



## CLASS NOTES

# Metal 101: Introduction to Metalworking

### CLEARANCES

Bench Grinders  
Chop Saw (Metal)  
Disk Grinder  
Drill Press (Metal)  
Metal Grinder Dust Collection  
Vertical Band Saw (Metal)



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# Welcome

Welcome to the Introduction to Metalworking class at Protohaven!

## Shop Rules

### Be Safe

- Get safety clearances
- Wear protective equipment
- Watch and reset equipment after use
- Never use equipment that is red-tagged

### Take Care of Each Other

- Be aware of your surroundings
- Don't use a tool if it poses a danger to someone else

### Take Care of the Tools

- Get tool clearances
- Do not alter or use equipment beyond limits
- Notify staff when maintenance is needed

### Keep the Shop Clean

- Clean up after yourself
- Return tools to their original locations

## Tool Status Tags

Every tool at Protohaven has a status to let you know if the tool is safe to use.

If the tool status is *green*, the tool is safe to use. All features should be expected to work, and no extra care should need to be taken while using the tool.

If the tool status is *yellow*, the tool may still be used, but with extra caution. The information on the physical tag or in the online maintenance history will indicate what special care needs to be taken while using the tool. If the physical tag and the maintenance log disagree, alert a tech.



If the tool status is *red*: **DO NOT USE THE TOOL**. The tool is not safe to use. The information on the physical tag or in the online maintenance history will indicate what fixes are pending, and when a repair is expected.



Some tools in the shop are explicitly green tagged to let you know they are working. Other tools in the shop are not explicitly green tagged when they are working to reduce sign fatigue.

If you are in doubt about the status of a tool with no visible tag, check the tool status by following the link in the QR code attached to the tool, or check the Protohaven website for the tool status page:

<https://www.protohaven.org/equipment/>

## **Filing a Tool Report**

If you are using a tool, and the tool becomes unsafe, damaged, or is not working properly, you must notify a tech. The tech may instruct you to submit a tool report:

<https://airtable.com/appbIl0RlmbIxNU1L/shrluff2WSzy8c3xd>

Notifying the tech will help us keep signage up to date, and make sure the users who come in after you have all the information they need to use the tool safely, even if they don't use discord.

# Metalworking Safety

Do not work in the metal shop wearing anything that could end up pulling you into a machine. Do not wear:

- Long hair
- Loose sleeves
- Loose clothing
- Gloves

If you feel unsure of something, feel free to ask!

DRAFT  
2024-09-20

# Introduction

## Learning Objectives

### Terminology

<b>swarf</b>	Chips and dust carried away from the workpiece by the saw blade during the cut.
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# Tools

## Metal Chop Saw

The metal chop saw is a power tool suited for making cuts through thin stock: square rod, round rod, angle iron, or square tube. This tool is best for shallow cutting angles.

The metal chop saw can be very dangerous: be very careful using this tool.

### Notes

#### Safety

##### **Safety Warning!**

**No freehand cuts.** Freehand cutting is a major cause of accidents and should not be attempted.

Be mindful of the area to the right of the metal chop saw; waste pieces may go in that direction after a cut is complete. Be extra careful if another shop member is using the metal drill press or grinders.

Do not use the metal chop saw to cut small pieces. If the cut will cause your fingers to be within 150mm of the saw blade, the workpiece is too small.

Do not make cuts that produce waste pieces smaller than 8mm (5/16") in length. The waste piece must be 8mm (5/16") or greater to avoid the piece falling through the blade slot and causing any potential danger.

Don't use the metal chop saw for 45° angle cuts. Use this saw for cuts close to or at 90°.

When making a cut, only let the blade approach the workpiece from the back or from the top. Do not let the workpiece touch the back part of the blade where the teeth are traveling upward: the teeth may pull the workpiece up and out of the vise.

The metal chop saw is not bolted down.

Unplug the saw while setting up a workpiece or performing any maintenance.

#### Use

If you see several chipped teeth in a row during the blade inspection step, the blade needs to be replaced: please inform a tech on duty.

We have a 14" blade, but the signage on the saw lists capacities for a 15" blade. Be conservative.

Apply gentle pressure during a cut. The idea is to take light chips or shavings with the cutting heads, not grind through the workpiece. Applying excess pressure will not make the machine perform any better, and may reduce the lifetime of the motor and the blade.

## Parts of the Metal Chop Saw

## Full View

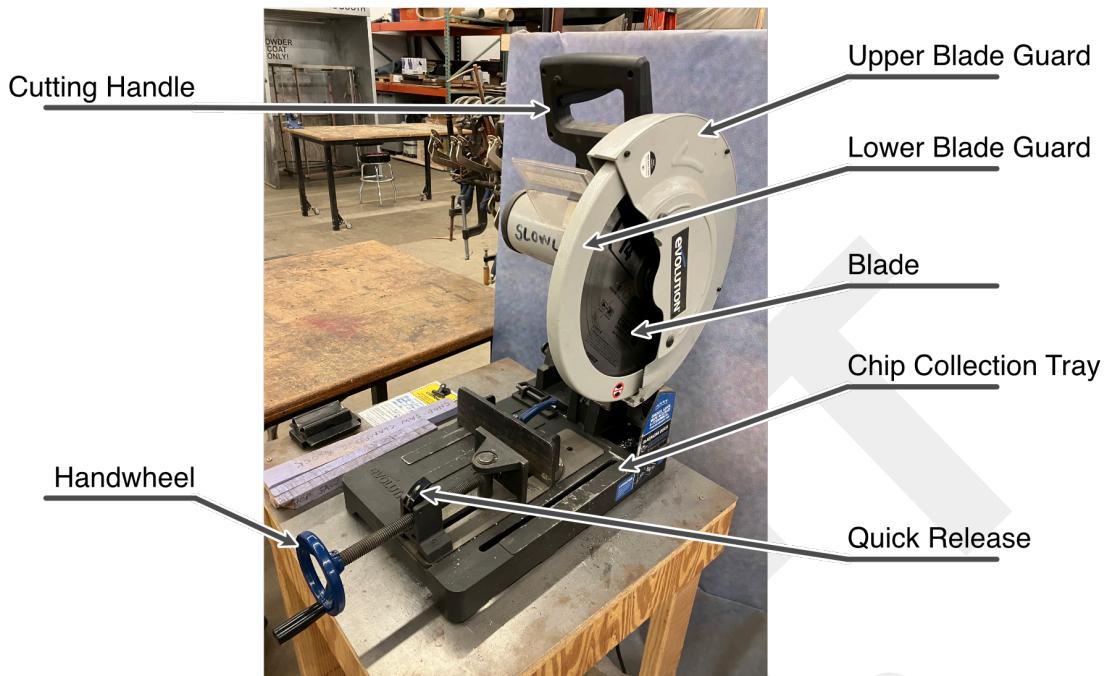


Figure 1: An annotated full view of the metal chop saw.

## Table View

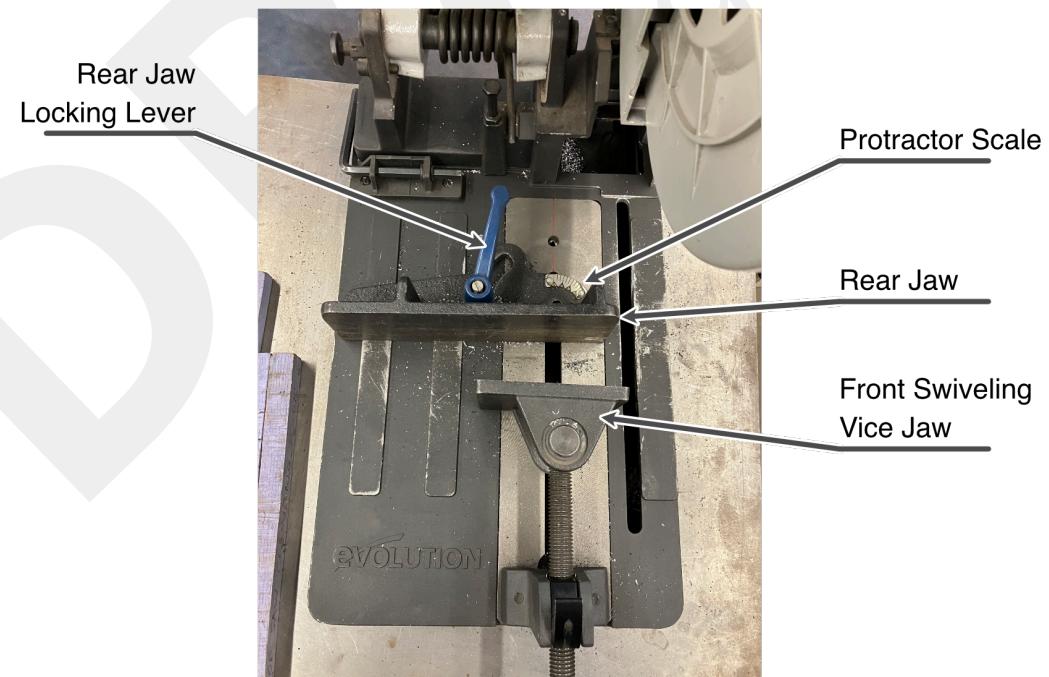


Figure 2: An annotated full view of the metal chop saw table.

### Lower Blade Guard

The lower blade guard will automatically retract as the saw is lowered into the cut, and then automatically cover the blade as the saw is lifted from the cut.

Do not hold the lower blade guard open.

### **Upper Blade Guard**

The upper blade guard is fixed in position to cover the top half of the blade at all times when in use.

### **Handwheel**

The handwheel tightens or loosens the vice jaws.

### **Quick Release Mechanism**

The quick release mechanism releases the clamping screw on the front vice jaw, so that the front swiveling jive jaw can be quickly adjusted.

Lift the blue handle to slide the front vice jaw away from or into the workpiece. Always replace the quick release mechanism before using the saw to make sure proper camping force is being applied to the workpiece.

### **Front Swiveling Vice Jaw**

The front vise jaw can swivel to accommodate workpieces held at an angle.

Always make sure the front vice jaw has stable and full contact with the workpiece; see [Workholding](#) for more information about workholding with this tool.

### **Repositionable Rear Vice Jaw**

The rear vise jaw can be locked into position to accommodate workpieces held at an angle.

Always make sure the rear vice jaw has stable and full contact with the workpiece; see [Workholding](#) for more information about workholding with this tool.

### **Cutting Handle**

Use the cutting handle to lower the cutting head into the work piece.

Only use the cutting handle with your right hand.

### **Rear Vice Jaw Locking Lever**

The rear vice jaw locking lever locks the rear vice jaw into place.

### **Protractor Scale**

Use the protractor scale to align the rear vice jaw to an angle.

Set the rear vice jaw at an angle to make angled cuts. **Do not set the rear vice jaw to an angle more/less than n degrees; to shallow/stEEP of an angle may cause the cutoff to fly away from the machine.**

### **On/Off Trigger Switch**

The on/off switch has two parts: the safety lock and the trigger switch. The safety lock is the button under the thumb when gripping the handle, and must be pressed to turn on the saw. The trigger switch is on the inside of the handle.

To turn on the motor, depress the safety lock, then squeeze the trigger switch.

## Chip Collection Tray

The chip collection tray catches chips and dust that are ejected downward out of the cut.

Check the chip collection tray for any material that extends into the cutting area, and might interfere with a cut. Clear out any interfering material before making a cut.

## Basic Operation

### Workholding

- Clear the machine of swarf and dust before clamping the workpiece.
- Make sure the workplace is secure.
- Make sure the workpiece doesn't rack in the clamp.
- Make sure the workpiece is in full contact with the table.  
*If the piece drops during the cut, it could rack and move into the blade.*
- Make sure the front clamp is tight.
- Make sure the back clamp is set and clamped.

Check that **both** ends of the workpiece are secure in the vise (not just the end near the blade).

Bring the unpowered saw blade down on the workpiece to check position of the cut:

- Make sure the cut is positioned where you want it on the workpiece.
- Secure the part so the blade catches it on the down or through swing, not on the upswing.
- Make sure the waste piece is at least 8mm (5/16") in length.

### Setting Up

Inspect the entire blade for chipped teeth.

Clean the clamps and table before securing the workpiece. Make sure the clamping area is free of swarf and dust, and nothing will get on the clamping surfaces that may cause the workpiece to loosen or shift.

Ensure that the cut-off portion of the workpiece is free to move away from the blade at the end of the cut. Be very careful to make sure that the waste piece will not get jammed in the clamping area, against the blade, or in any other part of the machine.

Ensure that the workpiece is held securely in the vise. (see [Workholding](#))

Check to make sure no one is nearby who could get hit by a flying waste piece.

### Making a Cut

1. Plug in the machine.

*Do NOT put the electrical box on the table of the drill press.*

2. **Only use the right hand to operate the saw.**

*Keep your body away from cut, and out of the path of any flying debris.*

3. With the saw in a fully upright position, turn on the motor and let the blade come up to full speed.
4. Gently lower the saw blade toward the workpiece. Go slowly!

5. Gradually increase the pressure as the saw blade enters the workpiece.  
*Do not force the saw blade into the workpiece. Let the saw blade do the work.*
6. Adjust the cutting pressure to suit the material.  
*Use the least amount of pressure needed to make the cut. Use more pressure to move the blade through thicker parts of the workpiece, less pressure to move the blade through thinner parts of the workpiece.*
7. Reduce pressure as the blade begins to exit the material.
8. Upon completion of the cut, allow the saw blade assembly to rise completely into its upper position.
9. Turn off the motor.
10. Do not remove your hands or the workpiece from the tool until the blade has come to a complete stop and the blade is completely covered by the blade guard.

### Cleaning Up

- Use chip brushes and dust pans to clean up any swarf and dust.
- Pick up any waste pieces.
- Unplug the saw, and stow the power cable.

## Metal Drill Press

### Notes

### Safety

Keep workpiece firmly attached to the table at all times. If the workpiece becomes loose, it may lift up and begin to spin on the drill bit, creating a very dangerous cutting hazard.

### Use

Drilling produces a lot of heat, and it's easy to overheat a drill bit when cutting for an extended period in a hard material. Go slowly, take frequent breaks, and use a good cutting oil to help cool the work and improve the cut.

### Consumables

The are shop-use drill bits available in the shop cart by the metal band saw, and there is a drill bit set available for checkout at the front desk. If you need a particular bit size, or want to make fine cuts in a work piece, you may wish to invest in your own drill bit set.

## Parts of the Metal Drill Press

### Full View

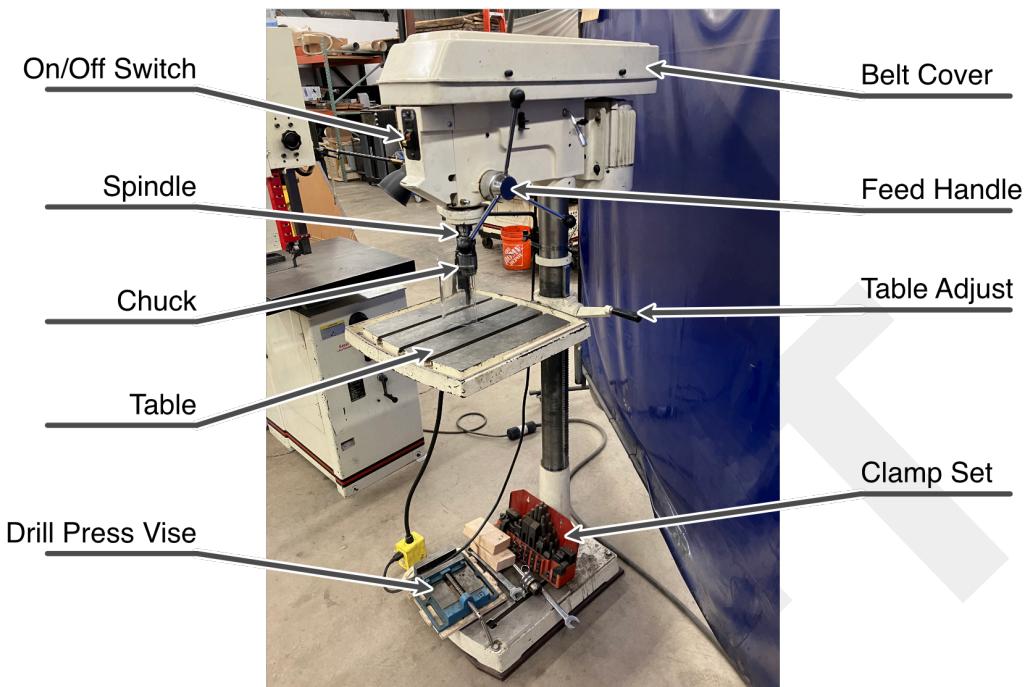


Figure 3: An annotated full view of the metal drill press.

## Belt Drive



Figure 4: An annotated view of the belt drive system.

## On/Off Switch

Put the switch into the **on** position to turn on the drill.

Put the switch into the **off** position to turn off the drill.

## Chuck

The chuck holds the drill bit in the spindle.

The chuck uses a set of jaws, which tighten around the shaft of the bit. Always make sure that the bit is firmly held by all three jaws.

## **Depth Stop**

The depth stop limits the amount of downward travel for the spindle.

Set the depth stop to drill holes of a specific depth in a work piece.

## **Feed Handle**

The feed handle lowers the spindle towards the workpiece.

## **Spindle**

The spindle is driven by the motor to turn the chuck and the bit.

## **Table**

The table supports the workpiece. The workpiece can be clamped to the table with the clamp set, or with the drill press vise.

## **Table Adjust Clamp**

Use the table adjust clamp to reposition the table. With the table adjust clamp loose, the table can be swung from side to side or moved up and down the drill press post.

Always make sure the table adjust clamp is fully tight before drilling a workpiece.

## **Belt Cover**

At the top of the drill press, the belt cover protects the belt drive system. Make sure the belt cover is closed before turning on the drill press.

## **Motor Tension Lock Screw**

There are two motor tension lock screws on either side of the drill cabinet. Loosen both screws to free the motor and enable the motor tension release lever.

Make sure the motor tension lock screws are firmly tightened before running the drill press.

## **Motor Tension Release Lever**

The motor tension release lever pulls the motor into a slack position, so the drive belts can be repositioned.

Always make sure the drive belts are under tension before running the drill press.

## **Clamp Set**

At the base of the drill press is a clamp set for use with the drill press table. The clamp set offers various screws and clamping bars that can secure a workpiece to the table.

## **Drill Press Vise**

At the base of the drill press is a drill press vise, which can hold a workpiece for drilling. The drill press vise must be clamped to the table using the clamp set to securely hold the workpiece.

The drill press vise is particularly useful for holding thin, flat stock. Always make sure that the workpiece is securely in the vise, and will not lift out and begin to spin on the drill bit.

## Basic Operation

### Setting Up

Ready the work area:

1. Turn on the light.
2. Clear off table of tools.

Set the appropriate speed:

1. Open the top of the drill press.
2. Loosen the two motor slide lock screws.
3. Release the motor tension release lever.
4. Configure the belts for the appropriate cutting speed.
5. Set the motor tension release lever.
6. Tighten the two motor slide lock screws.
7. Close the top of the drill press.

Secure a bit in the chuck:

1. Close the jaws of the chuck all the way.
2. Open the jaws just enough to accept the bit.  
*This will help keep the bit centered in the chuck.*
3. Slide the bit up into the jaws of the chuck.
4. Tighten the chuck.

*The metal drill press has a keyless chuck.*

Briefly run the drill to make sure the bit is on axis.

*The bit should not wobble when the drill is running.*

If needed, set the depth stop to make sure the drill press stops cutting at a specific depth.

### Workholding

#### Safety Warning!

Proper workholding is critical to the safe use of the metal drill press.

If the workpiece comes loose while the drill is running, the workpiece will rise up and begin to spin, becoming a very dangerous hazard for anyone nearby.

Always make sure that your workpiece is securely clamped to the table of the metal drill press.

There is a clamp set stored at the base of the metal drill press which can be used to secure the workpiece to the table.

The clamp set can also be used to secure the table vise, which is useful for securing thin stock.

### Drilling

1. Turn on the drill.

2. Pull the feed handle with a slow firm pressure to advance the bit through the workpiece.  
*Using cutting oil is recommended to control the temperature of the cut, and help carry away swarf.*
3. Reduce feed pressure near the end of the cut.  
*Do not drill into the table.*
4. Turn off the drill.

If you are making a deep hole in the workpiece, you may wish to complete the cut in several passes.

### Cleaning Up

1. Unclamp the workpiece from the table.
2. Clear off the table of tools and clamps.
3. Clean the table of swarf.
4. Turn off the light.

## Vertical Metal Band Saw

The vertical metal band saw can remove large amounts of material from a workpiece.

### Notes

#### Use

In general, use of the vertical metal bandsaw is limited to cutting either mild steel or aluminum. A comprehensive chart of permitted materials is inside the upper cabinet.

A good rule of thumb is to only cut material that is at least as thick as the height of three teeth on the saw blade. This will reduce the chances of a tooth catching the top edge of the workpiece too deeply. There are better methods for cutting thin materials (see the Sheetmetal classes for more).

#### Materials

This tool can be used to cut:

- mild steel
- aluminum
- brass

This tool must not be used to cut:

- Ordinary tool steel
- High speed steel
- Stainless steel

## Parts of the Vertical Metal Band Saw

### Front Quarter View

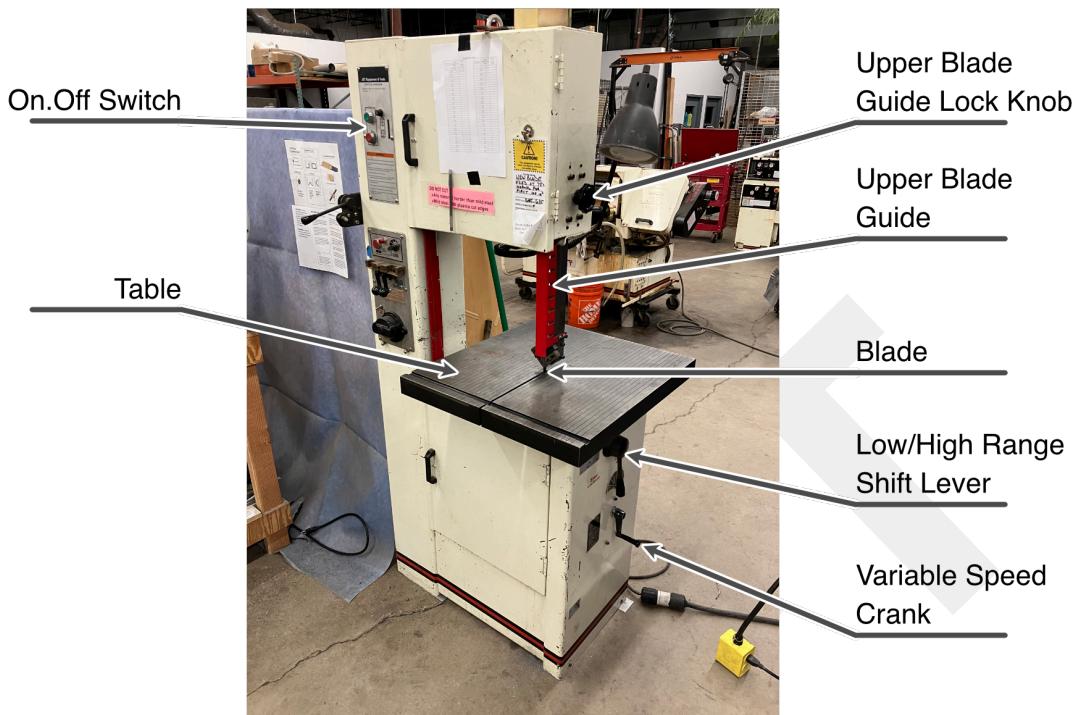


Figure 5: An annotated front quarter view of the vertical metal band saw.

### On/Off Switch

Press the **on** button to start the saw.

Press the **off** button to stop the saw.

### Low/High Range Shift Lever

The low/high range shift lever changes the gearing for cutting aluminum (low) and steel (high).

**Do not use this lever while the saw is running.** Turn off the saw before making any changes to the speed range.

### Variable Speed Crank

The variable speed crank adjusts the speed of the saw blade within the selected speed range.

**Do not turn this crank while the saw is stopped.** Only make speed adjustments when the blade is moving under power.

### Fence

Used the optional fence to register the workpiece a specific distance from the blade.

### Table Tilt

The table can be tilted to support angled cuts.



Figure 6: Annotated view of the vertical metal band saw table tilt mechanism.

To tilt the table left or right, loosen the two screws under the back of the table. Use the angle guide to set the necessary angle.

To tilt the table front to back, loosen the four screws under the right and left sides of the table.

Always re-tighten and screws under the table before making a cut.

### **Upper Blade Guide Lock Knob**

Use the upper blade guide lock knob to release or lock the upper blade guide during setup.

Use caution when releasing the blade guide: it is very heavy, and may cause injury if not properly supported when released.

### **Upper Blade Guide**

The upper blade guide can be moved up and down to cover the unused part of the blade during a cutting operation.

Always cover as much of the blade as possible for a particular cut, leaving a 1/4" gap between the bottom of the blade guide and the top of the workpiece. Test the workpiece clearance first with the saw turned off. Be careful of workpieces with complicated profiles: make sure that all parts of the workpiece will clear the upper blade guide.

### **Work Lamp Switch**

Turn on the work lamp for better illumination during a cut.

## **Basic Operation**

### **Setting Up**

1. Plug in the vertical metal band saw.
2. Loosen the guard screw to free the blade guard.  
*Be careful: the guard is heavy, and may drop unexpectedly.*
3. Set the blade guard to just above the height of the workpiece.
4. Tighten the guard screw to lock the blade guard in place.

5. Check the blade alignment with the guides.

*The blade guides should be just barely supporting the blade, and still turn freely. Make sure that the blade guides are clear of the teeth.*

6. Turn on the work light.

### Setting the Speed

1. Set the speed range shift lever to *high* or *low* as appropriate for the workpiece material.

*Make sure that the gearing is fully engaged in the new setting: you may need to manually advance the drive wheel to make sure the gears properly mesh.*

1. Set the speed crank to a speed appropriate for the material you are cutting.

### Workholding

- Support the workpiece with the fence during the cut, if possible.
- If the fence cannot support the workpiece, hold the workpiece firmly during the cut. Hold the workpiece on both sides of the cut if it is safe to do so.

### Making a Cut

1. Turn on the saw.
2. Using the fence or with a firm grip, bring the workpiece up to the blade.
3. Push the workpiece gently into the blade with constant pressure.  
*Go slowly. A gentle, consistent pressure will yield a better cut, and protect the workpiece and the tool.*
4. Adjust pressure during the cut as needed.  
*If the workpiece becomes thicker over the course of the cut, increase pressure.*
5. Use gentle pressure at the end of the cut.
6. Turn off the saw.

Wait until the blade has completely stopped before starting cleanup.

### Cleaning Up

1. Use a chip brush to clean off the table.
2. Sweep up any chips and dust in the surrounding area.
3. Turn off the work light.
4. Unplug the vertical metal band saw.

## Resources

### Metal Shop Dust Collection (Grinder Area)

Dust collection is an important part of any shop. Dust is a health hazard: dust is an irritant, and specific sizes of dust particles (PM2.5) can lodge in the lungs and accumulate there, leading to long-term and possibly severe health issues. Dust is also hard on metal tools, and can encourage surface rust and pitting.

## Notes

## Safety

Always use the metal grinder dust collector when using the bench grinders or the disk grinder.

Check the ducting from the metal dust collector to the grinders. Make sure all of the ducts are attached firmly to the grinders.

## Parts of the Metal Shop Dust Collection

### Front Quarter View



Figure 7: An annotated view of the metal dust collection in the grinder area.

### On/Off Switch

Put the switch in the **on** position to turn on the metal dust collection.

Put the switch in the **off** position to turn off the metal dust collection.

## Basic Operation

### Setting Up

Turn on the metal dust collection before grinding.

### Cleaning Up

Turn off the metal dust collection after grinding.

## Bench Grinders

Protohaven has a pair of two-disk bench grinders in the metal shop, useful for removing material from a workpiece.

The first bench grinder (on the left) holds:

- Wire brush wheel, suitable for any material (left)
- Aluminum grinding wheel, suitable for aluminum (right)

The second bench grinder holds (on the right):

- Coarse grinding wheel, suitable for steel (left)
- Fine grinding wheel, suitable for steel (right)

## Notes

### Safety

Do not let the workpiece get drawn into the gap between the tool rest and grinding wheel.

### Care

- Only grind appropriate materials with each wheel.  
*Using the wrong material may damage the grinding wheel.*

## Parts of the Grinders

### Front View



Figure 8: An annotated front view of the bench grinders. From left to right, the grinders are set up with: wire brush, aluminum, steel (coarse grit), steel (fine grit).

### On/Off Switch

Put the switch in the **on** position to turn on the motor in the grinder.

Put the switch in the **off** position to turn off the motor in the grinder. Wait for the grinder to completely spin down before leaving the area.

### Aluminum Grinding Wheel

The aluminum grinding wheel should be used for aluminum grinding only. Using other materials on this wheel may damage it.

### Blast Gates

The blast gates control airflow from the grinders to the dust collection system.

Make sure to open the appropriate blast gate and turn on the dust collection system before grinding.

### Coarse Steel Grinding Wheel

The coarse grinding wheel can be used to rapidly hog off material from steels.

This grinding wheel should only be used with steels. Grinding other materials with this wheel may damage the wheel.

## Fine Steel Grinding Wheel

The course grinding wheel can be used to remove fine layers from steels.

This grinding wheel should only be used with steels. Grinding other materials with this wheel may damage the wheel.

## Spark Shield

A plastic shield that keeps sparks from flying up at the user. Use the spark shield if your workpiece can be used with it. Always wear personal eye protection (goggles or face shield) when using the grinders.

## Quench Cup

The quench cup is used to cool down a workpiece that is getting too hot from grinding. Only use water in the quench cups.

## Tool Rest

Use the tool rest to steady the workpiece while grinding. Be careful not to let the workpiece pinch in the gap between the tool rest and the grinding wheel.

## Wheel Guard

The wheel guard is an important piece of safety equipment. The guard will help protect you and other shop members if the grinding wheel breaks up under load.

## Wire Wheel

The wire wheel is useful for softening the edges of cut materials and cleaning surfaces. Use any material with the wire wheel (but check the results on a test piece first).

## Basic Operation

### Setting Up

1. If needed, check to make sure there is sufficient water in the quench cup to quench the workpiece.
2. If needed, adjust the tool rest to bring it close to the wheel surface.
3. Adjust the shield so that it will not impede the workpiece.
4. Inspect the grinding wheel you will be using for any chips or cracks.
5. Open the appropriate blast gate.
6. Turn on the metal grinder dust collection.

### Grinding

1. Turn on the bench grinder.
2. Hold the workpiece firmly.  
*Use two hands if needed.*
3. Register the workpiece against the tool rest.
4. Present the workpiece to the wheel surface.  
*Make sure the workpiece does not get pulled down into the gap between the wheel and the tool rest.*

5. With steady and gentle pressure, move the surface of the workpiece slowly and smoothly across the face of the wheel.  
*If the workpiece is getting too hot, cool it in the quench cup.*
6. Turn off the bench grinder.
7. Wait until the grinding wheels come to a complete stop before cleaning up.

### Cleaning Up

1. Turn off the metal shop dust collection.
2. Close any open blast gates.

## Disk Grinder

The disk grinder can quickly remove material from a metal workpiece.

### Notes

#### Safety

##### **Safety Warning!**

##### **DO NOT WEAR GLOVES WHILE USING THIS MACHINE.**

Gloves can be pulled around by the disk into the gap between the disk and the table resulting in serious injury.

Do not leave the disk grinder unattended while the wheel is turning. Wait for the wheel to come to a complete stop before leaving the area after using the disk grinder.

#### Use

The disk grinder can remove a lot of material very quickly: use caution to make sure you do not grind off more material than required for your part.

## Parts of the Disk Grinder

### Front View



Figure 9: An annotated front view of the disk grinder.

### On/Off Switch

Use the green button to turn on the disk grinder. The grinder may take a moment to spin up to full speed.

Use the red button to turn off the disk grinder. The abrasive disk will continue moving at speed for some time after power is turned off.

### Brake

The brake will slow the abrasive disk.

When the machine is powered off, gently depress the brake to gradually lower the speed of the abrasive disk.

### Fence

Use the fence to support a work piece while grinding. THe fence can be set at a specific angle to grind an angel in the workpiece.

### Grinding Disk

The grinding disk is a large, very heavy disk covered with 80 grit (?) abrasive paper.

### Shield

The shield protects the top of the grinding disk.

### Table

The table is used to support the workpiece while grinding.

## Basic Operation

### Setting Up

Rotate the disk by hand to check for any places where the abrasive disk has worn or torn away.

If you find a spot where a small amount of abrasive has worn away, you can mark it on the table and use undamaged parts of the disk. If a large section of abrasive has worn away, notify a shop tech.

## Grinding

1. Turn on the metal grinder dust collector.
2. Turn on the disk grinder.
3. Hold the workpiece firmly.

*Use two hands if needed.*

4. Register the workpiece flat against the table.
5. Only use the right side of the disk.
6. Present the workpiece to the disk surface.

*Make sure the workpiece does not get pulled down into the gap between the wheel and the table.*

7. With steady and gentle pressure, move the surface of the workpiece slowly and smoothly across the face of the wheel.

*If you have marked areas where the abrasive surface is torn on the table, avoid those areas when grinding..*

8. Turn off the grinder.
9. Wait until the grinding wheels come to a complete stop before cleaning up.

*Gently press the brake pedal to reduce the disk speed.*

## Cleaning Up

Sweep up any dust.

Turn off the metal grinder dust collector.

# Resources

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