

# **3D Printer**

Submitted in partial fulfillment of the requirements  
of the degree of

## **Bachelor of Engineering**

in

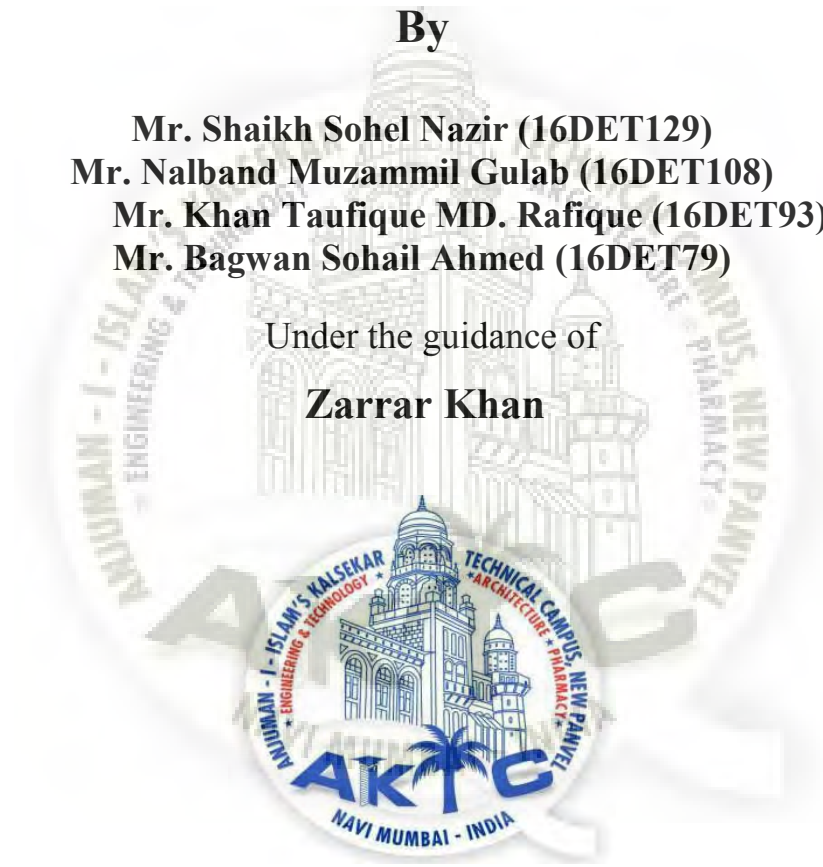
## **Electronics & Telecommunication**

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2018-19

# CERTIFICATE



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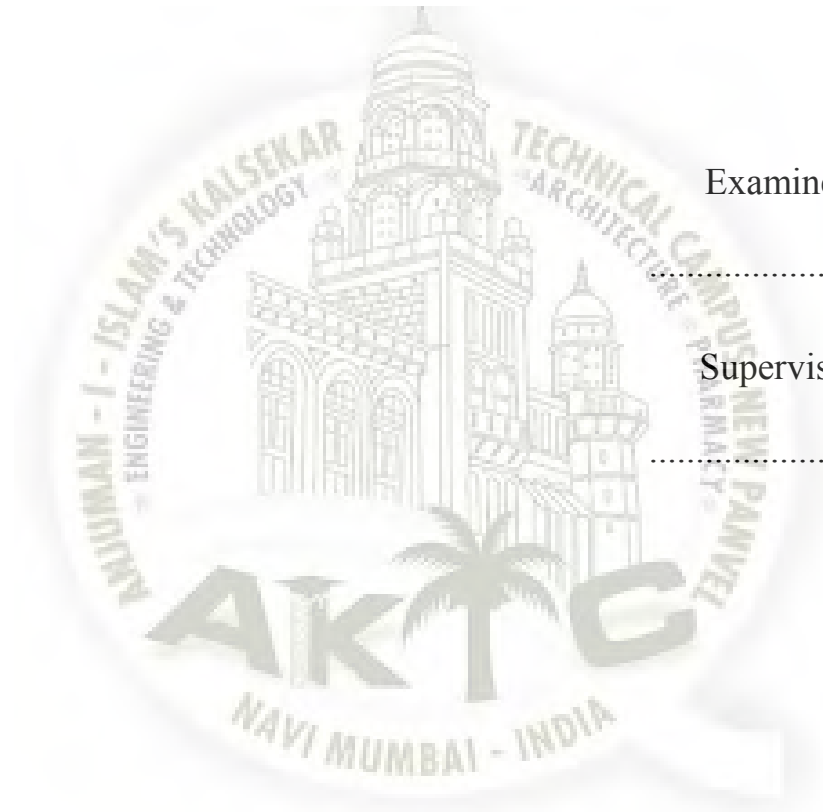
This is to certify that the project entitled “**3D PRINTER**” is a bonafide work of **Mr. Shaikh Sohel Nazir (16DET129)**, **Mr. Nalband Muzammil Gulab (16DET108)**, **Mr. Khan Taufique MD. Rafique (16DET93)**, **Mr. Bagwan Sohail Ahmed (16DET79)** submitted to the University of Mumbai in partial fulfillment of the requirement for the award of the degree of Bachelor of Engineering in Department of Electronics and Telecommunication Engineering.

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## Project Report Approval for Bachelor of Engineering

This project entitled "**3D PRINTER**" by **Mr. Shaikh Sohel Nazir (16DET129), Mr. Nalband Muzammil Gulab (16DET108), Mr. Khan Taufique MD. Rafique (16DET93), Mr. Bagwan Sohail Ahmed (16DET79)** is approved for the degree of **Bachelor of Engineering Electronics and Telecommunication** .



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## Declaration

I declare that this written submission represents my ideas in my own words and where others ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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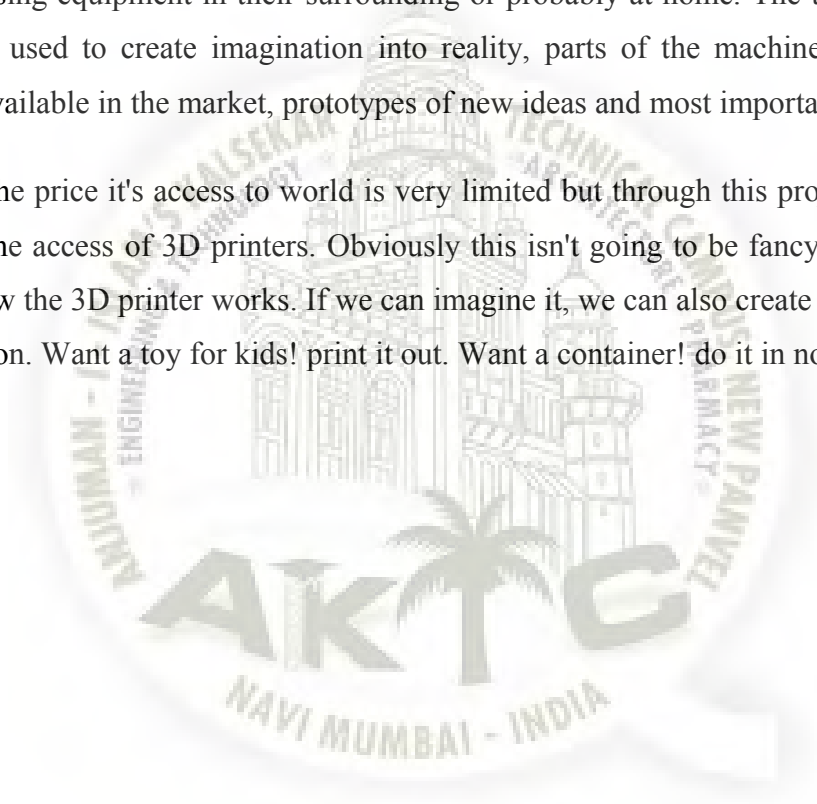
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## ABSTRACT

The inspiration for this project comes from the fact that 3D printer are really innovative and revolutionary idea but along with that they are very costly, one cannot afford the 3D printer just for fun or to use at home just to create ideas into reality. This high cost limits the imagination of the ordinary people. The high quality 3D printers comes at a range of 65000-140000 rupees.

It all starts with imagination of the object we want to create. One can create a affordable 3D printer by using equipment in their surrounding or probably at home. The technology of 3D printing can be used to create imagination into reality, parts of the machinery of equipment which are not available in the market, prototypes of new ideas and most importantly for fun.

Due to the price it's access to world is very limited but through this project there will be an increase in the access of 3D printers. Obviously this isn't going to be fancy but it will show the basics of how the 3D printer works. If we can imagine it, we can also create it. The only limit is our imagination. Want a toy for kids! print it out. Want a container! do it in no time.







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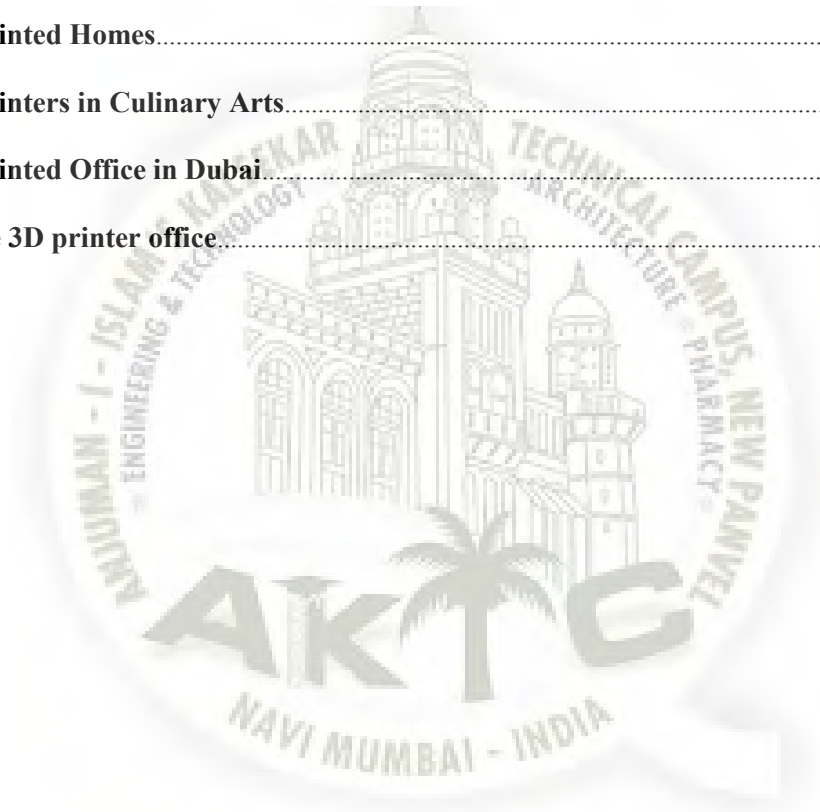
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# Chapter 1

## Introduction

3D printing is a form of additive manufacturing technology where a three dimensional object is created by laying down successive layers of material. It is also known as rapid prototyping, is a mechanized method whereby 3D objects are quickly made on a reasonably sized machine connected to a computer containing blueprints for the object. The 3D printing concept of custom manufacturing is exciting to nearly everyone. This revolutionary method for creating 3D models with the use of inkjet technology saves time and cost by eliminating the need to design; print and glue together separate model parts. Now, you can create a complete model in a single process using 3D printing. The basic principles include materials cartridges, flexibility of output, and translation of code into a visible pattern.



Fig 1.1 Typical 3D printer

3D Printers are machines that produce physical 3D models from digital data by printing layer by layer. It can make physical models of objects either designed with a CAD program or scanned with a 3D Scanner. It is used in a variety of industries including jewelry, footwear, industrial design, architecture, engineering and construction, automotive, aerospace, dental and medical industries, education and consumer products.

3D printing, also known as additive manufacturing (AM), refers to processes used to create a three-dimensional object[1] in which successive layers of material are formed under computer control to create an object.[2] Objects can be of almost any shape or geometry and are produced using digital model data from a 3D model or another electronic data source such as an Additive Manufacturing File (AMF) file.

The term "3D printing" originally referred to a process that deposits a binder material onto a powder bed with inkjet printer heads layer by layer. More recently, the term is being used in popular vernacular to encompass a wider variety of additive manufacturing techniques. United States and global technical standards use the official term additive manufacturing for this broader sense. ISO/ASTM52900-15 defines seven categories of AM processes within its meaning: binder jetting, directed energy deposition, material extrusion, material jetting, powder bed fusion, sheet lamination and vat photopolymerization.

## Chapter 2

### History

The 1980s: Birth of the 3 main 3D Printing Techniques.

The first 3D printing attempts are granted to Dr Kodama for his development of a rapid prototyping technique in 1980. He was the first to describe a layer by layer approach for manufacturing, creating an ancestor for SLA: a photosensitive resin was polymerised by an UV light.. Unfortunately, he did not file the patent requirement before the deadline. Four years later, a French team of engineers was interested by the stereolithography but abandoned due to a lack of business perspective. In the same time, Charles Hull was also interested in the technology and deposited a first patent for stereolithography (SLA) in 1986. He founded the 3D Systems Corporation and a year later, released the SLA-1. In 1988, at the University of Texas, Carl Deckard brought a patent for the SLS technology, another 3D printing technique in which powder grains are fused together locally by a laser. In the meantime, Scott Crump, a co-founder of Stratasys Inc. filed a patent for Fused Deposition Modelling (FDM): the third of the main 3D printing technologies, in which. Over less than ten years, the three main technologies of 3D printing were patented and 3D printing was born!

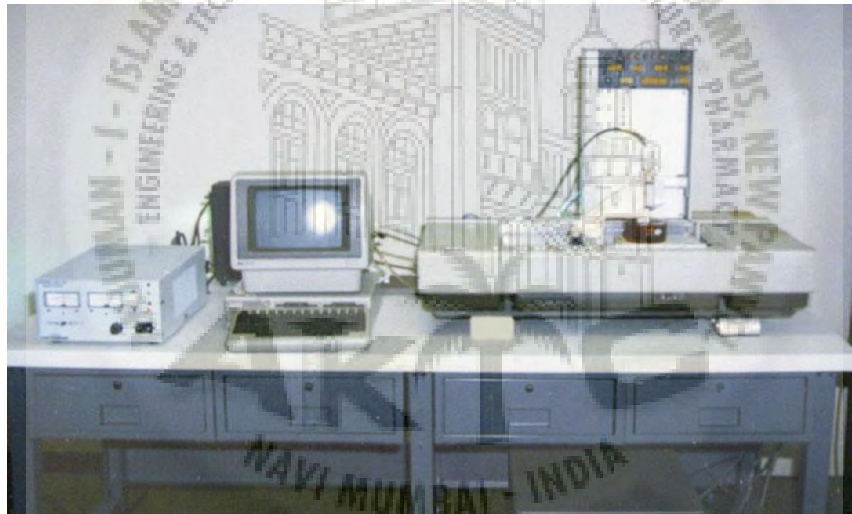


Fig 2.1 3D Printer in 1980's

Recap:

1980: first patent by Japanese Dr Kodama Rapid prototyping

1984: Stereolithography by French then abandoned

1986: Stereolithography taken up by Charles Hull

1987: First SLA-1 machine

1988: first SLS machine by DTM Inc then buy by 3D system

The 1990s: Emergence of the Main 3D Printers Manufacturers & CAD tools

In Europe, EOS GmbH was founded and created the first EOS —Stereosl system for industrial prototyping and production applications of 3D printing. Its industrial quality is today recognized worldwide in SLS technology for plastics and metals. In 1992, the Fused Deposition Modeling patent was issued to Stratasys, who that developed many 3D printers for both professional and individuals. From 1993 to 1999, the main actors of the 3D

printing sector emerged with various techniques: ZCorp and binder jetting: Based on MIT's inkjet printing technology, they created the Z402, which produced models using starch- and plaster-based powder materials and a water-based liquid binder. Arcam MCP technology and

Selective Laser Melting. At the same time, CAD tools for 3D printing became more and more available and developed, with for example the creation of Sanders Prototype (now known as Solidscape), one of the first actors to develop specific tools for additive manufacturing. The 1990s were also the decade of the first application of 3D printing by medical researchers, who started to combine medicine and 3D printing, opening the path to many uses.



Fig 2.2 Charles Hull's 3D printer

Charles Hull was awarded the European Inventor Award in the Non-European countries category, by the European Patent Office Prize in 2014.

Recap:

1990: First EOS Stereos system

1992: FDM patent to Stratasys

1993: Solidscape was founded

1995: Z Corporation obtained an exclusive license from the MIT

1999: Engineered organs bring new advances to medicine

The 2000s: 3D Printing Gains Media Visibility

In 2000, the millennium saw the first 3D printed working kidney. We will have to wait 13 more years to see it transplanted into a patient. 3D printed kidneys are now perfectly working and researchers are experimenting on accelerated growth to transplant organs very rapidly. 2004 was the year of the initiating of the RepRap Project which consists in a self-replicating 3D printer. This open source project led to the spreading of the FDM 3D desktop 3D printers, and of the popularity of the technology in the makers community. In 2008, 3D printing reached an even greater media presence thanks to another medical application: the first 3D printed prosthetic limb. It incorporated all parts of a biological limb, was printed 'as is', without the need for any later assembly. Nowadays, combined with 3D scanning, medical prosthesis and orthosis are more and more cheaper and extremely fast to obtain. 2009 was the year in which the FDM patents fell into the public domain, opening the way to a wide wave of innovation in FDM 3D printers, a drop of the desktop 3D printers price, and consequently, since the technology was more



accessible, an increased visibility. 2009 was also the year Sculpteo was created, one of the pioneer of the now flourishing online 3D printing services, another step toward 3D printing accessibility.

Recap:

2000: a 3D printed working kidney is created

2000: MCP Technologies (an established vacuum casting OEM) introduced the SLM technology

2005: Z Corp. launched Spectrum Z510. It was the first high-definition color 3D Printer on the market.

2006: An open source project is initiated (Reprap)

2008: The first 3D printed prosthetic leg

2009: FDM patents in the public domain

2009: Sculpteo is created

The 2010s: Years of Visibility, Innovation and Hopes for 3D Printing

The recent years have been very important for 3D Printing. With the FDM patent expiration, the first years of the decade have become the years of 3D printing. The desktop technology invaded the market and made the industrial sector rethink about additive manufacturing as a reliable production technique. The revolution additive manufacturing could bring in common consumption was written about extensively, and even though this total shift of consumption habits hasn't happened yet, 3D printing is getting into common imaginations and practices. In 2013, President Barack Obama mentioned 3D printing as a major issue for the future in his State of the Union speech, which finished to make —3D printing an absolute buzzword. It is now very present in the general public's mind, and in policy makers' decisions. The technology is forever progressing, just as are the uses of this technology. More and more small and big companies take advantage of the low prototyping price that 3D printing offers, and have fully integrated it in their iteration, innovation and production processes. In 2010, Urbee was the first 3D printed prototype car. Its body was fully 3D printed using a very large 3D printer. Now, the 3D printed car is much more a dream than a reality but in the manufacturing process, many actors are considering it as a good alternative to traditional methods. In 2011, Cornell University began to build a 3D food printer. At first sight, it could seem slightly trivial, but NASA is now researching how astronauts could 3D print food for in space. In 2014, NASA brought a 3D printer in space to make the first 3D printed object off of the earth. Many medical 3D printing advances: tissues, organs and low-cost prosthesis. New 3D printers are being issued regularly, they are more efficient, they print faster, they give access to new 3D printing materials, A good example is the Carbon 3D CLIP technology, which we offer as a service on our platform since March 2016, and which 3D prints strong mechanical resins at an unequaled speed.

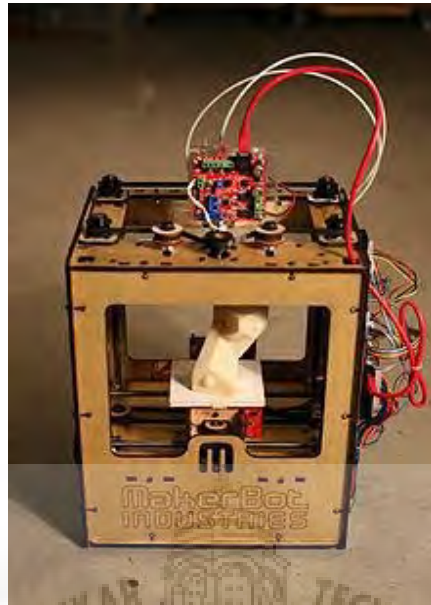


Fig 2.3 Carbon 3D CLIP technology

New 3D printing materials are being explored every day, from Daniel Kelly's lab who's 3D printing bone to the French startup XtreeE, who's 3D printing concrete to revolutionize the construction industry!

At the same time, efforts are constantly made to make 3D printing more accessible, through education (see our ebook on how to Graduate in 3D printing), shared spaces like fablabs and makerspaces, and of course 3D printing services like ours: we're constantly adding new materials to our catalogue, new repair and optimisation tools to make sure you 3D print exactly what you had in mind, and new ebooks and tutorials so you master the technology from design to finish.

Recap:

- 2010: Urbee is the first 3D printed prototype car presented
- 2011: Cornell University began to build 3D food printer.
- 2012: The first prosthetic jaw is printed and implanted
- 2013: —3D printing in Obama's State of the Union speech
- 2015: Carbon 3D issues their revolutionary ultra-fast CLIP 3D printing machine
- 2016: Daniel Kelly's lab announces being able to 3D print bone

## Chapter 3

### Principle

#### 3.1 Modeling

3D printable models may be created with a computer-aided design (CAD) package, via a 3D scanner, or by a plain digital camera and photogrammetry software. 3D printed models created with CAD result in reduced errors and can be corrected before printing, allowing verification in the design of the object before it is printed.

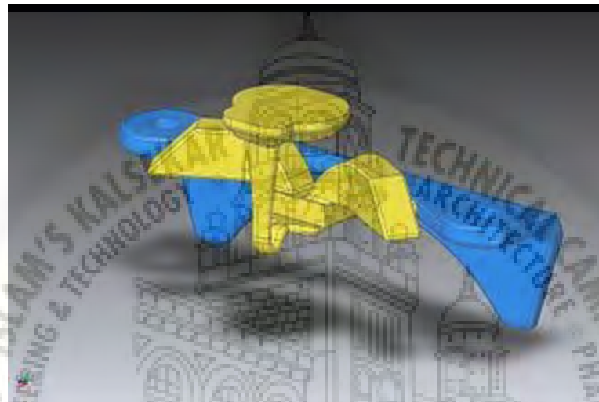


Fig 3.1 CAD model used for 3D printing

**Stereolithography (SLA):** The most commonly used technology in this processes is Stereolithography (SLA). This technology employs a vat of liquid ultraviolet curable photopolymer resin and an ultraviolet laser to build the object's layers one at a time. For each layer, the laser beam traces a cross-section of the part pattern on the surface of the liquid resin. Exposure to the ultraviolet laser light cures and solidifies the pattern traced on the resin and joins it to the layer below.

After the pattern has been traced, the SLA's elevator platform descends by a distance equal to the thickness of a single layer, typically 0.05 mm to 0.15 mm (0.002" to 0.006"). Then, a resin-filled blade sweeps across the cross section of the part, re-coating it with fresh material. On this new liquid surface, the subsequent layer pattern is traced, joining the previous layer. The complete three dimensional object is formed by this project. Stereolithography requires the use of supporting structures which serve to attach the part to the elevator platform and to hold the object because it floats in the basin filled with liquid resin. These are removed manually after the object is finished.

This technique was invented in 1986 by Charles Hull, who also at the time founded the company, 3D Systems.

**Digital Light Processing (DLP):** DLP or Digital Light Processing refers to a method of printing that makes use of light and photosensitive polymers. While it is very similar to stereolithography, the key difference is the light-source. DLP utilises traditional light-sources like arc lamps.

Carbon (who invented a subtype of DLP called CLIP).

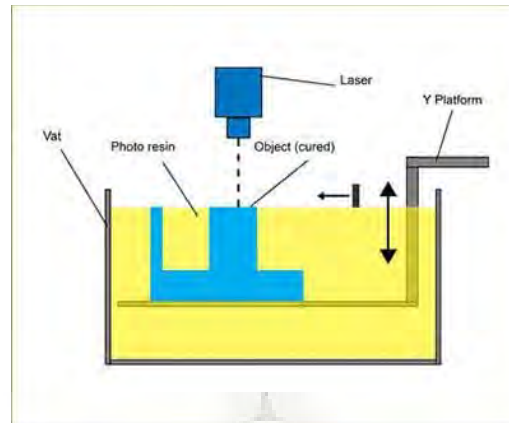


Fig 3.2 Continuous Liquid Interface Production (CLIP)

Continuous Liquid Interface Production (CLIP) : Other technologies using Vat Photopolymerisation are the new ultrafast Continuous Liquid Interface Production or CLIP and marginally used older Film Transfer Imaging and Solid Ground Curing.

### 3.2 Material Jetting

In this process, material is applied in droplets through a small diameter nozzle, similar to the way a common inkjet paper printer works, but it is applied layer-by-layer to a build platform making a 3D object and then hardened by UV light.

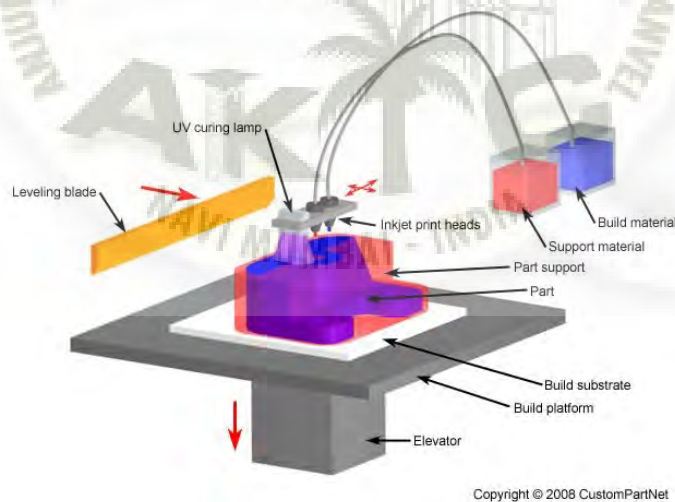


Fig 3.3 Material Jetting

The manual modeling process of preparing geometric data for 3D computer graphics is similar to plastic arts such as sculpting. 3D scanning is a process of collecting digital data on the shape and appearance of a real object, creating a digital model based on it.



Once completed, the STL file needs to be processed by a piece of software called a "slicer," which converts the model into a series of thin layers and produces a G-code file containing instructions tailored to a specific type of 3D printer (FDM printers).[citation needed] This G-code file can then be printed with 3D printing client software (which loads the G-code, and uses it to instruct the 3D printer during the 3D printing process).

Printer resolution describes layer thickness and X-Y resolution in dots per inch (dpi) or micrometers ( $\mu\text{m}$ ). Typical layer thickness is around  $100\ \mu\text{m}$  (250 DPI), although some machines can print layers as thin as  $16\ \mu\text{m}$  (1,600 DPI). X-Y resolution is comparable to that of laser printers. The particles (3D dots) are around 50 to  $100\ \mu\text{m}$  (510 to 250 DPI) in diameter.

Construction of a model with contemporary methods can take anywhere from several hours to several days, depending on the method used and the size and complexity of the model. Additive systems can typically reduce this time to a few hours, although it varies widely depending on the type of machine used and the size and number of models being produced simultaneously.

Traditional techniques like injection moulding can be less expensive for manufacturing polymer products in high quantities, but additive manufacturing can be faster, more flexible and less expensive when producing relatively small quantities of parts. 3D printers give designers and concept development teams the ability to produce parts and concept models using a desktop size printer.

Seemingly paradoxically, more complex objects can be cheaper for 3D printing production than less complex objects.



Fig 3.4 Complex object Design

### ***3.3 Finishing***

Though the printer-produced resolution is sufficient for many applications, printing a slightly oversized version of the desired object in standard resolution and then removing material with a higher-resolution subtractive process can achieve greater precision.

Some printable polymers such as ABS, allow the surface finish to be smoothed and improved using chemical vapor processes based on acetone or similar solvents.

Some additive manufacturing techniques are capable of using multiple materials in the course of constructing parts. These techniques are able to print in multiple colors and

color combinations simultaneously, and would not necessarily require painting. Some printing techniques require internal supports to be built for overhanging features during construction. These supports must be mechanically removed or dissolved upon completion of the print.

All of the commercialized metal 3D printers involve cutting the metal component off the metal substrate after deposition. A new process for the GMAW 3D printing allows for substrate surface modifications to remove aluminum or steel.

### 3.4 Printing Process

A large number of additive processes are available. The main differences between processes are in the way layers are deposited to create parts and in the materials that are used. Each method has its own advantages and drawbacks, which is why some companies offer a choice of powder and polymer for the material used to build the object.[39] Others sometimes use standard, off-the-shelf business paper as the build material to produce a durable prototype. The main considerations in choosing a machine are generally speed, costs of the 3D printer, of the printed prototype, choice and cost of the materials, and color capabilities. Printers that work directly with metals are generally expensive. However less expensive printers can be used to make a mold, which is then used to make metal parts.

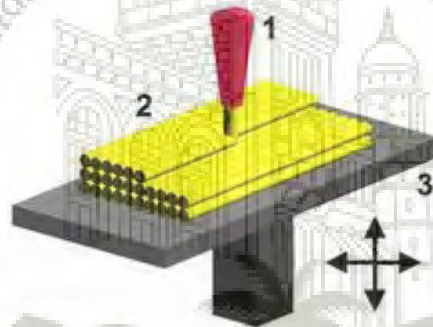


Fig 3.5 Fused deposition modeling:

1 – nozzle ejecting molten material, 2 – deposited material, 3 – movable table.

Some methods melt or soften the material to produce the layers. In Fused deposition modeling (FDM), the model or part is produced by extruding small beads or streams of material which harden immediately to form layers. A filament of thermoplastic, metal wire, or other material is fed into an extrusion nozzle head (3D printer extruder), which heats the material and turns the flow on and off. FDM is somewhat restricted in the variation of shapes that may be fabricated. Another technique fuses parts of the layer and then moves upward in the working area, adding another layer of granules and repeating the process until the piece has built up. This process uses the unfused media to support overhangs and thin walls in the part being produced, which reduces the need for temporary auxiliary supports for the piece. Laser sintering techniques include selective laser sintering, with both metals and polymers, and direct metal laser sintering. Selective laser melting does not use sintering for the fusion of powder granules but will completely melt the powder using a high-energy laser to create fully dense materials in a layer-wise method that has mechanical properties similar to those of conventional manufactured metals. Electron beam melting is a similar type of additive manufacturing technology for metal parts (e.g. titanium alloys). EBM manufactures parts by melting metal powder layer by layer with an electron beam in a high vacuum. Another method consists of an inkjet 3D

printing system, which creates the model one layer at a time by spreading a layer of powder (plaster, or resins) and printing a binder in the cross-section of the part using an inkjet-like process. With laminated object manufacturing, thin layers are cut to shape and joined together.

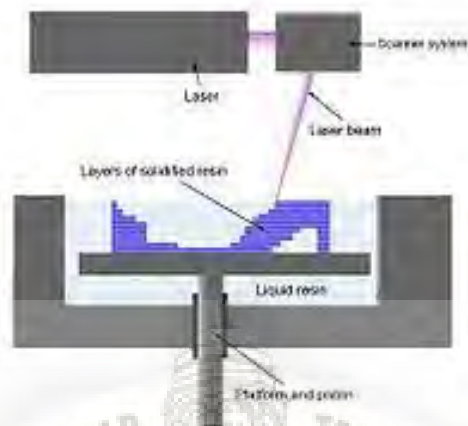


Fig 3.6 Object Manufacturing



## Chapter 4

### Construction And Working

#### 4.1 CNC Machine Hardware

The 3D printers basically depend on the construction and principle of CNC machine. Most of the 3D printers are expensive, but there are some recent trends in 3D printer which causes reduction in the price of 3D printer. Mostly 3D printer are use for more in hobbies rather than industrial application. Companies have also realized the potential of a consumer market for 3D printers and as such have been aggressively courting enthusiasts with cheaper and better models.

The first step is to collect all the requirements for the project. The basic equipment require is stepper motor. The base for the stepper motor. Computer CD ROM hard drive can also used for the stepper motor along with its base.

- ⌚ stepper motor with driver board or CD and DVD drive
- ⌚ Floppy Drive Motor
- ⌚ 1x Desktop Computer Power Supply
- ⌚ 1x Arduino mega
- ⌚ Wires
- ⌚ Various screws/nuts/bolts
- ⌚ Soldering Iron
- ⌚ 2x rectangular casing for printing
- ⌚ 2x metallic square plate
- ⌚ M-M/M-F wires
- ⌚ Drill.



Fig 4.1 Materials required

### 4.1.1 CD ROM

A CD-ROM in the tray of a partially open CD-ROM drive.

CD-ROMs are identical in appearance to [audio CDs](#), and data are stored and retrieved in a very similar manner (only differing from audio CDs in the standards used to store the data). Discs are made from a 1.2 mm thick disc of [polycarbonate plastic](#), with a thin layer of [aluminium](#) to make a reflective surface. The most common size of CD-ROM is 120 mm in diameter, though the smaller [Mini CD](#) standard with an 80 mm diameter, as well as [shaped compact discs](#) in numerous non-standard sizes and molds (e.g., [business card-sized media](#)) are also available.

Data is stored on the disc as a series of microscopic indentations. A [laser](#) is shone onto the reflective surface of the disc to read the pattern of pits and lands ("pits", with the gaps between them referred to as "lands"). Because the depth of the pits is approximately one-quarter to one-sixth of the wavelength of the laser light used to read the disc, the reflected [beam's phase](#) is shifted in relation to the incoming beam, causing [destructive interference](#) and reducing the reflected beam's intensity. This pattern of changing intensity of the reflected beam is converted into binary data.

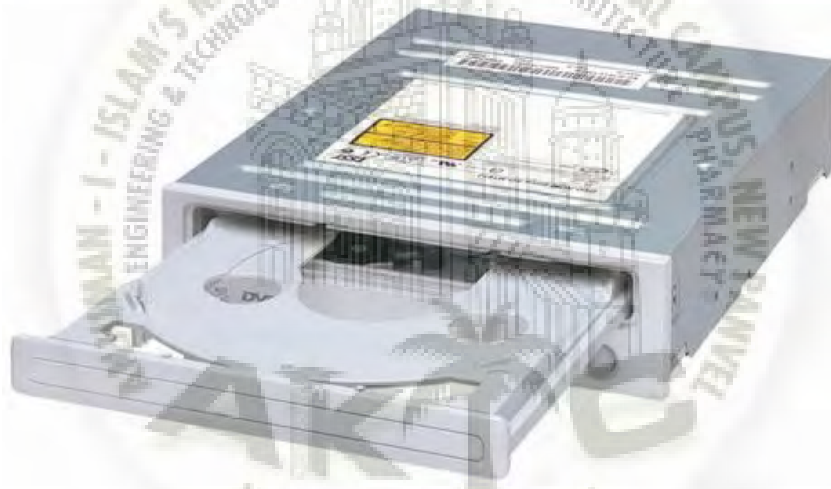


Fig 4.2 CD ROM

### 4.1.2 Power supply

A **switched-mode power supply** (**switching-mode power supply**, **switch-mode power supply**, **switched power supply**, **SMPS**, or **switcher**) is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently. Like other power supplies, an SMPS transfers power from a DC or AC source (often mains power) to DC loads, such as a personal computer converting voltage and current characteristics.





Fig 4.3. SMPS

Unlike a linear power supply, the pass transistor of a switching-mode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy. Ideally, a switched-mode power supply dissipates no power. Voltage regulation is achieved by varying the ratio of on-to-off time. In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. This higher power conversion efficiency is an important advantage of a switched-mode power supply. Switched-mode power supplies may also be substantially smaller and lighter than a linear supply due to the smaller transformer size and weight

#### 4.1.3 Stepper motor

A stepper motor or step motor or stepping motor is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor's position can then be commanded to move and hold at one of these steps without any feedback sensor (an open-loop controller), as long as the motor is carefully sized to the application in respect to torque and speed.

Stepper motors effectively have multiple "toothed" electromagnets arranged around a central gear-shaped piece of iron. The electromagnets are energized by an external driver circuit or a micro controller. To make the motor shaft turn, first, one electromagnet is given power, which magnetically attracts the gear's teeth. When the gear's teeth are aligned to the first electromagnet, they are slightly offset from the next electromagnet. This means that when the next electromagnet is turned on and the first is turned off, the gear rotates slightly to align with the next one. From there the process is repeated. Each of those rotations is called a "step", with an integer number of steps making a full rotation.

A step motor can be viewed as a synchronous AC motor with the number of poles (on both rotor and stator) increased, taking care that they have no common denominator. Additionally, soft magnetic material with many teeth on the rotor and stator cheaply multiplies the number of poles (reluctance motor). Modern steppers are of hybrid design, having both permanent magnets and soft iron cores.

time is spent at full current — thus reducing motor torque. As speeds further increase, the current will not reach the rated value, and eventually the motor will cease to produce torque.

**Bipolar Motors :** Bipolar motors have a single winding per phase. The current in a winding needs to be reversed in order to reverse a magnetic pole, so the driving circuit must be more complicated, typically with an H-bridge arrangement (however there are several off-the-shelf driver chips available to make this a simple affair). There are two leads per phase, none are common.

Static friction effects using an H-bridge have been observed with certain drive topologies. Dithering the stepper signal at a higher frequency than the motor can respond to will reduce this "static friction" effect. Though a bipolar stepper motor is more complicated to drive, the abundance of driver chips means this is much less difficult to achieve. An 8-lead stepper is wound like a unipolar stepper, but the leads are not joined to common internally to the motor.

Because windings are better utilized, they are more powerful than a unipolar motor of the same weight. This is due to the physical space occupied by the windings. A unipolar motor has twice the amount of wire in the same space, but only half used at any point in time, hence is 50% efficient (or approximately 70% of the torque output available). Though a bipolar stepper motor is more complicated to drive, the abundance of driver chips means this is much less difficult to achieve.

An 8-lead stepper is wound like a unipolar stepper, but the leads are not joined to common internally to the motor.

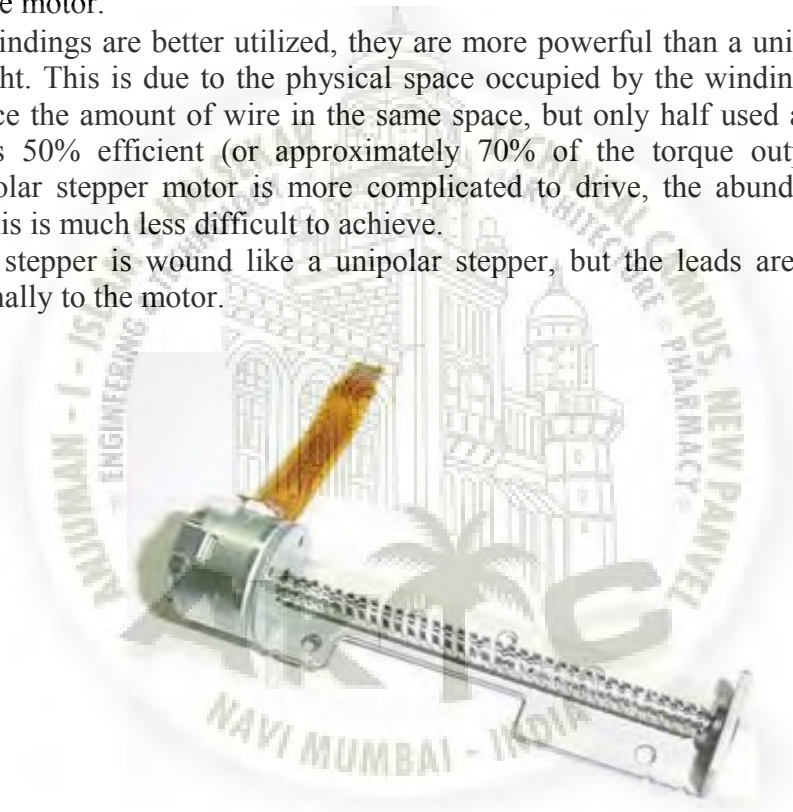


Fig 4.4 Stepper Motor

#### ***4.1.4 Arduiono Mega***

Arduino is an open source, computer hardware and software company, project, and user community that designs and manufactures microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical world. The project's products are distributed as open-source hardware and software, which are licensed under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL), permitting the manufacture of Arduino boards and software distribution by anyone. Arduino boards are available commercially in preassembled form, or as do-it-yourself kits.



Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers. The microcontrollers are typically programmed using a dialect of features from the programming languages C and C++. In addition to using traditional compiler toolchains, the Arduino project provides an integrated development environment (IDE) based on the Processing language project. Common examples of such devices intended for beginner hobbyists include simple robots



Fig 4.5 Arduino Mega

#### 4.1.5 RAMPS 1.4

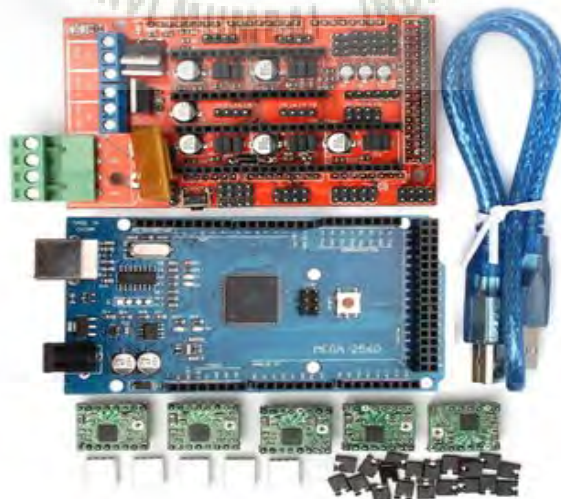


Fig 4.6 Ramps 1.4 with A488

RAMPS 1.4 is probably the most widely used electronics for RepRap machines as of March 2014. It consists of a RAMPS 1.4 shield, an Arduino Mega 2560 board (or a clone), and a max of five Pololu Stepper drivers. It can control up to 5 stepper motors with 1/16 stepping precision and interface with a hotend, a heatbed, a fan (or a second hotend), a LCD controller, a 12V (or 24V with appropriate modification) power supply, up to three thermistors, and up to six end stoppers.

The A4988 is a microstepping driver for controlling bipolar stepper motors which has built-in translator for easy operation. This means that we can control the stepper motor with just 2 pins from our controller, or one for controlling the rotation direction and the other for controlling the steps.

The Driver provides five different step resolutions: full-step, half-step, quarter-step, eighth-step and sixteenth-step. Also, it has a potentiometer for adjusting the current output, over-temperature thermal shutdown and crossover-current protection. Its logic voltage is from 3 to 5.5 V and the maximum current per phase is 2A if good addition cooling is provided or 1A continuous current

#### 4.1.6 Mk8 Extruder Kit

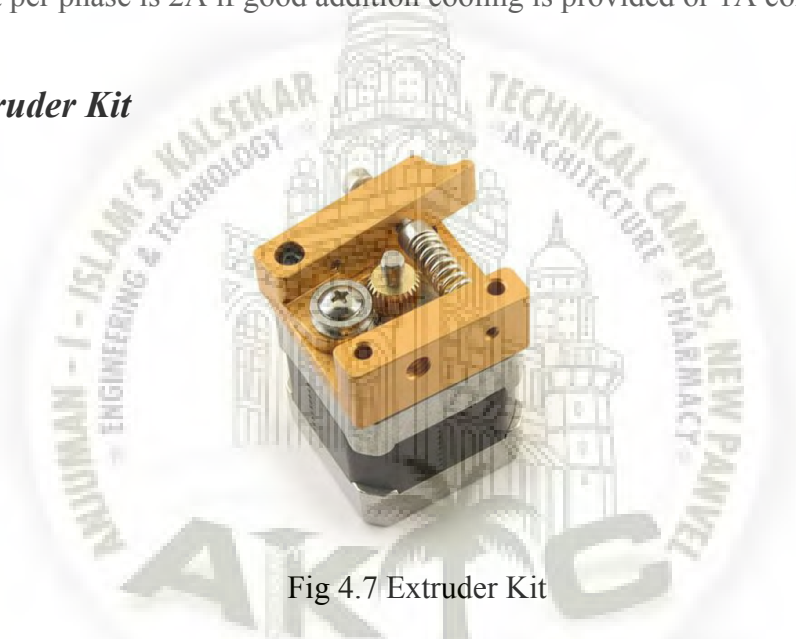


Fig 4.7 Extruder Kit

The fan blows cold air onto the heat sink, so the heat sink deflects the heat from the upper part of the silver column and the filament stays rigid. The rigid filament pushes down on the molten filament and also creates a pressure or force on the molten filament, thus **extruding** it out of the tiny hole in the **nozzle**.

The **filament** extruder on a FDM printer is the part that extrudes the plastic **filament** in a liquid form and deposits it on a printing platform by adding successive layers.

#### 4.1.7 Hot End

The hot end is where the heated filament comes out and moves across the print bed to create your 3D object! Since this is where the filament heats up & partially liquifies, it get's quite hot (250 degrees celsius!) and is insulated from the rest of the printer because you wouldn't want something like this to happen...



Fig 4.8 Hot End

Ok, it definitely won't light you on fire. However, the extruder is hot so be careful not to touch it and burn yourself. Different materials may print best at different temperatures so the sensor is important and it's temperature can be set with your slicing program.

#### 4.1.8 PTFE Tube

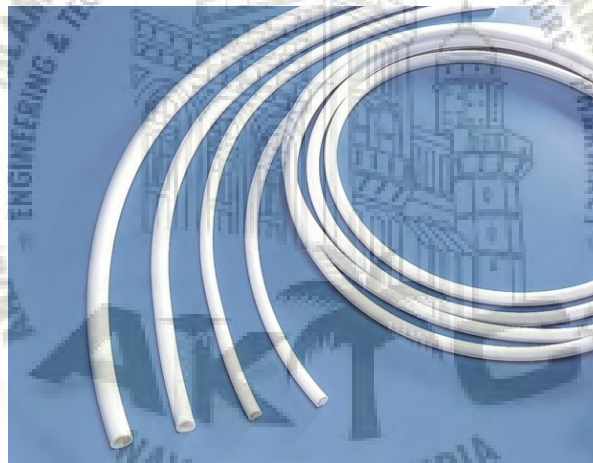


Fig 4.9 PTFE Tube

The highest quality in tubing can be obtained with PTFE tubing. PTFE [stands for polytetrafluoroethylene](#). This substance allows for an extremely durable and yet flexible tube. In fact, PTFE offers the maximum flexibility of any type of tubing.

In addition, the range of temperatures it can withstand is truly staggering — from negative 400 degrees Fahrenheit to 500 degrees Fahrenheit. It is resistant to corrosive substances in both liquid and gas form and maintains this resistance even at high temperatures. Due to its durability and ability to withstand temperatures and corrosives, it is perfect for many applications:

- Laboratory use
- Transfer and containment in chemical processing
- Applications involving high temperatures
- Bearing & brushing applications
- The automotive industry

PTFE tubing is coveted for its low permeability and the fact that it is FDA compliant. In 3D printing applications, it is resistant to the high temperatures present at the print head. It is also extremely flexible, making it perfect for tracking the print head as it moves around the build plate.

#### 4.1.9 Filament

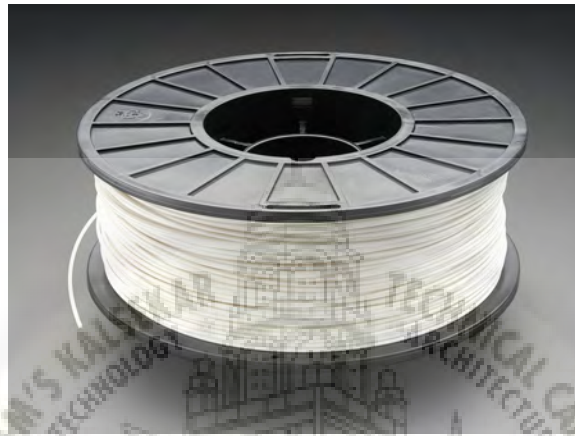


Fig 4.10 Filament

3D printing filament is the thermoplastic feedstock for fused deposition modeling 3D printers.

There are many types of filament available with different properties, requiring different temperatures to print. Filament is available in two standard diameters; 1.75 and 2.85 mm/3 mm

The plastic nurdles are always white or clear. Pigments or other additives are added to the material before it is melted to create coloured filament or filament with special properties, e.g. increased strength or magnetic properties. Before the filament is extruded the nurdles are heated to 80°C to dry it and reduce water content. The nurdles must be dried as many thermoplastics are **hygroscopic** and extrusion of damp plastic causes dimensional flaws (this is also the case when the finished filament is being **printed**). From there the nurdles are fed into a single screw extruder where it is heated and extruded into a filament. The diameter is often measured by a laser as part of a quality control mechanism to ensure correct diameter of the filament. The filament is then fed through a warm water tank which cools the filament which gives the filament its round shape. The filament is then fed through a cold water tank to cool it to room temperature. It is then wound onto a spool to create the finished product.

## 4.2 Mounting the motor trays

Rectangular casing are required to mount the motor trays . The motors are mount in X, Y and Z axis. First the mounting of Y-axis is done. This axis move back and forth. A motor tray is mount on the one of the rectangular casing with the help of nuts and bolts.



Fig 4.11 Required Part of CD ROM

For the X-axis mount it perpendicular to the length of another rectangular casing, again making it close to one end and aligning it as straight as possible.

### X-Axis and Z-Axis

These style of printers have a floating X-axis(gantry) that raises and lowers on the Z-axis while the print head (hot-end) moves back and forth on the X-axis. The gantry moves up and down with two leadscrews powered by 2 motors working in parallel. The leadscrews have the best results when they are paired with a bearing and linear rail as close as possible.

### Y-axis

With these two axis alone, you can only print a flat wall. That is where they moving bed comes in. The Y-axis includes the entire bed and moves back and forth perpendicular to the X-axis. With all 3 of these working together, they can print 3D objects.

### Print platform

These style of printers may or may not have a heated print bed. I highly recommend having a heated bed. Not having a heated bed makes printing very difficult otherwise and it a minimal investment to add to a printer. And almost always having a heated bed, tempered glass is recommended over aluminum. Glass has less of a chance of permanently warping and is far more resistant to wear.





Fig 4.12 Required Part of Floppy Drive

Floppy disk drives use stepper motors for controlling read/write head position. Even early hard disk drives also used steppers, but nowadays hard drives have replaced the steppers with voice-coil servo motors.

The stepper motors used in 5 1/4" floppy disk drives usually move the read/write head using wheel and spring mechanism which works quite well. According one information source those stepper motors used in disk drives were usually 200 or 400 steps per revolution models. 200 steps per revolution models are used in standard density (40 track per disk) drives. High-density floppy-drives have 80 tracks and they use 400 steps per revolution stepper motors. One other information source says that in the old disks steppers each step was 3.6 degrees meaning that it takes 100 steps to fully rotate, in the HD drives each step was 1.8 degrees i.e. 200 steps. I have not have calculated the exact step number myself, so I am not completely sure which of those is correct (maybe there could be different motors used on different drivers, there has been different kind of drive mechanics)

### 4.3 CNC Machine Software

XLoader is program that can be used to upload your own \*.hex files to arduino boards using the bootloader. That means you don't need a flash programmer. To use it compile you're code in something like AvrStudio. Then simply start XLoader.exe, pick a hex file and press upload.

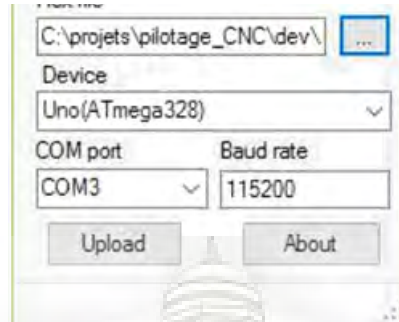


Fig 4.13 Xloader

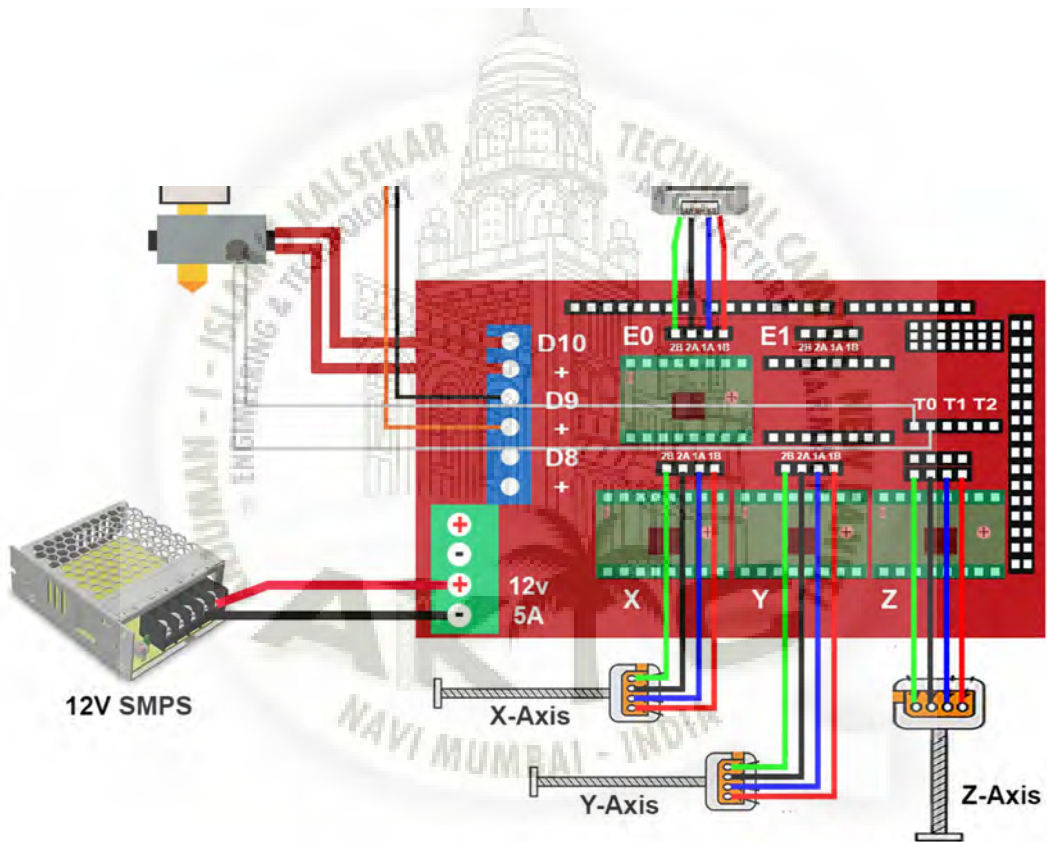
The only thing that's left to do now is to install the software that will make it run. The CNC hardware connection runs on a programming language called G-Code. It essentially tells the X, Y, and Z axis to move towards the specific coordinates. For Arduino to function properly we need to install a Arduino interpreter name Grbl in the computer. The steps that need to take to install Grbl on the Arudion (Uno) are as follows:

- ⌚ Download the Grbl Hex file for specific version of Arduino. For Arduino uno .8c file is preferable.
- ⌚ Download the XLoader software.
- ⌚ Connect Arduino to computer through Arduino cable.
- ⌚ Using the Xloader software, select the Grbl Hex file which was downloaded (as shown in step 1), select the Arduino from the dropdown menu, and select the COM port that the Arduino is connected to.
- ⌚ Click —Upload to upload the Grbl software to the Arduino[10].

Now that the Arduino is set-up and ready to go, we need to install some software that lets us control the moving mechanism of stepper motor. One of the most used program is called Grbl Controller. After downloading and installing it, open it up, select Arduino port and click —Open to connect (Fig. 10). Now use the arrows on the lower right to test the motors movement from step 1 to step 10. If any of the platforms are running backwards, go to Tools > Options and then invert the axis for the backwards motor.



### 4.4 3D Circuit Diagram



## 4.5 3D Printer Software

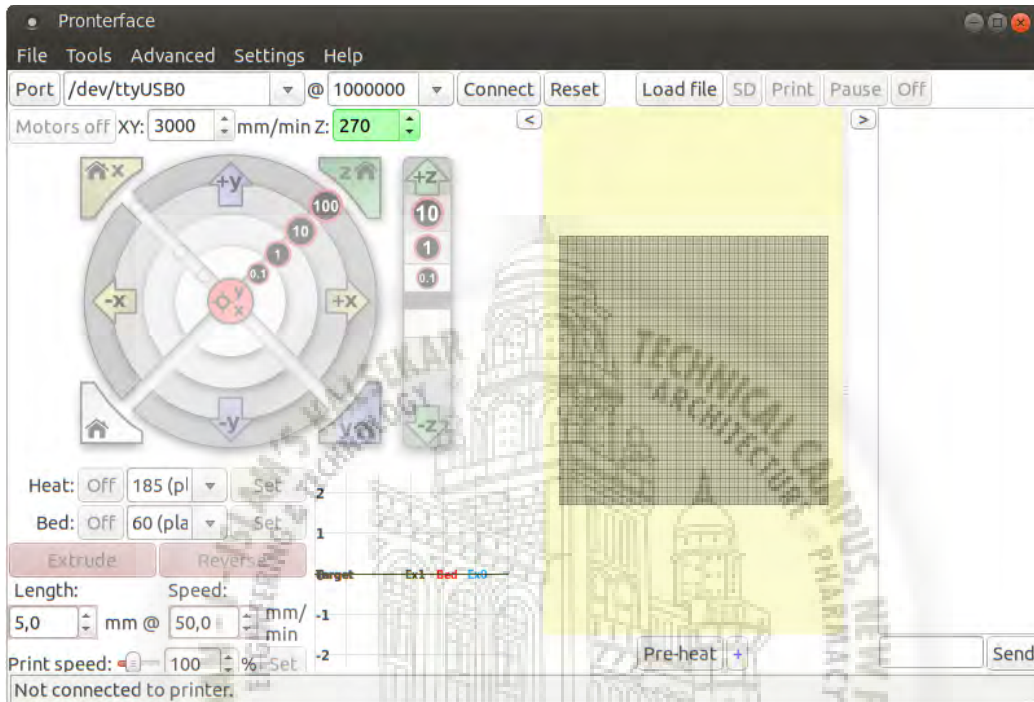


Fig 4.14 Pronterface Software

Pronterface is a graphical interface for the host software supplied with your printer. It is part of a set of software from Printron a group of G-code utility applications. It is with Pronterface that you can control your 3D printer

Pronterface is a host software for Reprap electronics, originally developed by Kliment.

It is mostly oriented towards 3D printing, but can also be used to control laser cutters and CNC routers.

Pronterface is a part of Printron, a free, open-source software suite, licensed under the GNU General Public License, version 3.

What sets Pronterface apart is its large and comfortable command line interface, and small footprint (it takes no space on your computer.) The interface is barely functionalist, but also highly functional.



## Chapter 5

### Advantages and Disadvantages

#### 5.1 Advantages Of 3D Printer

3D printing creates solid parts by building up objects one layer at a time. Producing parts via this method offers many advantages over traditional manufacturing techniques. While there are a large range of different 3D printing technologies the advantages discussed in this article generally apply to the industry as a whole.

3D printing is unlikely to replace many traditional manufacturing methods yet there are many applications where a 3D printer is able to deliver a design quickly, with high accuracy from a functional material. Understanding the advantages of 3D printing allows designers to make better decisions when selecting a manufacturing technique that results delivery of the optimal product.



Fig 5.1 Industrial 3D Printer

##### 5.1.1 Speed

One of the main advantages of additive manufacture is the speed at which parts can be produced compared to traditional manufacturing methods. Complex designs can be uploaded from a CAD model and printed in a few hours. The advantage of this is the rapid verification and development of design ideas.

Where in the past it may have taken days or even weeks to receive a prototype, additive manufacturing places a model in the hands of the designer within a few hours. While the more industrial additive manufacturing machines take longer to print and post process a part, the ability to produce functional end parts at low to mid volumes offers a huge time saving advantage when compared to traditional manufacturing techniques.



Fig 5.2 3D Printed object

### 5.1.2 Single step manufacture

One of the biggest concerns for a designer is how to manufacture a part as efficiently as possible. Most parts require a large number of manufacturing steps to produce and the order the steps occur in affects the quality and manufacturability of the design.

Consider a custom steel bracket that is made via traditional manufacturing methods. Like additive manufacturing the process begins with a CAD model. Once the design is finalized fabrication begins with the steel being cut to length. The cut lengths are then clamped into position and welded one at a time to form the bracket. Sometimes a jig will need to be made up to ensure all components are correctly aligned. The welds are then ground to give a good surface finish. Next holes are drilled so the bracket can be mounted to the wall. Finally the bracket is sand blasted, primed and painted to improve its appearance.



Fig 5.3 Single Step Manufacture

Additive manufacturing machines complete a build in one step with no interaction required during the build phase. For additive manufacturing as soon as the CAD design is finalized it can be uploaded to the printer and printed in one step in a couple of hours.

### **5.1.3 Cost**

The cost of manufacture can be broken down into 3 categories; machine operation costs, material cost and labor costs.

Machine operation costs: Most desktop 3D printers use the same amount of power as a laptop computer. More industrial additive manufacturing technologies consume a high amount of energy to produce a single part however the ability to produce complex geometries in a single step results in higher efficiency and turnaround. Machine operation costs are typically the lowest contributor to the overall cost of manufacture.

Material costs: The material cost for additive manufacturing varies significantly by technology. Desktop FDM printers use filament coils that cost around \$25 per kg while SLA printing requires resin that retails around \$150 per litre. The range of materials available for additive manufacturing make quantifying a comparison with traditional manufacturing difficult. Nylon powder used in SLS costs around \$70 per kg while comparable nylon pellets used in injection molding can be purchased for as little as \$2 - \$5 per kg. Material costs are the biggest contributor to the cost of a part made via additive manufacturing.

Labor costs: One of the main advantages of 3D printing is the the cost of labor. Post processing aside, the majority of 3D printers only require an operator to press a button. The machine then follows a completely automated process to produce the part. Compared to traditional manufacturing where highly skilled machinists and operators are typically required, the labor costs for a 3D printer are almost zero.

Additive manufacturing at low volumes is very cost competitive compared to traditional manufacturing. For the production of prototypes that verify form and fit, it is significantly cheaper than other alternative manufacturing methods (injection molding) and is often competitive for manufacturing one off functional parts. Traditional manufacturing techniques become more cost effective as volumes begin to increase and the high setup costs are justified by the large volumes of productions.

### **5.1.4 Complexity and design freedom**

The restrictions imposed by traditional manufacturing on what can be made are generally not relevant for additive manufacturing. Because components are constructed one layer at a time design requirements such as draft angles, undercuts and tool access do not apply when designing parts to be 3D printed. While there are some restrictions on the [minimum size features](#) that can be accurately printed most of the limitations of additive manufacturing center around how to optimally orientate a print to reduce support dependency and the likelihood of print failure. This allows designers a large amount of design freedom and means that very complex geometries can easily be created.



Fig 5.4 Less Complex

## 5.2 Disadvantages Of 3D Printer

3D printers have created amazing objects such as a violin, a dinosaur bone and even a bionic ear. While the technology boasts mind-boggling potential, it's still relatively new and has limitations. Before investing in a 3D printer or planning to develop a project on one, you may want to consider the disadvantages of the process.

### 5.2.1 Size

Most 3D printers sold to hobbyists print objects that are smaller than 10 inches sometimes significantly smaller. Inventors hoping to prototype a machine part can make excellent use of the technology. On the other hand, you shouldn't think you can press a button and print out a chair.



Fig 5.5 Size Drawback

### 5.2.2 Maintenance:

The capabilities of 3D printers are constantly improving, which means any unit you purchase today may be outdated within months and certainly in a year or two. The rods

need to be oiled, the firmware and software regularly updated and the extruder cleaned. Printers that print plastic can get clogged and mucked up. The heating element in the extruder can self-destruct. One nice thing about having a 3D printer is if a part breaks, you may be able to print a replacement, but this is not guaranteed.



Fig 5.6 High Maintainence

### 5.2.3 Limited Material Option

Most 3D printers create objects using plastic filament. Printing with [other materials](#), such as metal, is becoming more commonplace, but only high-end printers are currently capable of metal additive manufacturing. Printing complex pieces of plastic, such as a circuit board, is far beyond the capability of most 3D printers. Search the web and you may find printers that extrude chocolate and cheese, but these are just novelty items, at least for the time being. One day you may break a ceramic mug and then quickly print a replacement, but that day isn't quite here yet.



Fig 5.7 Limited Material Operation



### 5.2.4 Design Challenges

Given the structure of many 3D printers, you need to print an object that supports its own weight. That may not seem like big concern, but when you want to print a flower, it's going to topple over halfway through printing. Many printers can't offer the level of detail you envision and few print in multiple colors. An object often needs to be painted to attain the desired shading.

Unquestionably, 3D printing is an amazing technology that will only get more impressive. Before spending too much time or money on one, appreciate what each does and understand its shortcomings

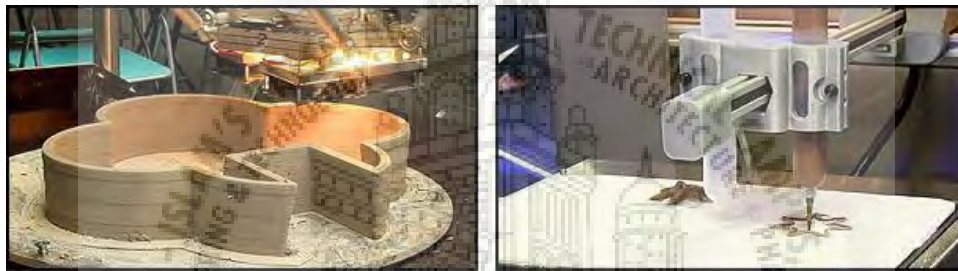


Fig 5.8 Requires Highly Skilled People

## Chapter 6

### Future Scope

3D printing -- also known as additive manufacturing -- turns digital 3D models into solid objects by building them up in layers. The technology was first invented in the 1980s, and since that time has been used for rapid prototyping (RP). However, in the last few years, 3D printing has additionally started to evolve into a next-generation manufacturing technology that has the potential to allow the local, on-demand production of final products or parts thereof. Already it is possible to 3D print in a wide range of materials that include thermoplastics, thermoplastic composites, pure metals, metal alloys, ceramics and various forms of food. Right now, 3D printing as an end-use manufacturing technology is still in its infancy. But in the coming decades, and in combination with [synthetic biology](#) and [nanotechnology](#), it has the potential to radically transform many design, production and logistics processes.



A WASP Big Delta 3D printing in clay, and a Robots in Gastronomy food printer

Fig 6.1 Large 3D Printer

3-D printing is moving in several directions at this time and all indications are that it will continue to expand in many areas in the future. Some of the most promising areas include medical applications, custom parts replacement, and customized consumer products. As materials improve and costs go down, other applications we can barely imagine today will become possible.

Perhaps the greatest area of potential growth for 3-D printing is in the medical field. As mentioned above, researchers are just starting to experiment with the idea of creating artificial bones with 3-D printers, but the process could potentially be used for so much more. Some companies are investigating the possibility of printing organic materials; these materials could be used in a much wider array of surgeries and potentially replace a much larger selection of defective human parts. Expect expansion of training techniques based on 3-D printed models of complex human systems, a greater effort to more explicitly explain surgeries or the workings of the human body to patients as detailed replicas of body parts to become more common, and more precise surgical and diagnostic equipment based on designs that can be printed but not manufactured using traditional means.

There is certainly a market for customized keepsakes and 3-D printing can take that industry to new heights. Shapeways is already marketing several basic designs of customized keepsakes using either personalized text or photographs supplied by the customer. Will we reach a time when all of our personal items are customized to exact user specifications? Perhaps not, but some people feel we're headed in that direction. There may come a time when choosing new cutlery doesn't involve selecting a pattern at the

store but designing it on your computer and printing out the resulting pieces. One day we may dial up just the right level of edge for a child starting to use sharp knives, build customized ergonomic handles that fit each individual's hands perfectly (perhaps color coded for easy identification), or shape spoon bowls to generate the perfect mouthful every time.

Another area of growth in the 3-D printing arena is replacement parts production. Need a new screw for your laptop? A new gear for your heirloom grandfather clock? A new piston for your car? Instead of trying to track down the part, pay for shipping, and waiting weeks for its arrival, you'll just be able to print it out and go. Mechanics will keep specs for every part of every car ever sold in a database and print out whatever they need immediately with no difficulty. While it would save time and money for any part, it's a particular boon for restoration jobs of all kinds where the original parts are extremely difficult to find or may not even exist anymore.

Another intriguing area is customized food production. Evil Mad Scientist Laboratories has created a low cost, low resolution capable of printing models made from ordinary granulated sugar. We could soon see edible centerpieces, customized candy gifts, novelty lollipops customized for gift shops attached to tourist attractions, or chocolate sculptures rivaling the most complex ice sculptures out there. It's unclear exactly how far we could go with printed food and if it will ever move out of the novelty area, but certainly an area to watch in the future.

### REAL WORLD EXAMPLES

- 🕒 3d Printing Has Far Reaching Potential And Is Already Starting To Disrupt The Biggest And Most Important Industries And Markets In The World.
- 🕒 Some Of Them Are Listed Below:

#### ***6.1 Environment & Improve Sustainability***



Fig 6.2 Environment Sustainability

From providing a tortoise with a new 3D-printed shell, to 3D printing solar cells and wind turbines, 3D printing is protecting the environment and increasing our sustainability.

Not only that, but 3D printing in itself is a much more efficient way to manufacture goods in comparison to the traditional manufacturing techniques that typically create a lot of waste product.

## ***6.2 3D Printing is Changing: Science, Research, and Education***



Fig 6.3 3D Printing Research

Imagine showing your students a life-sized replica of a dinosaur bone and giving them a hands-on learning experience, rather than relying on an image in a text book for your lesson. With 3D printing, this is a possibility and it is how the technology is changing the way we learn, research, and conduct studies. 3D printing is quickly getting adopted by schools, universities, and research labs across the world in large part due to its ability to produce affordable and complex models that aid in teaching and conducting research.

## ***6.3 Advancing The: Aerospace, Aviation, & Automotive Industries.***



Fig 6.4 3D printer Application

While 3D printing is having a big impact across a ton of different industries and markets, perhaps none will be more important—when it's all said and done—than the potential impact that it could have on the aerospace, aviation, and automotive industries. 3D printing is allowing aerospace companies, car makers, and airplane manufacturers to test out new designs, prototype more effective parts, and build better machines at lower costs—all of which are helping us travel further and cheaper than ever before.

### ***6.4 The Enormous Impact That 3D Printing Is Having on General Manufacturing.***



Fig 6.5 Impact On General Manufacturing

While 3D printing is changing markets and industries that typically haven't been linked to traditional manufacturing (like fashion and medicine), the technology is *still* having a big impact on traditional manufacturing as well. From 3D printing in metal, to printing out electronics, additive manufacturing is transitioning from being just a nice new way to produce cost-effective prototypes into a fully-functioning manufacturing outlet.

### ***6.5 3D Print Your Own Home and Custom Home Décor.***



Fig 6.6 3D Printed Homes

If you thought that 3D printing was just being used to create small plastic items, you better think again. In fact, there are a handful of large-scale 3D printers across the world that are *actually* printing out full-sized homes. Yes, you read that right... there are now *3D*

printed homes. And, amazing as that is, 3D printing is also making big waves in the home improvement and home decor industries by offering custom solutions at affordable prices. So, whether you need a brand new concrete home (or mansion...) or some new decorations to liven up your living space, 3D printing can help you out.

### ***6.6 3D Printers Are Now Being Used In Culinary Arts and Cooking.***



Fig 6.7 3D Printers in Culinary Arts

Hamburgers, pizza, pancakes, chocolate, and more... 3D printing has now entered into the world of cooking and culinary arts and is helping expert chefs and novice cooks make food in new and more creative ways. 3D printed food can also solve a host of issues that come with traditional cooking, such as allowing astronauts to 3D print food in space, creating intricately designed cakes, treats, and baked goods, and designing tasty food that has specific nutritional values.

### ***6.7 World's first 3D-printed office building completed in Dubai.***



Fig 6.8 3D Printed Office in Dubai

3D printing technology promises to revolutionize architecture in the near-future, allowing designers to literally click-and-print complex buildings at a lower cost and faster speed than traditional construction methods allow. Another step forward in the field comes via Dubai, where what's hailed as the world's first 3D-printed office was recently completed.

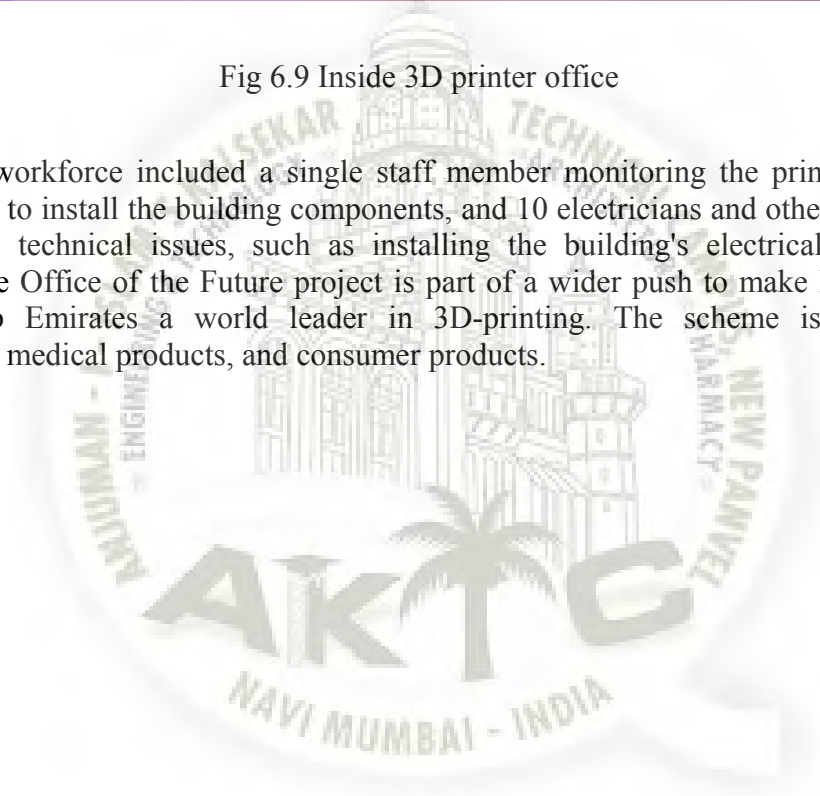
We [first reported](#) on what's now dubbed the Office of the Future back in 2015. Taking up a footprint of 250 sq m (2,690 sq ft), the building is located within Dubai's Emirates Towers complex and will serve as a fully-functional office.

A very large 3D printer measuring 20 x 120 x 40 ft (6 x 36 x 12 m) did most of the work, printing the building by extruding a cement mixture layer by layer, in a similar method by which WinSun's [3D-printed homes](#) were made (WinSun is involved in this project too). There were also some additional smaller mobile 3D-printers used too, however. It took 17 days to print the basic building, but it then required finishing both internally and externally. Though not detailed by the source, it seems that, like WinSun's 3D-printed homes, the building was printed in sections elsewhere before being assembled over two days on-site. We've reached out to the Dubai government to try and glean more information on this aspect.



Fig 6.9 Inside 3D printer office

The workforce included a single staff member monitoring the printer's progress, seven people to install the building components, and 10 electricians and other specialists to handle more technical issues, such as installing the building's electrical systems, for example. The Office of the Future project is part of a wider push to make Dubai and the United Arab Emirates a world leader in 3D-printing. The scheme is focusing on construction, medical products, and consumer products.





## Chapter 7

### Applications

**The possibilities of 3D Printing for your product development and manufacturing are endless.**

- 🕒 Entertainment & Broadcasting
- 🕒 Industrial Goods
- 🕒 Optics
- 🕒 Robotics
- 🕒 Textile
- 🕒 Automotive
- 🕒 Drones
- 🕒 Mechanics
- 🕒 Food Industry



## Chapter 8

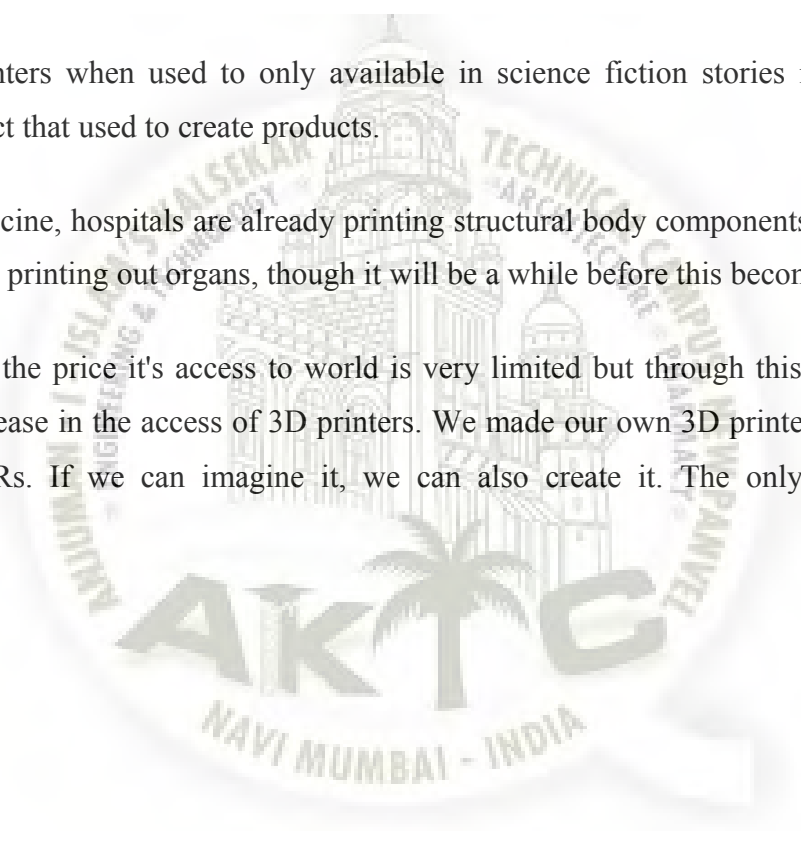
### Conclusion

It's easy to imagine a future where items manufactured in China will be complemented with 3D printed customization in stores. Recent innovations using 3D printers like within the biotech industry provide insight into both the significant market advantages of high-value 3D-printed products and the significant initial costs to realize those advantages. Once printers become commonplace in the home, one can conceive printing custom glasses and plates for a dinner party.

3D printers when used to only available in science fiction stories is now a real tangible product that used to create products.

In medicine, hospitals are already printing structural body components. In labs they are working on printing out organs, though it will be a while before this becomes common.

Due to the price it's access to world is very limited but through this project there will be an increase in the access of 3D printers. We made our own 3D printer with a price of just 6000 Rs. If we can imagine it, we can also create it. The only limit is our imagination.



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