For this project, you'll have to do some reading first. Two resources have been provided. Read them both and then create a google slideshow, with pictures, diagrams, captions (with your assigned partner) to address the followings questions/prompts:

1) How do 3D printers work? Make sure to provide a diagram and present this verbally.
2) Trace the history of 3D printing technologies.

Resource # 1:

Why is 3D printing significant? Why do we care?

This technology has the potential to provide innovation within many disciplines. Specifically sciences, where visualizing structures through modeling is of value for everything from DNA, to proteins and molecules, and down to subatomic structures within physics. There is also extensive potential for architecture, art, design, history, even culinary and many other areas. The ability to recreate an object from antiquity is powerful as it gives a student a chance for a hands-on encounter, and for expression, the number of materials and the nature of production provide a channel that is somewhere between the canvas and the sculpture. The ability to manifest something with relative ease and direct simplicity opens new doors for learning and creativity.

Some food for thought as to the potential of 3D printing:

- ★ 3D printed cars
- ★ 3D printed buildings
- ★ 3D printed food
- ★ 3D printed body parts
- ★ 3D printed modules for spacecraft using iron mined from asteroids

HOW 3D PRINTERS WORK

A 3D printer builds a model, prototype or object from a digital file one layer at a time. The student uses a computer-aided design (CAD) tool, such as the free Tinkercad or professional level SolidWorks or AutoCAD — or any kind of program that can output an STL file — to model what he or she wants to produce. Standard Tessellation Language (STL) is a common format that defines the details of every surface of the object to be printed.

That STL output goes through a “slicing” process to tell the printer the structure of each layer. When the printing begins, a flexible material, usually a form of plastic, is heated up and sent through an extruder that applies a thin layer of the material onto a platform. Layer by layer, the object is built from the bottom up.

Different kinds of 3D printers follow variations on this process. For example, the Connex line of Stratasys 3D Printers can print multiple materials and colors at the same time — each being sprayed from a separate extruder — creating ultra-realistic prototypes. Another distinguishing feature of 3D printers is their level of reliability. Some users like to “fuss” with the inner-workings of the printer to keep it operating as part of the “maker” process. Others seek high reliability so they can apply their time to other aspects of the design process, such as teaching their students how to correct any shortcomings that their prototypes reveal.

3D PRINTING TECHNOLOGY OVERVIEW

Technologies and materials used:

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.

Material extrusion

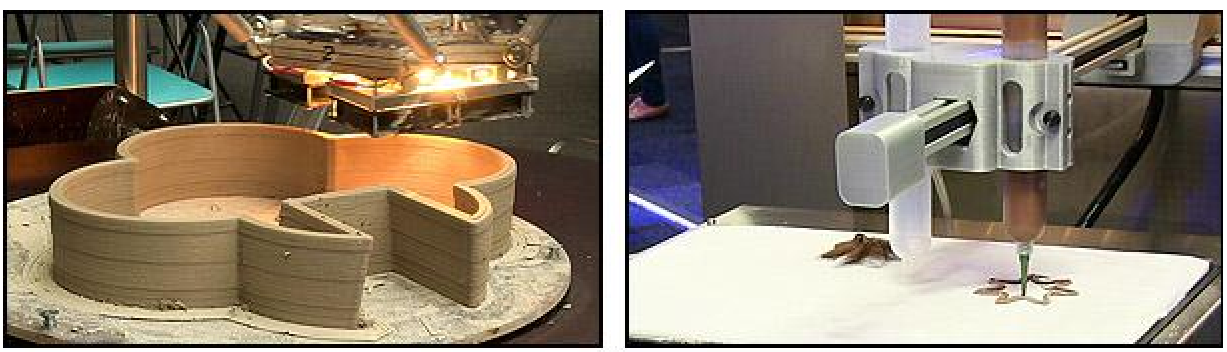
Material extrusion uses a nozzle to extrude a semi-liquid material to create successive object layers. Most usually the 'build material' is a thermoplastic such as acrylonitrile butadiene styrene (ABS), polycarbonate (PC), nylon, or the bioplastic polylactic acid (PLA). Whatever material is used, it is usually delivered to a print head as a solid, thin strand or 'filament' that is then heated into a molten state.

Today, material extrusion is the most common 3D printing process. The technology was invented by Scott Crump in 1988, who set up a company called Stratasys to commercialize his invention. Crump chose to name the technology 'fused deposition modelling' or 'FDM', and patented and trademarked these terms. Hence, while many people use the phrase 'FDM' to refer to this kind of 3D printing, only Stratasys actually makes FDM 3D printers. Other manufacturers refer to the same process as 'thermoplastic extrusion', 'plastic jet printing' (PJP), the 'fused filament method' (FDM) or 'fused filament fabrication' (FFF).
Consumer material extrusion 3D printers can now be purchased for a few hundred dollars. At the other end of the spectrum, high-end industrial machines -- such as the Stratasys 900mc 3D Production System -- cost hundreds of thousands of dollars and can produce final objects with a comparable quality to injection molded parts. There are now also some very large 3D printers that extrude thermoplastics, including the Big Rep ONE and the Big Area Additive

Manufacturing Machine (BAAM) from Cincinnati Incorporated. The latter is large enough to fabricate the chassis and body of a full-sized car.

A BigRep ONE material extrusion 3D printer, and a table it has printed out.

In addition to pure thermoplastics, there are an increasing number of thermoplastic composites that can be 3D printed, including thermoplastics mixed with metals, carbon fiber and carbon nanotubes. As illustrated below, it is also possible to materially extrude concrete, clay and many different kinds of food.



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

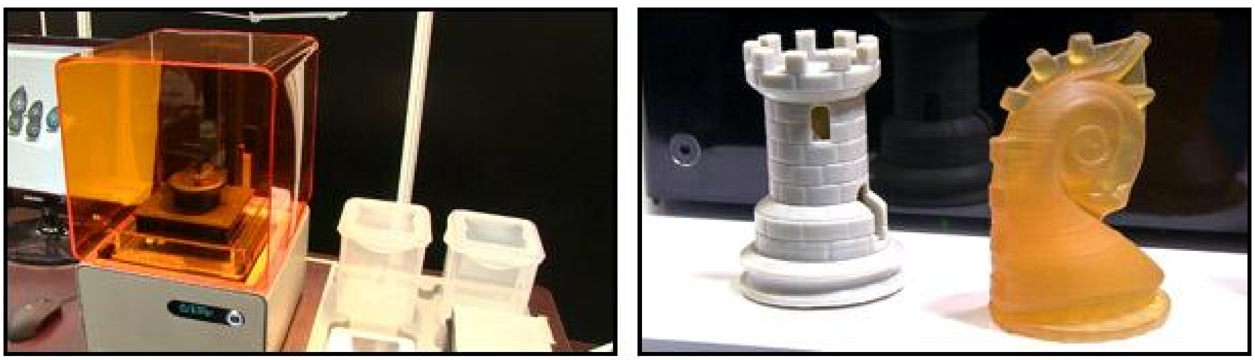
Vat photopolymerization

Vat photopolymerization uses a laser or other light source to solidify successive object layers on the surface or base of a vat of liquid photopolymer. The very first commercial 3D printer was based on a vat photopolymerization technique called 'stereolithography'. This was invented by Charles Hull in 1984, who subsequently founded 3D Systems.

Stereolithographic 3D printers (known as SLAs) position a perforated platform just below the surface of a vat of liquid photopolymer. A UV laser beam then traces the first slice of an object on the surface of this liquid, causing a very thin layer of photopolymer to harden. The perforated platform is then lowered very slightly and the process repeats until a complete object has been printed out.

Another vat photopolymerization technology is 'DLP projection'. This uses a projector to solidify object layers one complete cross-section at a time. One of the leading manufacturers of this kind of 3D printer is EnvisionTEC.

Vat photopolymerization 3D printers are expensive to run due to the cost of their photopolymer resins, but offer very high resolutions and deliver excellent surface quality. Until a few years ago, vat photopolymerization 3D printers themselves remained very expensive. However, there are now several manufacturers -- including FormLabs and Photocentric 3D -- who offer this kind of hardware for a few thousand or even a few hundred dollars.



A FormLabs desktop vat photopolymerization 3D printer and Photocentric 3D prints

Material jetting

Material jetting uses a print head to spray liquid layers that are usually then solidified by exposure to UV light. This again offers very high resolution 3D printing, and is even capable of producing multicolor and multi-material output by spraying several different materials from a multi-nozzle print head in varying combinations.

The latest material jetting 3D printer from Stratasys -- the J750 -- can fabricate objects out of six different materials (both rigid and flexible) in up to 360,000 colours, and with a 0.014 mm (14 micron) layer resolution. Material jetting remains an expensive 3D printing technology, but as the images below demonstrate, the results can be spectacular.

Objects 3D Printed on Stratasys "PolyJet" Material Jetting Hardware

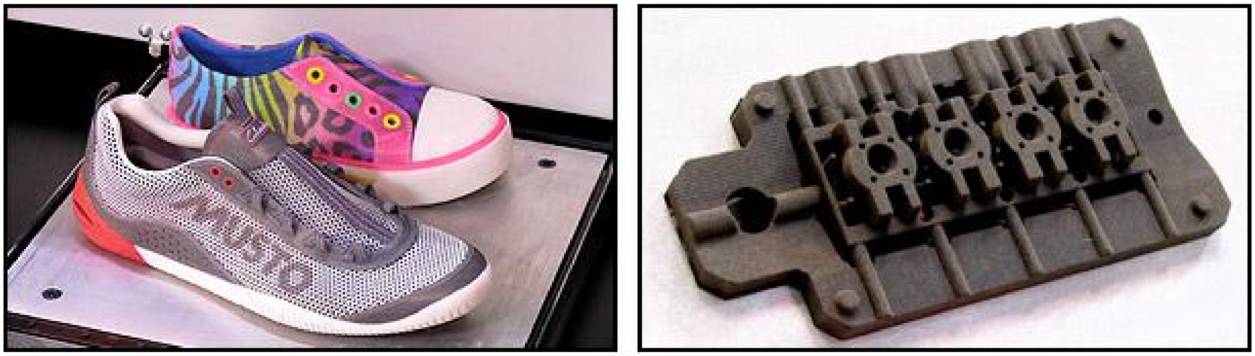
In the near future, a new material jetting technology called 'NanoParticle Jetting' (NPJ) is due on the market. Developed by Xjet (who also developed the above material jetting technology now owned by Stratasys), this jets solid metal nanoparticles within a liquid suspension, allowing inkjet-style technology to directly 3D print highly detailed metal parts.

Binder jetting

Binder jetting uses a print head to selectively spray a binder (or in other words glue) onto successive layers of powder. Many binder jetting 3D printers spray colored inks as well as the binder onto their powder layers, thus allowing them to produce full colour output.

Most commonly the powder used in binder jetting is a delicate gypsum-based composite that needs to have its surface coated and hardened after printout if a robust object is required. However, the ProJet 4500 from 3D Systems builds full-color objects from a durable plastic powder and needs no coating.

Other binder jetting hardware can build objects by sticking together sand or powdered metals. Where a binder is sprayed onto sand, the final object is used as a sand cast mold or pattern, into which molten metal is poured. Once the metal has cooled solid, the sand is then broken away.

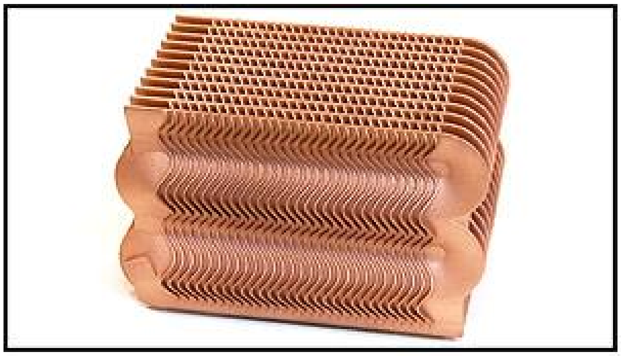


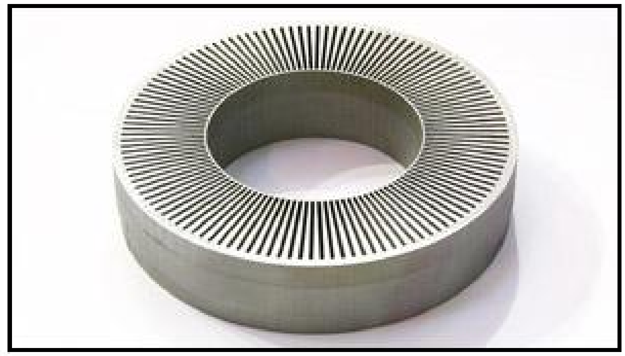
Colour output from a 3D Systems Projet 4500, and an ExOne sand cast pattern

Binder jetting metal printing has been developed by a company called ExOne (who also make 3D printers that binder jet sand cast molds). Here a layer of bronze, stainless steel or Inconel powder is laid down, and a printhead moves across it to selectively spray on a binder solution. A heating lamp then dries the layer, a fresh layer of powder is rolled over it, and the process repeats. Once all layers have been output, the object is then placed in an oven to fully cure the binder. At this stage the object is still very fragile, but is put in a kiln where it is infused with additional metal powder. The final result is a very solid object that is a least 99.9 percent solid metal.

Powder bed fusion

Powder bed fusion uses a laser, electron beam or other heat source to selectively fuse successive powder layers. The technology goes by a great many proprietary names, including 'laser sintering' (LS), 'selective laser sintering' (SLS) 'direct metal laser sintering (DMLS), 'selective heat sintering' (SHS), laserCUSING and 'electron beam melting' (EBM). Build materials range from plastics -- such as nylon -- to metals that include aluminium, copper, steel, nickel alloys, cobalt chrome, iron, titanium and high performance Inconel alloys. It is also possible to create objects using new composite materials such as 'alumide', which is a powdered mix of nylon and aluminium.



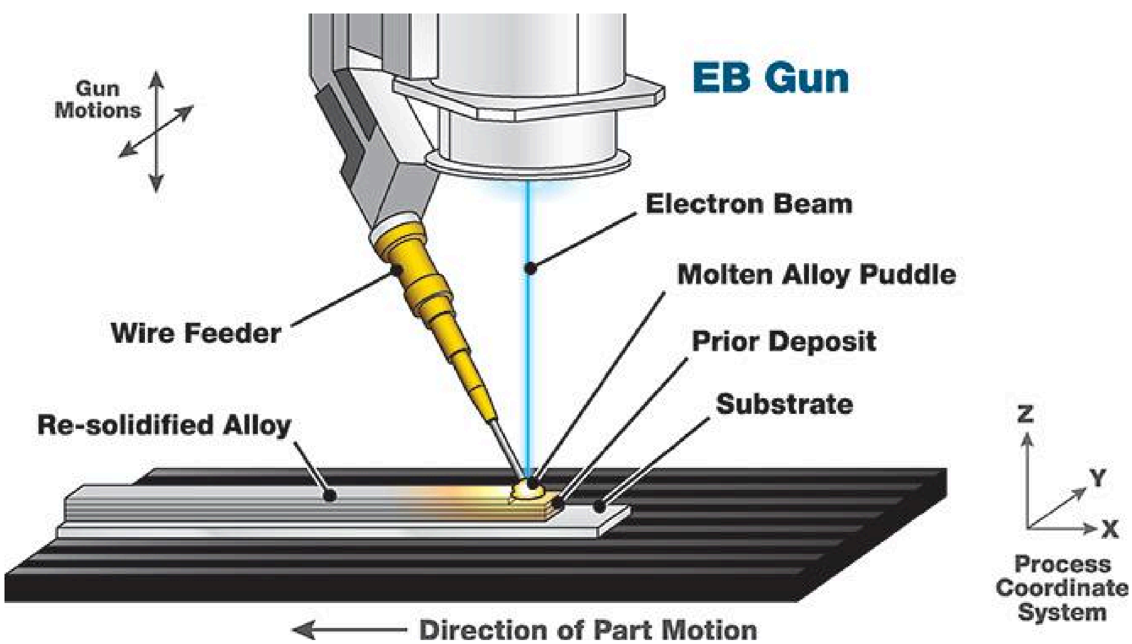


Final metal parts 3D printed via powder bed fusion

Powder bed fusion is currently both expensive and complex to master. Even so, the technology is starting to be used to produce very high quality industrial parts, including fuel injectors and other aerospace and rocket components. It is also already possible to produce small metal parts on the desktop using a Realizer SLM 50 powder bed fusion 3D printer.

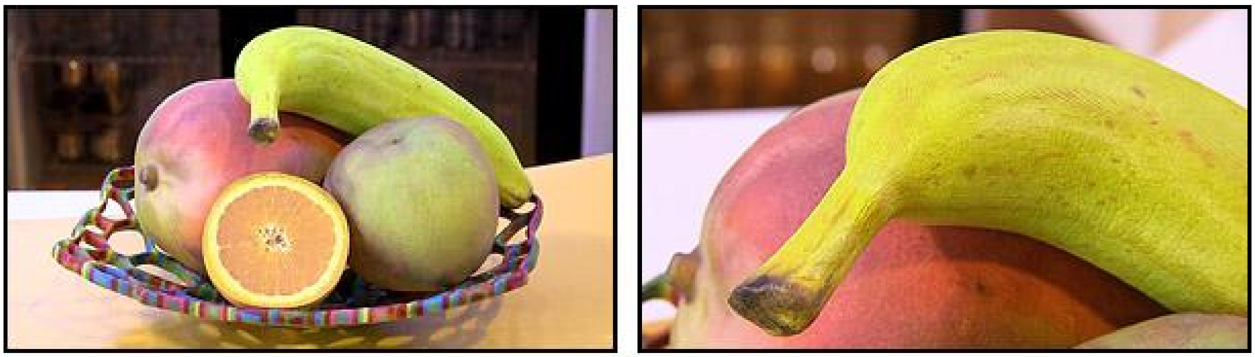
Directed energy deposition

Directed energy deposition uses a laser or other heat source to fuse a powdered build material as it is being deposited. Unlike in powder bed fusion, here the powdered build material is deposited from a nozzle into a high power laser or electron beam that fuses it into solid metal. Build materials include steel, copper, nickel and titanium. The technology is also unique in that it can be used not only to create new parts, but also to fuse metal back on to existing parts, such as worn or otherwise damaged turbine blades.



Sheet lamination

Sheet lamination sticks together sheets of cut paper, plastic or metal. For example, 3D printers manufactured by Mcor create their output from standard reams of copy paper that can also be sprayed with colour inks to create incredibly detailed colour models, such as the bowl of fruit illustrated below. Meanwhile, Fabrisonic use an ultrasonic welding process to fabricate objects from sheets of metal foil.



Fruit and bowl 3D printed in paper using an MCor sheet lamination 3D printer

Here is your second resource:

https://en.wikipedia.org/wiki/3D_printing