T.Y. B.Sc. (IT) : Sem. V

Internet of Things

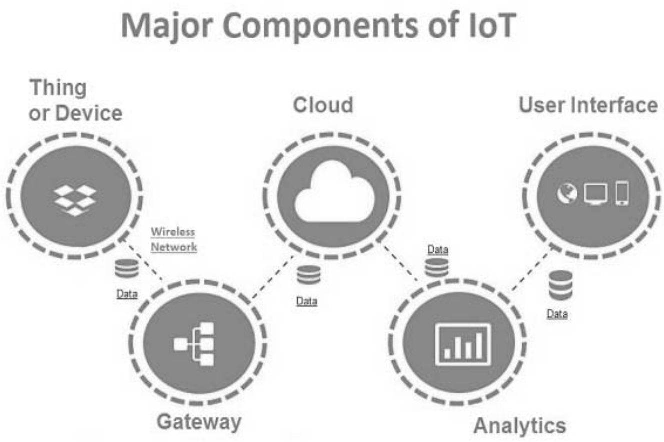
Time : 2½ Hrs.] Prelim Question Paper Solution [Marks : 75

N.B.: (1) **All** questions are **compulsory**.
(2) Make **suitable assumptions** wherever necessary and **state the assumptions** made.
(3) Answers to the **same questions** must be **written together**.
(4) Numbers to the **right** indicate **marks**.
(5) Draw **neat labeled diagrams** wherever **necessary**.
(6) Use of **Non-programmable** calculators is **allowed**.

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

Q.1(a) Explain the components of Internet of Things.

Ans.:



Smart devices and sensors – Device connectivity:

Devices and sensors are the components of the device connectivity layer. These smart sensors are continuously collecting data from the environment and transmit the information to the next layer. Common sensors are:

1. Temperature sensors and thermostats
2. Pressure sensors
3. Humidity / Moisture level
4. Light intensity detectors
5. Moisture sensors
6. Proximity detection
7. RFID tags

Gateway:

IoT Gateway manages the bidirectional data traffic between different networks and protocols. Another function of gateway is to translate different network protocols and make sure interoperability of the connected devices and sensors. Gateways can be configured to perform pre-processing of the collected data from thousands of sensors locally before transmitting it to the next stage. In some scenarios, it would be necessary due to compatibility of TCP/IP protocol. IoT gateway offers certain level of security for the network and transmitted data with higher order encryption techniques. It acts as a middle layer between devices and cloud to protect the system from malicious attacks and unauthorized access.

Cloud:

Internet of things creates massive data from devices, applications and users which has to be managed in an efficient way. IoT cloud offers tools to collect, process, manage and store huge amount of data in real time. Industries and services can easily access these data remotely and make critical decisions when necessary.

Basically, IoT cloud is a sophisticated high performance network of servers optimized to perform high speed data processing of billions of devices, traffic management and deliver accurate analytics. Distributed database management systems are one of the most important components of IoT cloud. Cloud system integrates billions of devices, sensors, gateways, protocols, data storage and provides predictive analytics. Companies use these analytics data for improvement of products and services, preventive measures for certain steps and build their new business model accurately.

Analytics:
Analytics is the process of converting analog data from billions of smart devices and sensors into useful insights which can be interpreted and used for detailed analysis. Smart analytics solutions are inevitable for IoT system for management and improvement of the entire system. One of the major advantages of an efficient IoT system is real time smart analytics which helps engineers to find out irregularities in the collected data and act fast to prevent an undesired scenario. Service providers can prepare for further steps if the information is collected accurately at the right time. Big enterprises use the massive data collected from IoT devices and utilize the insights for their future business opportunities. Careful analysis will help organizations to predict trends in the market and plan ahead for a successful implementation.

Information is very significant in any business model and predictive analysis ensures success in concerned area of business line.

User interface:
User interfaces are the visible, tangible part of the IoT system which can be accessible by users. Designers will have to make sure a well-designed user interface for minimum effort for users and encourage more interactions. Modern technology offers much interactive design to ease complex tasks into simple touch panels controls. Multicolor touch panels have replaced hard switches in our household appliances and the trend is increasing for almost every smart home devices.

Q.1(b) Write a note on Calm and Ambient Technology. [5]

Ans.: *Mark Weiser* coined the term "ubiquitous computing" for when computing power becomes cheap enough that it can be embedded into all manner of everyday objects. With focus on computing power being embedded everywhere, ubiquitous computing is often also referred to as *ambient computing*. However, the term "ambient" also has connotations of being merely in the background, not something to which we actively pay attention and in some cases as something which we seek to remove.

The term *calm technology – as Mark Weiser defined* —systems which don't vie for attention yet are ready to provide utility or useful information when we decide to give them some attention. Such proliferation of computing devices into the world comes with all manner of new challenges. Issues include configuration, how to provide power to all these items, how they talk to each other, and how they communicate with us.

When the devices start interacting with people, things get more complicated. Already we're seeing the number of notifications, pop-ups, and indicator noises on our computers and mobile phones proliferate. When we scale up this number to include hundreds of new services and applications and then spread that across the rest of the objects in our world, it will become an attention-seeking cacophony.

Mark Weiser and John Seely Brown proposed an antidote to such a problem by suggesting we design ubiquitous computing systems to seek to blend into their surroundings; in so doing, we could keep them in our peripheral perception until the right time to take centre stage.
A great example of this approach is *Live Wire*, one of the first Internet of Things devices. Created by artist Natalie Jeremijenko when she was in residence at Xerox PARC under the guidance of Mark Weiser, Live Wire (also sometimes called Dangling String) 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 (who is used to the normal behaviour) that something is amiss and lets him investigate further.

Q.1 (c) Discuss the issue of Privacy in Internet of Things. [5]

Ans.: Privacy

- The Internet of Things devices that we own aren't the only ones that should concern us when it comes to matters of trust.
- With more sensors and devices watching us and reporting data to the Internet, the privacy of third parties who cross our sensors' paths (either by accident or design) is an important consideration.

Keeping Secrets

- For certain realms, such as health care, privacy concerns are an obvious issue, even see mingly innocuous applications can leak personal information, so you should be alert to the danger and take measures to avoid it.
- Don't share more than you need to provide the service.
- If you can avoid gathering and/or storing the data in the first place, you need not worry about disclosing it accidentally.
- In this day and age, it is standard practice to never store passwords as clear text. You could also consider applying the standard mechanisms for password encryption, such as the one-way hash, to other pieces of data.

Whose Data is it Anyway?

- With the number of sensors being deployed, it isn't always clear whose data is being gathered.
- Consider the case of a camera deployed in an advertising hoarding.
- Adam Greenfield, a leading practitioner of urban computing, makes a convincing argument that in a public space this data is being generated by the public, so they should at least have equal rights to be aware of, and also have access to, that data.
- When convening to debate such issues in the summer of 2012, the participants at the Open Internet of Things Assembly coined the term data subjects—those people to whom the data pertains.
- There's no clear understanding of what rights, if any, such "data subjects" will enjoy, but it is an area that deserves more debate and attention.

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

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.

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.

Fig.: Automated

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) Differentiate between static IP address and Dynamic IP address [5]

Ans.: Static IP address:

A static IP address is an address that is permanently assigned to you by your ISP (as long as your contract is in good standing), and does not change even if your computer reboots. A static IP address is usually assigned to a server hosting websites, and providing email, database and FTP services. A static IP address is also assigned to a commercial leased line, or public organization requiring same IP address each and every time. Since static IP address is assigned to you, you'll have to manually configure your machine (router or server) to use the static IP address assigned to you.

Advantages :

1. Address does not change - good for web servers, email servers and other Internet servers.
2. Use DNS to map domain name to IP address, and use domain name to address the static IP address.
3. Similar can be achieved with Dynamic DNS for dynamic IP address, but it's not as clean as the static IP address.

Disadvantages :
1. Expensive than dynamic IP address - ISPs generally charge additional fee for static IP addresses.
2. Need additional security - Since same IP is assigned to a machine, hackers try brute force attack on the machine over period of time.

Dynamic IP address:
A dynamic IP address is an IP address dynamically assigned to your computer by your ISP. Each time your computer (or router) is rebooted, your ISP dynamically assigns an IP address to your networking device using DHCP protocol. Since your ISP dynamically assigns an IP address to a computing device on reboot, your device may not always receive the same IP address previous assigned to it. Even if your machine is always on and permanently connected, some ISPs do change IP address on-the-fly even though this is very rare. A sticky nature of DHCP generally reassigns same IP address to the same machine, it is not guaranteed to receive same IP address as IP pool may exhaust at times and lease time may expire. To find your dynamic IP address, you may visit What is my IP address page.

Advantages :
1. Cheaper than static IP address.
2. Changing IP address gives more privacy.

Disadvantages :
1. Requires DHCP server to obtain an IP address.
2. Non-static. Each time IP address changes, you may have to find you IP address again.

Q.1 (f) Define protocol. Explain the following application layer protocols : HTTP, HTTPS, SMTP, FTP **[5]**

Ans.: **Protocol:** A protocol is a set of rules and guidelines for communicating data. Rules are defined for each step and process during communication between two or more computers. Networks have to follow these rules to successfully transmit data.

HTTP: The Hypertext Transfer Protocol (HTTP) is an application protocol for distributed, collaborative, hypermedia information systems. HTTP is the foundation of data communication for the World Wide Web, where hypertext documents include hyperlinks to other resources that the user can easily access, for example by a mouse click or by tapping the screen. HTTP was developed to facilitate hypertext and the World Wide Web.

HTTPS : Hypertext Transfer Protocol Secure (HTTPS) is an extension of the Hypertext Transfer Protocol (HTTP) for secure communication over a computer network, and is widely used on the Internet. In HTTPS, the communication protocol is encrypted using Transport Layer Security (TLS), or, formerly, its predecessor, Secure Sockets Layer (SSL). The protocol is therefore also often referred to as HTTP over TLS, or HTTP over SSL.

SMTP : Simple Mail Transfer Protocol (SMTP) is an Internet standard for electronic mail (email) transmission.

FTP : The File Transfer Protocol (FTP) is a standard network protocol used for the transfer of computer files between a client and server on a computer network.

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

Q.2 (a) Differentiate between open source and closed source. **[5]**

Ans.:

Open Source	Closed Source
Provides the original source code so that advanced user can modify it to make it work better	No one can duplicate or distribute without permission of the company
Available to all free of cost	Protected by copyrights
Any individual can develop or modify	Development is centralised undertaken by expert developers
Quality assurance or bug removal is done by individuals at their free will	Number of individuals are employed for improving quality and bug removal
Less secure than closed source.	More secure than open source
Android	Apple

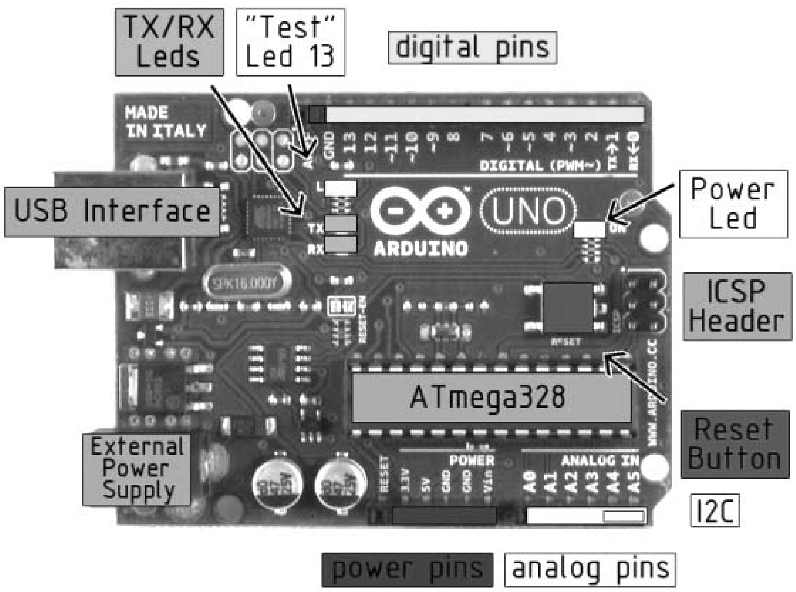
Q.2 (b) Write note on Raspberry Pi. **[5]**

Ans.: The Raspberry Pi is a small, barebones computer developed by The Raspberry Pi Foundation, a UK charity, with the intention of providing low-cost computers and free software to students. Their ultimate goal is to foster computer science education and they hope that this small, affordable computer will be a tool that enables that.

- It is a small single board computer used for making different project based on electronics and Robotics etc.
- There are different version of Raspberry Pi viz Raspberry Pi A(1,1+) Raspberry Pi B Model (1,1+,2,1.2,3,3+).
- These basically comes with a Processor, HDMI, SD Card slot, USB port, Ram etc.
- Every generation is enhanced with some new features in it.
- Let us see the pin diagram for Raspberry Pi 3 b model: -

Q.2 (c) 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 (d) Explain the following with respect to prototyping embedded devices: Processor Speed, RAM, Networking, USB, Power Consumption and Physical size and Form Factor.

Ans.: The following sections discuss about choosing the platform required to design the systems.

Processor Speed :
The speed of the processor tells how fast the instruction will be executed. It is always defined in the form of MIPS (Millions of Instructions Per Seconds).

RAM :
Random Access memory also known as primary memory is fastest memory available in the system. All the programs are executed in RAM, and it is always better to have higher size of RAM.

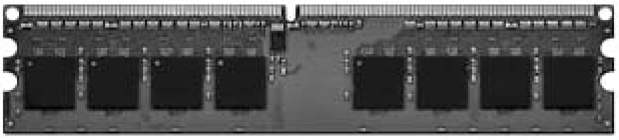


Fig.: RAM Chip

Networking :
This is the most important thing for IoT, which tells how the devices are connected. It is possible to connect a device with wired LAN but only issue is physical cable.
Wireless connection though it gives mobility but it is a costly affair and is bad in power consumption.

Fig.: Networks

USB :
For more powerful computer, tethering to it via USB can be easy way to provide power and networking. So it is better that microcontrollers include support for USB, so no extra chip is not required.

Power Consumption :
Always fast processors consume more power and hence required very high power supply. For portable device major issue will be power supply.

Interfacing with Sensors and Other Circuitry :
This is the main concept of IoT, device needs to interact with sensors to gather data about its environment, motors, LEDs, screens etc.

Q.2 (e) How is development done for Arduino ?Explain.

Ans.: Following are the steps to develop any application on Arduino :

1. Get the Arduino board and USB connector to connect board to Machine.

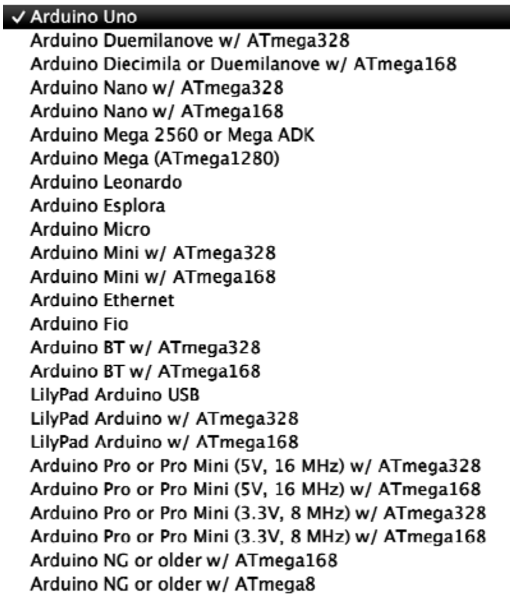
2. Switch on and off board and then look in to making it blink on and off for 2 seconds at a time.
3. Now plug your USB cable in to your Arduino and your computer, LED will be blinking.
4. The USB cable powers the device. Arduinos can also run standalone by using a power supply in the bottom left of the board.
5. Now Download Arduino Software :

Fig.: IDE Representation.

This is where you type the code you want to compile and send to the Arduino board.

6. The Initial Setup on IDE :
Now select **Tools** menu and select **Board**.

Then select the type of Arduino you want to program, Example, Arduino Uno.



7. **The Code :**
The code you write for your Arduino are known as **sketches**. They are written in **C++**.
Every sketch has two void type functions, setup() and loop().

The setup() is executed just after the Arduino is powered and the loop() executed thereafter. The setup() is where you want to do any initialization steps, and in loop() you want to run the code you want to run over and over again.

So, your basic sketch or program should look like this:

```
void setup()
{
}
void loop()
{
}
```

Now let us write a code to start LED.
The onboard LED we want to control is on pin 13.
Now in setup() method let's create a variable called ledPin.

```
int ledPin = 13;
void setup()
{
}
void loop()
{
}
```

setup() method we want to set the ledPin to the output mode.

```
int ledPin = 13;
void setup()
{
        pinMode(ledPin, OUTPUT);
}
void loop()
{
}
```

Example, switch off the LED.

So now call method called digitalWrite(). This also takes two values, the pin number and the level, HIGH or the on state or LOW the off state.

```
int ledPin = 13;
void setup()
{
        pinMode(ledPin, OUTPUT);
}
void loop()
{
        digitalWrite(ledPin, LOW);
}
```

Next we want to compile to machine code and deploy or *upload* it to the Arduino.

8. *Compiling the Code :*

On **Tools** menu, Select **Serial Port** and plug Arduino UNO board to your computer. Now on **Tools > Serial Port** menu, select COM port that appears.

Once you have selected your serial or COM port you can then press the button with the arrow pointing to the right. Now you should see the **TX** and **RX** LEDs below the LED flash. The **LED flash** may flicker too and finally LED should be off.

Q.2 (f) Compare Raspberry Pi Arduino?

Ans.:

	Raspberry Pi	**Arduino**
1.	It is mini-computer with Raspbian OS. It can run multiple programs at a time.	Arduino is a microcontroller, which is a part of the computer. It runs only one program again and again.
2.	It is difficult to power using a battery pack.	Arduino can be powered using a battery pack.
3.	It requires complex tasks like installing libraries and software for interfacing sensors and other components	It is very simple to interface sensors and other electronic components to Arduino.
4.	It is expensive.	It is available for low cost.
5.	Raspberry Pi can be easily connected to the internet using Ethernet port and USB Wi–Fi dongles.	Arduino requires external hardware to connect to the internet and this hardware is addressed properly using code.
6.	Raspberry Pi did not have storage on board. It provides an SD card port.	Arduino can provide onboard storage.
7.	Raspberry Pi has 4 USB ports to connect different devices.	Arduino has only one USB port to connect to the computer.
8.	The processor used is from ARM family.	Processor used in Arduino is from AVR family Atmega328P
9.	This should be properly shutdown otherwise there is a risk of files corruption and software problems.	This is a plug and play device. It power is connected it starts running the program and if disconnected it simply stops.
10.	The Recommended programming language is python byt C, C++, Python, ruby are pre–installed.	Arduino uses Arduino, C/C++.

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

Q.3(a) Discuss the methods of 3D printing.

Ans.: **Fused filament fabrication (FFF)**

- Also known as fused deposition modelling (FDM)
- It works by extruding a fine filament of material from a heated nozzle.
- The nozzle can be moved horizontally and vertically by the controlling computer
- The resulting models are quite robust, as they're made from standard plastic. However, the surface can have a visible ridging from the thickness of the filament.

Laser sintering

- This process is sometimes called selective laser sintering (SLS), electron beam melting (EBM), or direct metal laser sintering (DMLS).
- It is used in more industrial machines but can print any material which comes in powdered form and which can be melted by a laser.

- It provides a finer finish than FDM, but the models are just as robust, and they're even stronger when the printing medium is metal.
- This technique is used to print aluminium or titanium, although it can just as easily print nylon.

Powder bed

- Like laser sintering, the powder-bed printers start with a raw material in 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, the models are quite brittle and so need postprocessing where they are sprayed with a hardening solution.
- The great advantage of these printers is that when the binder is being applied, it can be mixed with some pigment; therefore, full-colour prints in different colours can be produced in one pass.

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.
- The Mcor IRIS is an example of this sort of printer.

Stereolithography and digital light processing

- Stereolithography is possibly the oldest 3D printing technique and similar to digital light processing.
- Stereolithography uses a UV laser to trace the pattern for each layer, whereas digital light processing uses a DLP projector to cure an entire layer at a time.
- Whilst these approaches are limited to printing with resin, the resultant models are produced to a fine resolution.
- The combination of this with the relatively low cost of DLP projectors makes this a fertile area for development of more affordable high-resolution printers.

Q.3(b) Explain the term Scraping.

Ans.: Scraping

- In many cases, companies or institutions have access to fantastic data but don't want to or don't have the resources or knowledge to make them available as an API.
- While you saw in the Flickr example above that getting a computer to pretend to be a browser and navigate it by looking for UI elements was fragile, that doesn't mean that doing so is impossible.
- In general, we refer to this, perhaps a little pejoratively, as "screen-scraping.

Q.3(c) Write note on MQTT Protocol.

Ans.: Message Queuing Telemetry Transport :

MQTT (MQ Telemetry Transport) is a lightweight messaging protocol that provides resource-constrained network clients with a simple way to distribute telemetry information. The protocol, which uses a publish/subscribe communication pattern, is used for machine-to-machine (M2M) communication and plays an important role in the internet of things (IoT).

An MQTT session is divided into four stages: connection, authentication, communication and termination. A client starts by creating a TCP/IP connection to the broker by using either a standard port or a custom port defined by the broker's operators.

The client may also provide a client certificate to the broker during the handshake, which the broker can use to authenticate the client.

Now the communication starts and finally the connection is terminated.

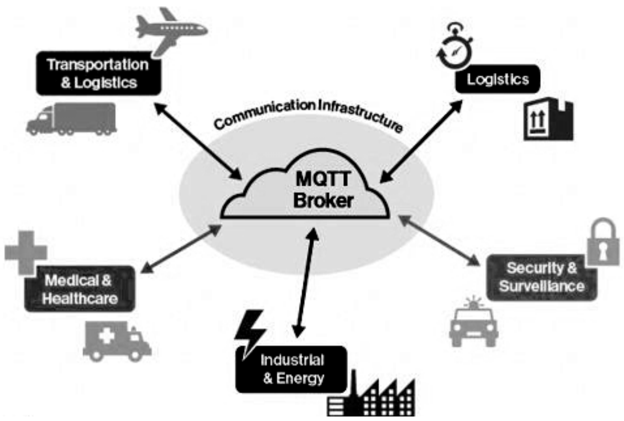


Fig.: MQTT Architecture.

Q.3(d) What is CNC Milling? Explain.

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.

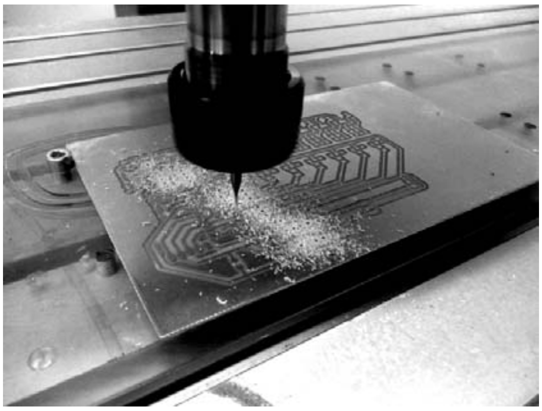


Fig.: CNC printer.

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) Explain the non-digital methods if prototyping.

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.

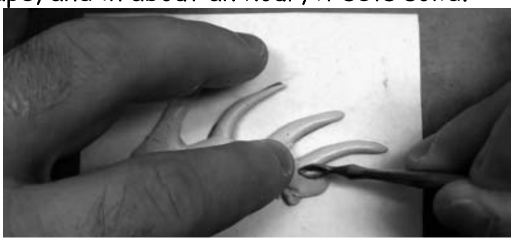


Fig.: Epoxy putty Design.

- **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.

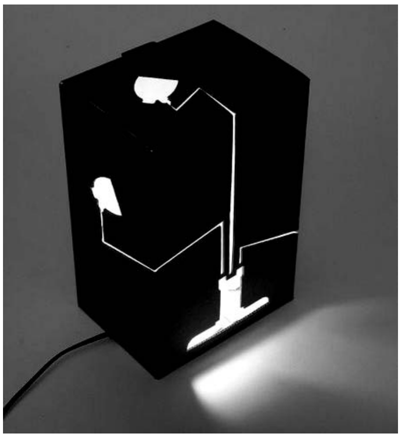


Fig.: Design of cardboard for lamp.

- **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.

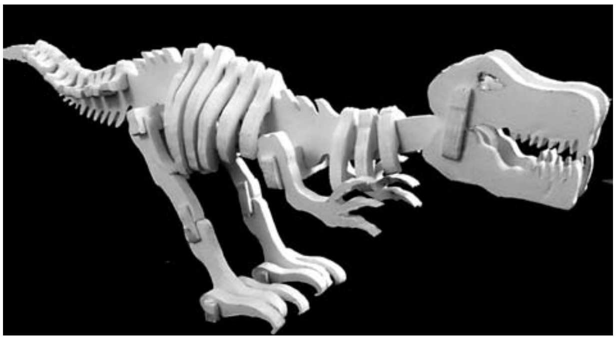


Fig.: Foamcore Design.

- **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(f) What are laser cutters? Explain the main features to consider while choosing a laser cutter.

Ans.: 3D printers makes more complicated parts, but for simpler design it is better to go for laser cutter and since this technology is faster makes it a versatile concept. Laser cutters range from desktop models to industrial units, most of the laser cutter is given over to the bed; this is a flat area that holds the material to be cut. The bed contains a two-axis mechanism with mirrors and a lens to direct the laser beam to the correct location and focus it onto the material being cut. It is similar to a flatbed plotter but one that burns things rather than drawing on them. The computer controls the two-axis positioning mechanism and the power of the laser beam.

Fig.: Laser Cutter.

Features of Laser cutting:

Consider two main features while using laser cutter :

- **The size of the bed:** Here the sheets are cut, so a larger bed can cut larger items.
- **The power of the laser:** The more the power of laser, it can cut through thicker material. For example, 40W laser can cut up to 10 mm thick acrylic, 60W laser can cut upto 25 mm thick acrylic.

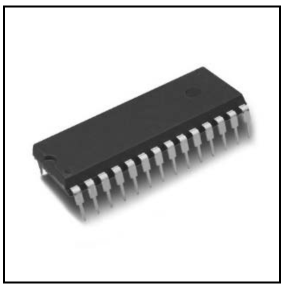
Depending on what you're trying to create, you can cut all sorts of different materials in a laser cutter. For example, laserable rubber can be used to create ink stamps,

Fig.: Rubber Stamp designed using Laser cutter.

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

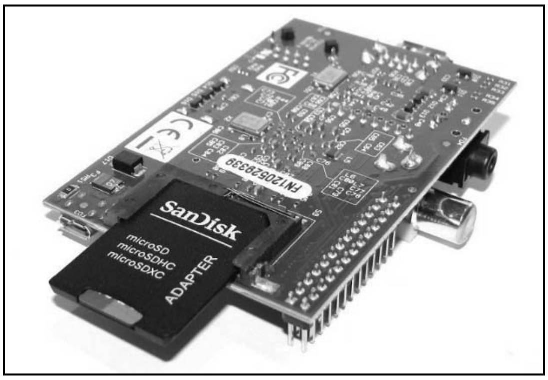
Q.4(a) Explain the difference types of memories.

Ans.: **ROM:**



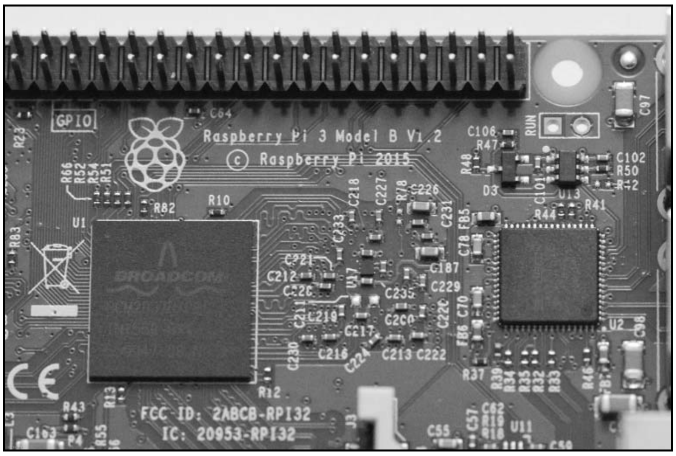
Read-only memory refers to memory where the information stored in the chips is hard-coded at the chips' creation and can only be read afterwards. This memory type is the least flexible and is generally used to store only the executable program code and any data which is fixed and never changes. Originally, ROM was used because it was the cheapest way of creating memory, but these days it has no cost advantage over Flash chips, so their greater flexibility means that pure ROM chips are all but extinct.

Flash:



Flash is a semi-permanent type of memory which provides all the advantages of ROM—namely, that it can store information without requiring any power, and so its contents can survive the circuit being unplugged — without the disadvantage of being unchangeable forever more. The contents of flash memory can be rewritten a maximum number of times, but in practice it is rare that you'll hit the limits. Reading from flash memory isn't much different in speed as from ROM or RAM. Writing, however, takes a few processor cycles, which means it's best suited to storing information that you want to hold on to, such as the program executable itself or important data that has been gathered.

RAM:



Random-access memory trades persistence for speed of access. It requires power to retain its contents, but the speed of update is comparable with the time taken to read from it. As a result it is used as the working memory for the system—the place where things are stored while being processed. Systems tend to have a lot more persistent storage than they do RAM, so it makes sense to keep as much in flash memory as is possible. If you know that the contents of a variable won't ever change, it is better to define that variable as a constant instead. In the C and C++ programming languages (which are commonly used in embedded systems), you do this by using the const keyword. This keyword lets the compiler know that the variable doesn't need to live in RAM because it will never be written to—only read from. The Arduino platform, for example, provides an additional macro to let you specify that certain strings should be stored in flash memory rather than RAM.

Q.4 (b) Explain how to achieve customization in Internet of Things devices.

Ans.: **Customization:**

For an Internet of Things device, at the intersection between solid thing and software, there are options for customization that we believe may lead to new business models. For a mass-produced item, any customization must be strictly bounded to a defined menu: a selection of different colours for the paintwork, options for fittings such as tyres, the trimmings and upholstery inside, and for features like the onboard computer control and display. The world of software is, by contrast, pathologically malleable, if we let it be. Early websites explored the new medium of HTML to its garish extremes, with <blink> tags and animated .gif images. Yet today's equivalent of home pages, offered by incumbents such as Facebook, Twitter, and Pinterest, offer small degrees of customization within strictly defined boundaries: a selection of (tasteful) colour schemes and a choice of image to use as your avatar. Many Internet of Things products have some possibility of customization. The new manufacturing techniques, such as laser cutting and 3D printing, should allow great possibilities for customizing even the physical devices. MakieLab make dolls that can be designed online. Built to your specification, they are therefore unique and entirely yours in a way that a mass-produced doll couldn't be.

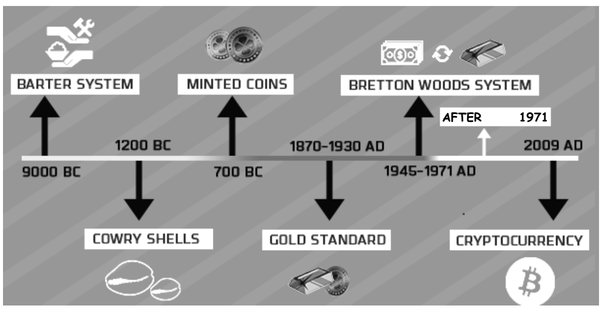
Q.4 (c) What is a business model? Who is the business for? Explain.

Ans.: Business Model is a company's plan for how to make money out of a project and generate revenue. It is collection of many factors such as customers, what are their needs, how your business could meet those needs, practices that could help achieve this goal, and success criterion to make the profit.

- **History of Business Models :**
  Business is process of give and take in whichever form available. After a survey on tribes of early times, it was known that they followed Gift Economy. Gift Economy is the process wherein a skilled person sells his product to other people but does not expect the repayment immediately. Rather it used to be considered as gift with comparable cost later.

- **Space and Time :**
  In early times, Barter system was used to develop trade. In Barter system, trade is carried out by exchanging goods in return of goods. In other words, suppose one village has good quality of animals, crafts, pottery etc whereas the other nearby village has good quality of spices then the traders could take their commodities to other village and sell them in exchange of spices. But this kind of long distance trade also brings many problems with it: early people had to find their food and make their home also along with trade. So, going everyday to other villages in need of some good was not possible. In this case, there was a need to preserve the commodities like spices for a long time and a proper transportation channel was also required in order to sell the preserved commodities at once and remaining time could be then utilised to make their home.

  This gave rise to new system, money system which abstracted trade further. This system made the calculations easy as the exchange rate was fixed for every product. So, money is a technology that allows travel through time. This ease of calculation led to the development of new business models like people started investing in others trade for a given share and even there was a interest on loans.



Q.4 (d) Explain the following business models: Make Things, Sell Things, Subscriptions, Customization.

Ans.: **Make Thing, Sell Thing :**

The simplest category of models, "make a Thing and sell it," is, of course, valid for the Internet of Things. Adrian sells custom-built Bubblini, and the startup Good Night Lamp is preparing to ramp up production of its eponymous lamps as an off-the-shelf product. As you will see in Chapter 10, electrical products sold in shops (physical or online) may be subject to legislation and certification (RoHS, Kitemarks, and so on), which is an additional factor and cost to consider. Many small-scale projects take the option of selling the product in "kit" form, with some assembly required. Because kits are assumed to be for specialists and hobbyists rather than the general public, the administrative burden may be lower. However, making a decision to limit your target market may well limit the potential revenue also.

Subscriptions :

A Thing would be a dumb object if it weren't for the important Internet component which allows the device to remain up to date with useful and current content. But, of course, this ongoing service implies costs to the provider—development, maintenance of servers, hosting costs, and in some cases even connection costs. A subscription model might be appropriate, allowing you to recoup these costs and possibly make ongoing profit by charging fees for your service. Many products could legitimately use this method, but perhaps the more complex, content-driven services would find it more convincing. Paying Bubblino a monthly fee to blow bubbles might seem steep, but the BERG Cloud, which delivers nicely formatted news and entertainment to its Little Printer, might have seemed an ideal product for this model. As it stands, content consumers do not pay for either BERG Cloud or for any content subscriptions.

Customisation :

We touched on the improvements to mass production whereby the process of buying a car can be tweaked to the buyer's requirements. For an Internet of Things device, at the intersection between solid thing and software, there are options for customisation that we believe may lead to new business models.

For a mass-produced item, any customisation must be strictly bounded to a defined menu: a selection of different colours for the paintwork, options for fittings such as tyres, the trimmings and upholstery inside, and for features like the onboard computer control and display. Fordian logic dictates that all these components must be optimised for manufacture and fit well together.

Q.4 (e) Write a short note on venture capital.

Ans.: Getting funding for a project from an external investor presents its own work and risks. The process of applying for funding takes time, and although much of this time can be justified as thrashing out the business model, it's not directly related to the work you actually want to be doing on the product itself. Startups often concentrate their fundraising activities into rounds, periods in which they dedicate much of their effort into raising a target amount of money, often for a defined step in their business plan. Before any official funding round comes the informal idea of the friends, family, and fools (FFF) round. This stage may be the one in which you've contributed your life savings, and persuaded your aunt, your best friend, and a local small business to pitch in the rest, on the basis of your reputation. Although it's important to consider the possible impact on your personal relationships, this round of funding may be the most straightforward to get hold of.

A common next step would be an angel round. The so-called angels are usually individual investors, often entrepreneurs themselves, who are willing to fund some early-stage startups which a more formal investor (such as venture capitalists that we look at shortly) might not yet touch. The reason might be that these angels have a technical or business background in your product or simply that, as individual investors, they may have more scope to go with their own intuition about your worth. Angels typically disburse sums that are significant for early-stage startups—in the region of tens or possibly hundreds of thousands of pounds. However, the personal interest and experience that angels can bring to your company means that their advice, contacts, and other help may well be as useful as any money they provide. A good place to find an angel in the US could be AngelList, a long tail aggregator where investors can meet startups.

The Venture Capital (VC) round is similar, but instead of your courting individual investors, the investor is a larger group with significant funds, whose sole purpose is to discover and fund new companies with a view to making significant profit. VCs may be interested if angels have already funded you and will certainly be interested if other VC companies are already looking at funding you. VCs will certainly want equity, probably a significant amount of it, and a position on your board of directors. Again, this last role may be as much to help fill gaps that your management team don't cover as much as it is to keep an eye on you and their money. Typically, VC funding will be larger chunks of money, from half a million pounds up.

Q.4 (f) What is debugging? Explain some tools for debugging.

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.

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

Q.5(a) What is Crowdsourcing? Explain.

Ans.: One fascinating feature of modern Internet life is "crowdsourcing", from knowledge (Wikipedia, et al.) to funding projects (Kickstarter, Indiegogo) to work (Mechanical Turk). In the Internet of Things world, this concept has manifested itself in sensor networks such as Xively.

Founder Usman Haque has said that their original intent wasn't simply "making data public" but also letting "the public making data".

Governments and companies simply do not and cannot have a monopoly on all recording of data: there are infinite combinations of data sources. Choosing which data to record is a creative and engaged act, as well as, perhaps, a political one.

After the Fukushima Daiichi nuclear disaster, there were fears that insufficient information was available to track the spread of the leaked radioactive materials. Many hackers around the world built Geiger counters, and Xively was a focal point for Japanese engineers to publish their data to.

Perhaps the Japanese government or the management of the Fukushima plant would have provided that kind of accurate, widespread data if they could. But power or financial interests might have worked against this.

Andrew Fisher, a technologist with interests in big data and ubiquitous computing, has written persuasively about a quiet revolution of the "sensor commons", his term for this collaborative voluntary effort to provide environmental data.
Fisher's original definition observed five critical requirements for a sensor commons project. It must
Gain trust: Trust is largely about the way that an activist project handles itself beyond the seemingly neutral measurements; understanding local issues, being sensitive about the ways that the sensor network itself affects the environment, engaging the public with accessible and readable information about the project, and dealing with the local authorities to get access to the systems the project wants to measure.

Become dispersible: Becoming dispersible means spreading the sensors throughout the community. Getting mass adoption will be easier if the proposed sensors are inexpensive and if the community already trusts the project.

Be highly visible: Being visible involves explaining why the project's sensors are occupying a public space. Being honest and visible about the sensor will help to engender trust in the project and also advertise and explain the project further.

Be entirely open: Being open is perhaps what distinguishes the sensor commons from a government project the most. The openness makes up for this because all the facts about the devices and the possible errors are admitted upfront and can be improved by anyone in the community. The project should also have an API and permissive licensing so that the community can choose to do different, complementary things with the data from the network.

Be upgradable: Finally, the project should be designed to be upgradable, to enable the network to remain useful as the needs change or hardware gets to the end of its working life.

While Fisher writes specifically on sensor networks, the principles he proposes are, we suggest, relevant to consider for any ethical project in the field of the Internet of Things.

Q.5(b) Explain common PCB (Printed Circuit Board) making techniques.

Ans.: The different techniques for manufacturing printed circuit boards are:

1. Etching Boards

   The most common PCB-making technique for home use is to etch the board. The first step is to get the PCB design onto the board to be etched. This process generally involves printing out the design from your PCB design software onto a stencil. If you're using photo-resist board, it will be onto a stencil which masks off the relevant areas when you expose it to UV light; or if you're using the toner-transfer method, it will be for your laser printer to print onto glossy paper ready to transfer. Your stencil then needs to be transferred to the board. For photo-resist board, you will expose it under a bright lamp for a few minutes; and for the toner-transfer method, you'll use a super-hot iron. With the board suitably prepared, you can immerse it into the etching solution, where its acidic make-up eats away the exposed copper, leaving the tracks behind. After all the unnecessary copper has been etched away, and you've removed the board from the etching bath and cleaned off any remaining etchant, your board is almost ready for use. The last step is to drill the holes for any mounting points or through-hole components. You can do this by hand, or, if you have access to a CNC mill, you can export the drill file from your PCB design package to provide the drill locations for your mill.

2. Milling Boards
   In addition to using a CNC mill to drill the holes in your PCB, you can also use it to route out the copper from around the tracks themselves. To do this, you need to export the copper layers from your PCB software as Gerber files. These were first defined by Gerber Systems Corp., hence the name, and are now the industry standard format used to describe PCBs in manufacture. To translate your Gerber file into the G-code that your mill needs requires another piece of software. Some CNC mills come with that software already provided, or you can use a third-party program such as Line Grinder. The mill effectively cuts a path round the perimeter of each track to isolate it from the rest of the copper. As a result, PCBs which have been milled look a bit different from those which are etched because any large areas of copper that aren't connected to anything are left on the board.

3. Third Party Manufacturing
   If your design has more than two layers, if you want a more professional finish, or if you just don't want to go to the trouble of making the PCBs yourself, many companies can manufacture the boards for you. The price for getting the boards made varies based on the complexity and the size of the design but also varies quite a bit from company to company, so it's worth getting a few quotes before deciding which one to use. If you need the boards quickly, a local firm is your best bet and generally has a lead time measured in days. If you have the luxury of more time, you can cast your net further, including to China, which might reduce your costs but could mean a few weeks' wait before you receive your order. Either way, the Gerber files are what you need to provide to the manufacturer. Make sure you export all the relevant layers from your design, meaning each of the copper layers you're using, plus the solder mask, silkscreen and drill files.

4. Assembly
   After your PCBs have been manufactured, you still need to get the components soldered onto them. If you're selling them as kits, the customers will solder things up, so you just need to pack everything into bags and let them get on with it. Otherwise, you have to take responsibility for making that happen. For small runs, you can solder them by hand. For through-hole boards, break out your soldering iron. Surface-mount assembly is a little more involved but quite achievable if you don't have any components with particularly complicated package types. For assembling surface-mount boards, you need one more item from your PCB design Gerber collection: the solder paste layer. You use it to generate a stencil that allows you to apply the solder. You can laser-cut one from a thin sheet of Mylar plastic or have one made for you out of thin steel. The solder for surface-mount work comes as a paste, supplied in tubs or tubes. Using a squeegee and the solder paste stencil, you need to put down an even layer of solder over all the component locations and then carefully lift the stencil off the board. Using tweezers and ideally a loupe or magnifying glass, place each component onto the relevant spot on the PCB. The paste holds the parts in place to a degree but take care not to knock the board at this point in case some of the parts get displaced. When you have all the

components on the board, you need to melt the solder to fix everything in place. You can do this with a soldering iron but doing it by hand is easier if you use a hot-air rework station. You can solder all the connections at once if you use a reflow oven. As the name suggests, this oven heats up the PCB and components evenly until the solder melts. After you outgrow hand assembly, you will need some help from robots. In this case, you will need robots that can pick up components using a tiny vacuum nozzle, rotate and place them in the right location on the PCB, and then repeat that process at a rate of tens of thousands of components per hour. These robots are known as pick-and-place assembly machines. The components to feed into the machine are supplied in a form known as tape and reel.

Using an assembly house saves you from buying the expensive machinery yourself. But offloading the work to someone who specialises in it has other benefits, too. The extra throughput that they deal with means they will naturally employ dedicated staff to run the production lines. Paradoxically, those staff will most likely be both more skilled than you are at running the pick-and-place machines and doing any hand soldering and cost less per hour than you do. This then frees you up for the many other tasks involved in bringing a product to market or to working on your next idea. If you do decide to use a contract manufacturer, having a conversation about components is worthwhile. For common parts, if you don't have specific requirements for tolerances, and the like, you might be able to specify that the assembler should use the parts it already holds in stock. If the manufacturer has dealt with the supplier before, its reputation might let you negotiate a better deal.

Q.5(c) Discuss the phase of Testing in manufacturing of Internet of Thing devices.

Ans.: Now your boards are all ready and assembled, but how do you know that they all work as they're meant to? This is where testing comes in.
Actually, through the automated assembly process, you might have had some testing steps included already. Assembly lines can include automatic optical inspection (AOI).

In this process, a high-resolution camera inspects some aspect of the board and its components; for example, it could check that the solder paste is laid properly before the board goes into the pick-and-place machine and compare it to a known good version.

Any boards which vary from the "golden" reference version by too high a margin are flagged for further checks from a skilled human operator.
After the boards pass the AOI, the next step is to run them through a functional test.
This step is something that you can, and should, be doing even with boards that you've soldered by hand.

The functional test just involves powering up the board as it will be used in the finished product and ensuring that it does what it is supposed to. However, that might take a nontrivial amount of time.
The focus here is not on ensuring it will run through all normal operations, but just that the PCB and its components are soldered correctly, that none

of the components are faulty, and that there aren't any manufacturing defects in the PCB itself.

A better approach is to build a specific test rig to exercise the different parts of the circuit and measure the voltages at set points on the board. These measurements can then be compared against known-good values and a decision made automatically as to whether or not the device under test (DUT) has passed.

Because you don't want to spend time making individual connections for each test, the normal practice for the test rig is to use the mounting holes for the PCB for alignment and then have it held by some clips against a number of carefully prepositioned, spring-loaded pins.
These pins are known as pogo pins, and the spring means they can make a good connection to the board without any extra work, such as soldering, when the board is placed into the test rig.
The test program can then run through its tests and measure voltages at different pogo pins at the relevant time in the test to see how the board being tested performs.

If the DUT includes a microcontroller chip, the test rig could flash it with a test program to help with the testing, and even at the end of the test, assuming it has passed, flash it with the final firmware image ready for deployment.

Q.5(d) Write a short note on Cautious optimism.

Ans.:

1. Between the tempting extremes of technological Luddism and an unquestioning positive attitude is the approach that we prefer: one of cautious optimism. Yes, the Luddites were right—technology did change the world that they knew, for the worse, in many senses. But without the changes that disrupted and spoilt one world, we wouldn't have arrived at a world, our world, where magical objects can speak to us, to each other, and to vastly powerful machine intelligences over the Internet.
2. It is true that any technological advance could be co-opted by corporations, repressive governments, or criminals. But (we hope) technology can be used socially, responsibly, and (if necessary) subversively, to mitigate against this risk. Although the Internet of Things can be, and we hope will always be, fun, being aware of the ethical issues around it, and facing them responsibly, will help make it more sustainable and more human too.
3. As a massively interdisciplinary field, practitioners of Internet of Things may have an opportunity (or perhaps responsibility) to contribute to providing moral leadership in many of the upcoming ethical challenges we have looked at. Before we let that get to our heads though, we should remember an important lesson on humility from Laura James's keynote at the OpenIoT assembly.
4. 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.

Q.5 (e) What are different software options for designing PCB? Explain.

Ans.: As you might expect, you have many different choices when looking for some software to help you design your PCB. If you are working with a contract electronics design house, the staff may well use something like Altium Designer.

Fritzing : Fritzing is a free, open source design package aimed particularly at beginners in PCB design. It deliberately starts with a design screen resembling a breadboard and lets you map out your circuit by copying whatever you have prototyped in real life. It then converts that design to a schematic circuit diagram and lets you arrange components and route the traces on the PCB view.

KiCad : KiCad is another open source offering but with a more traditional workflow. It has a more comprehensive library of predefined parts and can be used to design boards with up to 16 layers of copper, compared to the double-sided boards that Fritzing produces.

Eagle : The reason for its popularity most likely comes down to its long having a free version for noncommercial use, allowing beginners to get started. That led to a wealth of how-to guides and other helpful resources for EAGLE being developed and shared by the user community. So EAGLE is a good choice to learn PCB design, although in addition to its noncommercial licence, the free version is also restricted to two layers and a maximum board size of 100mm x 80mm.

Q.5 (f) What is the importance of Certification for IoT devices? Explain.

Ans.:

1. One of the less obvious sides of creating an Internet of Things product is the issue of certification. If you forget to make the PCB or write only half of the software for your device, it will be pretty obvious that things aren't finished when it doesn't work as intended. Fail to meet the relevant certification or regulations, and your product will be similarly incomplete—but you might not realise that until you send it to a distributor, or worse still, after it is already on sale.
2. For the main part, these regulations are there for good reason. They make the products you use day in, day out, safer for you to use; make sure that they work properly with complementary products from other suppliers; and ensure that one product doesn't emit lots of unwanted electromagnetic radiation and interfere with the correct operation of other devices nearby.
3. The regulations that your device needs to pass vary depending on its exact functionality, target market (consumer, industrial, and so on), and the countries in which you expect to sell it. Negotiating through all this isn't for the faint of heart, and the best approach is to work with a local testing facility. They not only are able to perform the tests for you but also are able to advise on which sets of regulations your device falls under and how they vary from country to country.
4. Electromagnetic interference is the "electrical noise" generated by the changing electrical currents in circuitry. When generated intentionally, it can be very useful: radio and television broadcasts use the phenomenon to transmit a signal across great distances, as do mobile phone networks and any other radio communication systems such as WiFi and ZigBee. The problem arises when a circuit emits a sufficiently strong signal unintentionally which disrupts the desired radio frequencies. This is sometimes noticeable in the "dit, dit-dit-dit" picked up by a poorly insulated stereo just before your mobile phone starts ringing.

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