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 alter a material
- Fabricating – Creating a part
- Malleable: Ability to bend without breaking
- Ferrous: magnetic
- 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
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)
## Properties of Wood

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Easy to work with</td>
<td>• Heavy/bulky</td>
</tr>
<tr>
<td>• Cheap</td>
<td>• Not weather-resistant unless stained</td>
</tr>
<tr>
<td>• Easy to obtain</td>
<td>• Warps/weathers</td>
</tr>
<tr>
<td>• Can stain/paint easily</td>
<td>• Flammable</td>
</tr>
</tbody>
</table>

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

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

Common Methods of Machining

<table>
<thead>
<tr>
<th>Cutting/Drilling</th>
<th>Binding</th>
</tr>
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</table>
| • 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 or low-feed & low-speed | • Nearly anything works  
• Screws and bolts easy to apply  
• Most glues are effective as wood is porous |

- **Types**
- **Properties**
- **Machining**
- **Metals**
- **Types**
- **Properties**
- **Machining**
- **Plastics**
- **Types**
- **Properties**
- **Machining**
# Types of Metals

<table>
<thead>
<tr>
<th></th>
<th>Iron</th>
<th>Steel</th>
<th>Stainless Steel</th>
<th>Copper</th>
<th>Aluminum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Types</td>
<td>Magnetic</td>
<td>Magnetic</td>
<td>Some magnetic, some non-magnetic</td>
<td>Weakly magnetic</td>
<td>Weakly magnetic</td>
</tr>
<tr>
<td></td>
<td>Easily rusts</td>
<td>Contains iron and carbon</td>
<td>Similar to steel, but non-corrosive and non-rusting</td>
<td>Highly conductive (used in most wires)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>heavy</td>
<td>Strong but heavy</td>
<td></td>
<td>Cheap</td>
<td>Light weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Easy to machine</td>
<td></td>
<td>Very malleable</td>
<td>Less malleable than most metals</td>
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- How it’s commonly bought
  - Sheets
  - Strips
  - Scrap pieces
## Properties of Metals

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<th>Cons</th>
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<tr>
<td>• Can be conductive/magnetic</td>
<td>• Expensive</td>
</tr>
<tr>
<td>• Very strong and durable</td>
<td>• Heavy</td>
</tr>
<tr>
<td>• High strength/weight ratio</td>
<td>• Hard to machine</td>
</tr>
<tr>
<td>• Heat/weather resistant</td>
<td></td>
</tr>
</tbody>
</table>

- Other properties
  - All are conductive
  - Malleable (can be bent)
# Machining with Metal

- **Big Takeaway:** Tough to Machine, but very strong

## Common Methods of Machining

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<td>• Specialized tools needed (angle grinder, special metal blades)</td>
<td>• Bolting requires extreme precision as metal has no “give”</td>
</tr>
<tr>
<td>• Lathe, mill</td>
<td>• Can’t screw/nail into metal like wood</td>
</tr>
<tr>
<td>• Metal blades have small “teeth” due to the hard nature of metal</td>
<td>• Few glues work as metal is non-porous</td>
</tr>
<tr>
<td>• Metals warp with heat from cutting</td>
<td>• welding</td>
</tr>
<tr>
<td>• Caution needed with metal shards and heat</td>
<td></td>
</tr>
<tr>
<td>• High-speed &amp; low-feed</td>
<td></td>
</tr>
</tbody>
</table>

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
# Properties of Plastics

- **Pros**
  - Can be 3D printed or molded into unique shapes which are difficult to machine with wood/metal
  - Can be very cheap on a large scale
  - Weather resistant (hence non-biodegradable...)

- **Cons**
  - Often brittle and difficult to machine
  - Specialized plastics are expensive
  - Non-biodegradable
  - Many melt/warp with heat

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

<table>
<thead>
<tr>
<th>Cutting/Drilling</th>
<th>3D Printing &amp; Injection Molding</th>
<th>Bonding</th>
</tr>
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<tbody>
<tr>
<td>Most are very brittle and easily snap</td>
<td>Allows for the creation of highly detailed and precise parts</td>
<td>Some too brittle to screw into, but bolting works well</td>
</tr>
<tr>
<td>Usually soft and require little force to cut/drill</td>
<td>3D printing (Cheap for a few parts, expensive on a large scale)</td>
<td>Wide range of specialized plastic glues</td>
</tr>
<tr>
<td>High speeds often ideal</td>
<td>Injection Molding: melting plastic in a mold. (Expensive initial cost to create mold then very cheap)</td>
<td>Glues stronger than metal</td>
</tr>
<tr>
<td>Generally very small teeth on blades/bits due to brittle nature</td>
<td></td>
<td></td>
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- 3D Printing (Cheap for a few parts, expensive on a large scale)
- Injection Molding: melting plastic in a mold. (Expensive initial cost to create mold then very cheap)
- Some too brittle to screw into, but bolting works well
- Wide range of specialized plastic glues
- Glues stronger than metal
Other Materials

- Composites
  - Made of two or more significantly different materials

- Ceramics
  - Made from clay hardened by heat (think bricks)
Your Task

- Create a Graphic Organizer Comparing the benefits and tradeoffs of using different materials
  - Template available on my blog

- Research and choose a specific material
  - On the back of your graphic organizer (or another piece of paper) look up:
    - specific properties
    - Common uses/applications
    - cost
    - Advantages and disadvantages