Rapid Prototyping Details
ENGR 1182
Objectives

- Examples of different methods of Rapid Prototyping
- How a 3D printer works
- 3D Printing in EED
- Tools for printing and examples of good and bad parts
- Laser Cutting in EED
- Limitations and design concerns
- Design your own part option – See Rapid Prototyping Project document
What is 3D printing?

- Wikipedia states that 3D Printing, also known as Additive Manufacturing “refers to various processes used to synthesize (create) a three-dimensional object”

- The printer software analyzes solid model files that have been converted into an .stl format to create the code needed to print objects.

- The printer lays down material layer by layer to create the desired object.

- 3D Printing is less wasteful than traditional machining.
  - Traditional machining removes material from a block to create the desired part and is called subtractive manufacturing.
  - 3D printing uses a supply of new raw material to create the desired part and is called additive manufacturing.
Types of 3D Printing

- **LOM** – Laminated Object Manufacturing
  - stacks of paper or other material glued together
- **FDM** - Fused Deposition Modeling
  - plastic filament melted and extruded in layers
- **SLA** – Stereolithography
  - U/V curable plastic resin applied in layers
- **SLS** – Selective Laser Sintering
  - powdered metals fused into layers with a high-power laser
- Many other hybrids and variations
How an FDM 3D Printer Works

FDM 3D printing is an additive manufacturing process that creates a part by adding layers of melted plastic one layer at a time onto a flat base that incrementally lowers by computer control for each new layer. The plastic that is used for this process is frequently ABS (used in Legos) or PLA (used in biodegradable food packaging/containers).
3D Printing in the EED

- The EED has 11 *MakerBot Replicator 2* printers for lab support.
- These printers extrude PLA (polylactic acid) plastic and dispense it onto the build plate.
The time required to create a printed part varies with the size and complexity of the object.

- Variables such as layer thickness, the quantity of feature boundaries and internal density are all variables that can be adjusted based on desired results.
- Our MakerBot printers use the same material for making both the model and the automatic supports, unlike some higher-end printers which use a water-soluble material for supports, and allows for printing of complex assemblies, etc.
- The MakerBot build envelope is about 11” wide x 6” deep x 6” tall.
- Due to the FDM printing method, parts will have a “grain” to them based on how they are oriented on the build plate. Printed parts will be strongest in the horizontally-printed direction, which flows with the grain.
Design Guidelines

Guidelines:

• Avoid very small details (less than 1/8’’), small text (at least #12 font, and bold format), and overhanging geometry (think wings)
• Avoid designing parts with large, flat bottom features, as these tend to warp. Flat panel parts are better created using the laser cutter.
• Object geometry with an angle greater than 45-deg can be printed without supports (see next slide). Geometry with an angle less than 45-deg will require supports which will require some removal/shaving following printing. See bottom picture.
• The size of the object to be printed must fit inside 11X6X6 inches.

Tolerances:

• The Makerbots are pretty precise, but not perfect.
• Machine tolerances, plastic warping and shrinkage and geometry designs, all have an effect on the size of the final part being printed.
• If you are designing parts to fit other parts, you should leave some tolerances (gaps) in them to allow parts to fit together. It is recommended to leave about .015” gap on parts that fit onto other parts.
• If you have holes that need to be an exact fit, design the holes a few thousandths smaller, and then drill them to the final size.
Supports for Printing

- **Support Material**
  - When desired, support geometry is automatically generated by the MakerWare software to provide structural support to ensure successful builds for parts with overhanging geometry.
  - Support material can be removed once the print is finished.

- **Raft**
  - A flat surface automatically generated by the software before printing the intended part, to improve printing quality and success.
  - The raft helps small objects stick to the build plate, and also creates a flat building surface for any part that is having difficulty adhering to the build plate.
Part files to be printed need to be saved in .STL format. This file format is imported into the 3D printer software and is used to generate the code that will ultimately be read by the 3D printer to make the part.

It does not matter if the geometry is skewed or straight to generate a proper .STL file.
What is Laser Cutting?

- Laser cutting is a subtractive manufacturing method that uses a powerful laser to etch the surface, or cut completely through many materials.
  - Common materials include: acrylics and other plastics, wood, fabric, rubber, ceramics, organic materials, etc.

- Etching text or graphics onto surfaces adds aesthetic value

- EED Laser – Manufactured in the USA by Universal Laser Systems →
  - It is another way for students in 1182 to have parts created for their AEV project.
Types of Lasers

- **CO2** – industrial cutting and etching, metals, paper, plastic, wax, fabrics, etc.
  - Our laser is CO2
- **YAG** – very high laser power, for metals and ceramics
- **Fiber** – utilizes a very tiny laser diameter, ideal for cutting reflective metal material
Here are a few of the many parts in the AEV kits were cut using a laser.
Laser Cutting in the EED

- Our laser can cut or etch most materials other than metal.

- Materials available to use for AEV parts include:
  - 1/8” and 1/4” acrylic – clear or red color
  - 1/8” plywood, 1/4” MDF
  - 1/8” polypropylene - whitish plastic with holes in it used for many of the AEV panels
  - 3/32” ABS – black plastic, textured on one side, used for AEV main support brackets that attach to the wheels

- Tolerances
  - The laser creates a “kerf”, much like a sawblade, in that it makes a slot in the material when it cuts. The kerf is about .006” wide, so, it is a good idea to offset holes, cuts, etc accordingly. It is better to have a little extra tolerance of a few thousandths of an inch for where your laser cut parts will fit other parts. The laser follows the center of the line that it cuts, so in reality, only about half of the kerf affects your line geometry, or about .003”. For holes, it takes a full kerf off of the diameter because it is a circle.

- Words or graphics can be etched onto surface as required
  - Etching does not work well on ABS or polypropylene.
Part files for laser cutting must be saved in .DWG file extension. Also, when the file is saved, the part must be “Normal” (perpendicular) to the screen, usually the “Front” or “Top” view. When saving in the DWG format, it is basically taking a screen shot of your part geometry, and if it is skewed, your geometry will be skewed when it is cut.