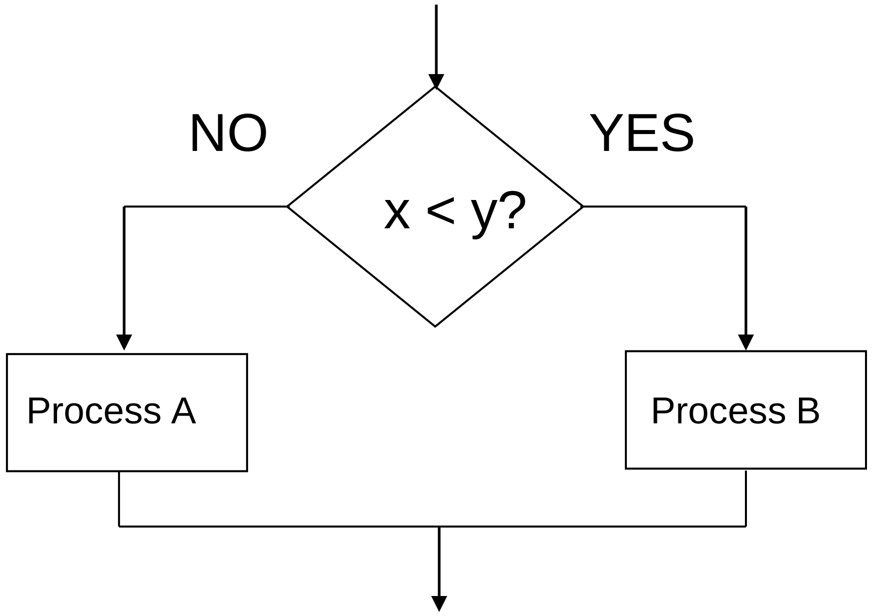
Selection Structure

- A new symbol, the **diamond**, indicates a **yes/no question**.
  - If the answer to the question is yes, the flow follows one path.
  - If the answer is no, the flow follows another path



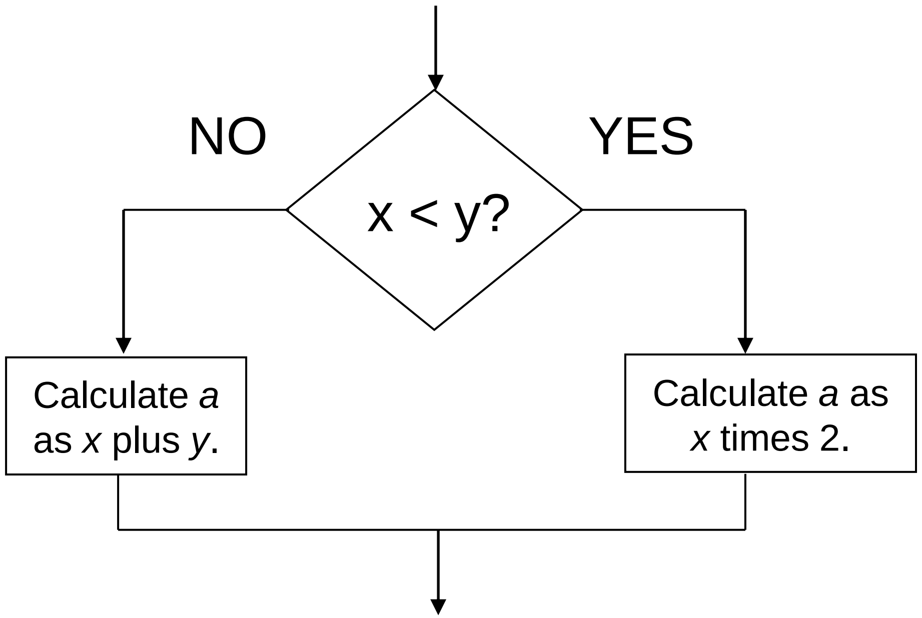
Selection Structure

- In the flowchart segment below, the question “**is x < y?**” is asked.
  - If the answer is no, then process A is performed.
  - If the answer is yes, then process B is performed.



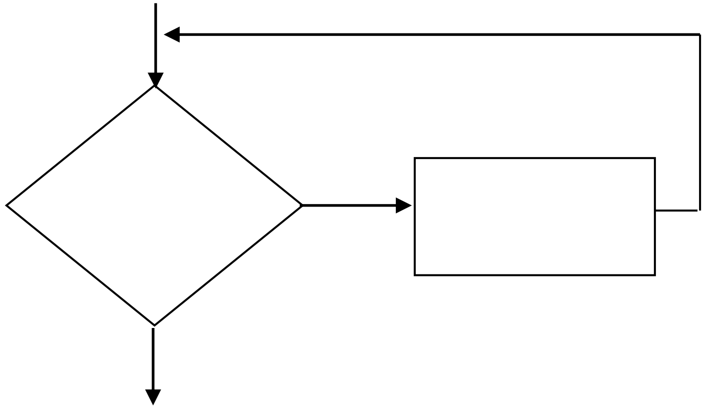
Selection Structure

- The flowchart segment below shows a decision structure is expressed in C++ as an if/else statement.



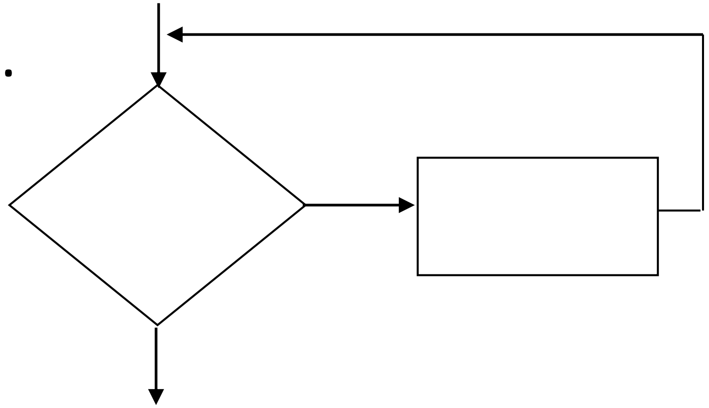
Iteration Structure

- An **iteration** structure represents part of the program that **repeats**. This type of structure is commonly known as a **loop**.



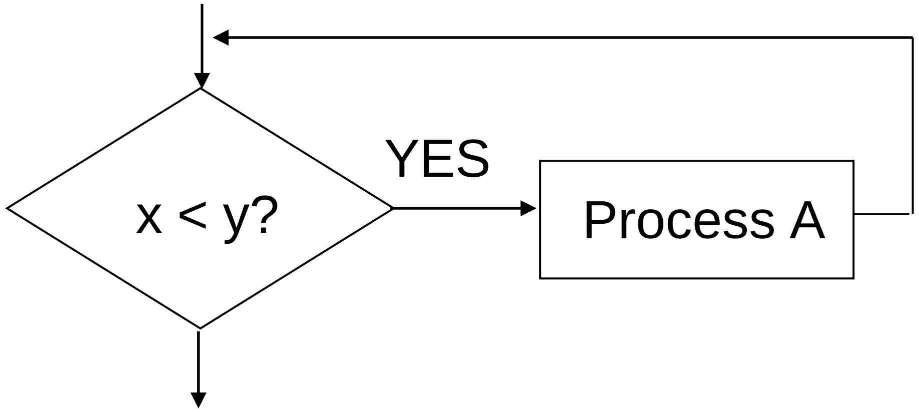
Iteration Structure

- Notice the use of the diamond symbol.
- A loop tests a condition,
  - and if the condition exists, it performs an action.
  - Then it tests the condition again. If the condition still exists, the action is repeated.
  - This continues until the condition no longer exists.



Iteration Structure

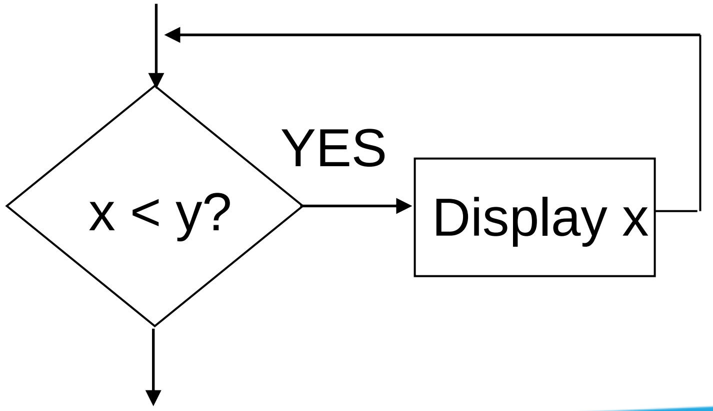
- In the flowchart segment, the question “**is x < y?**” is asked.
    - If the answer is *yes*, then **Process A** is performed.
    - The question “*is x < y?*” is asked again. Process A is repeated as long as *x* is less than *y*.
    - When *x* is no longer less than *y*, the iteration stops and the structure is exited.



Controlling an Iteration Structure

- The action performed by an iteration structure MUST eventually cause the loop to terminate.
- Otherwise, an **infinite loop** is created.

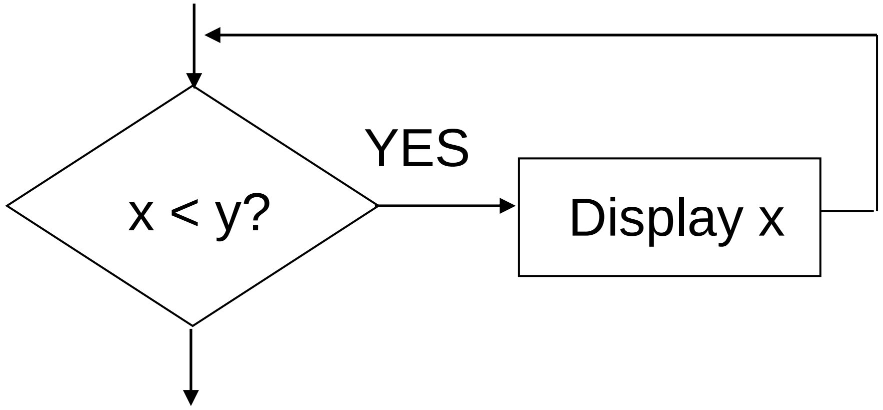
- In this flowchart segment, *x* is never changed. Once the loop starts, it will never end.



Controlling an Iteration Structure

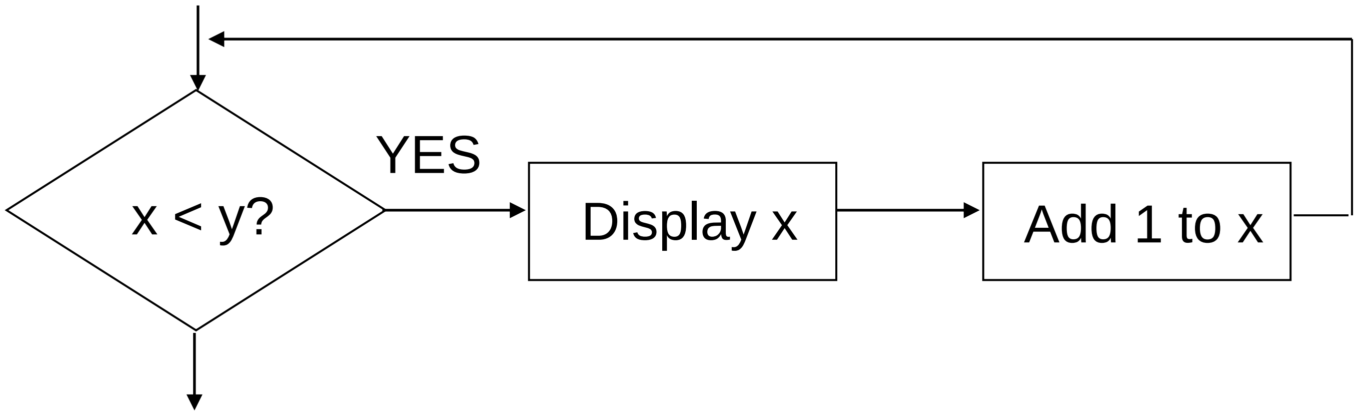
- *x* is never changed. Once the loop starts, it will never end.

- **How can this flowchart be modified so it is no longer an infinite loop?**



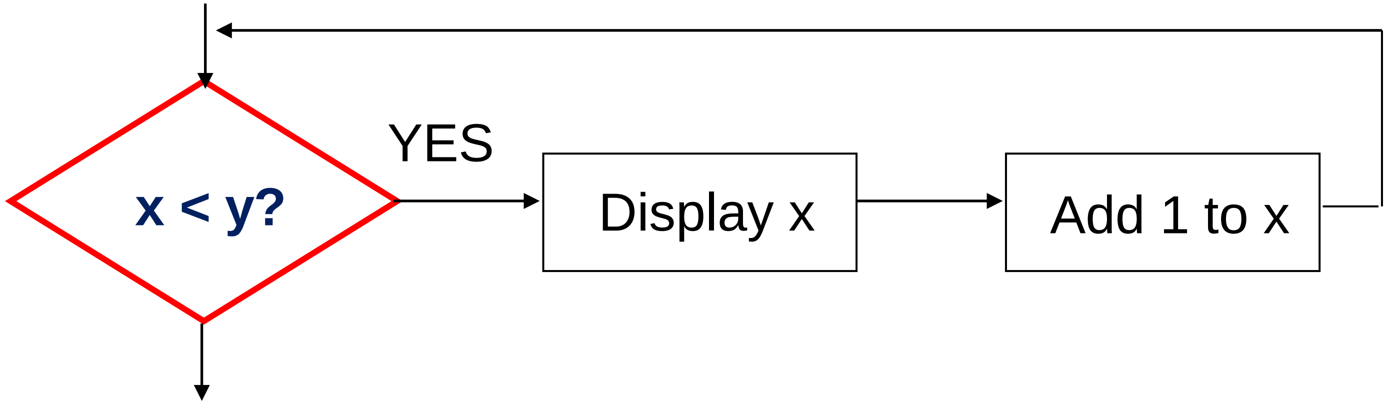
Controlling an Iteration Structure

- By adding an action within the iteration that changes the value of *x*.



A Pre-Test Iteration Structure

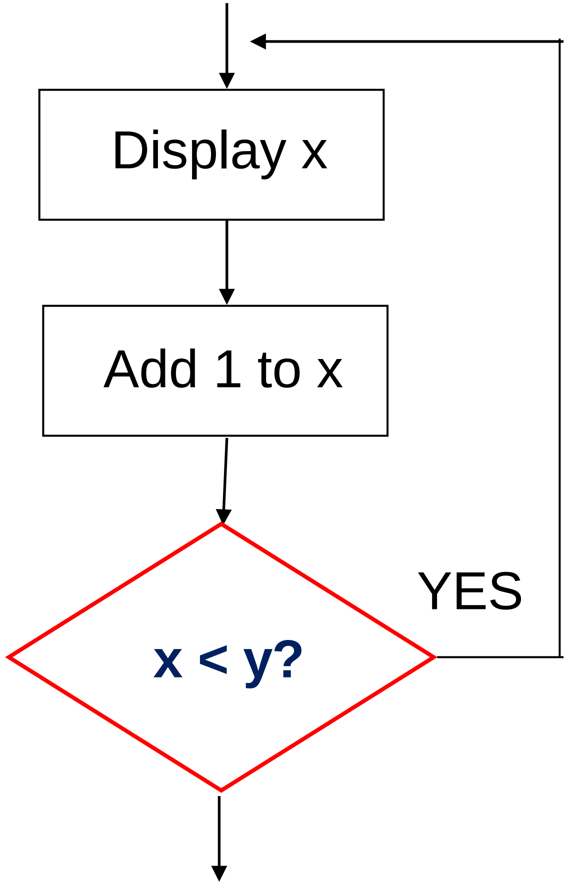
- This type of structure is known as a **pre-test iteration structure**. The condition is tested **BEFORE** any actions are performed.



- if the condition does not exist, the loop will never begin.

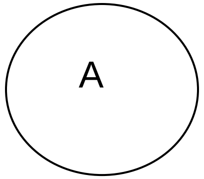
A Post-Test Iteration Structure

- This flowchart segment shows a **post-test iteration** structure.
- The condition is tested **AFTER** the actions are performed.
- A post-test iteration structure always performs its actions **at least once**.



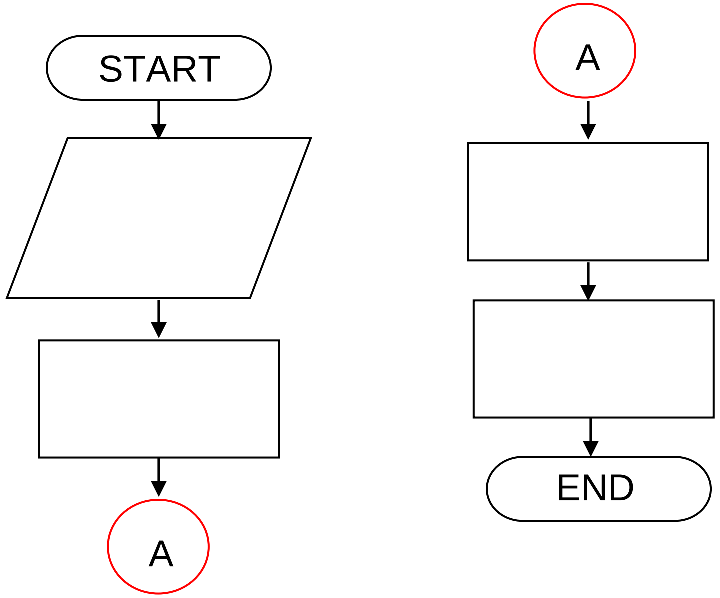
Connectors

- Sometimes a flowchart will not fit on one page.
- A **connector** (represented by a small circle) allows you to connect two flowchart segments.



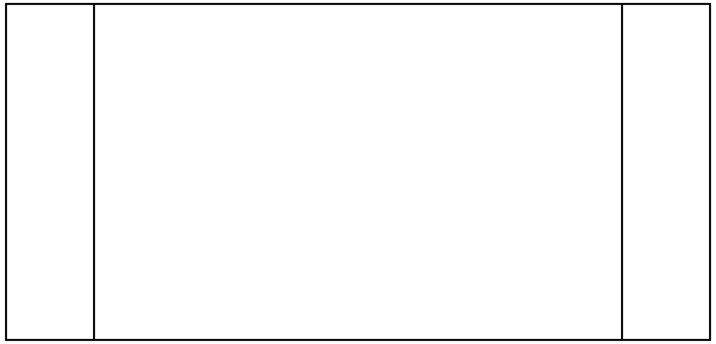
Connectors

- The “A” connector indicates that the second flowchart segment begins where the first segment ends.



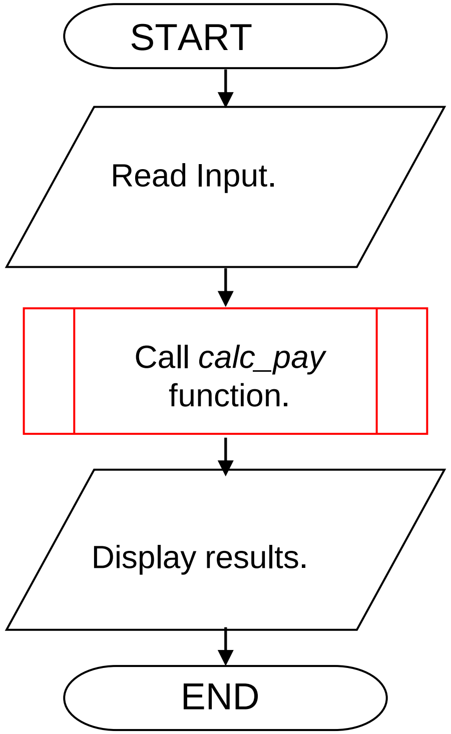
Modules

- A program module, such as a subprogram (or function in C++), is represented by a special symbol.



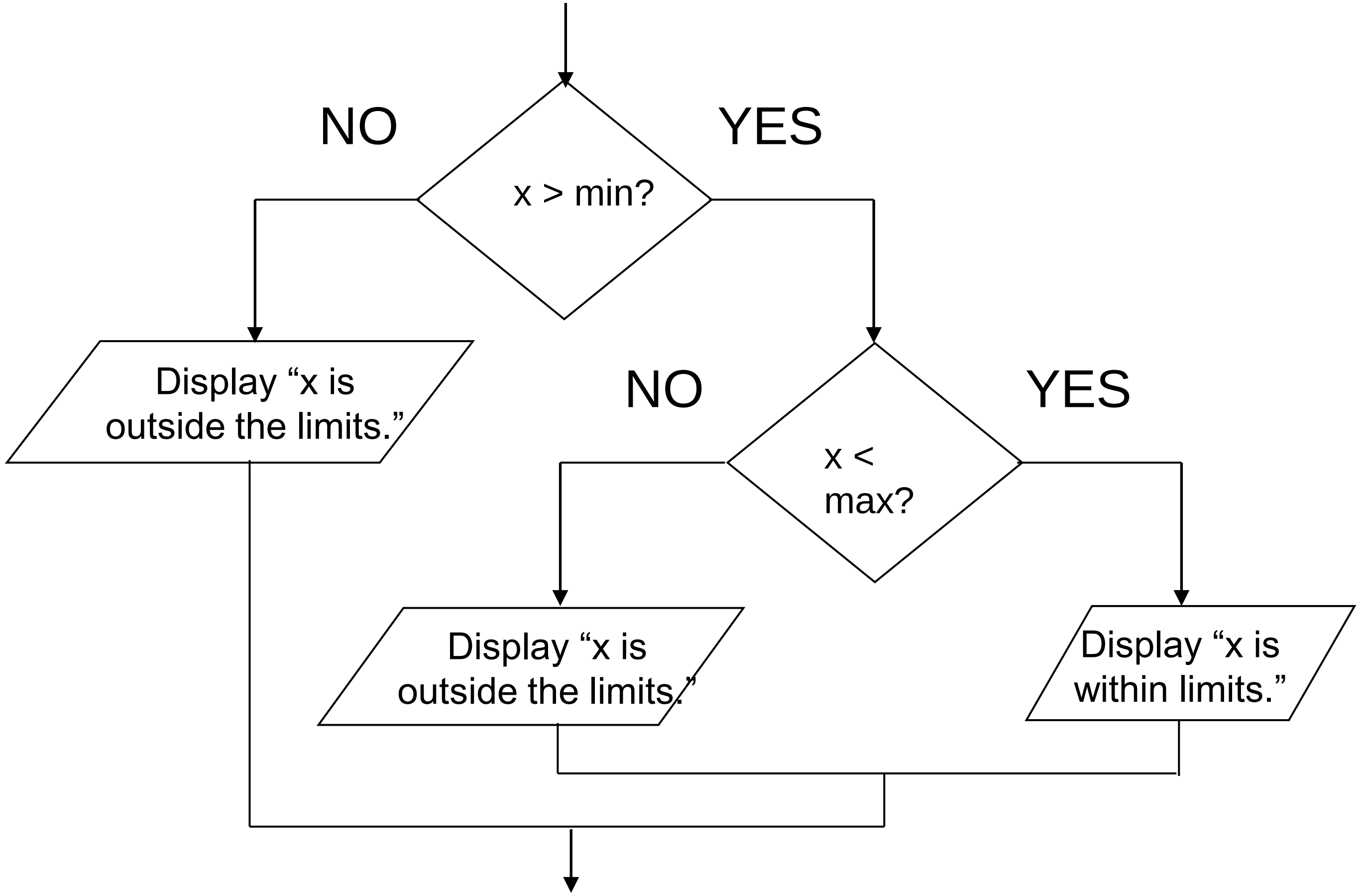
Modules

- The position of the module symbol indicates the point the module is executed.
- A separate flowchart can be constructed for the module.



Combining Structures

- This flowchart segment shows two selection structures combined.


NO
YES
x > min?
Display “x is outside the limits.”
NO
YES
x < max?
Display “x is outside the limits.”
Display “x is within limits.”

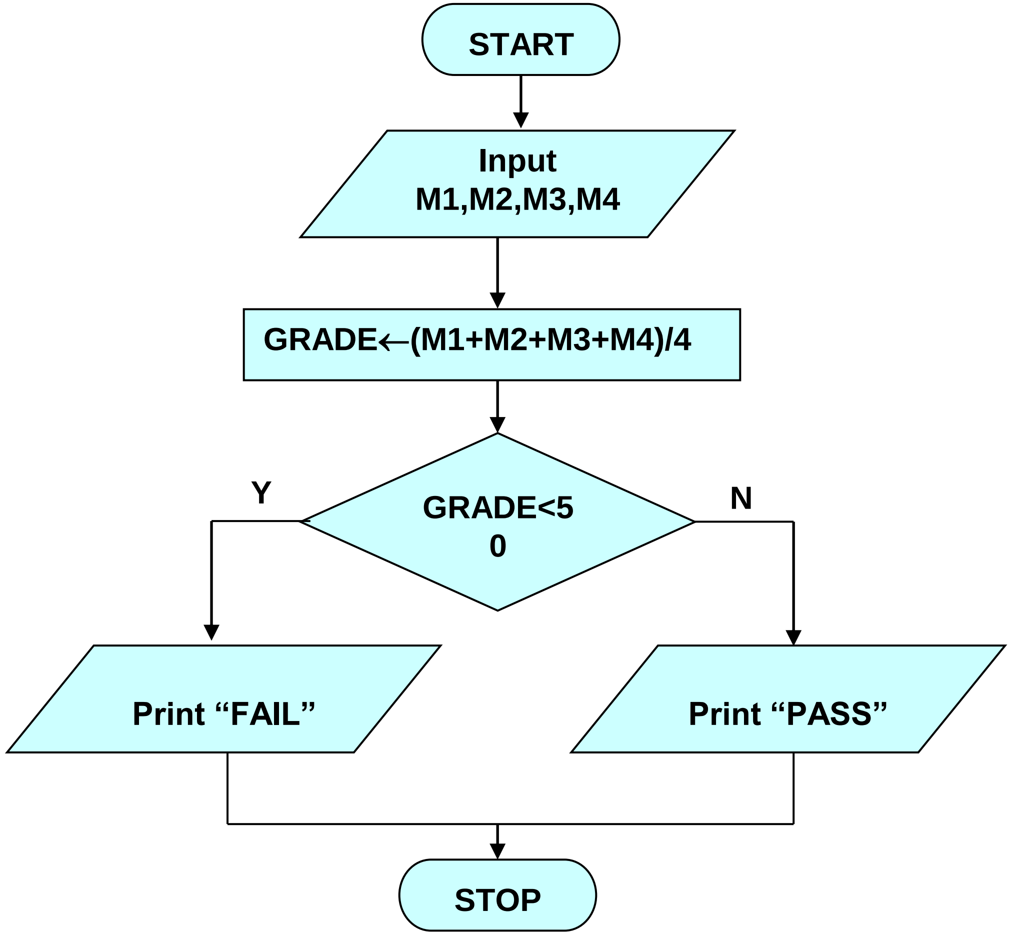
Examples

Example 01

```
Step 1:    Input M1,M2,M3,M4
Step 2:    GRADE ← (M1+M2+M3+M4)/4
Step 3:    if (GRADE <50) then
                Print “FAIL”
           else
                Print “PASS”
           endif
```

Example 01

```
Step 1:    Input M1,M2,M3,M4
Step 2:    GRADE ← (M1+M2+M3+M4)/4
Step 3:    if (GRADE <50) then
                Print "FAIL"
           else
                Print "PASS"
           endif
```



Example 02

- Write an algorithm and draw a flowchart to convert the length in feet to centimeter.

- Pseudocode:

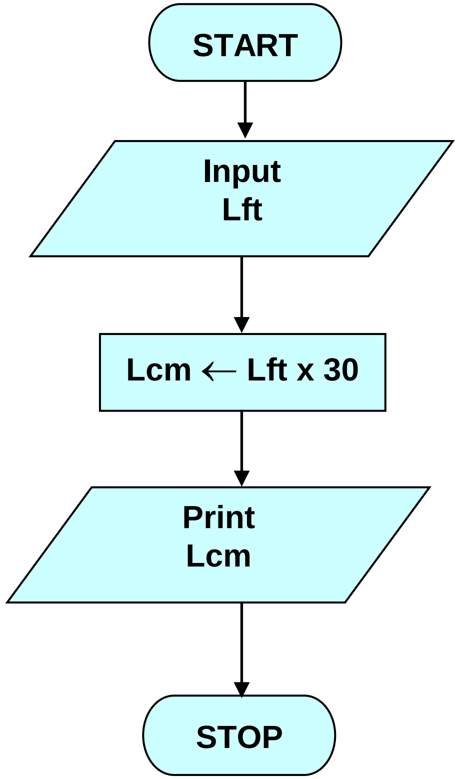
```
Input the length in feet (Lft)
Calculate the length in cm (Lcm) by multiplying Lft with 30
Print length in cm (Lcm)
```

Example 02

- Write an algorithm and draw a flowchart to convert the length in feet to centimeter.

- Pseudocode:

```
Input the length in feet (Lft)
Calculate the length in cm (Lcm) by multiplying Lft with 30
Print length in cm (Lcm)
```



Example 03

- Write an algorithm and draw a flowchart that will read the two sides of a rectangle and calculate its area.

Example 03

- Write an algorithm and draw a flowchart that will calculate the roots of a quadratic equation.

Example 03

- Write an algorithm and draw a flowchart that will calculate the roots of a quadratic equation.

- Hint:

```
d = sqrt($b^2$ - $4ac$),
if d < 0, there is no root.
    else if d == 0, x1 = x2 = -b/2a
    else the roots are:  x1 = $(-b + d)/2a$   and x2 = $(-b - d)/2a$
```

Example 04

- Write an algorithm that reads two values, determines the largest value and prints the largest value with an identifying message.

Example 05

- Write an algorithm that reads **three** numbers and prints the value of the largest number.

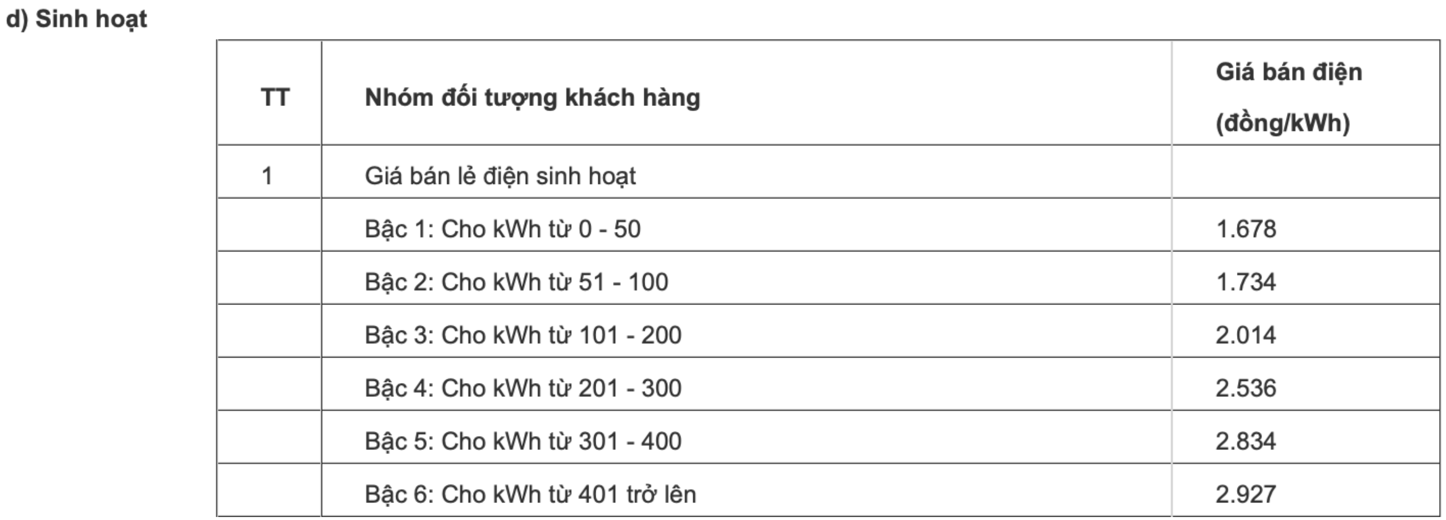
Exercises

Exercises

- Check whether an input year is a *leap* year.
  - Ref: https://en.wikipedia.org/wiki/Leap_year#Algorithm

Exercises

- ○ Electricity cost calculator:
  - Ref: https://www.evn.com.vn/c3/evn-va-khach-hang/Bieu-gia-ban-le-dien-9-79.aspx
  - Ref: https://www.evn.com.vn/c3/calc/Cong-cu-tinh-hoa-don-tien-dien-9-172.aspx



d) Sinh hoạt

TT	Nhóm đối tượng khách hàng	Giá bán điện (đồng/kWh)
1	Giá bán lẻ điện sinh hoạt	
	Bậc 1: Cho kWh từ 0 - 50	1.678
	Bậc 2: Cho kWh từ 51 - 100	1.734
	Bậc 3: Cho kWh từ 101 - 200	2.014
	Bậc 4: Cho kWh từ 201 - 300	2.536
	Bậc 5: Cho kWh từ 301 - 400	2.834
	Bậc 6: Cho kWh từ 401 trở lên	2.927

Questions and Answers