COMPSCI 105/119/120: Programming, Flowcharting, and Running Program Flowcharts

Programs are:

- **Source code** written in a text editor,
- Following the syntax of a **language**,
- Specifying both memory locations (**variables**) and instructions (**statements**),
- That must be translated into a form the computer can actually use (often **binary instructions** directly executable by the CPU).

Translators

- Assemblers
  – Translate very low-level statements into binary instructions (1→1), creating stand-alone .EXE files.
- Compilers
  – Translate high-level statements into many binary instructions (1→many), creating stand-alone .EXE files.
- Interpreters
  – Translates and executes each statement as it is encountered, requiring translator to run programs.

Errors

- Syntax Errors
  – Violations of the rules of the language
- Run-Time Errors (Bugs)
  – Computations giving the wrong results
  – Computations halting the program (unchecked divide-by-zero, for example)
- Both require editing the source text of the program, retranslating it, and trying again.

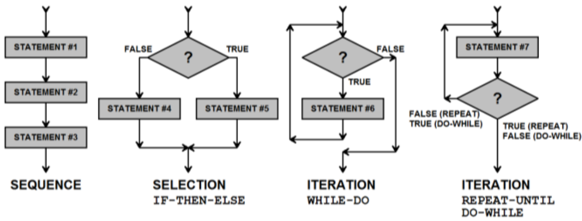
Languages

- Early compiled languages (FORTRAN, COBOL, ALGOL, PL/I) from the 1950s and 1960s.
- Later compiled languages (Pascal, C, C++, Ada) from the 1970s and 1980s.
- Early interpreted languages (BASIC, LISP, APL) from the 1960s.
- Later interpreted languages (Python, JavaScript, Perl, many scripting languages for Web servers)
- Modern languages compiled to a "generic" computer model, then interpreted by a virtual machine (Java)

Flowcharts

- Provide a visual, non-language-specific way of describing a program,
- Used to be how programmers designed programs in the first place,
- Are a good teaching tool to illustrate how programs work.

Statements (Flowchart)

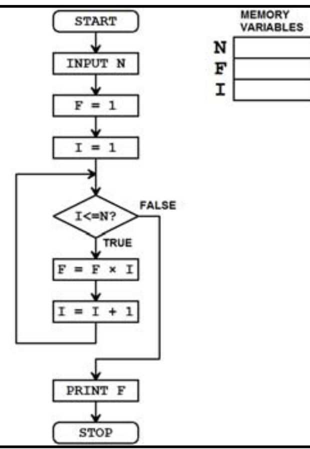


Example: Factorial

- The factorial of an integer N is the product of all integers from 1 up through N.
- N factorial is written as N!
- N! = 1 × 2 × 3 × … × N (iterative definition)
- N! = N × (N-1)! (recursive definition)
- 0! = 1 (makes recursion work)
- 5! = 1 × 2 × 3 × 4 × 5 = 120

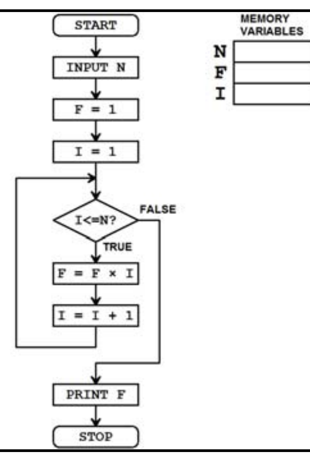
Flowcharts

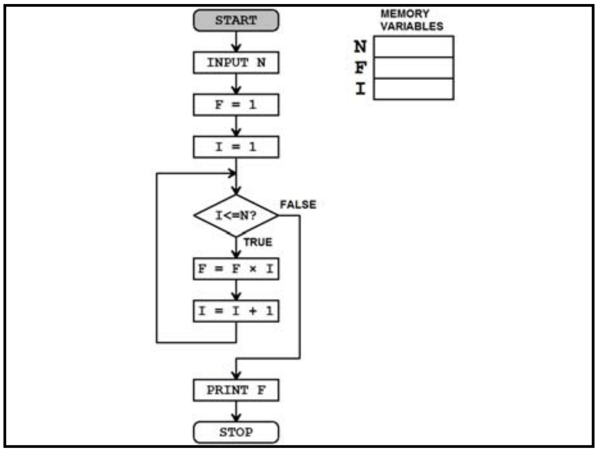
- Here's the flowchart version of the factorial program:

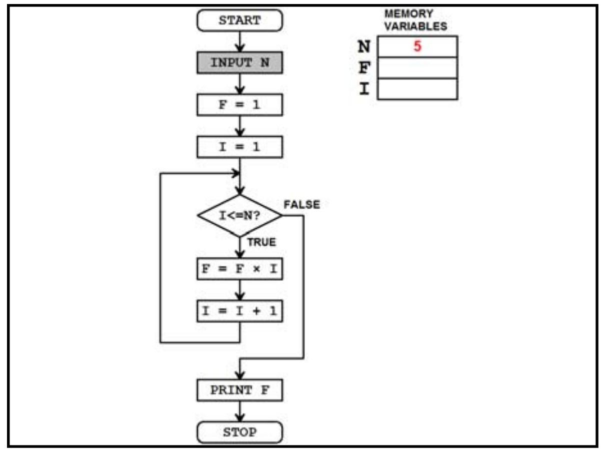


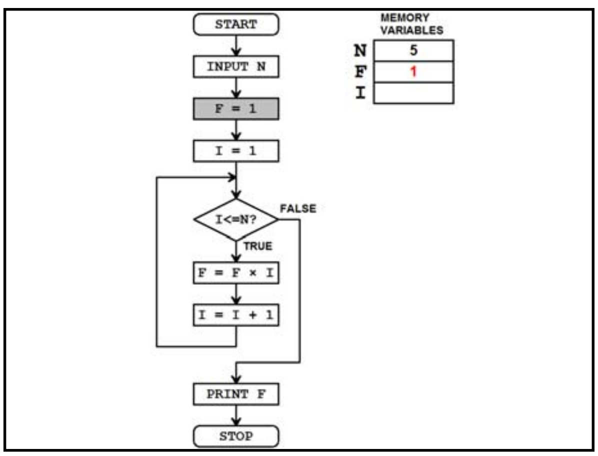
Tracing Flowcharts

- Put your finger on the START box,
- Follow the flow-arrows,
- When you enter a box do what it says,
- Update the variables appropriately,
- Don't take your finger off until you hit STOP.




START
INPUT N
F = 1
I = 1
I<=N?
FALSE
TRUE
F = F × I
I = I + 1
PRINT F
STOP
MEMORY VARIABLES
N
F
I


START
INPUT N
F = 1
I = 1
I<=N?
FALSE
TRUE
F = F × I
I = I + 1
PRINT F
STOP
MEMORY VARIABLES
N 5
F
I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TRUE
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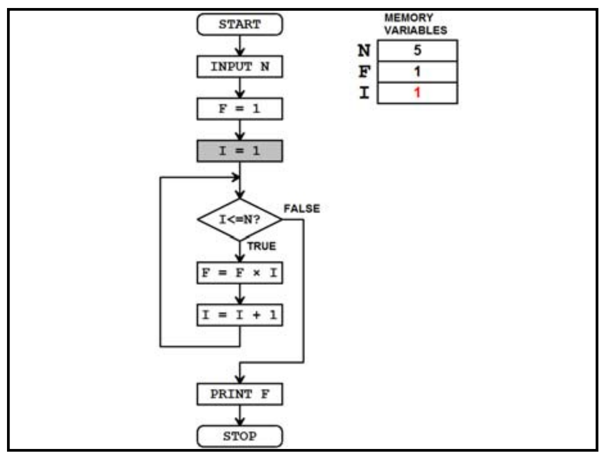
PRINT F
STOP
MEMORY VARIABLES
N 5
F 1
I


START
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FALSE
TRUE
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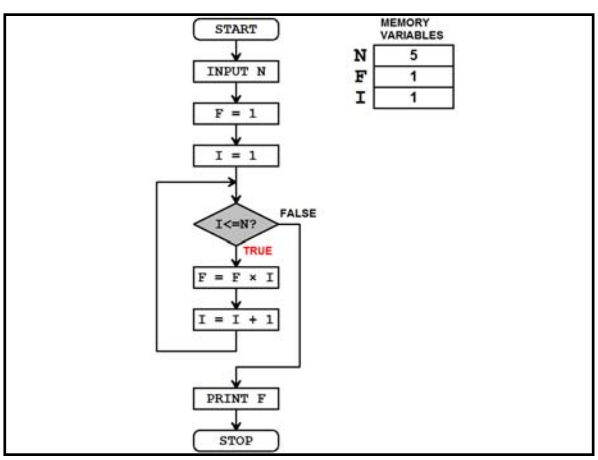
PRINT F
STOP
MEMORY VARIABLES
N 5
F 1
I 1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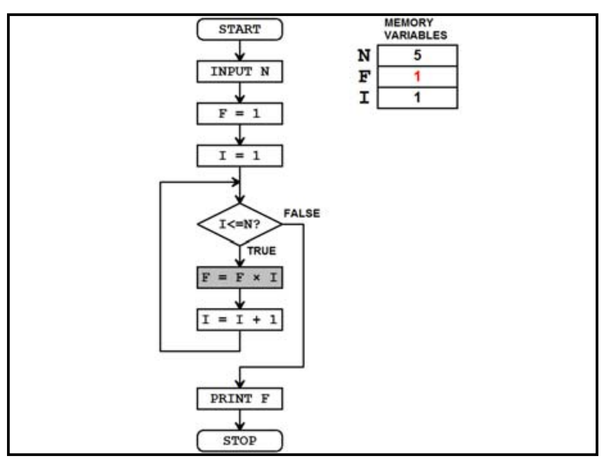
MEMORY VARIABLES
N 5
F 1
I 1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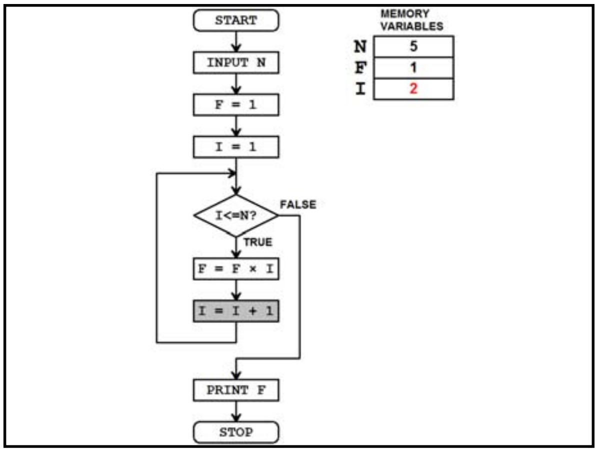
MEMORY VARIABLES
N 5
F 1
I 1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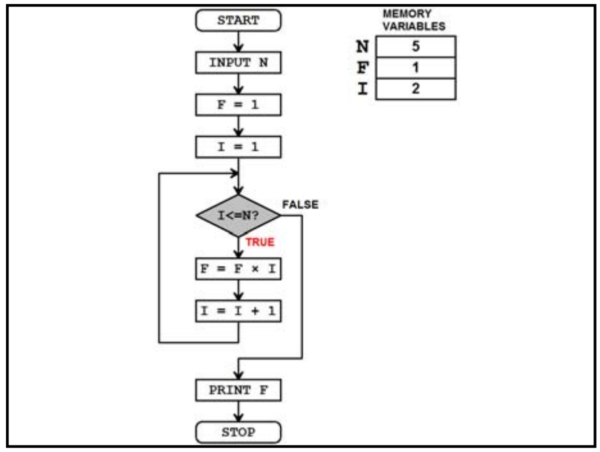
STOP
MEMORY VARIABLES
N 5
F 1
I 2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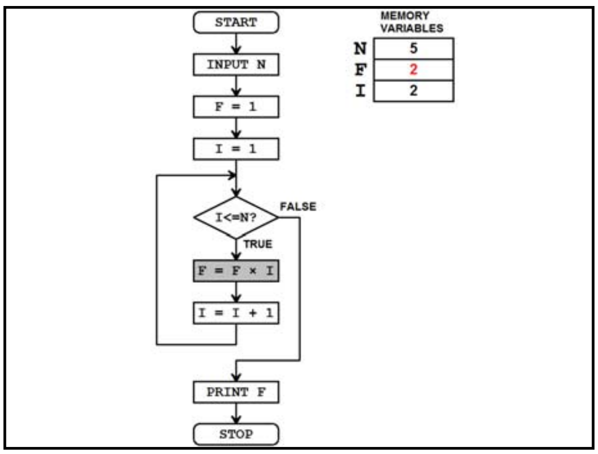
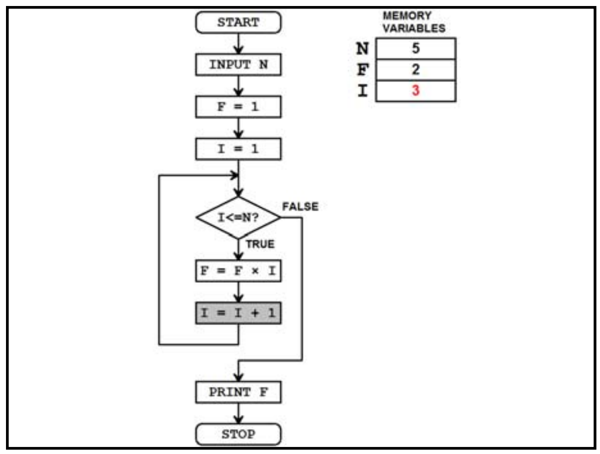
MEMORY VARIABLES
N 5
F 1
I 2


START
INPUT N
F = 1
I = 1
I<=N?
FALSE
TRUE
F = F × I
I = I + 1
PRINT F
STOP
MEMORY VARIABLES
N 5
F 2
I 2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F = 1
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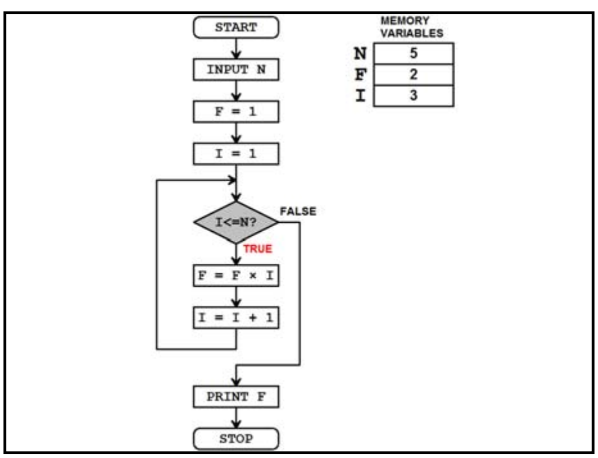
I = I + 1
PRINT F
STOP
MEMORY VARIABLES
N 5
F 2
I 3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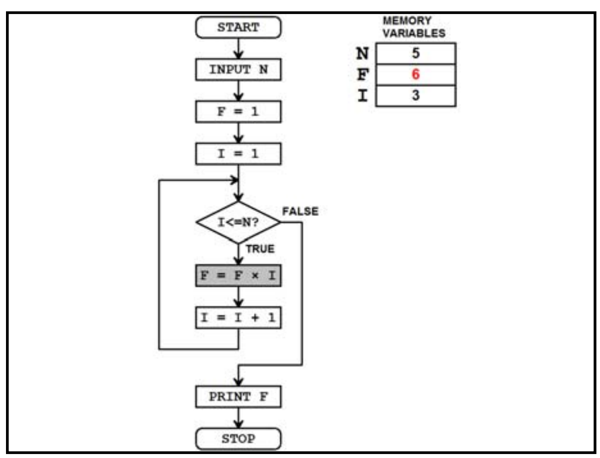
I 3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INPUT N
F = 1
I = 1
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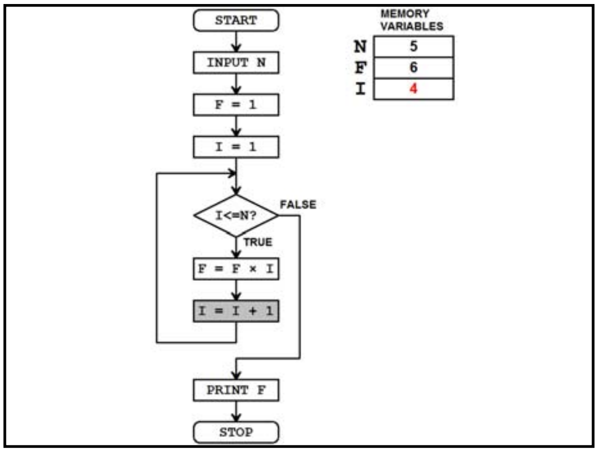
FALSE
TRUE
F = F × I
I = I + 1
PRINT F
STOP
MEMORY VARIABLES
N 5
F 6
I 3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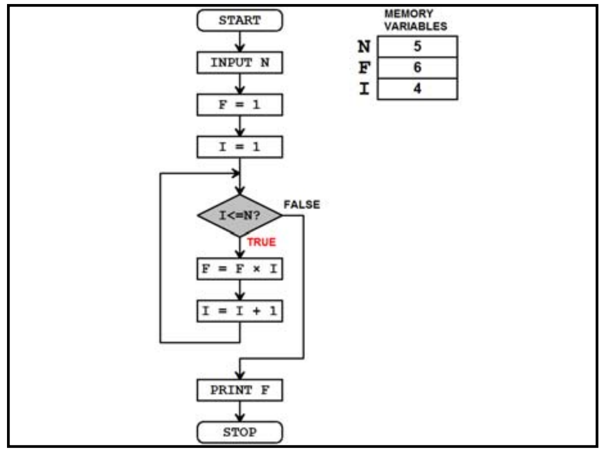
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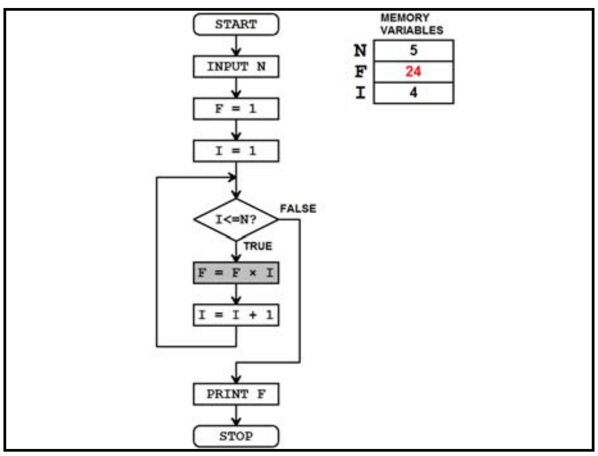
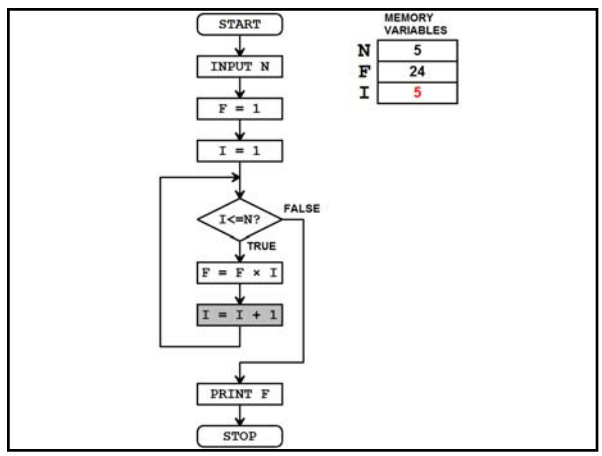

START
INPUT N
F = 1
I = 1
I<=N?
FALSE
TRUE
F = F × I
I = I + 1
PRINT F
STOP
MEMORY VARIABLES
N 5
F 24
I 4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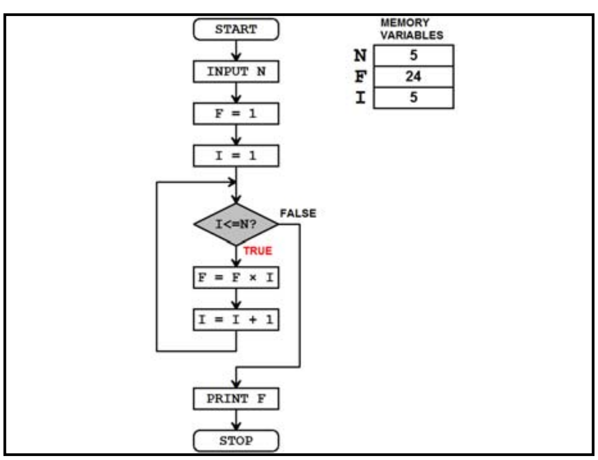
N 5
F 24
I 5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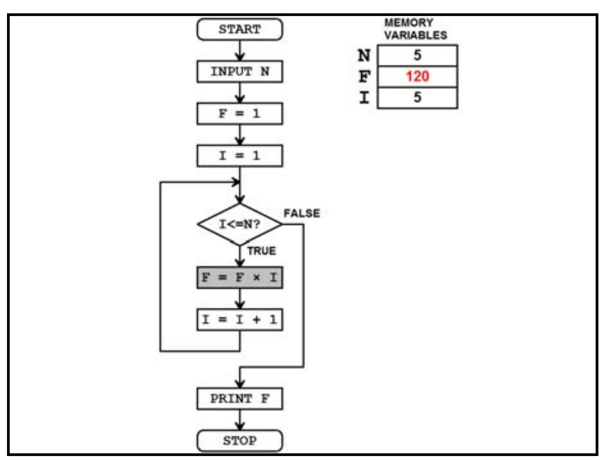
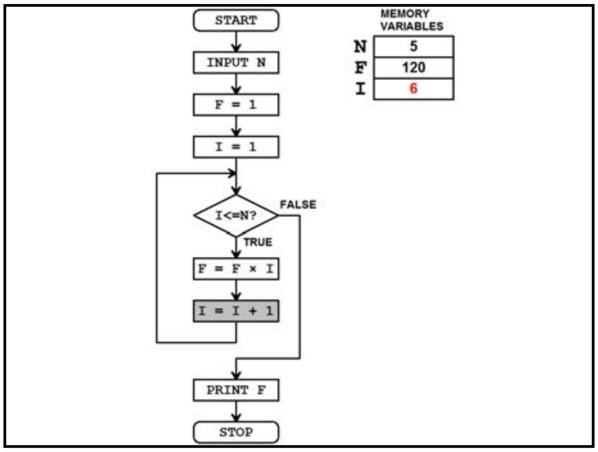
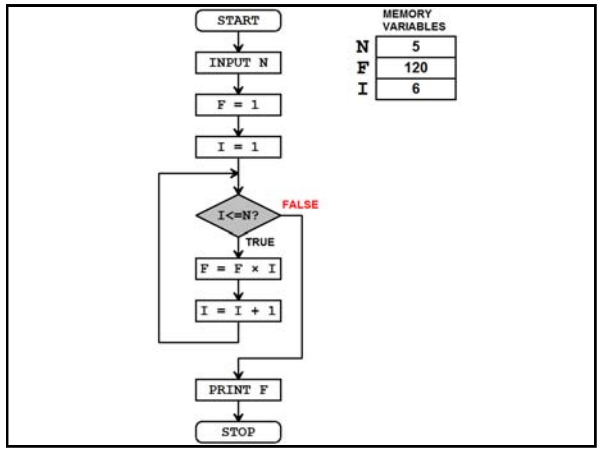
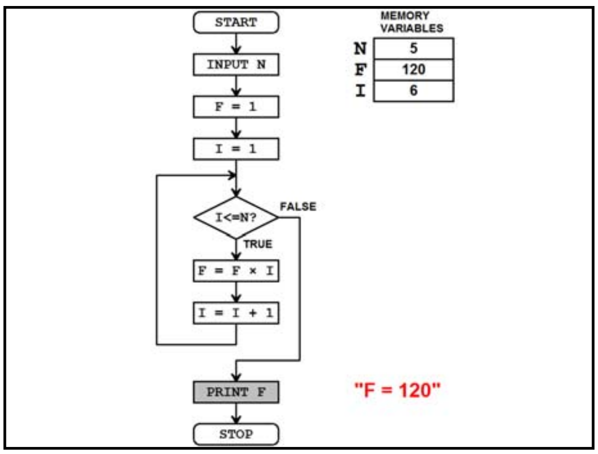
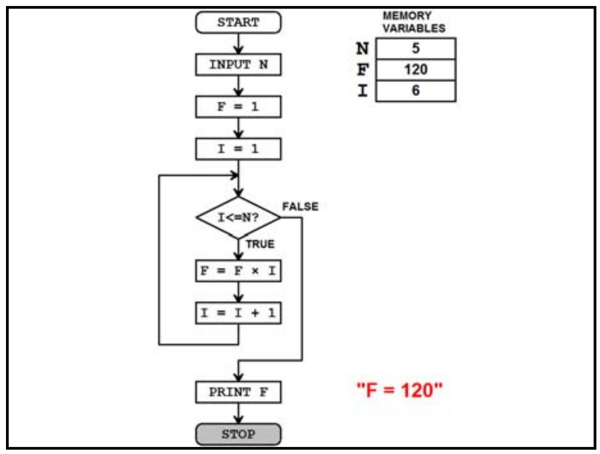
I = 1
I<=N?
FALSE
TRUE
F = F × I
I = I + 1
PRINT F
STOP
MEMORY VARIABLES
N 5
F 24
I 5


START
INPUT N
F = 1
I = 1
I<=N?
FALSE
TRUE
F = F × I
I = I + 1
PRINT F
STOP
MEMORY VARIABLES
N 5
F 120
I 5









What Does This Give Us?

- By following a flowchart, we see how computers execute their programs,
- We also see how detailed programs must be to accomplish any task,
- But computers do each step extremely fast (on the order of a few nanoseconds).

Programs may be written in Different Ways:

- Some are shorter
- Some are faster
- Some use less memory
- Some use bizarre techniques
- Some are easier to teach
- Some are easier to debug
- Some languages are easier than others

The Factorial Program in Python 3

```
N = int(input("Enter Number: "))
F = 1
I = 1
while (I <= N):
    F = F * I
    I = I + 1
print (F)
```


Here's the same program in JavaScript (embedded in HTML Web Page)

```
<SCRIPT TYPE="text/javascript">
    <!--
        N = parseFloat(window.prompt(
                     "Enter Number: ")) ;
        F = 1 ;
        I = 1 ;
        while (I <= N) {
            F = F * I ;
            I = I + 1 ;
        }
        document.writeln (F) ;
    //-->
</SCRIPT>
```


Here's the same program in Pascal

```
Program Factorial ;
    Var N,F,I : Integer ;
Begin
    Write ('Enter Number: ') ;
    Readln(N) ;
    F := 1 ;
    I := 1 ;
    While (I <= N) Do
        Begin
            F := F * I ;
            I := I + 1 ;
        End ;
    Writeln (F) ;
End.
```


Here's the same program in BASIC

```
10 INPUT N
20 LET F = 1
30 LET I = 1
40 IF I > N THEN 80
50 LET F = F * I
60 LET I = I + 1
70 GOTO 40
80 PRINT F
90 END
```


Here's the same program in 8088 Assembly Language

```
          MOV  AX,1     ; F=1
          MOV  BX,5     ; N=5
          MOV  CX,1     ; I=1
TopLoop:  CMP  CX,BX    ; Test I:N
          JG   EndLoop  ; Jump if >
          MUL  CX       ; F=F*I
          ADD  CX,1     ; I=I+1
          JMP  TopLoop  ; Jump back
EndLoop:  CALL PRINT    ;
```


Languages (1/3)

- Python:
  - Interpreted,
  - Dynamically Typed,
  - One statement per line,
  - Whitespace (indentation) determines lexical scope.
- JavaScript (not Java):
  - Interpreted (typically by Web browser),
  - Dynamically Typed,
  - Statements terminated by semicolons (**;**),
  - Curly braces (**{}**) determine lexical scope.

Languages (2/3)

- Pascal:
  - Compiled,
  - Statically Typed,
  - Statements separated by semicolons (**;**)
  - Keywords (**Begin-End**) determine lexical scope.
- BASIC (as originally implemented):
  - Interpreted,
  - Statically Typed (suffixes carry type: **A**, **A$**, **A%**),
  - One statement per line,
  - What lexical scope?

Languages (3/3)

- Java (not JavaScript):
  - Compiled to intermediate form interpreted by JVM,
  - Statically Typed,
  - Statements terminated by semicolons (**;**)
  - Curly braces (**{}**) determine lexical scope.
- Assembly Language:
  - Assembled (for particular machine architecture),
  - Instructions carry type (**ADD** vs. **FADD**),
  - One statement per line,
  - What lexical scope?

The Factorial Program in Python 3 Again

```
N = int(input("Enter Number: "))
F = 1
I = 1
while (I <= N):
    F = F * I
    I = I + 1
print (F)
```


Here's a more efficient way

```
N = int(input("Enter Number: "))
F = 1
for I in range(1,N+1): F = F * I
print (F)
```


Here's a radically different way:

```
def Factorial(N):
    if (N <= 1): return 1
    else return N*Factorial(N-1)

N = int(input("Enter Number: "))
print (Factorial(N))
```


On the 105 Final Exam…

- I will provide a flowchart of roughly this complexity (but not the same program),
- I will provide boxes for each of the variables,
- You will trace the flowchart and determine the final results.
- I will NOT ask you to draw a flowchart.