Programming Fundamentals

Abdul Haseeb

Course Objectives

- *The aim is not to make you the expert of computer programming but only the basics of computer programming.*

- *To familiarize students with the use of C++.*

- *To equip students with tools and techniques to implement a given problem programmatically*

Recommended Books

- *Problem Solving with C++ 10th edition by Walter Savitch- Pearson Prentice-Hall*
- *C++ Programming from Problem Analysis to Program Design, 7th Edition, By, DS Malik*
- *Programming in C++ by Dietel and Dietal*
- *Programming in C++ by Robert Laphore*
- *Lecture Handouts*

Grading Criteria

Mid Term	=	30%
Final Exam	=	40%
Sessional	=	60%

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bout Course Instructor

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Ex-Lecturer at Sukkur IBA University Kandhkot Campus

Ex-Subject Specialist at IBA Community College Khairpur

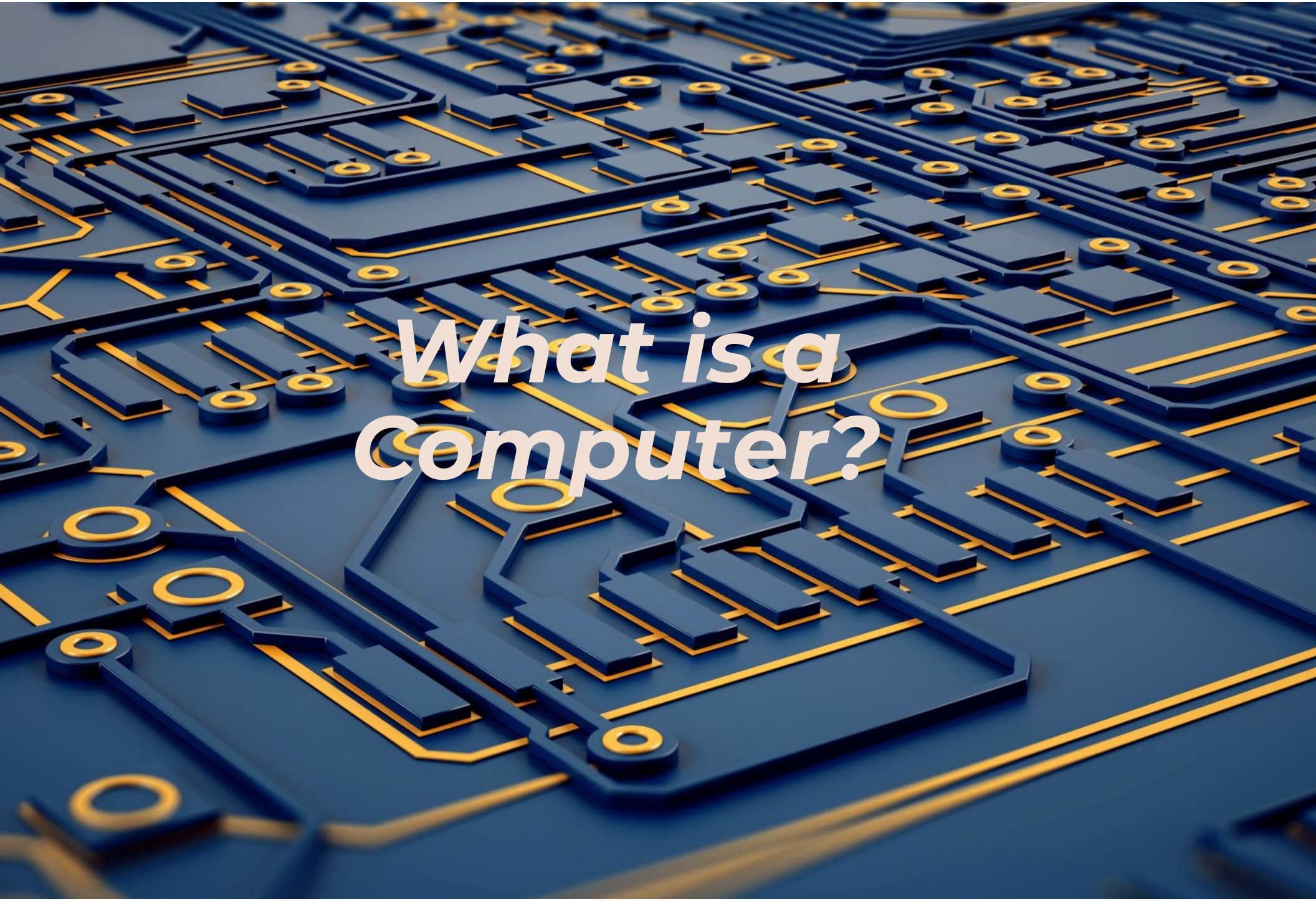
Research Interests: Cybersecurity, Machine Learning, Deep Learning, AI in Cybersecurity

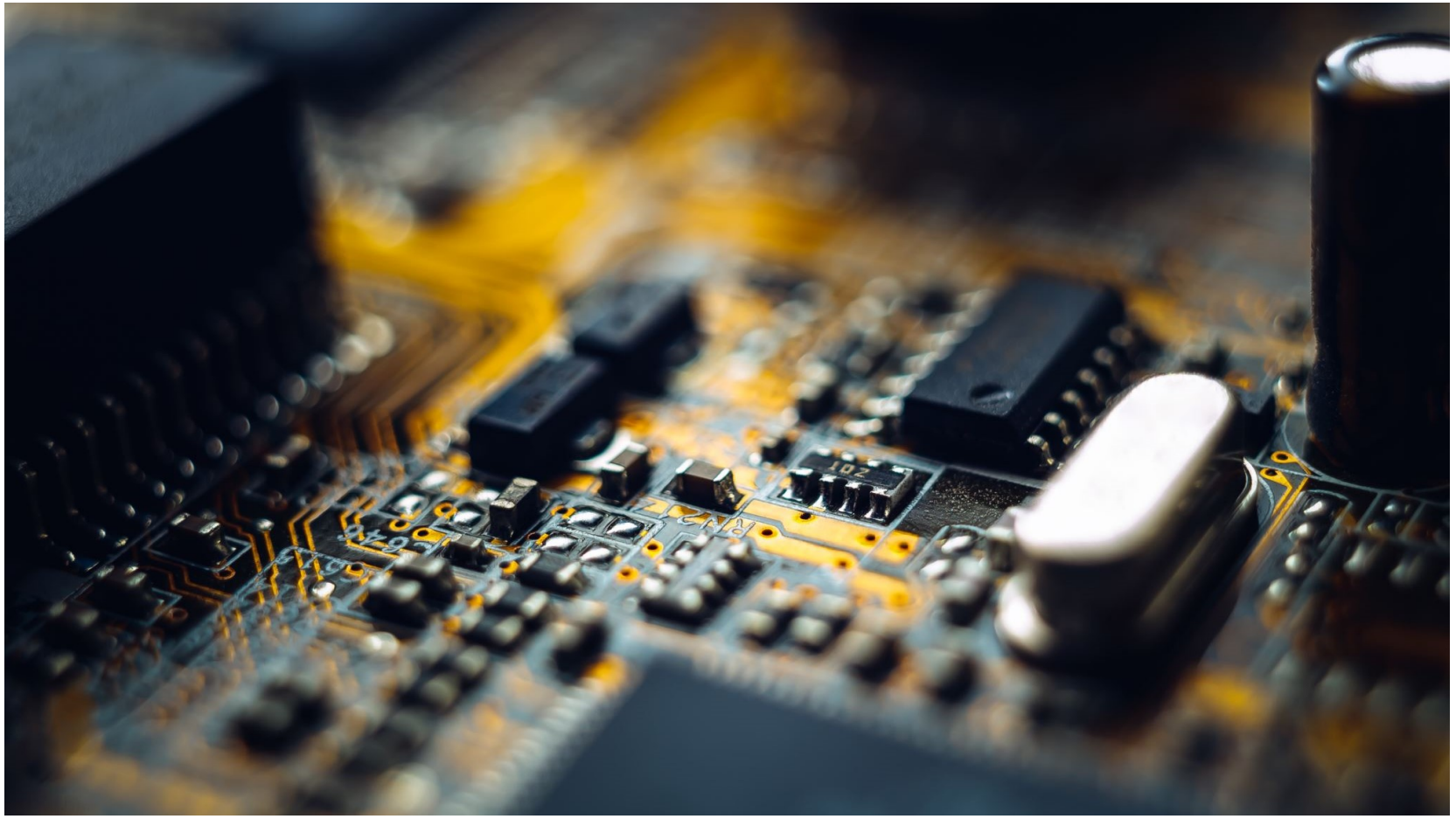
Programming Languages:

- *C++, Java, Python*

How to Reach me?

- *ahaseeb.faculty@aror.edu.pk*


What is a
Computer?

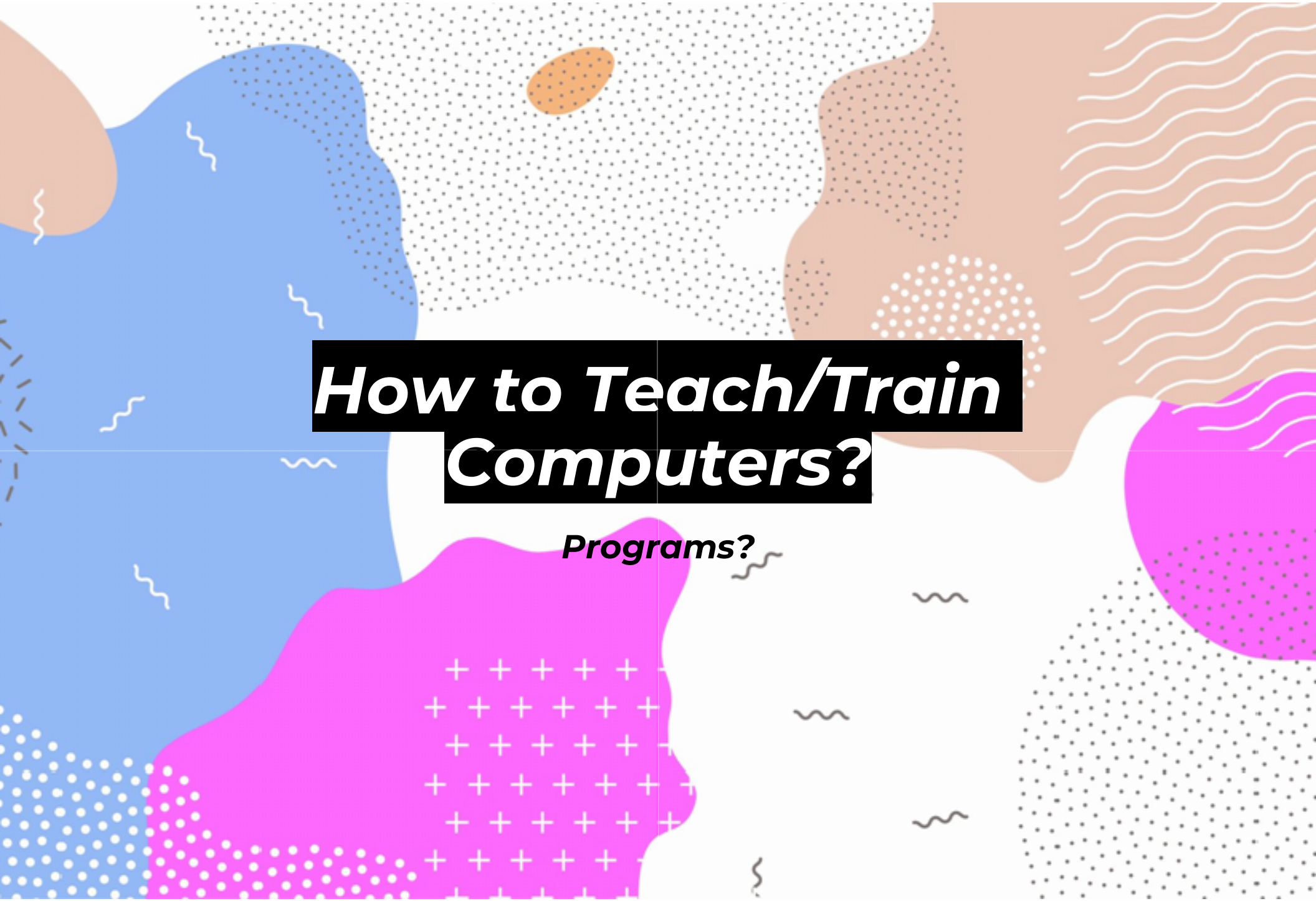


WHAT IS COMPUTER?

An Electronic device which can accept data as input, processes it and produces output

RE COMPUTERS ORE NTELLIGENT HAN HUMANS?

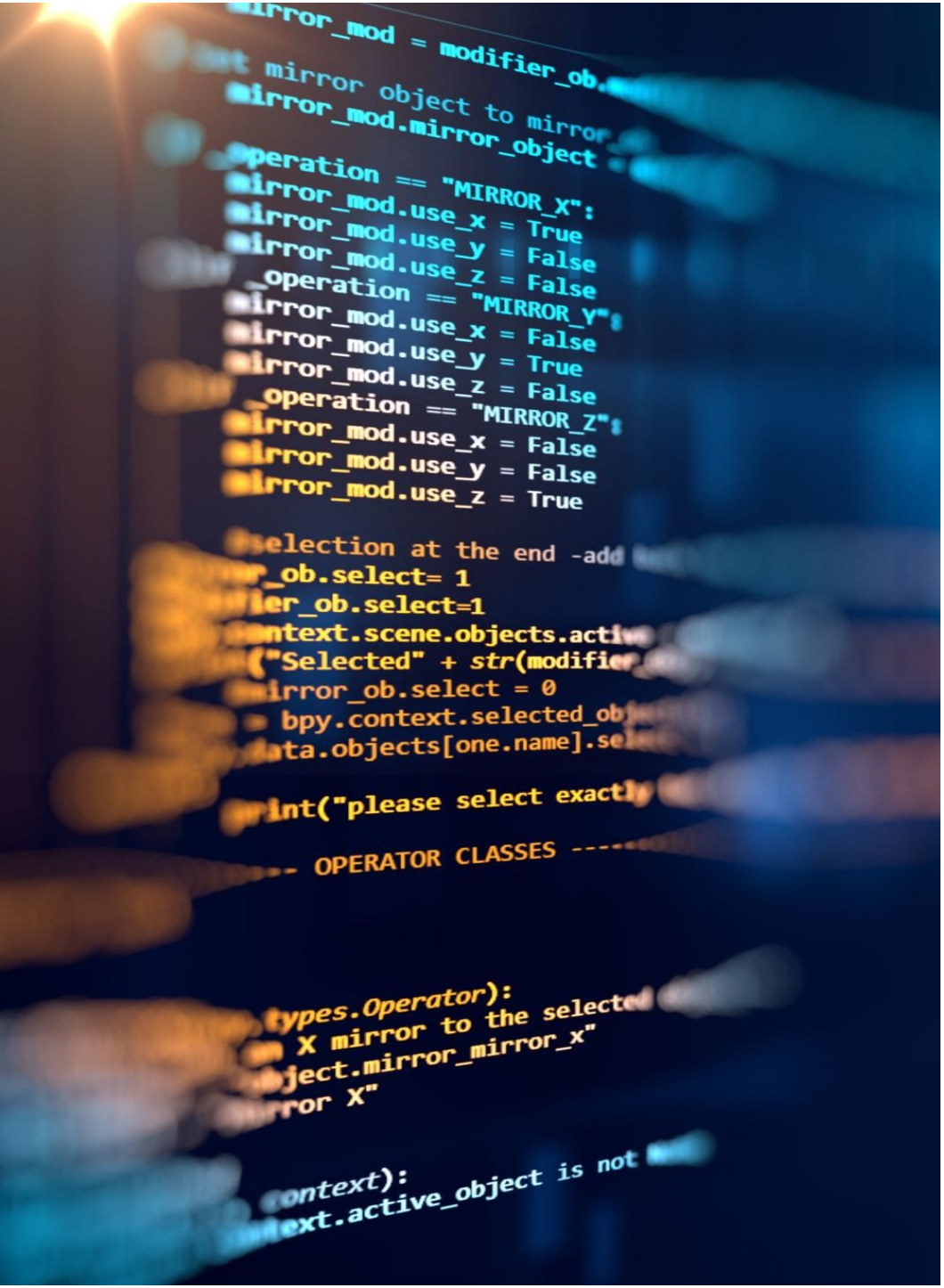
Computers can outperform humans in some tasks like playing games etc, but they cant match the intelligence of a human


How to Teach/Train Computers?
Programs?

Definition of a Program

List/Set of Instructions which allows a computer to perform specific task

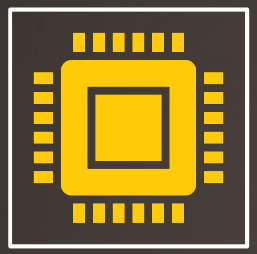

Programming
The process of Writing a program



Programming Languages

- ***What is a Language?***
  - ***Means of communication***
- ***Different Languages like C++, Java, Python, Julia, Ruby, Swift, Javascript, Fortan, Pascal, Basic etc***

hy was ogramming eveloped?



Automation:

Past computers used to perform complex calculations

- Manual Adjustment for each calculation

Complex Problem Solving:

As computer technology advanced, there was a need to solve complex problems

Why learn Programming?

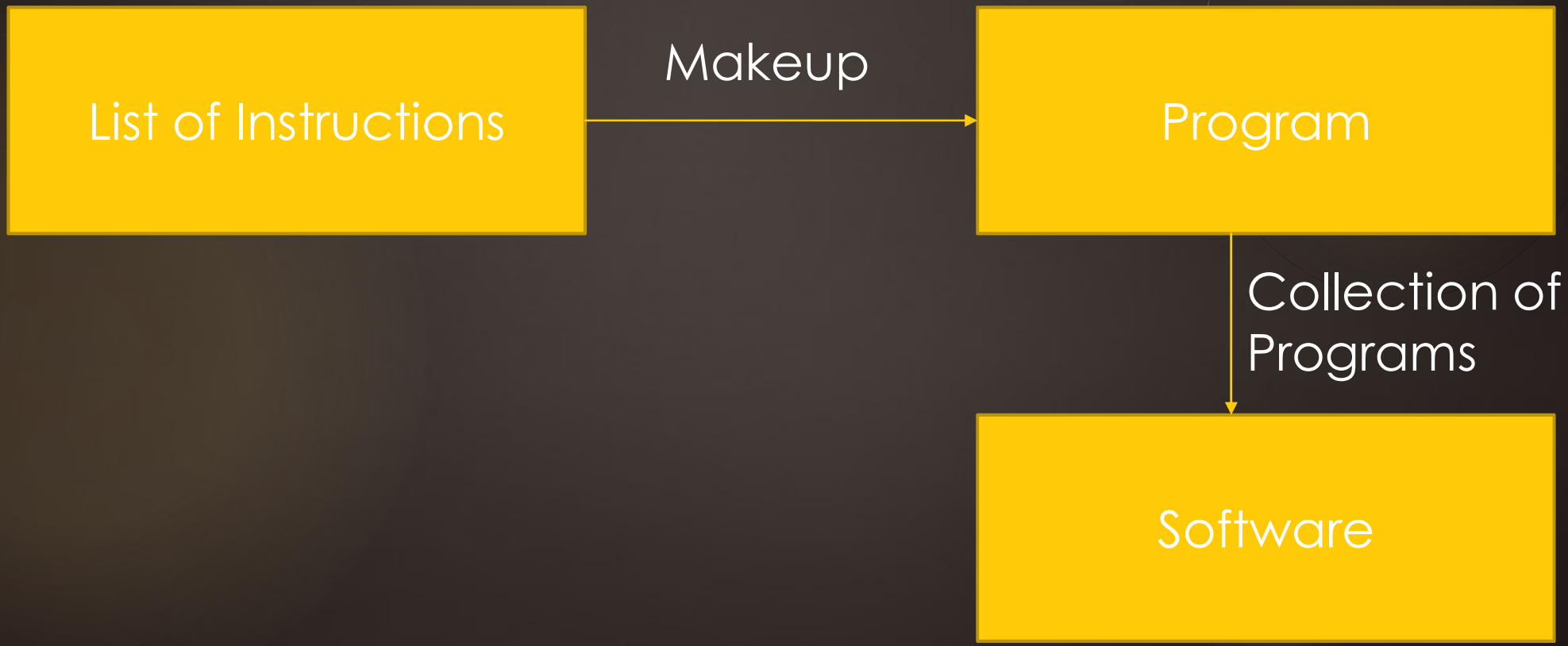
Foundation of CS:

- For every advanced CS Subject, you will need programming at some point

Problem solving:

- Complex problems require creative solutions, provided with programming

What is Software?



Languages to write computer programs

Computer Programs can be written in **low level language or high level language**

A person who write computer programs is called **programmer**

Most programmers use **high level language** to write programs

igh Level languages

High Level Languages allow the programmers to just focus on the problem to be solved, and they don't need to worry about the knowledge of hardware.

High Level Languages are portable

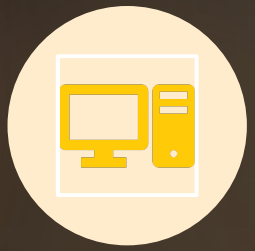
Example of a code snippet written in high level language to add two numbers:

Sum := FirstNumber+ SecondNumber

igh Level Languages

- C++, Delphi, Java, Python, Pascal, Visual Basic are the examples of High Level Language
- Once you learn concepts of programming, you can easily switch between the languages

Advantages of High Level Languages



They use very easy statements so that programmer can easily write the programs

Read and Understand the program as it is closer to human language

Low Level Languages

- Low Level Languages are closer to the understanding of Computers
  - Machine Language
  - Assembly Language

Machine Language (Low Level)

- Programmers don't write in machine code, as is very difficult to understand and is very complicated.
- Code Snippet to add two numbers using Machine Language

1	12	0001	00010010
4	13	0100	00010011
0	1A	0000	00011010
Hexadecimal		**Binary**	

Figure 7.3

Assembly Language (Low Level)

- Use **Mnemonics** for writing code

```
LDA    First
ADD    Second
STO    Sum
```

imple Quiz!

- Which type of language is Java
- How do programmers write code in Assembly Language

What do you think how programming is going to transform your life?

Concept of Translators

- Programmers write code in high level
- Computers understand Machine code
- There is the need for translation High Level language to Machine Code

Compiler

- Translates a program written in high level language into machine code at once
- Compiled program can be reused without recompilation
- C++ uses compiler
  - GCC (GNU Compiler Collection)

Compiler

The high-level program statement

```
Sum := FirstNumber + SecondNumber
```

becomes the following machine code instructions when translated

```
0001   00010010
0100   00010011
0000   00011010
```

nterpreter

Interpreter reads one statement at a time from the program written in high level language, performs action, and does the same with the next statement.

Python, perl, ruby use interpreter

ssembler

- It translates program written in assembly language into machine code, so that it can be directly used by a computer to perform a required task.
- It works like a compiler for assembly language.

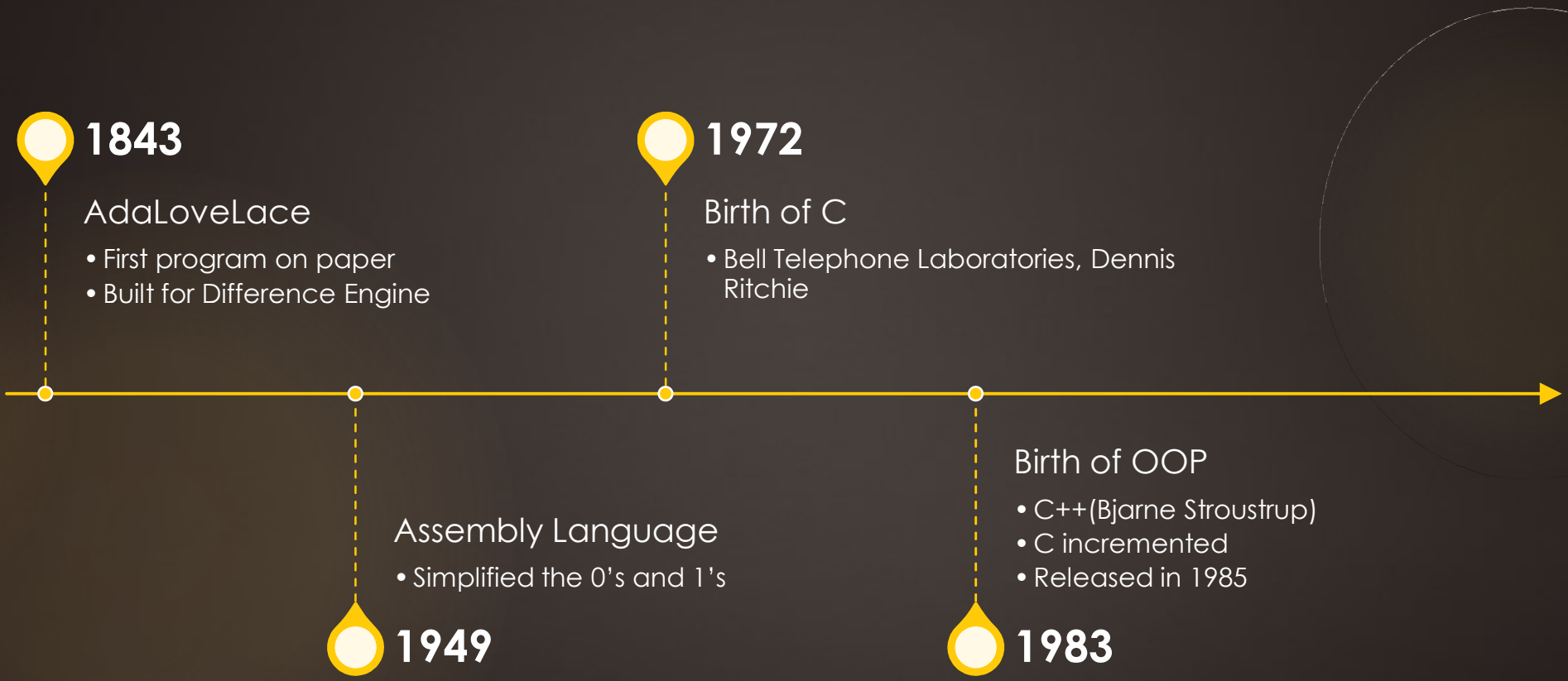
imple Quiz #02

- Which Language Translator you think is fast?
- Which Language Translator are you going to use for the course?

What happens when things go wrong?

- Programmers being humans make errors
- There are two main types of errors
  - **Syntax Errors**
    - Grammatical rules of Langu are violated
    - Easy to identify
  - **Logical Errors**
    - Human Error, Program will n perform what it is desired to
    - Like giving the sign of addit when actually wanted to perform subtraction

istory of C++


1843
AdaLoveLace
• First program on paper
• Built for Difference Engine
1949
Assembly Language
• Simplified the 0's and 1's
1972
Birth of C
• Bell Telephone Laboratories, Dennis Ritchie
1983
Birth of OOP
• C++(Bjarne Stroustrup)
• C incremented
• Released in 1985

What is C++

C++ is a cross-platform, object oriented language that can be used to create high-performance applications.

C++ is used in developing browsers, operating systems, and applications, as well as in-game programming,

DE

- For writing C++ Programs we need a Code Editor and Compiler
- ***"A software that provides programming environment to facilitate programmers in writing and executing a computer programs is known as IDE."***
- An IDE has Graphical user interface and it helps the programmers, in writing, executing and testing a computer program
- Visual Studio, Xcode and DevC++ are some famous IDE for C++ Language

nstalling DevC++

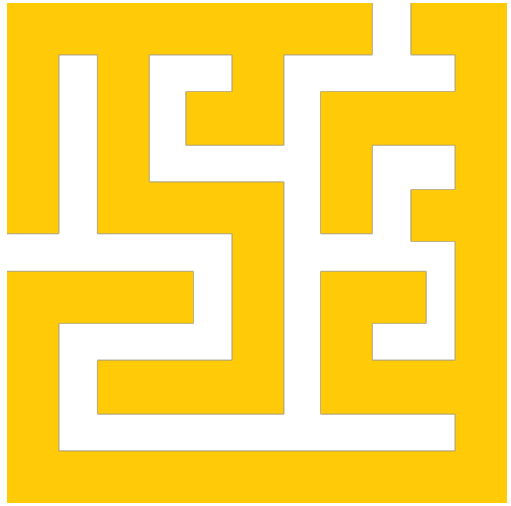
olya's 4 Steps of roblem Solving

Problem Solving Phase

- U – Understand the Problem
- D – Devise a Good Plan to Solve

Implementation Phase

- I – Implement the Plan
- E – Evaluate the Solution



lgorithm

- A sequence of precise instructions which leads to a solution is called an **algorithm.**

- Some approximately equivalent words are *recipe*, *method*, *directions*, *procedure*, and *routine*.

DISPLAY 1.6 An Algorithm

Algorithm that determines how many times a name occurs in a list of names:

1. Get the list of names.
2. Get the name being checked.
3. Set a counter to zero.
4. Do the following for each name on the list:
   Compare the name on the list to the name being checked,
   and if the names are the same, then add one to the counter.
5. Announce that the answer is the number indicated by the counter.

irst Program in C++


```
#include<iostream>
using namespace std;
int main(){
    cout<<“Hello World”;
    return 0;
}
```

.3.2 Structure of C++ Program

- **Structure of C++ Program:**
  - *Format of Writing C++ Program*

1.Preprocessor directives
2.Global Declarations
3.Main Function{
Local Declarations
Statements
Comments
}
4.User-Defined Functions

Body of Main

. Preprocessor Directives

- Begin with # Symbol like #include, #define etc
- Used to include header files, like stdio.h, conio.h etc or to define constants like #define max 10
- Placed at the top of C++ Program

. Main Function

Special Function, Entry Point for every C++ Program

Starts the execution of program

void main(){} returns nothing

int main(){return 0;} returns 0

. Main Function (Body)

- **Body of Main Function starts after opening curly brackets and ends before closing curly brackets, It may contain:**
  - Statements
  - Variable Declarations
  - Calling of Functions
  - Return Statement
  - Comments

eatures of C++ Language

C++ is considered as High level language.

C++ is case sensitive language.

C++ has compiler as a language translator.

C++ is hybrid language (Combination of structured as well as Object orientation paradigm)

Comments

Code statements

- Ignored by Compiler
- Not Executed

Add **clarity** to your code

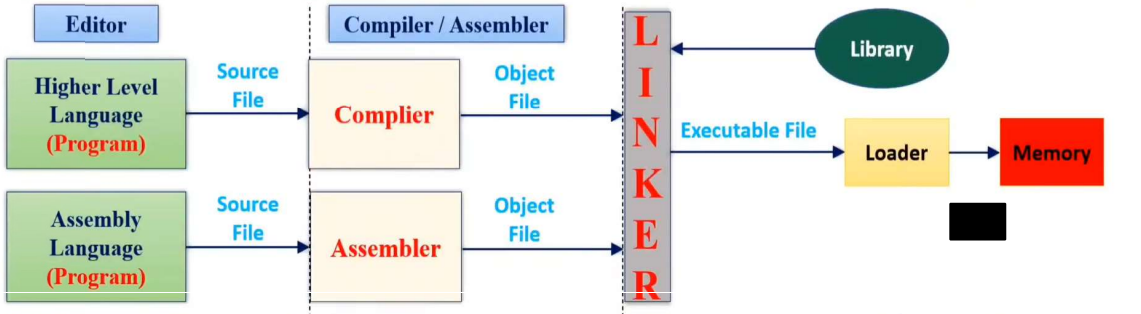
Make your code more **understandable**

Used for **Documentation** of the Code

Single line vs **Multi-Line Comments**

rocessing
f a C++
rogram

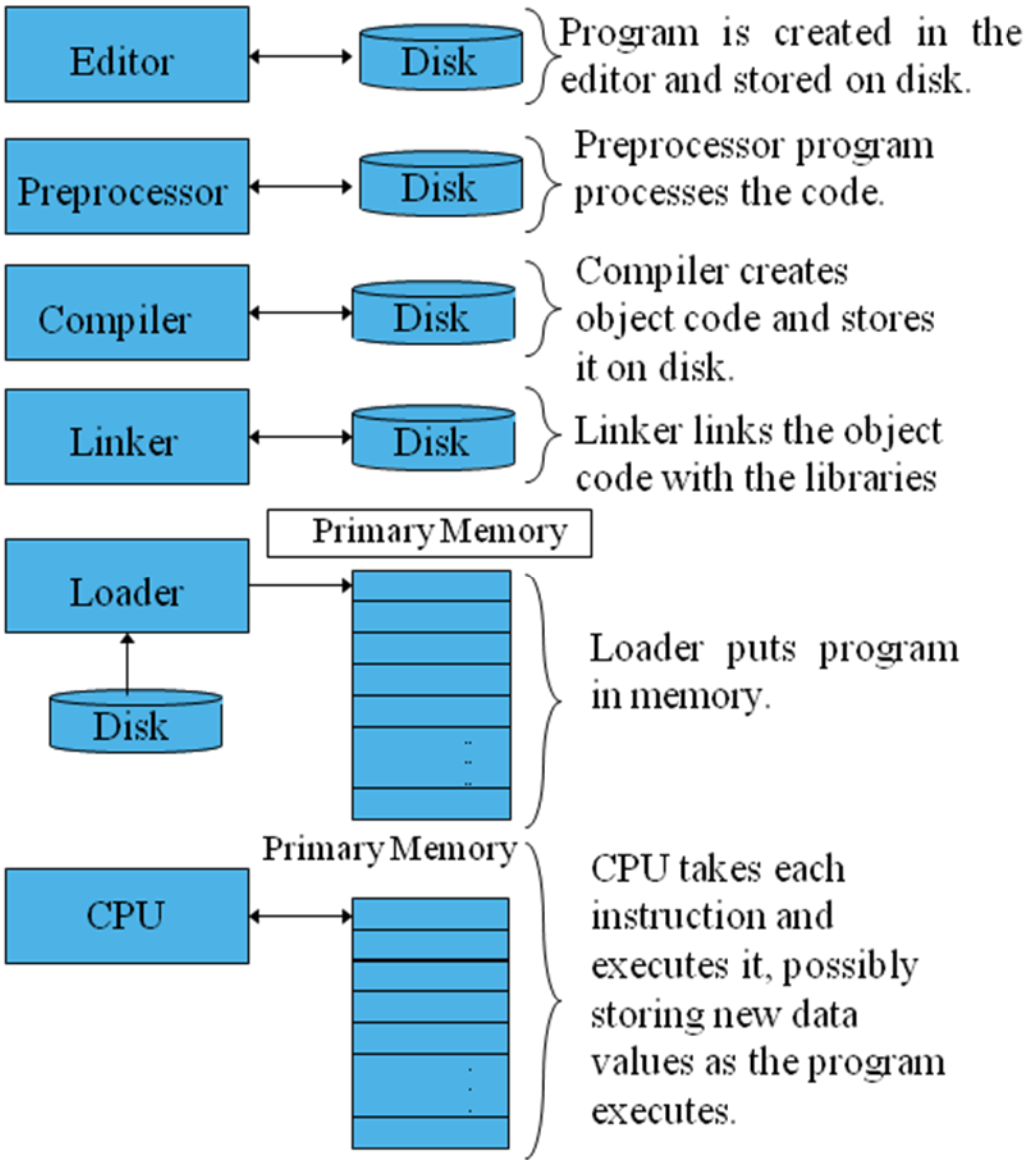
Editor, Compiler, Assembler, Linker & Loader



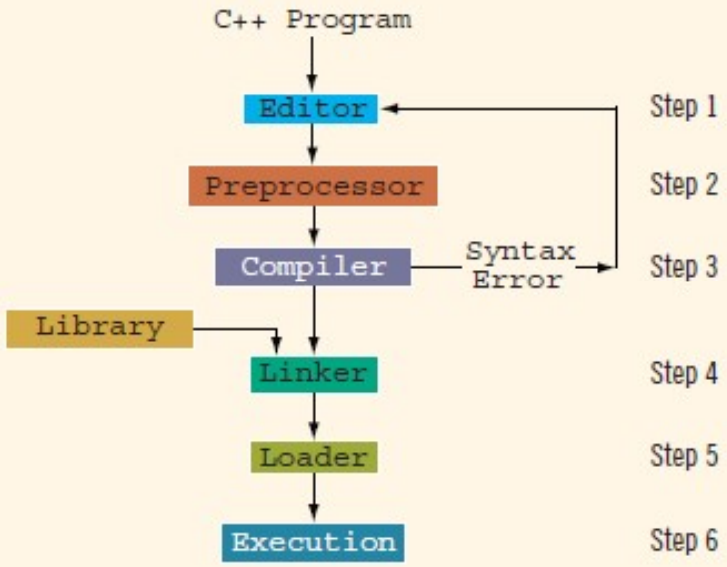
- In Editor we write programs for Microcontroller.
- Programs may be written in Assembly Language or Higher Level Language {C Language}.
- By writing program we generate source file.
- Assembler : It is used to convert Assembly language into machine code or object file. It also shows errors if any syntax error is there in program.
- Complier : It is used to convert Higher Level language into machine code or object file. It also shows errors if any syntax error is there in program. It also gives warnings if it is there with programs.

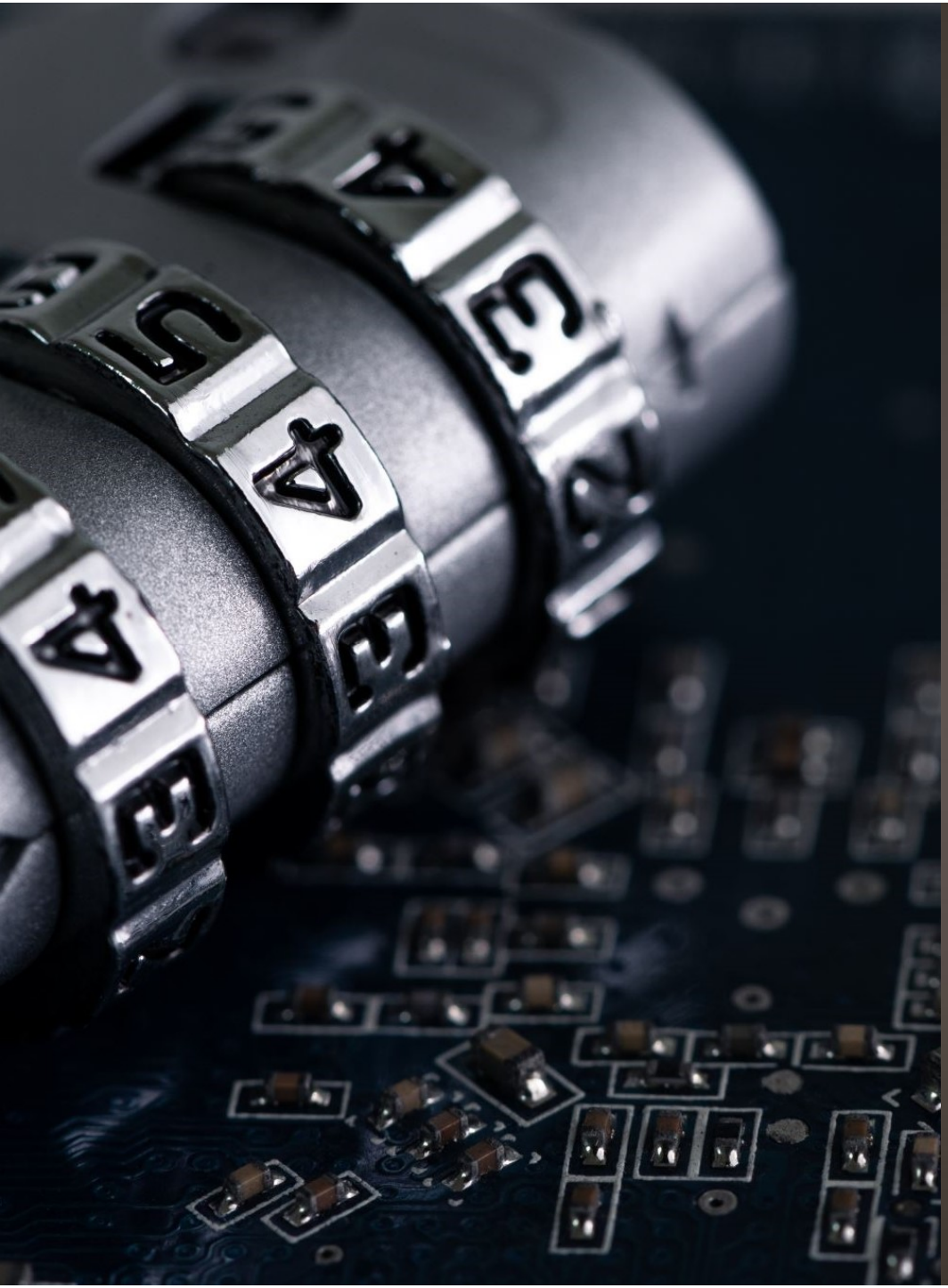
- Linker : It is linking all the object files of compiler and assembler with the use of library.
- It will generate executable files.
- Loader: It is used to load executable files into the memory of microcontroller.
- Once program is loaded into memory, microcontroller can execute it as per the requirement of USER.

Processing of a C++ Program



Processing of a C++ Program





Variables

- We often use **different types of data**
  - Variables are used:
    - To store value for a particular type of data

ariables

- Each variable in C++ has:
  - Data Type
  - Name
  - Value

hree Actions for ariables

Declaring a Variable:

1. Set the name and data type for a variable
   a) These two properties don't change

```
eclaring (giving the variable a type)
 number;
 true_or_false;
 letter;
```

hree Actions for ariables

Assigning (Initializing) a Variable:

1. Set the value of a variable
   a) It can change

```
signing (giving the variable a value)
er = 99;
_or_false = true;
er = 'a';
```

hree Actions for ariables

Accessing a Variable:

1. Retrieve the value, by calling it's name.
2. You must declare and assign a variable before you can access it.

```
essing (retrieving the value of the data by printing)
<<number <<endl;
<< true_or_false << endl;
<< letter << endl;
```

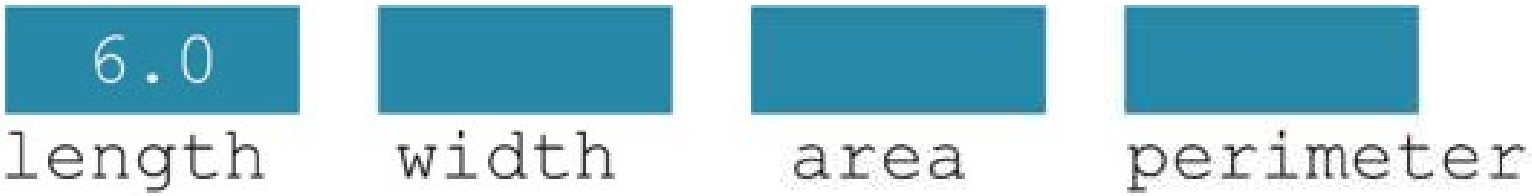
Characteristics of a Variable

- Variables are changeable
- Variables are container
- Variables are identifier
- Example: a, name, age, salary, x

ariable and its values in memory

- Variable: a memory location whose contents can be changed

Figure 2-2 Memory allocation



ules for defining a variable name

A to Z

a to z

Alphanumerical like a1, day1, name1 etc

Multiple characters like name, fName, etc.

Can not use special characters except '_' underscore.

Can not be keywords of C/C++

xamples

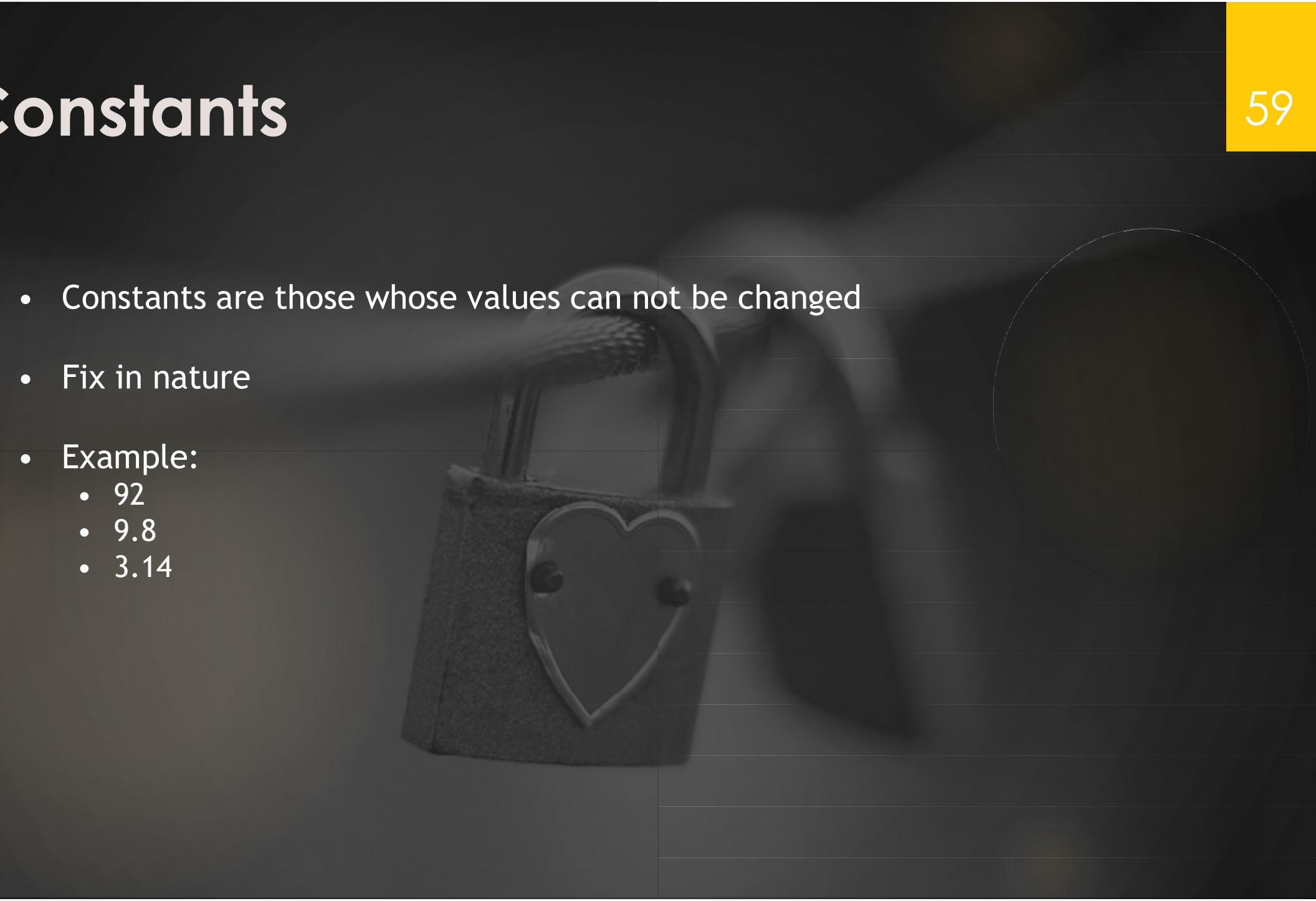
a	Correct
A	Correct
Age	Correct
name	Correct
name1	Correct
first_name	Correct
_age	Correct
first-name	Incorrect
2age	Incorrect
my@age	Incorrect
include	Incorrect
Include	Correct
delay	Incorrect

eserved words (Keywords) in C++

- Reserved word symbols (or keywords):
  - Cannot be redefined within program
  - Cannot be used for anything other than their intended use

  Examples:
    - `int`
    - `float`
    - `double`
    - `char`
    - `const`
    - `void`
    - `return`

Constants



- Constants are those whose values can not be changed
- Fix in nature
- Example:
  - 92
  - 9.8
  - 3.14

Whitespaces

- Every C++ program contains whitespaces
  - Include blanks, tabs, and newline characters
- Used to separate special symbols, reserved words, and identifiers
- Proper utilization of whitespaces is important
  - Can be used to make the program more readable

Data Types

- Shows the type of Data
- Example:
- 92 (Numeric data)
- 9.8 (Decimal Data)
- A (Character Data)
- Mujtaba (String / Wording Data)

Why different data types?

Data Representation

Memory efficiency

Different operations and functions (arithmetic on Integers, Comparison on Text Values)

Data Types

C++ data types fall into three categories:

- Simple data type
- Structured data type
- Pointers

imple Data Types

There are four simple data types in C / C++.

- Countable data types
- Measurable data types
- Character data types
- String data types

Countable Data Types

- unsigned short
- signed short
- unsigned integer
- signed integer
- unsigned long long
- signed long long

Countable Data Types


```cpp
#include <iostream>
#include <climits>
using namespace std ;
int main ()
{
    cout << "\n\n Check the upper and lower limits of integer :\n";
    cout << "-------------------------------------------------\n";
    cout << " The maximum limit of int data type :                 " << INT_MAX << endl;
    cout << " The minimum limit of int data type :                 " << INT_MIN << endl;
    cout << " The maximum limit of unsigned int data type :        " << UINT_MAX << endl;
    cout << " The maximum limit of long long data type :           " << LLONG_MAX << endl;
    cout << " The minimum limit of long long data type :            " << LLONG_MIN << endl;
    cout << " The maximum limit of unsigned long long data type :  " << ULLONG_MAX << endl;
    cout << " The minimum limit of short data type :               " << SHRT_MIN << endl;
    cout << " The maximum limit of short data type :               " << SHRT_MAX << endl;
    cout << " The maximum limit of unsigned short data type :      " << USHRT_MAX << endl;
    cout << endl;
    return 0 ;
}

```

Countable Data Types


```
Check the upper and lower limits of integer :
-----------------------------------------------
The maximum limit of int data type :                2147483647
The minimum limit of int data type :                -2147483648
The maximum limit of unsigned int data type :       4294967295
The maximum limit of long long data type :          9223372036854775807
The minimum limit of long long data type :           -9223372036854775808
The maximum limit of unsigned long long data type :  18446744073709551615
The minimum limit of short data type :              -32768
The maximum limit of short data type :              32767
The maximum limit of unsigned short data type :     65535


--------------------------------
Process exited after 0.08577 seconds with return value 0
Press any key to continue . . .
```

Countable Data Types


```cpp
#include <iostream>
using namespace std ;
int main ()
{
    short s1 = 10 ;
    signed short s2 = 20 ;
    unsigned short s3 = 30 ;
    int i1 = 10 ;
    signed int i2 = 20 ;
    unsigned int i3 = 30 ;
    long l1 = 10 ;
    signed long l2 = 20 ;
    unsigned long l3 = 30 ;
    long long ll1 = 10 ;
    signed long long ll2 = 20 ;
    unsigned long long ll3 = 30 ;
    cout <<"The s1 size in memory = " <<sizeof (s1) <<endl;
    cout <<"The s2 size in memory = " <<sizeof (s2) <<endl;
    cout <<"The s3 size in memory = " <<sizeof (s3) <<endl;
    cout <<"The i1 size in memory = " <<sizeof (i1) <<endl;
    cout <<"The i2 size in memory = " <<sizeof (i2) <<endl;
    cout <<"The i3 size in memory = " <<sizeof (i3) <<endl;
    cout <<"The l1 size in memory = " <<sizeof (l1) <<endl;
    cout <<"The l2 size in memory = " <<sizeof (l2) <<endl;
    cout <<"The l3 size in memory = " <<sizeof (l3) <<endl;
    cout <<"The ll1 size in memory = " <<sizeof (ll1) <<endl;
    cout <<"The ll2 size in memory = " <<sizeof (ll2) <<endl;
    cout <<"The ll3 size in memory = " <<sizeof (ll3) <<endl;
    return 0 ;
}
```

```
The s1 size in memory = 2
The s2 size in memory = 2
The s3 size in memory = 2
The i1 size in memory = 4
The i2 size in memory = 4
The i3 size in memory = 4
The l1 size in memory = 4
The l2 size in memory = 4
The l3 size in memory = 4
The ll1 size in memory = 8
The ll2 size in memory = 8
The ll3 size in memory = 8
```

Measurable Data Types

- float
- double
- long double

Measurable Data Types


```cpp
#include <iostream>
#include <cfloat>
using namespace std ;
int main ()
{
    float f = 9.9 ;
    double d = 9.9 ;
    long double ld = 9.9 ;
    cout << "\n\n Check the upper and lower limits of countable datatypes :\n";
    cout << " The minimum limit of float data type :                " << FLT_MIN << endl;
    cout << " The maximum limit of float data type :                " << FLT_MAX << endl;
    cout << " The minimum limit of double data type :                " << DBL_MIN << endl;
    cout << " The maximum limit of double data type :                " << DBL_MAX << endl;
    cout << " The minimum limit of long double data type :                    " << LDBL_MIN << endl;
    cout << " The maximum limit of long double data type :                    " << LDBL_MAX << endl;
    cout << endl;
    cout << "\n\n Check the space of memory occupied by countable datatypes :\n";
    cout <<"The f size in memory = " <<sizeof (f) <<endl;
    cout <<"The d size in memory = " <<sizeof (d) <<endl;
    cout <<"The ld size in memory = " <<sizeof (ld) <<endl;
    return 0 ;
}
```

Measurable Data Types


```
 Check the upper and lower limits of countable datatypes :
 The minimum limit of float data type :                1.17549e-038
 The maximum limit of float data type :                3.40282e+038
 The minimum limit of double data type :                2.22507e-308
 The maximum limit of double data type :                1.79769e+308
 The minimum limit of long double data type :                3.3621e-4932
 The maximum limit of long double data type :                1.18973e+4932



 Check the space of memory occupied by countable datatypes :
The f size in memory = 4
The d size in memory = 8
The ld size in memory = 16
```

Character Datatype

- Store single character
- In coding we use ***char*** for character datatype
- The value must be enclosed in single quotes (**‘ ’**)
- Syntax: char variable_name = ‘Value’ ;
- Example: char grade = ‘A’ ;
- Character datatype will take **1 byte** of memory
- Range of character is **-128 to 127**
- Range of unsigned character is **255**
- **CHAR_MIN**
- **CHAR_MAX**
- **UCHAR_MAX**

Character Datatype


```
#include <iostream>
using namespace std ;
int main ()
{
cout << CHAR_MIN <<endl ;
cout << CHAR_MAX <<endl ;
cout <<UCHAR_MAX <<endl ;
char sub1_grade = 'A' , sub2_grade = 'B+' ;
cout << sub1_grade <<endl <<sub2_grade <<endl ;
return 0 ;
}
```

Character Datatype


```
#include <iostream>
using namespace std ;
int main ()
{
char c = 65 ;
cout <<c <<endl ;
c = '65' ;
cout << c <<endl ;
c = 200 ;
cout << c <<endl ;
return 0 ;
}
```

tring Datatype

- Store sequence of characters
- In coding we use ***char*** **[]** or **string** for string datatype
- The value must be enclosed in single quotes (**“ “**)
- Syntax: char variable_name [size in number] = “Value” ;
- Example: char std_name = “Ahmad” ;
- string variable_name = “value” ;
- string std_name = “Mujtaba” ;
- Char [***n***] datatype will take ***n*** **number of bytes** of memory.
- String datatype will take ***n*** **number of bytes** of memory where ***n*** represents the number of characters in string.

Character Datatype

- **What will be the output of following program?**

```
#include <iostream>
using namespace std ;
int main ()
{
char name [10] = "Mujtaba" ;
string name1 = "Mujtaba" ;
cout << name << "\t" << sizeof (name) <<endl;
cout << name1 << "\t" << sizeof (name1) <<endl;
return 0 ;
```