1
Basic C Programming

Basic C Programming

- **Structure of a C Program**
- Data Types, Constants, Variables, Operators, Data Type Conversion, Mathematical Library
- Simple Input/Output
- Self-Learning Programming Example

Why Learning C Programming Language?

- **Advantages** on using C
  - Powerful, flexible, efficient, portable
  - Enable the creation of well-structured programs
- Any **disadvantages**?
  - Free style and **not strongly-typed**
  - The use of ***pointers***, which may confuse many students
- **Why** doing data structures in C
  - Efficient
  - Provide ***pointers*** for building data structures which are powerful
  - Bridge to C++ (OO Programming)

Dennis Ritchie

Structure of a C Program

A simple C program has the following structure:

```
/* comment line 1 */
//  or comment line 2
preprocessor instructions
int main()
{
    statements;
    return 0;
}
```

Structure of a C Program

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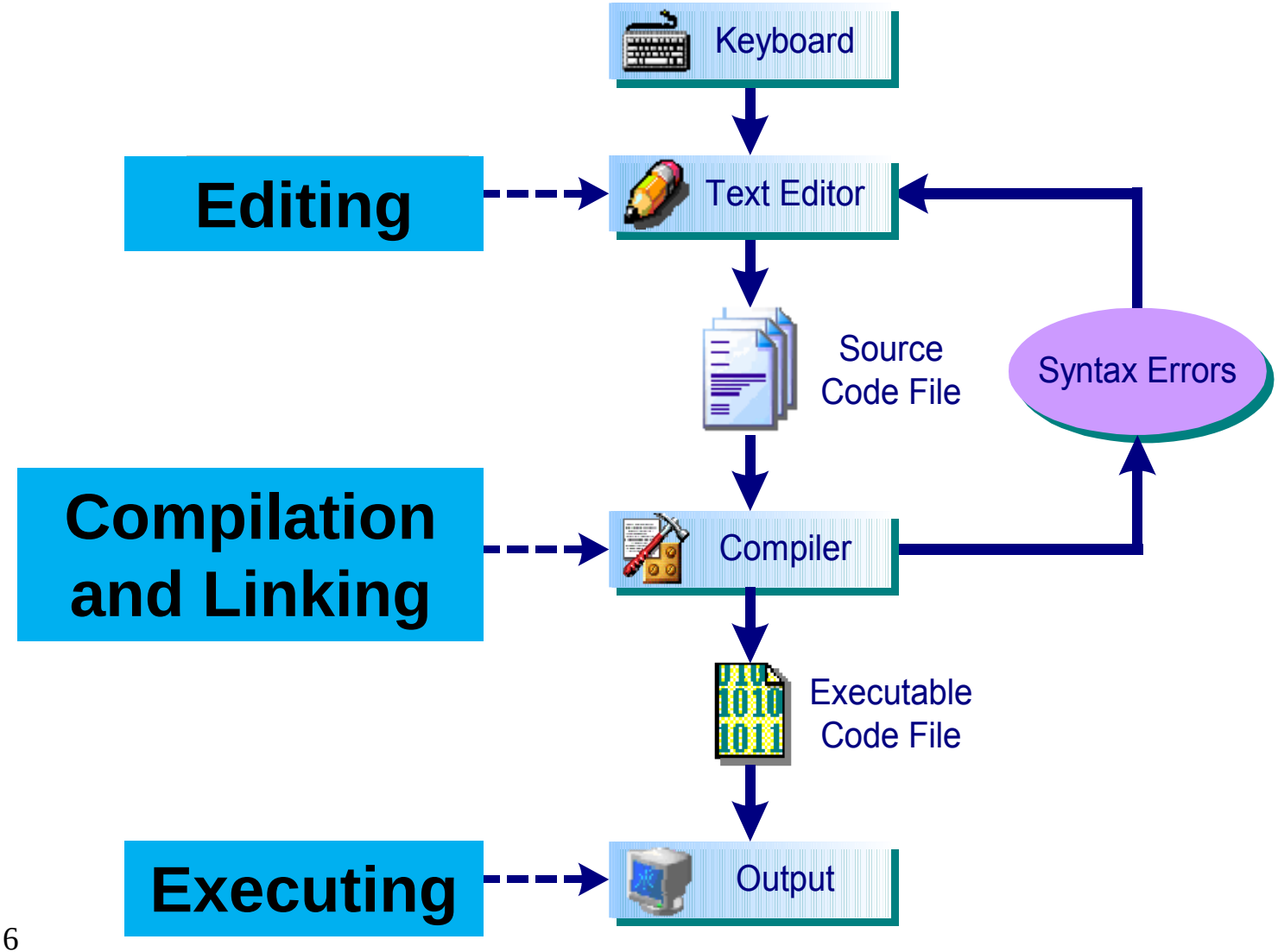
//  or comment line 2
preprocessor instructions
int main()
{
   statements;
   return 0;
}
```

An Example C Program

```
 /* Purpose: a program to
print Hello World! */
#include <stdio.h>
int main()
{  // begin body
   printf("Hello World! \n");
   return 0;
}  // end body
```

Development of a C Program



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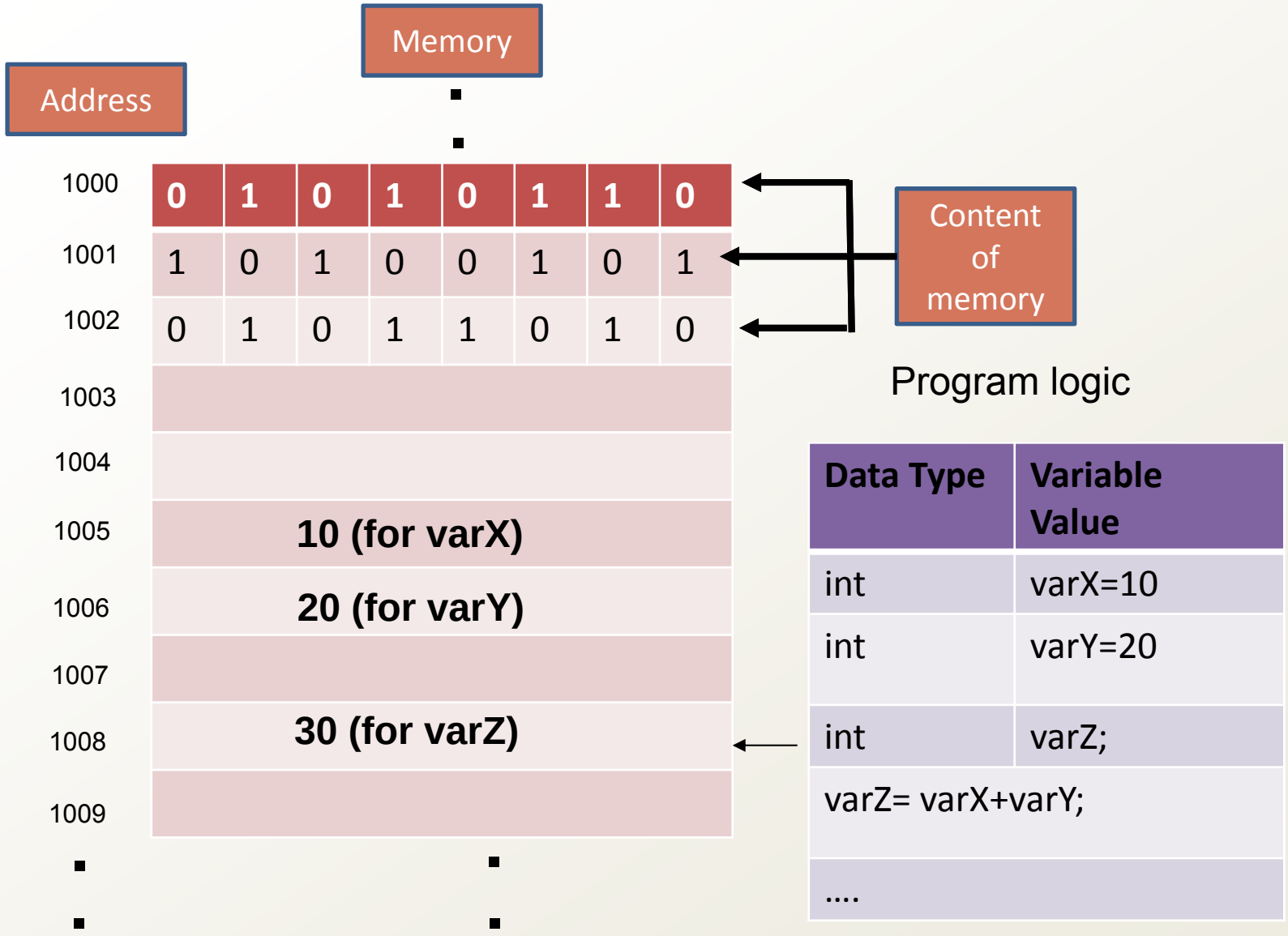
Computer Memory and Variables



Data and Types

- Data type determines the **kind of data** that a **variable** can hold, how many **memory cells** (bytes) are reserved for it and the operations that can be performed on it. (Note – the size in memory depends on machines.)
- **Integers**
  - **int (4 bytes or 2 bytes in some older systems)**
  - short (2 bytes – 16 bits)
  - long (4 bytes)
  - unsigned (4 bytes)
  - unsigned short (2 bytes)
  - unsigned long (4 bytes)
- **Floating Points**
  - float (4 byte – 32 bits)
  - **double** (8 bytes – 64 bits)
- **Characters**
  - 128 distinct characters in the ASCII character set.
  - Two C character types: **char** and unsigned char.
    - **char** (1 byte – 8 bits, range: -128 – 127)
    - unsigned char (1 byte – 8 bits, range: 0 – 255)

Note: Operations involving the **int** data type are always ***exact***, while the **float** and **double** data types can be ***inexact***.

Constants

- A constant is an object whose value is **unchanged** throughout the life of the program. There are four types of constants: integer constants, floating point constants, character constants and string constants.
- Four types of constant values:
  - **Integer**: e.g. 100, –256; **Floating-point**: e.g. 2.4, –3.0;
  - **Character**: e.g. 'a', '+' ; **String**: e.g. "Hello Students "

- **Defining Constants – by using the preprocessor directive #define**

  Format: **#define** CONSTANTNAME **value**

  E.g. **#define TAX_RATE** 0.12

  /* define a constant TAX_RATE with 0.12 */

- **Defining Constants - by defining a constant variable**

  Format: **const type varName = value;**

  E.g. **const** float **pi = 3.14159**;

  /* declare a float constant variable pi with value 3.14159 */

  printf("pi = %f\n", pi);

Characters - ASCII Set (1 byte)

	0	1	2	3	4	5	6	7	8	9
0	NUL							BEL	BS	TAB
1	LF		FF	CR						
2								ESC		
3			SP	!	"	#	$	%	&	'
4	(	)	*	+	,	-	.	/	0	1
5	2	3	4	5	6	7	8	9	:	;
6	<	=	>	?	@	A	B	C	D	E
7	F	G	H	I	J	K	L	M	N	O
8	P	Q	R	S	T	U	V	W	X	Y
9	Z	[	\	]	^	_	'	a	b	c
10	d	e	f	g	h	i	j	k	l	m
11	n	o	p	q	r	s	t	u	v	w
12	x	y	z	{	|	}	~	DEL		

- **Character Constants**
  - '**A**' or 65
- **Non-printable Characters:**
  - '**\n**', '**\t**', '**\a**'
- **Character vs String Constants**
  - '**A**' or "**A**"

Variables

- A variable declaration always contains 2 components:
  - its **data_type** (eg. short, int, long, etc.)
  - its **var_name** (e.g. count, numOfSeats, etc.)

  The syntax for variable declaration: **data_type var_name**[, **var_name**];
- Declare your variables at the **beginning** of a function in your program. Examples of variable initializations:

  int count = 20;

  float temperature, **result**;
- The following C **keywords** are **reserved** and **cannot** be used as variable names:

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

Operators

- Fundamental Arithmetic operators: +, -, *, /, %
  - E.g. 7/3 = 2; 7%3 = 1; 6.6/2.0=3.3;
- Assignment operators:
  - E.g. float amount = 25.50;
  - Chained assignment: E.g. a = b = c = 3;
- Arithmetic assignment operators: +=, -=, *=, /=,%=
  - E.g. a += 5;
- Increment/decrement operators: ++, --
- Relational operators: ==, !=, <, <=, >, >=
  - E.g. 7 >= 5
- Conditional operators: ?:

Increment Operators

- The increment operator increases a variable by 1. It can be used in two modes: *prefix* and *postfix*.
- In **prefix mode**: **++**var_name
  (1) var_name is incremented by 1 and
  (2) the value of the expression is the updated value of var_name.
- In **postfix mode**: var_name**++**
  (1) The value of the expression is the current value of var_name
  (2) then var_name is incremented by 1.

```
#include <stdio.h>
int main()
{     int    num = 4;
      printf("value of num is %d\n", num);
      num++;      // ++num; i.e., num = num+1;
      printf("value of num is %d\n", num);
      num = 4;
      printf("value of num++ is %d\n", num++);
      printf("value of num is %d\n",num);
      printf("value of ++num is %d\n", ++num);
      printf("value of num is %d\n\n",num);
      return 0;
}
```

Output

```
value of num is 4
value of num is 5

value of num++ is 4
value of num is 5
value of ++num is 6
value of num is 6
```

Decrement Operators

- The way the **decrement operator** '--' works in the same way as the ++ operator, except that the variable is decremented by 1.
  - **--var_name -** decrement **var_name** before any operation with it (prefix mode).
  - **var_name-- -** decrement **var_name** after any operation with it (postfix mode).

```
#include <stdio.h>
int main()
{
        int    num = 4;
        printf("value of num is %d\n", num);
        num--;   // same as --num;
        printf("value of num is %d\n", num);
        num = 4;
        printf("value of num-- is %d\n", num--);
        printf("value of num is %d\n", num);
        printf("value of --num is %d\n", --num);
        printf("value of num is %d\n", num);
        return 0;
}
```

Output

```
value of num is 4
value of num is 3

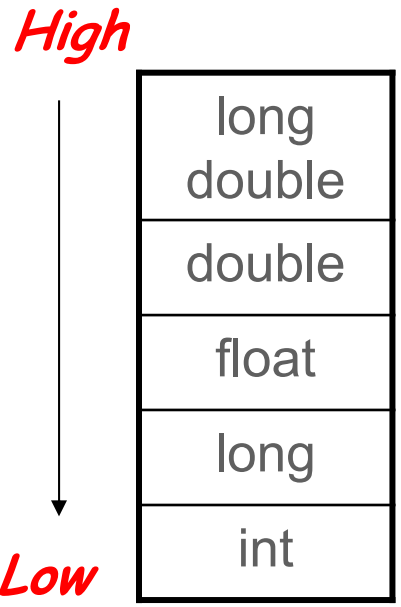
value of num-- is 4
value of num is 3
value of --num is 2
value of num is 2
```

Data Type Conversion

Arithmetic operations require **two numbers** in an expression/assignment are of the **same type**.

If not, three kinds of conversion are available:

1. ***Explicit conversion*** - uses type casting operators, i.e. (int), (float), ..., etc.
   - e.g. (int)2.7 + (int)3.5
2. ***Arithmetic conversion*** - in mix operation, it converts the operands to the type of the **higher ranking** of the two.
   - e.g. double a; a = **2**+ 3.5; // 2 to 2.0 then add
3. ***Assignment conversion*** - converts the type of the result of computing the expression to that of the type of the left hand side if they are different.
   - e.g. int b; b = **2.7 + 3.5**; // 6.2 to 6 then to b



Note: Possible *pit-falls* about type conversion -
Loss of precision: e.g. from **float** to **int**, the fractional part will be lost.

Mathematical Libraries

#include <math.h>

Function	Argument Type	Description	Result Type
`ceil(x)`	`double`	Return the smallest `double` larger than or equal to `x` that can be represented as an `int`.	`double`
`floor(x)`	`double`	Return the largest `double` smaller than or equal to `x` that can be represented as an `int`.	`double`
`abs(x)`	`int`	**Return the absolute value of `x`, where `x` is an `int`.**	`int`
`fabs(x)`	`double`	Return the absolute value of `x`, where `x` is a floating point number.	`double`
`sqrt(x)`	`double`	**Return the square root of `x`, where `x` >= 0.**	`double`
`pow(x,y)`	`double x, double y`	**Return x to the y power, x^y.**	`double`
`cos(x)`	`double`	Return the cosine of `x`, where `x` is in radians.	`double`
`sin(x)`	`double`	Return the sine of `x`, where `x` is in radians.	`double`
`tan(x)`	`double`	Return the tangent of `x`, where `x` is in radians.	`double`
`exp(x)`	`double`	Return the exponential of `x` with the base e, where e is 2.718282.	`double`
`log(x)`	`double`	Return the natural logarithm of `x`.	`double`
`log10(x)`	`double`	Return the base 10 logarithm of `x`.	`double`

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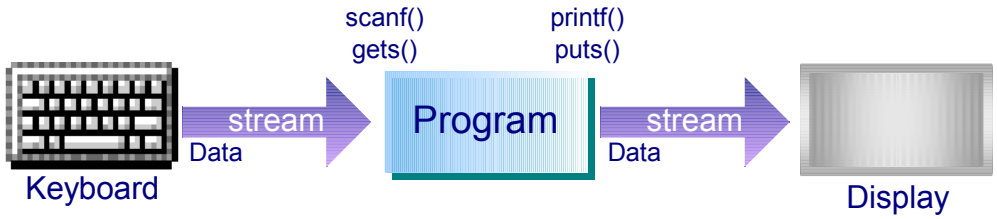
Simple Input/Output

- The following two Input/Output functions are most frequently used:

  - **printf()**: output function
  - **scanf()**: input function



- The I/O functions are in the C library **<stdio>**. To use the I/O functions, we need to include the header file:

  #include <stdio.h>

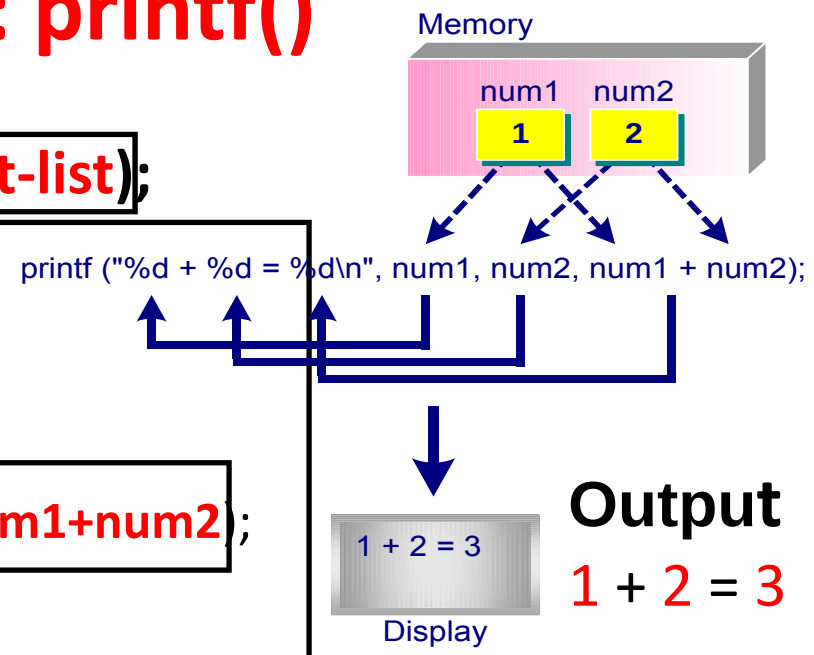
  as the **preprocessor instruction** in a program.

Simple Output: printf()

The printf() statement has the form:

printf (control-string, argument-list);

```
#include <stdio.h>
int main()
{
    int num1 = 1, num2 = 2;
    printf("%d + %d = %d\n", num1, num2, num1+num2);
    return 0;
}
```



- The **control-string** is a string constant. It is printed on the screen. %d is a **conversion specification**. An item will be substituted for it in the printed output.
- The **argument-list** contains a list of items such as item1, item2, …, etc.
  - Values are to be substituted into places held by the conversion specification in the control string.
  - An item can be a constant, a variable or an expression like num1 + num2.
- The **number** of items must be the same as the number of conversion specifiers.
- The **type** of items must also match the conversion specifiers.

Control-String: Conversion Specification

- A **conversion specification** is of the form

% [flag] [minimumFieldWidth] [.precision]conversionSpecifier

  - ***%*** and ***conversionSpecifier*** are compulsory. The others are optional.

Note:

- We will focus on using the compulsory options **%** and **conversionSpecifier**.
- If interested, please refer to your textbook for the other options such as *flag*, *minimumFieldWidth* and *precision*.

Control-String: Conversion Specification

Some common types of *Conversion Specifier*:

d	signed decimal conversion of int
o	unsigned octal conversion of unsigned
x,X	unsigned hexadecimal conversion of unsigned
c	single character conversion
f	signed decimal floating point conversion
s	string conversion

printf(): Example

```
#include <stdio.h>
int main( )
{
    int             num = 10;
    float           i = 10.3;
    double          j = 100.3456;

    printf(“int num = %d\n”, num);
    printf("float i = %f\n", i);
    printf("double j = %f\n", j);
      /* by default, 6 digits are printed
            after the decimal point */
    printf("double j = %.2f\n", j);
    printf("double j = %10.2f\n", j);
      /* formatted output */
    return 0;
}
```

Output

```
int num = 10
float i = 10.300000
double j = 100.345600
double j = 100.35
double j =      100.35
```

Simple Input: scanf()

- A **scanf()** statement has the form

  scanf (control-string, argument-list);

- ***control-string*** is a string constant containing conversion specifications.
- The **argument-list** contains the **addresses** of a list of items.
  - The **items** in **scanf()** may be any variable matching the type given by the conversion specification. It cannot be a constant. It cannot be an expression like n1 + n2.
  - The **variable name** has to be preceded by an **&**. This is to tell **scanf()** the **address** of the variable so that **scanf()** can read the input value and store it in the variable's memory.
- **scanf()** uses whitespace characters (such as tabs, spaces and newlines) to determine how to separate the input into different fields to be stored.
- **scanf()** stops reading when it has read all the items as indicated by the control string or the **EOF** (end of file) is encountered.

scanf(): Example

- A scanf() statement has the form

  scanf (control-string, argument-list);

```
#include <stdio.h>
int main( )
{
      int    n1, n2;
      float f1;
      double f2;

      printf("Please enter 2 integers:\n");
      scanf("%d %d", &n1, &n2);
      printf("The sum = %d\n", n1+n2);
      printf("Please enter 2 floats:\n");
      scanf("%f %lf", &f1, &f2);
      // Note: use %lf for double data
      printf("The sum = %f\n", f1+f2);
      return 0;
}
```

Output

```
Please enter 2 integers:
5 10
The sum = 15
Please enter 2 floats:
5.3 10.5
The sum = 15.800000
```

Character Input/Output

putchar( )

- The syntax of calling putchar is

```
putchar(characterConstantOrVariable);
```

It is equivalent to

```
printf("%c", characterConstantOrVariable);
```

- The difference is that putchar is **faster** because printf needs to process the control string for formatting. Also, it returns either the integer value of the written character or EOF if an error occurs.

getchar ( )

- The syntax of calling getchar is

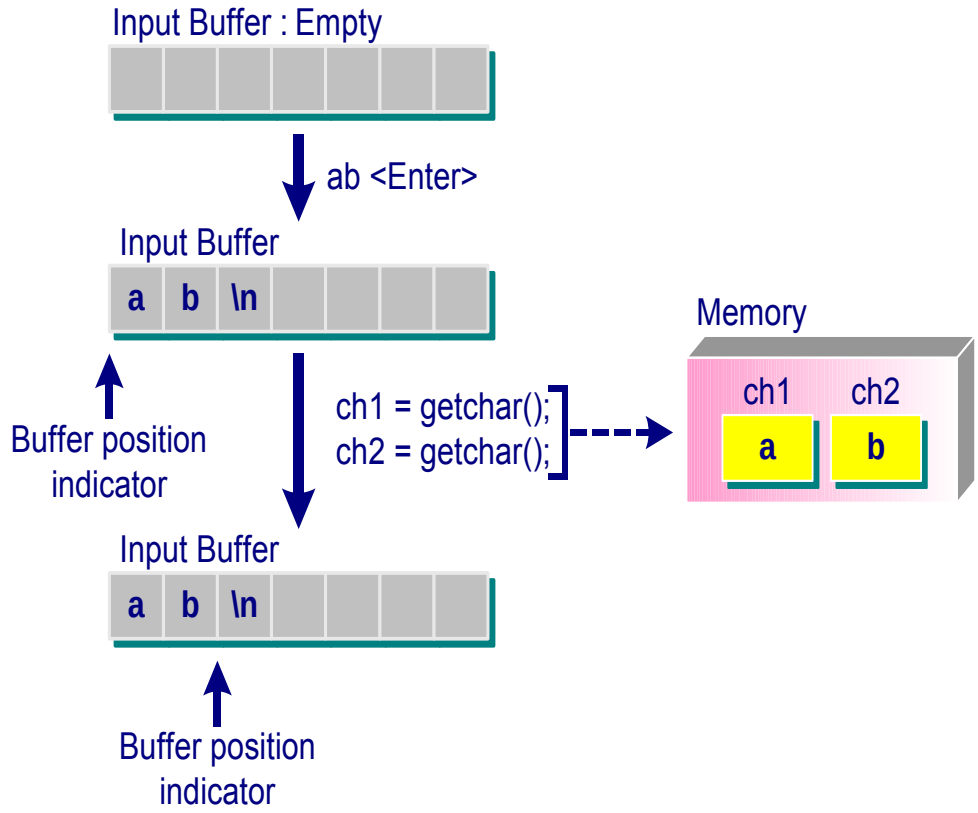
```
ch = getchar(); // ch is a character variable.
```

It is equivalent to

```
scanf("%c", &ch);
```

Character Input/Output

```
/* example to use getchar() and putchar()  */
 #include <stdio.h>
 int main(void)
{
      char ch, ch1, ch2;
      putchar('1');
      putchar(ch='a');
      putchar('\n');
      printf("%c%c\n", 49, ch);
      ch1 = getchar();
      ch2 = getchar();
      putchar(ch1);
      putchar(ch2);
      putchar('\n');
      return 0;
}
```



Output

1a

1a

ab *(User Input)*

ab

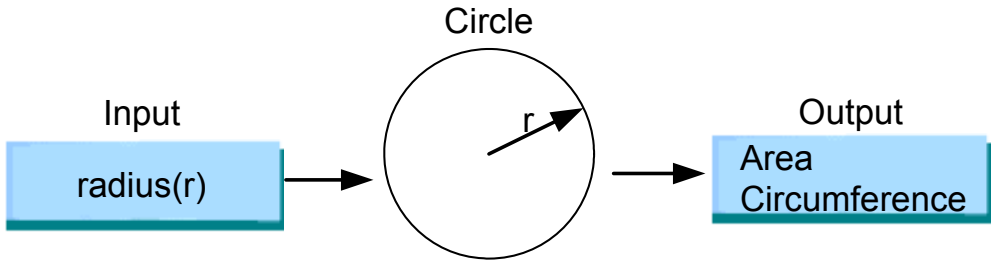
Summary of Basic C Concepts

- Data Types: integer (int); float (float, double); character (char)
- Constants
- Variables: declare variable with data type
- Operators: arithmetic, assignment, increment, decrement, etc.
- Data Type Conversion: explicit conversion and implicit conversion
- Mathematical Libraries
- Simple Input/Output: printf(), scanf(), putchar(), getchar()

Self-Learning Programming Example

Programming Example: Writing a Simple C Program
(Sequential Structure)

```
/* Purpose: A sample program to calculate the area and circumference.
   Author: S.C. Hui */
```



Area = π*r*r

Cirumference= 2*π*r

```
#include  <stdio.h>
#define PI 3.14
int main( )
{   // declare variables
    float radius, area, circumference;
    // Read input
       /* Write your code here */
    // Computation
       /* Write your code here */

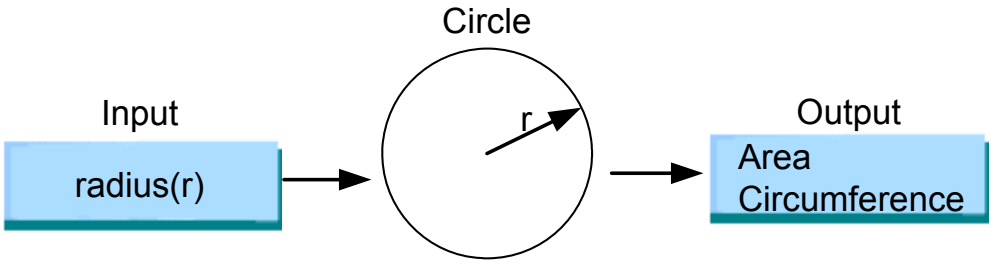
    // Print output
       /* Write your code here */
    return 0;
}
```

Output

Enter the radius: 5.0
The area is 78.50
The circumference is 31.40

Programming Example: Writing a Simple C Program (Sequential Structure)

```
/* Purpose: A sample program to calculate the area and circumference.
   Author: S.C. Hui */
#include  <stdio.h>
#define PI 3.14
int main( )
{  // declare variables
    float radius, area, circumference;
    // Read input
    printf("Enter the radius: ");
    scanf("%f", &radius);
    // Computation
    area = PI * radius * radius;
    circumference = 2 * PI * radius;
    // Print output
    printf("The area is %.2f\n", area);
    printf("The circumference is %.2f", circumference);
    return 0;
}
```



Area = π*r*r

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Output

Enter the radius: 5.0

The area is 78.50

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Thank you !!!