


**RoboJackets**



THE ARTHUR M. BLANK  
FAMILY FOUNDATION

2007 TE Sessions  
Fabrication and Safety  
October 23, 2007

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**Machinability**



**What does machinability mean?**

- Design your parts so they can actually be made
- No intersecting or interfering holes
- Parts fit together properly

**Keys**

- Good design discipline
- Keep records of designs and changes
- Make sure machinists are aware of changes!

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**Drafting**



**What does drafting mean?**

- Technical Drawings of parts to be fabricated
- Specify all relevant dimensions and tolerances
- Make drawing readable! Machinists can't read minds

**Keys**

- Dimension parts in only one unit (in. or mm)
- Don't overlap dimensions
- Callout hole sizes and threads
- Show 3 views of part (Top, Right, Front)

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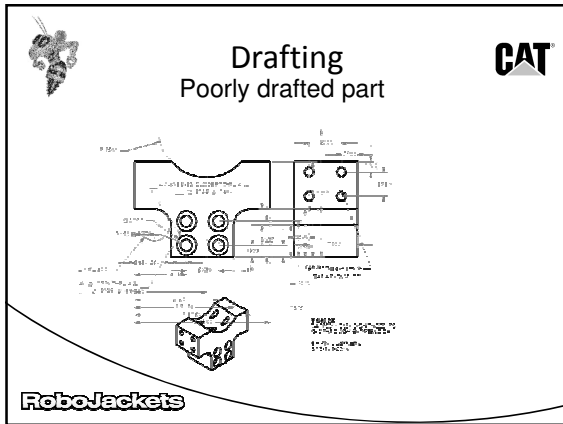
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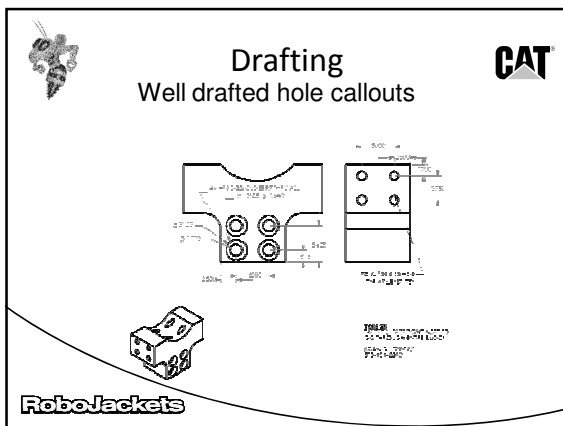
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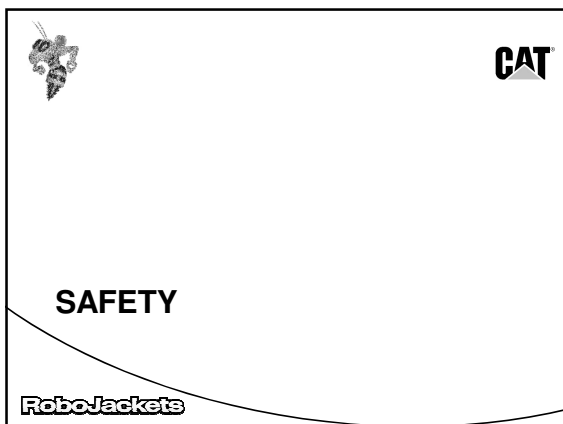
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## Safety



**General**  
 USE COMMON SENSE!!  
 IF YOU HAVE TO THINK TWICE, ITS NOT SAFE!!!  
 NEVER WORK ALONE

**Rules**  
 OBEY THEM OR GET OUT

**Safety**

- Accidents cause more than just pain
- Accidents will cause significant risk to your team
- Administration who hear about accidents will try to shut you down

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## Safety



**Glasses vs. Face Shields**

Glasses protect your eyes  
 in the direction you're looking  
 Face shields double protection, plus protect from  
 Sides, but not ok alone  
 Side shields must be worn on prescription glasses



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## Safety



**Welding Masks**

Welding masks must be worn while welding  
 Shades are from 7-14  
 Higher number is darker  
 Arc welding (TIG, MIG, Stick) – 10-14 shade  
 Gas welding (Oxy-Act) – 7-10 shade



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## Safety

### Clothing & Hair



**Shoes:**

- BAD: sandals
- OK: soft shoes
- GOOD: boots
- BETTER: steel toed boots

**Clothing:**

- BAD: tank tops and skirts
- OK: tee shirts and shorts
- GOOD: long sleeved shirts and pants
- BETTER: heavy snug shirts and jeans

**Hair:**

- BAD: long flowing hair
- OK: long hair pulled back
- GOOD: short hair
- BETTER: no hair




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## Safety

### Gloves



**Plasic and Latex:**



- Used for chemical handling
- Also used for sanitary issues

**Heavy Leather:**

- Used for welding
- Also for handling hot material

**Rubber lined fabric:**

- Good for general use
- Keeps hands clean
- Protects from sharp edges


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## Safety

### Ear Protection



**When to use:**



- Grinding on steel (especially thin gauge)
- Using air tools

**Ear Plugs:**

- Comfortable
- Cheap
- Easy to use
- Effective

**Ear Covers:**

- Bulky
- Effective
- Worn over ears


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## Safety

### Chemicals



**Dangers:**


- Fumes
- Overspray


**Protect:**

- Eyes (glasses)
- Mouth (mask)
- Skin (gloves)

**Spills:**

- Alert a teacher
- Make sure air is safe
- Sop up with litter or sawdust





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## Safety

### Air Quality



**Dust:**


- Sanding and cutting wood, plaster or drywall creates dust
- Fine particles are suspended in air

**Protection:**

- Dust masks must be worn
- Dust inhalation will cause respiratory damage

**Prevention:**

- Cut outdoors!!
- Vacuum
- Moisture (wet sanding)



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## Safety

### Machinery Hazards



**Moving Parts**


- Don't touch any moving parts
- Spinning bits are very sharp

**Fingers:**

- Fingers are easily cut and ripped off by blades
- Keep your fingers AWAY from sharp objects

**Maturity:**

- No horseplay in the shop
- No throwing tools
- No fighting



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## Safety

### Machinery Hazards







**Pinch Points**

- Some machinery parts will pinch
- You can become caught in a machine
- Wear proper clothing

**Fingers:**

- Keep fingers away from pinch point dangers
- Be Alert!




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## Safety

### Machinery Hazards



**Hot Parts**


- Machined parts will be hot!
- Especially after cutting and grinding

**Gloves**

- Wear appropriate gloves when handling hot parts

**Tools**

- Drill bits get hot too!
- Chips are also hot
- Quench in water to cool parts down




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## Safety

### Machinery Hazards



**Fixturing**



- Make sure workpieces are affixed to the tool
- Use a vise or clamps

**Vibration**

- Proper fixturing prevents inaccuracies caused by vibrations

**Danger**

- Improperly fixtured parts can fly out of clamp and cause injuries


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## Safety

### First Aid



**Injuries**

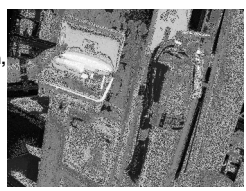
- Call for help
- Get the First Aid kit


**When to call for help**

- Notify an adult or teacher immediately
- Don't hesitate to dial 911

**First Aid Kit**

- Must be located in an open, accessible area
- Make sure it is stocked
- Know where it is





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## Safety

### First Aid



**Bleeding**


- Apply pressure
- Wrap with a clean bandage
- Go to ER if bleeding does not stop

**Shock**

- Massive blood loss will cause shock
- Body's defensive mechanism
- Keep person warm and awake
- Dial 911

**Fire**

- Know where your fire extinguisher(s) are
- Make sure they are charged
- Don't hesitate to use it!!!



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## Safety

### First Aid



**Falls**


- If person is unconscious call 911
- Don't move them, will cause worse injuries

**Broken bones & joints**

- Area will swell massively and be very painful
- Call 911
- Don't move the person or body part until help arrives

**Sprains and strains**

- Don't move the joint
- Put ice on the swelling
- Ibuprofen (Advil) will help pain and swelling
- Keep weight off of injury



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**Safety**  
Activity

**15 MINUTES**

1. Where is your First Aid Kit?
2. What's in it?
3. Where is your fire extinguisher?
4. What other safety equipment do you have?





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**FABRICATION**





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**Fabrication**  
Basics



**Drills**


- Make sure drill bits are spinning the right direction (clockwise)
- Use sharp bits

**Safety**

- Eye protection is always required

**Common Sense**

- If you don't think it's a good idea, don't do it!!!



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## Fabrication

### Drilling





**Drilling**

- Drill bits remove material quickly
- Drill bits are not precise

**Lubrication**

- Drilling creates a lot of heat and friction
- Oil helps disperse heat and protect bits
- Always use oil while drilling in metal





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## Fabrication

### Drilling




**Speed and Bit size**


ALUMINUM: 800-1000 RPM  
STEEL: 300-800 RPM

- As drill bit size increases, cutting speed must decrease
- Increased bit diameter requires more power to turn

**Chips**

- Watch chip formation
- Nice long chips are good
- Squeaking means speed too high and not enough oil





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## Fabrication

### Drilling



**Drills**



- Two types
- Handheld Drills
- Drill Presses


**Handheld Drills**

- Convenient
- Easy to use
- Battery or corded
- Inaccurate

**Drill Presses**

- Restrictive to parts that can fit
- Powerful
- Accurate



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## Fabrication

### Drilling



**Accuracy**

- Center punch your marks before drilling
- Drill pilot holes
- Step up drill bit sizes to make a large hole
- Ex. 1/2" hole:
  - Center punch mark
  - Drill 1/4" hole, then 3/8", then 1/2"

**Thick material**

- Peck drill
- Drill a little bit, pull out
- Keep oil in the hole
- Don't let drill bit get too hot

**Large bits (> 1/2")**

- Use only in lathe or mill
- Bits are too big for handheld drills
- Material removal rate too high for drill press

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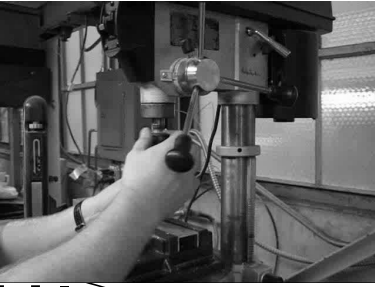
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## Fabrication

### Drilling





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## Fabrication

### Cutting



**Cutting**

- Material is removed along direction of blade travel
- Powered and Manual

**Manual (Hacksaw)**

- Simple & quick
- Can be accurate if part is fixtured properly
- Safe

**Powered (Bandsaws and Circular saws)**

- Quick
- Accurate
- Dangerous

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## Fabrication

### Cutting



**Materials**


- Cut metal, plastic or wood


**Metal**

- Aluminum: Toothed blades only
- Steel: Abrasive blades

**Plastic**

- Large toothed blades





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## Fabrication

### Cutting



**Rotary Saws**


- One round blade with multiple teeth
- Toothed or abrasive


**Chop saws**

- Blade is moved into the fixed workpiece

**Table saws**

- Plastic and wood only
- Workpiece is moved into spinning blade





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## Fabrication

### Cutting

**Milling**



- Good for cutting thick plates


**Shears**

- Good for cutting thin plates

**Hacksaws**

- Good for quick cuts



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## Fabrication

### Cutting







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## Fabrication

### Grinding



**Why Grind?**


- Grinding removes a small amount of material
- Leaves a smooth surface finish
- Creates a lot of heat

**Surfaces**

- Grinding surfaces are like thousands of small saw teeth
- Sandpaper, stone, or files

**Rated in "Grit"**

- Higher number means finer grinding surface
- Lower number means more material can be removed



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## Fabrication

### Grinding



**Grinders**


- Benchtop
- Handheld

**Bench Grinders**

- Workpiece is ground in the spinning wheels of the stationary tool

**Angle and Die grinders**

- Handheld tools grind on stationary workpiece
- Can also be used to cut steel with cutting disc



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## Fabrication

### Grinding





**Safety**


- Eye and ear protection
- Face shield

**Steel and Aluminum**

- Do not grind aluminum
- Aluminum melts and sticks to grinding wheels







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## Fabrication







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## Fabrication

### Milling



**Reasons to Mill**

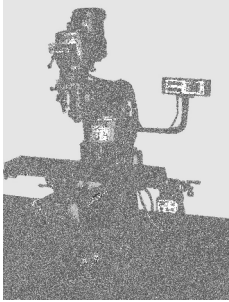
- Material removal
- Accurate hole placement
- Multi-axis machining


**Types of Mills**

- Vertical (most common)
- Horizontal

**Tooling**

- Endmills
- Facing bits
- Drills & Reams





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## Fabrication

### Milling



**Basics**


- Tool remains stationary
- Workpiece moves with table
- x,y,z axes

**CNC**

- Computer Numeric Control
- Allows precise shapes to be cut quickly

**Precision**

- Properly fixtured parts can be machined up to 0.0005" accuracy
- Material removal rates must be controlled to maintain precision



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## Fabrication

### Milling



**Endmills**


- Cut vertically or horizontally
- High material removal rates


**Facing tools**

- Remove uniform layer of material from horizontal surface

**Reams**

- Create an accurate hole diameter from a drilled hole
- Slow





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## Fabrication

### Milling







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## Fabrication

### Turning



**Reasons to Turn**

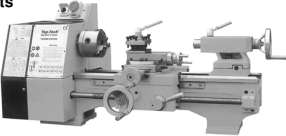
- Material removal
- Accurate round parts
- Make couplings
- Cut threads


**Types of Lathes**

- Metal
- Wood

**Tooling**

- Turning inserts
- Parting bits
- Single point cutting bits
- Drills & Reams





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## Fabrication

### Turning




**Terminology**

- Chuck
- Toolpost
- Tailstock
- Saddle
- Crossfeed
- Center

**Gearing**

- Lathes are geared to cut threads at a certain distance per revolution
- Constant feed rates provide good accuracy and surface finish



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## Fabrication

### Turning





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## Fabrication

### Tapping



**Reasons to Tap**

- Cut threads inside a hole
- Screw pieces together

**Tap sizes**

- Thread size is nominal diameter of bolt
- Also measured by Threads Per Inch
- Ex: 1/4" x 20, 1/4" x 28
  - 1/4" bolt, 20 threads per inch
  - 1/4" bolt, 28 threads per inch

**Lubrication**

- Always oil taps
- Slow cutting produces a lot of friction

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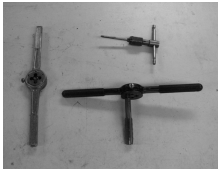
## Fabrication

### Tapping



**How to Tap**

- Drill the proper hole
- Consult tap table
- Turn tap 2-3 rotations
- Reverse direction to break chips inside hole
- Turn 1-2 turns, reverse 1/2 turn, repeat



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## Fabrication

### Tapping





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**Fabrication**  
Activity

**CAT**

**45 MINUTES**

1. Design a coupling
2. Connect this motor shaft to this gear shaft
3. Detail the machining processes involved
4. Draw and dimension your design

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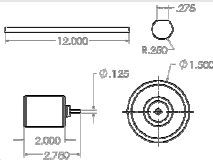
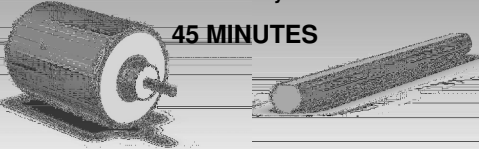
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**Fabrication**  
Activity

**CAT**

**45 MINUTES**



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