A thick black L-shaped frame surrounds the text. The top horizontal bar is on the left, the left vertical bar is on the left, and the bottom horizontal bar is on the right, with a vertical bar on the right side.

**BASIC MATERIALS  
SCIENCE AND  
MACHINING  
MATERIALS**

# Materials Science

- Branch of Engineering dealing with properties of materials
- Opening: Why might this be important for Mechanical Engineering?

# Key Vocab Terms to Learn

- Machining – Using a machine to cut away/alter a material
- Fabricating – Creating a part
- Malleable: Ability to bend without breaking
- Ferrous: magnetic
- Conductive: ability for electricity to pass through it
- Brittle: hard but liable to break/shatter
- Speeds & Feeds: When cutting a material, how fast the blade should move (**speed**) and how fast to push (**feed**) the material

# Materials Overview



|                 |
|-----------------|
|                 |
| <b>Wood</b>     |
| Types           |
| Properties      |
| Machining       |
| <b>Metals</b>   |
| Types           |
| Properties      |
| Machining       |
| <b>Plastics</b> |
| Types           |
| Properties      |
| Machining       |

# Wood - Types

- Soft woods – Generally cheaper and more common
  - Pine
  - Cedar
- Hard woods - Look fancier and more expensive
  - Cherry
  - Oak
- Specialty woods
  - Balsa wood: light weight
- How it's commonly bought
  - Plywood
  - Strips (example: an 8 ft. piece of 2x4 wood)



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|                 |
| <b>Wood</b>     |
| <b>Types</b>    |
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| Types           |
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| Types           |
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# Properties of Wood

| Pros  | Cons  |
|---|---|
| <ul style="list-style-type: none"><li>• Easy to work with</li><li>• Cheap</li><li>• Easy to obtain</li><li>• Can stain/paint easily</li></ul> | <ul style="list-style-type: none"><li>• Heavy/bulky</li><li>• Not weather-resistant unless treated</li><li>• Warps/weathers</li><li>• Flammable</li></ul> |

- Other properties
  - Non-electrically conductive nor magnetic
  - Soft relative to metal

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| <b>Wood</b>       |
| Types             |
| <b>Properties</b> |
| Machining         |
| <b>Metals</b>     |
| Types             |
| Properties        |
| Machining         |
| <b>Plastics</b>   |
| Types             |
| Properties        |
| Machining         |

# Machining with Wood

Big takeaway: Can be machined easily with a wide variety of tools

## Common Methods of Machining

### Cutting/Drilling

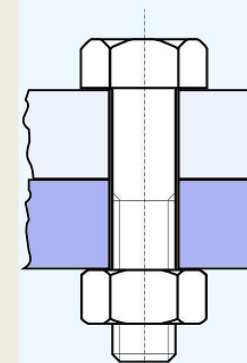
- Table saw, band saw, jig saw
- Wood blades have large “teeth” as wood is relatively soft
- Hand drill, drill press
- Mostly any drill bit will work
- High-speed & high-feed

### Binding

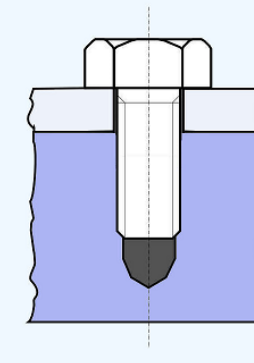
- Nearly anything works
- Screws and bolts easy to apply
- Most glues are effective as wood is porous



### BOLT



### SCREW



## Wood

Types

Properties

## Machining

## Metals

Types

Properties

Machining

## Plastics

Types

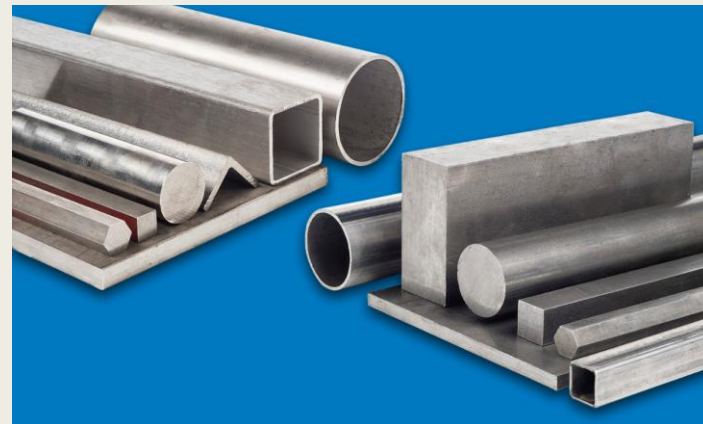
Properties

Machining

# Types of Metals

| • Iron  | Steel  | Stainless Steel   | Copper   | Aluminum   |
|---|--|---|--|--|
| <ul style="list-style-type: none"> <li>• Magnetic</li> <li>• Easily rusts</li> <li>• heavy</li> </ul> | <ul style="list-style-type: none"> <li>• Magnetic</li> <li>• Contains iron and carbon</li> <li>• Strong but heavy</li> </ul> | <ul style="list-style-type: none"> <li>• Some magnetic, some non-magnetic</li> <li>• Similar to steel, but non-corrosive and non-rusting</li> </ul> | <ul style="list-style-type: none"> <li>• Weakly magnetic</li> <li>• Highly conductive (used in most wires)</li> <li>• Cheap</li> <li>• Very malleable</li> </ul> | <ul style="list-style-type: none"> <li>• Weakly magnetic</li> <li>• Cheap</li> <li>• Light weight</li> <li>• Highly conductive</li> <li>• malleable</li> </ul> |

- How it's commonly bought
  - Sheets
  - Strips
  - Scrap pieces



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| <b>Wood</b>     |
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| Machining       |
| <b>Plastics</b> |
| Types           |
| Properties      |
| Machining       |



# Properties of Metals

| Pros   | Cons  |
|--|---|
| <ul style="list-style-type: none"><li>• Can be conductive/magnetic</li><li>• Very strong and durable</li><li>• High strength/weight ratio</li><li>• Heat/weather resistant</li></ul> | <ul style="list-style-type: none"><li>• Expensive</li><li>• Heavy</li><li>• Hard to machine</li></ul> |

- Other properties
  - All are conductive
  - Malleable (can be bent)

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| <b>Properties</b> |
| Machining         |
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| Types             |
| Properties        |
| Machining         |

# Machining with Metal

- Big Takeaway: Tough to Machine, but very strong

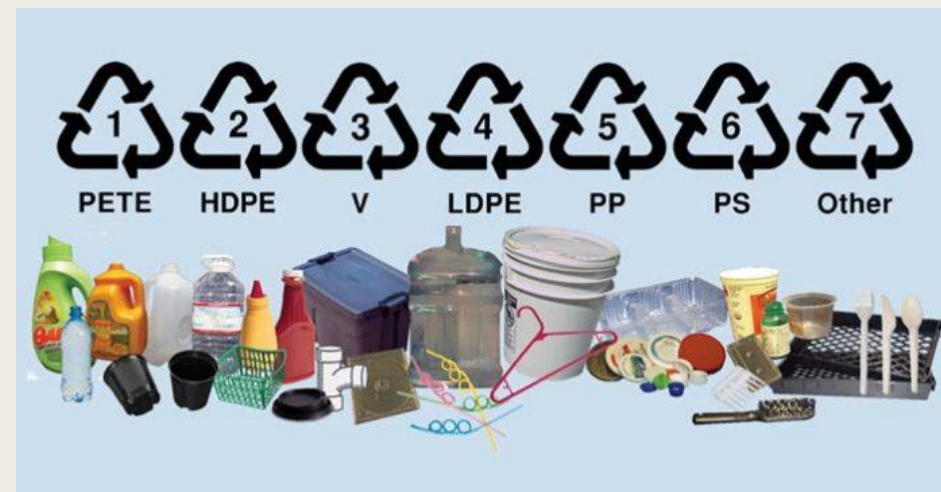
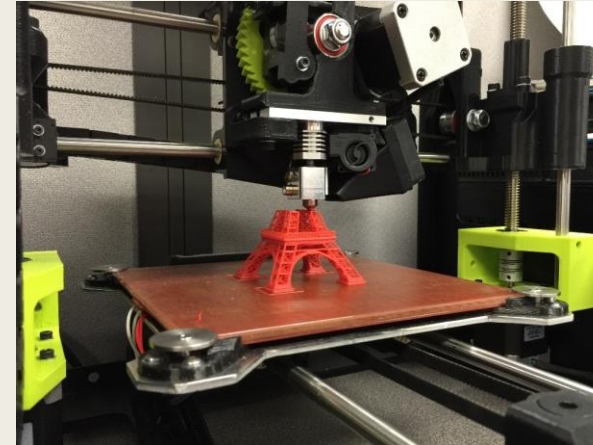
| Common Methods of Machining  |   |
|--|---|
| Cutting/Drilling   | Binding   |
| <ul style="list-style-type: none"><li>• Specialized tools needed (angle grinder, special metal blades)</li><li>• Lathe, mill</li><li>• Metal blades have small “teeth” due to the hard nature of metal</li><li>• Metals warp with heat from cutting</li><li>• Caution needed with metal shards and heat</li><li>• lower-speed &amp; low-feed</li></ul> | <ul style="list-style-type: none"><li>• Bolting requires extreme precision as metal has no “give”</li><li>• Can’t screw/nail into metal like wood</li><li>• Few glues work as metal is non-porous</li><li>• welding</li></ul> |



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| <b>Wood</b>      |
| Types            |
| Properties       |
| Machining        |
| <b>Metals</b>    |
| Types            |
| Properties       |
| <b>Machining</b> |
| <b>Plastics</b>  |
| Types            |
| Properties       |
| Machining        |

# Types of Plastics

- A wide variety – Too many to count and new types are regularly created
- A couple ones to know:
  - PVC: Rigid and used for piping
  - Polypropylene: Commonly used in plastic bottles
  - Teflon: Very strong and heat resistant
- How it's commonly bought
  - Scrap pieces
  - Online ordering for special plastics
  - 3D printing or Injection Molding



|            |
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|            |
| Wood       |
| Types      |
| Properties |
| Machining  |
| Metals     |
| Types      |
| Properties |
| Machining  |
| Plastics   |
| Types      |
| Properties |
| Machining  |

# Properties of Plastics

| Pros  | Cons   |
|---|--|
| <ul style="list-style-type: none"><li>• Can be 3D printed or molded into unique shapes which are difficult to machine with wood/metal</li><li>• Can be very cheap on a large scale</li><li>• Weather resistant (hence non-biodegradable...)</li></ul> | <ul style="list-style-type: none"><li>• Often brittle and difficult to machine</li><li>• Specialized plastics are expensive</li><li>• Non-biodegradable</li><li>• Many melt/warp with heat</li></ul> |

- Other Properties
  - Usually brittle
  - Highly variable in its properties

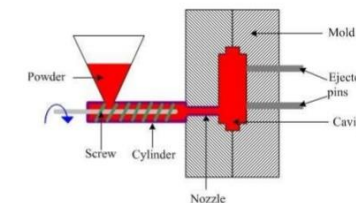
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| <b>Wood</b>       |
| Types             |
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| <b>Metals</b>     |
| Types             |
| Properties        |
| Machining         |
| <b>Plastics</b>   |
| Types             |
| <b>Properties</b> |
| Machining         |

# Machining with Plastics

- **Big Takeaway:** Highly variable in properties for specialized applications and often tricky to machine. However, their ability to be cheaply molded into highly precise parts has led to their widespread use

| Cutting/Drilling  | 3D Printing & Injection Molding  | Bonding  |
|---|--|--|
| <ul style="list-style-type: none"> <li>• Most are very brittle and easily snap</li> <li>• Usually soft and require little force to cut/drill</li> <li>• High speeds often ideal</li> <li>• Generally very small teeth on blades/bits due to brittle nature</li> </ul> | <ul style="list-style-type: none"> <li>• Allows for the creation of highly detailed and precise parts</li> <li>• 3D printing (Cheap for a few parts, expensive on a large scale)</li> <li>• Injection Molding: melting plastic in a mold. (Expensive initial cost to create mold then very cheap)</li> </ul> | <ul style="list-style-type: none"> <li>• Some too brittle to screw into, but bolting works well</li> <li>• Wide range of specialized plastic glues</li> <li>• Glues stronger than metal</li> </ul> |

How Does Injection Molding Work?



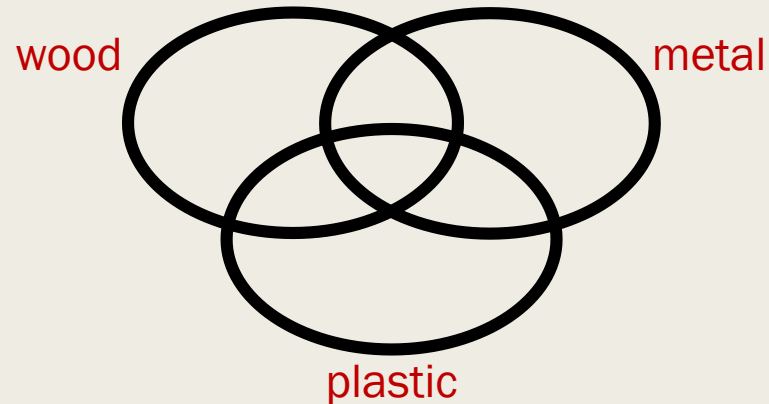
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| Wood             |
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| <b>Plastics</b>  |
| Types            |
| Properties       |
| <b>Machining</b> |

# Other Materials

- Composites
  - Made of two or more significantly different materials
- Ceramics
  - Made from clay hardened by heat (think bricks)

# Your Task

1. Create a Graphic Organizer Comparing the benefits and tradeoffs of using wood, plastic and metal
  - I recommend making a Venn Diagram on your notes from yesterday (or another sheet of paper) like this:



2. Research and choose a **specific** material (i.e. stainless steel)
  - Below your graphic organizer (or another piece of paper) look up:
    - specific properties
    - Common uses/applications
    - cost
    - Advantages and disadvantages