# New and Emerging Technologies

## 1. Internet of Things (IoT)

- The term Internet of Things refers to the collective network of connected devices and the technology that **facilitates communication between devices and the cloud,** as well as between the devices themselves.
- Basically, IoT integrates everyday "things" with the internet.

### 1.1. Working of IoT

- IoT systems work through the **real-time collection and exchange of data.** An IoT system has **three components: smart device, IoT application and a graphical user interface.**
- Smart device is a device, like a television, security camera, or exercise equipment that has been given **computing capabilities.** It collects data from its environment, user inputs, or usage patterns and communicates data over the internet to and from its IoT application.
- An IoT application is a **collection of services and software that integrates data received** from various IoT devices. It uses machine learning or artificial intelligence (AI) technology to analyze this data and make informed decisions.
- The decisions are communicated back to the IoT device and the IoT device then responds intelligently to inputs.
- The IoT device or fleet of devices can be managed through a graphical user interface.

### 1.2. Examples of IoT devices

**Connected cars**

- There are many ways vehicles, such as cars, can be connected to the internet. It can be through smart dashcams, infotainment systems, or even the vehicle's connected gateway.
- They collect data from the accelerator, brakes, speedometer, odometer, wheels, and fuel tanks to monitor both driver performance and vehicle health.

**Connected homes**

- Smart home devices are mainly focused on improving the efficiency and safety of the house, as well as improving home networking.
- Devices like smart outlets monitor electricity usage and smart thermostats provide better temperature control.
- Hydroponic systems can use IoT sensors to manage the garden while IoT smoke detectors can detect tobacco smoke.
- Home security systems like door locks, security cameras, and water leak detectors can detect and prevent threats, and send alerts to homeowners.

**Smart cities**

- IoT applications have made urban planning and infrastructure maintenance more efficient.
- IoT applications can be used for measuring air quality and radiation levels, reducing energy bills with smart lighting systems, detecting maintenance needs for critical infrastructures and increasing profits through efficient parking management.

**Manufacturing**

- IoT applications can predict machine failure before it happens, reducing production downtime.

- Wearables in helmets and wristbands, as well as computer vision cameras, are used to warn workers about potential hazards.

**Logistics and transport**
- Commercial and Industrial IoT devices can help with supply chain management, including inventory management, vendor relationships, fleet management, and scheduled maintenance.
- Shipping companies use Industrial IoT applications to keep track of assets and optimize fuel consumption on shipping routes.

**Smart Stores**
- Smart stores, also known as connected stores, are brick-and-mortar stores that incorporate various technologies to enhance the shopping experience, optimize operations, and improve customer engagement and lifetime value.
- They often incorporate IoT technologies in the form of smart devices and sensors, and artificial intelligence (AI) technologies such as computer vision to power cashierless checkout.
- Smart retail also leverages in-store data analytics to create a seamless and personalized environment for both customers and workers.
- Smart stores offer features such as personalized product recommendations, frictionless checkout experiences, real-time inventory tracking, and targeted marketing messages.
- With data-driven insights and enhanced connectivity, smart stores revolutionize the way retailers engage with customers, streamline operations, and drive business growth.

## 1.3. Benefits of IoT
- Real-time resource visibility.
- Reduced costs.
- Improved operational efficiency and productivity.
- More business opportunities.
- Data-driven insights for quick decision-making.
- End-to-end, remote monitoring and management of assets/resources.
- Real-time, predictive and prescriptive insights.
- Improve end-customer experience.
- Increased mobility and agility.

# 2. Hyperloop

## 2.1. What is Hyperloop?
- Hyperloop is a mode of ultra-fast mass transportation solution that **transports people and cargo through a pod in a vacuum environment.**
- It was proposed as a concept by Elon Musk in a white paper, back in 2013.
- In 2020, the US-based company "Virgin Hyperloop" tested the Hyperloop system with passengers for the first time.
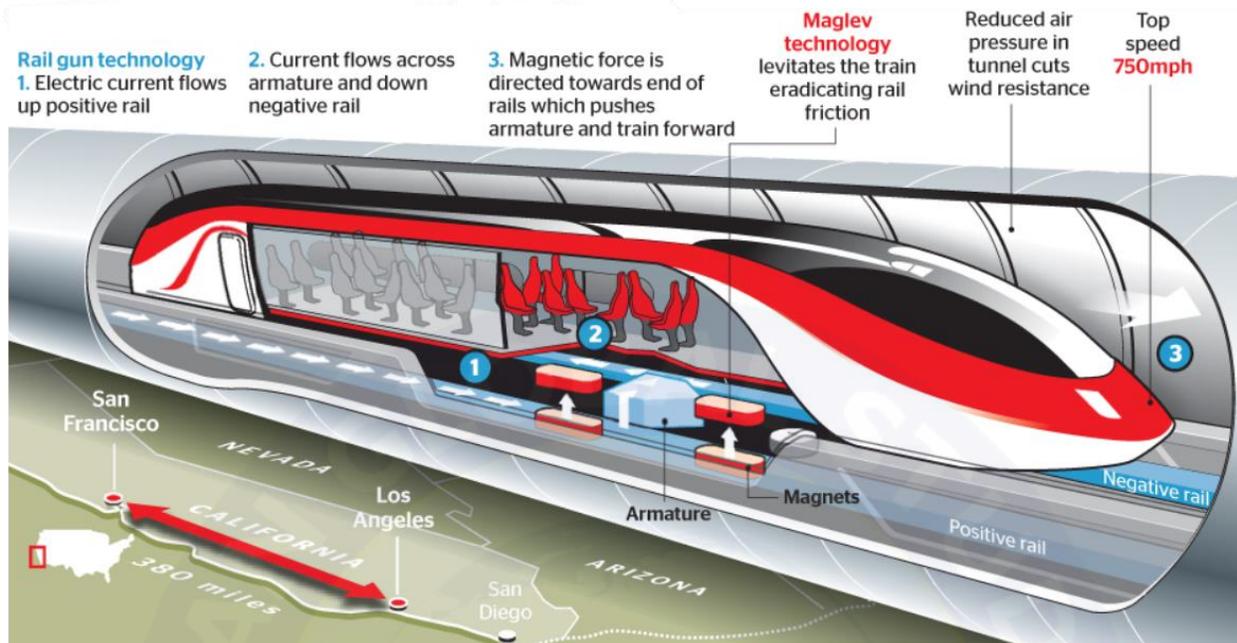
**Figure.2. Hyperloop**

## 2.2. Working of a Hyperloop Train

- A hyperloop train is based on the concept of a **vactrain,** which is a **train that travels in a vacuum tube, using magnetic levitation** (maglev) to float above the tracks and reduce friction.
- It **uses superconducting magnets** to create a powerful magnetic field that propels the train forward.
- It also uses a linear motor to accelerate and decelerate the train and a compressor to suck the remaining air out of the tube.
- The result is a train that can travel at hypersonic speeds, with minimal energy consumption and environmental impact.
- A hyperloop train could potentially transport passengers and cargo across continents in minutes, revolutionizing the transportation industry.

## 2.3. Advantages of Hyperloop

- **Speed:** The technology aims to propel passenger or cargo pods at speeds of over 1000 km/h. This is **3x faster** than high-speed rail and more than 10x faster than traditional rail.
- **Lower carbon emissions:** The hyperloop offers **low-energy long-distance travel,** running on electricity and solar energy. **Solar panels** on the roof of above-ground hyperloops could generate energy. The tubes could also **store electricity** with the help of batteries.
- **Weatherproof:** The hyperloop is **less vulnerable** to bad weather such as rain, snow, wind, and earthquakes. There's no risk of train tracks buckling due to the heat in summer as with high-speed rail.
- **Less invasive:** It's easier to add layers of tunnels than a lane to a road. Stations could be as small as two parking spaces and thus easily integrated into city centers, parking garages, and residential areas.

## 2.4. Limitations of Hyperloop

- **Costs:** It's hard to price the construction and infrastructure costs. They will also require regular maintenance.
- **Fire Safety:** While the low-pressure environment prevents fire from breaking out in the tubes, a fire inside a pod is a real threat.
- **Communication system challenges:** The steel tube prevents wireless signals from reaching the pod. Further, due to the high speeds, pods often switch between communication cells, increasing the chance of handover failure, and temporary communication loss.
- **Emergency evacuation:** Evacuating a hyperloop is difficult as the tubes are designed to have a limited number of exits.

# 3. Autonomous Vehicle

## 3.1. What is an Autonomous Vehicle?
- An autonomous vehicle, or a driverless vehicle, is one that is able to operate itself and perform necessary functions without any human intervention, through the ability to sense its surroundings.
- An autonomous vehicle **utilizes a fully automated driving system** in order to allow the vehicle to respond to external conditions that a human driver would manage.

## 3.2. Levels of Autonomous Vehicles
- **0 Level (No Driving Automation):** Car has no control over its operation. Human driver does all of the driving.
- **1st Level (Driver Assistance):** Vehicle's ADAS (advanced driver assistance system) has the ability to support the driver with either steering or accelerating and braking.
- **2nd Level (Partial Driving Automation):** ADAS can oversee steering, accelerating and braking in some conditions. Human driver is required to continue paying complete attention to the driving environment throughout the journey and perform the remainder of the necessary tasks.
- **3rd Level (Conditional Driving Automation):** Advanced driving systems can perform all parts of the driving task in some conditions, but the human driver is required to be able to regain control when required.
- **4th Level (High Driving Automation):** Advanced driving systems perform all driving tasks independently in certain conditions where human attention is not required.
- **5th Level (Full Driving Automation):** Full automation. Advanced driving systems perform all tasks in all conditions, and no driving assistance is required from the human driver.

## 3.3. Advantages of Autonomous Vehicles
- **Decreased Casualties:** Vehicle crashes cause many deaths every year, and automated vehicles could potentially decrease the number of casualties as the software used in them is likely to make fewer errors in comparison to humans.
- **Reduce traffic congestion:** A decrease in the number of accidents could also reduce traffic congestion, which is a further potential advantage posed by autonomous vehicles.
- **Benefit for old and disabled people:** People who are not able to drive – due to factors like age and disabilities – could be able to use automated cars as more convenient transport systems.

- **Less fatigue:** Additional advantages that come with an autonomous car are elimination of driving fatigue.

## 3.4. Limitations of Autonomous Vehicles

- **Security issues:** To communicate and coordinate with one another, automated vehicles must use the same network protocol. However, if many cars share the same network, they are vulnerable to a hack. Therefore, autonomous cars may have serious security issues.
- **High Cost of Vehicles:** Although significant progress has been made in lowering the cost of producing their implements, these reductions are not significant enough to make them a financially viable option for the average family. Autonomous vehicles could cost hundreds of thousands of dollars. As a result, a large group will be unable to afford it.
- **Who Will Be Guilty:** Who is to blame if a car crashes without a driver: the software designer or the vehicle owner? Undoubtedly, driverless cars will spark numerous debates about legal, ethical, and financial responsibility.
- **Misunderstanding:** Human behavior is complex and unpredictable. A computer cannot comprehend heavy foot traffic, jaywalking, or hand signals. In situations where drivers must deal with erratic human behaviour or communicate with one another, the driverless vehicle may fail.
- **Rise In Unemployment:** Another disadvantage of self-driving cars will be increased unemployment in the transportation sector, as many cab drivers will no longer be needed.
- **Weather issues:** The sensors in self-driving cars are also vulnerable to inclement weather. For example, if there is heavy rain or a snowstorm, it is difficult for autonomous vehicles to navigate properly because the sensors may not work reliably.

# 4. Unmanned Aerial Vehicles

## 4.1. What are Unmanned Aerial Vehicles?

- Unmanned aerial vehicles (UAVs) are aircraft with no on-board crew or passengers. They can be **automated 'drones' or remotely piloted vehicles** (RPVs).
- UAVs are a component of an unmanned aircraft system (UAS), which include additionally a ground-based controller and a system of communications with the UAV.
- UAV uses **aerodynamic forces** to provide vehicle lift. It can be expendable or recoverable, and can carry a lethal or nonlethal payload.

## 4.2. UAV Application Areas

**Disaster Management**

- UAVs can **visit disaster regions** that are unsafe for manned action in the event of a man-made or environmental catastrophe, such as terrorist strikes, tsunamis, and flooding.
- UAVs can assist in the **collection of data,** the need for quick answers, and the navigation of debris.
- UAVs equipped with sensors, radars, and high-resolution cameras can **aid rescue teams in identifying damage, launching urgent recovery efforts,** and dispatching supplies including first-aid manned helicopters and medical kits.
- A swarm of drones equipped with firefighting equipment can watch, analyze, and track any region in the event of a wildfire without jeopardizing human life.

**Remote Sensing**

- The usage of UAVs serves as a **link between aerial, ground-based and space-borne remotely sensed data.** UAVs' cost-effectiveness and ultralight features enable spatial and temporal resolution observation.
- Disease diagnosis, water quality inspection, famine monitoring, gas and oil yield estimations, conservation of natural resources, geological calamity survey, topographical survey, woodland mapping, hydrological modeling, and crop management are all possible applications of UAV remotely sensed.

**Infrastructure and Construction Inspection**
- Tracking the development of the building project from start to finish ensures that the work on the site is of high quality.
- It may deliver reports to prospective stakeholders that include pictures, video, and 3D mapping. Infrastructure and construction inspection applications can benefit greatly from this approach.
- UAVs are gaining high popularity for evaluating the global system for mobile communication (GSM) towers, keeping an eye on gas pipelines, inspecting power cables, and keeping an eye on building projects.

**Precision Agriculture**
- UAVs could be installed in smart agriculture to **obtain specific information through ground sensors** (quality of water, soil composition, humidity, and so on), spray pesticides, diagnose illness, schedule irrigation, detect weeds, and monitor and manage crops.
- The applicability of UAVs in precision agriculture is a cost-effective and time-saving strategy that can improve agricultural systems' revenue, performance, and agricultural production.
- UAVs combined with remote sensing have the potential to **revolutionize smart farming.** It offers temporal, geographical, and spectral resolution, as well as multi-angular observation and comprehensive vegetation height data.

**Real-time Monitoring of Road Traffic**
- UAVs can accomplish **100% automation** of the transportation industry in road traffic monitoring. As compared to traditional monitoring systems e.g., surveillance cameras, ultrasonic sensors, and circuit analyzers, low-cost UAVs, or drones, can inspect large sections of road.
- Local police can use drones to gain a clear picture of road accidents or to conduct a large security crackdown on illegal activities along the highway, including car theft.
- Some of the other implications include vehicle recognition; raids on suspect cars; pursuing hijackers and armed robbers, or anybody who breaches traffic regulations.

**Forest Inspection and Restoration**
- UAVs could be used to aid in the accomplishment of re-vegetation activities e.g., site infrastructure, site inspection, restoration plan, seedling supply, site maintenance, and biodiversity survey after restoring interventions.
- Existing technology, such as GPS and image sensors, assists UAVs in performing specific tasks, such as fundamental **pre-restoration site inspections** and **monitoring various aspects of biodiversity revival.**

- UAVs could evaluate any alterations in temperature, forest functions, and ecological composition, hence assisting in the surveillance of replanting.
- High-resolution cameras mounted on UAVs can give useful data on natural forests to aid in forest restoration initiatives.

**Space Exploration**
- UAVs offer tremendous potential to carry our space missions such as study about the moon surface and atmosphere.
- Although several planetary exploration techniques are available to perform these missions including rovers, landers, orbiters, flying balloons, flying spacecraft, etc. these techniques are restricted by resolution, limited information and versatility.
- Several government bodies and space agencies including National Aeronautics and Space Administration (NASA) have started using UAVs for other solar bodies.
- UAVs offer a wide coverage area as compared to existing orbiters and rovers.

**Maritime Communication and Surveillance**
- Some UAVs can be installed and remotely operated from small boats, while larger systems rely on onshore architectures to launch and operate.
- This technology is complementary to surface and underwater vehicles since it can be easily controlled in the air at some distance and altitude, and thus communicate at a different speed and position.
- Due to the enormous benefits of UAVs in maritime communication, UAV-to-ship wireless channels must be developed. Furthermore, efficient system testing must be conducted for the promising UAV-to-ship networks.

## 4.3. Challenges and Limitations
- One of the critical challenges is to ensure the security of sensitive data such as position, location etc., from drones or UAVs. As there is **no encryption** on UAV, there is risk of being hijacked.
- In military operations, UAVs are vulnerable to potential **threats of data leakage.** Hackers may usurp complete control of UAV to steal data, invasion of privacy and any illegal activity such as for smuggling.
- Despite the extensive emergence of UAVs, there is a dire **need to devise standardizations from regulatory bodies** for the operations of UAVs in geographic areas of different countries.
- UAVs can also **affect the navigation of commercial airplanes.** So countries should implement regulations and rules for proper operations of UAVs.
- **Limited transmission range, processing capability and slower speed** are also some major concerns in UAVs which need more research contributions and investigations to mature this technology.
- Another major concern of privacy arises with the use of UAVs. UAVs are **incorporated with cameras or other equipment** which can capture photos or record videos; which may result in violation of an individual's privacy.

## 4.4. Drone Rules, 2021
- The Ministry of Civil Aviation has notified the Drone Rules, 2021 in August, 2021.
- These Rules were **published under the Aircraft Act, 1934** and **replaced the Unmanned Aircraft System (UAS) Rules, 2021.**

- The Drone Rules 2021 remove the requirement of any certificate for operating or importing drones.
- The Rules mandated seeking **approval from the Director-General** for the transfer of drones to another person in India.
- The **digital sky platform** shall be developed as a business-friendly single-window online system.
- **No flight permission** is required up to 400 feet in green zones and up to 200 feet in the area between 8 and 12 km from the airport perimeter.
- No pilot license is required for micro drones (for non-commercial use), nano drones and R&D organizations.
- Coverage of drones under Drone Rules, 2021 increased from 300 kg to 500 kg.

**Drone (Amendment) Rules, 2022**
- Drone (Amendment) Rules, 2022 has been notified on 11th February 2022, abolishing the requirement of a drone pilot license.
- **No remote pilot certificate** will be required for operating a drone up to two-kilogram for non-commercial purposes.
- The Remote Pilot Certificate issued by a Directorate General of Civil Aviation approved drone school through the single window Digital Sky platform will be sufficient for operating drones in the country.
- An individual owning any unmanned aircraft system manufactured in India or imported into India on or before 30th of November, 2021 must make an application to register and obtain a unique identification number and state the required details in form D-2 and the stipulated fee under Rule 46.
- To promote Made in India drones, the **import of foreign drones has been prohibited** in the country.

**Drone (Amendment) Rules, 2023**
- The Ministry of Civil Aviation has notified the Drone (Amendment) Rules, 2023 for drone pilots, effective from the 27th of September 2023.
- The move aims to liberalize, promote and facilitate drone operations across the country and make India a global drone hub by 2030.
- The most significant change in the new rules is the removal of the requirement for drone pilots to possess a passport for obtaining a Remote Pilot Certificate.
- Instead, individuals can now use government-issued proof of identity and proof of address, such as Voter ID, Ration Card, or Driving License, to apply for the certificate.
- This change is particularly beneficial for aspiring drone pilots in rural areas, especially those in the agricultural sector, who may not have passports.

# 5. Wi-Fi 7

## 5.1. What is Wi-Fi?
- Wi-Fi, Wireless Fidelity, is a wireless networking technology that allows devices such as computers (laptops and desktops), mobile devices (smartphones and wearables), and other equipment (printers and video cameras) to interface with the Internet.
- It **uses radio waves** to provide high-speed wireless internet and network connections.

## 5.2. What is Wi-Fi 7?

- Wi-Fi 7 is the next-generation Wi-Fi standard to be launched, **based on IEEE 802.11be** — extremely high throughput (EHT).
- The seventh generation of Wi-Fi promises major improvements over Wi-Fi 6 and 6E and could offer speeds up to four times faster.

## 5.3. Key Features of Wi-Fi 7

- With the help of backward compatibility, a Wi-Fi 7 router could connect with devices in 2.4GHz, 5GHz and 6GHz bands, without ever requiring new hardware for the standard.
- Lower Latency will enable faster cloud-based operations like file transfers and gaming.
- With a Multi-Link Operation (MLO), Wi-Fi 7 would be able to combine multiple channels on different frequencies to speed up the connections and hence, lead to better network performance.
- Wi-Fi 7 could theoretically support a bandwidth of up to 330 Gigabits per second per access point. Four times faster than the maximum speed of Wi-Fi 6.

## 5.4. Benefits of Wi-Fi 7

- Wi-Fi 7 is faster, supports more connections, and is more adaptive to maintain reliable low-latency performance.
- These benefits help deliver high-quality video and better cloud gaming, and they serve augmented reality and virtual reality applications that require high throughput and low latency.
- Wi-Fi 7 also tackles congestion and interference, bringing tangible benefits to areas with densely packed devices or neighboring networks that overlap.

| Parameters | WiFi-5 | WiFi 6 | WiFi 6E | WiFi 7 |
|---|---|---|---|---|
| Introduced | 2013 | 2019 | 2021 | 2024 |
| Max Speed | 3.5 Gbps | 9.6 Gbps | 9.6 Gbps | 46 Gbps |
| Bands | 2.4 GHz, 5 GHz | 2.4 GHz, 5 GHz | 6 GHz | 2.4 GHz, 5 GHz, and 6 GHz |
| Multi-link Operation | No | No | No | Yes |
| Security | WPA 2 | WPA 3 | WPA 3 | WPA 3 |
| Channel Size | 20, 40, 80, 80+80, 160 MHz | 20, 40, 80, 80+80, 160 MHz | 20, 40, 80, 80+80, 160 MHz | 20, 40, 80, 80+80, 160MHz, 320MHz |

# 6. 3D Printing

## 6.1. What is 3D Printing?

- 3D printing or additive manufacturing **uses computer-aided designing to make prototypes or working models of objects** by laying down successive layers of materials such as plastic, resin, thermoplastic, metal, fiber or ceramic.
- With the help of software, the model to be printed is first developed by the computer, which then gives instructions to the 3D printer.

## 6.2. How does 3D Printing Work?

**Virtual Design**
- First, a virtual design of the object is made. This design will work like a blueprint for the 3D printer to read.
- The virtual design is made **using computer-aided design (CAD) software.** A virtual design can also be made using a **3D scanner,** which creates a copy of an existing object by basically taking pictures of it from different angles.

**Slicing**
- Once the virtual model is made, it must be prepared for printing. This is done by breaking down the model into many layers using a process called slicing.
- Slicing takes the model and slices it into hundreds or even thousands of thin, horizontal layers using special software.

**Printing**
- After the model has been sliced, the slices are ready to be uploaded to the 3D printer.
- This is done using a USB cable or Wi-Fi connection to move the sliced model from the computer it's on to the 3D printer.
- When the file is uploaded to the 3D printer, it reads every slice of the model and prints it layer by layer.

## 6.3. Applications

**Prototyping**
- 3D printing is used to quickly create prototypes for visual aids, assembly mockups and presentation models.

**Lightweight Parts**
- Fuel efficiency and emissions reductions are driving the need for lightweight parts via 3D printing in aerospace and automotive applications.

**Functionally Enhanced Products**
- 3D printing removes many of the constraints imposed by traditional manufacturing processes that prevent engineers from truly designing for optimal performance.

**Custom Medical Implants**
- To achieve osseointegration, manufacturers are using 3D printing to precisely control surface porosity to better mimic real bone structure.

**Toolings, Jigs And Features**
- 3D printed composite tooling and machining fixtures are often cheaper and faster to produce and conformally cooled inserts for injection moulds can dramatically reduce cycle times.

**Metal Casting Patterns**
- Combining 3D printing with metal casting bridges the gap between generative designed parts and proven manufacturing approaches for large metal objects.

## 6.4. Advantages of 3D printing

- **Flexible Design:** 3D printing allows for the **design and print of more complex designs** than traditional manufacturing processes.
- **Rapid Prototyping:** 3D printing can **manufacture parts within hours,** which speeds up the prototyping process.
  - When compared to machining prototypes, 3D printing is **inexpensive and quicker at creating parts**.
- **Print on Demand:** As 3D printing **doesn't need a lot of space to stock inventory,** unlike traditional manufacturing processes.
  - **Edits to designs can also be made at very low costs** by editing individual files without wastage of out of date inventory and investing in tools.
- **Strong and Lightweight Parts:** The main 3D printing **material used is plastic,** which **offer advantages** as they are **lighter than their metal equivalents.**
  - Also, parts **can be created from tailored materials to provide specific properties** such as heat resistance, higher strength or water repellency.
- **Reduction in Waste:** The production of parts only requires the materials needed for the part itself, with **little or no wastage as compared to alternative methods** which are cut from large chunks of non-recyclable materials.
- **Cost Effective:** As a single step manufacturing process, 3D printing **saves time and therefore costs associated** with using different machines for manufacture.
- **Advanced Healthcare:** 3D printing is being **used in the medical sector to help save lives** by printing organs for the human body such as livers, kidneys and hearts.

## 6.5. Limitations of 3D printing
- **Limited Materials:** As **not all metals or plastics can be temperature controlled** enough to allow 3D printing. In addition, **many of these printable materials cannot be recycled.**
- **Restricted Build Size:** 3D printers currently have **small print chambers which restrict the size of parts** that can be printed.
  - Anything bigger will **need to be printed in separate parts and joined** together after production.
- **Post Processing:** Most 3D printed parts **need some form of cleaning up to remove support material** from the build and to smooth the surface to achieve the required finish.
- **Part Structure:** With 3D printing, parts are **produced layer-by-layer.** Although these layers adhere together it also means that they **can delaminate under certain stresses or orientations.**
- **Reduction in Manufacturing Jobs:** Another of the disadvantages of 3D technology is the **potential reduction in human labour, since most of the production is automated** and done by printers.
- **Design Inaccuracies:** Another potential problem with 3D printing is directly related to the type of machine or process used, with **some printers having lower tolerances,** meaning that **final parts may differ** from the original design.
- **Copyright Issues:** As 3D printing is becoming more popular and accessible there is a greater possibility for people to create **fake and counterfeit products** and it will almost be impossible to tell the difference.