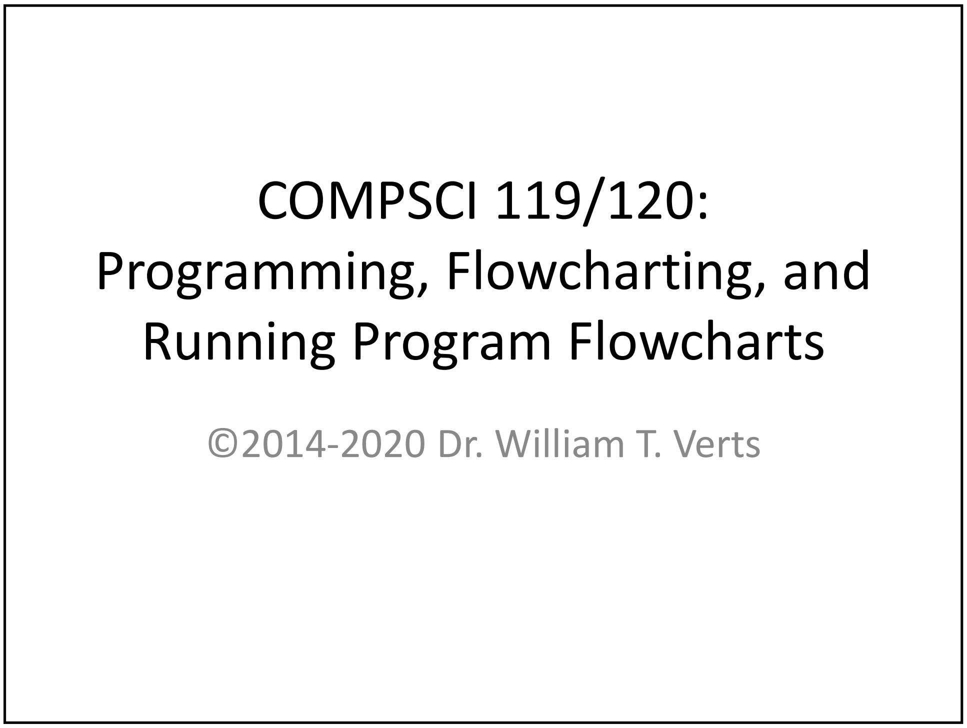
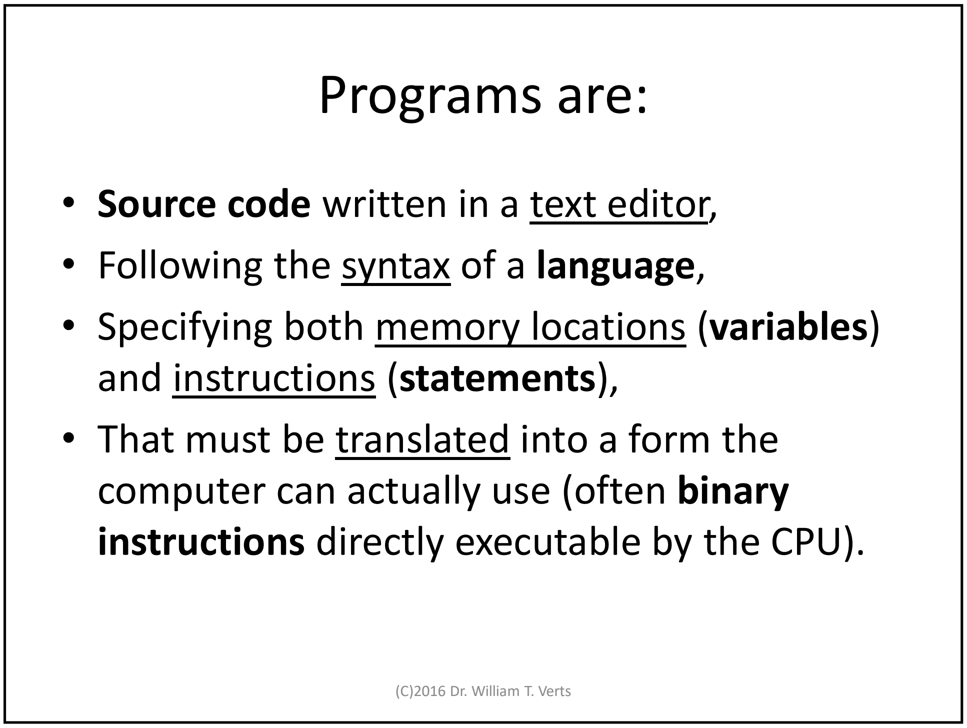


COMPSCI 119/120: Programming, Flowcharting, and Running Program Flowcharts

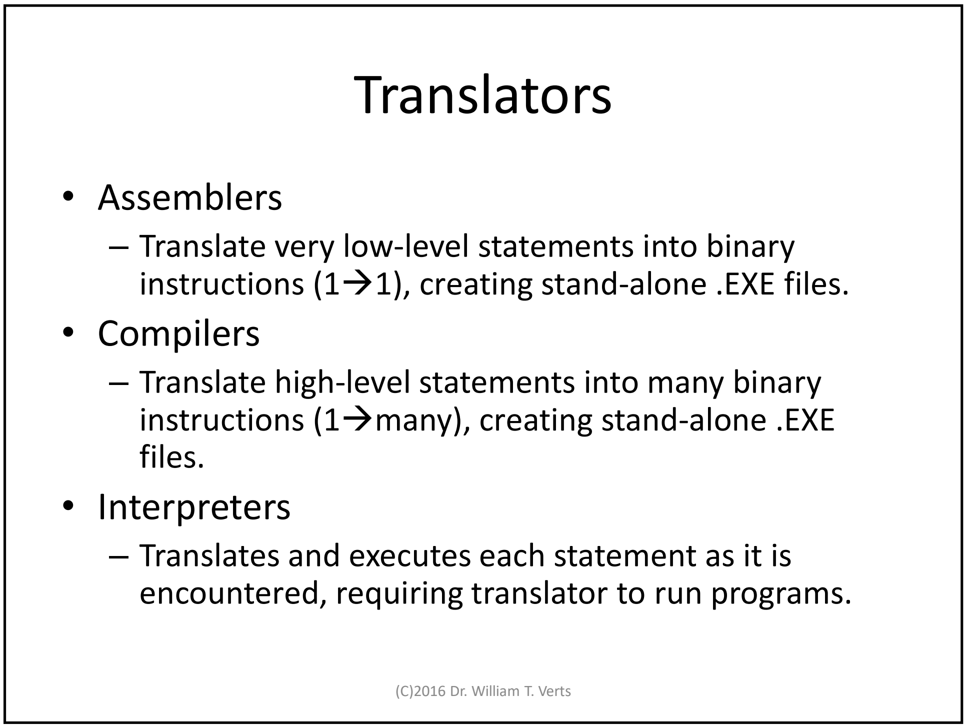
1



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).

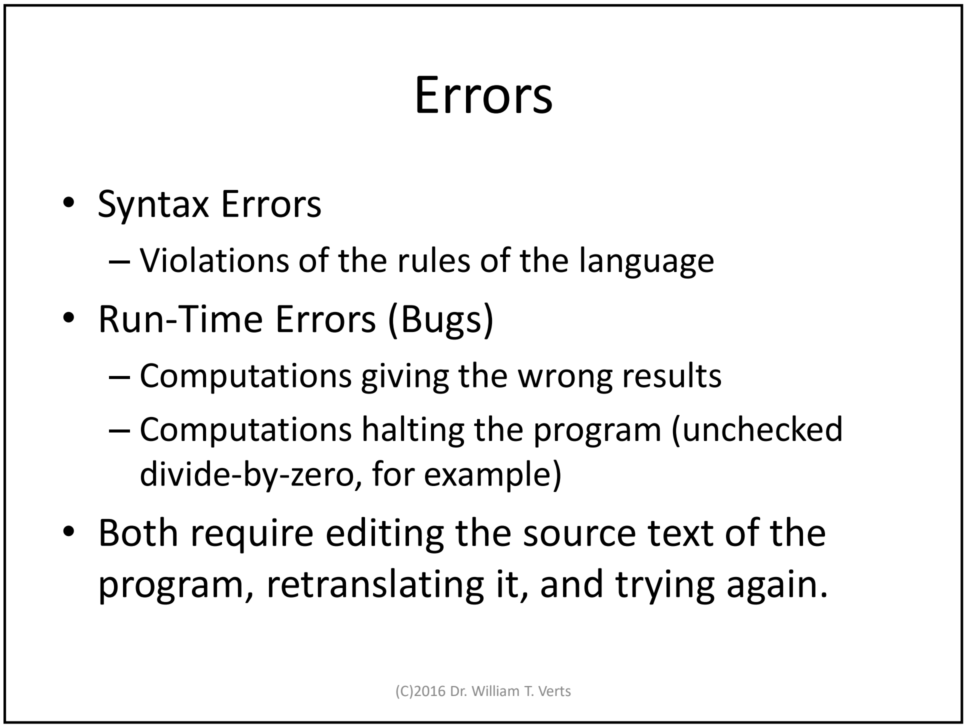
2



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.

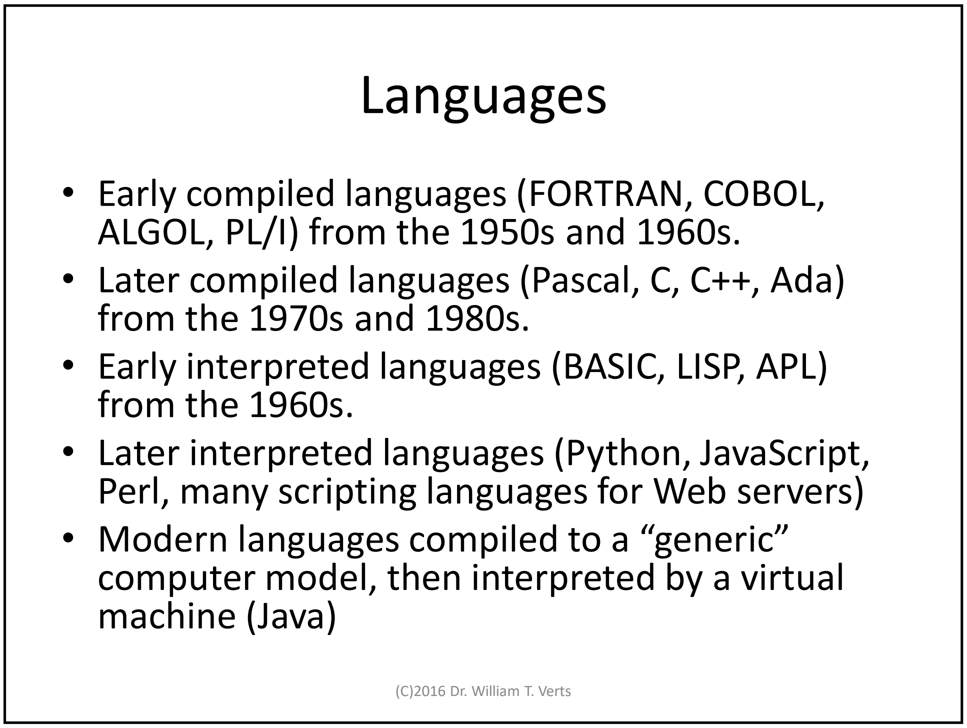
3



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.

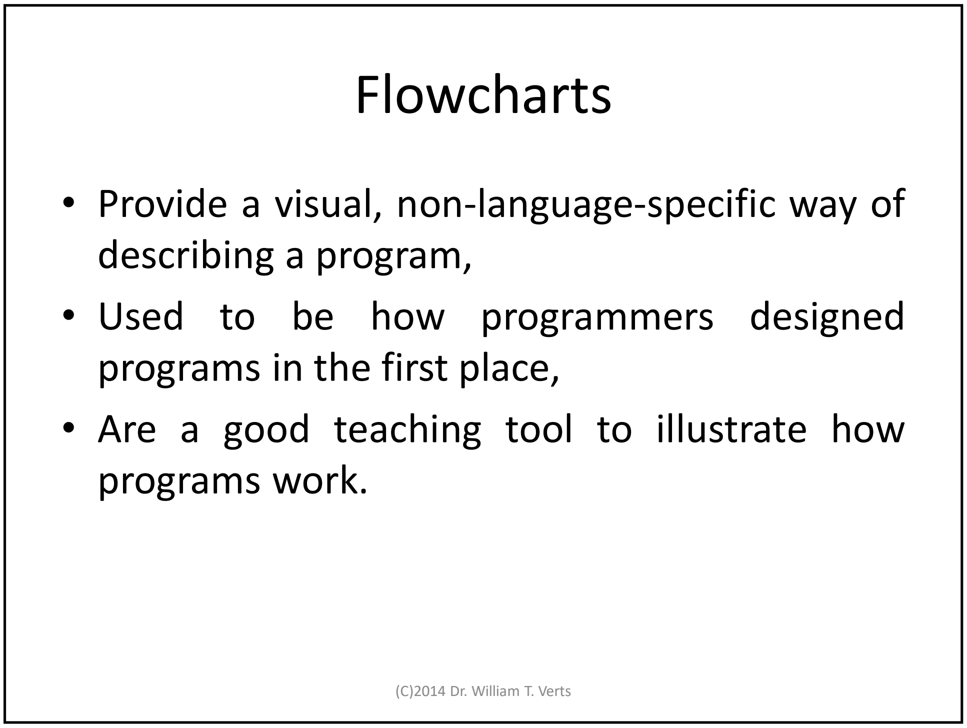
4



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)

5

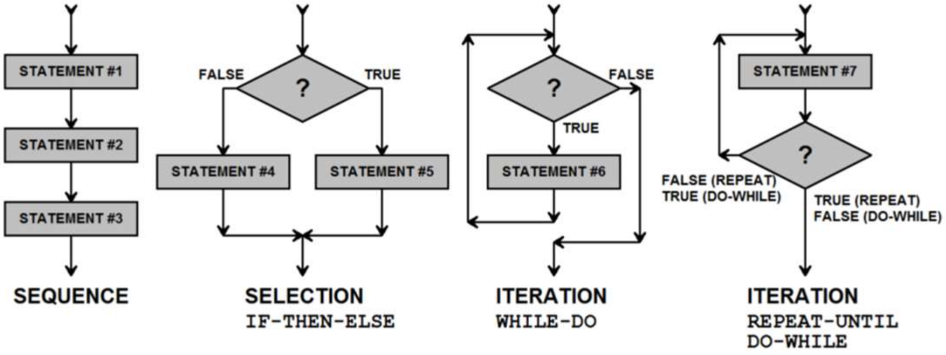


Flowcharts

- 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.

6

Statements (Flowchart)



7

Example: Factorial

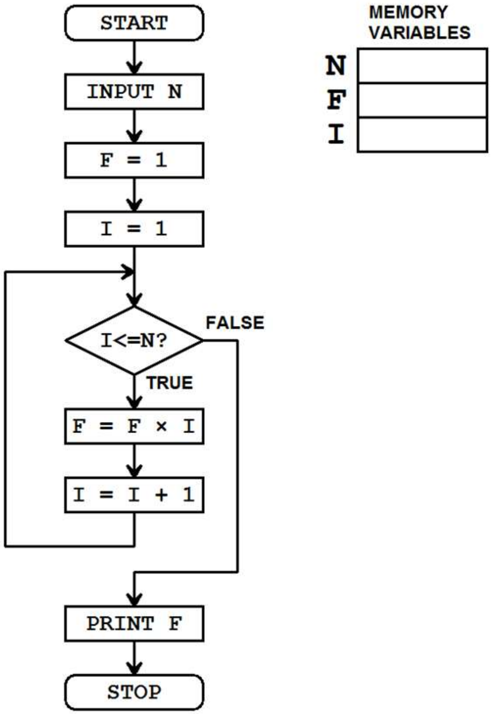
- The factorial of an integer N is the product of all integers from 1 up through N.
- N factorial is written as N!
- N! = 1 × 2 × 3 × … × N (iterative definition)
- N! = N × (N-1)! (recursive definition)
- 0! = 1 (makes recursion work)
- 5! = 1 × 2 × 3 × 4 × 5 = 120

8

Flowcharts

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

9

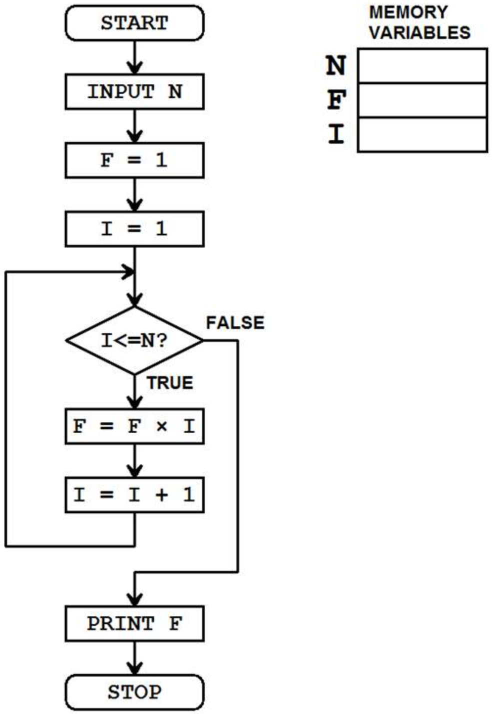


10

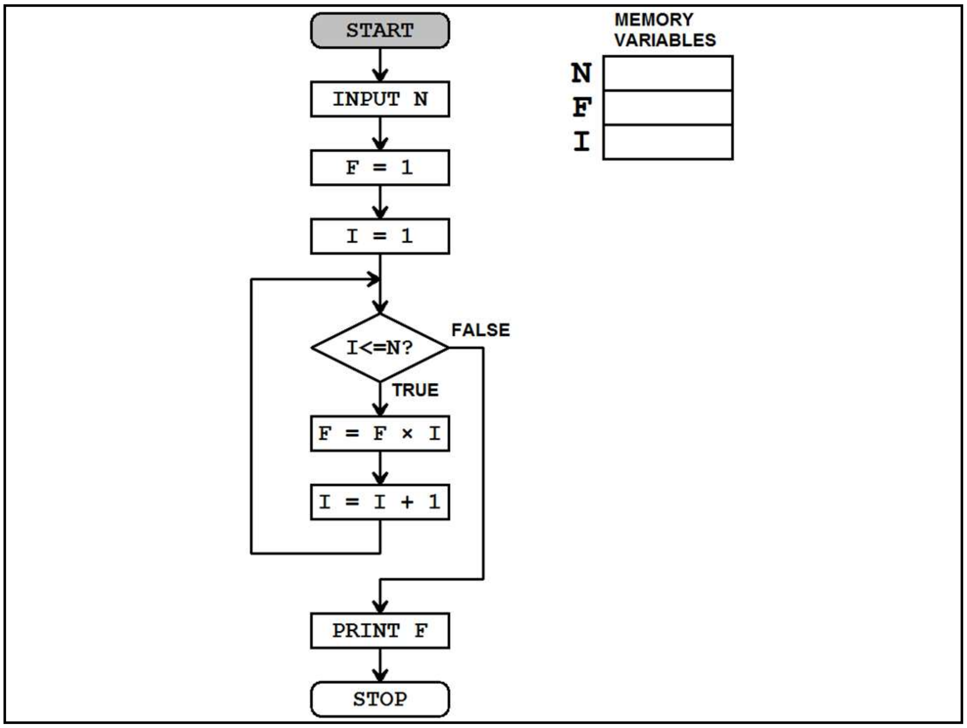
Tracing Flowcharts

- 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.

11



12



START

INPUT N

F = 1

I = 1

I<=N?

FALSE

TRUE

F = F × I

I = I + 1

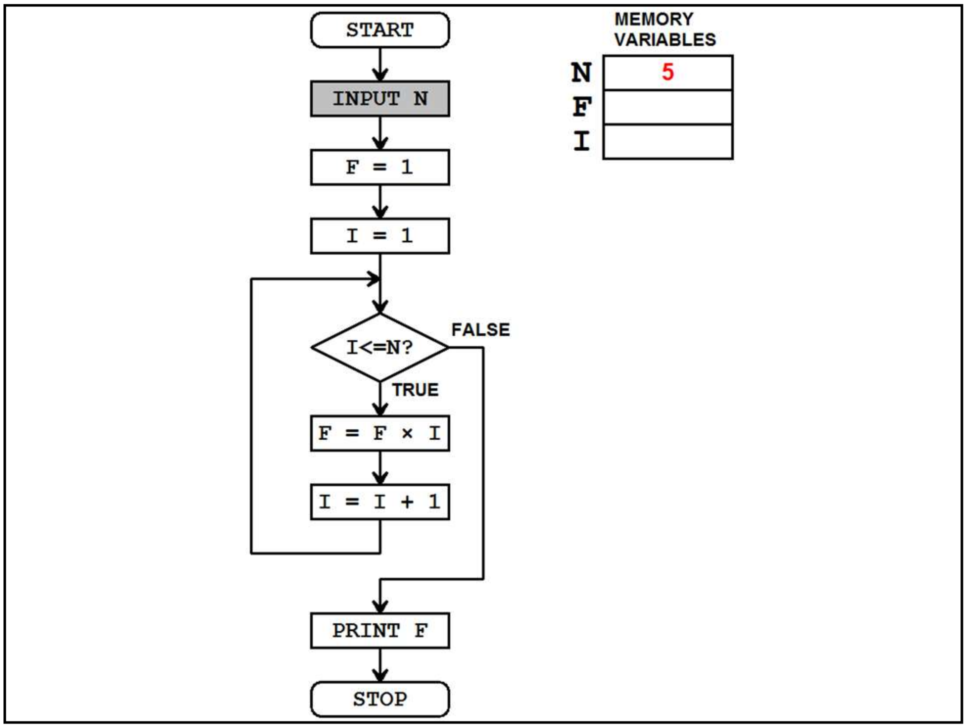
PRINT F

STOP

MEMORY VARIABLES

N	
F	
I	

13



START

INPUT N

F = 1

I = 1

I<=N?

FALSE

TRUE

F = F × I

I = I + 1

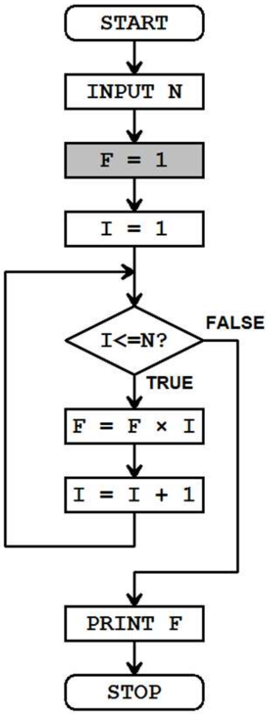
PRINT F

STOP

MEMORY VARIABLES

N	5
F	
I	

14



START

INPUT N

F = 1

I = 1

I<=N?

FALSE

TRUE

F = F × I

I = I + 1

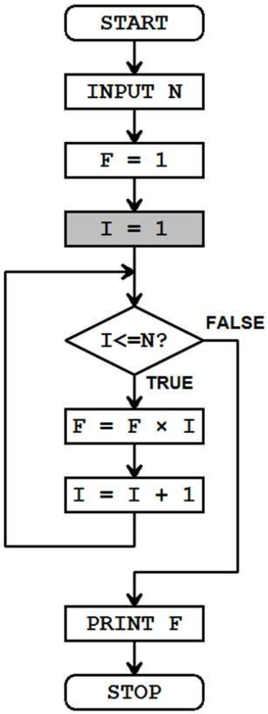
PRINT F

STOP

MEMORY VARIABLES

N	5
F	1
I	

15



START

INPUT N

F = 1

I = 1

I<=N?

FALSE

TRUE

F = F × I

I = I + 1

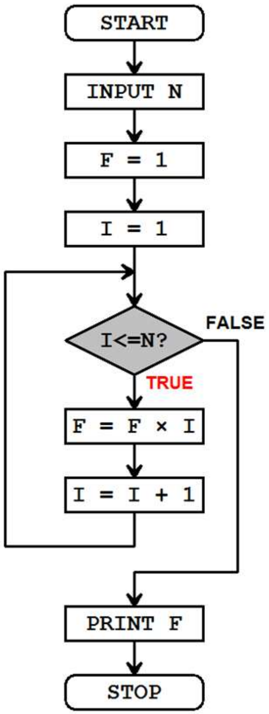
PRINT F

STOP

MEMORY VARIABLES

N	5
F	1
I	1

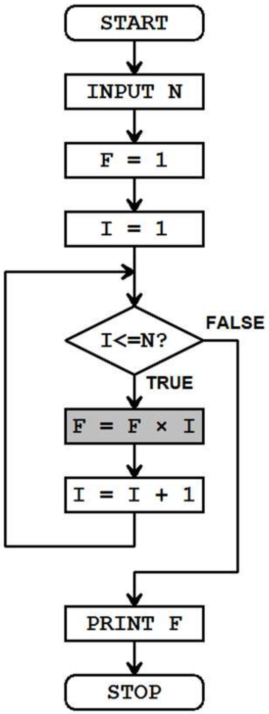
16



MEMORY
VARIABLES

N	5
F	1
I	1

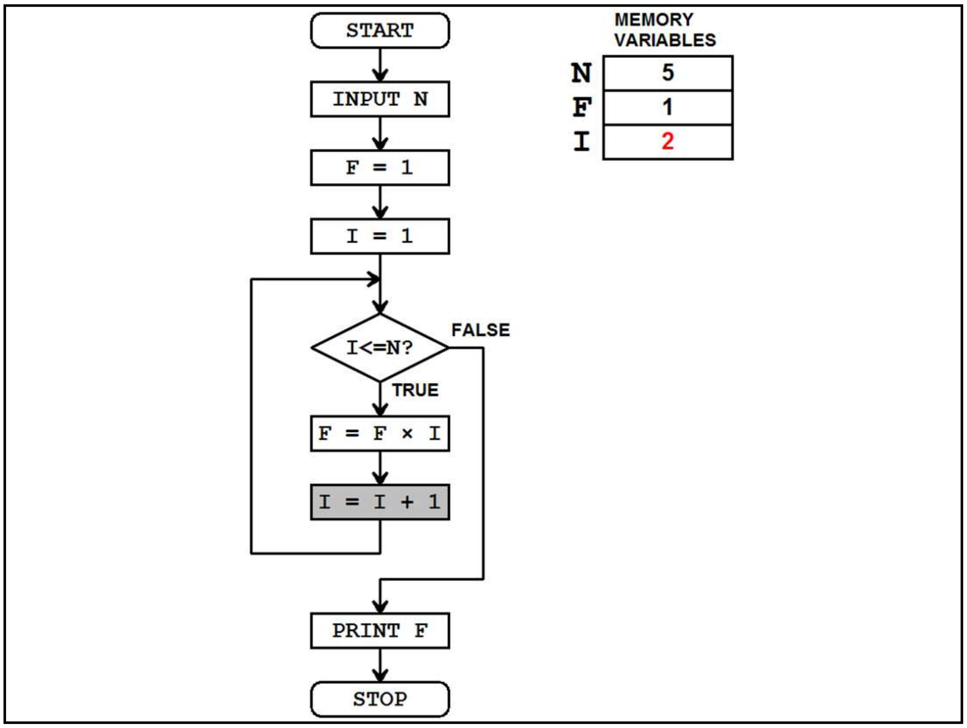
17



MEMORY
VARIABLES

N	5
F	1
I	1

18



START

INPUT N

F = 1

I = 1

I<=N?

FALSE

TRUE

F = F × I

I = I + 1

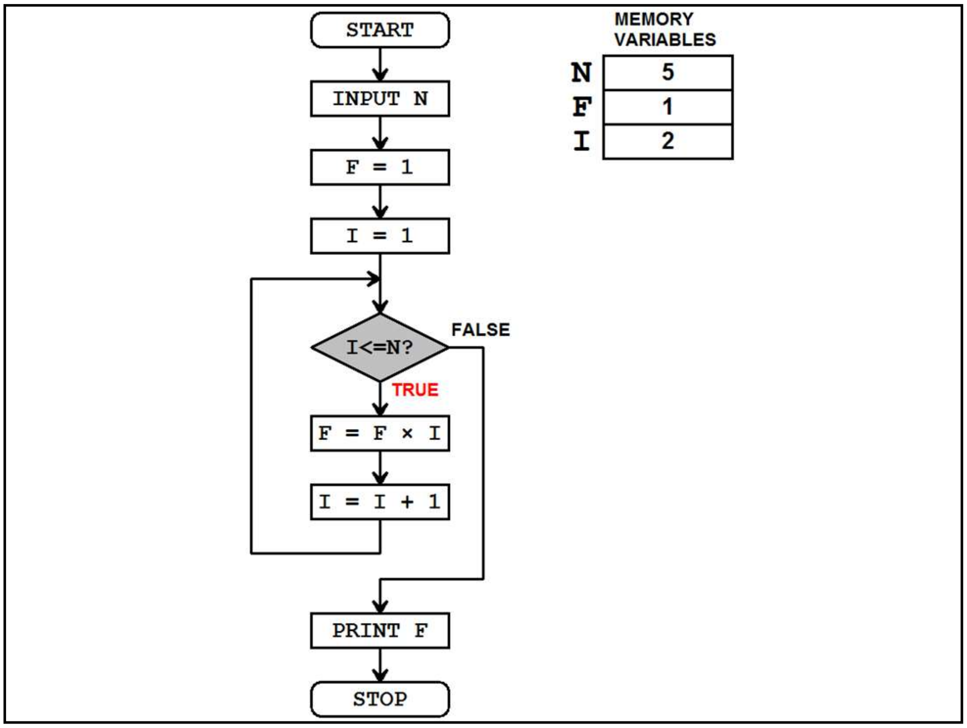
PRINT F

STOP

MEMORY VARIABLES

N	5
F	1
I	2

19



START

INPUT N

F = 1

I = 1

I<=N?

FALSE

TRUE

F = F × I

I = I + 1

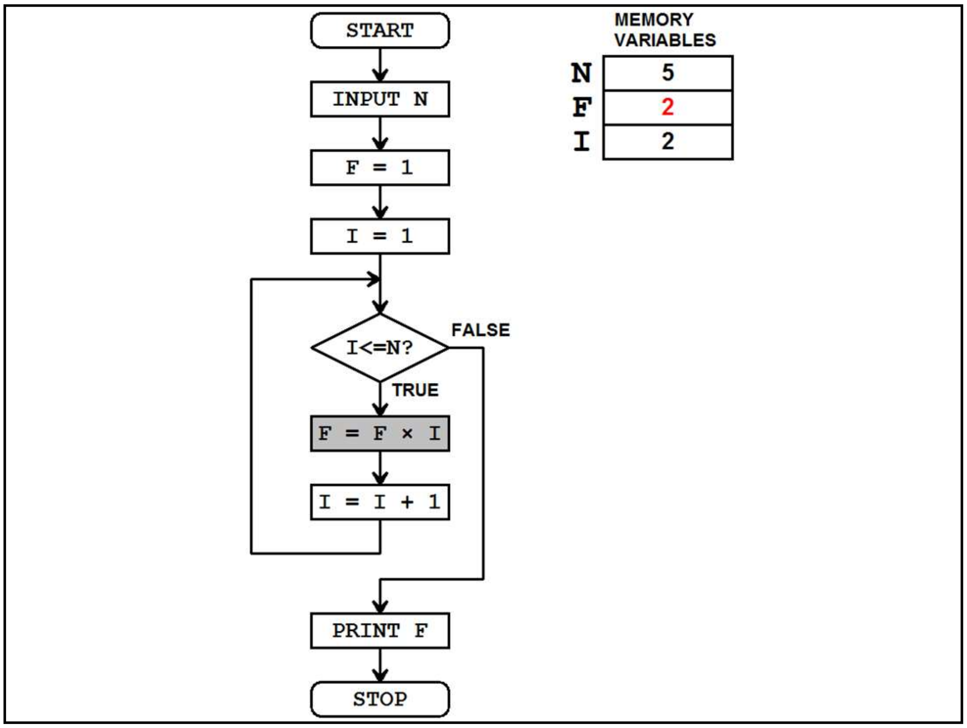
PRINT F

STOP

MEMORY VARIABLES

N	5
F	1
I	2

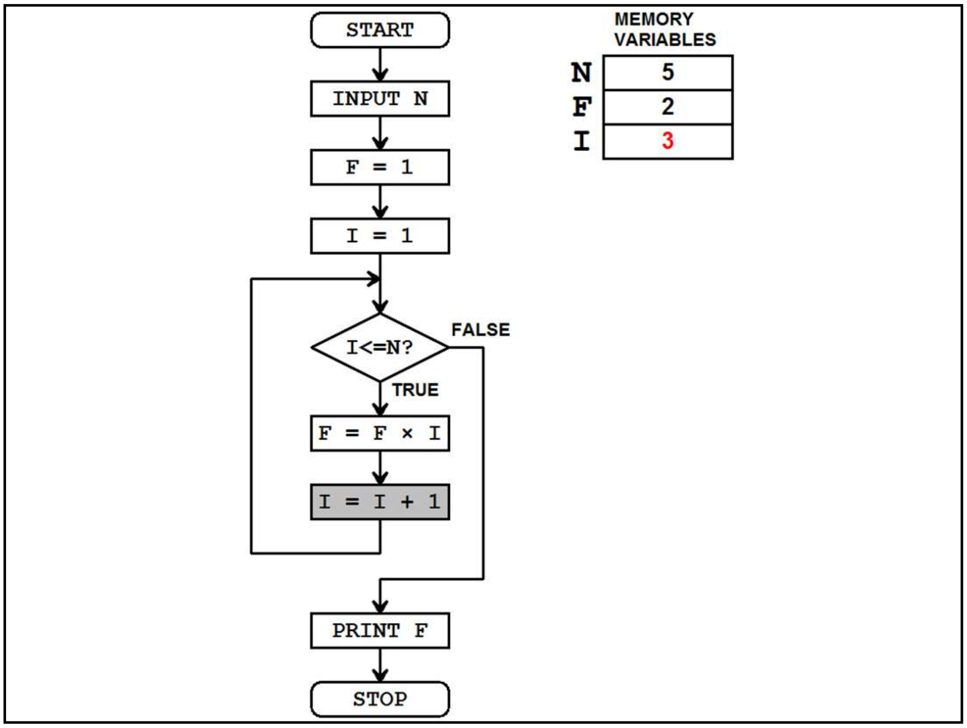
20



MEMORY
VARIABLES

N	5
F	2
I	2

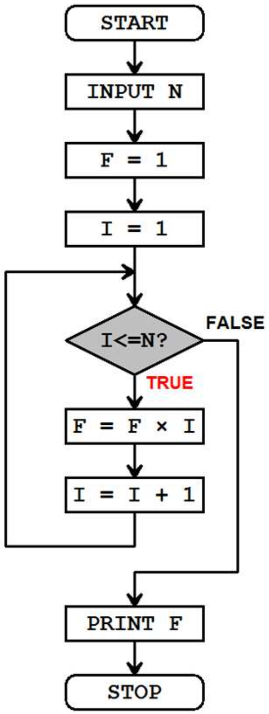
21



MEMORY
VARIABLES

N	5
F	2
I	3

22



START

INPUT N

F = 1

I = 1

I<=N?

FALSE

TRUE

F = F × I

I = I + 1

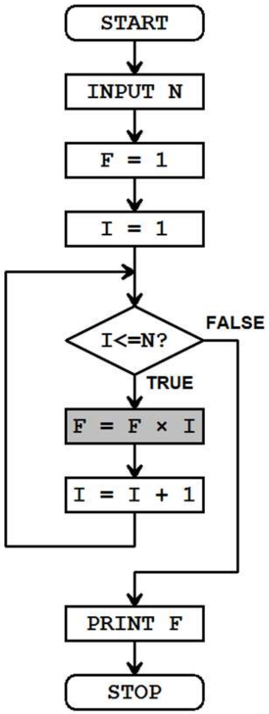
PRINT F

STOP

MEMORY VARIABLES

N	5
F	2
I	3

23



START

INPUT N

F = 1

I = 1

I<=N?

FALSE

TRUE

F = F × I

I = I + 1

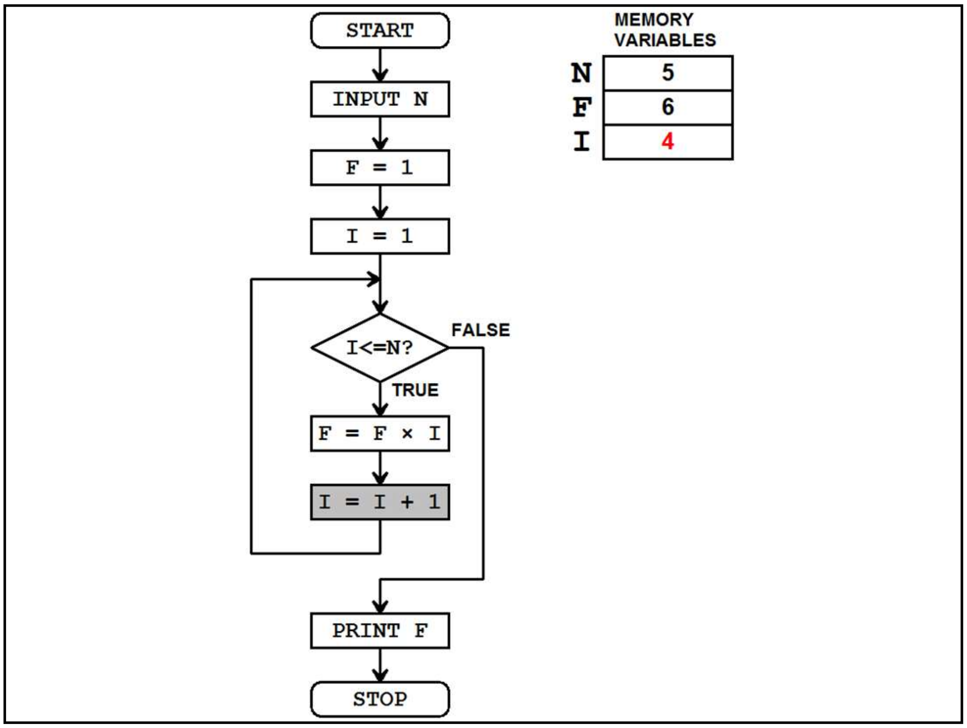
PRINT F

STOP

MEMORY VARIABLES

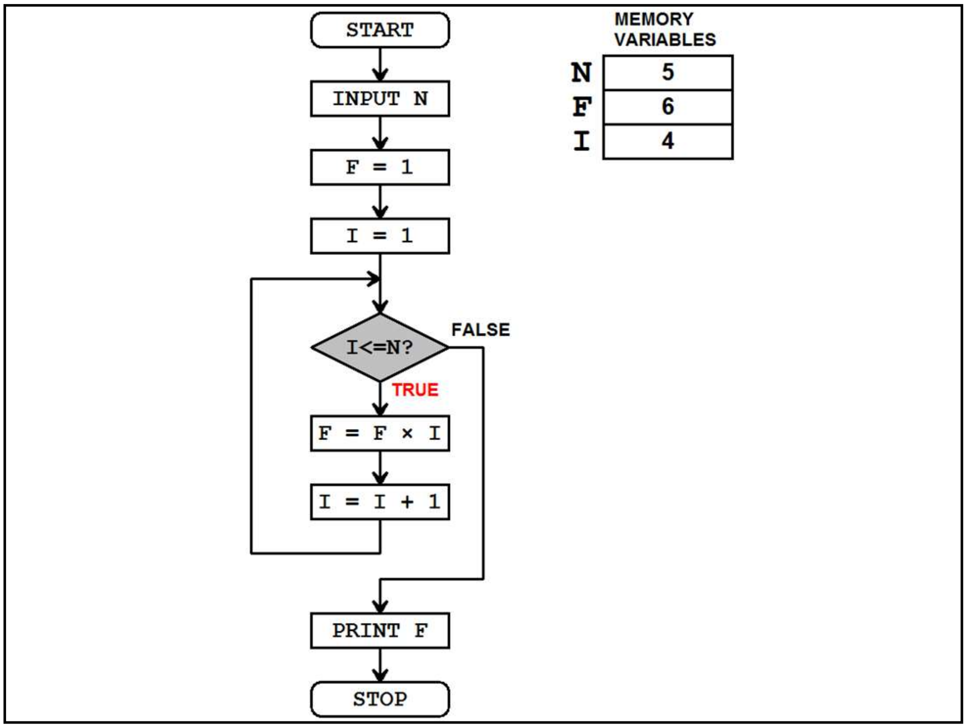
N	5
F	6
I	3

24



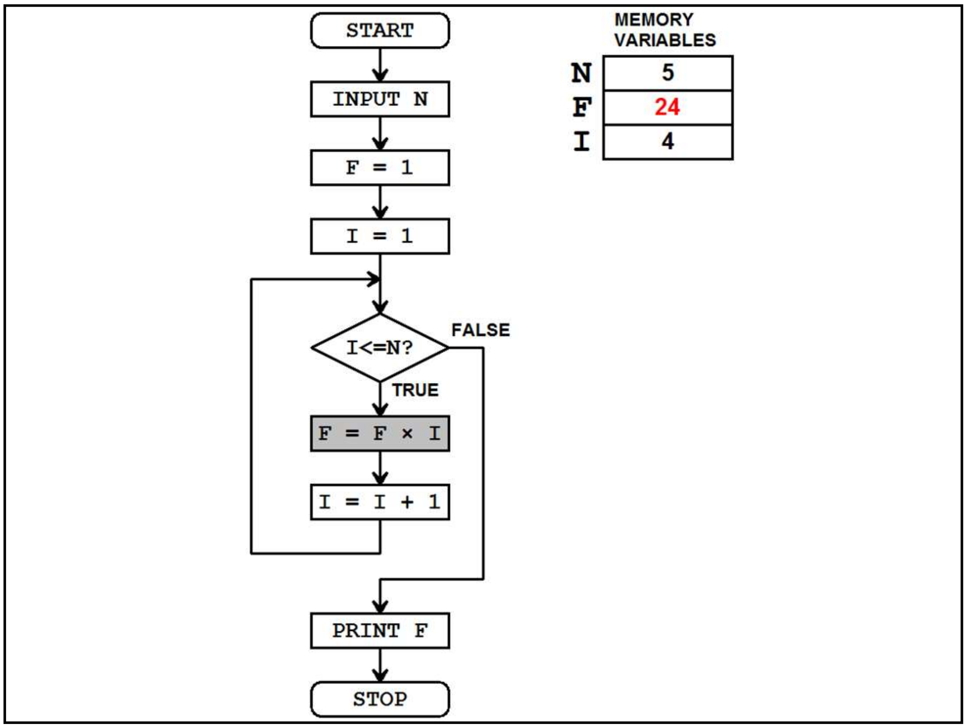
MEMORY VARIABLES

N	5
F	6
I	4



MEMORY VARIABLES

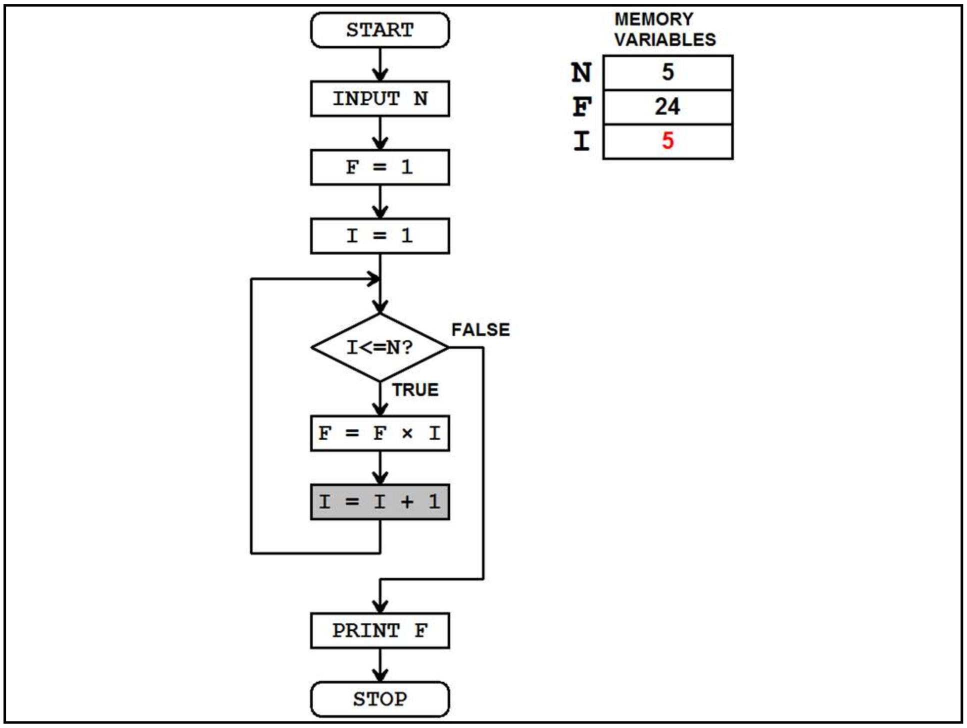
N	5
F	6
I	4



MEMORY VARIABLES

N	5
F	24
I	4

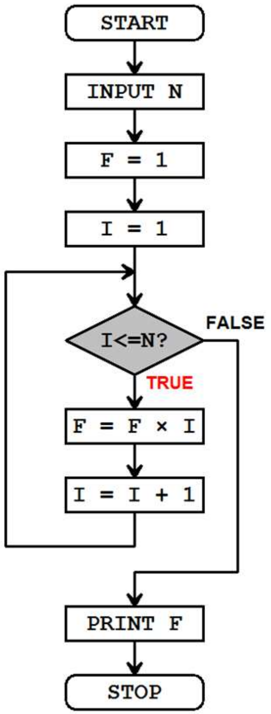
27



MEMORY VARIABLES

N	5
F	24
I	5

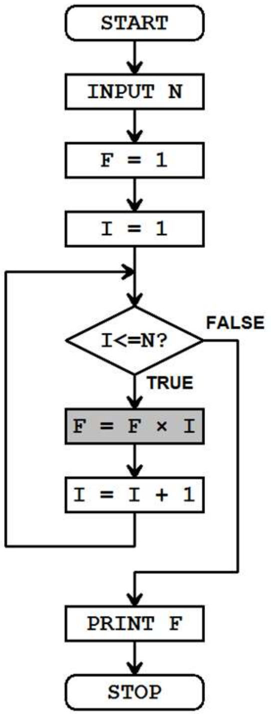
28



MEMORY VARIABLES

N	5
F	24
I	5

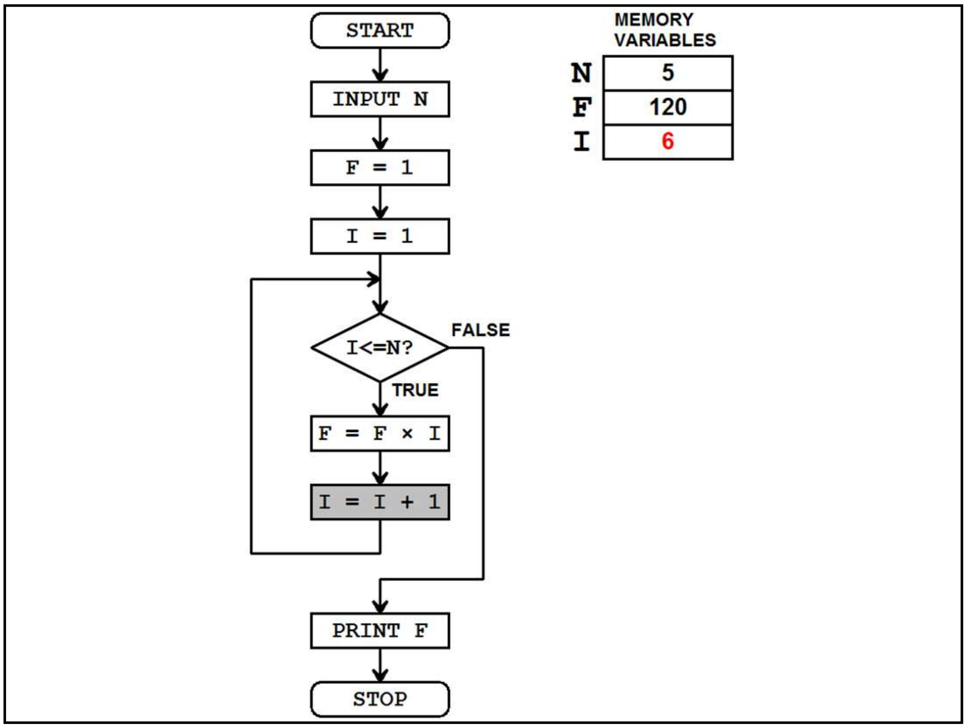
29



MEMORY VARIABLES

N	5
F	120
I	5

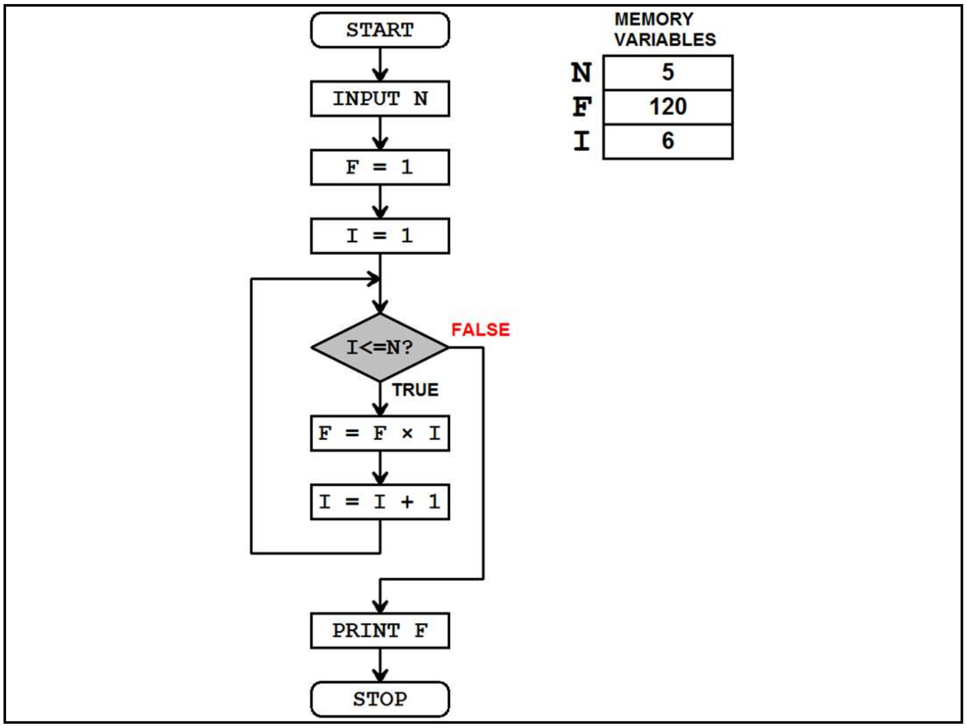
30



MEMORY
VARIABLES

N	5
F	120
I	6

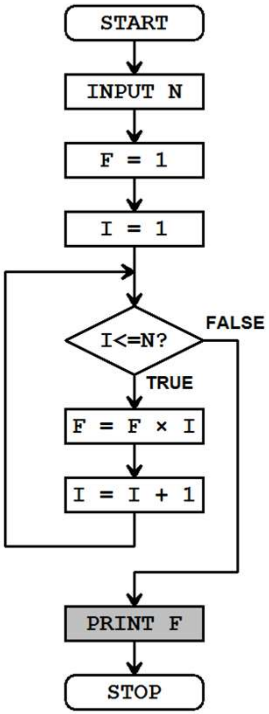
31



MEMORY
VARIABLES

N	5
F	120
I	6

32



START

INPUT N

F = 1

I = 1

I<=N?

FALSE

TRUE

F = F × I

I = I + 1

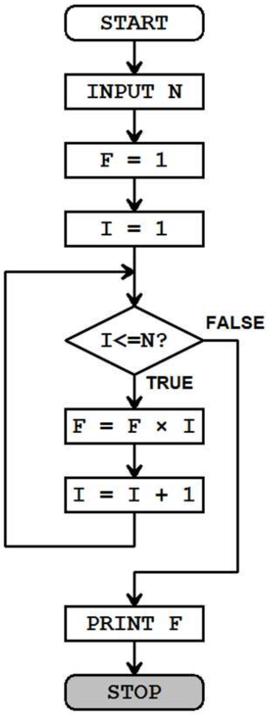
PRINT F

STOP

	MEMORY VARIABLES
N	5
F	120
I	6

"F = 120"

33



START

INPUT N

F = 1

I = 1

I<=N?

FALSE

TRUE

F = F × I

I = I + 1

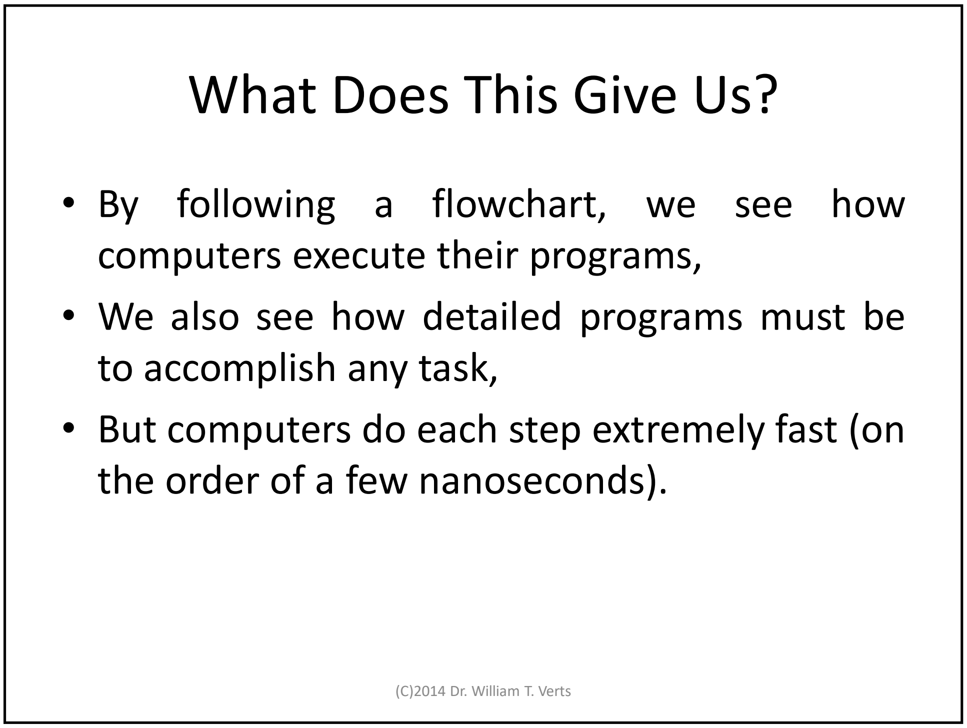
PRINT F

STOP

	MEMORY VARIABLES
N	5
F	120
I	6

"F = 120"

34



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).

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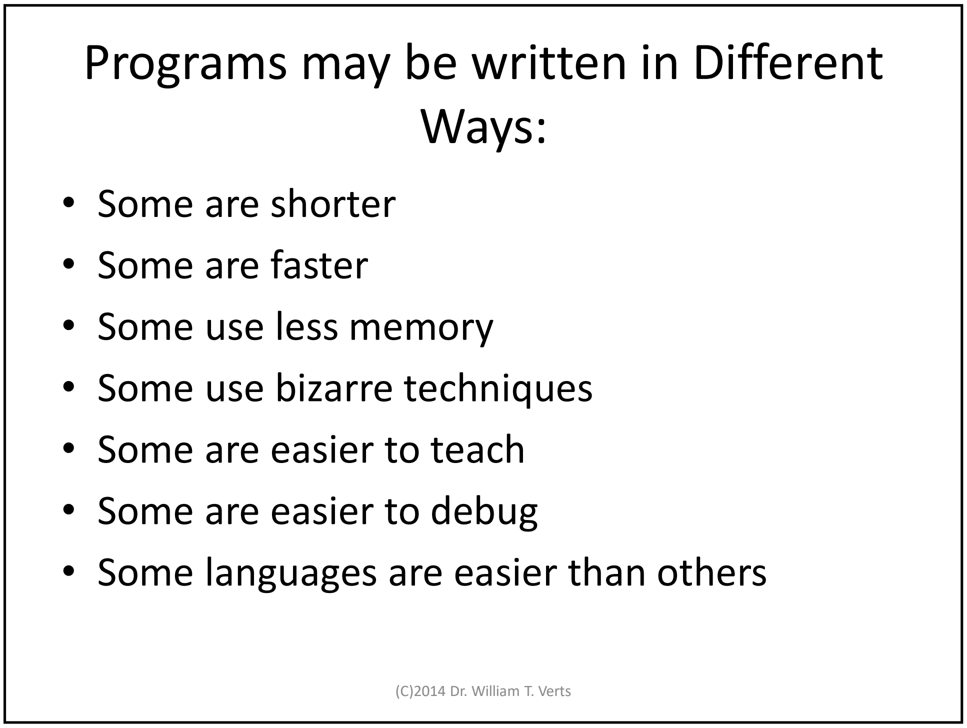

Programs may be written in Different Ways:

- 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

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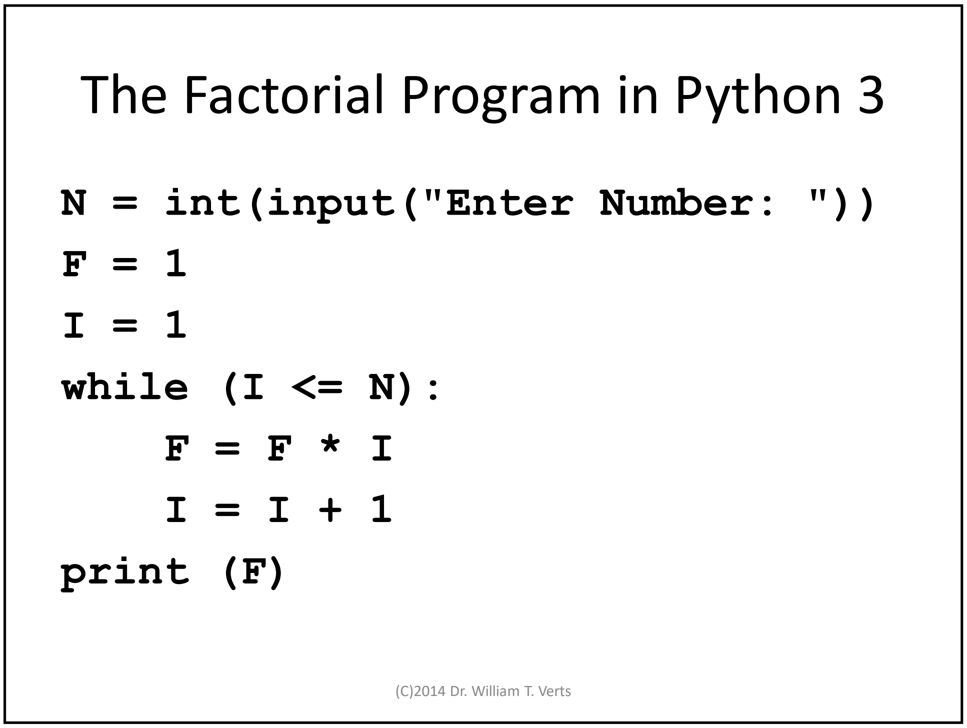
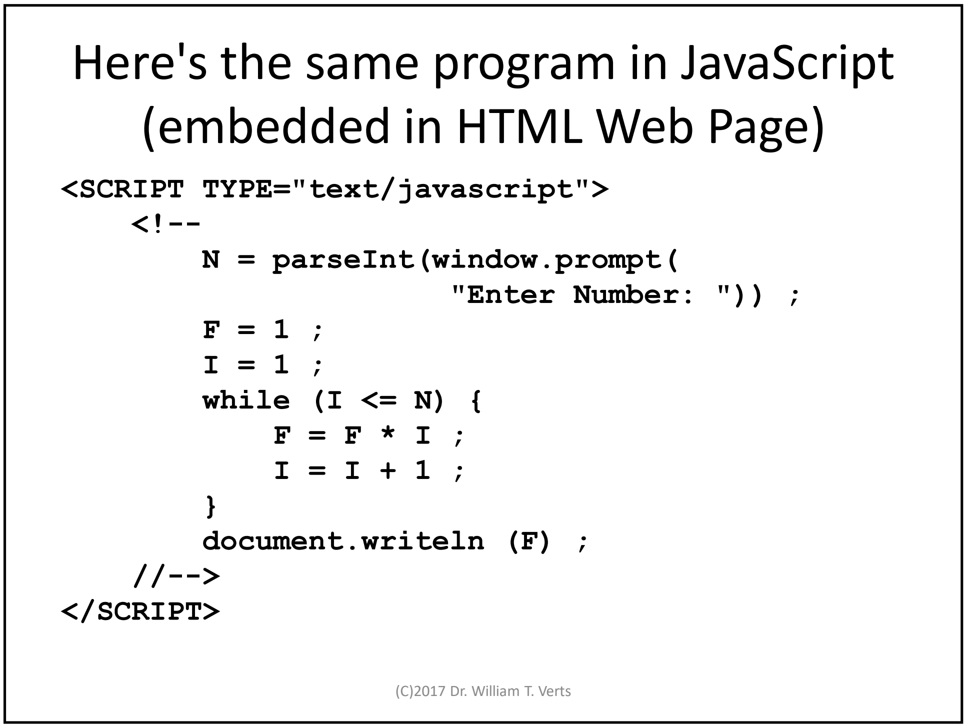


The Factorial Program in Python 3

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

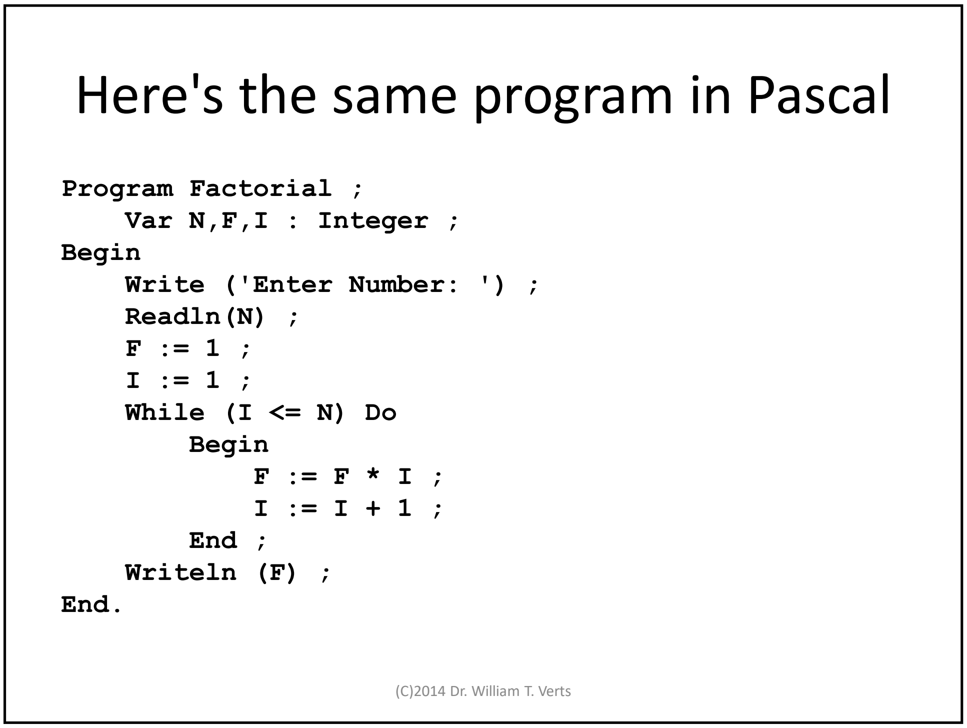
37



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

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

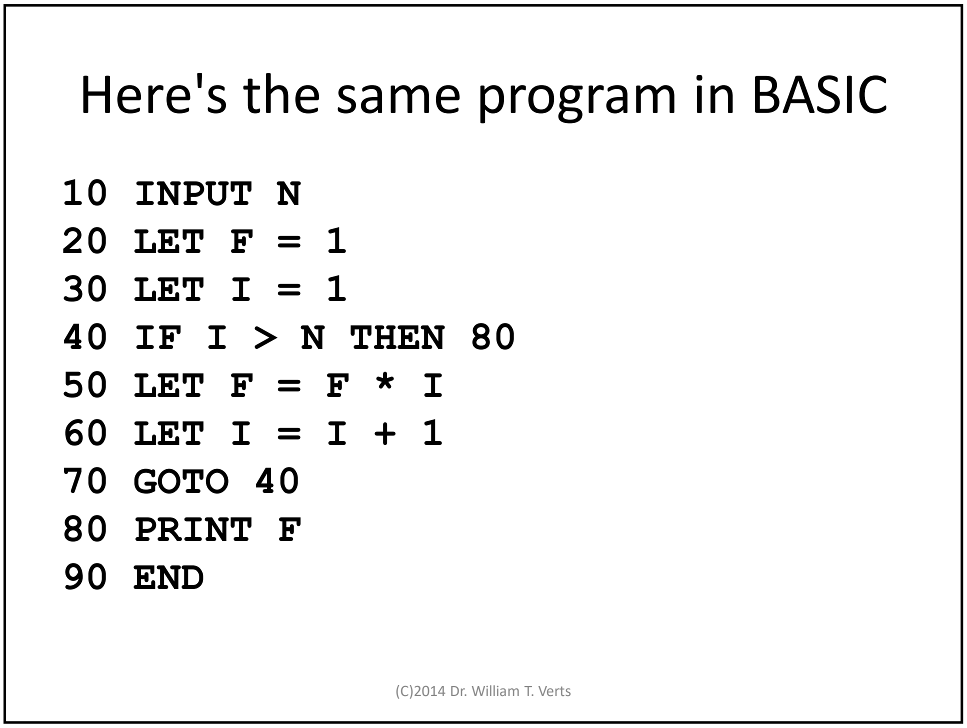
38



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.
```

39



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
```

40

Here's the same program in 8088 Assembly Language

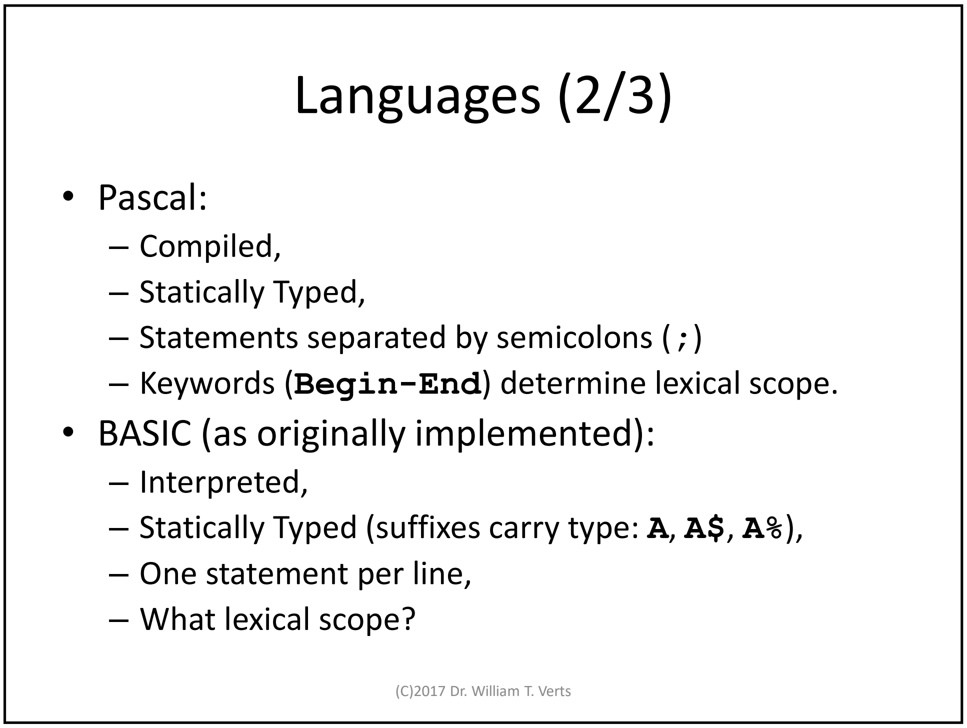
```
          MOV  AX,1      ; F=1
          MOV  BX,5      ; N=5
          MOV  CX,1      ; I=1
TopLoop:  CMP  CX,BX     ; Test I:N
          JG   EndLoop   ; Jump if >
          MUL  CX        ; F=F*I
          ADD  CX,1      ; I=I+1
          JMP  TopLoop   ; Jump back
EndLoop:  CALL PRINT     ;
```

41

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.

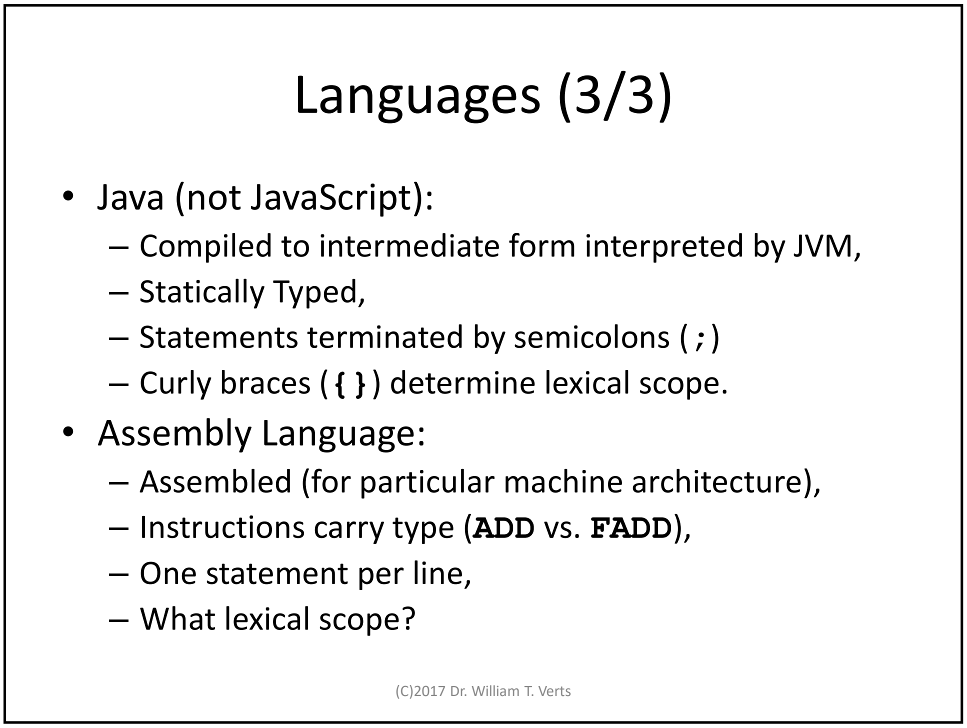
42



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?

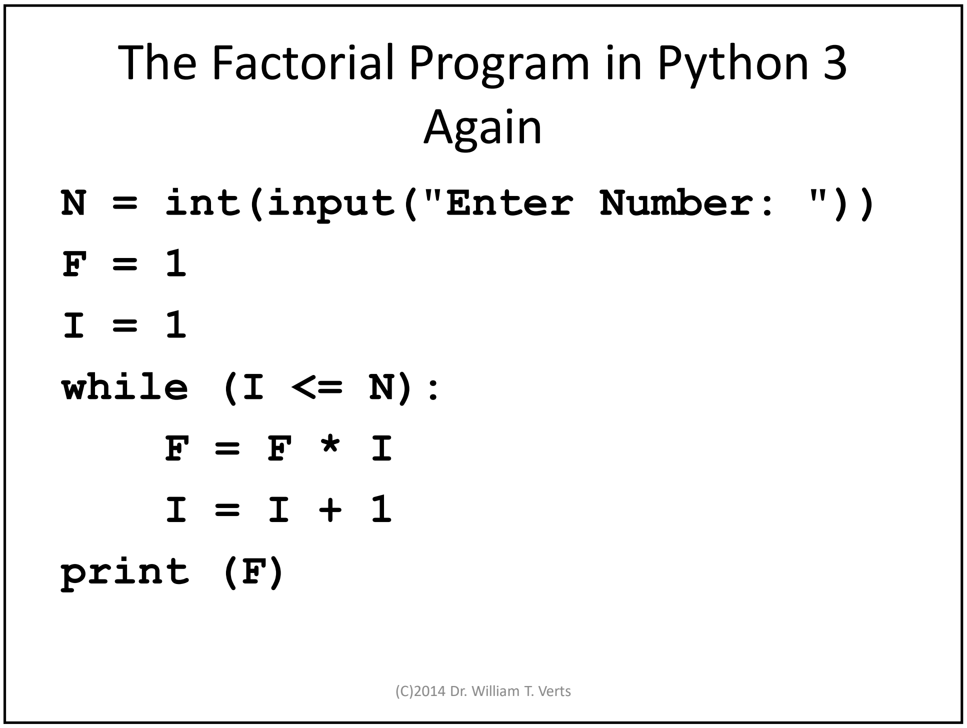
43



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?

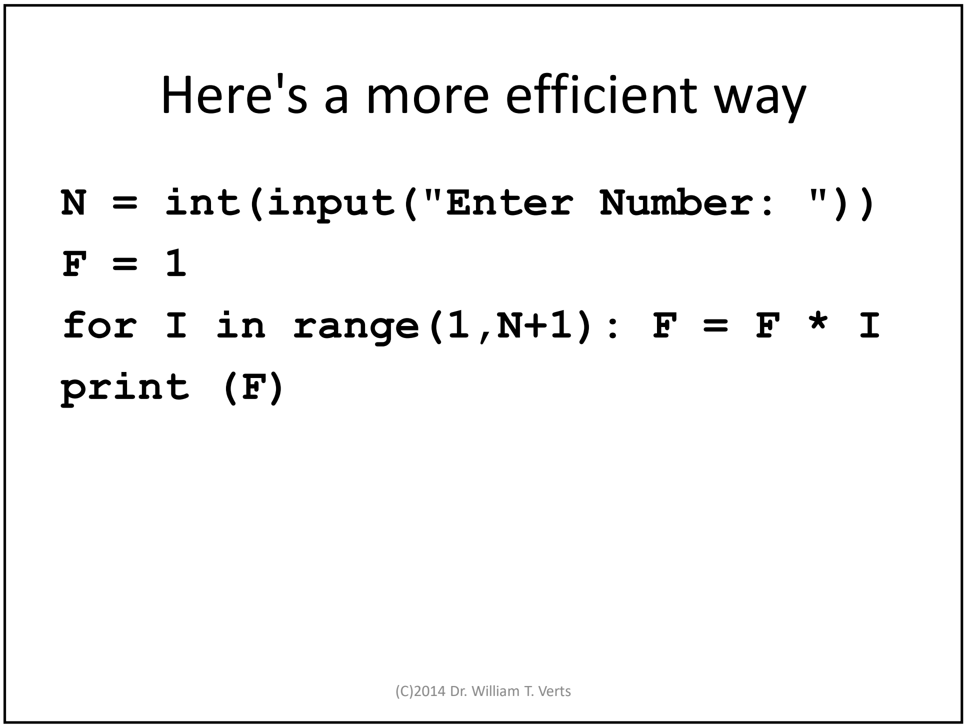
44



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)
```

45



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)
```

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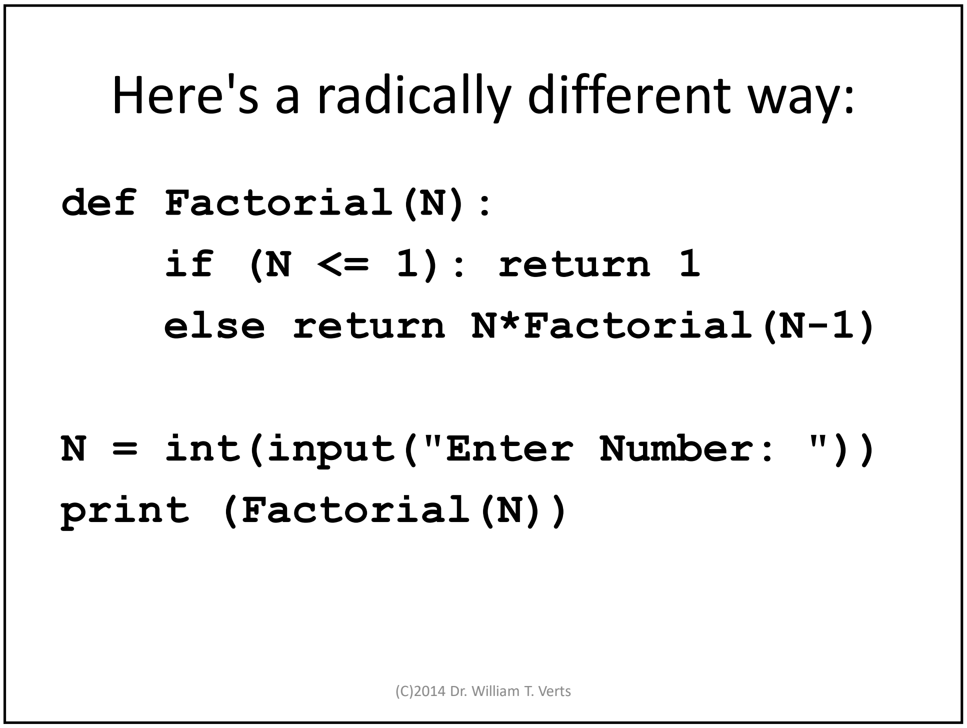

Here's a radically different way:

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

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

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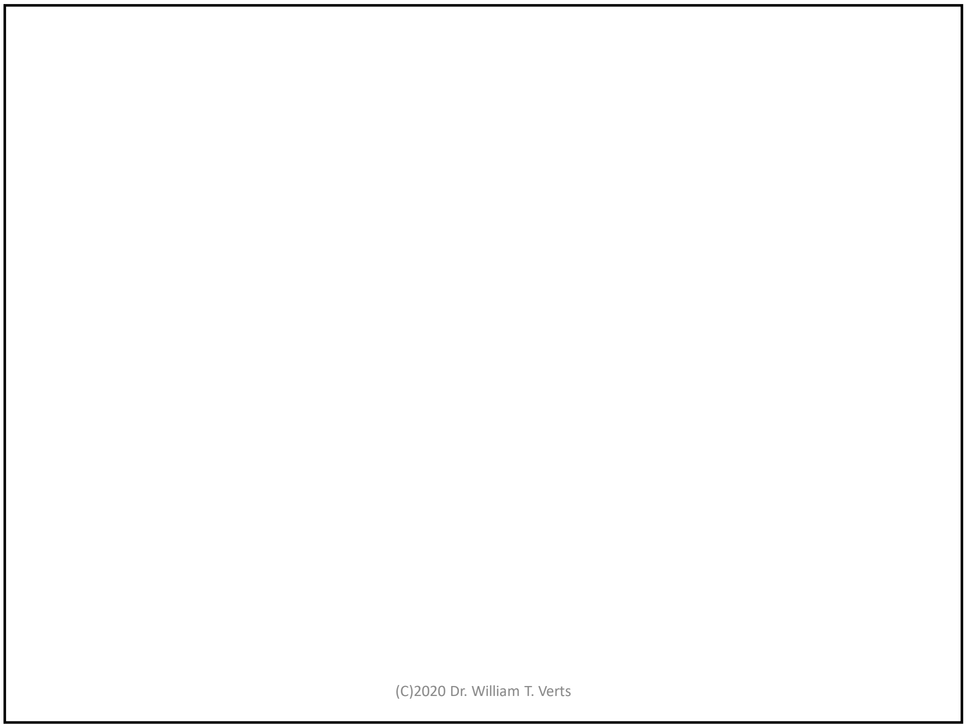

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