

Programming and Data Structure

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Some General Announcements

About the Course

- L-T-P rating of 3-1-0.
- There is a separate laboratory of 0-0-3.
 - Grading will be separate.
- Tutorial classes (one hour per week) will be conducted on a “per section” basis.
- Evaluation in the theory course:
 - Mid-semester 30%
 - End-semester 50%
 - Two class tests and attendance 20%

Course Materials

- The slides for the lectures will be made available on the web (in PDF form).

<http://144.16.192.60/~pds>

- All important announcements will be put up on the web page.

ATTENDANCE IN THE CLASSES IS MANDATORY

Students having poor attendance will be penalized in terms of the final grade / deregistration.

Any student with less than 75% attendance would be debarred from appearing in the examinations.

Text/Reference Books

1. Kernighan and Ritchie

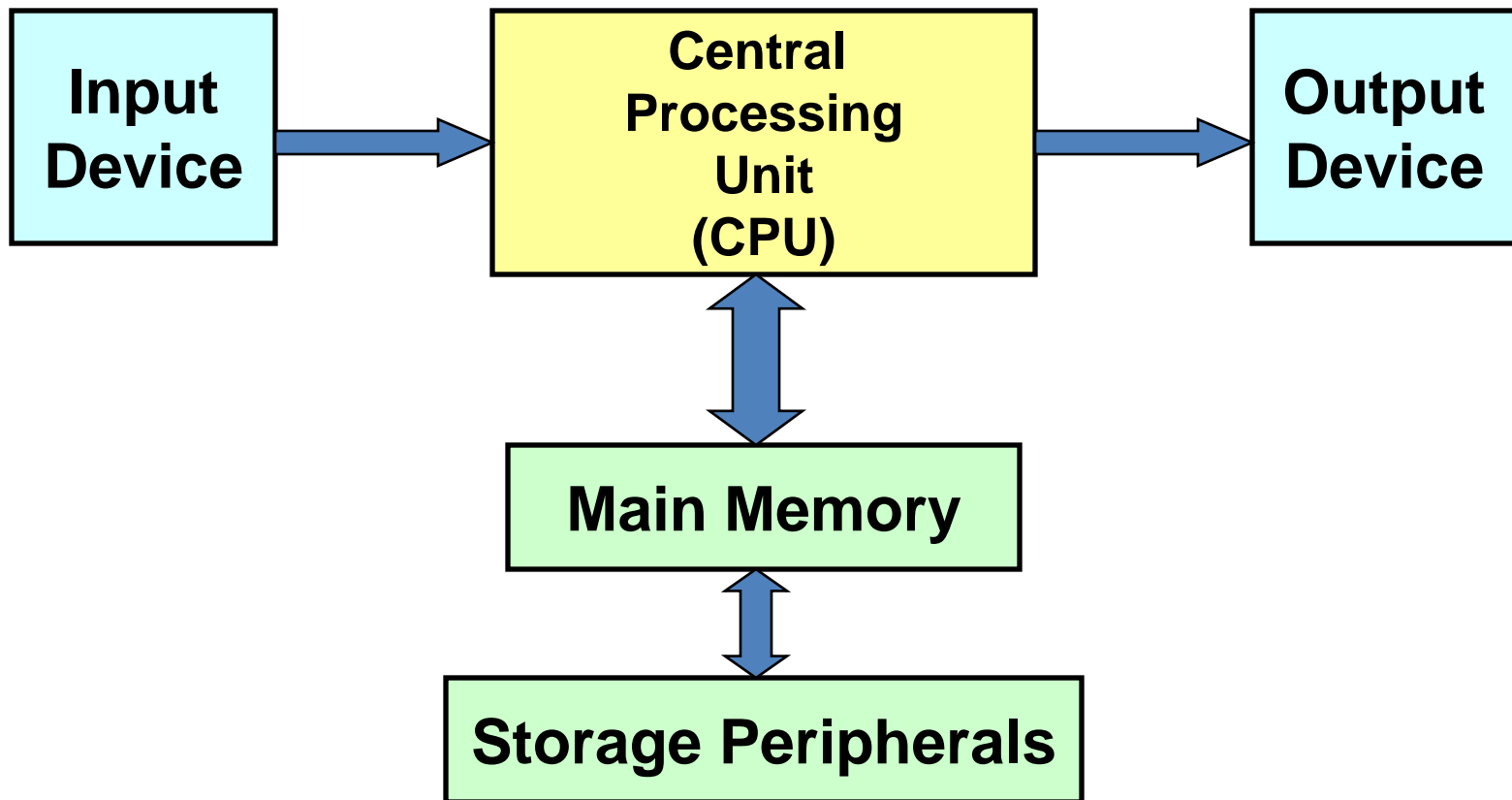
2. Programming with C

B.S. Gottfried, Schaum's Outline Series, Tata McGraw-Hill, 2006.

Introduction

What is a Computer?

It is a machine which can accept data, process them, and output results.



- CPU

- All computations take place here in order for the computer to perform a designated task.
- It has a large number of registers which temporarily store data and programs (instructions).
- It has circuitry to carry out arithmetic and logic operations, take decisions, etc.
- It retrieves instructions from the memory, interprets (decodes) them, and perform the requested operation.

- Main Memory

- Uses semiconductor technology

- Allows direct access

- Memory sizes in the range of 256 Mbytes to 4 Gbytes are typical today.

- Some measures to be remembered

- $1 \text{ K} = 2^{10}$ (= 1024)
 - $1 \text{ M} = 2^{20}$ (= one million approx.)
 - $1 \text{ G} = 2^{30}$ (= one billion approx.)

- Input Device
 - Keyboard, Mouse, Scanner, Digital Camera
- Output Device
 - Monitor, Printer
- Storage Peripherals
 - Magnetic Disks: hard disk, floppy disk
 - Allows direct (semi-random) access
 - Optical Disks: CDRom, CD-RW, DVD
 - Allows direct (semi-random) access
 - Flash Memory: pen drives
 - Allows direct access
 - Magnetic Tape: DAT
 - Only sequential access

Typical Configuration of a PC

- CPU: Pentium IV, 2.8 GHz
- Main Memory: 512 MB
- Hard Disk: 80 GB
- Floppy Disk: Not present
- CDROM: DVD combo-drive
- Input Device: Keyboard, Mouse
- Output Device: 17" color monitor
- Ports: USB, Firewire, Infrared

How does a computer work?

- Stored program concept.
 - Main difference from a calculator.
- What is a program?
 - Set of instructions for carrying out a specific task.
- Where are programs stored?
 - In secondary memory, when first created.
 - Brought into main memory, during execution.

Number System :: The Basics

- We are accustomed to using the so-called *decimal number system*.
 - Ten digits :: 0,1,2,3,4,5,6,7,8,9
 - Every digit position has a weight which is a power of 10.

- Example:

$$234 = 2 \times 10^2 + 3 \times 10^1 + 4 \times 10^0$$

$$250.67 = 2 \times 10^2 + 5 \times 10^1 + 0 \times 10^0 + 6 \times 10^{-1} + 7 \times 10^{-2}$$

Contd.

- A digital computer is built out of tiny electronic switches.
 - From the viewpoint of ease of manufacturing and reliability, such switches can be in one of two states, ON and OFF.
 - A switch can represent a digit in the so-called *binary number system*, 0 and 1.
- A computer works based on the binary number system.

Concept of Bits and Bytes

- Bit
 - A single binary digit (0 or 1).
- Nibble
 - A collection of four bits (say, 0110).
- Byte
 - A collection of eight bits (say, 01000111).
- Word
 - Depends on the computer.
 - Typically 4 or 8 bytes (that is, 32 or 64 bits).

Contd.

- A k-bit decimal number
 - Can express unsigned integers in the range 0 to $10^k - 1$
 - For $k=3$, from 0 to 999.
- A k-bit binary number
 - Can express unsigned integers in the range 0 to $2^k - 1$
 - For $k=8$, from 0 to 255.
 - For $k=10$, from 0 to 1023.

Classification of Software

- Two categories:
 1. Application Software
 - Used to solve a particular problem.
 - Editor, financial accounting, weather forecasting, etc.
 2. System Software
 - Helps in running other programs.
 - Compiler, operating system, etc.

Computer Languages

- Machine Language
 - Expressed in binary.
 - Directly understood by the computer.
 - Not portable; varies from one machine type to another.
 - Program written for one type of machine will not run on another type of machine.
 - Difficult to use in writing programs.

Contd.

- Assembly Language
 - Mnemonic form of machine language.
 - Easier to use as compared to machine language.
 - For example, use “ADD” instead of “10110100”.
 - Not portable (like machine language).
 - Requires a translator program called *assembler*.



Contd.

- Assembly language is also difficult to use in writing programs.
 - Requires many instructions to solve a problem.
- Example: Find the average of three numbers.

```
MOV  A,X    ; A = X
ADD  A,Y    ; A = A + Y
ADD  A,Z    ; A = A + Z
DIV  A,3    ; A = A / 3
MOV  RES,A  ; RES = A
```

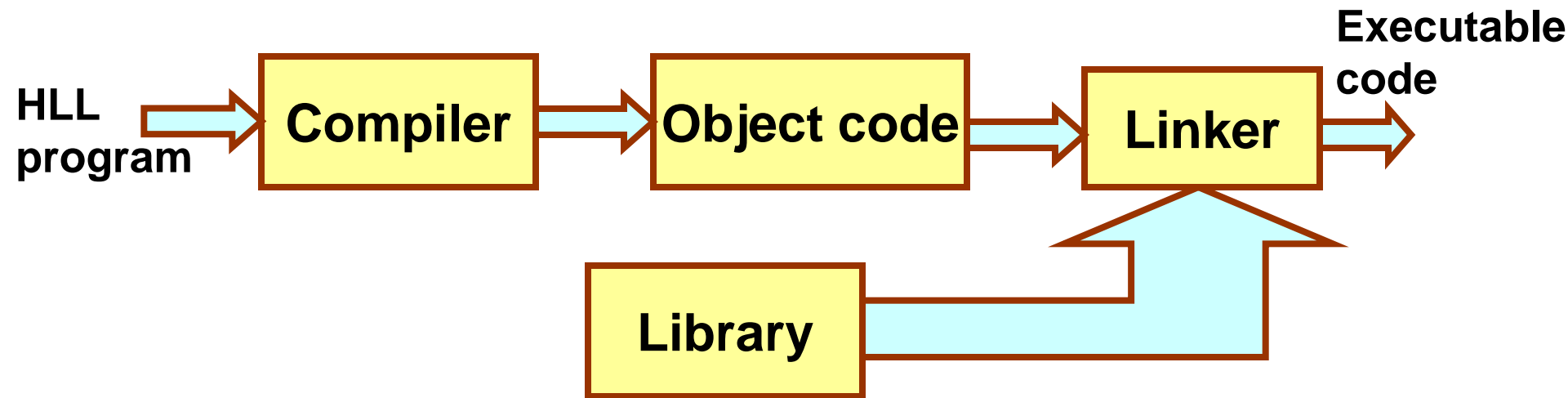
In C,

```
RES = (X + Y + Z) / 3
```

High-Level Language

- Machine language and assembly language are called low-level languages.
 - They are closer to the machine.
 - Difficult to use.
- High-level languages are easier to use.
 - They are closer to the programmer.
 - Examples:
 - Fortran, Cobol, C, C++, Java.
 - Requires an elaborate process of translation.
 - Using a software called *compiler*.
 - They are portable across platforms.

Contd.



To Summarize

- **Assembler**
 - Translates a program written in assembly language to machine language.
- **Compiler**
 - Translates a program written in high-level language to machine language.

Operating Systems

- Makes the computer easy to use.
 - Basically the computer is very difficult to use.
 - Understands only machine language.
- Operating systems make computers easy to use.
- Categories of operating systems:
 - Single user
 - Multi user
 - Time sharing
 - Multitasking
 - Real time

Contd.

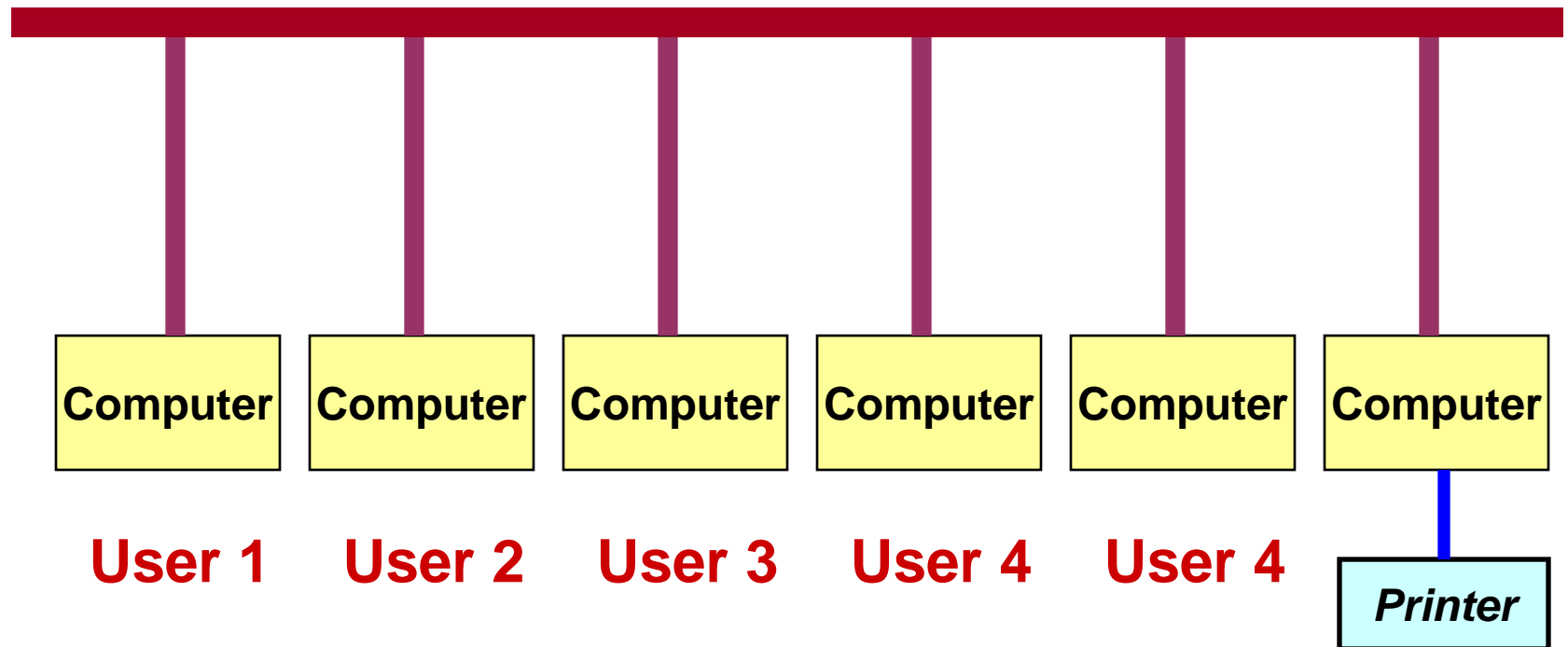
- Popular operating systems:
 - DOS: **single-user**
 - Windows 2000/XP: **single-user multitasking**
 - Unix: **multi-user**
 - Linux: **a free version of Unix**
- The laboratory class will be based on Linux.
- Question:
 - How multiple users can work on the same computer?

Contd.

- Computers connected in a network.
- Many users may work on a computer.
 - Over the network.
 - At the same time.
 - CPU and other resources are shared among the different programs.
 - Called time sharing.
 - One program executes at a time.

Multiuser Environment

Computer Network



Basic Programming Concepts

Some Terminologies

- Algorithm / Flowchart
 - A step-by-step procedure for solving a particular problem.
 - Should be independent of the programming language.
- Program
 - A translation of the algorithm/flowchart into a form that can be processed by a computer.
 - Typically written in a high-level language like C, C++, Java, etc.

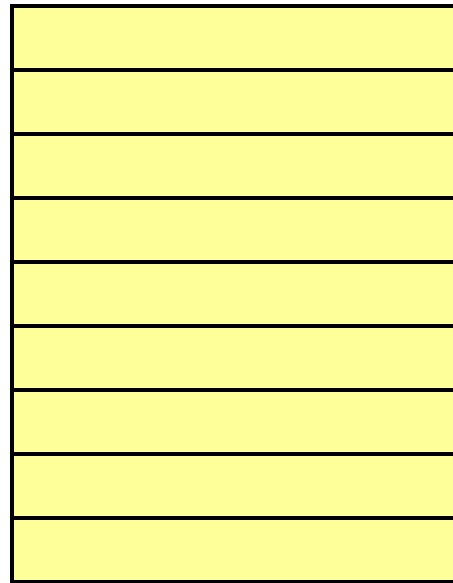
Variables and Constants

- Most important concept for problem solving using computers.
- All temporary results are stored in terms of variables and constants.
 - The value of a variable can be changed.
 - The value of a constant do not change.
- Where are they stored?
 - In main memory.

Contd.

- How does memory look like (logically)?
 - As a list of storage locations, each having a unique address.
 - Variables and constants are stored in these storage locations.
 - Variable is like a *house*, and the name of a variable is like the *address* of the house.
 - Different people may reside in the house, which is like the *contents* of a variable.

Memory map



Address 0
Address 1
Address 2
Address 3
Address 4
Address 5
Address 6

Every variable is mapped to a particular memory address

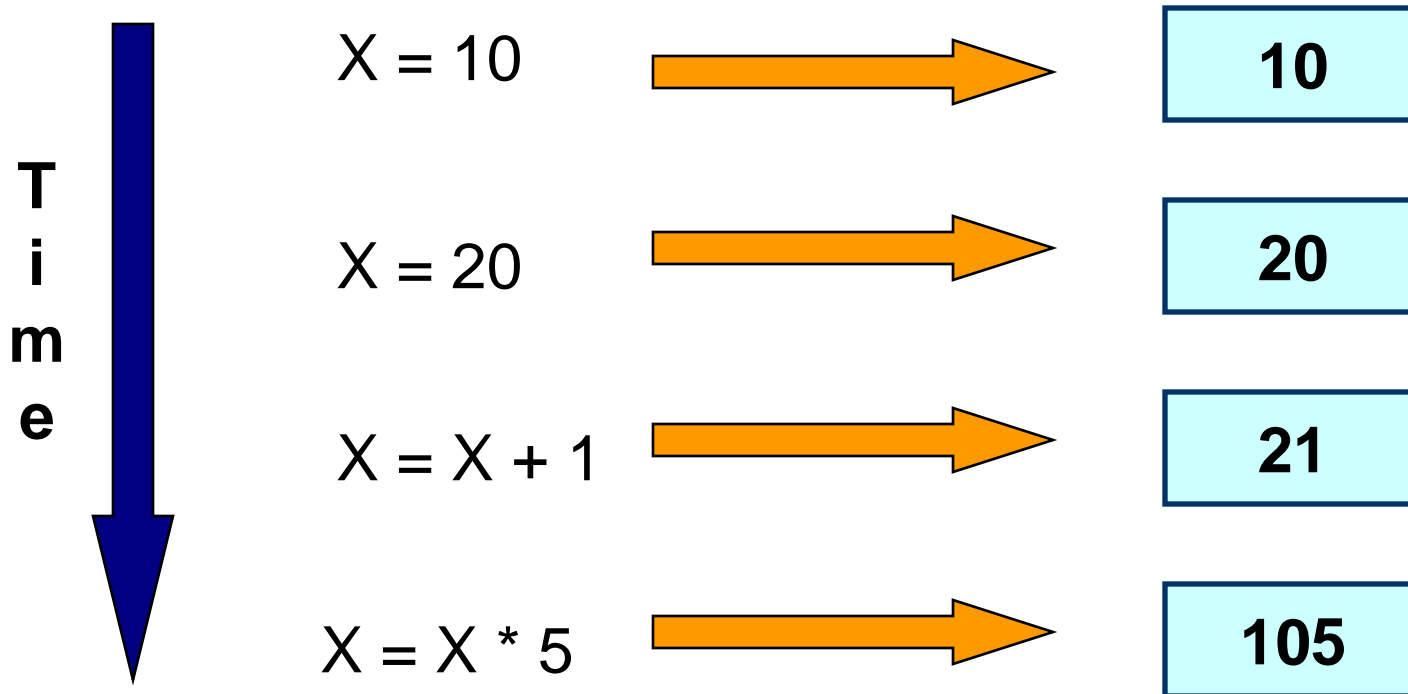


Address N-1

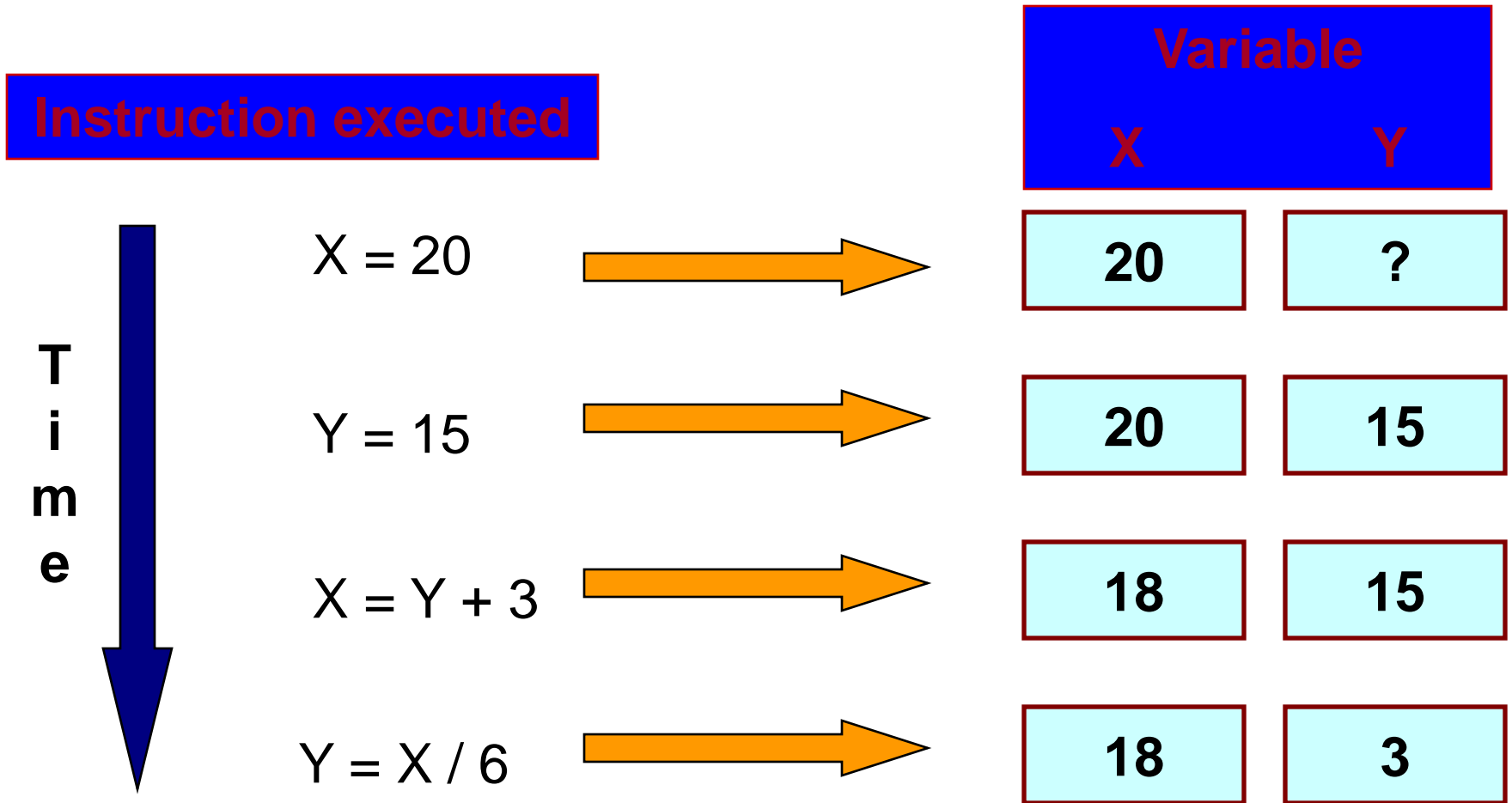
Variables in Memory

Instruction executed

Memory location allocated to a variable X



Variables in Memory (contd.)



Data types

- Three common data types used:
 - Integer :: can store only whole numbers
 - Examples: 25, -56, 1, 0
 - Floating-point :: can store numbers with fractional values.
 - Examples: 3.14159, 5.0, -12345.345
 - Character :: can store a character
 - Examples: 'A', 'a', '*', '3', '', '+'

Data Types (contd.)

- How are they stored in memory?
 - Integer ::
 - 16 bits
 - 32 bits
 - Float ::
 - 32 bits
 - 64 bits
 - Char ::
 - 8 bits (ASCII code)
 - 16 bits (UNICODE, used in Java)

Actual number of bits varies from one computer to another

Problem solving

- Step 1:
 - Clearly specify the problem to be solved.
- Step 2:
 - Draw flowchart or write algorithm.
- Step 3:
 - Convert flowchart (algorithm) into program code.
- Step 4:
 - Compile the program into object code.
- Step 5:
 - Execute the program.

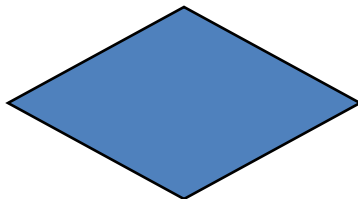
Flowchart: basic symbols



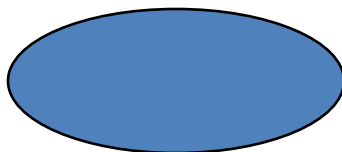
Computation



Input / Output



Decision Box



Start / Stop

Contd.

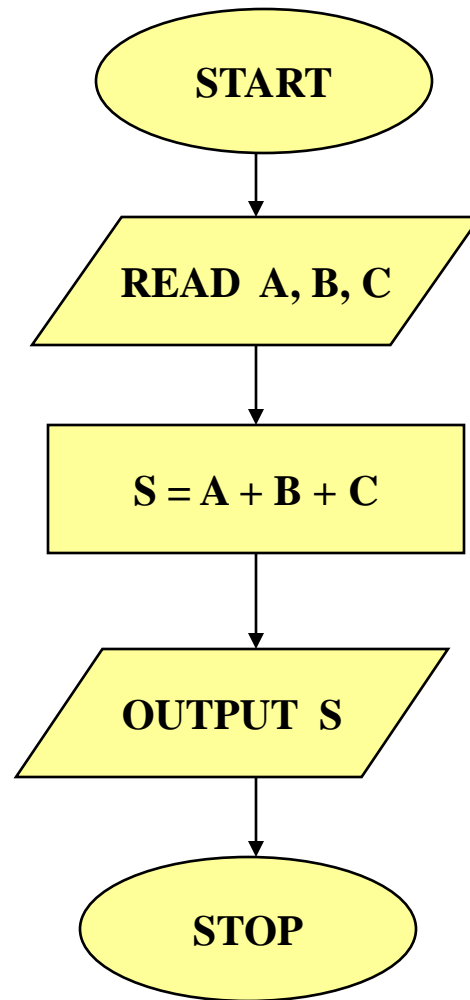


**Flow of
control**

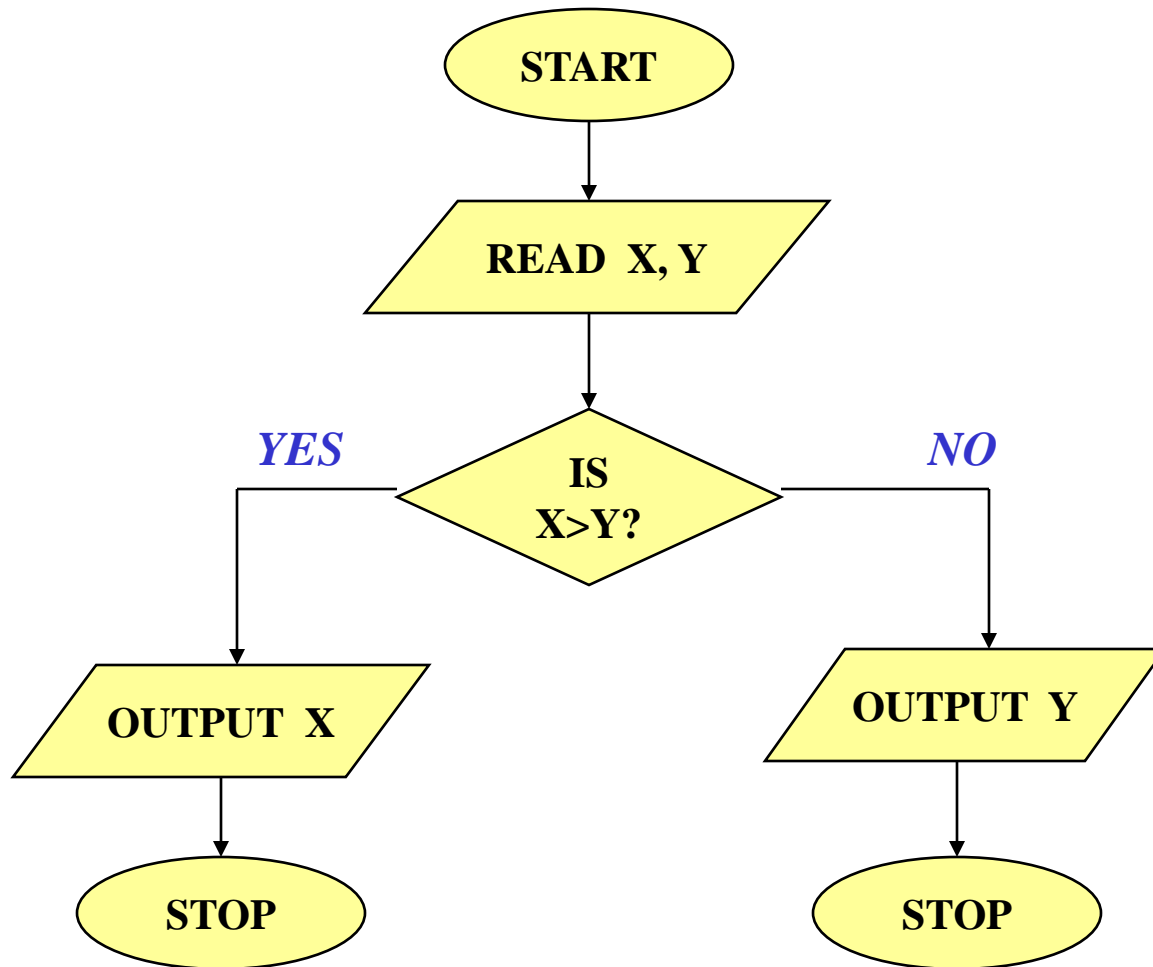


Connector

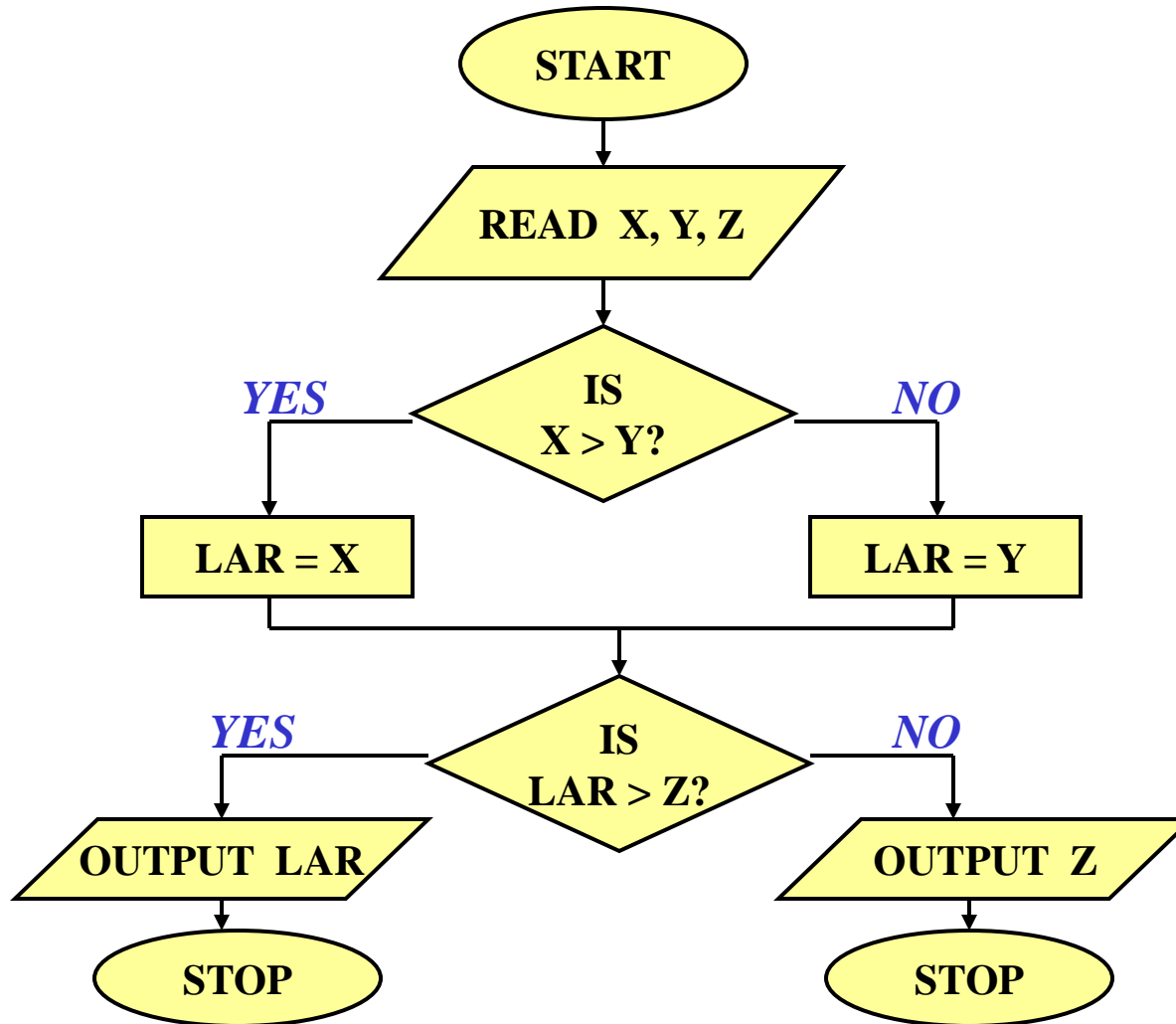
Example 1: *Adding three numbers*



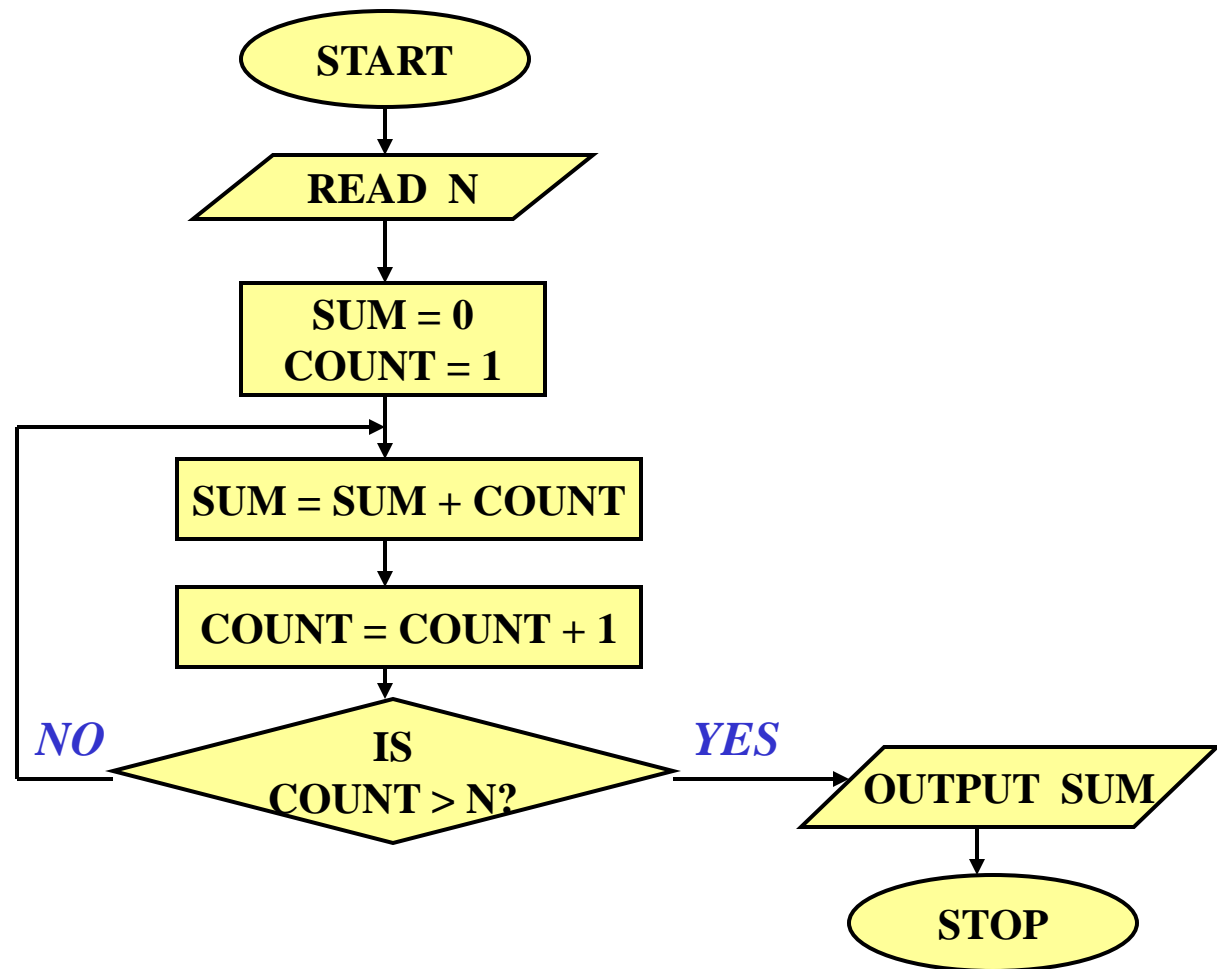
Example 2: *Larger of two numbers*



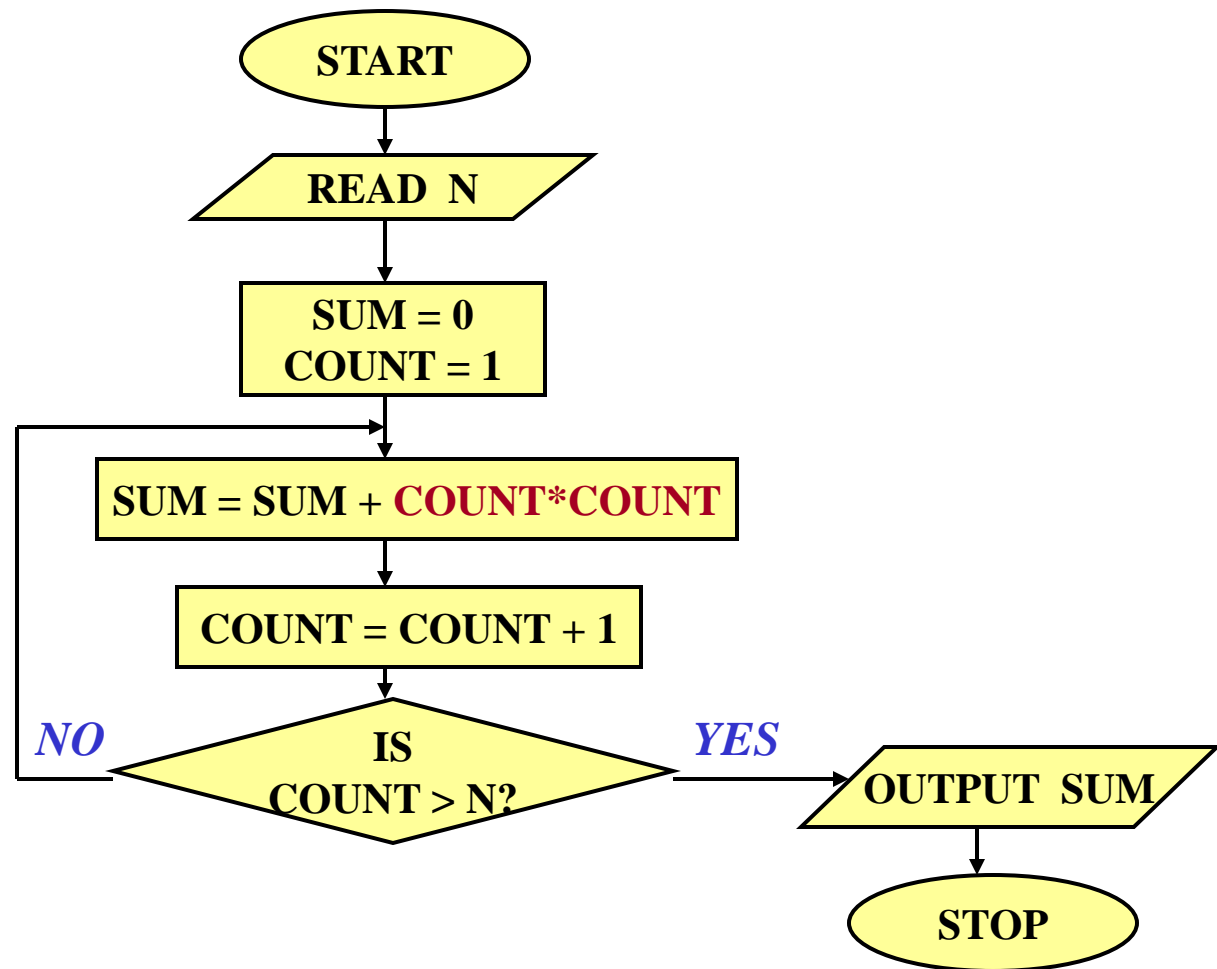
Example 3: *Largest of three numbers*



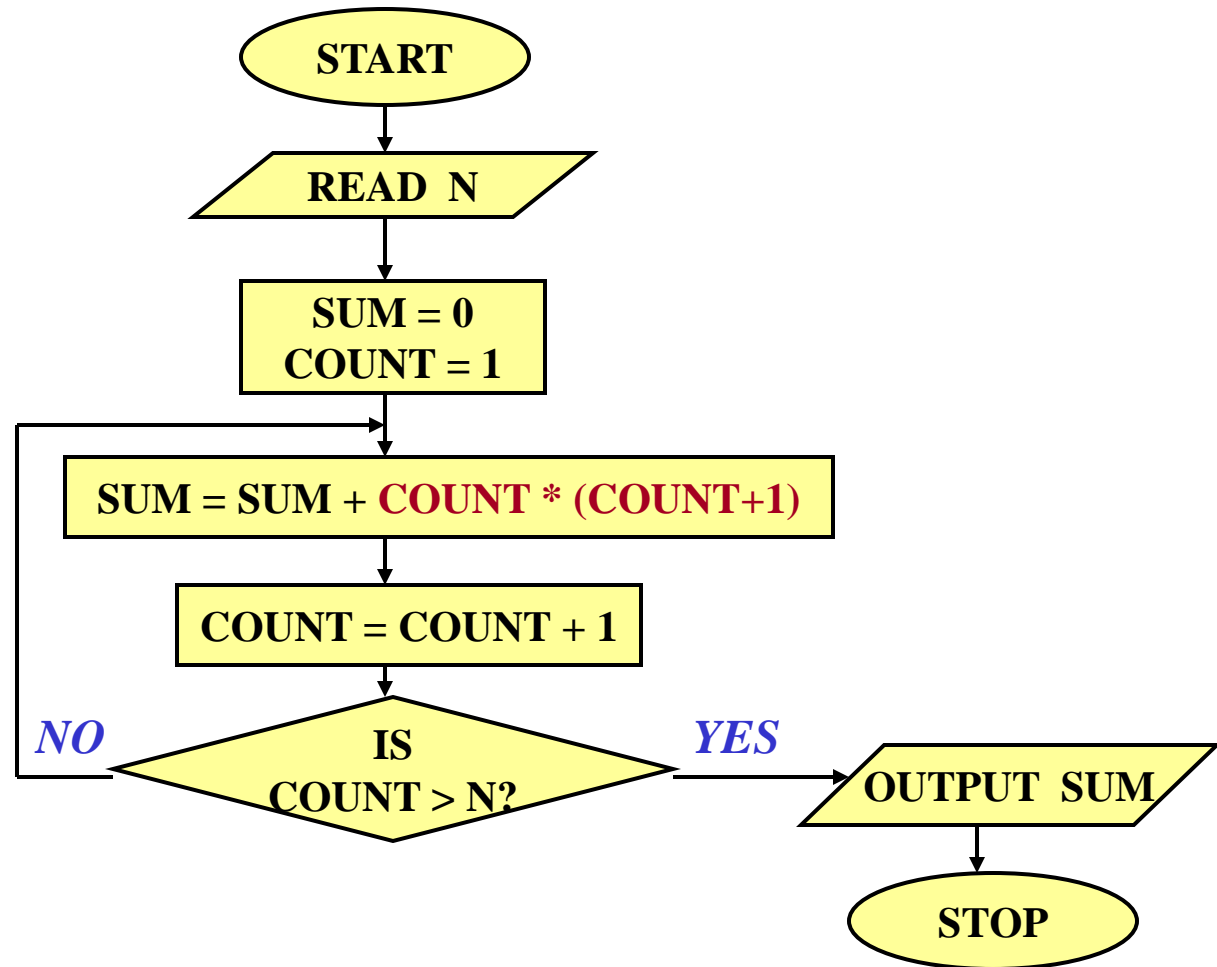
Example 4: *Sum of first N natural numbers*



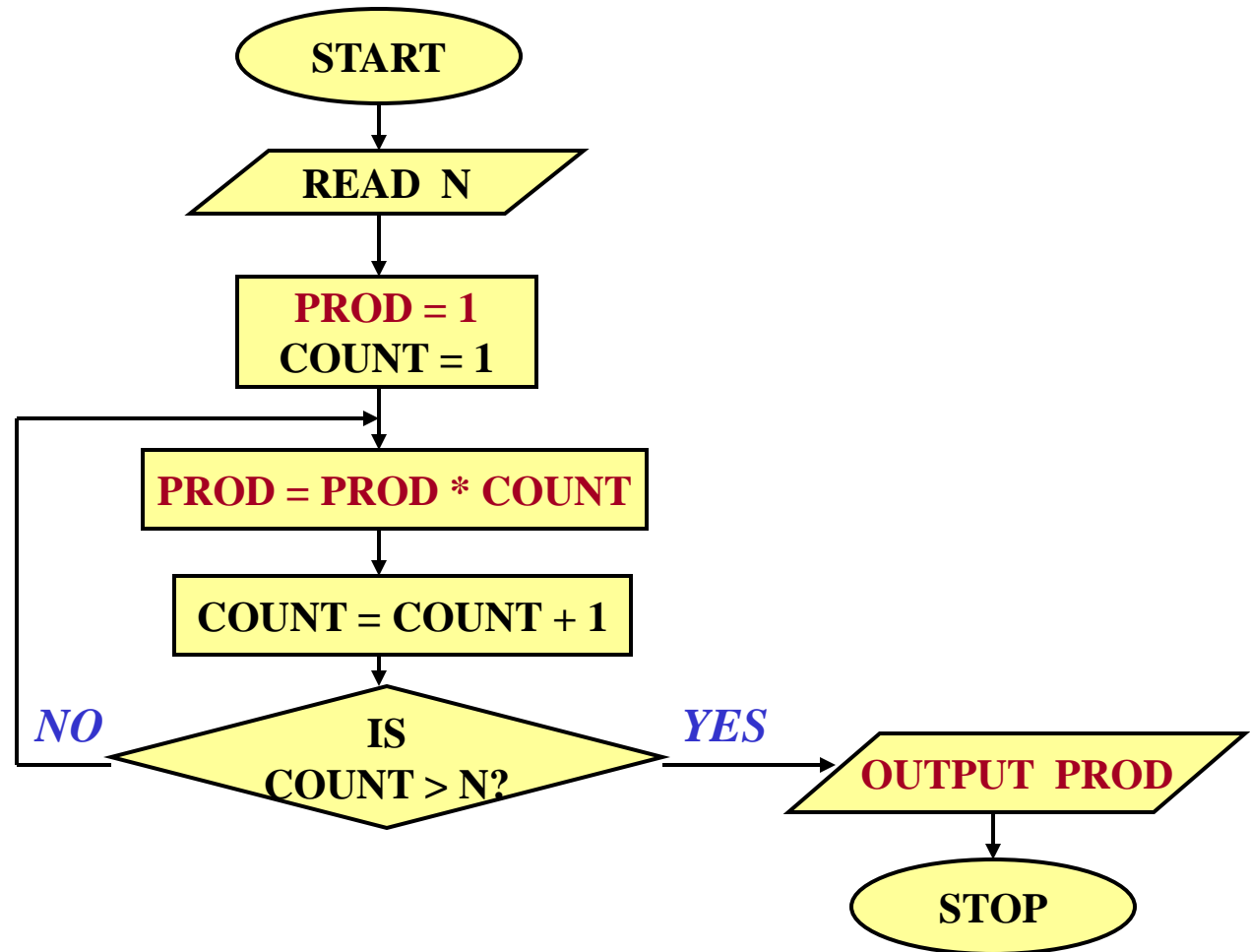
Example 5: $SUM = 1^2 + 2^2 + 3^2 + N^2$



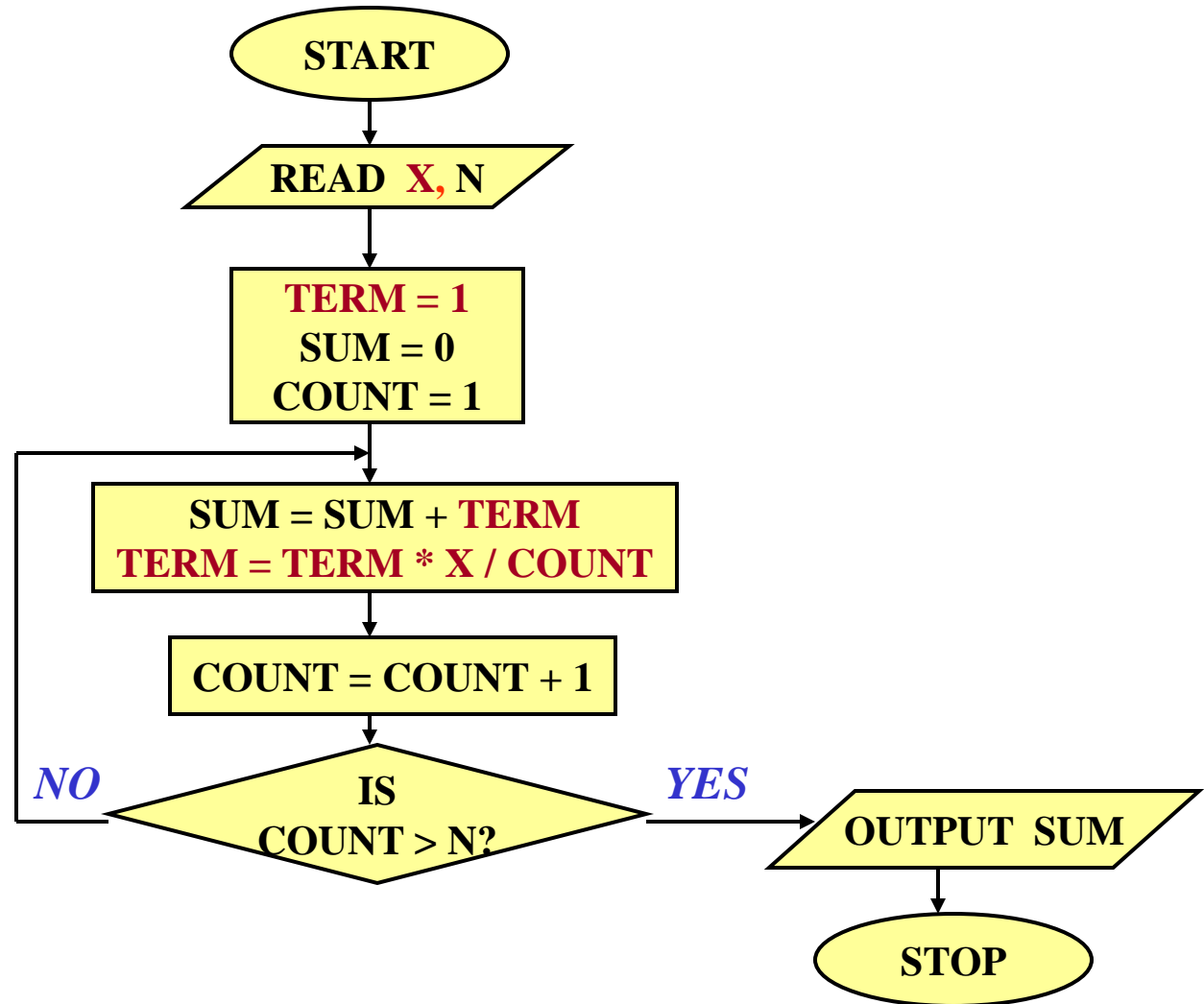
Example 6: $SUM = 1.2 + 2.3 + 3.4 + \dots$ to N terms



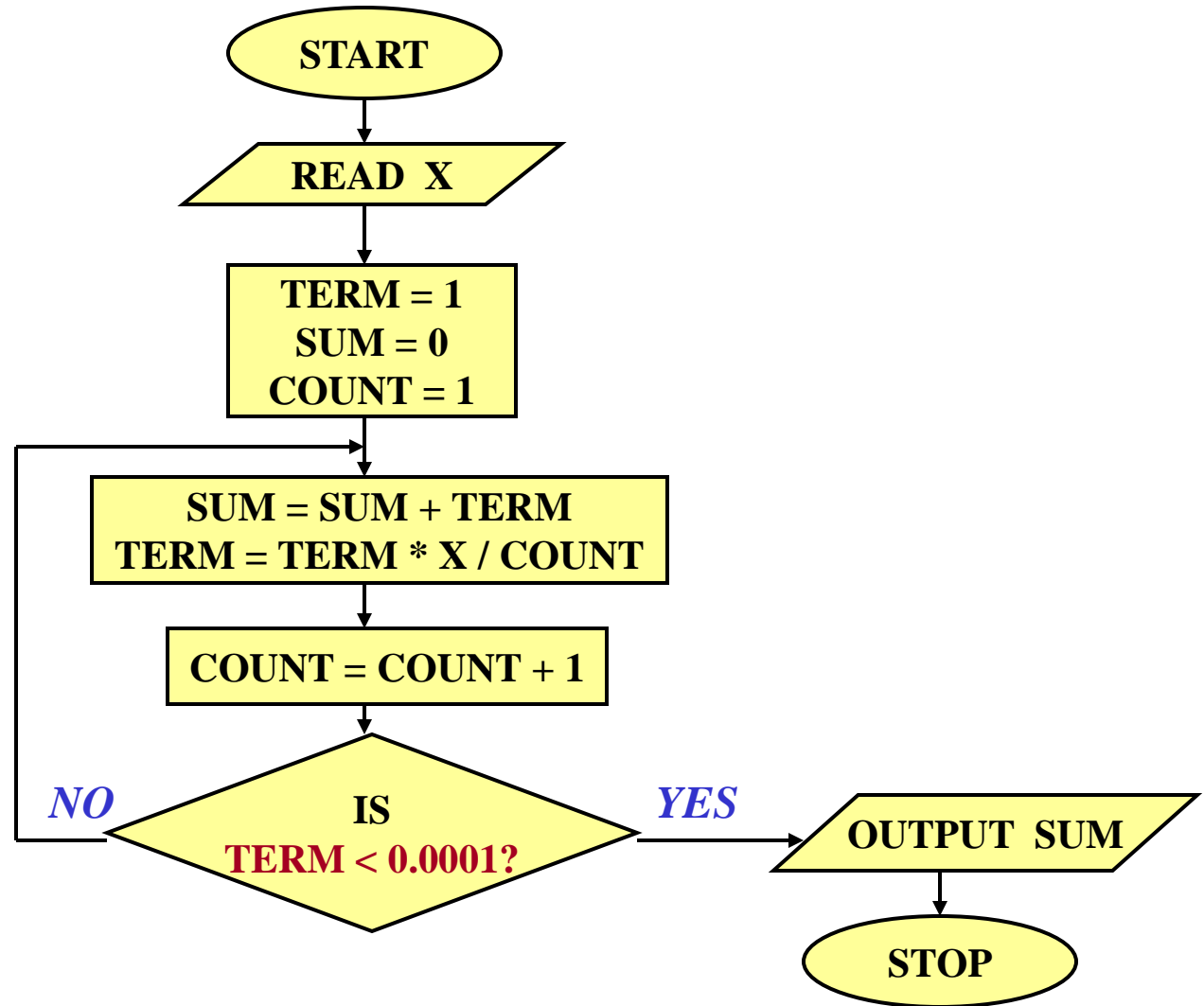
Example 7: *Computing Factorial*



Example 8: *Computing e^x series up to N terms*



Example 9: *Computing e^x series up to 4 decimal places*



Example 10: *Roots of a quadratic equation*

$$ax^2 + bx + c = 0$$

TRY YOURSELF

Example 11: *Grade computation*

MARKS \geq 90 \rightarrow Ex

89 \geq MARKS \geq 80 \rightarrow A

79 \geq MARKS \geq 70 \rightarrow B

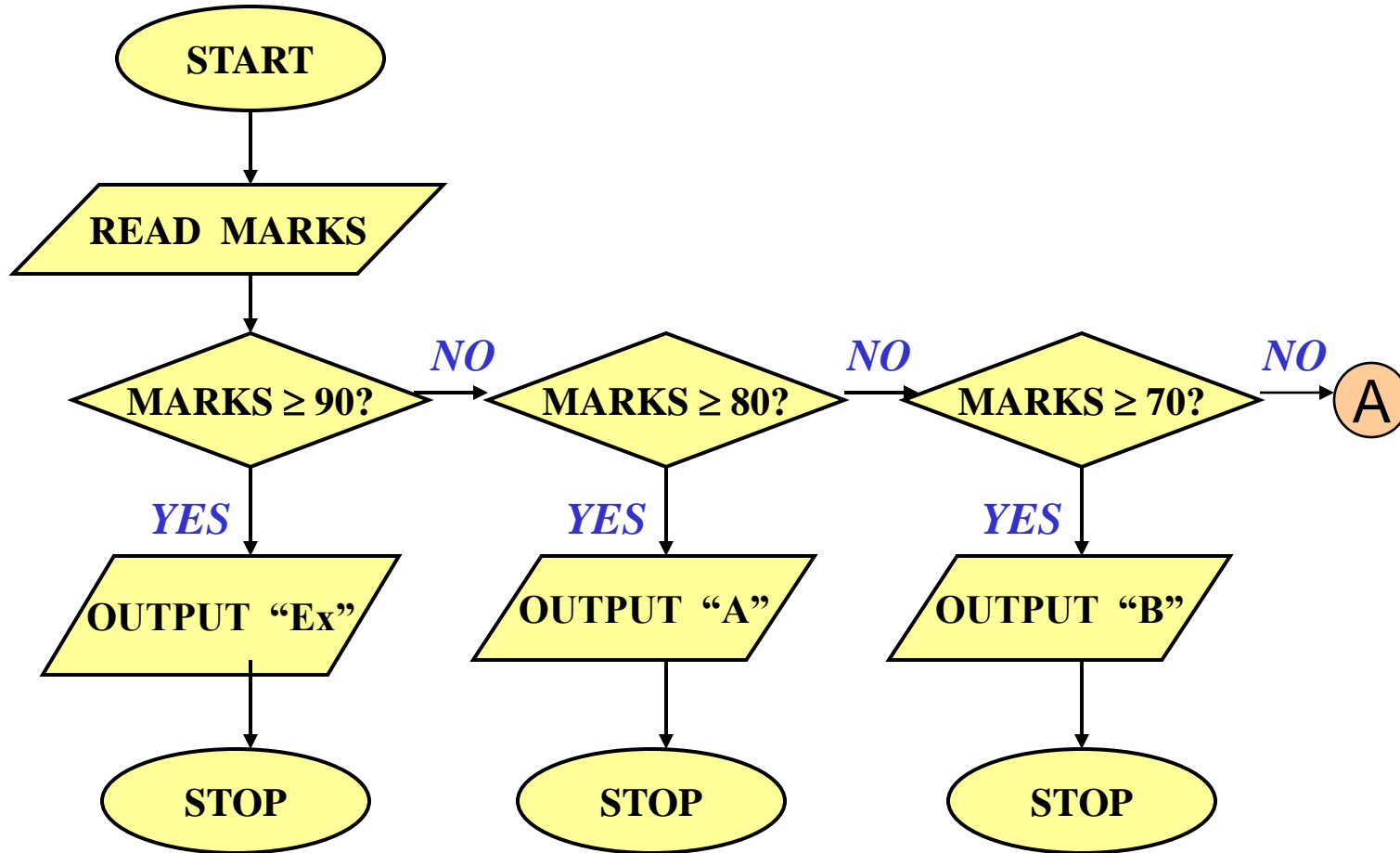
69 \geq MARKS \geq 60 \rightarrow C

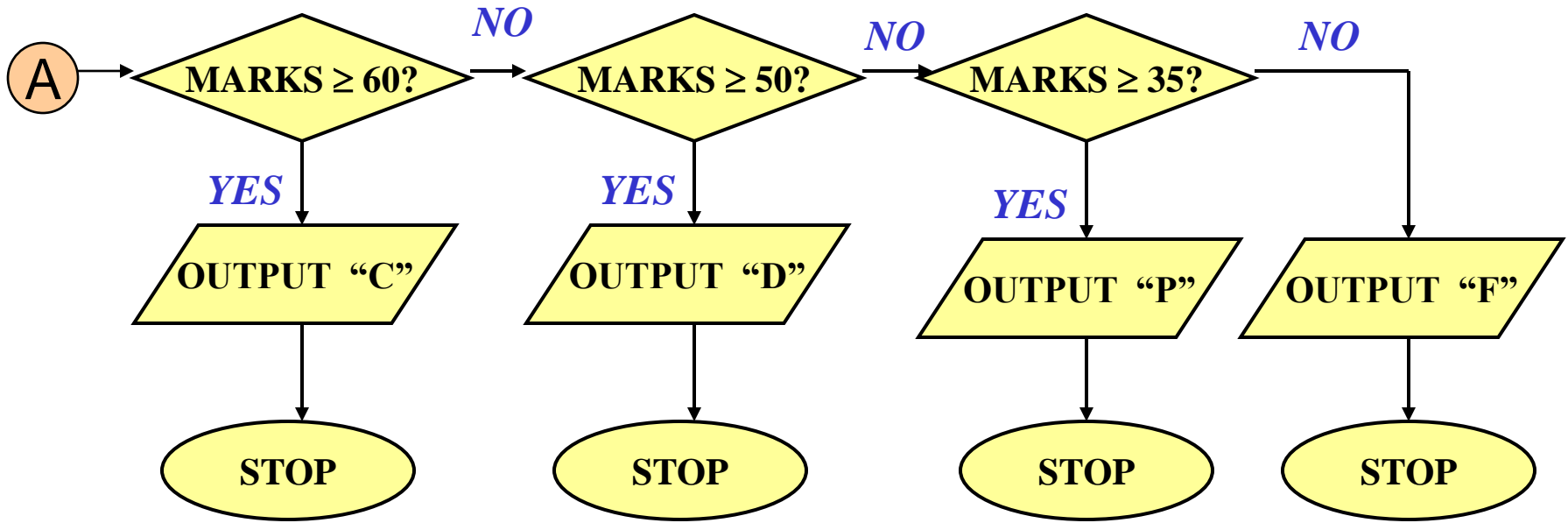
59 \geq MARKS \geq 50 \rightarrow D

49 \geq MARKS \geq 35 \rightarrow P

34 \geq MARKS \rightarrow F

Grade Computation (contd.)





Programming in C

Introduction to C

- C is a general-purpose, structured programming language.
 - Resembles other high-level structured programming languages, such as Pascal and Fortran-77.
 - Also contains additional features which allow it to be used at a lower level.
- C can be used for applications programming as well as for systems programming.
- There are only 32 keywords and its strength lies in its built-in functions.
- C is highly portable, since it relegated much computer-dependent features to its library functions.

History of C

- Originally developed in the 1970's by Dennis Ritchie at AT&T Bell Laboratories.
 - Outgrowth of two earlier languages BCPL and B.
- Popularity became widespread by the mid 1980's, with the availability of compilers for various platforms.
- Standardization has been carried out to make the various C implementations compatible.
 - American National Standards Institute (**ANSI**)
 - **GNU**

Structure of a C program

- Every C program consists of one or more functions.
 - One of the functions must be called *main*.
 - The program will always begin by executing the main function.
- Each function must contain:
 - A function *heading*, which consists of the function *name*, followed by an optional list of *arguments* enclosed in parentheses.
 - A list of argument *declarations*.
 - A *compound statement*, which comprises the remainder of the function.

Contd.

- Each compound statement is enclosed within a pair of braces: ‘{’ and ‘}’
 - The braces may contain combinations of elementary statements and other compound statements.
- Comments may appear anywhere in a program, enclosed within delimiters ‘/*’ and ‘*/’.
 - Example:

```
a = b + c; /* ADD TWO NUMBERS */
```

Sample C program #1

Header file includes functions for input/output

```
#include <stdio.h>
```

Main function is executed when you run the program. (Later we will see how to pass its parameters)

```
main ()
```

```
{
```

```
    printf ("\n Our first look at a C program \n");
```

```
}
```

Curly braces within which statements are executed one after another.

Statement for printing the sentence within double quotes (“..”). ‘\n’ denotes end of line.

Our first look at a C program

Sample C program #2

```
#include <stdio.h>
main ()
{
    int    a, b, c;
    a = 10;
    b = 20;
    c = a + b;
    printf ("\n The sum of %d and %d is %d\n",
           a,b,c) ;
}
```

Integers variables declared before their usage.

Control character for printing value of a in decimal digits.

The sum of 10 and 20 is 30

Sample C program #3

```
#include <stdio.h>

/* FIND THE LARGEST OF THREE NUMBERS */

main()
{
    int a, b, c;
    scanf ("%d %d %d", &a, &b, &c);
    if ((a>b) && (a>c))
        printf ("\n Largest is %d", a);
    else
        if (b>c)
            printf ("\n Largest is %d", b);
        else
            printf ("\n Largest is %d", c);
}
```

Comments within /* .. */

Input statement for reading three variables from the keyboard

Conditional statement

Composite condition check */

Simple condition check */

Sample C program #4

Preprocessor statement.

Replace PI by 3.1415926

before compilation.

Example of a function

Called as per need from

Main programme.

```
#include <stdio.h>
#define PI 3.1415926

/* Compute the area of a circle */
main()
{
    float radius, area;
    float myfunc (float radius);

    scanf ("%f", &radius);
    area = myfunc (radius);
    printf ("\n Area is %f \n", area);
}
```

```
float myfunc (float r)
{
    float a;
    a = PI * r * r;
    return (a); /* return result */
}
```

Function called.

main() is also a function

```
#include <stdio.h>
main()
{
    int    a, b, c;

    a = 10;
    b = 20;
    c = a + b;
    printf ("\n The sum of %d and %d is %d\n",
           a,b,c);
}
```

Desirable Programming Style

- Clarity
 - The program should be clearly written.
 - It should be easy to follow the program logic.
- Meaningful variable names
 - Make variable/constant names meaningful to enhance program clarity.
 - 'area' instead of 'a'
 - 'radius' instead of 'r'
- Program documentation
 - Insert comments in the program to make it easy to understand.
 - Never use too many comments.

Contd.

- Program indentation
 - Use proper indentation.
 - Structure of the program should be immediately visible.

Indentation Example #1 :: Good Style

```
#include <stdio.h>
#define PI 3.1415926
/* Compute the area of a circle */

main()
{
    float radius, area;
    float myfunc (float radius);

    scanf ("%f", &radius);
    area = myfunc (radius);
    printf ("\n Area is %f \n", area);
}
```

```
float myfunc (float r)
{
    float a;
    a = PI * r * r;
    return (a);    /* return result */
}
```

Indentation Example #1 :: Bad Style

```
#include <stdio.h>
#define PI 3.1415926
/* Compute the area of a circle */
main()
{
float radius, area;
float myfunc (float radius);
scanf ("%f", &radius);
area = myfunc (radius);
printf ("\n Area is %f \n", area);
}
```

```
float myfunc (float r)
{
float a;
a = PI * r * r;
return (a); /* return result */
}
```

Indentation Example #2 :: Good Style

```
#include <stdio.h>

/* FIND THE LARGEST OF THREE NUMBERS */

main()
{
    int  a, b, c;
    scanf ("%d %d %d", &a, &b, &c);
    if ((a>b) && (a>c))                /* Composite condition check */
        printf ("\n Largest is %d", a);
    else
        if (b>c)                        /* Simple condition check */
            printf ("\n Largest is %d", b);
        else
            printf ("\n Largest is %d", c);
}
```

Indentation Example #2 :: Bad Style

```
#include <stdio.h>

/* FIND THE LARGEST OF THREE NUMBERS */

main()
{
int  a, b, c;
scanf ("%d %d %d", &a, &b, &c);
if ((a>b) && (a>c)) /* Composite condition check */
printf ("\n Largest is %d", a);
else
if (b>c) /* Simple condition check */
printf ("\n Largest is %d", b);
else
printf ("\n Largest is %d", c);
}
```

The C Character Set

- The C language alphabet:
 - Uppercase letters 'A' to 'Z'
 - Lowercase letters 'a' to 'z'
 - Digits '0' to '9'
 - Certain

!	#	%	^	&	*	()
-	_	+	=	~	[]	\
	;	:	'	"	{	}	,
.	<	>	/	?	blank		

Identifiers and Keywords

- Identifiers
 - Names given to various program elements (variables, constants, functions, etc.)
 - May consist of *letters*, *digits* and the *underscore* ('_') character, with no space between.
 - First character must be a letter.
 - An identifier can be arbitrary long.
 - Some C compilers recognize only the first few characters of the name (16 or 31).
 - Case sensitive
 - 'area', 'AREA' and 'Area' are all different.

Contd.

- **Keywords**
 - Reserved words that have standard, predefined meanings in C.
 - Cannot be used as identifiers.
 - OK within comments.

auto	break	case	char	const	continue	default	do
double	else	enum	extern	float	for	goto	if
int	long	register	return	short	signed	sizeof	static
struct	switch	typedef	union	unsigned	void	volatile	while

Valid and Invalid Identifiers

- Valid identifiers

X

abc

simple_interest

a123

LIST

stud_name

Empl_1

Empl_2

avg_empl_salary

- Invalid identifiers

10abc

my-name

“hello”

simple interest

(area)

%rate

Data Types in C

int :: integer quantity

Typically occupies 4 bytes (32 bits) in memory.

char :: single character

Typically occupies 1 byte (8 bits) in memory.

float :: floating-point number (a number with a decimal point)

Typically occupies 4 bytes (32 bits) in memory.

double :: double-precision floating-point number

Contd.

- Some of the basic data types can be augmented by using certain data type qualifiers:
 - short
 - long
 - signed
 - unsigned
- Typical examples:
 - short int
 - long int
 - unsigned int

Some Examples of Data Types

- int

0, 25, -156, 12345, -99820

- char

'a', 'A', '*', '/', ''

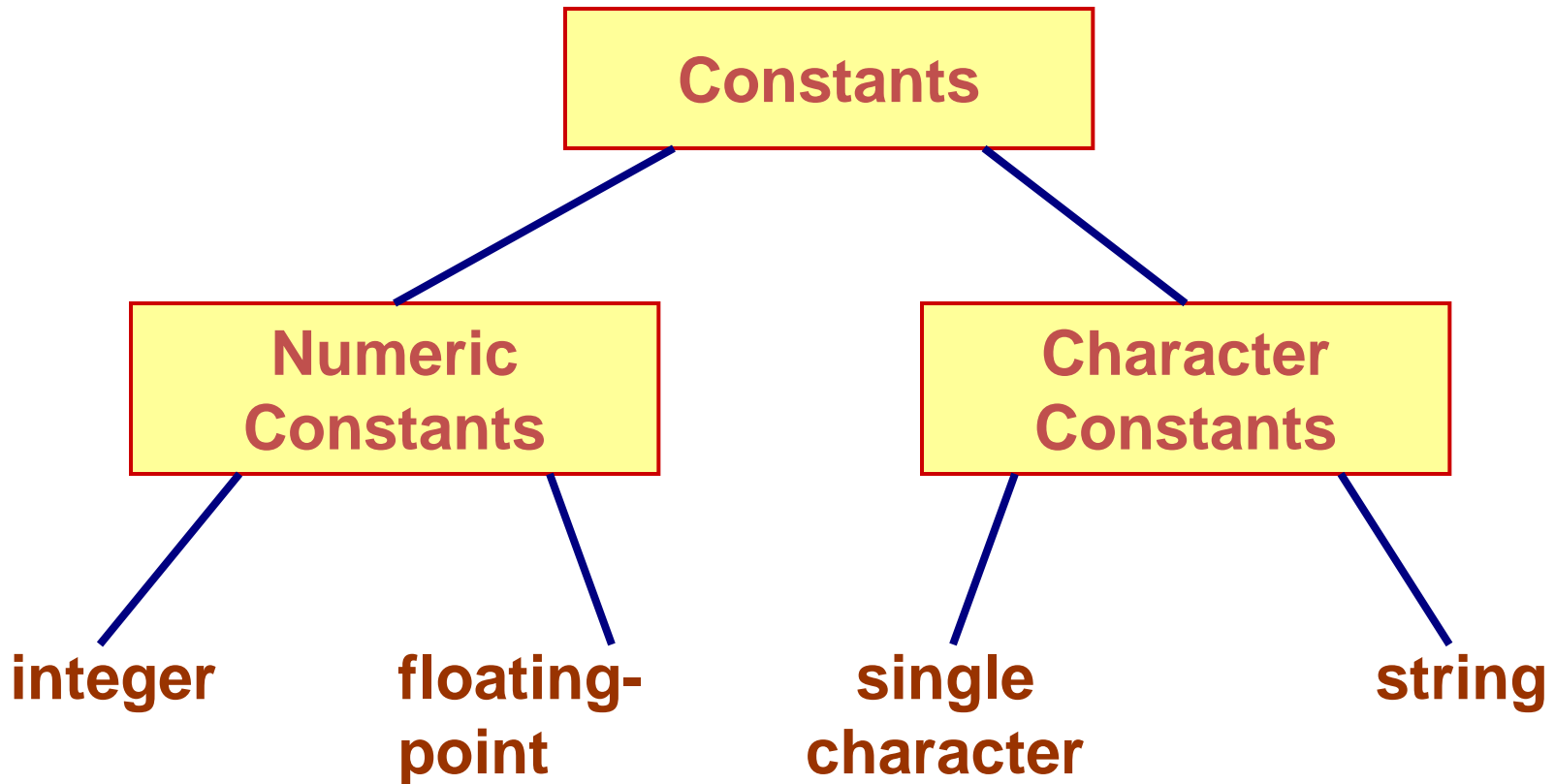
- float

23.54, -0.00345, 25.0

2.5E12, 1.234e-5

E or e means “10 to the power of”

Constants



Integer Constants

- Consists of a sequence of digits, with possibly a plus or a minus sign before it.
 - Embedded spaces, commas and non-digit characters are not permitted between digits.
- Maximum and minimum values (for 32-bit representations)
 - Maximum :: 2147483647
 - Minimum :: – 2147483648

Floating-point Constants

- Can contain fractional parts.
- Very large or very small numbers can be represented.

23000000 can be represented as $2.3e7$

- Two different notations:

1. Decimal notation

25.0, 0.0034, .84, -2.234

2. Exponential (scientific) notation

3.45e23, 0.123e-12, 123E2

e means “10 to the power of”

Single Character Constants

- Contains a single character enclosed within a pair of single quote marks.
 - Examples :: '2', '+', 'Z'
- Some special backslash characters
 - '\n' new line
 - '\t' horizontal tab
 - '\'' single quote
 - '\"' double quote
 - '\\' backslash
 - '\0' null

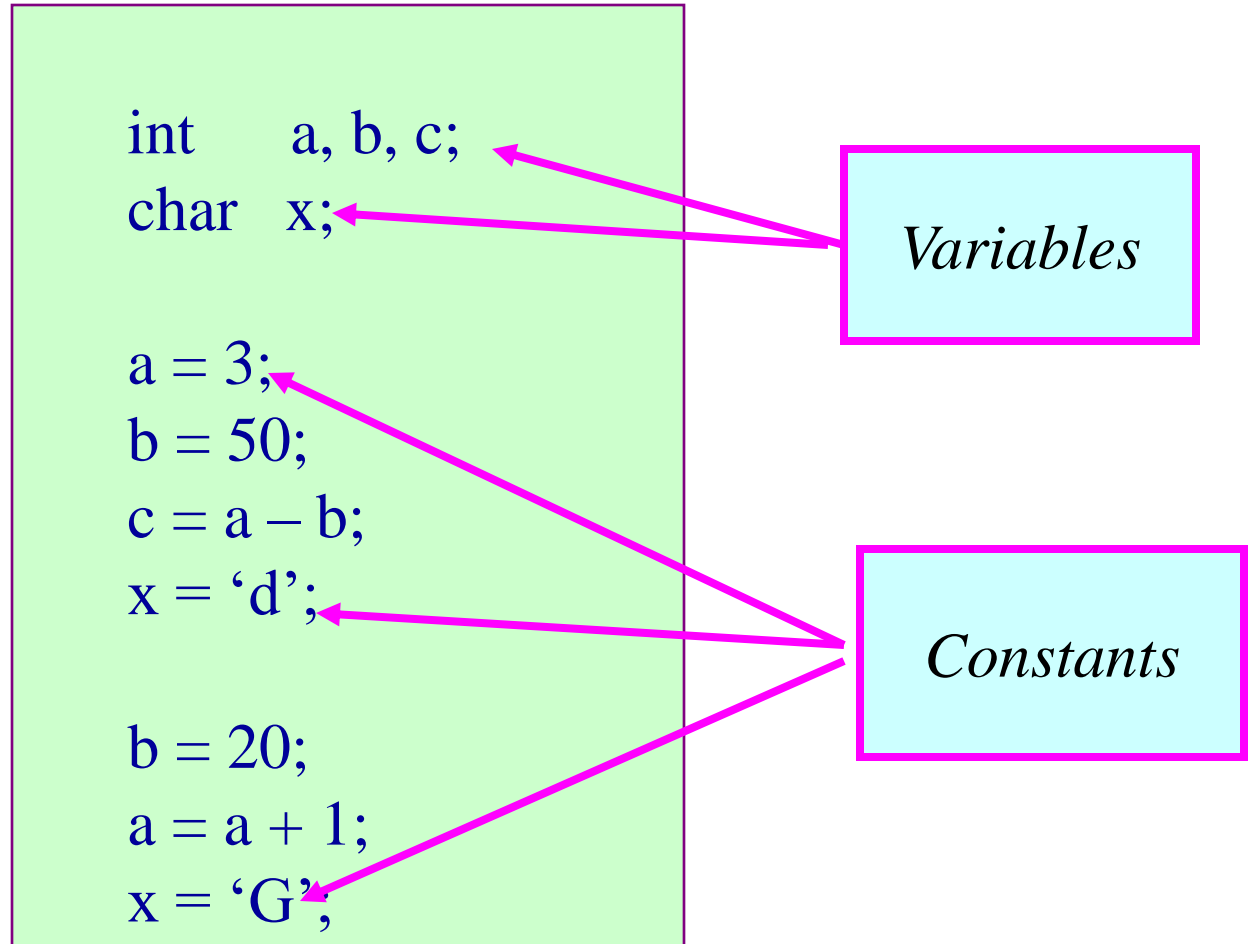
String Constants

- Sequence of characters enclosed in double quotes.
 - The characters may be letters, numbers, special characters and blank spaces.
- Examples:
 - “nice”, “Good Morning”, “3+6”, “3”, “C”
- Differences from character constants:
 - ‘C’ and “C” are not equivalent.
 - ‘C’ has an equivalent integer value while “C” does not.

Variables

- It is a data name that can be used to store a data value.
- Unlike constants, a variable may take different values in memory during execution.
- Variable names follow the naming convention for identifiers.
 - Examples :: temp, speed, name2, current

Example



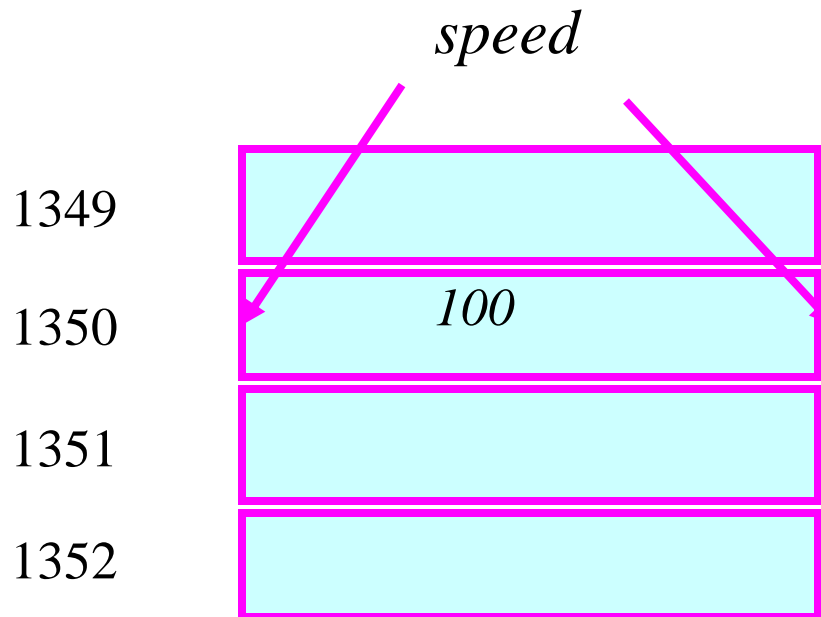
Declaration of Variables

- There are two purposes:
 1. It tells the compiler what the variable name is.
 2. It specifies what type of data the variable will hold.
- General syntax:
 data-type variable-list;
- Examples:
 int velocity, distance;
 int a, b, c, d;
 float temp;
 char flag, option;

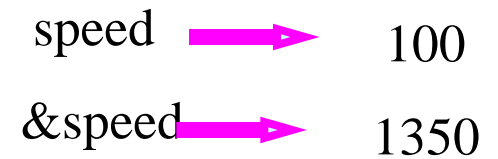
A First Look at Pointers

- A variable is assigned a specific memory location.
 - For example, a variable **speed** is assigned memory location **1350**.
 - Also assume that the memory location contains the data value **100**.
 - When we use the name **speed** in an expression, it refers to the value **100** stored in the memory location.
$$\text{distance} = \text{speed} * \text{time};$$
- Thus every variable has an *address* (in memory), and its *contents*.

Address and Content



```
int speed;  
speed=100;
```



Contd.

- In C terminology, in an expression `speed` refers to the contents of the memory location.
`&speed` refers to the address of the memory location.
- Examples:

```
printf ("%f %f %f", speed, time, distance);  
scanf ("%f %f", &speed, &time);
```

An Example

```
#include <stdio.h>
main()
{
    float speed, time, distance;

    scanf ("%f %f", &speed, &time);
    distance = speed * time;
    printf ("\n The distance traversed is: \n", distance);
}
```

Address of speed

Content of speed

Assignment Statement

- Used to assign values to variables, using the assignment operator (=).

- General syntax:

`variable_name = expression;`

- Examples:

`velocity = 20;`

`b = 15; temp = 12.5;`

`A = A + 10;`

`v = u + f * t;`

`s = u * t + 0.5 * f * t * t;`

Contd.

- A value can be assigned to a variable at the time the variable is declared.

```
int speed = 30;
```

```
char flag = 'y';
```

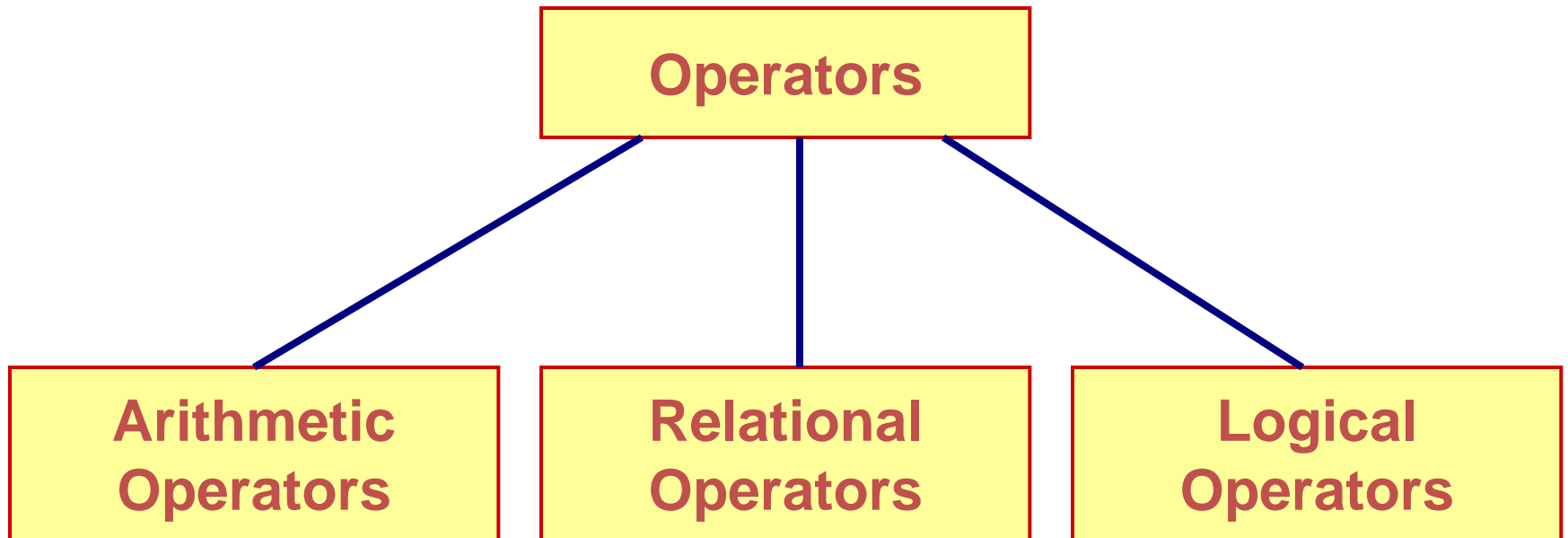
- Several variables can be assigned the same value using multiple assignment operators.

```
a = b = c = 5;
```

```
flag1 = flag2 = 'y';
```

```
speed = flow = 0.0;
```

Operators in Expressions



Arithmetic Operators

- Addition :: +
- Subtraction :: −
- Division :: /
- Multiplication :: *
- Modulus :: %

Examples

distance = rate * time ;

netIncome = income - tax ;

speed = distance / time ;

area = PI * radius * radius;

y = a * x * x + b*x + c;

quotient = dividend / divisor;

remain =dividend % divisor;

Contd.

- Suppose x and y are two integer variables, whose values are 13 and 5 respectively.

$x + y$	18
$x - y$	8
$x * y$	65
x / y	2
$x \% y$	3

Operator Precedence

- In decreasing order of priority
 1. Parentheses :: ()
 2. Unary minus :: -5
 3. Multiplication, Division, and Modulus
 4. Addition and Subtraction
- For operators of the *same priority*, evaluation is from *left to right* as they appear.
- Parenthesis may be used to change the precedence of operator evaluation.

Examples: Arithmetic expressions

$$a + b * c - d / e \quad \rightarrow \quad a + (b * c) - (d / e)$$

$$a * -b + d \% e - f \quad \rightarrow \quad a * (-b) + (d \% e) - f$$

$$a - b + c + d \quad \rightarrow \quad (((a - b) + c) + d)$$

$$x * y * z \quad \rightarrow \quad ((x * y) * z)$$

$$a + b + c * d * e \quad \rightarrow \quad (a + b) + ((c * d) * e)$$

Integer Arithmetic

- When the operands in an arithmetic expression are integers, the expression is called *integer expression*, and the operation is called *integer arithmetic*.
- Integer arithmetic always yields integer values.

Real Arithmetic

- Arithmetic operations involving only real or floating-point operands.
- Since floating-point values are rounded to the number of significant digits permissible, the final value is an approximation of the final result.
 $1.0 / 3.0 * 3.0$ will have the value 0.99999 and not 1.0
- The modulus operator cannot be used with real operands.

Mixed-mode Arithmetic

- When one of the operands is integer and the other is real, the expression is called a *mixed-mode* arithmetic expression.
- If either operand is of the real type, then only real arithmetic is performed, and the result is a real number.
$$25 / 10 \rightarrow 2$$
$$25 / 10.0 \rightarrow 2.5$$
- Some more issues will be considered later.

Problem of value assignment

- Assignment operation

variable= **expression_value**;

or

variable1=**variable2**;


Data type of the **RHS** should be compatible with that of LHS.

e.g. **four byte** floating point number is not allowed to be assigned to a **two byte** integer variable.

Type Casting

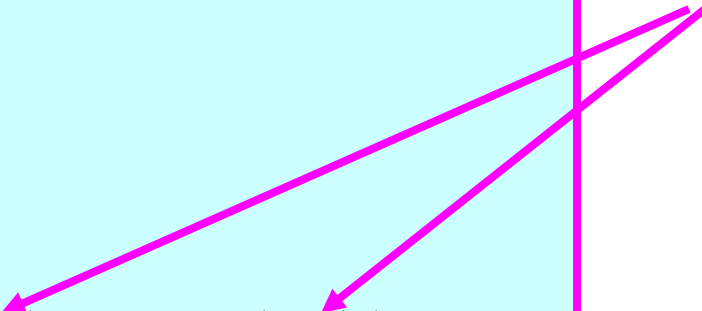
```
int x;  
float r=3.0;  
  
x= (int)(2*r);
```

Type casting of a floating point expression to an integer variable.



```
double perimeter;  
float pi=3.14;  
int r=3;  
  
perimeter=2.0* (double) pi * (double) r;
```

Type casting to double



Relational Operators

- Used to compare two quantities.
 - <** is less than
 - >** is greater than
 - <=** is less than or equal to
 - >=** is greater than or equal to
 - ==** is equal to
 - !=** is not equal to

Examples

$10 > 20$ is false

$25 < 35.5$ is true

$12 > (7 + 5)$ is false

- When arithmetic expressions are used on either side of a relational operator, the arithmetic expressions will be evaluated first and then the results compared.

$a + b > c - d$ is the same as $(a+b) > (c+d)$

Examples

- Sample code segment in C

```
if (x > y)
    printf ("%d is larger\n", x);
else
    printf ("%d is larger\n", y);
```


Logical Operators

- There are two logical operators in C (also called logical connectives).
 - && → Logical AND
 - | | → Logical OR
- What they do?
 - They act upon operands that are themselves logical expressions.
 - The individual logical expressions get combined into more complex conditions that are true or false.

– Logical AND

- Result is true if both the operands are true.

– Logical OR

- Result is true if at least one of the operands are true.

X	Y	X && Y	X Y
FALSE	FALSE	FALSE	FALSE
FALSE	TRUE	FALSE	TRUE
TRUE	FALSE	FALSE	TRUE
TRUE	TRUE	TRUE	TRUE

Input / Output

- `printf`
 - Performs output to the standard output device (typically defined to be the screen).
 - It requires a format string in which we can specify:
 - The text to be printed out.
 - Specifications on how to print the values.
`printf ("The number is %d.\n", num) ;`
 - The format specification `%d` causes the value listed after the format string to be embedded in the output as a decimal number in place of `%d`.
 - Output will appear as: `The number is 125.`

- `scanf`

- Performs input from the standard input device, which is the keyboard by default.
- It requires a format string and a list of variables into which the value received from the input device will be stored.
- It is required to put an ampersand (&) before the names of the variables.

```
scanf ("%d", &size) ;  
scanf ("%c", &nextchar) ;  
scanf ("%f", &length) ;  
scanf ("%d %d", &a, &b);
```