

University of Notre Dame
2021-2022



NOTRE DAME ROCKETRY TEAM
STANDARD OPERATING PROCEDURES

NASA STUDENT LAUNCH 2022

LAUNCH VEHICLE IDENTIFICATION SYSTEM AND APOGEE CONTROL SYSTEM

Submitted January 3, 2022

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1 Introduction

The Notre Dame Rocketry Team (NDRT) utilizes a separate standard operating procedure (SOP) document for ease of access to all personnel. The most updated version of all SOPs will be readily available in print in the workshop at all times. Additionally, a digital version of this document will be uploaded to the team website and emailed to each member of the team upon every revision.

This standard format will allow all team members to quickly and easily locate, read, and utilize desired information. Each SOP is intended to be clear, concise, and related to one single topic. Each piece of equipment in the workshop is documented separately in individual SOPs.

Each SOP is comprised of a title and responsible individual, revision history, required PPE, introduction, purpose, scope, procedure, image, and additional information if applicable. The responsible individual for all Standard Operating Procedures is the NDRT Safety Officer, Michael Bonaminio. For further SOP questions, please email mbonamin@nd.edu.

*****NEVER** use any equipment unless you are 100% certain on how to operate on it. Please reach out to any NDRT lead if you have any questions on operation before use

1.1 Tools

1.1.1 Dremel



STANDARD OPERATING PROCEDURE

Dremel

Responsible Individual: NDRT Safety Officer

Revision Number	Date	Change Description
1.0	12/11/2021	Initial

Required PPE

Safety Glasses Respirator, if dealing with plastics, such as fiberglass

Introduction

A dremel is a rotary tool used for various tasks in the workshop, and standard operating procedures have been written in order to ensure safe and consistent results.

Purpose

A dremel is a rotary tool, and the tip of the tool can be modularly attached with different bits depending on the desired task. Various uses of the dremel include but are not limited to: carving, engraving, polishing, cutting, and sanding. To perform the different tasks, unique drill bits are to be inserted into the dremel.


Scope





Any NDRT member who wishes to carve, engrave, polish, cut, and/or sand a material, especially wood, plastics, and certain metals.



Dremel Image



Procedure

Step	Action	Image
1	Ensure you are wearing the proper PPE and have a clean workspace around you. Wear a respirator if working with plastics.	 A photograph of a clean workshop workspace. It features a long wooden workbench with a metal frame, a black metal stool with a wooden seat, and a concrete floor. The background shows a door and some equipment.

2	<p>Locate the desired dremel tip for the intended task. Inspect the bit for any defects. If defects are found, do not use the bit; dispose of it immediately to avoid anyone else using it. If the bit is of quality, move onto the next step.</p>	 A close-up photograph showing a person's hands holding a small, dark-colored dremel bit between their fingers. The person is wearing a dark blue shirt. The background is a light-colored wooden workbench.
3	<p>Attach the desired bit to the tip of the dremel. Ensure the bit is properly secured before moving onto the next step. From this moment onward, no bodily part should come anywhere near the tip of the dremel.</p>	 A close-up photograph showing a person's hands attaching a bit to the end of a grey dremel motor. The person is wearing a dark blue shirt. The background is a light-colored wooden workbench.
4	<p>Properly secure the material the dremel will be used on. Reminder: if your hand is being used to secure the material, never bring your extremities anywhere near the dremel's bit.</p>	 A photograph showing a person's hands using an orange-handled clamp to secure a piece of light-colored material to a wooden workbench. The person is wearing a dark blue shirt. The background is a light-colored wooden workbench.
5	<p>Position yourself away from the plane of the rotation of the dremel. Never position yourself in the direct plane of rotation.</p>	 A photograph showing a person's hands holding a grey dremel motor. The person is wearing a dark blue shirt and khaki pants. The background is a light-colored wooden workbench.

6	<p>Turn on the dremel, and bring the rotating head near the desired area on the material.</p>	 A close-up photograph showing a person's hand holding a blue and grey dremel tool. The tool is positioned over a piece of light-colored wood on a workbench. The person is wearing a blue shirt and khaki pants.
7	<p>If dealing with plastics, use a dust collector to clean up the plastic debris as it is created; this job is done by another NDRT member.</p>	 A photograph showing two people working on a red plastic pipe. One person is using a dremel tool to work on the pipe, while another person is holding a dust collector to capture the debris. They are in a workshop setting.
8	<p>Kickback is a sudden jerk of the dremel due to misuse. This is extremely dangerous for all nearby personnel. The following are steps to avoid kickback:</p> <ol style="list-style-type: none">1. All previous steps should be followed2. Do not attempt to remove the dremel bit when the dremel is still rotating3. Never apply too much force on the surface of the material4. Always move the dremel in the direction of the rotating plane. Never attempt to move the dremel perpendicular to the plane	
9	<p>Once the job is completed, turn off the dremel, remove the bit from the dremel, and clean up the workshop area.</p>	

If uncertain how to operate, consult any NDRT lead for additional guidance. If in the Engineering Innovation Hub (EIH), you can also consult William Mathis (wmathis@nd.edu) or any EIH TA present. NEVER use any equipment without a complete understanding of how to use it.

1.1.2 Hand Saw



STANDARD OPERATING PROCEDURE

Hand Saw

Responsible Individual: NDRT Safety Officer

Revision Number	Date	Change Description
1.0	12/11/2021	Initial

Required PPE

Safety Glasses Respirator, if plastics, such as fiberglass, are being cut

Introduction

A hand saw is a common tool for cutting a material into two pieces. and standard operating procedures have been written in order to ensure safe and consistent results.

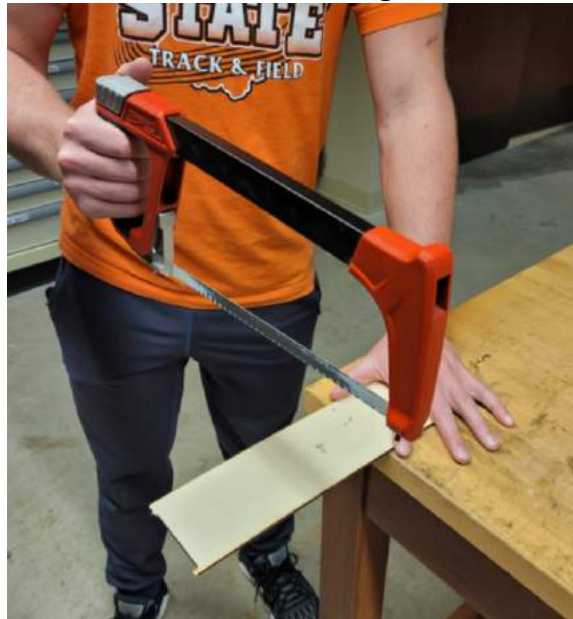
Purpose

A hand saw is moved back and forth in order to cut a material into two pieces. It is most commonly used on wood, but it can be used in certain plastics and metal.



Scope

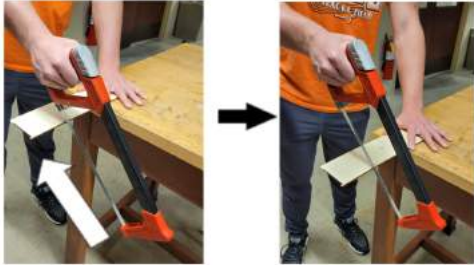
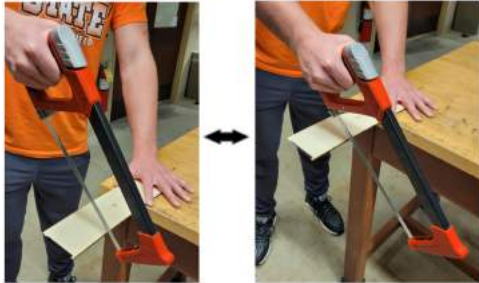
Any NDRT member who wants to cut a piece of material into two or more pieces.

Hand Saw Image



Procedure

Step	Action	Image
1	Ensure you are wearing the proper PPE and the workspace is clean. Wear a respirator if working with plastics.	
2	Grip the hand saw with your dominant hand, and grip the material you are cutting with your other hand. At no time should any bodily part come close to the teeth of the hand saw.	
3	Line up the hand saw with the location where you want to cut the material. Position the hand saw at a 45 degree angle from the face of the material	

4	Place the teeth of the saw that are closest to the handle at the end of the material farthest from the user, and gently pull the saw towards the user. A short stroke should be made here; do not use the entire length of the saw. Remove the saw from the material once the stroke is completed. In general, excessive force is not necessary to use a hand saw; let the teeth of the saw do most of the work. If the material does not seem to easily cut, then another tool should be used.	
5	Repeat step 4 until a significant cut has been started	
6	Place the teeth of the saw in the existing cut. Start to cut with a “rocking” back and forth motion. Long strokes should be used here.	
7	Continue to saw until the material is about to become two pieces; at this point, start to cut in shorter strokes and at a larger cutting angle than the original 45 degrees.	

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1.1.3 Portable Drill**STANDARD OPERATING PROCEDURE****Portable Drill**

Responsible Individual: NDRT Safety Officer

Revision Number	Date	Change Description
1.0	12/11/2021	Initial

Required PPE

Safety Glasses Respirator, if drilling through plastics

Introduction

A portable drill is a common rotary tool used for inserting screws or creating holes into material, and standard operating procedures have been written in order to ensure safe and consistent results.

Purpose




The portable drill allows for flexible construction work flow during the development and build of components. A power drill is effective against wood and certain plastics.

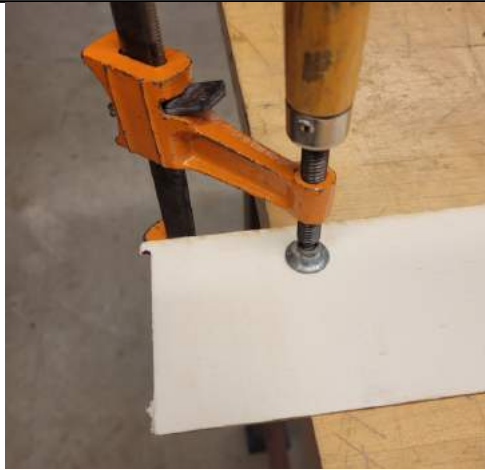
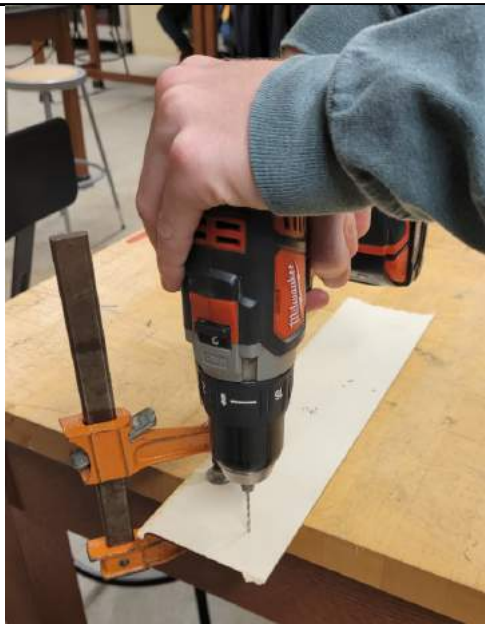
Scope


Any NDRT member who wishes to cut a hole or insert a screw into material

Portable Drill Image

Procedure

Step	Action	Image
1	Ensure you are wearing the proper PPE and the workspace is clean.	
2	Check battery for charge status, if of desired charge insert into the proper connection at the base of the drill handle	
3	Insert bit into the chuck at the tip of the drill and ensure that the chuck is tight	
4	Adjust direction of motor using switch to desired motion	

<p>5</p>	<p>Secure the work piece to the work table using either non-dominant hand or clamp setup</p>	
<p>6</p>	<p>Firmly grasp drill handle with dominant hand with fingers away from the activate trigger and use non-dominant hand to secure the back of the drill if not securing the work piece</p>	

7	<p>Orient the drill at the desired angle to the work piece and maintain a firm grasp as the trigger is activated and the motor begins turning. If drilling through plastics, use a dust collector to clean up the debris.</p>	
8	<p>Once the job is completed, clean up the workspace and put away all equipment</p>	

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1.1.4 Soldering Iron**STANDARD OPERATING PROCEDURE****Soldering Iron**

Responsible Individual: NDRT Safety Officer

Revision Number	Date	Change Description
1.0	12/11/2021	Initial

Required PPE

Safety Glasses

Introduction

Soldering is an effective and common method for joining electrical components together, and soldering standard operating procedures have been written in order to ensure safe and consistent results.

Purpose

Soldering is accomplished by heating up solder (conductive) material and applying it between the electrical components one wants to connect. Once the solder cools, the electrical components are connected.



Scope


Any NDRT member who wishes to meld two electrical components together

Soldering Iron Image


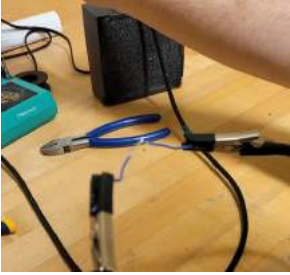
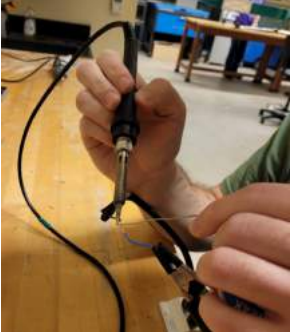


Procedure for Preparing the Soldering Iron

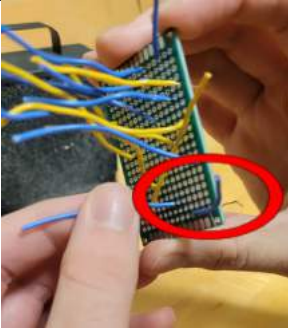
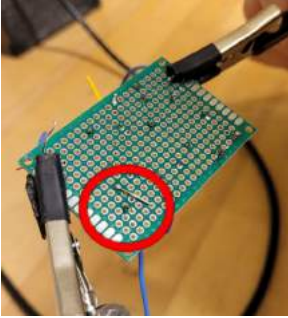
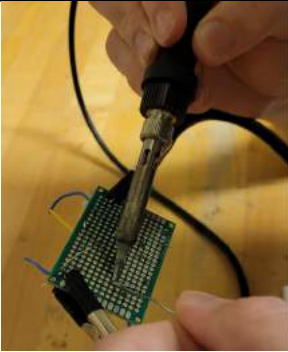
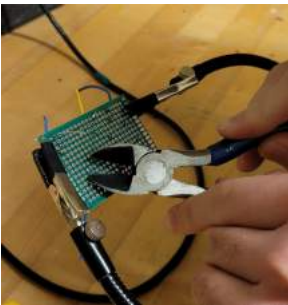
Step	Action	Image
1	Make sure your workspace is clear of any fire hazards before you start to heat the soldering iron. As well, wear proper PPE and prepare the soldering iron stand by wetting the sponge. Turn on the fan too.	
2	Make sure the tip of the soldering iron is screwed in tightly.	
3	Start to heat the soldering iron. Once the soldering iron is sufficiently hot (at least 400 Degrees Fahrenheit), rub the tip in the sponge of the soldering iron stand. This is done to remove any old, leftover solder. Note: from this point onward, never touch anywhere near the tip of the soldering iron; you will get burnt, or worse.	

4	<p>Allow a small portion of the solder to melt on the tip of the soldering iron. This will improve the results of the soldering. If too much solder is melted onto the tip, turn off the soldering iron, clean the tip as instructed in step 3, and repeat step 4.</p>	
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Procedure for Soldering Wires Together



Step	Action	Image
1	<p>Make sure all procedures for preparing the soldering iron are completed first.</p>	
2	<p>Make sure the wires tips are stripped of any insulation material before soldering them together. Reference the Wire Strippers/Cutters Standard Operating Procedure for the necessary steps for stripping wire insulation off.</p>	
3	<p>Place the two wires together</p>	
4	<p>Touch the soldering iron to the two wires. Keep the soldering iron on the wires until they are sufficiently melted together.</p>	

Procedure for Soldering Onto a Circuit

Step	Action	Image
1	Make sure all procedures for preparing the soldering iron are completed first.	
2	Place the desired component into the holes on the same side of the circuit board.	
3	Bend the extremities of the component; this will secure the position of the component. Once all solder extremities are bent, turn over the circuit board so the extremities are facing the user.	
4	Touch the soldering iron at the location where the solder extremity meets the base of the circuit board. Keep the soldering iron on the location until they are sufficiently melted together. A good soldering job will create a cone-shaped solder.	
5	Once the extremity is sufficiently melted, remove the soldering iron and check the quality of the melted joint again. If the joint is still deemed sufficiently melted, then remove the rest of the solder extremity. Note: do not remove too much of the solder extremity because it will become difficult to remove the solder (if needed) if there is no solder extremity tip.	

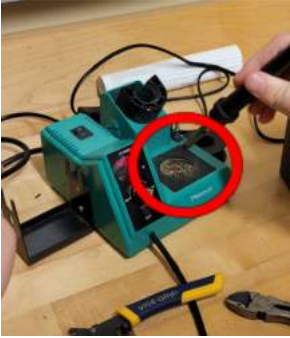

6	Repeat steps 4 for all other extremities on the component	
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Procedure for De-soldering

Step	Action	Image
1	Make sure all procedures for preparing the soldering iron are completed first.	
2	Place the desoldering braid material on top of the soldered piece you want to desolder. The use of the desoldering braid material is to absorb the melted solder.	
3	Solder the desoldering braid/soldered location. Once the spot has been sufficiently heated up, remove the soldering iron first, and then remove the desoldering braid. Note: do not touch the desoldering braid because it will be extremely hot from the melted solder and soldering iron contact.	
4	Evaluate the quality of the desoldering job. If additional solder needs to be removed, repeat steps 2-3	

Post-Soldering Procedure

Step	Action	Image
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1	Rub the tip of the soldering iron in the sponge of the soldering iron stand. This is done to remove any leftover solder.	
2	Turn off the soldering iron.	
3	Keep the solder iron clear of any fire hazard while the soldering iron cools down. Only once the soldering iron is completely cool can any personnel remove it from the workspace	

If uncertain how to operate, consult any NDRT lead for additional guidance. If in the Engineering Innovation Hub (EIH), you can also consult William Mathis (wmathis@nd.edu) or any EIH TA present. NEVER use any equipment without a complete understanding of how to use it.

1.1.5 Wire Cutters and Strippers



STANDARD OPERATING PROCEDURE

Wire Cutters and Strippers

Responsible Individual: NDRT Safety Officer

Revision Number	Date	Change Description
1.0	12/11/2021	Initial

Required PPE

Safety Glasses

Introduction

Wire strippers and cutters are crucial equipment for the construction of most electrical equipment, and standard operating procedures for these tools have been written in order to ensure safe and consistent results.

Purpose

The use of wire strippers is to remove insulation around wires while maintaining the integrity of the conducting wires. The use of wire cutters is to completely remove a section of a wire.





Scope



Any NDRT member who wished to cut a wire in half, or strip the insulation off of a wire

Wire Cutters/Strippers Image







Procedure for Wire Stripping

Step	Action	Image
1	Ensure you are wearing the proper PPE and the workspace is clean.	
2	Ensure the wires to be cut have zero electrical flow through them before wire stripping occurs. This can be determined through the use of an altimeter or voltmeter at the ends of the wire. Touch one part of the multimeter to the wire, and ground the other end. Both the multimeter can be found in the NDRT workshop.	 A person is using a multimeter to test a wire. The multimeter is held in their left hand, and the red and black probes are touching the wire and a ground point on a wooden workbench.
3	Line up the location where the wires want to be cut with the blades on the wire stripper. It is recommended that you strip off around one to one and a half inches from the tip of the wire. Keep all fingers away from the blades of the wire strippers from this point onward.	 A person is using wire strippers to cut a wire. The wire is held in their left hand, and the wire strippers are being applied to the wire with their right hand.
4	Insert the wire into the correct gauge on the wire stripper. This can be determined from looking at the guide located on the side of most wire strippers.	 A close-up view of wire strippers. A wire is inserted into the correct gauge slot on the side of the tool.
5	Gently clamp down on the wire cutters until the insulation has been penetrated by the wire strippers; the user should feel moderate resistance in their ability to clamp harder if the insulation has been penetrated. The user does not want to squeeze down too hard because they can possibly damage the wires.	 A close-up view of wire strippers clamping down on a wire. The wire is held in the correct gauge slot, and the tool is being applied to the wire.

6	Start to rotate the wire strippers, This will ensure that the wire has been cut along the entire exterior of the wire. Continue to rotate the wire until one full rotation has been complete	
7	While continuing to clamp down, pull the wire strippers away from the user; this will also pull the insulating away from the user and off of the wire. If the insulation around the wires does not come off easily, repeat steps 3-6 or change the gauge on the wire stripper	
8	Repeat steps 1-7 if additional insulation needs to be removed.	

Procedure for Wire Cutting

Step	Action	Image
1	Ensure you are wearing the proper PPE and the workspace is clean.	
2	Ensure the wires to be cut have zero electrical flow through them before wire cutting occurs. This can be determined through the use of an altimeter or voltmeter at the ends of the wire. Both the altimeter and voltmeter can be found in the NDRT workshop.	

3	Line up the location where the wires want to be cut with the blades on the wire cutters. Keep all fingers away from the blades of the wire cutters from this point onward.	
4	Insert the wire into the correct gauge on the wire cutter. This can be determined from looking at the guide located on the side of most wire cutters.	
5	Clamp down on the wire cutters until the wire has been cut into two pieces. If the wire is unable to be cut, change the gears	
6	Repeat steps 1-5 if additional sections of the wire need to be removed.	

If uncertain how to operate, consult any NDRT lead for additional guidance. If in the Engineering Innovation Hub (EIH), you can also consult William Mathis (wmathis@nd.edu) or any EIH TA present. NEVER use any equipment without a complete understanding of how to use it.

1.2 Equipment

1.2.1 3D Printer



STANDARD OPERATING PROCEDURE

3D Printer

Responsible Individual: NDRT Safety Officer

Revision Number	Date	Change Description
1.0	12/11/2021	Initial

Required PPE

Safety Glasses

Introduction

A 3D printer molds a user's created drawing into reality by applying small amounts of plastic in layers, and 3D printer standard operating procedures have been written in order to ensure safe and consistent results. Notably, this procedure exists to ensure that all personnel understand that only EIH personnel should operate on the 3D printers.

Purpose

A 3D printer allows the user to create intricate parts with the intense accuracy only a machine can provide. Another advantage of a 3D printer is that the part can be made without the need to oversee the process.

Scope

Any NDRT individual who wishes to create a unique part with plastic.

Image**Procedure**

Step	Action
1	Upload your CAD model of the part in .STL format to the Engineering Innovation Hub (EIH) portal.
2	Wait until the part is completed. The teaching assistants (TAs) will assist in the removal and cooling of the 3D printed part, so there is no need to ever touch the equipment. Only EIH TAs have the necessary training to operate on such equipment.
3	Consult an EIH TA if there are any special instructions to the printing process.
4	When the part is ready for pickup, go to the EIH during available hours to retrieve it.

1.2.2 Band Saw**STANDARD OPERATING PROCEDURE**

Band Saw

Responsible Individual: NDRT Safety Officer

Revision Number	Date	Change Description
1.0	12/11/2021	Initial

Required PPE

Safety Glasses

Respirator, if working with plastics

Introduction

The use of the band saw is necessary for many cutting aspects of the construction process, and band saw standard operating procedures have been written in order to ensure safe and consistent results.

Purpose

The band saw is used to rough cut a variety of materials in many different cut types in order to get a close product to the desired shape.


Scope



Any NDRT individual who wishes to cut a material, especially wood and certain plastics and metals.

Image



Procedure

Step	Action	Image
1	Ensure you are wearing the proper PPE and a clean workspace around you. Wear a respirator if working with plastics.	
2	Set blade guard to about $\frac{1}{4}$ of an inch above the thickness of the cutting stock.	
3	Prepare a push stick or position hands properly on the stock to be cut. NEVER have any fingers in line with the blade.	

<p>4</p>	<p>Turn on the bandsaw.</p>	
<p>5</p>	<p>Proceed to make cuts slowly and carefully. Take extra care to ensure that after the cut you don't move anything toward blade.</p>	

<p>6</p>	<p>Turn off the bandsaw and engage the break until the saw comes to a complete stop.</p>	
<p>7</p>	<p>Remove cut stock and any excess material from the bandsaw. Clean up the workspace before leaving too.</p>	

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1.2.3 Belt Sander**STANDARD OPERATING PROCEDURE**

Belt Sander

Responsible Individual: NDRT Safety Officer

Revision Number	Date	Change Description
1.0	12/11/2021	Initial

Required PPE

Safety Glasses

Respirator (if using plastics or fiberglass)

Introduction

Belt sander is needed in order to sand off large amounts of material quickly, and belt sander standard operating procedures have been written in order to ensure safe and consistent results.

Purpose

A belt sander is used to take sand off a large amount of various materials to smooth the material to the intended form.

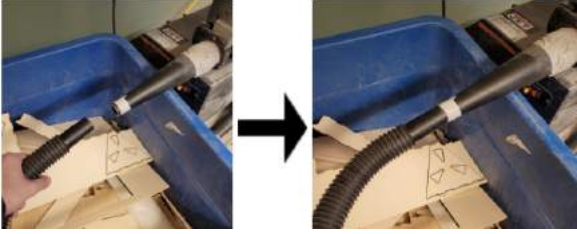

Scope



Any NDRT personnel that wishes to sand off large amounts of stock material, especially wood and fiberglass


Image



Procedure

Step	Action	Image
1	Start by ensuring you have proper PPE on and a clean workspace around you.	Image
2	Make sure the dust collector is on and plugged in.	
3	Hold sanding stock on the far edge away from paper.	

<p>4</p>	<p>Turn on sander and be careful not to touch moving sand paper.</p>	
<p>5</p>	<p>Apply gentle pressure and constantly move stock to apply even sanding and to avoid kickback.</p>	

6	Periodically stop to clean off removed material.	
7	Repeat steps 5 and 6 until the desired amount of material is removed. Turn off sander when finished.	

1.2.4 Drill press**STANDARD OPERATING PROCEDURE****Drill Press**

Responsible Individual: NDRT Safety Officer

Revision Number	Date	Change Description
1.0	12/11/2021	Initial

Required PPE

Safety Glasses Respirator (if using plastics, such as fiberglass)

Introduction

The drill press is a rotary tool used to hand drill precise holes, and drill press standard operating procedures have been written in order to ensure safe and consistent results.

Purpose

The drill press is used to drill more precise holes than a hand drill. It can be used for many different materials providing that you have a proper bit.

Scope




Any NDRT personnel that wishes to create a precise hole in material, especially wood, plastics, and certain metals.

Drill Press Image



Procedure

Step	Action	Image
1	Ensure you are wearing the proper PPE and a clean workspace around you. Wear a respirator if working with plastics.	
2	Select the proper bit for whatever material you may be drilling. To insert the bit, first loosen the chuck with the tool found on the right side of the drill press. Once loose, place the bit in the chuck and retighten. Make sure you tighten appropriately.	

3	Use the lever on the side to pull the bit and chuck down to line up material with the bit properly.	
4	Once everything is in line, clamp down the material.	
5	Turn on the drill press and proceed to pull the lever down to drill hole to its intended depth. Oil may need to be used when drilling metal. If plastics, such as fiberglass, are being drilled, use a dust collector to collect the dust as it drills the bit.	
6	Once drilled, return the bit to the starting position and turn off the drill press. Remove material once bit has come to a complete stop	
7	Remove the drill bit and clean the workspace	

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1.2.5 Laser Cutter



STANDARD OPERATING PROCEDURE

Laser Cutter

Responsible Individual: NDRT Safety Officer

Revision Number	Date	Change Description
1.0	12/11/2021	Initial

Required PPE

Safety Goggles supplied by laser cutter company

Introduction

A laser cutter utilized a high power laser to cut stock material, and laser cutting standard operating procedures have been written in order to ensure safe and consistent results.

Purpose

The laser cutter allows CAD files to be accurately translated to components for construction.

Scope

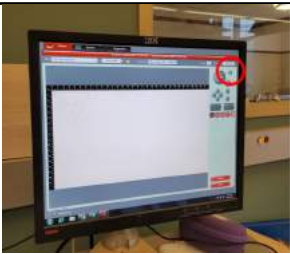
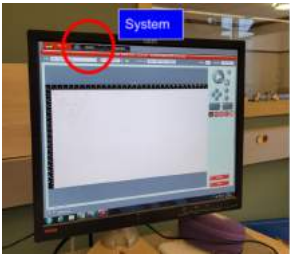
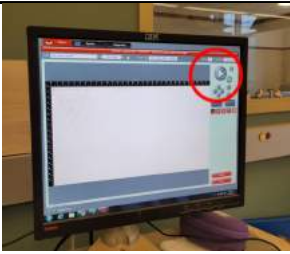

Any NDRT personnel that wants to cut stock material, especially wood, with accurate precision

Laser Cutter Image



Procedure

Step	Action	Image
1	Ensure you are wearing the proper PPE and the workspace is clean.	
2	Activate the air filtration system located directly to the right of the main laser cutter using the center button and open the flow of gas by rotating the yellow handle vertically upward.	
3	Place material in the laser cutter, properly aligning the position on the cutting bed with the dimensions listed in the CAD file using the rulers on the bed. Ensure there is no debris on top of or below the material and that the material is level compared to the cutting bed.	
4	Securely close the door. If the operation is initiated while the door is open the machine will trace the desired cuts without the activation of the laser.	

5	Turn on the laser cutter	
6	Using the computer above the air filtration system, upload the proper CAD file to the laser cutter using the designated UCP software. Check the print queue in the “System” tab to ensure a previous print job is not being overwritten.	
7	Check the settings in the software against the dimensions and specifications of the material that is being cut, primarily thickness and material. Ensure that the material will not burn or release harmful gas when exposed to the heat of the laser or any other hazards specific to the material.	
8	Initiate the cutting process using the controls on the UCD software and monitor the operation until it is complete.	
9	Once complete, turn the yellow knob back to the horizontal position and press the center button again. This will turn off the system	

If uncertain how to operate, consult any NDRT lead for additional guidance. If in the

Engineering Innovation Hub (EIH), you can also consult William Mathis (wmathis@nd.edu) or any EIH TA present. NEVER use any equipment without a complete understanding of how to use it.

1.2.6 Lathe



STANDARD OPERATING PROCEDURE

Lathe

Responsible Individual: NDRT Safety Officer

Revision Number	Date	Change Description
1.0	12/11/2021	Initial

Required PPE

Safety Glasses Respirator, if using plastics, such as fiberglass

Introduction

The lathe is a fast rotary machine that is used to machine cylindrical or conical shapes into material, and lathe standard operating procedures have been written in order to ensure safe and consistent results.

Purpose

A lathe is used for machining cylindrical shapes and cones into specific shapes and designs.



Scope

Any NDRT individual who wishes to cut material in cylindrical or conical shapes. Plastics and metals are typically used on a lathe.

Lathe Image



Procedure

Step	Action	Image
1	Ensure you are wearing the proper PPE and the workspace is clean.	
2	Loosen the chuck screws on each end and put stock in, then tighten chuck screws to secure stock	
3	Select the proper tool for the type of cutting you would like to do; the bigger and sharper the tool the more aggressively it takes material off	
4	Set the rest bar to the proper position so you will remove material in the right area.	
5	Turn on the lathe to start spinning the stock.	
6	While resting the tool on the rest bar, slowly move the tool closer to stock until it is barely touching to slowly remove material. Any attempt to remove material too fast may result in material or personnel damage	

7	Periodically turn the lathe off to check progress and consider tool change or re-positioning the rest bar.	
8	Repeat steps 6 and 7 until the desired shape is achieved, turn off lathe when done and loosen screws to remove stock.	

If uncertain how to operate, consult any NDRT lead for additional guidance. If in the Engineering Innovation Hub (EIH), you can also consult William Mathis (wmathis@nd.edu) or any EIH TA present. NEVER use any equipment without a complete understanding of how to use it.

1.2.7 Water Jet



STANDARD OPERATING PROCEDURE

Water Jet

Responsible Individual: NDRT Safety Officer

Revision Number	Date	Change Description
1.0	12/11/2021	Initial

Required PPE

Safety Glasses

Introduction

A water jet is used to cut a piece of material into a specific shape, and water jet standard operating procedures have been written in order to ensure safe and consistent results.

Purpose

A water jet applies a high pressure stream of water onto a piece of material to cut it. This is achieved through the use of a software to accurately position the stream of water.

Scope

This Standard Operating Procedure applies to any NDRT individual who wants to use a water jet to cut a piece of material. The following are some materials that can be cut with a water jet: steel, aluminum, titanium, copper, copper, and glass. Additional materials may be used, but it is advised to consult the head of the Engineering Innovation Hub (EIH) (wmathis@nd.edu) or EIH TAs before use.

Water Jet Image



Procedure

Step	Action
1	Ensure you are wearing the proper PPE and the workspace is clean.
2	Consult a TA in the EIH before use of the water jet. Their supervision is mandatory given the cost and complexity of the machinery
3	Place the piece of material to be cut onto the water jet table.
4	Secure the material to the water jet table with clamps or other methods
5	Turn on the water jet. From this moment onward, never place any body part onto the table of the water jet.
6	On the controller, specify what you want to cut and how. Make sure to account for tolerances and design intent.
7	Adjust the height of the noddle, and zero the nozzle position.
8	Perform a dry run of the machine. This can ensure that the nozzle will move in the intended direction. If complications arise, repeat all previous steps
9	Remove the guard around the water jet nozzle
10	Raise the water on the table just high though so that it starts to overflow.
11	Let the water jet cut the material. When the job is completed, clean up the area.

If uncertain how to operate, consult any NDRT lead for additional guidance. If in the Engineering Innovation Hub (EIH), you can also consult William Mathis (wmathis@nd.edu) or any EIH TA present. NEVER use any equipment without a complete understanding of how to use it.

1.2.8 CNC Mill**STANDARD OPERATING PROCEDURE****CNC Mill**

Responsible Individual: NDRT Safety Officer

Revision Number	Date	Change Description
1.0	12/11/2021	Initial

Required PPE

Safety Glasses

Respirators, if working with plastics, such as fiberglass

Introduction

The CNC mill is a computer operated rotary device that removes material, and CNC mill standard operating procedures have been written in order to ensure safe and consistent results.

Purpose

The CNC mill is operated based on the inputted commands. This is beneficial to the user because it ensures consistent results. The larger size of the CNC mill, as compared to the desktop mill, allows for larger material to be used

Scope


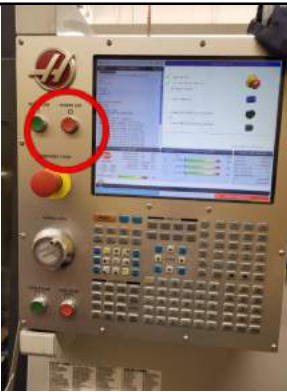
Any NDRT individual who wished to remove material from most metals and plastics. Additional materials may be used, but it is advised to consult the head of the Engineering Innovation Hub (EIH) (wmathis@nd.edu) or EIH TAs before use of other materials.

CNC Mill Image



Procedure

Step	Action	Image
1	Ensure you are wearing the proper PPE and a clean workspace around you. Note, an EIH TA must be present during the operating of this machine.	
2	Open the CNC mill doors and place the material into the base. Secure the material with clamps.	
3	Close the door, and turn on the CNC mill. If the CNC mill needs to be turned off at any moment, push the kill button	

4	Use the terminal to input the necessary commands for the intended task	
5	Once the part is cut, turn off the mill.	
6	Open the doors and remove the material. Clean the workspace before leaving.	

If uncertain how to operate, consult any NDRT lead for additional guidance. If in the Engineering Innovation Hub (EIH), you can also consult William Mathis (wmathis@nd.edu) or any EIH TA present. NEVER use any equipment without a complete understanding of how to use it.

1.2.9 Desktop Mill



STANDARD OPERATING PROCEDURE

Desktop Mill

Responsible Individual: NDRT Safety Officer

Revision Number	Date	Change Description
1.0	12/11/2021	Initial

Required PPE

Safety Glasses Respirators, if working with plastics, such as fiberglass

Introduction

The desktop mill is a computer operated rotary device that removes material, and desktop mill standard operating procedures have been written in order to ensure safe and consistent results.

Purpose

The desktop mill is operated based on the inputted commands. This is beneficial to the user because it ensures consistent results. The smaller size of the desktop mill also limits the size of the material that can be cut.

Scope





Any NDRT individual who wished to remove material from most plastics and wood. Additional materials may be used, but it is advised to consult the head of the Engineering Innovation Hub (EIH) (wmathis@nd.edu) or EIH TAs before use of other materials.

Image



Procedure

Step	Action	Image
1	Ensure you are wearing the proper PPE and a clean workspace around you. Note, an EIH TA must be present during the operating of this machine.	

2	Open the desktop mill doors and place the material into the base. Secure the material with clamps.	
3	Close the door, and turn on the desktop mill. If the desktop mill needs to be turned off at any moment, push the kill button	
4	Use the terminal to input the necessary commands for the intended task	
5	Once the part is cut, turn off the mill.	
6	Open the doors and remove the material. Clean the workspace before leaving.	

If uncertain how to operate, consult any NDRT lead for additional guidance. If in the Engineering Innovation Hub (EIH), you can also consult William Mathis (wmathis@nd.edu) or any EIH TA present. NEVER use any equipment without a complete understanding of how to use it.

1.2.10 Bridgeport Mill**STANDARD OPERATING PROCEDURE**

Bridgeport Mill

Responsible Individual: NDRT Safety Officer

Revision Number	Date	Change Description
1.0	12/11/2021	Initial

Required PPE

Safety Glasses

Introduction

A Bridgeport mill is a common rotary tool used to cut into the desired material, and Bridgeport mill standard operating procedures have been written in order to ensure safe and consistent results.

Purpose

A Bridgeport mill rotates at intense speeds, and the drill tip allows the machine to cut into the material it touches. Notably, a Bridgeport mill is suitable for soft metals and wood cutting. It is also a user operated mill, compared to the desktop or CNC mill.

Scope



Bridgeport mill can be used by any NDRT member who wants to cut into a metal or wood material

Bridgeport Mill Image



Procedure

Step	Action	Image
1	Ensure you are wearing the proper PPE and a clean workspace around you.	
2	Place the material on the base of the Bridgeport mill. Make sure to secure the part using the clamp built into the system. Rotate the three knobs to move the material in the intended location.	
3	Adjust the drill bit of the mill for your desired cut. From this moment onwards, make sure no bodily parts are anywhere near the drill of the mill.	

4	Turn on the Bridgeport mill. If the drill needs to be turned off immediately, push the kill switch.	
5	To cut into the material, push down on the lever on the right side. This will lower the mill drill	
6	Once completed, turn off the mill and clean up the area	

If uncertain how to operate, consult any NDRT lead for additional guidance. If in the Engineering Innovation Hub (EIH), you can also consult William Mathis (wmathis@nd.edu) or any EIH TA present. NEVER use any equipment without a complete understanding of how to use it.

1.3 Other

1.3.1 Epoxying



STANDARD OPERATING PROCEDURE

Epoxying

Responsible Individual: NDRT Safety Officer

Revision Number	Date	Change Description
1.0	12/11/2021	Initial

Required PPE

Safety Glasses Nitrile Gloves

Introduction

Epoxy is used to adhere multiple pieces during construction of components, and standard operating procedures have been written in order to ensure safe and consistent results.

Purpose

Epoxy is an extensively utilized adhesive method used to attach parts due to its heat resistance and multitude of options for strength and work time.

Scope

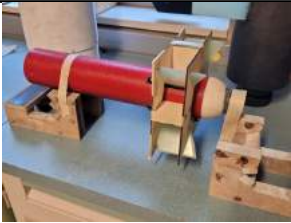
Epoxy is used by any NDRT member who wants to apply a strong adhesive to any launch vehicle component.

Epoxying Image



Procedure

Step	Action	Image
1	Ensure you are wearing the proper PPE and the workspace is clean.	
2	Open an epoxy container with gloves on. At no point during the process should your gloves come off	
3	Use popsicle sticks to extrude two part adhesive out of jars and place the components on a disposable surface, such as cardboard.	Two side-by-side photographs showing the process of extruding epoxy from the jars onto a piece of cardboard. The left photo shows a single jar with a stick inserted into the opening. The right photo shows both jars with sticks inserted, and a dollop of epoxy is visible on the cardboard.
4	Mix two part epoxy on a disposable surface with the use of a popsicle stick.	
5	Apply epoxy to desired surface with the use of a popsicle stick. Be careful not to drip epoxy onto unwanted surfaces. If epoxy does get on an unwanted surface, the use of a paper towel should be used to immediately remove the epoxy.	A photograph showing a person wearing black gloves applying epoxy to a red cylindrical object. The person is using a wooden popsicle stick to apply the epoxy. The object is on a wooden workbench.

6	Set pieces in strong configuration during drying phase	
7	Dispose of all material in the correct location. Be sure to remove the gloves inside out to avoid any potential contact with epoxy residue on the gloves.	

If uncertain how to operate, consult any NDRT lead for additional guidance. If in the Engineering Innovation Hub (EIH), you can also consult William Mathis (wmathis@nd.edu) or any EIH TA present. NEVER use any equipment without a complete understanding of how to use it.

1.3.2 Sandpaper



STANDARD OPERATING PROCEDURE

Sandpaper

Responsible Individual: NDRT Safety Officer

Revision Number	Date	Change Description
1.0	12/11/2021	Initial

Required PPE

Safety Glasses Respirator, if dealing with plastics

Introduction

Hand sanding is a crucial process for smoothing most launch vehicle surfaces, and standard operating procedures have been written in order to ensure safe and consistent results.

Purpose

Hand sanding is the process of rubbing an abrasive material onto a rough surface with the purpose of smoothing down the surface. Additionally, hand sanding can be used to remove paint from a surface.

Scope


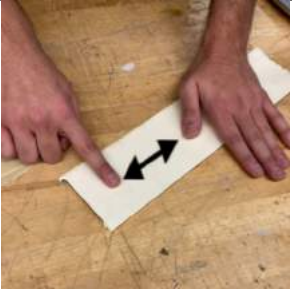
Any NDRT member who wishes to smooth off a surface

Sandpaper Image





Procedure for Sanding Surfaces

Step	Action	Image
1	Place the sandpaper on the surface of the material you want to smooth down. Reminder: put on a respirator if the material being sanded is harmful to the touch or inhalation, such as plastics	A photograph showing a person's hands placing a piece of red sandpaper onto a wooden workbench. The sandpaper is being laid flat on the surface.

2	<p>Start to rub the sandpaper on the surface of the material. For wood, it is best to rub the sandpaper in the direction of the grain; this will yield faster results. If the sandpaper is rubbed against the grain, larger chunks of the material will be removed, but it will not yield a smooth result. When in doubt, hand sand in a crosshatch style. Continue sand until the surface is moderately smooth.</p>	
3	<p>Periodically remove all dust on the surface of the sanded surface. If the dust is unsafe to touch, extra precautions should be taken. Nevertheless, dispose of the dust in a proper manner before moving onto step 4.</p>	
4	<p>Rub your finger on the surface of the sanded material periodically to check the progress.</p>	
5	<p>Change the sandpaper after a period of time or if reduced results are observed. Used sandpaper results in poorer quality results. Additionally, change the grit number of the sandpaper if progress is dwindling. The number of the grit should increase as the hand sanding progress occurs.</p>	
6	<p>Repeat steps 2-5 until the surface is at an optimal smoothness</p>	

Procedure for Sanding Surfaces to Remove Paint

Step	Action	Image
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1	Place the sandpaper on the surface of the paint you want to remove. Reminder: put on latex gloves and/or a respirator if the material being sanded is harmful to the touch or inhalation.	
2	Start to rub the sandpaper on the surface of the material. When in doubt, hand sand in a crosshatch style. Continue to sand until the material under the paint is clearly visible.	
3	Periodically remove all paint chips on the surface of the sanded surface. If the paint is unsafe to touch, extra precautions should be taken. Nevertheless, dispose of the paint in a proper manner.	
4	Change the sandpaper after a period of time or if reduced results are observed. Used sandpaper results in poorer quality results. Additionally, change the grit number of the sandpaper if progress is dwindling. The number of the grit should increase as the hand sanding progress occurs.	
5	Repeat steps 2-4 until the paint is fully removed from the desired area	

If uncertain how to operate, consult any NDRT lead for additional guidance. If in the Engineering Innovation Hub (EIH), you can also consult William Mathis (wmathis@nd.edu) or any EIH TA present. NEVER use any equipment without a complete understanding of how to use it.