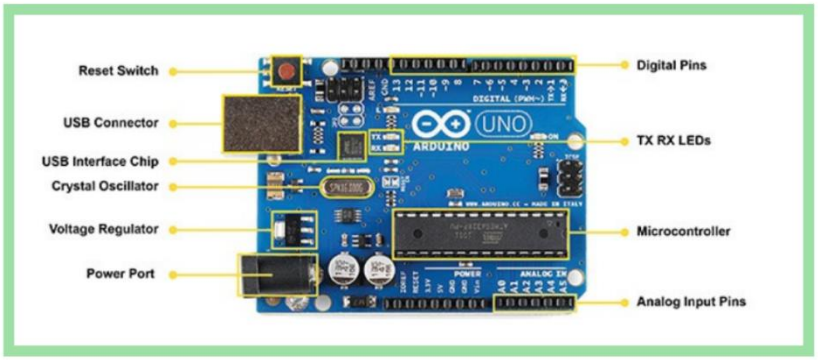
Relevant Tools, Standards, and Engineering Constraints

Hardware

An embedded system uses a hardware platform to perform the operation. The hardware of the embedded system is assembled with a microprocessor/microcontroller. It has elements such as input/output interfaces, memory, user interface, and the display unit. Generally, an embedded system comprises of the following

- Power Supply
- Memory
- Processor
- Timers
- Output/Output circuits
- Serial communication ports
- SASC (System application-specific circuits)

Example:

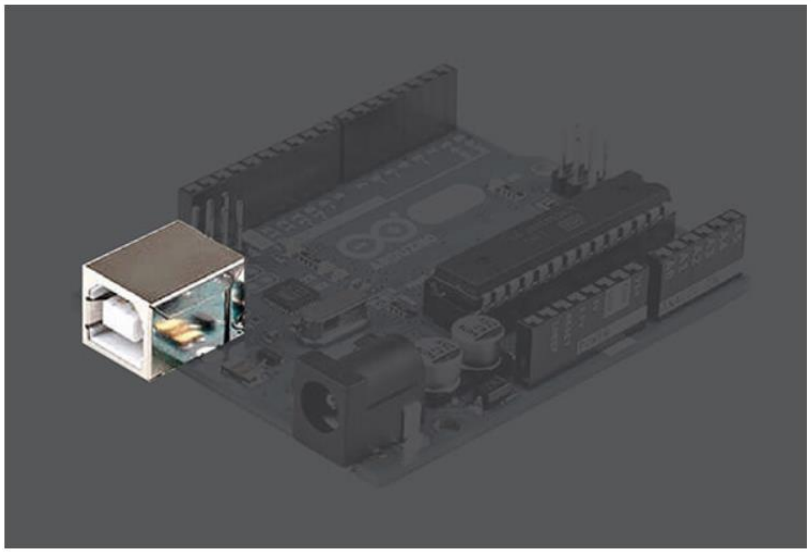
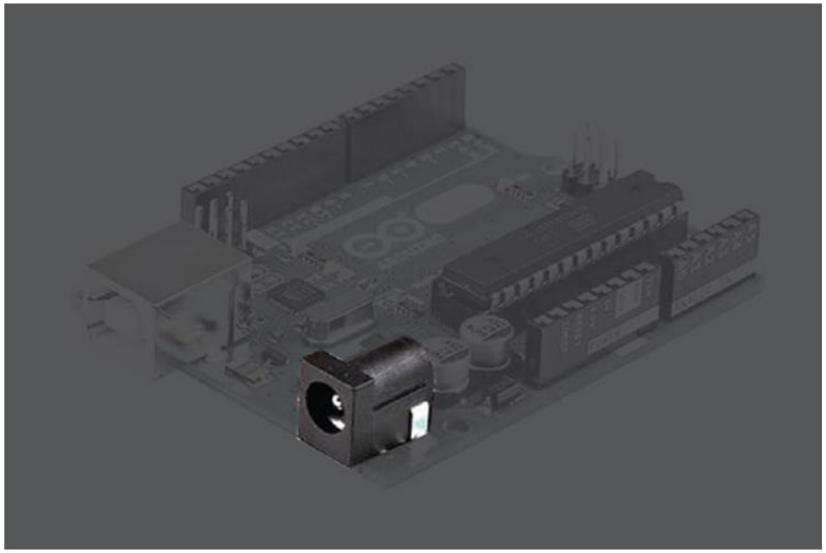


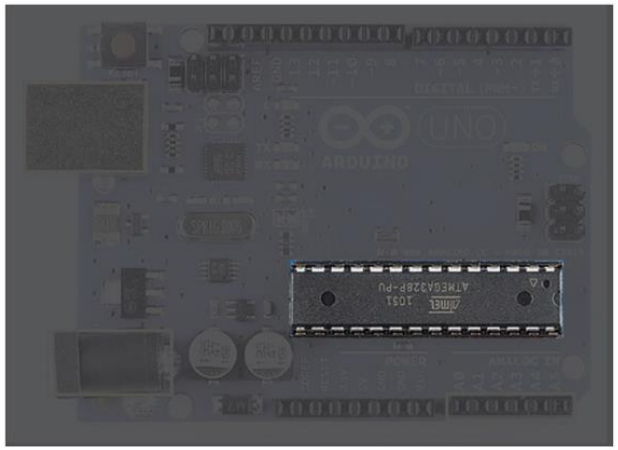
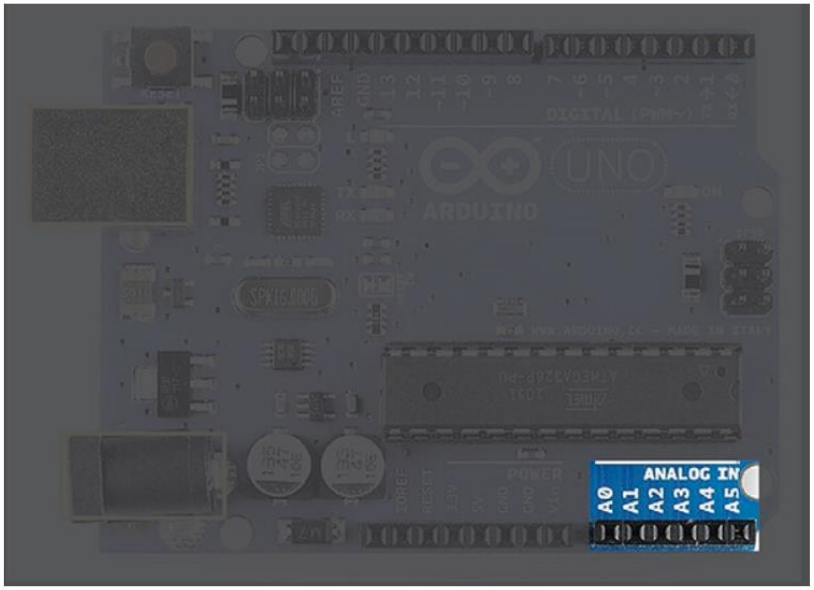
The major components of Arduino UNO board are as follows:

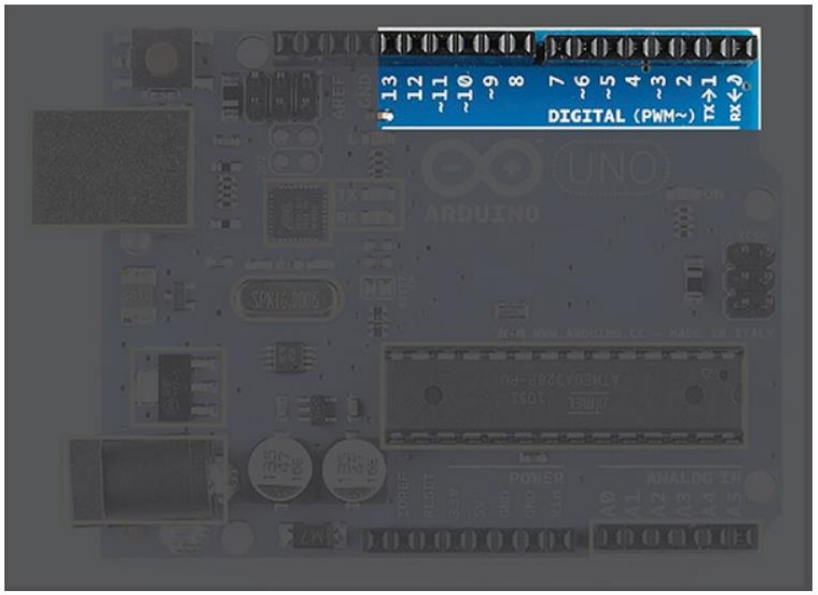
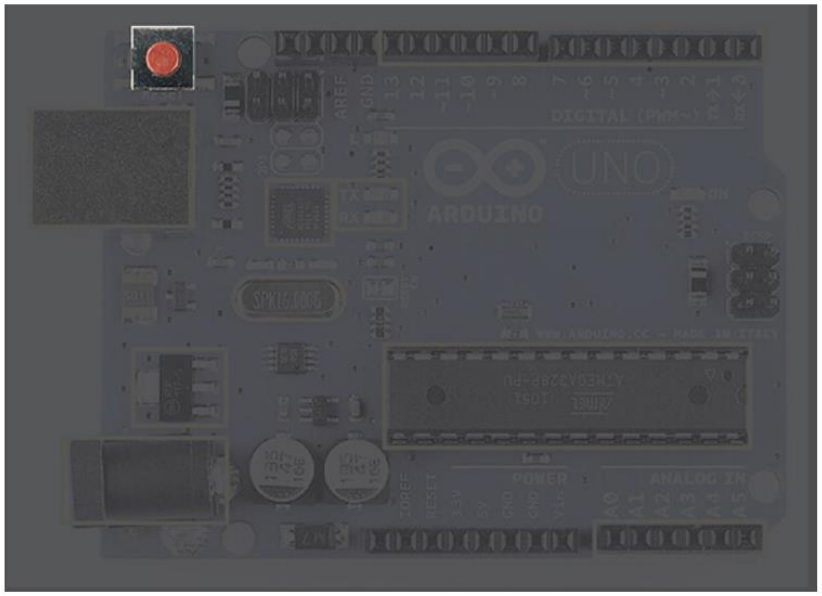
- USB connector

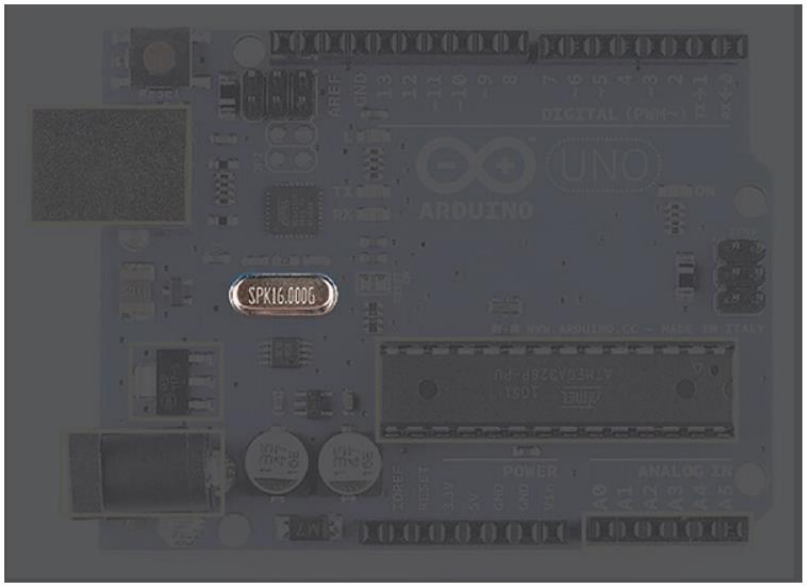
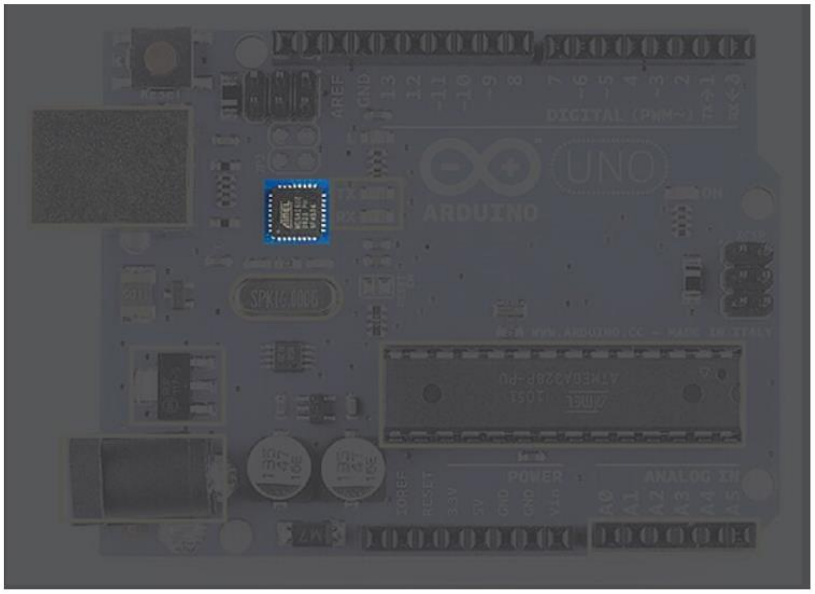
- Power port
- Microcontroller
- Analog input pins
- Digital pins
- Reset switch
- Crystal oscillator
- USB interface chip
- TX RX LEDs

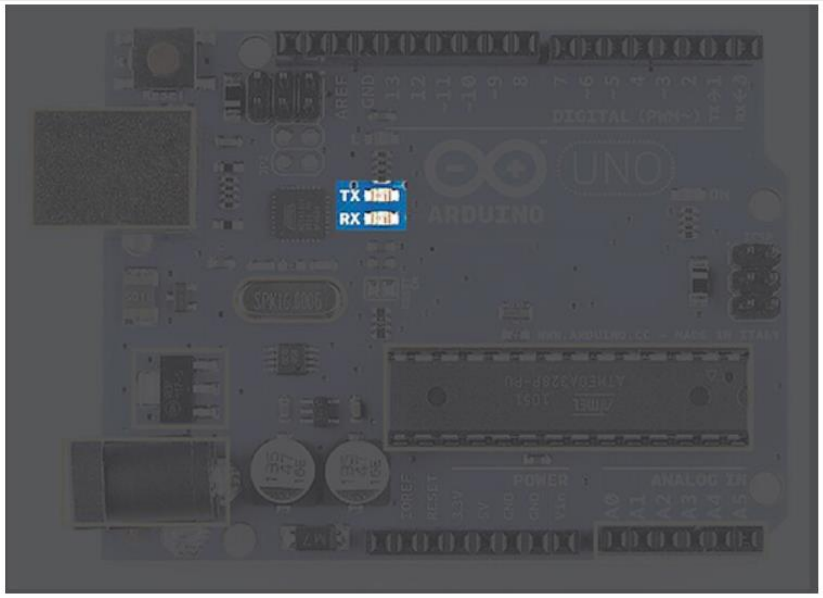
Now let’s take a closer look at each component.

Part of Arduino Uno	Image	Description
USB Connector		This is a printer USB port used to load a program from the Arduino IDE onto the Arduino board. The board can also be powered through this port.
Power Port		The Arduino board can be powered through an AC-to-DC adapter or a battery. The power source can be connected by plugging in a 2.1mm center-positive plug into the power jack of the board.

Microcontroller		It is the most prominent black rectangular chip with 28 pins. Think of it as the brains of your Arduino. The microcontroller used on the UNO board is Atmega328P by Atmel (a major microcontroller manufacturer). Atmega328P has the following components in it: • **Flash memory** of 32KB. The program loaded from Arduino IDE is stored here. • **RAM** of 2KB. This is a runtime memory. • **CPU**: It controls everything that goes on within the device. It fetches the program instructions from flash memory and runs them with the help of RAM. • **Electrically Erasable Programmable Read-Only Memory (EEPROM)** of 1KB. This is a type of non-volatile memory, and it keeps the data even after the device restarts and reset. Atmega328P is pre-programmed with a bootloader. This allows you to directly upload a new Arduino program into the device, without using any external hardware programmer, making the Arduino UNO board easy to use.
Analog Pins		The Arduino UNO board has 6 analog input pins, labeled "Analog 0 to 5." These pins can read the signal from an analog sensor like a temperature sensor and convert it into a digital value so that the system understands. These pins just measure voltage and not the current because they have very high internal resistance. Hence, only a small amount of current flows through these pins. Although these pins are labeled analog and are analog input by default, these pins can also be used for digital input or output.

Digital Pins		You can find these pins labeled "Digital 0 to 13." These pins can be used as either input or output pins. When used as an output, these pins act as a power supply source for the components connected to them. When used as input pins, they read the signals from the component connected to them. When digital pins are used as output pins, they supply 40 milliamps of current at 5 volts, which is more than enough to light an LED. Some of the digital pins are labeled with a tilde (~) symbol next to the pin numbers (pin numbers 3, 5, 6, 9, 10, and 11). These pins act as normal digital pins but can also be used for Pulse-Width Modulation (PWM), which simulates analog output like fading an LED in and out.
Reset Switch		When this switch is clicked, it sends a logical pulse to the reset pin of the Microcontroller, and now runs the program again from the start. This can be very useful if your code doesn't repeat, but you want to test it multiple times.

Crystal Oscillator		This is a quartz crystal oscillator which ticks 16 million times a second. On each tick, the microcontroller performs one operation, for example, addition, subtraction, etc.
USB Interface Chip		Think of this as a signal translator. It converts signals in the USB level to a level that an Arduino UNO board understands.

TX-RX LEDs		TX stands for transmit, and RX for receive. These are indicator LEDs that blink whenever the UNO board is transmitting or receiving data.

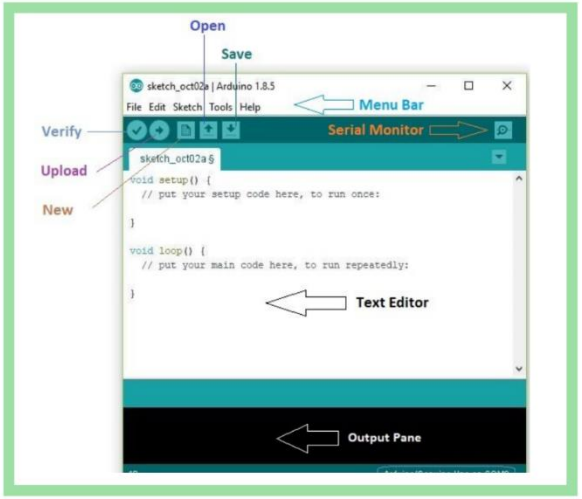
Software

Software components constitute programs such as compilers, integrated development environments (IDE), assemblers, simulators, etc., which are used to create codes that “instruct” the hardware to do the assigned job in an efficient manner.

Notable computer languages that are used for programming in embedded systems are embedded C, embedded C++, embedded JAVA, and assembly. Here embedded C and others contain a specific library for a microcontroller to work. (Like the specific header files such as math.h, conio.h). Mostly, for simple applications, an assembly is used, which produces more efficient, compact codes.

Example:

Arduino IDE



The bar appearing on the top is called **Menu Bar** that comes with five different options as follow:

1. **File** – You can open a new window for writing the code or open an existing one. The following table shows the number of further subdivisions the file option is categorized into.

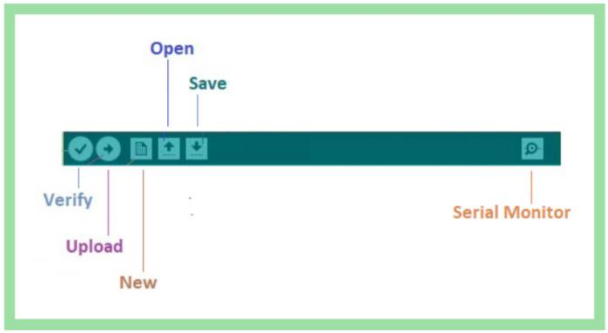
2. **Edit** – Used for copying and pasting the code with further modification for font

3. **Sketch** – For compiling and programming

4. **Tools** – Mainly used for testing projects. The Programmer section in this panel is used for burning a bootloader to the new microcontroller.

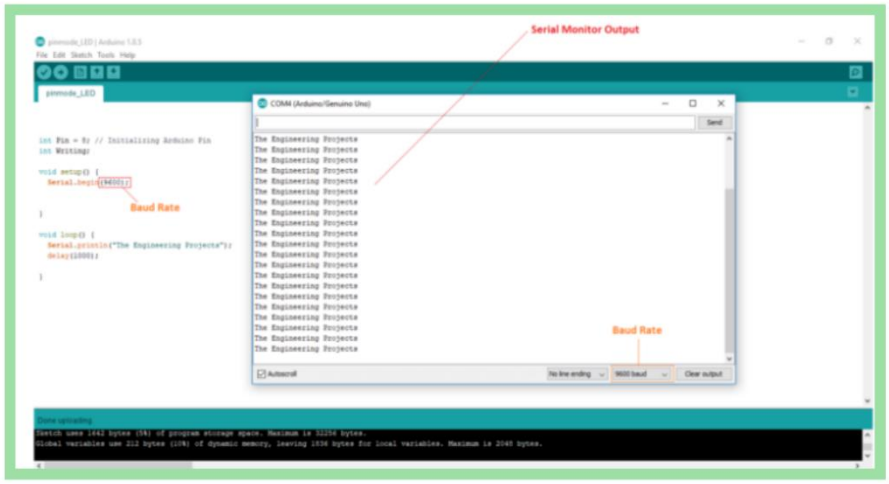
5. **Help** – In case you are feeling skeptical about software, complete help is available from getting started to troubleshooting.

The six buttons appearing under the Menu tab are connected with the running program as follow:

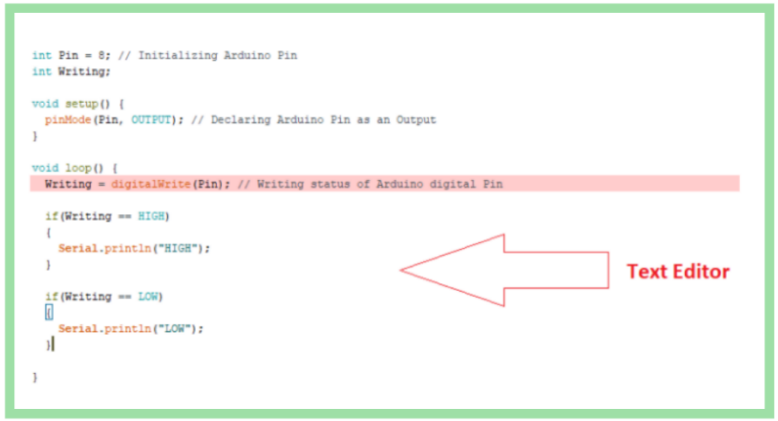


Button	Symbol	Description
Verify	Check mark	Used to verify the code. Click this once you have written your code.
Upload	Arrow key	Upload and transfer the required code to the Arduino board.
New	Dotted paper	Used for creating new file/program.
Open	Upward arrow	Reserved for opening an existing Arduino project.
Save	Downward arrow	Used to save the current running program/code.
Serial Monitor	Magnifying glass	A separate pop-up window that acts as an independent terminal and plays a vital role for sending and receiving the Serial Data. You can also go to the Tools panel and select Serial Monitor, or pressing Ctrl+Shift+M all at once will open it instantly. The Serial Monitor will actually help to debug the written Sketches where you can get a hold of how your program is operating. Your Arduino Module should be connected to your computer by USB cable in order to activate the Serial Monitor.

NOTE: You need to select the baud rate of the Arduino Board you are using right now. For my Arduino Uno Baud Rate is 9600, as you write the following code and click the Serial Monitor, the output will show as the image below.



The main screen below the Menu bard is known as a simple text editor used for writing the required code.



The bottom of the main screen is described as an Output Pane that mainly highlights the compilation status of the running code: the memory used by the code, and errors occurred in the program. You need to fix those errors before you intend to upload the hex file into your Arduino Module.

Libraries

Libraries are very useful for adding extra functionality to the Arduino Module. There is a list of libraries you can add by clicking the Sketch button in the menu bar and going to Include Library.

As you click the Include Library and Add the respective library it will on the top of the sketch with a #include sign. Suppose, I Include the EEPROM library, it will appear on the text editor as

#include <EEPROM.h>.

Most of the libraries are preinstalled and come with the Arduino software. However, you can also download them from external sources.

Standards

A standard is a repeatable, harmonized, agreed, and documented way of doing something. Standards contain technical specifications or other precise criteria designed to be used consistently as a rule, guideline, or definition. They help to make life simpler and increase the reliability and the effectiveness of many of the goods and services we use. Standards result from collective work by experts in a field and provide a consensus at the time when the standards are developed. As standards in the international arena are established on a consensus and broad stakeholder basis, they represent what can be agreed upon. A published standard is therefore the harmonized synthesis of what the group is prepared to publish. In terms of international and regional standardization, this is even more important than at the national level: the importance of consensus is critical because of large and diverse stakeholder groups and needs. Ultimately this may mean that a standard might lack some of the clarity, detail, or specific criteria certain stakeholder groups or individuals would have preferred.

How do Standards work?

Adherence to standards is voluntary, unless they are a requirement of legislation or regulation, or are incorporated as part of a formal contract. To increase global tradability and compatibility of products and services, it is important that, whenever possible, standards are harmonized globally to ensure they are truly trans-boundary.

What are the Standards for?

Standards are an important way of protecting consumers. While consumer protection is often visible through government policies or consumer protection organizations, standards create an extra protective environment that lies behind the perception of most consumers. This is particularly true where consumers have little or no choice in what they are offered. In rural communities in developing countries, consumers do not generally have the luxury of comparing features and selecting their suppliers or products from the Internet. Therefore it is incumbent on the standards to ensure that whatever product or service is provided is fit for purpose, safe, and has value. An important aspect of this protection is to ensure the product or service delivers as claimed, performs as specified, and is reliable, durable, and safe.

How Standards are Used?

Standards are an important aspect of ensuring that products and services are delivered in a harmonized and consistent way while providing consumers and users with the confidence that whatever products and services they are using deliver to specification. Many of the standards identified provide this support by ensuring that, for example; The characteristics of a particular component are measured, calculated, or evaluated in a consistent way – typically these may be the determination of chemical and physical properties.

Standard Organizations

International Organization for Standardization (ISO)

The International Organization for Standardization (ISO) was founded in 1947 and is headquartered in Geneva, Switzerland. ISO has three official languages: English, French, and Russian. Its membership comprises national standards organizations, one from each of 163 countries.

The American National Standards Institute (ANSI)

The American National Standards Institute (ANSI) was founded in 1918 and is headquartered in Washington, D.C., with an operational office in New York City. Its mission is “to enhance both the global competitiveness of U.S. business and the U.S. quality of life by promoting and facilitating voluntary consensus standards and conformity assessment systems, and safeguarding their integrity.”

The International Electrotechnical Commission (IEC)

The International Electrotechnical Commission (IEC) creates and publishes standards for electrical and electronic technologies. It was founded in 1906 and is headquartered in Geneva, Switzerland. Members of the IEC are called National Committees. Each country can have just one National Committee in the IEC. There are 82 members. ANSI represents the United States.

The International Telecommunication Union (ITU)

The International Telecommunication Union (ITU) is a specialized agency of the United Nations. Its original name was the International Telegraph Union, and it was founded in Paris in 1865. It serves the field of information and communications technology. Now headquartered in Geneva, it has a membership of 193 countries and over 700 private-sector entities and academic institutions. It operates using the six official languages of the United Nations: Arabic, Chinese, English, French, Russian, and Spanish.