Q.1 Attempt the following (any THREE) [15]

Q.1(a) What is IOT? Discuss different technologies involved in IOT. [5]

Ans.: The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

A thing, in the Internet of Things, can be a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has built-in sensors to alert the driver when tire pressure is low — or any other natural or man-made object that can be assigned an IP address and provided with the ability to transfer data over a network.

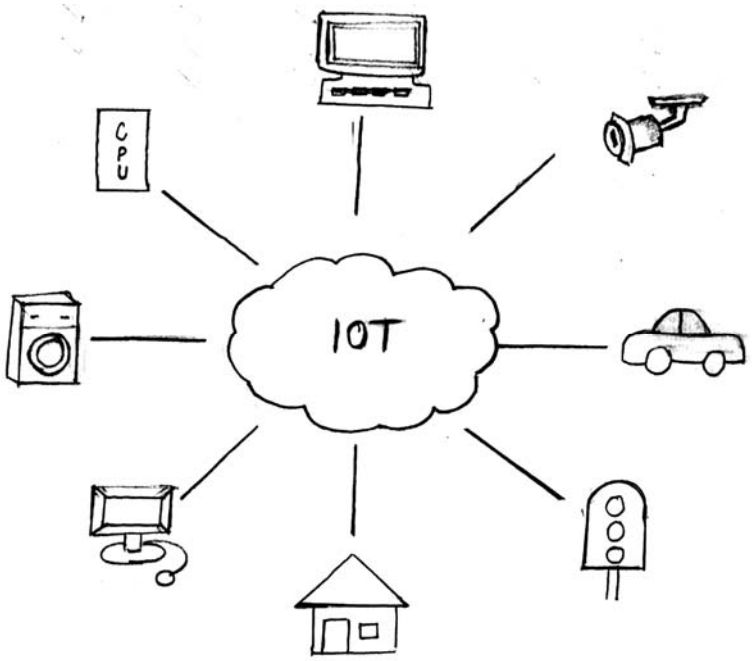


Fig. 1 : IoT

All the cases we saw used the Internet to send, receive, or communicate information. And in each case, the gadget that was connected to the Internet wasn't a computer, tablet, or mobile phone but an object, a Thing. These Things are designed for a purpose: the umbrella has a retractable canopy and a handle to hold it. A bus display has to be readable to public transport users, including the elderly and partially sighted and be able to survive poor weather conditions and the risk of vandalism. The sports bracelet is easy to wear while running, has a display that is large enough and bright enough to read even when you are moving, and will survive heat, cold, sweat, and rain.

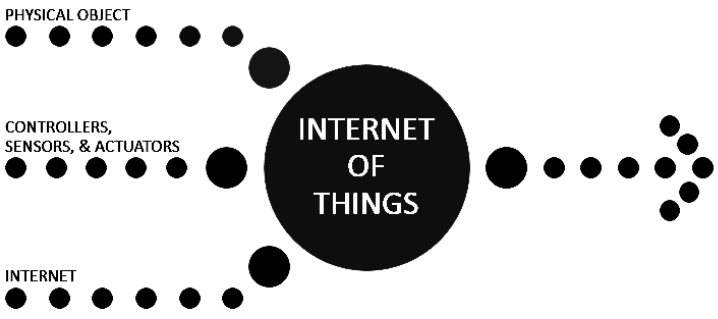


Fig.: IoT Equation.

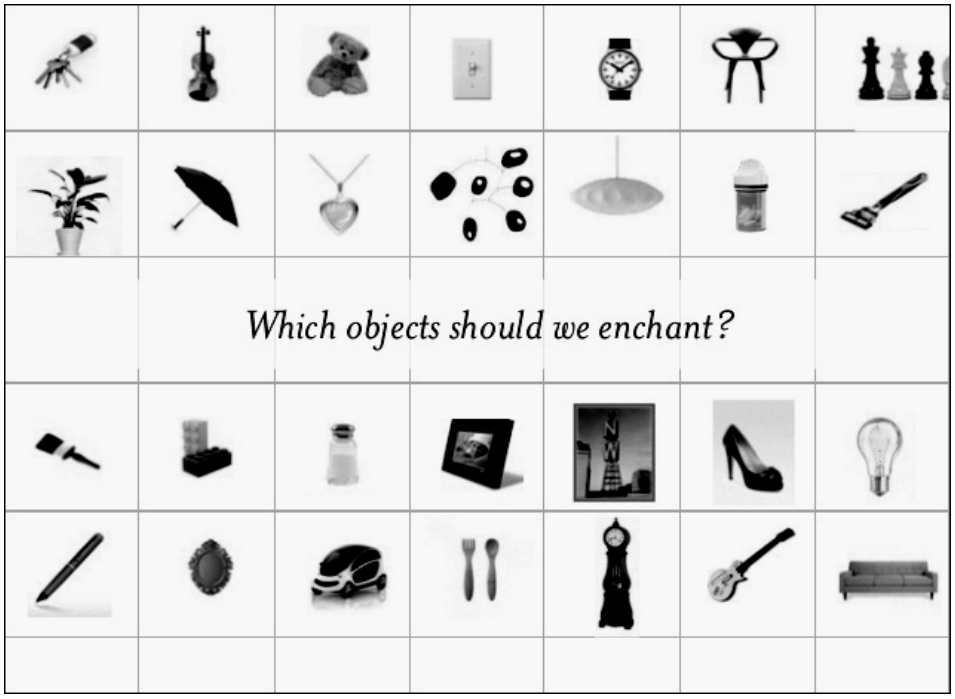
A simple equation for the Internet of Things is shown in above figure in which a physical object follows the function of the thing and being connected to the internet, it can be controlled and monitored through internet.

The sensor within or attached to the objects are connected to the internet via wired or wireless internet connections. Various local area connections for these sensors include ZigBee, Bluetooth, RFID, Wi-Fi, etc. These sensors also use wide area networks including GSM, GPRS, 3G, 4G, etc.

It refers to the network of physical objects that are embedded with electronics, sensors, actuators, software and communication connectivity, in which the whole arrangement enables the exchanging of data, remote sensing and control of various objects or things.

Q.1(b) (i) Why have we yet to be enchanted by the internet of things? [5]
(ii) Who is making the Internet of Things?

Ans.: (i)



Some believe the future will look like more of the same—more smartphones, tablets, screens embedded in every conceivable surface. David Rose has a different vision: technology that atomizes, combining itself with the objects that make up the very fabric of daily living. Such technology will be woven into the background of our environment, enhancing human relationships and channelling desires for omniscience, long life, and creative expression. The enchanted objects of fairy tales and science fiction will enter real life.

Q.1(c) Explain the term Calm and Ambient Technology. [5]

Ans.: The IoT has its roots in the work done by Mark Weiser at Xerox PARC. The work he did was not assumed that there would be network connectivity but focused more on how the system would look when the objects would be integrated this term is said to be ubiquitous computing.

Ambient term has nothing related with foreground but is present in background. As per Mark Weiser, the term calm technology means systems which are not paid attention yet are ready to provide utility or useful information when we decide to give them some attention.

Major issues for designing such systems are configuration, how to provide power to all these items, how they talk to each other, and how they communicate with us.

Configuration and user interaction, are difficult problems to solve with just technical solutions. This is where good design and usability comes into picture.

Example : **Apple iPod**
Though wasn't the first portable MP3 player, its overall interface made it easy to use.

Fig.: Apple

It is never better to design a connected device in isolation, but always design it in a way how the system will work in connection. As per Saarinen's "Always design a thing by considering it in its next larger context".

It becomes very complicated when system start interacting with each other.

A great example is Live Wire, one of the first Internet of Things devices. Developed by Natalie Jeremijenko under the guidance of Mark Weiser, Live Wire which is known as Dangling String. It is a simple device: an electric motor connected to an eight-foot long piece of plastic string. The power for the motor is provided by the data transmissions on the Ethernet network to which it is connected, so it twitches whenever a packet of information is sent across the network. Under normal, light network load, the string twitches occasionally. If the network is overloaded, the string whirls madly, accompanied by a distinctive noise from the motor's activity. Conversely, if no network activity is occurring, an unusual stillness comes over the string. Both extremes of activity therefore alert the nearby human.

Fig.: Live Wire

Talking about the displays, split-flap displays have been phased out in and are replaced by dot-matrix LED displays. The newer displays are much easier to update with new destinations.

Fig.: Split-Flap

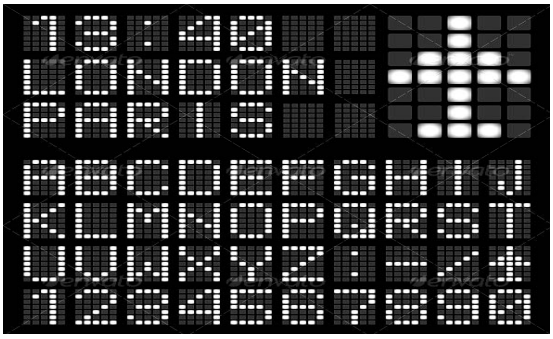


Fig.: Dot Matrix LED Display

They also have capabilities such as horizontally scrolling messages which were impossible to add with the split-flap technology. The only problem is display updates, passengers waiting in a station terminal must stare endlessly up at the display waiting for their train to be announced.

There has been some interesting experimentation in the use of screens around what has been called glanceable displays.

Example : AirTunes WiFi speakers, which anyone play music through. Users will often wonder exactly what a particular track was but had no way of finding out who was in charge of the music at that moment and what was playing right now.

Fig.: WiFi Speaker

To solve that problem it was suggested to use the display along with the system.

Q.1(d) (i) Explain the reason why loosely coupling is encouraged? [5]
(ii) Explain the term Affordances with example.

Ans.: (i) One of the most important ideas in the world of software engineering is the concept of loose coupling. In a loosely coupled design, components are independent, and changes in one will not affect the operation of others. This approach offers optimal flexibility and reusability when components are added, replaced, or modified. Conversely, a tightly coupled design means that components tend to be interdependent. Changes in a single component can have a system wide impact, with unanticipated and undesirable effects.

Loose Coupling is when two objects can interact with each other but have very limited knowledge about what the other object can do.

While this concept is relatively simple to understand, it's difficult to implement. Sometimes you may be under the gun to get a project out the door (hey, you gotta ship it, right?).

Some advantages of making your code loosely coupled include :

- **Better Testability :** Because your code isn't dependent on other objects and they are just passed in, this makes your unit tests easier to write.
- **Easy-to-understand code :** When your code is decoupled from other objects, they are usually passed in or dependency injected into the code. Your code provides a self-documenting service to your users.
- **Swappable components :** While most developers don't think about a plug-in architecture, this is ultimately what developers strive to achieve. If you want to swap out the Oracle database component with a SQL Server component, if developed properly, it can be done easily.
- **Scalability :** As your system grows, you can provide a diverse number of components to plug into your application, making it more scalable. There is a term I use when a system can't scale properly. It's called "painting yourself into a corner" where you need to re-evaluate your design.
- **Isolated Code/Features :** Adding new features to a system means that you can write additional code without breaking existing functionality and feel safe writing it.

(ii) Affordances are clues about how an object should be used.

Fig.: Automated

For example, A coffee mug which is used for drinking coffee can also use for holding writing utensils or even as a pot for growing small plants.

For example, A light dimmer switch which has knob to give fine-grained control over the brightness. But when it is switched to home-automation, the issue is of synchronizing both the knob and the light level, as the brightness can be managed remotely.

So the user cannot make rapid large changes and smaller, fine grained adjustments. The best way is whenever the lights are adjusted remotely let even the knob move automatically.

Q.1(e) Explain OSI Model with diagram. **[5]**

Ans.: OSI Model :

The Open Systems Interconnection (OSI) model defines a networking framework to implement protocols in layers, with control passed from one layer to the next. It is primarily used today as a teaching tool. It conceptually divides computer network architecture into 7 layers.

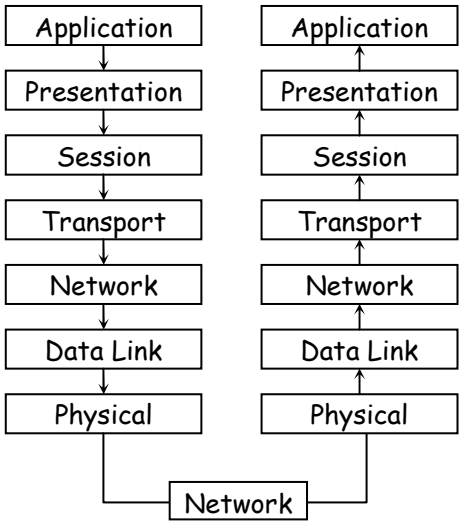


Fig.: OSI Model.

1. **Application Layer :** The Application layer supplies network services to end-user applications. Network services are typically protocols that work with user's data. For example, in a Web browser application, the Application layer protocol HTTP packages the data needed to send and receive Web page content.
2. **Presentation Layer :** It handles syntax processing of message data such as format conversions and encryption / decryption needed to support the Application layer above it.
3. **Session Layer :** The Session Layer manages the sequence and flow of events that initiate and tear down network connections.
4. **Transport Layer :** It performs process to process communication for which it uses 16-bits port address. It supports a range of optional capabilities including error recovery, flow control, and support for re-transmission.
5. **Networks Layer :** It performs host to host communication for which it uses 32-bits IP address. It also performs fragmentation.
6. **Data Link Layer :** When obtaining data from the Physical layer, the Data Link layer checks for physical transmission errors and packages bits into data "frames". The Data Link layer also manages physical addressing schemes such as MAC addresses for Ethernet networks, controlling access of any various network devices to the physical medium.
7. **Physical Layer :** At Layer 1, the Physical layer of the OSI model is responsible for ultimate transmission of digital data bits from the Physical layer of the sending (source) device over network communications media to the Physical layer of the receiving (destination) device.

Q.1(f) (i) What is HTTPS? Also explain importance of encrypted HTTP. [5]
(ii) Discuss other application layer protocols.

Ans.: (i) As seen, the request and response are created in a simple text format i.e. in plaintext. In case of Man in the Middle attack, someone eavesdropped your connection that person can easily read the conversation. Thus compromising three goals if security i.e. Integrity, Confidentiality, Availability.

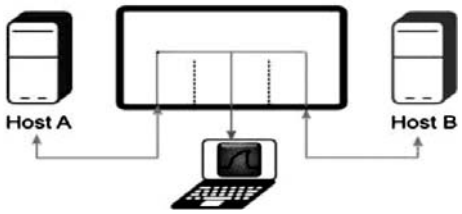


Fig.: Man in the Middle Attack.

The solution to this is send the request and response in an encrypted form, for this use a protocol service HTTPS.

The HTTPS protocol is actually just a mix-up of plain old HTTP over the Secure Socket Layer (SSL) protocol. An HTTPS server listens to a different port (usually 443) and on connection sets up a secure, encrypted connection with the client). When that's established, both sides just speak HTTP to each other as before!

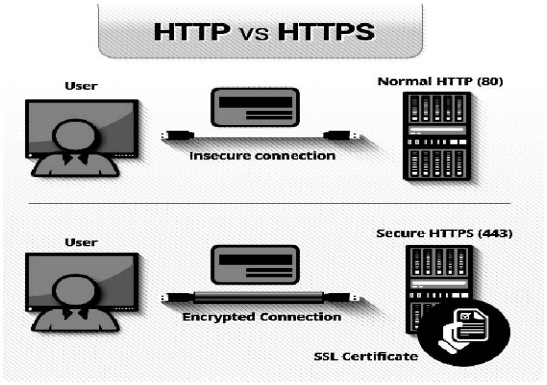


Fig.: HTTP VS HTTPs.

(ii) FTP (File Transfer Protocol) :

- It used to exchange files on the internet, to enable the data transfer FTP uses TCP/IP, FTP is most commonly used to upload and download files from the internet.
- It uses a reserved port no 21.

DHCP :

- Dynamic Host Configuration Protocol (DHCP) is used assigning IP addresses to computers in a network, the IP addresses are assigned dynamically. IP address may change even when the computer is in network this means that DHCP leases out the IP address to the computer for some time. Main advantage of DHCP is that the software can be used to manage IP address rather than the administrator.

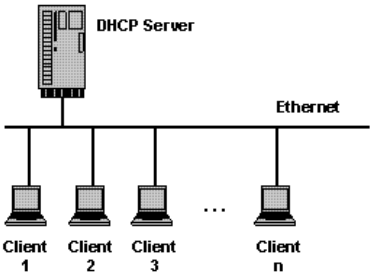


Fig.: DHCP Client server.

Telnet :

- It is an application layer protocol, which can be used on the internet or LAN(Local Area Network).
- It provides a bi-directional interactive text oriented communication service by using virtual terminal connection.
- Telnet is basically a client server protocol, which is based on a reliable connection-oriented transport.
- It uses a port number 23, to establish the connection with TCP (Transmission Control Protocol).

SMTP (Simple Mail Transport Protocol) :

- It is an internet standard for e-mail Transmission. SMTP connections are secured with SSL (Secure Socket Layer). In SMTP, the messages are stored and then forwarded to the destination. SMTP uses a port number 25 of TCP.

Q.2 Attempt the following (any THREE) [15]

Q.2(a) (i) What is a Prototype? Explain the benefits of prototyping. [5]

(ii) What is Sketching?

(iii) State difference between Sketching vs. Prototyping.

(iv) Explain with an example how cost affects the ease of Prototyping.

Ans.: (i) Prototype

A Prototype is said to be the early stage or a preliminary model of a product which explains its core functionalities. The process of creating a preliminary model of a product is called as Prototyping.

Benefits of Prototyping :

1. It allows you to use the product physically and check whether it functions properly.
2. It helps to collaborate between the developers and designers to work on the same objectives as well as it serves a vital role when they pitch idea to the investors.
3. It helps saving the costs at the time of actual production.

(ii) Sketching is the first and the most important step in the process of Prototyping. Sketch gives a visualization to the idea. It involves noting down the ideas and exploring the problem space. It extends beyond the strict definitions to form a sketch. Sketching is the result of iterating through different approaches to check whether the idea works out as per expectation or not. Sketching offers a visual model for offering cognitive scaffolding to modify the perception.

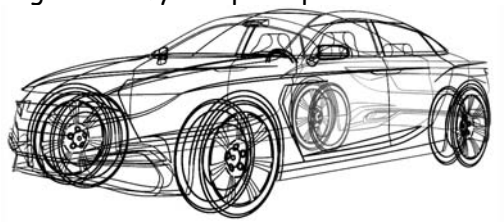


Fig.: Sketching process.

(iii) Difference between Sketching vs. Prototyping

	Sketching	Prototyping
1.	Expressive	Persuasive
2.	Suggest	Describe
3.	Exploring	Reforming
4.	Recommend	Finalize
5.	Experimental	Certain

(iv) Though familiarity provides ease for prototyping, but there is one more factor which needs to be taken into consideration, i.e., relation between cost of the platform and the efforts required to develop that platform. In other words, relation between the prototyping cost and production cost is one of the important factors in prototyping. It is not mandatory, but it would be beneficial if you use the same platform for both prototyping and the final production. This would not hamper the cost much at the time final production.

Q.2(b) Discuss Open Source Versus Closed Source. **[5]**

Ans.: Open Source :

Open source allows computer source code to be shared and modified free of charge by other users or organisations under a licensing agreement.

In other words, it is a piece of software which can evolve and be iterated upon by other developers anywhere in the world. In case of Open Source, the software is evolved many times and during this evolution, it takes many twists and turns and becomes entirely different than its original version.
For example, Android

Closed Source :

On the other hand, closed source is those software that are issued to authorized users or organisations with customized modifications and copying limitations. In other words, the software cannot be used or modified by anyone and anywhere. For example, Apple

Key Points	Open Source	Closed Source
Cost	Free	Cost vary with respect to complexity of software
Service	Poor	Good
Innovation	Innovation is more as the code could be changed	Innovation is less as the R&D is discussed only on discussion forums.
Usability	Less as it is not reviewed by experts	High
Security	Less as the software is not always developed in a controlled environment	High

Q.2(c) What are the ways the electronics devices are placed? **[5]**

Ans.: The main part for prototyping is usually a breadboard which allows to fit components and wires to build up circuits without requiring any soldering. Further it can be switched to protoboard, Stripboard and PCB.

Circuit Journey :

1. **Using Breadboard :** Breadboards are one of the most fundamental pieces when learning how to build circuits.

   While designing the circuits the first step is placing the electronic devices properly on breadboard. This is very easy and simple to configure and reconfigure as per the requirements.

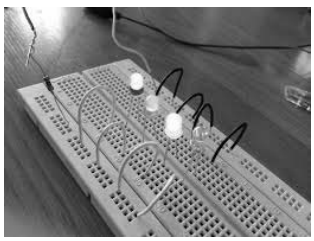


Fig.: Breadboard

2. **Using Strip Board :** A stripboard is a circuit board with holes and printed strips of metal. These boards are a good way of connecting simple to medium complicated circuits. They give you a lot of control of your connections and it's relatively easy to fix errors.

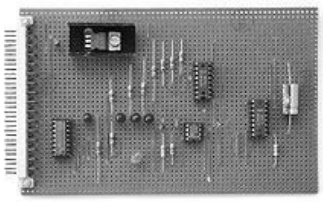


Fig.:

Once the circuit is finalized it is always better to solder all the components on the stripboard. This is useful only if only one copy is to be maintained.

3. **Using Printed Circuit Board :** A printed circuit board (PCB) is an electronic circuit used in devices to provide mechanical support and a pathway to its electronic components.

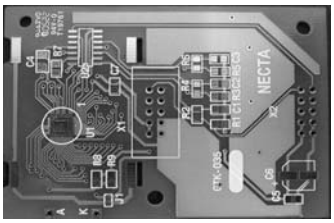


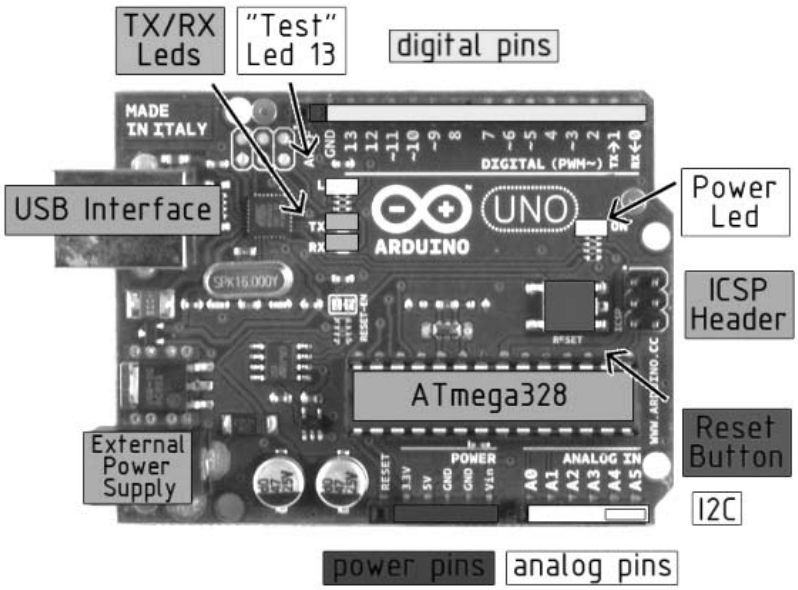
Fig.: PCB Layout

It is the traditional name for the bare board of which you supply us with the layout data and which you use to mount your components.

To have more than one copy of the circuit design the circuit with a PCB as it is simple develop the circuit because the position of each component will be labelled, there will be holes only where the components can be integrated.

Q.2(d) Explain the Different components involved in Arduino. [5]

Ans.:



Power USB :

Arduino board can be powered by using the USB cable from your computer. All you need to do is connect the USB cable to the USB connection.

Power (Barrel Jack) :

Arduino boards can be powered directly from the AC mains power supply by connecting it to the Barrel Jack.

Voltage Regulator :

The function of the voltage regulator is to control the voltage given to the Arduino board and stabilize the DC voltages used by the processor and other elements.

Crystal Oscillator :

The crystal oscillator helps Arduino in dealing with time issues.

Arduino Reset :

You can reset your Arduino board, i.e., start your program from the beginning. You can reset the UNO board in two ways. First, by using the reset button on the board. Second, you can connect an external reset button to the Arduino pin labelled RESET.

Pins (3.3, 5, GND, Vin) :

- Most of the components used with Arduino board works fine with 3.3 volt and 5 volt.
- GND (Ground) – There are several GND pins on the Arduino, any of which can be used to ground your circuit.
- Vin – This pin also can be used to power the Arduino board from an external power source, like AC mains power supply.

Analog pins :

The Arduino UNO board has five analog input pins A0 through A5. These pins can read the signal from an analog sensor like the humidity sensor or temperature sensor and convert it into a digital value that can be read by the microprocessor.

Main microcontroller :

Each Arduino board has its own microcontroller. It is the brain of your board.

ICSP pin :

Mostly, ICSP is a tiny programming header, it is often referred to as an SPI (Serial Peripheral Interface)

Power LED indicator :

This LED should light up when you plug your Arduino into a power source to indicate that your board is powered up correctly.

TX and RX LEDs :

On your board, you will find two labels: TX (transmit) and RX (receive). They appear in two places on the Arduino UNO board. First, at the digital pins 0 and 1, to indicate the pins responsible for serial communication. Second, the TX and RX led. The TX led flashes with different speed while sending the serial data. The speed of flashing depends on the baud rate used by the board. RX flashes during the receiving process.

Digital I/O :

The Arduino UNO board has digital I/O pins, these pins can be configured to work as input digital pins to read logic values.

AREF :

AREF stands for Analog Reference. It is sometimes, used to set an external reference voltage (between 0 and 5 Volts) as the upper limit for the analog input pins.

Q.2(e) State difference between Arduino and Raspberry Pi. [5]

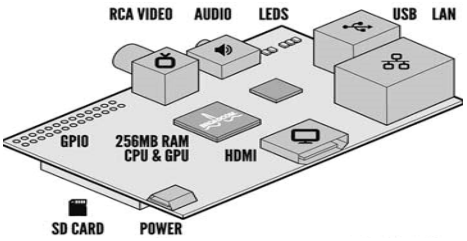
Ans.:

	Arduino Uno	**Raspberry Pi Model B**
Price	$30	$36
Size	7.6 × 1.9 × 6.4 cm	8.6 cm × 5.4 cm × 1.7 cm
Memory	0.002 MB	512 MB
Clock Speed	16 MHz	700 MHz
On Board Network	None	10/100 Wired Ethernet RJ45
Multitasking	No	Yes
Input Voltage	7 to 12 V	5 V
Flash	32 KB	SD Card (2 to 16G)
USB	One, Input only	Two, Peripherals OK
Operation System	None	Linux distributions
Integrated Development Environment	Arduino	Scratch, IDLE, anything with Linux support

Q.2(f) Explain the block diagram of Raspberry pi. [5]

Ans.: Here are the various components on the Raspberry Pi board :

- **ARM CPU/GPU :** The CPU performs all basic computations and the GPU performs graphics related functions.
- **GPIO :** These are exposed general-purpose input/output connection points that will allow the real hardware hobbyists the opportunity to tinker.



- **RCA :** Used for connecting analog devices.
- **Audio out :** It is 3.5mm audio output jack.
- **LEDs :** Used for giving some notification.
- **USB :** Used for connecting some peripherals or even cascading the USB ports.
- **HDMI :** Used for connecting HD devices.
- **Power :** Used for power supply.
- **SD card slot :** It has OS in it used while booting.
- **Ethernet :** Used for wired LAN.

Q.3 Attempt the following (any THREE) [15]

Q.3(a) Discuss different non digital methods for designing. [5]

Ans.: Let's look at some of the more common non digital methods for designing :

- **Modelling clay :** The most well-known brands are Play-Doh and Plasticine, like Play-Doh, have a tendency to dry out and crack if left exposed to the air. Plasticine doesn't suffer from this problem, but as it remains malleable, it isn't ideal for prototypes which are going to be handled. Modelling clay is best used for short-term explorations.

Fig.: Designing a car using a Clay.

- **Epoxy putty :** You might have encountered this product as the brand Milliput; it is similar to modelling clay although usually available in fewer colours. You could mould it to the desired shape, and in about an hour, it sets solid.

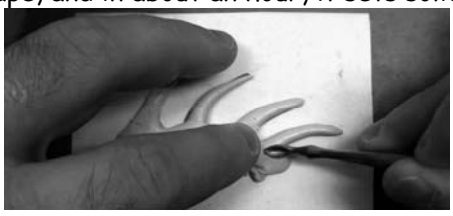


Fig.: Epoxy putty Design.

- **Sugru:** Sugru is a mouldable silicone rubber. It is good at sticking to most other substances and gives a soft-touch grippy surface, which makes it a great addition to the designer's toolkit.

Fig.: Sugru Design.

- **Toy construction sets :** You can use LEGO sets.
- **Cardboard :** Cardboard is cheap and easy to shape with a craft knife or scissors, and available in all manner of colours and thicknesses.

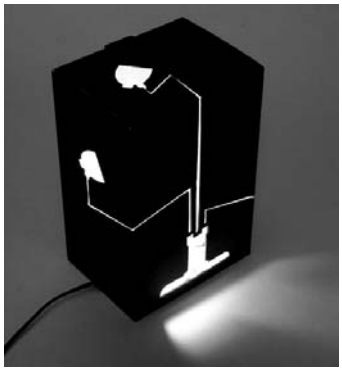


Fig.: Design of cardboard for lamp.

- **Foamcore or foamboard**: This sheet material is made up of a layer of foam sandwiched by two sheets of card. It's readily available at art supplies shops and comes in 3 mm or 5 mm thicknesses in a range of sizes.

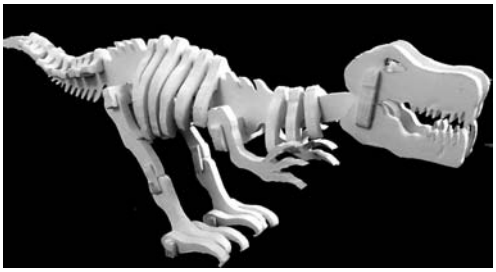


Fig.: Foamcore Design.

- **Extruded polystyrene :** This product is similar to the expanded polystyrene that is used for packaging but is a much denser foam that is better suited to modelling purposes. It is often referred to as "blue foam", although it's the density rather than the colour which is important.

Fig.: Extruded polystyrene.

The combination of Moore's Law driving down the cost of computing and the expiration of the patents from the early developments in the 1980s has brought such technology within the reach of the economical and small business.

Q.3(b) (i) What is 3D printing? **[5]**
(ii) How 3D printer works?

Ans.: (i) 3D printing

It is becoming one of the most popular in rapid prototyping.

Additive manufacturing also known as 3D printing is used because it starts with nothing and keep adding material to develop a final model. Unlike in laser cutting and CNC milling, where you start with more material and cut away the parts you don't need.

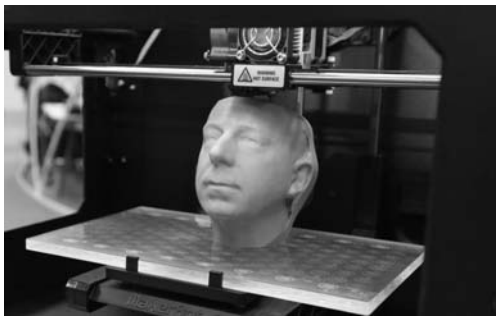


Fig.: 3D Printer Technology.

The software of the 3D printer slices the computer model into many layers, each a fraction of a millimeter thick, and the physical version is built up layer by layer.

(ii) 3D printer works

There are 3 main steps in 3D printing :

- The first step is the preparation just before printing, when you design a 3D file of the object you want to print. This 3D file can be created using CAD software, with a 3D scanner or simply downloaded from an online marketplace. Once you have checked that your 3D file is ready to be printed, you can proceed to the second step.
- The second step is the actual printing process. First, you need to choose which material will best achieve the specific properties required for your object. The variety of materials used in 3D printing is very broad. It includes plastics, ceramics, resins, metals, sand, textiles, biomaterials, glass, food and even lunar dust! Most of these materials also allow for plenty of finishing options that enable you to achieve the precise design result you had in mind, and some others, like glass for example, are still being developed as 3D printing material and are not easily accessible yet.
- The third step is the finishing process. This step requires specific skills and materials. When the object is first printed, often it cannot be directly used or delivered until it has been sanded, lacquered or painted to complete it as intended.

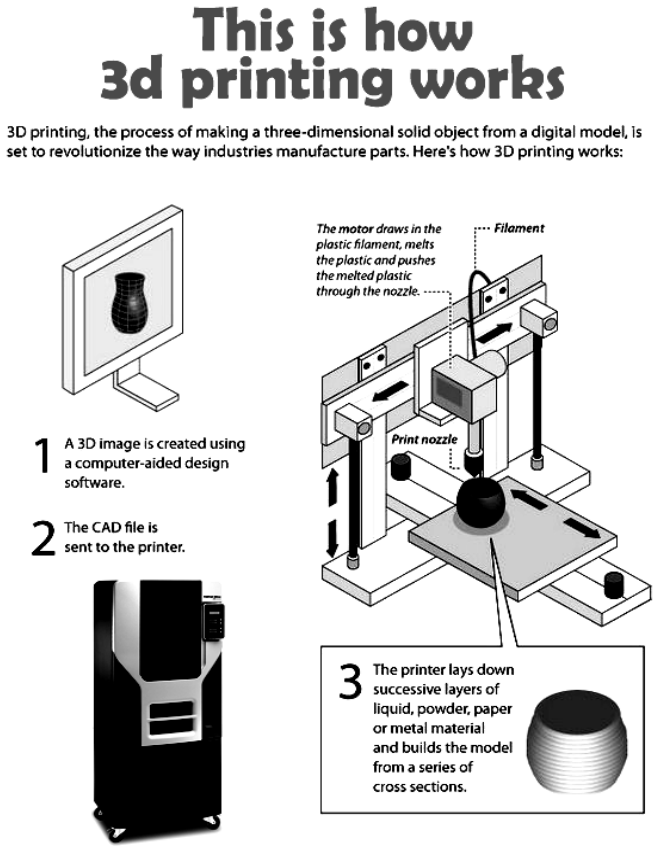


Fig.: How 3D printer works representation.

Q.3(c) Explain different types 3D printing technologies. [5]

Ans.:

- **Fused Filament Fabrication (FFF) :** Also known as fused deposition modeling (FDM, is a relatively new method of rapid prototyping) which works by laying down consecutive layers of material at high temperatures, allowing the adjacent layers to cool and bond together before the next layer is deposited.

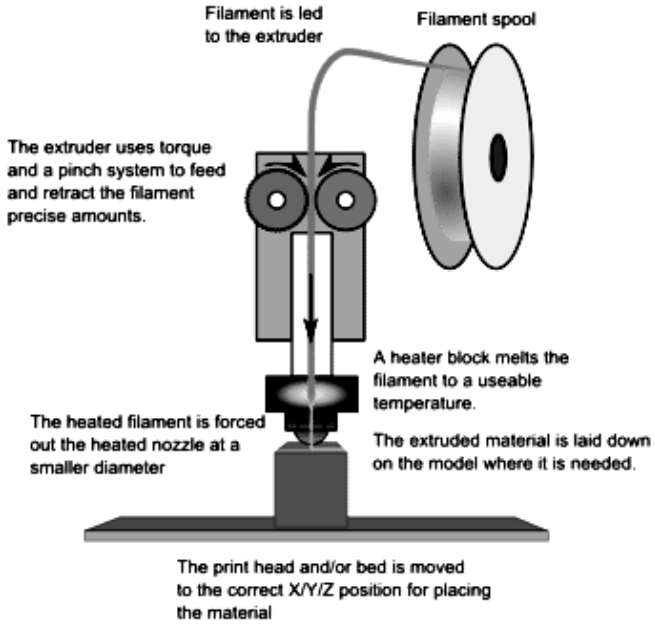


Fig.: 3D printing.

3D models are transformed into g-code, essentially a set of instructions which positions the motors precisely and generates the required volume extrusions to create the part. For most simple objects, the FFF method only uses the amount of material required for the part, as opposed to a CNC machine which requires significant amounts of scrap material. One exception to this case is when overhangs are introduced into the part features.

- **Laser Sintering :** The Selective Laser Sintering process mainly describes the method through which miniature particles of plastic, glass or ceramics are exposed to heat by high-power laser; in order to fuse them together forming a 3-Dimensional solid object. In the most basic sense, this is exactly what happens in the Selective Laser Sintering process.

  The process often starts by creating a CAD file. The CAD file is what will have all the details related to the design of the object which is to be created.

  Once the design is complete, the CAD file has to be converted to STL format for easy comprehension of the design by an SLS machine. At this stage, the printing process can begin.

  Bear in mind that all the 3D printing materials to be used in the SLS process have to be powdered. Before the printing starts, the powdered materials must be dispersed above the build platform in a thin layer. The build platform is always found inside the SLS machine.

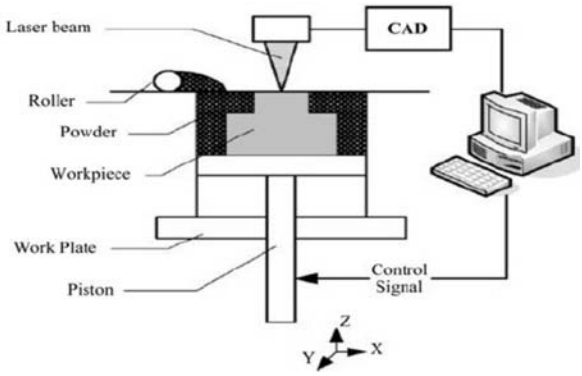


Fig.: Working of Laser sintering

The next step will now be to direct a laser down to the platform. The laser normally is controlled by a computer and therefore through the computer the designer can easily determine what will be fabricated using the laser. When the laser is directed to the platform, it begins tracing cross-sections of the designed digital object onto the powdered material.

The laser's main purpose is to heat the powder just below its melting point fusing the tiny particles together forming a solid object. Immediately the first layer is created, the platform of the Selective Laser Sintering machine drops by about 0.1mm to expose a new layer of the powdered material for another cross-section of the object to be traced and fused together by the laser.

This process repeats itself over and over again until the entire object has been fabricated.

- **Powder bed :** Like laser sintering, the powder-bed printers start with a powder form, but rather than fusing it together with a laser, the binder is more like a glue which is dispensed by a print head similar to one in an inkjet printer. After the printing process, we need post processing where they are sprayed with a hardening solution.

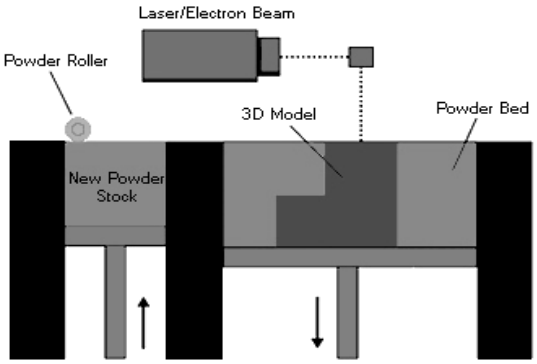


Fig.: Working of Powder bed.

- **Laminated object manufacturing (LOM) :** This is another method which can produce full-colour prints. LOM uses traditional paper printing as part of the process. Because it builds up the model by laminating many individual sheets of paper together, it can print whatever colours are required onto each layer before cutting them to shape and gluing them into place.

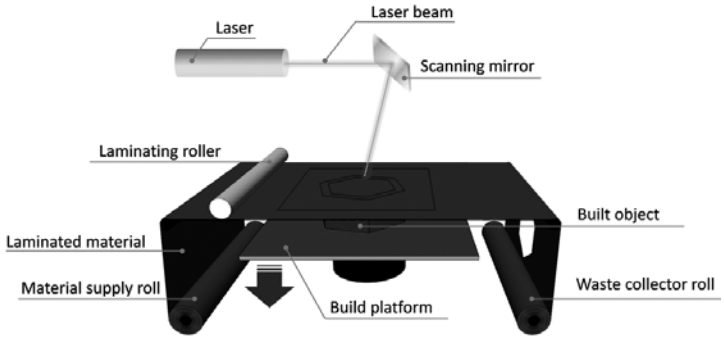


Fig.: Laminated object manufacturing (LOM)

Stereolithography and digital light processing: Stereolithography is possibly the oldest 3D printing technique and has a lot in common with digital light processing, which is enjoying a huge surge in popularity and experimentation at the time of this writing. Both approaches build their models from a vat of liquid polymer resin which is cured by exposure to ultraviolet light.

Q.3(d) Explain the concept of CNC milling. **[5]**

Ans.; It is very similar to 3D printing but is a subtractive manufacturing process rather than additive.

In CNC, computer controls the movement of the milling head, here rather than building up the model layer by layer from nothing, it starts with a block of material larger than the finished piece and cuts away the parts which are not needed.

CNC is simple, it works with a much greater range of materials than 3D printers can. Example, steel, wax, wood, plastic, aluminium, and even mild steel.

Most commonly used CNC machine application is design of PCB.

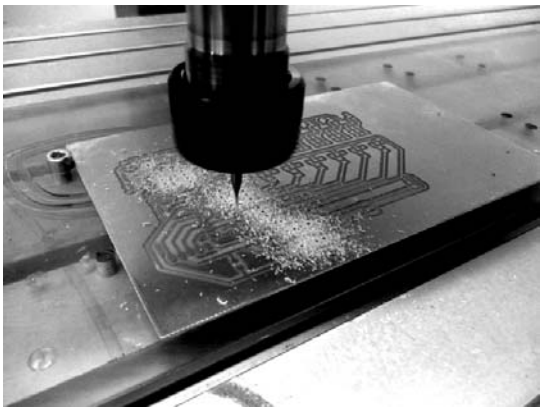


Fig.: CNC printer.

The main component of CNC is number of axis:

- 2.5 axis : It can move only at any two direction but one at a time.
- 3 axis : It moves in all three direction at the same time.
- 4 axis : This machine adds a rotary axis to the 3-axis mill to allow the piece being milled to be rotated around an extra axis.
- 5 axis : This machine adds a second rotary axis—normally around the Y—which is known as the B axis.
- 6 axis : A third rotary axis—known as the C axis if it rotates around Z—completes the range of movement in this machine.

As with 3D printing, the software you use for CNC milling is split into two types:

- CAD (Computer-Aided Design) software lets you design the model.
- CAM (Computer-Aided Manufacture) software turns that into a suitable toolpath—a list of co-ordinates for the CNC machine.

Q.3(e) (i) Write short note on real time reactions. **[5]**
(ii) Explain, what is comet?

Ans.: (i) Real time reactions

To establish an HTTP request requires several round-trips to the server. There is the TCP "three-step handshake" consisting of a SYN (synchronise) request from the client, a SYN-ACK from the server to "acknowledge" the request, and finally an ACK from the client. Although this process can be near instantaneous, it could also take a noticeable amount of time.

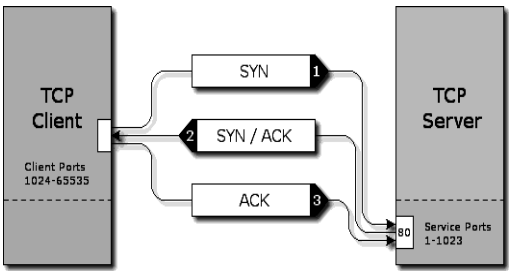


Fig.: 3 Way Handshaking for Connection Establishment.

Some time will be taken to establish the connection. Most powerful boards is able to run the connection in the background and respond to it when it's completed.

For a bare-bones board, the current Ethernet/HTTP shields and libraries tend to block during the connection.

Since the connection is usually made on a "breakout board" with its own processor, there is no reason that the connection couldn't happen in parallel, without blocking the main thread.

If you want to perform an action the instant that something happens on your board, you may have to factor in the connection time. If the server has to perform an action immediately, that "immediately" could be nearly a minute later, depending on the connection time. For example, with the task timer example, you might want to register the exact start time from when the user released the dial, but you would actually register that time plus the time of connection.

We look at two options here: polling and the so-called "Comet" technologies.

Q.3(f) What is repurposing or recycling of components? [5]

Ans.: Until now we saw designing and developing a product from scratch, but you can't start making your own nuts and bolts from some iron ore, sometimes you should consider reusing more complex mechanisms or components.

Main reason to reuse mechanisms or components would be to reducing the overall price for building up the product, buying those items can often be cheaper than making them in-house.

We've drifted away from the idea of prototyping as a way to explore and develop your idea, but that is probably the most common case where reuse and repurposing of existing items.

Fig.: Reusability Representation.

The prototyping phase is all about rapid iteration through ideas, anything that helps speed up the construction and gets you to where you can test your theories is useful and hence going for reusability is the best solution. This will not only save time but also the overall cost of implementation.

Q.4 Attempt the following (any THREE) [15]

Q.4(a) What is debugging? Explain some tools for debugging. [5]

Ans.: It is one of the most important parts of any software development lifecycle, the most irritating part of writing a code is knowing your code has an error after debugging.

With embedded environment it is far more frustrating, as it becomes difficult to understand whether the problem is with software or hardware. Modern IDE's have a good support for understanding where and in which part there is a problem.

It allows to set breakpoints, perform memory management, and interpret the code line by line. The debugging environment for embedded systems is usually more primitive.

Following are some examples of debugging tools :

1. **Simulators :** Software instruction simulators provide simulated program execution with read and write access to the internal processor registers.
2. **Burn-and-learn method :** A chip is burned with a device programmer; and after plugging it into the hardware, the system crashes. At this point, an attempt is made to figure out what went wrong; the source code is changed, the executable is rebuilt, and another chip is burned. This cycle is repeated until the chip works properly.

Q.4(b) (i) How to make most of the RAM? Explain. [5]
(ii) Explain the concept of stack and heap in RAM.

Ans.: (i) It is better to move unwanted part to flash memory so as to maximum make RAM memory utilized efficiently.

Ram will be utilized efficiently if a programmer can easily identify how much memory will be required to execute the program, a deterministic approach, but this approach is very difficult.

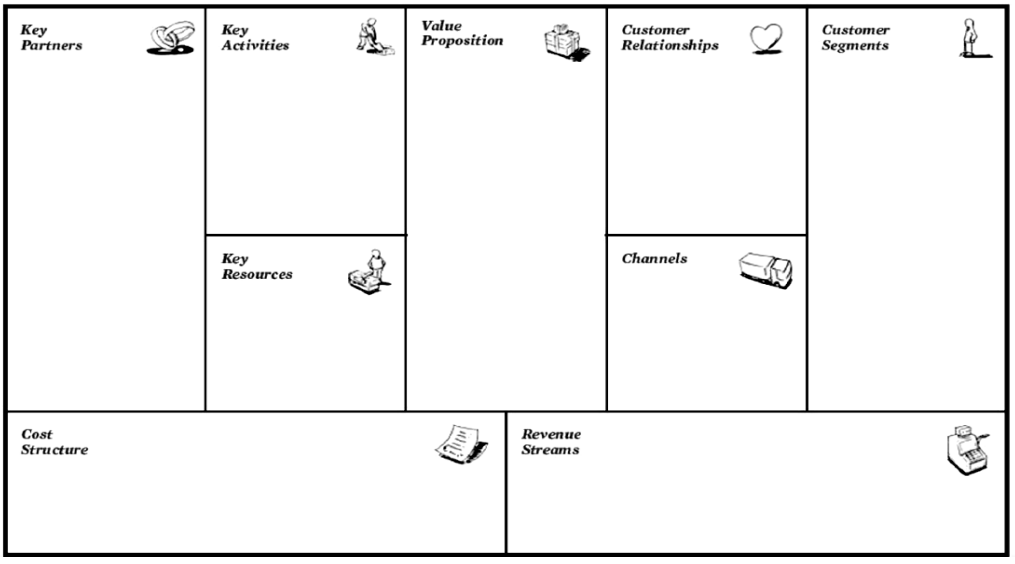
In a deterministic model, don't allocate space for the entire data, keep some reserved space to store the important data and also maintain a buffer of memory. Now don't download the entire data into at once, download it in chunk.

With an upside approach it is possible to handle datasets which are bigger than the entire available memory for the system.

With an upside approach after you discard the chunk you were working on, it's lost. If some data is needed in part of the file, you can keep some space reserved.

Q.4(c) Explain the Business Model Canvas with a neat diagram. [5]

Ans.:



The Business Model looks like a nine-point checklist. Each point of the checklist is described below :

1. **Revenue Streams :** This point describes how the company generates its revenue.
2. **Value Propositions :** It describes about what value the company brings to the customers.
3. **Customer Segment :** It describes about the targeted customers to whom the product needs to be delivered.

4. **Customer Relationship** : It discusses about how the company retains its relationship with its customers. Though it is beneficial from the business point of view but is costly to maintain such communities which connects the company to its customers.
5. **Channels** : It tells about by what means does the company reaches out to its customer.
6. **Key Activities** : It describes about the activities that needs to be carried out in order to make the company successful.
7. **Key Resources** : It describes about how the company gets its resources for fulfilling the customer demands.
8. **Key Partners** : Every new company invest money to do the key activities themselves but at same time for its product to be launched successfully in the market, it requires key partners who can do some of these key activities in a much better manner as they are experienced in that particular activity and that they have their own business model for it.
9. **Cost Structure** : In Cost structure, one has to discuss about what cost does the company incur? i.e., whether the product is cost driven (selling large number of products at cheaper rate) or whether the product is value driven (selling limited number of products but at a higher rate).

Q.4(d) Explain the various Business Models. [5]

Ans.:

1. **Make things, sell things** : It is the simplest business model of Internet of Things. However, there are many small projects that choose option of selling their product in kit form which requires some additional assembly work. As these kind of kit products are aimed for specific customers and not of general people, the administrative burden reduces. Thus, limiting to the sell of specific product also limits the revenue generation.
2. **Subscription** : Now-a-days maximum number of things are available on subscription form. It helps in maintaining the rapidly growing demand of the customers efficiently. As the price in this model is fixed, the customers are known what services they are availing and how does that fit into their budget. Subscription helps in recurring sales, thus, it is easy to determine the revenue generation which in turn helps to maintain the resources and inventories and manage the growth of the business. For example, Netflix, HotStar, etc.
3. **Customisation** : Mass Production helped in development of business and generation revenue. But there are many premium customers who demand for customization of the product they buy. Thus, option for customization may also lead to the rise of new business models. When it comes to achieve both mass production and customisation, it becomes difficult as it is time consuming and more number of resources are utilised in completing the customer demand. Thus, it can be limited by allowing customization in a fixed boundary. For eg. Let us consider a company called makieMe that produces customised dolls. This company has its own website wherein, the customer and customize their doll by changing the wigs, scarves, dresses and make your doll unique. All these changes are done in a fixed boundary.
4. **Be a Key Source** : Not all the business would sell a product with mass production. There would be business who would specialize in manufacturing some of the parts of a device such as PCBs. Such companies would result to be a key source to those companies which require PCBs for making their products.
5. **Provide Infrastructure** : Sensor Networks
   Internet of Things provides many such systems where the system requires sensor data as input. This sensor data must be accurately calibrated and is very expensive to create. Such large but finite data is created by government agencies and organization. These organizations provide infrastructure to the companies that produce such system which requires sensor data.
6. **Take a Percentage** : In case, if the value of the gathered data is more than that of the physical device, then it might happen that you might sell the physical product for free. For example, the energy providing companies follows this strategy with the smart meters.

Q.4(e) Explain Lean startups. [5]

Ans.: Cost and revenue, both are the vital factors of A Business Model. But there comes a time when cost goes on increasing but the income is comparatively less or zero. In such case, a company requires funding which is difficult to get if your company is at its initial stage. There are several ways to get funding as discussed below :

1. **Hobby Projects and Open Source :**
   It may happen that your project is your hobby which would not require any extra cost as it is a free time activity. Then too, to make your project grow rapidly, you can open-source your project and get connected to different communities. With this, along with general public, different collaborators, software experts and investors would get to know about your work. The problem here is, you cannot close source your project, once it is open source. The solution to this problem is that you may fork the project and work on it secretly. Though your project is open source, as project owner/maker, you are likely to get benefits through the relationship with community as many good coders would be testing your code and even fixing the bugs and also many users would give you feedback about your product through social media.
2. **Venture Capital :**
   Every Startup requires funding at some or other point of time. Getting funds from external agencies involves a lot of risk. This funding process goes in 3 rounds, i.e., Friends, family and fools (FFF)round, angel round and venture capital (VC)round.
   (a) Friends, Family and Fools (FFF) Round : It is the most straight forward round. In this round, you try to get funds from your savings, your family members or best friends and even local business pitch into it. This round totally depends on how strong your relationship is with the person you have approached for funding.
   (b) Angels Round : This is the next round for raising funds. The angels here are the entrepreneurs who are willing to invest in the startups. These entrepreneurs invest in such startup because of their similar background and experience in this field. Such investors generally invest in multiple startups as they are at risk since they are funding to those companies who have yet not even proved themselves in the market. They may demand to add their representative to be on the board of your company to examine their investment. In this round, not only the funds are important but also the advices given by the investors matters a lot.
   (c) Venture Capital (VC) Round : Venture capital provides large amount of funds only if angels have already invested in your company and have gained profit out of it. Unlike angel, VCs would also demand to be board member and even a significant amount of equity.
3. **Government Funding :**
   Government generally aims at funding different projects so as to have financial and technological development of the country. The money provided depends on different things as described below :
   (a) Outputs : It is a kind of metric which determines whether your company is giving the expected outputs/deliverables and whether the funds provided are managed properly or not. If the funds are provided in parts then you may be required to cross a milestone for acquiring the next part of the fund. Such funds are dependent on your progress. You may also be required to submit reports about the current status of your project at regular intervals. It may happen that you might not get all the fund you require from the investor. In that case you need to raise the remaining amount of funds by yourself. You would thus need to understand the whole process and manage the cash flow and expenditure.
   (b) Spending Constraints : Spending constraints will depending on the project site and company one will decide upon the spending.
   For example : Business consultancy or web development, etc. one can also have multiple sources of funding.

4. **Crowdfunding :**
   As the name suggests, it is getting funds from many people at time as done by Walter Gervaise to build a bridge over Exe river in 1238. He made a public subscription (www.exeter.gov.uk/index.aspx?articleid=2879) by approaching to his friends, well wishers and other rich citizens. Also with the long tail Internet, it is very easy today to raise funds by approaching people through social media.
5. **Lean Startups :**
   It is about making big things with being less wasteful. Being less wasteful means spending time and money only when it is necessary – in layman terms being hungry and lean. It was pioneered by Silicon Valley entrepreneurs, Eric Reis.

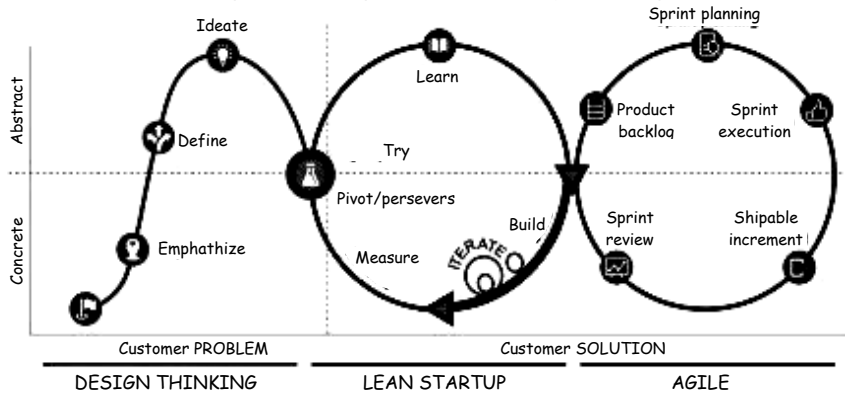
   People generally begin startups with an idea for a product that they think people want. Then they spend months, sometimes years, perfecting that product without ever showing the product, even in a very rudimentary form, to the targeted customers. When they fail to reach broad uptake from customers, it is often because they never spoke to the targeted customers and determined whether or not the product was interesting. When customers ultimately communicate, through their indifference, that they don't care about the idea, the startup fails. In such conditions, lean startup approach helps company to reduce the chaos by providing a tool to constantly test their vision.

Q.4(f) Explain three key principles of lean method. **[5]**

Ans.: The lean method has three key principles :
First, rather than engaging in months of planning and research, entrepreneurs accept that all they have on day one is a series of untested hypotheses—basically, good guesses. So instead of writing an intricate business plan, founders summarize their hypotheses in a framework called a business model canvas. Essentially, this is a diagram of how a company creates value for itself and its customers. (See the exhibit "Sketch Out Your Hypotheses.")

Second, lean start-ups use a "get out of the building" approach called customer development to test their hypotheses. They go out and ask potential users, purchasers, and partners for feedback on all elements of the business model, including product features, pricing, distribution channels, and affordable customer acquisition strategies. The emphasis is on nimbleness and speed: New ventures rapidly assemble minimum viable products and immediately elicit customer feedback. Then, using customers' input to revise their assumptions, they start the cycle over again, testing redesigned offerings and making further small adjustments (iterations) or more substantive ones (pivots) to ideas that aren't working. (See the exhibit "Listen to Customers.")

Combine Design Thinking, Lean Startup and Agile



Third, lean start-ups practice something called agile development, which originated in the software industry. Agile development works hand-in-hand with customer development. Unlike typical yearlong product development cycles that presuppose knowledge of customers' problems and product needs, agile development eliminates wasted time and

resources by developing the product iteratively and incrementally. It's the process by which start-ups create the minimum viable products they test. (See the exhibit "Quick, Responsive Development.")

Q.5 Attempt the following (any THREE) [15]

Q.5(a) (i) What Are You Producing? [5]

(ii) What are the different parts involved in designing any kit?

Ans.: (i) Unless and until we understand what is to be produced, it becomes difficult to plan for how to scale up the production of the machine.

While producing, the decision is to be made regarding the machine will be given as a final product to the consumer or you will be providing the different items required to build the system which would be then assembled. In the other scenario it is necessary to give the required document of build process (Source code, design document etc.).

So coming to conclusion, while producing you can generally use following three categories:

1. A device that your customers can assemble :

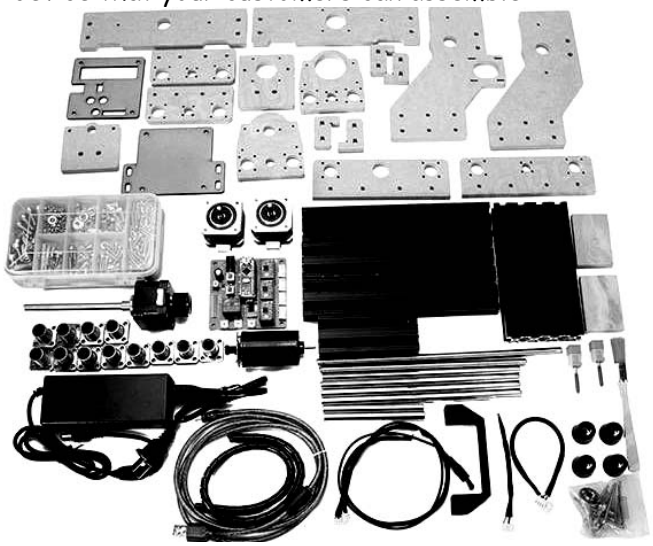


Fig.: Components yet to be assembled.

2. Full-fledged ready device :

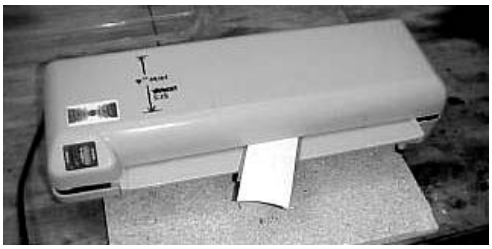
Fig.: Ready assembled Device.

Q.5(b) How the PCB's are manufactured? Explain the steps. [5]

Ans.: Once the PCB design is ready, start the manufacturing process :

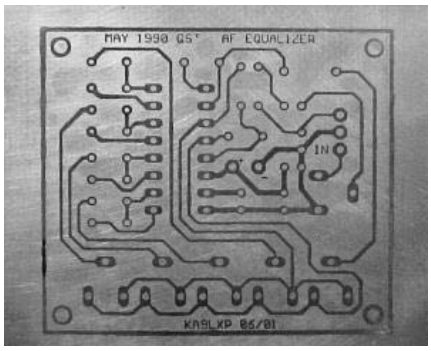
1. **Etching Boards :** This is the first step to get the PCB design onto the board. In this, PCB design is printed on stencil. Now stencil will be then transferred to the board.

   This board "image" is transferred to the bare copper board with a laminating machine, or a hot clothes iron.



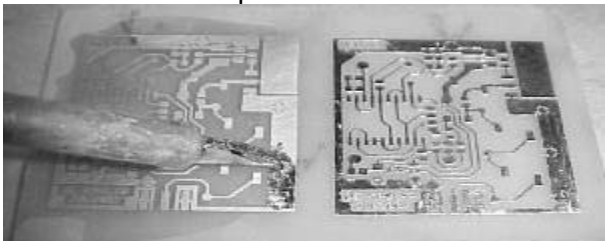
2. After laminating, the board with the paper stuck to it is soaked to remove the paper, leaving only the toner behind .

3. To the right is a photo of the raw copper board with toner remaining, after the transfer paper has been soaked off.



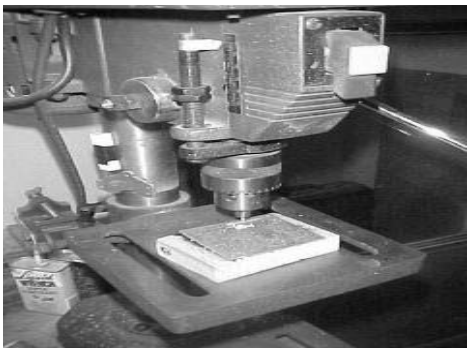
4. Inside the etch tank, two aquarium pumps circulate etchant (Ammonium Persulfate) over the copper boards while two aquarium heaters keep the solution at 110F. This process can take anywhere from 10-30 minutes depending on the freshness of the solution and thickness of the copper.

5. After etching, the toner is removed with solvent and the board is tinned using a soldering iron and a small piece of tinned solderwick. Tinning isn't absolutely necessary but it improves the appearance of the board, and prevents the copper from oxidizing before it's time to solder the parts to the board.

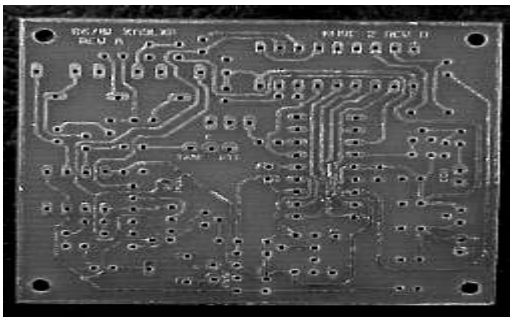


The last step is to drill the holes for any mounting points, this can be done manually or by CNC drill machine.

6. **Milling Boards :** At this point, holes are drilled for any leaded components and mounting holes.



7. Here is the completed board ready to be populated.



For multilayer PCB design use Third Party manufacturers help.

Q.5(c) Why to scale up the software and what are the key points for doing the same? [5]

Ans.: As like the hardware, software needs to be polished before releasing to the real world.

Following factors that require this polish is correctness, maintainability, security, performance, and community.

Deployment :

- The process of moving a software from machine to where it is to be executed is known as deployment of the software.
- In case if embedded system, the software will be burnt on the controller during manufacturing itself.
- The software for an online service will tend to run in a single location and is more vulnerable to malicious inputs that might cause it to stop working. You should also focus on the topic on how the software will be regularly updated.
- If you are using a hosted service such as Heroku, there will be simple, standard ways to do this. If you are running your own dedicated web server or perhaps a virtual machine such as an Amazon EC2 instance, there are many solutions, from shell scripts using scp, rsync, or git to copy code, to deployment frameworks such as Capistrano.

Correctness and Maintainability :

- While dealing with an embedded environment, the software should do what it has meant to be.
- Example, it shouldn't happen the coffee machine makes cappuccinos when the customer asked it for a latte.
- So the software should do its given task efficiently and safely.

- Testing your code before it is deployed is an important step in helping to avoid such a situation.
- The embedded code in the device, however, is particularly important to test. Also you should focus on updating the software efficiently.

Security :

Following are some of the more important guidelines :

1. Servers should be kept up-to-date with the latest security patches, user passwords should never be stored in plain text. If your database were ever compromised, an attacker could easily log in as any user. Use of Hashing is encouraged.
2. Never simply trust user input, be alert with spoofing attack and attacks like SQL injection.
3. Be aware of cross-site request forgery (CSRF) attacks from other malicious or compromised websites.

Performance :

- Whenever you think of scaling up a software see to it that the system performance is not degraded.

User Community :

- Once the software is made available, you should be in state to provide a good customer service. While few large companies can boast Apple's famous commitment to "insanely great customer service", a small, focused startup can often match them for responsiveness and enthusiasm.
- If not then at least keep good online tutorials, forums, blogs and chat room that lets users support each other.

Q.5(d) Write a short note on Environment and other components. [5]

Q.3 Write a short note on Environment and other components.

Ans.: Let us focus on the classic environmental concerns about the production and running of the Thing.

Physical Thing :

- Whenever any product is developed it will include cost of different components which includes the raw materials, the processes used to shape, the packing materials, and the shipping required to ship them from the manufacturing plant to the customer. The cost also includes different plastics used for 3D printing.
- While developing any new product, make sure environmental ethics are followed like waste disposal/recycling.

Human Cost :

- It is also important to consider the human cost, the communications, transport, and logistics required are certainly a part of the technology. The combination of technical expertise and relatively low labour costs, has reduced overall manufacturing cost. The advances in operator-less manufacturing tools such as 3D printers and laser cutters are, however, enabling small-scale industry to return to the First World

Electronics :

- The electronics contained in a Thing have their own environmental cost. Ranging from PCB to advance tools like CNC milling, laser cutter, 3D printer etc. Shipping the raw material from mine to refinery to manufacturer has its own cost too.

Internet Service :

- This is one of the main component of IoT, running the Internet has a cost: the electricity to run the routers and the DNS lookups, plus establishing the

infrastructure—laying cabling across the sea, setting up microwave or satellite links, and so on.

- As well as the cost of transferring the data across the Internet, running your own web server uses power.

Solutions

- The main aim for IoT will be high speed internet with lot of low powered intelligent sensors and that too focusing the implementation with least cost.

Q.5(e) Define the solution and different applications of IoT. [5]

Ans.: Consider some following IoT solutions:

- **Waste Management for Smart Cities :**
  Imagine smart bins placed at street corners. These bins are developed to act as trash compactors with in-built sensors. So as you dump trash into them they will compact them to take in probably 4 times more waste and additionally give out signals to the waste management system when the bins are nearing full to schedule for pickups. Wow I would love to see that on my street.
- **Public Safety for Smart Cities :**
  With lifestyles becoming more mobile and busy, an IoT enabled city will be like the constant pair of eyes that can help individuals, communities and government keep a friendly safety watch on people. Smart video surveillance for public monitoring, hovering drones acting as alarm sensors, rapid action team dispatch technology and a dynamic security system can all work together to make cities safer and traceable. IoT enabled security system could be the eyes and ears that authorities needs in order to be more efficient and agile. With IoT huge clouds of data can be accessed dynamically and tracked with single clicks.
- **Automotive industry :**
  Today, vehicles become advanced with having advanced sensors, actuators. In the automotive industry, smart things can be used to monitor and get a report from air pressure in tires to a different part of vehicle status. RFID technology has already been used increase quality control and improve customer services. The device attached to vehicle part contains information about the part like manufacturing date, serial number, product code and some also have location information according to vehicle movement. Vehicle-to-vehicle (V2V) and Vehicle-to-infrastructure (V2I) communications is an advanced Intelligent Transportation Systems (ITS) which can be used in smart traffic control and vehicle safety service. The IoT devices can be integrated with the Intelligent Transportation Systems for a better result.
- **Pharmaceutical Industry :**
  In IoT, the smart label can be attached to drugs and track them through supply chain management and monitor the status of drugs. Suppose, medicine required cold storage and cold storage has not been provided during the transportation. The smart label on drugs will discard that medicine. This way medicine can keep the supply chain free of fraudsters. The smart label can also help the patient by sending information regarding dosage and expiry date. It can remind patient to take their at appropriate interval and patient compliance can be the monitor.
- **Manufacturing Industry :**
  In the manufacturing industry, the production process can be optimized with the use of smart devices or unique identifiers. It can interact with an intelligent supporting network and monitor the process from production to disposal. Status of production machine can get by tagging item and container. Self-organizing and intelligent manufacturing solutions can be derived with identifiable items in manufacturing industry.
- **Agriculture and Breeding :**
  In agriculture, IoT devices can be used to trace agricultural animal and their movement. In many countries, government issues subsidy based on a number of animal in farms. But,

it's very difficult to determine the exact number. With the help of IoT devices, this type of frauds can be minimized. With the help of IoT, a farmer can deliver crops directly to small as well as the wide region. This will change the supply chain management that is handle by large companies.

Q.5(f) Write a short note on Cautious optimism. [5]

Ans.: Be generally optimistic, but not wildly optimistic. Believe that the future will be mostly good. See opportunities, weigh them up in a positive light, and then take the best route to a good future rather than just selecting the route to the safest future.

A feeling of general confidence regarding a situation and/or its outcome coupled with a readiness for possible difficulties or failure. I've prepared for this exam for weeks, so I have a cautious optimism that it will turn out well. It's best to exercise cautious optimism when starting any new business.

It is true that any technological advance adopted by corporations, governments etc. we always aim that technology can be used socially, responsibly, efficiently to mitigate and manage the given set of operations.

Assuming that Internet of Things can be fun, but being aware of the ethical issues around it, and facing them responsibly, will help make it more sustainable and efficient.

When designing the Internet of Things, or perhaps when designing anything, you have to remember two contrasting points :

- **Everyone is not you.** Though you might not personally care about privacy or flood levels caused by global warming, they may be critical concerns for other people in different situations.
- **You are not special.** If something matters to you, then perhaps it matters to other people too.

This tension underscores the difficulty of trying to figure out overriding concerns about any complex area, such as the Internet of Things!

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