CS1100 – Introduction to Programming

Lecture 4

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Goals for the day

- Edit, compile and execute the first C program.
- Get simple yet useful tasks done via C programs.
  - Add a set of numbers.
  - Find roots of a quadratic equation.
  - Multiply 2 polynomials.

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- Learn the syntax of C language.
  - Basics – structure of a C program, using standard library.
  - How to store data – variables, data types.
  - How to get inputs, how to print outputs?

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  - How to store data – variables, data types.
  - How to get inputs, how to print outputs?
- Learn about the working environment (Linux based OS).
  - editors – gedit and others.
  - compiler – gcc.
  - executing a compiled program.

First C program

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#include <stdio.h>

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- main : a function that every C program must have.
- printf : a useful library function to print several things in C.

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- main : a function that every C program must have.
- printf : a useful library function to print several things in C.

To do anything more useful than merely printing we need to have more operations / commands and storage to store temporary computations.

Variables in C

Add 2 numbers x and y and store the value in z.

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    Say marks in Maths and marks in Physics respectively.

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- Use the $+$ operator defined to sum up the values of x and y.
- Use an assignment operator to store the value in z.

Sum of 2 numbers

```
#include <stdio.h>

/* sum 2 integers */

main() {
    int x;
    int y;
    int z;

    z = x+y;
    printf("%d\n", z);
}
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- z = x+y : evaluates x+y and stores it in z.

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Sum of 2 numbers – with initialization

```
#include <stdio.h>

/* sum 2 integers */

main() {
    int x = 98;
    int y = 99;
    int z;

    z = x+y;
    printf("%d\n", z);
}
```

- int : defines that x, y, z are of type integers.
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Input statement: scanf

scanf(format-string, &var1, &var2, ... , &var3);

- scanf is a function which allows us to accept inputs.
- Usually functions take fixed number of parameters/ arguments.
- scanf takes variable number of arguments.
- Notice the **&** preceeding the variables.

Weighted sum of 2 numbers

- Recall x denotes marks in Maths, y denotes marks in Physics.
- We wish to calculate weighted total such that Maths marks are given 30% weightage and Physics marks are given 70% weightage.
- $z = \frac{30}{100}x + \frac{70}{100}y$.

Weighted sum of 2 numbers

```
#include <stdio.h>

/* weighted sum 2 integers */

main() {
    int mathMarks = 98;
    int phyMarks = 99;
    int total;

    total = (30/100)*mathMarks + (70/100)*phyMarks;
    printf("%d\n", total);
}
```

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- What is the output of the program?

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- What is the output of the program?
- Is the variable total still guaranteed to be an integer?

Weighted sum of 2 numbers

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#include <stdio.h>

/* weighted sum 2 integers */

main() {
    int mathMarks = 98;
    int phyMarks = 99;
    float total;        /* float variable */

    total = (30/100)*mathMarks + (70/100)*phyMarks;
    printf("%f\n", total); /* change here */
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- What is the output of the program?
- $\frac{30}{100}$ and $\frac{70}{100}$ evaluate to 0 and therefore total is zero.

Weighted sum of 2 numbers – a correct program

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#include <stdio.h>

/* weighted sum 2 integers */

main() {
    int mathMarks = 98;
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Learnings so far..

- C allows different kinds of variables to be declared.
- C defines arithmetic operators, like +, -, *, /,...
- Have meaningful names for variables
  mathMarks, phyMarks, total

  choose variable names to be indicative – good programming practice

  avoid reserved words like int, float, .. as variable names.

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  avoid reserved words like int, float, .. as variable names.
- C defines arithmetic operators, like +, -, *, /,...
- Assignment operator "=": used to change contents of a variable.

Exercise: Swap two integers

- Two integers x and y contain 10 and 20 respec.
- Need to exchange values in x and y.
  swap two integers.
- Write a C program to do the same.

Swap – fill in correct code

```
#include<stdio.h>

main() {
    int x, y;

    printf("Enter x:");
    scanf("%d", &x);
    printf("Enter y:");
    scanf("%d", &y);

    /* Fill in code here */

    printf("x = %d\n", x);
    printf("y = %d\n", y);
}
```

Variable modification

- A C program is a sequence of commands that modify different variables using different operators.
- Basic operators in C.
  - Operator precedence and associativity.
- Basic data types in C.
  - How much space does a particular data type take?
  - How to input and output variables of a particular type?

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Operator precedence:

- first: parenthesized sub-expression; inner-most to outer-most.
- second: *, /, % ; left to right.
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- z = a + b * c * d % e - f / g

  z = a + (((b * c) * d) % e) - (f / g)

Increment / decrement operators

- ++, - -
- prefix and post-fix only to a variable.

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```
#include<stdio.h>

main() {
    int x, y;

    int n = 10;

    x = n++;
    y = ++n;
    printf(" x =  %d, y = %d\n", x, y);

}
```

Assignment operator =

Form: variable-name = expression

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  - x = y = z = (a + b);
  - evaluations happen right to left.

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  - What happens if you assign float to int and vice versa?
- Multiple assignments.
  - x = y = z = (a + b);
  - evaluations happen right to left.
- x = x + 10 can be written as x += 10;
- instead of +, we can also have -, *, /, %

Exercises

Write a program that reads an integer from the input and prints 0 if the integer is even and 1 if the integer is odd.

Write a program that takes as input a 3 digit integer, separates the digits of the integer and prints the individual digits separated by spaces.
For example if the input is 194, then your program must print
1 9 4

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- There are limits to representation - we better choose the right type.
- What other data type can we use to store integers?
- **unsigned int**, **long**, **unsigned long**.

unsigned int

- Typically 4 bytes storage.
- Output an unsigned int: printf("%u", x);
- Input an unsigned int: scanf("%u", &x);
- Storage: binary format.

The Integers - The detailed Chart

int	2 or 4 bytes	-32,768 to 32,767 or -2,147,483,648 to 2,147,483,647
unsigned int	2 or 4 bytes	0 to 65,535 or 0 to 4,294,967,295
short	2 bytes	-32,768 to 32,767
unsigned short	2 bytes	0 to 65,535
long	4 bytes	-2,147,483,648 to 2,147,483,647
unsigned long	4 bytes	0 to 4,294,967,295

char

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- Output a character: printf("%c", x);
- Input a character: scanf("%c", &x);

float

- Typically 4 bytes storage.
- Output a float: printf("%f ", x);
- Input a float: scanf("%f ", &x);
- How are fractions stored?

Binary vs decimal fractions

- $(10.11)_2 = (1 \times 2) + (0 \times 1) + (1 \times \frac{1}{2}) + (1 \times \frac{1}{2^2}) = (2.75)_{10}$

Binary vs decimal fractions

- $(10.11)_2 = (1 \times 2) + (0 \times 1) + (1 \times \frac{1}{2}) + (1 \times \frac{1}{2^2}) = (2.75)_{10}$
- $(0.90625)_{10} = (\quad)_2$
- $(0.9)_{10} = (\quad)_2$

Decimal Fraction → Binary Fraction (1)

Convert $(0.90625)_{10}$ to binary fraction

	0.90625	
	× 2	
	0.8125	+ integer part
1	× 2	
	0.625	+ integer part
1	× 2	
	0.25	+ integer part
1	× 2	
	0.5	+ integer part
0	× 2	
	0	+ integer part 1

$0.90625 = \frac{1}{2}(1+0.8125)$
$= \frac{1}{2}(1+\frac{1}{2}(1+0.625))$
$= \frac{1}{2}(1+\frac{1}{2}(1+\frac{1}{2}(1+0.25)))$
$= \frac{1}{2}(1+\frac{1}{2}(1+\frac{1}{2}(1+\frac{1}{2}(0+0.5))))$
$= \frac{1}{2}(1+\frac{1}{2}(1+\frac{1}{2}(1+\frac{1}{2}(0+\frac{1}{2}(1+0.0)))))$
$= ½+1/2^2+1/2^3+0/2^4+1/2^5$
$= (0.11101)_2$

Thus, $(0.90625)_{10} = (0.11101)_2$

Decimal Fraction → Binary Fraction (2)

Convert $(0.9)_{10}$ to binary fraction

0.9			
× 2			
0.8	+	integer part	1
× 2			
0.6	+	integer part	1
× 2			
0.2	+	integer part	1
× 2			
0.4	+	integer part	0
× 2			
0.8	+	integer part	0

For some fractions, we do not get 0.0 at any stage! These fractions require an infinite number of bits! Cannot be represented exactly!

Repetition

$(0.9)_{10} = 0.1110011001100 1100 \ldots = 0.\overline{11100}$

Binary vs decimal fractions

- $(10.11)_2 = (1 \times 2^1) + (0 \times 2^0) + (1 \times \frac{1}{2}) + (1 \times \frac{1}{2^2}) = (2.75)_{10}$
- $(0.90625)_{10} = (0.11101)_2$
- $(0.9)_{10} = (0.11100\color{red}{11100}11100..)_2$

Fixed point vs floating point representation

Fixed point

- Position of radix point is fixed and is same for all numbers.
- Lets say we have 3 digits after radix point.

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- Lets say we have 3 digits after radix point.
- $(0.120 \times 0.120)_{10} = (0.014)_{10}$
- A digit is lost.

Floating point

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Floating point

- $1.20 \times (10)^{-1} \times 1.20 \times (10)^{-1} = 1.44 \times (10)^{-2}$
- Wider range of numbers can be represented.
- IEEE standard: 32 bits are split as follows:
  - First bit for sign.
  - Next 8 bits for exponent.
  - Next 23 bits for mantissa.

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- Wider range of numbers can be represented.
- IEEE standard: 32 bits are split as follows:
  - First bit for sign.
  - Next 8 bits for exponent.
  - Next 23 bits for mantissa.
  - $(-39.9)_{10} = (-100111.11100)_2 = (-1.0011111100)_2 \times 2^5$.

Floats - different types

Type	Storage size	Value range
float	4 byte	1.2E-38 to 3.4E+38
double	8 byte	2.3E-308 to 1.7E+308
long double	10 byte	3.4E-4932 to 1.1E+4932

Output floats in C

printf(" %w.p f ", x);

- w.p is optional.
- w : total width of the field.
- p : precision (digits after decimal).

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```
#include<stdio.h>
main() {

    float x = 2.00123;
    printf ("x = %5.4f\n", x);
    printf ("x = %8.7f\n", x);
}
```

Circumference of circle

```
#include<stdio.h>

main() {
    float radius;
    float circum;

    printf("Enter radius : ");
    scanf("%f", &radius);
    circum = 2* (22.0/7) * radius;

    printf ("radius = %f, circum = %f\n", radius, circum);
}
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}
```

- How to print output only upto 2 decimals?

Circumference of circle – formatted output

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#include<stdio.h>

main() {
    float radius;
    float circum;

    printf("Enter radius : ");
    scanf("%f", &radius);
    circum = 2* (22.0/7) * radius;

    printf ("radius = %5.2f, circum = %5.2f\n", radius, ci
}
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Output statement

`printf (format-string,` $var_1, var_2, ..., var_n$`)`

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Format string specifies

- How many variables to expect?
- Type of each variable.
- How many columns to use for printing? (width)
- What is the precision? (if applicable)

Output statement

`printf (format-string,` $var_1, var_2, ..., var_n$`)`

Format string specifies

- How many variables to expect?
- Type of each variable.
- How many columns to use for printing? (width)
- What is the precision? (if applicable)
- Common mistakes:
  - comma missing after the double quotes.
  - mismatch in the actual number of variables given and those expected in the format string.

Formatted output

```
printf (‘‘%w.pC", x);
```

Formatted output

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printf (‘‘%w.pC", x);
```

- w, p and C are place holders, can take different values.
- w: width of the output. (optional)
- p: precision of the output. (optional)
- C: Conversion character.

Formatted output

```
printf (‘‘%w.pC", x);
```

- w, p and C are place holders, can take different values.
- w: width of the output. (optional)
- p: precision of the output. (optional)
- C: Conversion character.
  - d : integer
  - f : float
  - c : character
  - x : hexadecimal
  - o : octal
  - u : unsigned int
  - e : real decimal in exponent form

Input Statement

`scanf (format-string,` $\&var_1, \&var_2, \ldots, \&var_n$`)`

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Format string specifies

- How many variables to expect?
- Type of each variable.
- Common mistakes:
  - comma missing after the double quotes.
  - mismatch in the actual number of variables given and those expected in the format string.
  - & missing before the variable.

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- What is coming up?
  - Compilation and Exection of C-programs.
  - More Programming.