Unit 1

Introduction to Robotics

Robotics and Robots.....

Definition: Robotics

- **T**he branch of technology that deals with the design, construction, operation and application of robots. The objective of the robotics field is to create intelligent machines that can assist humans in a variety of ways. A robot is normally designed to assist a human worker.

Definition: Robots

- Robot is a formally defined by the international standard of organization ISO as a reprogrammable multifunctional manipulator designed to move material, parts, tools or specialized devices through variable programmed motions for the performance of variety of tasks.
- They are reprogrammable and multifunctional.

Origin of the word 'robot' can be traced in the Czech word '*robota*', which means 'forced' or compulsory labor.

What are the four Ds of robotics ….....

Robots Helps Humans in **Dull, Dirty, Dangerous and Dear Jobs**

Four D's of Robotics are

- Dull
- Dirty
- Dangerous
- Dear

History: Evolution of Robots

The term "robot" was first used in a play, **"Rossum's Universal Robots" (R.U.R.)**, published by the Czech Karel Čapek in 1921. R.U.R. was a satire in which robots were manufactured biological beings that performed all unpleasant manual labor.

Origin of the word 'robot' can be traced in the Czech word '*robota*', which means 'forced' or compulsory labor.

➢ What are the laws of Robotics?

Laws of Robotics:

In 1941 and 1942, **Isaac Asimov** formulated the **Three Laws of Robotics,** and in the process coined the word "robotics".

1. A robot may not injure a human being, or, through inaction, allow a human being to come to harm.

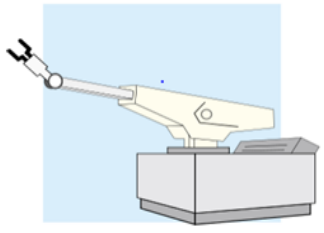
2. A robot must obey the orders given to it by human beings unless that is in conflict with the first law.

3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

➢ Name the first industrial robot.

1961:

Unimate was the first industrial robot, was installed in a **General Motors** automobile factory in New Jersey. It was invented by George Devol in the 1950s using his original patent filed in 1954 and granted in 1961.



Sketch of a Unimate robot

The machine undertook the job of transporting die castings from an assembly line and welding these parts on auto bodies, a dangerous task for workers, who might be poisoned by toxic fumes or lose a limb if they were not careful.

➢ Name the world's first humanoid intelligent robot

1972:

- 

WABOT-1 (1973)

Waseda University initiated the WABOT project in 1967, and in 1972 completed the **WABOT-1**, the world's first full-scale humanoid intelligent robot.
The **WABOT-1** was able to communicate-with a person in Japanese and to measure distances and directions to the objects using external receptors, artificial ears and eyes, and an artificial

mouth.
The **WABOT-1** walked with his lower limbs and was able to grip and transport objects with hands that used tactile-sensors.

1984:

- In 1984 Wabot-2 was revealed; capable of playing the organ, **Wabot-2** had 10 fingers and two feet. Wabot-2 was able to read a score of music and accompany a person.

➢ Name a robotic dog capable of interacting with humans

1990's

Sony introduced the **AIBO**, a robotic dog capable of interacting with humans in 1999.

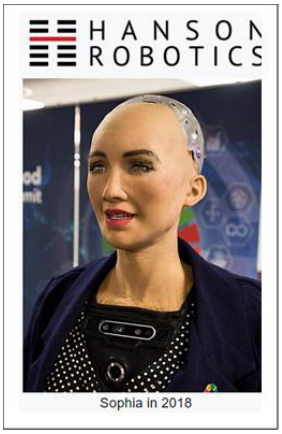
Sony created AIBO (Artificial Intelligence roBOT), an entertainment robotic pet and promotes AIBO as having the capability to interact with its human owner in many of the same ways a living pet would - without high maintenance.

2000- present

➢ Name a vacuum cleaner robot by iRobot

ASIMO ROBOT

The popular **Roomba**, a robotic vacuum cleaner, was released in 2002 by the company iRobot.
Self-driving cars had made their appearance by around 2005.
In 2005 Honda revealed a new version of **ASIMO** robot updated with new behaviors and capabilities.



Sophia in 2018

Sophia is a social humanoid robot developed by the Hong Kong based company Hanson Robotics. Sophia was activated on February 14th 2016 and made her first public appearance in mid-March 2016 at South by Southwest (SXSW) in Austin,Texas United States

Classification of Robots

- What are the different types of Robots

Robots are broadly classified as

Industrial Robots.....

An industrial robot is a reprogrammable, multifunctional manipulator designed to move materials, parts, tools or special devices through programmable motions for the performance of variety of tools.

Special- purpose Robot……

It is the one that is used in places other than factories.

Automatic Guided Vehicles: An Automatic Guided Vehicle (AGVs) is type of mobile robot, which has wheels for its locomotion. Their movement is directed by a combination of software and sensor-based guidance systems.

Walking Robots: These robots walk like human beings. They are used in military, undersea exploration and places where rough terrains exist. They offer high precision and speed, and are generally used in pick & place applications.

Parallel Robots: Those robots with similarity as walking robots, have parallel configurations, in contrast to the serial-like structure of an industrial robot. A walking robot with all its legs touching the ground is a parallel robot. Such robots find applications in machine tools and medical surgery.

Note : There are other classifications also shown below

How They Move:

Stationary Robots: Stay in one place.

Mobile Robots: Move around, like robots on wheels or legs.

How They're Controlled:

Remote-Controlled Robots: Controlled by a person.

Smart Robots: Can do things on their own using sensors and programming.

Where They Work:

Underwater Robots: Work in the ocean.

Space Robots: Used for space exploration.

Aerial Robots (Drones): Fly in the air.

Ground Robots: Move on the ground.

Who They Work With:

Collaborative Robots (Cobots): Work alongside people.

Applications of Robotics:

- State different applications of Robot

Robotics finds applications across various industries, enhancing efficiency, precision, and safety. Here are some examples of how robotics is applied in different fields:

Manufacturing:

- Automated Assembly Lines: Robots are used for tasks like welding, painting, and assembly in manufacturing plants.

- 3D Printing: Robotic arms can be employed in 3D printing processes for precision and consistency.

Healthcare:

- Surgery: Robotic-assisted surgery allows for minimally invasive procedures with increased precision, like the da Vinci Surgical System.
- Rehabilitation Robots: Devices assist in physical therapy for patients recovering from injuries or surgeries.

Agriculture:

- Harvesting Robots: Autonomous robots can harvest crops, improving efficiency and reducing the need for manual labor.
- Weeding Robots: Robots equipped with computer vision can identify and remove weeds, reducing the need for herbicides.

Logistics and Warehousing:

- Automated Guided Vehicles (AGVs): Robots navigate warehouses to transport goods, optimizing logistics processes.
- Mobile robots are extensively used in warehouses for material handling and logistics. Autonomous Mobile Robots (AMRs) can navigate through the warehouse environment, pick up items, and transport them to designated locations.

Space Exploration:

- Rovers: Vehicles like NASA's Mars rovers, such as Curiosity and Perseverance, explore the Martian surface autonomously.
- Satellite Servicing: Robots are designed to repair and maintain satellites in orbit.

Automotive Industry:

- Robotic Welding: Industrial robots perform precise welding in car manufacturing.
- Automated Inspection: Robots with vision systems inspect and identify defects in the production line.

Construction:

- Bricklaying Robots: Autonomous machines can lay bricks with precision, speeding up construction processes.
- Drones for Surveying: Unmanned aerial vehicles equipped with cameras survey construction sites for planning and monitoring.

Environmental Monitoring:

- Underwater Robots: Autonomous underwater vehicles (AUVs) collect data on ocean conditions, marine life, and pollution.
- Agricultural Drones: Drones equipped with sensors monitor crop health and optimize irrigation.

Entertainment:

- Theme Park Animatronics: Robots are used in theme parks for creating lifelike characters and interactive experiences.
- These examples illustrate the versatility of robotics in addressing a wide range of tasks, from mundane and repetitive to highly complex and specialized, across various industries and sectors.

Security and Surveillance:

- Mobile robots equipped with cameras and sensors are utilized for security and surveillance purposes. These robots can patrol predefined areas, monitor for unusual activities, and provide real-time video feeds to security personnel.


TIN
KER
CAD

Introduction to Tinkercad

Tinkercad is free, easy-to-use cloud-based online software for electronics, circuit designing, coding, 3D designing, and modeling software. It is created keeping in mind that user of any age is comfortable to use it and can make projects using it. It can work on any computer with the internet. Using Tinkercad, students can create their own imagination. Tones of 3D models can be formed using tinkercad. Also, there are multiple in-built designs like a chair, window, etc.

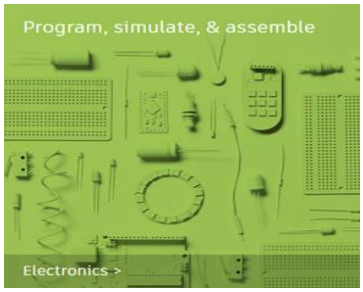
It has three basic features-

1. 3D design:

In 3D designing, there are several blocks that can be used to make any 3D model.

2. Electronics (Circuit designing, coding, and simulation):

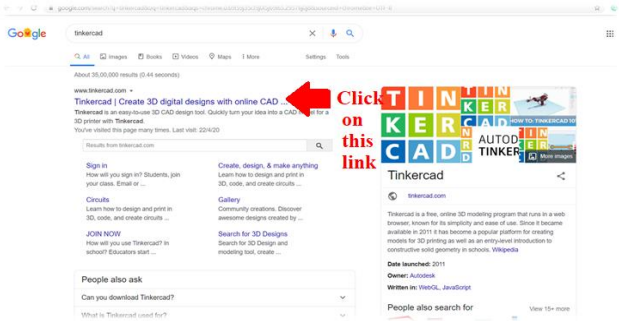
In this feature, you can do various applications of electronics. Here you can design electronics circuits that will be based on Arduino microcontroller. You can design your circuits and also code your circuits using the Arduino microcontroller. There are two options to program either you can follow block coding or you can follow text coding. You can also simulate your circuit here to test if your code and circuit is working properly or not.



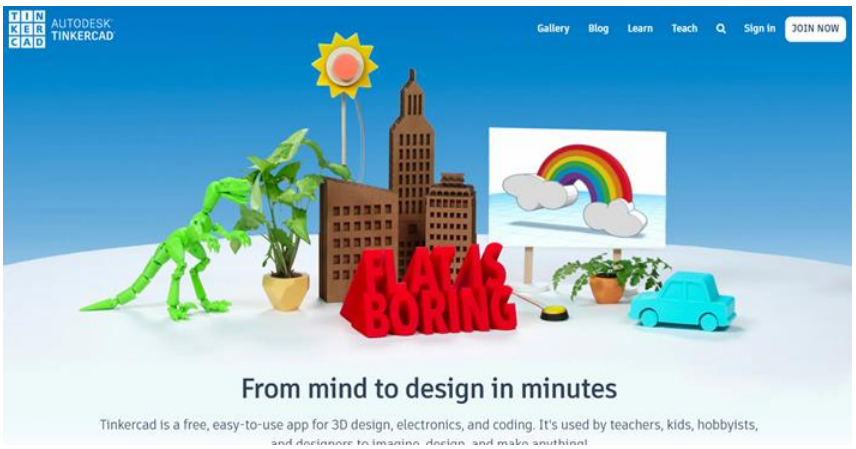
How to open Tinkercad

1. Open any browser (Chrome, Mozilla).

2. Search Tinkercad on Google. After that several links will open, click on the first link (www.tinkercad.com).



3. Then, the tinkercad home page will open as shown below:

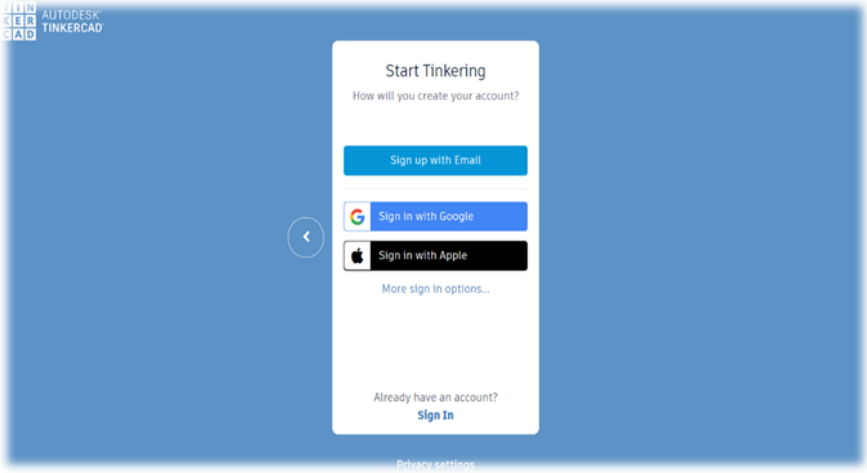


How to make an account on Tinkercad?

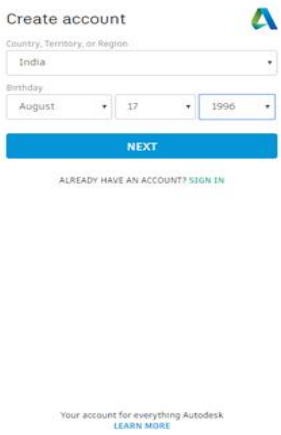
1. Click on the **"Join now"** option as shown below:

2. After clicking on the "Join now" option the following page will open:

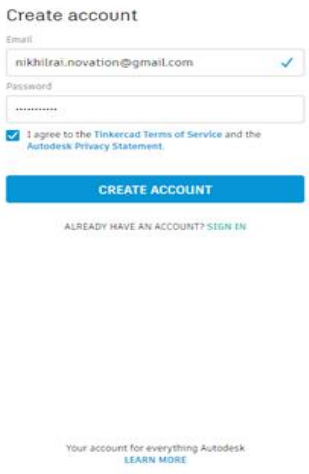
3. Click on **“create a personal account”** if you don’t have an account on tinkercad or click on “sign-in” if you already have an account. After clicking on "create a personal account" the following page will open:



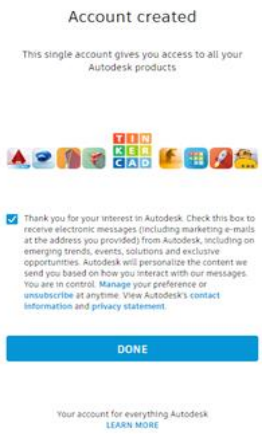
4. Now click on **“Sign up with Email”** so the following page will open. Enter your details like entering the country name and your age.



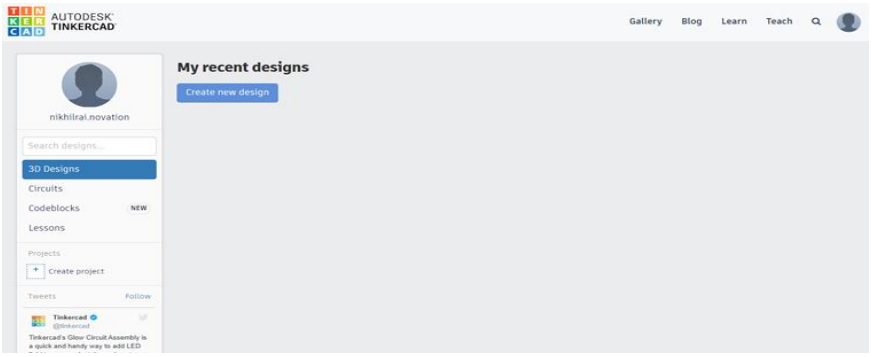
5. After entering the details, click the next button. So, the following page will open. In this enter your email id and password.



6. After entering the email id and password click on “create account”. Your account is created as shown below:



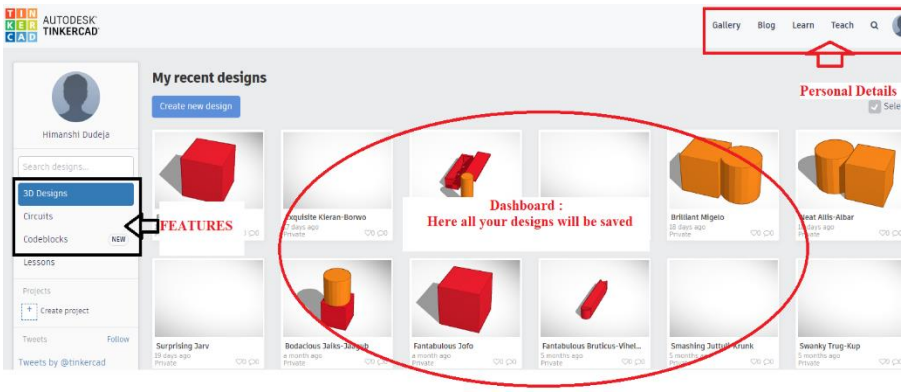
7. Click on the Done option and then you will be directed to the following page:



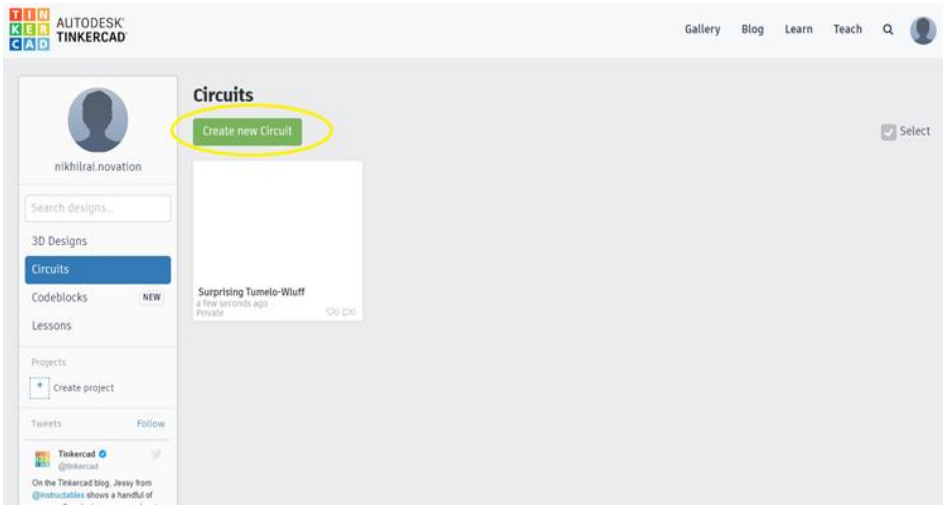
How To use Tinkercad Software

Steps to use Tinkercad after making an account

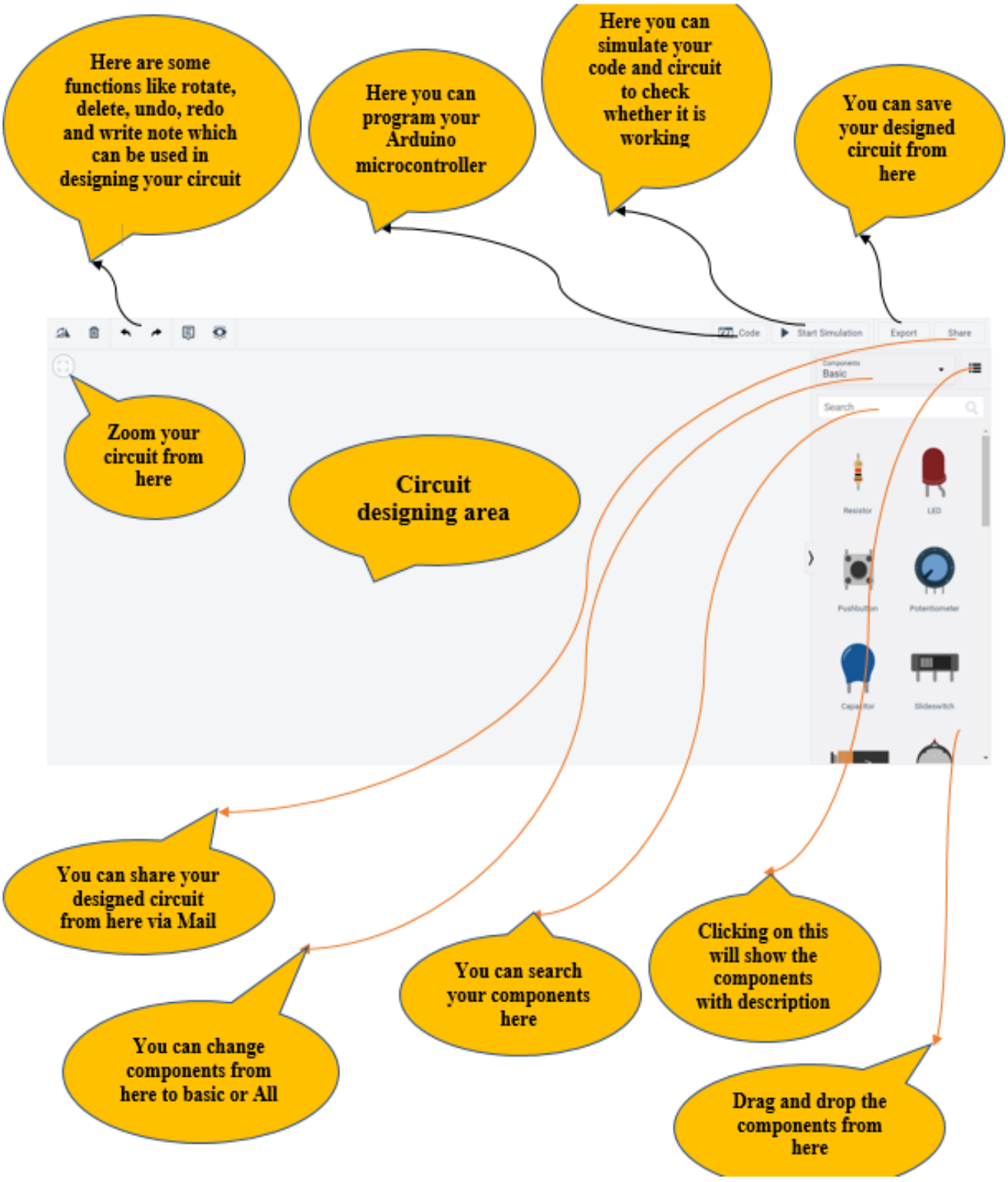
1. After making an account, the following screen will open with three different features 3D designs, Circuits, and Code blocks.



2. For accessing Circuit designing and Arduino stuff, we need to select "Circuits".After selecting "Circuits" the following screen will open and then click on "Create new circuit'.



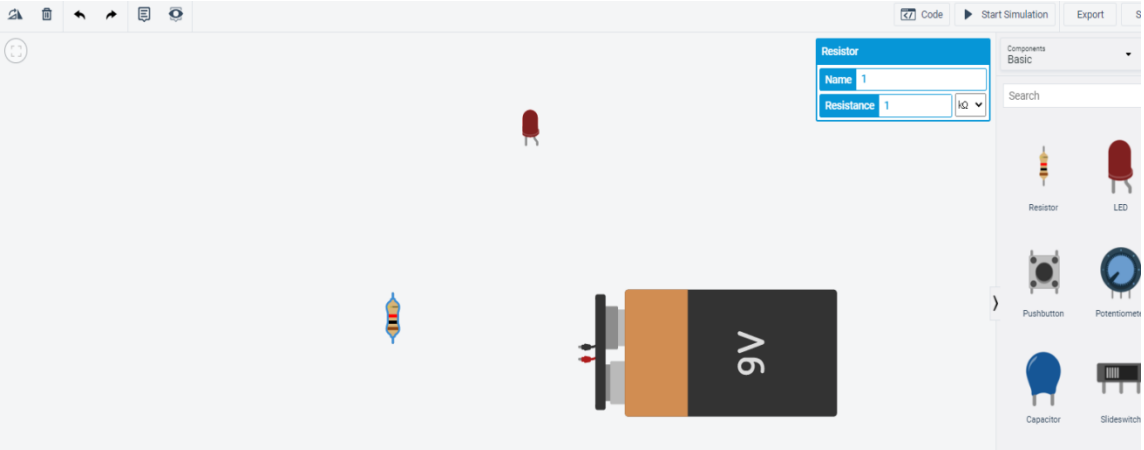
Explanation of Default screen of Circuit Designing in Tinkercad:



How to connect a LED with resistor and battery

Steps to connect LED with a Resistor:

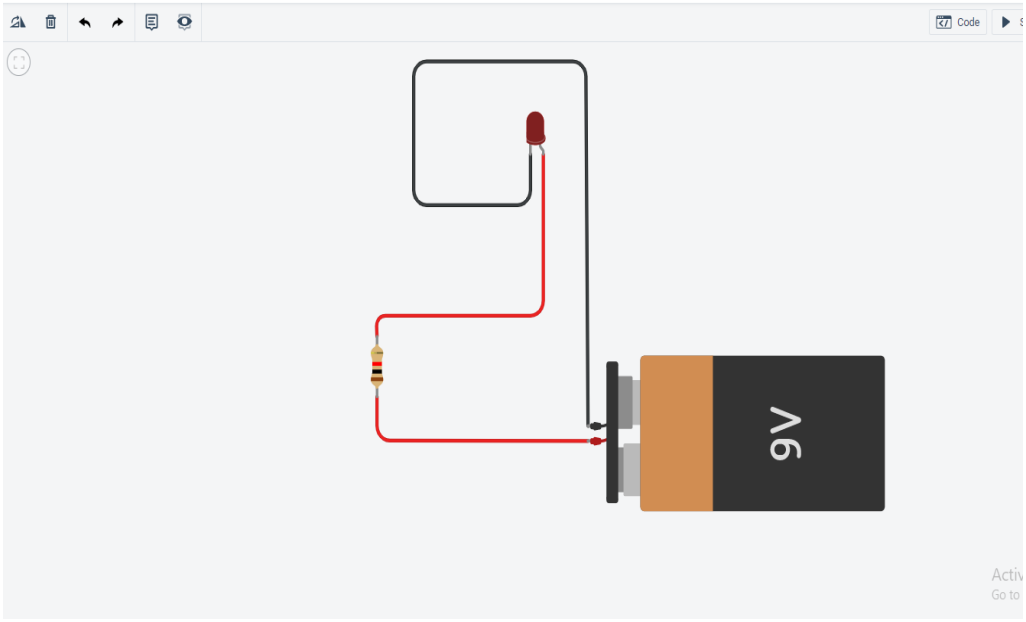
1. Open tinkercad, sign-in with your registered I'd. Click on circuits, and then click on create new circuits the following page will open.
2. Now, Drag and Drop LED, Resistor and battery into the "circuit designing area" as shown below:



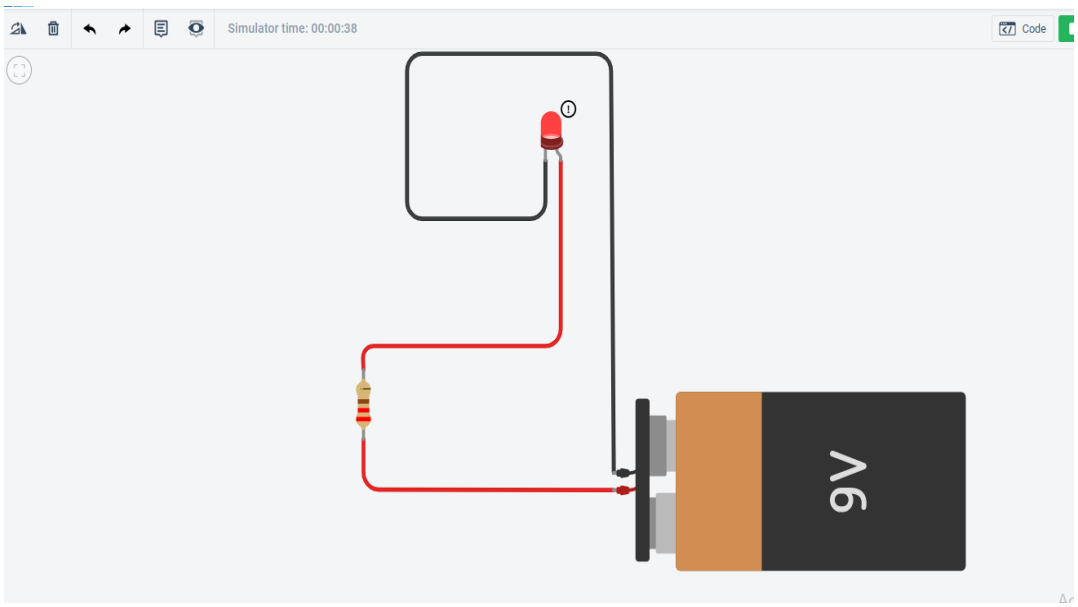
3. Now, Connect Led with a resistor and a battery.

How to Connect:

- Connect the Anode leg of Led to one terminal of the resistor and then connect another terminal of the resistor to the positive end of the battery.
- Now, Connect Cathode leg of Led to the negative end of the battery.



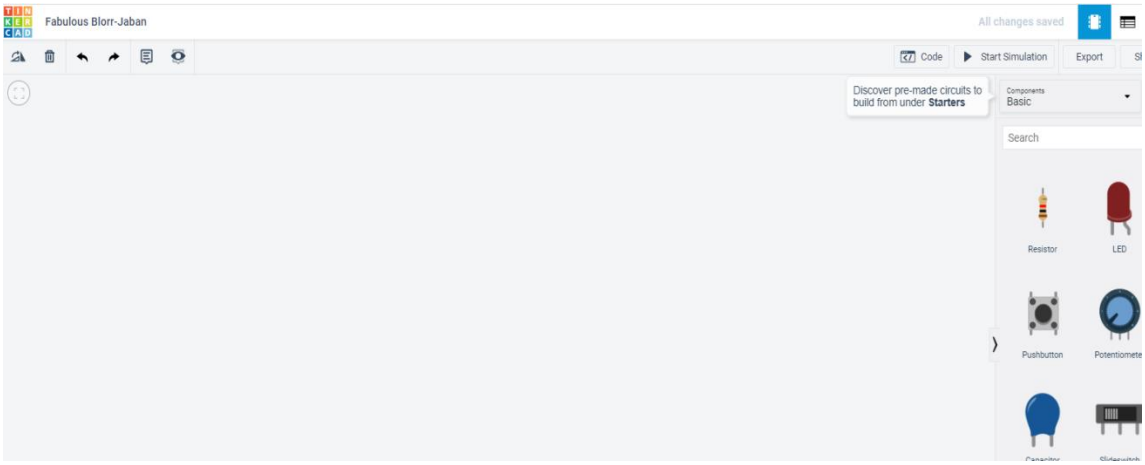
4. You can also test your circuit by clicking on the start simulation button as shown below :



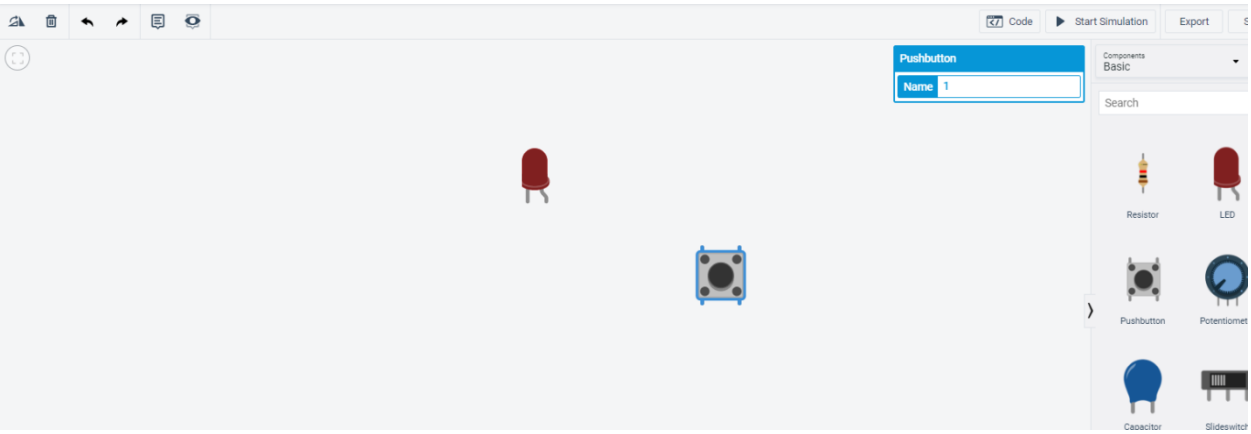
How to connect a switch with LED

<u>Steps to connect a Switch with LED</u>

1. Open the Tinkercad circuit designing page as shown below:



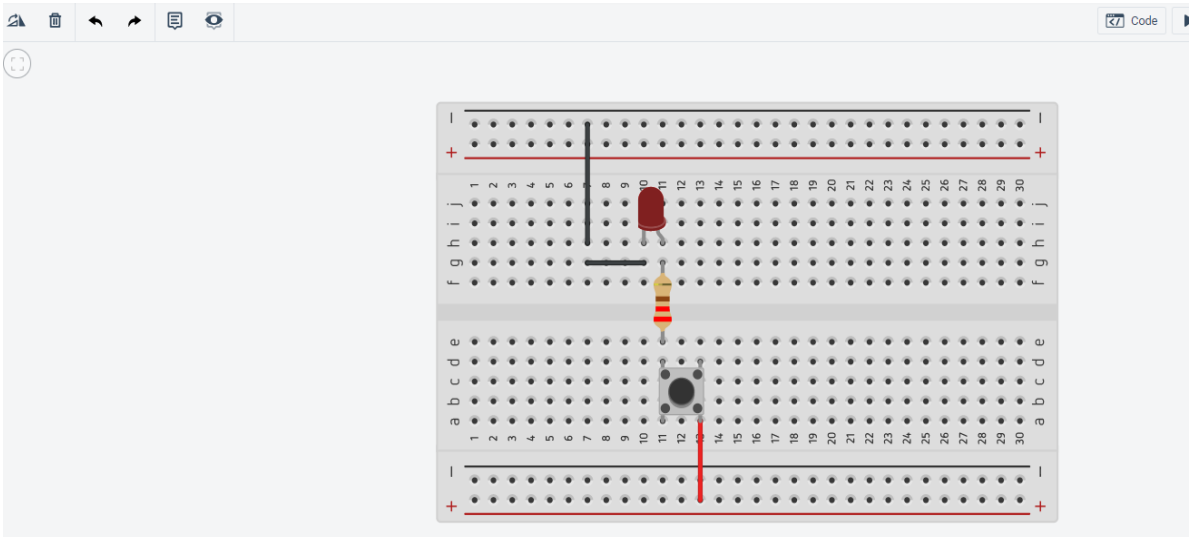
2. Drag and Drop Switch & LED in the circuit designing area.



3. Now, connect LED with a switch :

How to connect :

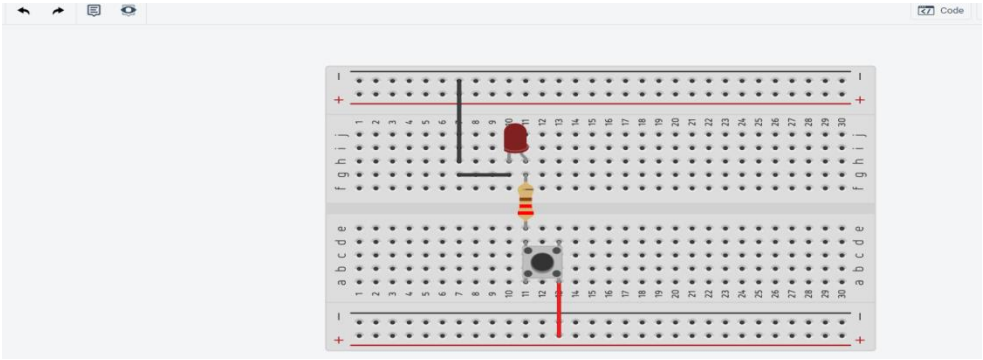
- Connect one leg of the resistor with an Anode pin of LED and another leg of the resistor to any one pin of the switch as shown below.



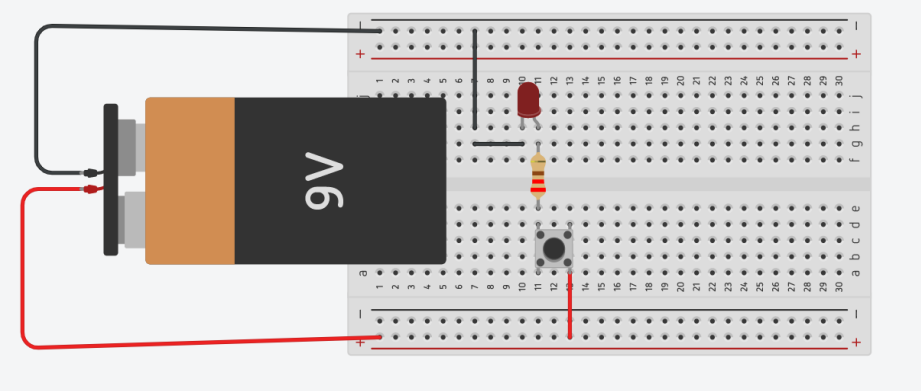
How to make a LED ON/OFF circuit

LED ON-OFF circuit using a switch

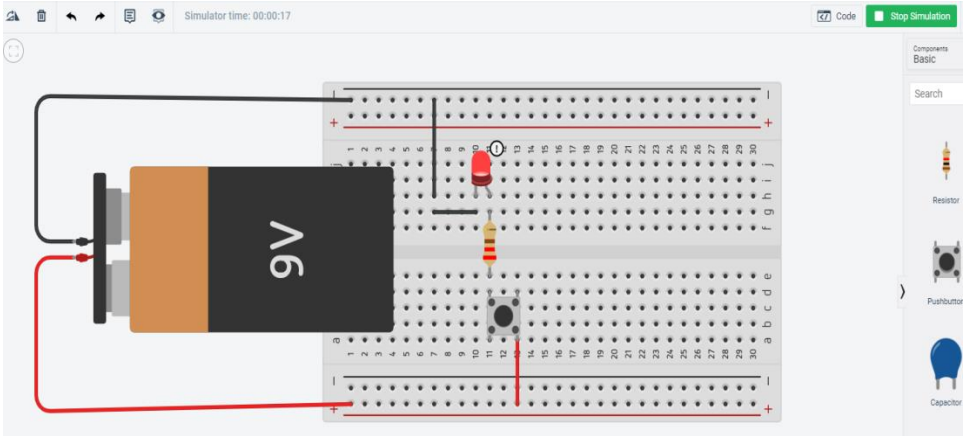
1. Connect Led with a switch as shown below.



2. Now, connect positive of the battery with positive of the breadboard and negative of the battery to the negative of the breadboard.



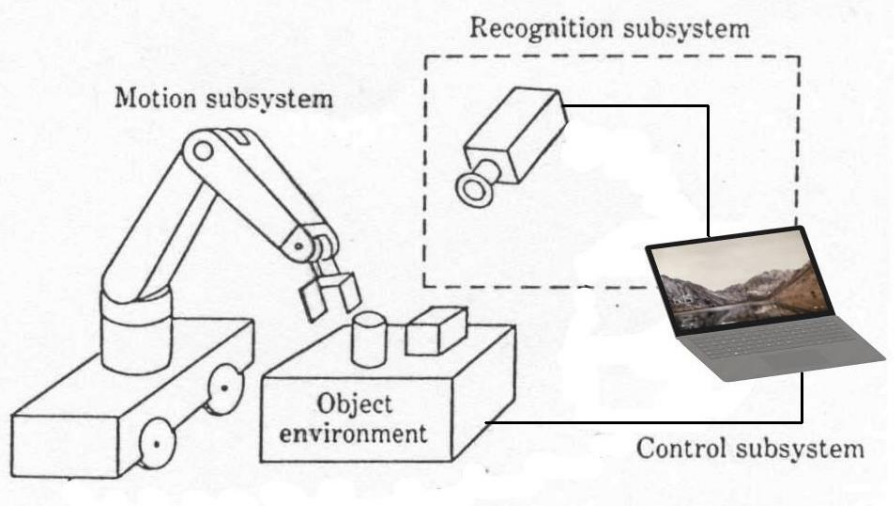
3. Now, Run the simulation and press the push button with the mouse pointer. The LED will remain ON while the button is pressed. Release the button and the LED will turn OFF.



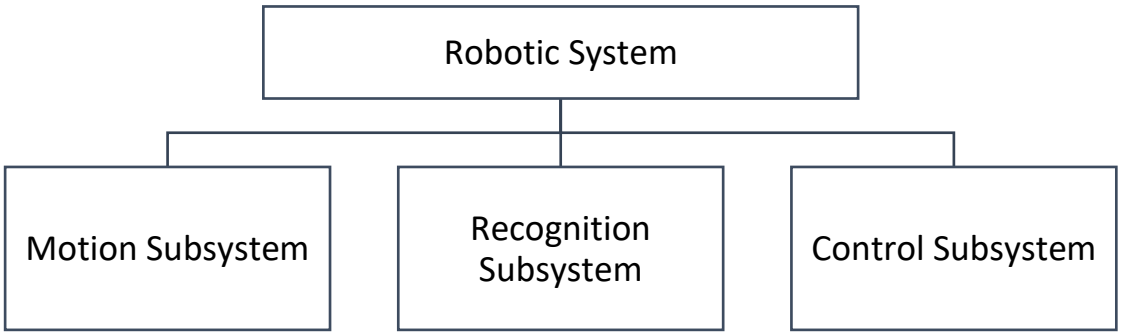
This is the complete circuit of LED ON/OFF using a switch.

Elements of Robotic Systems

2.1. Can you name the different subsystems of the robot



Block diagram representation of Robotic System



2.1. Elements of Robotic System:

A robotic system generally consists of three subsystems, namely a motion subsystem, recognition subsystem and control subsystem

2.1.1. Motion Subsystem: The motion subsystem is the physical structure of the robot that carries out desired motion similar to human arms.

Recognition Subsystem: The recognition subsystem uses various sensors to gather information about the robot itself and any object being acted upon and about the environment. Based on sensor data, it recognizes the robot's state, the objects and the environment.

Control Subsystems: The control subsystem is a device or a set of devices to manage, command, direct or regulate the behavior of the process. The control subsystem influences the robot's motion to achieve a given task using the information provided by the recognition subsystem.

2.1.2. What are the elements of motion subsystem…….

Motion subsystem

Manipulator: This is the physical structure which moves around. It comprises of *links* and *joints* normally connected in series. Manipulator is the mechanical structure of the robot.

End-effector: This is the part attached at the end of a robot manipulator. This is equivalent to the human hand. An end effector is mechanical hand that manipulates an object or holds it before they are moved by the robot arm.

Actuator: The motion to the manipulator, end-effectors and links are provided by the actuators. They are classified as pneumatic, hydraulic or electric based on their principle of operation.

Types of Actuators:

Electric Actuator: An electric actuator is a type of mechanical device that converts electrical energy into mechanical motion.

Example: Servomotors, Stepper Motor

Pneumatic Actuator: A pneumatic actuator converts energy in the form of compressed air into motion.

Hydraulic Actuator: The hydraulic actuators are used in robots handling heavy loads. These actuators can produce very high force if we compared them with other actuators. These actuators are deployed where higher speed, accuracy, and stability are required. Hydraulic actuators are similar to pneumatic actuators, but uses incompressible mineral oils in lieu of air. It has no connection with water.

2.1.3. What are the elements of Recognition subsystem…….

Recognition Subsystem: The recognition subsystem uses various sensors to gather information about any object being acted upon, about the robot itself, and about the environment. It recognizes the robot's state, the objects, and the environment from this information.

Analog-to-Digital Converter (ADC): This electronic device converts the sensors analog output to a digital signal to be compatible with the robot's controller. An analog-to-digital converter is a system that converts an analog signal, such as a sound picked up by a microphone or light entering a digital camera, into a digital signal.

Sensors: Sensors are electronic components that allow electronic devices to interact with the world. Once the sensors have been read, the device has the information needed to decide how to respond.

Sensors are essentially transducers. Transducers convert one form of signal to another. For example: Human ye converts light patterns into electrical signals.

Types of Sensors: Robotic Sensors are generally categorized into five categories

1. **Tactile Sensors:** A tactile sensor is a device that measures the forces in response to the physical interaction with the environment. Tactile sensors are used in robotics, computer hardware, and security systems. Tactile means connected with the sense of touch.

2. **Proximity and Range Sensors:** A proximity sensor is a non-contact sensor that detects the presence of an object (often referred to as the "target") when the target enters the sensor's field.

   Depending on the type of proximity sensor, sound, light, infrared radiation (IR), can be utilized by the sensor to detect a target.

3. **Miscellaneous sensors and sensor-based systems:** There are also other sensors used by us to interact with the outside environment.
   Ultra-sonic Sensor, Temperature, Pressure, Humidity.

2.1.4. What are the elements of the Control subsystem…….

Control subsystem:

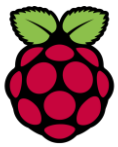
Digital to Analog Converter (DAC)

A Digital to Analog Converter, or DAC, converts a digital signal to an analog signal.

Digital Controller: The digital controller is a special electronic device that has a CPU, memory and sometimes hard disk to store programmed data. These components are kept inside a box referred as controller in robotic systems.

A controller processes the user-programmed commands and sends signals to the actuators through the Digital to Analog Converter (DAC).

2.2 Introduction to Controllers



A prototyping board is any electronic board used to make electric and electronic circuits prototypes before printing them on a fabricated PCB board.
Some popular microcontroller development boards are Arduino boards, Raspberry Pi etc.

Arduino boards are available in different sizes and different no. of I/O pins. Some of the frequently used Arduino boards are Arduino UNO, Arduino Mega, Arduino Nano, Arduino Mini, Arduino Leonardo and Arduino Lilypad.

The Raspberry Pi is a single-board computer developed by the Raspberry Pi Foundation in UK and was designed for Education Application only.

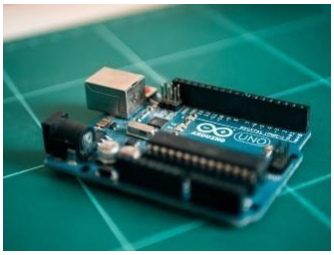
Procedure to connect an Arduino Board

1. Connect the Arduino UNO board to your device using a USB cable.

2. Observe the board and answer to the following questions:

Q. What happened when you connected the Arduino UNO board to your device?
Answer. A green light turned on and another light on the board started blinking.

Q. Read the markings next to both lights. What do they say?
The unblinking green light shows the power supply is connected to Arduino board. The marking next to it says ON.



The blinking light may show a marking of TX, RX, or L.
All the lights are LEDs that glow depending on the inputs and outputs.

3. We will input commands in the computer to blink the inbuilt LED (L) on Arduino UNO board by following the steps given below:

- Double-click on Arduino IDE to open the Arduino programming interface.
- Click on File → Examples → Basics → Blink. (To open sample blink program for Inbuilt LED)
- Click on Tools → Board. (Select the Arduino UNO board from the list)
- Click on Tools → Port. (Select the COM port connected to the computer)
- Click on Sketch → Verify/Compile. (To check whether the program is free from errors)
- Click on Sketch → Upload. (To upload the program in Arduino)

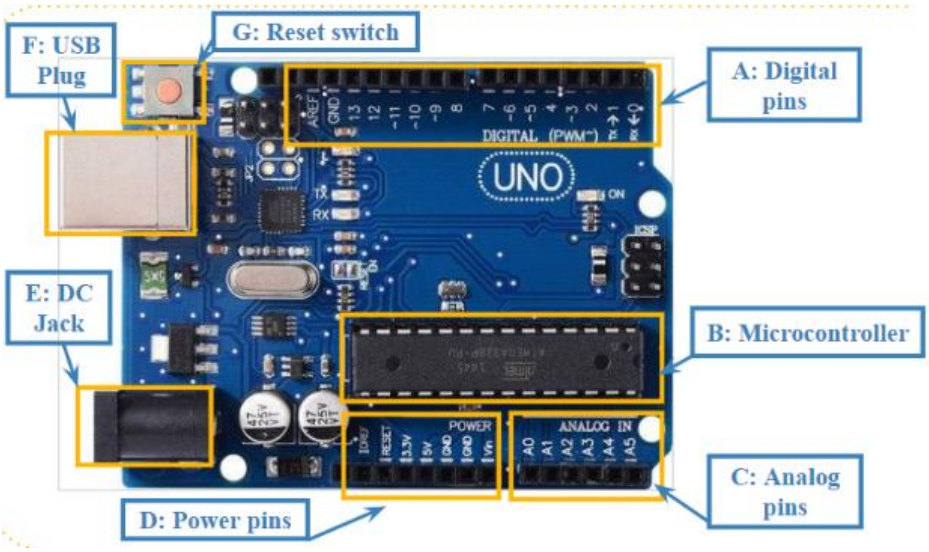
4. Note your observation in the record sheet.

As shown in the code, we define **two different functions** in Arduino IDE for coding, i.e.,

1. **Setup();:** Here, we initialize the code by declaring functions, variables, and pins on the Arduino board. This function allows Arduino to run the code once. In our sample code, we initialized the code by defining the built-in LED (marked as L) as the output pin.
2. **Loop();:** Here, we write the body of the functions defined in the setup(). This will allow the function to repeat continuously.

- Arduino is an open-source physical computing platform for creating interactive objects such as sensing devices.
- These sensing devices may stand alone or collaborate with software on your computer to respond to changes in the physical environment. For example, Amazon Alexa is a sensing device that responds to verbal commands from the users.
- The Arduino hardware and software is open source and free of cost.
- The Arduino project was developed in an educational environment in Italy and is a very popular educational tool.

Components of Arduino Uno



A: Digital pins: These pins are used to connect digital devices. These pins could work as input pins or output pins.

B: Microcontroller: The microcontroller is the brain of the board. This controller controls all the components. The program is uploaded in the controller. Based on the program, the controller takes inputs from the sensors, processes them, and based on logic, gives an output command in response.

C: Analog pins: These pins are used to connect analog devices. For example, temperature sensor or light sensor. Recall that 'analog' means 'variable values changing continuosly over a given period of time'.

D: Power pins: We use these pins to supply power to the sensors. We could take 5 V or 3.3 V from the on-board supply which we could use for the sensors depending on the voltage rating mentioned on the sensor.

E: DC Jack: This DC jack is used to connect the power supply to the board. We can supply 6 V to 20 V supply through DC adapter. We cannot connect the Arduino board directly to the main supply socket because it has a high AC voltage of 220V. Arduino board requires DC supply of not more than 12 V and 1 A. So, it is always connected through an adapter with a specific rating.

F: USB Plug: This USB plug is used to connect the board to a laptop. We use the USB plug to upload the program into the controller.

G: Reset switch: This is a reset switch. This switch will restart the program.

Arduino Programming:

Syntax

We define two different functions in Arduino IDE for coding, i.e.,

1. setup(): Here, we initialize the code by declaring functions, variables, and pins on Arduino board. This function allows Arduino to run the code once. In our sample code, we initialized the code by defining the built-in LED (marked as L) as the output pin.

2. loop(): Here, we write the body of the functions defined in the setup(). This will allow the function to repeat continuously.

Explore the instructions to define pins as an INPUT or OUTPUT in void setup() function.

Syntax: pinMode(pin, mode);

Here,

pin (in brackets) = the Arduino pin number.

mode = INPUT or OUTPUT.

; (semicolon) is mandatory to keep after each instruction which indicates end of the instruction.

Example: An LED is connected to pin no.13 of the Arduino.

Instruction: pinMode(13, OUTPUT);

(Note: In pinMode, M is always capital. It is used as one word with no space in between.)

Explore the instructions to ON/OFF pin in void loop() function

Syntax: digitalWrite(pin, status);

Here,

pin (in brackets) = the Arduino pin number.

status = HIGH / LOW (High means ON and low means OFF.)

; (semicolon) is mandatory to keep after each instruction which indicates end of the instruction.

Example: We want an LED connected at pin 13 to turn ON.

Instruction: digitalWrite(13, HIGH);

(Note: In digitalWrite, W is always capital. HIGH and LOW always will be in full caps.)