

# Basic Lathe Laboratory Manual

## Objective

The goal of the lab is to gain proficiency in the lathe and understand basic subtractive turning operations.

## Background

When performing any kind of machining process where you are removing material the speed at which you remove that material is of utmost importance. End mills, drill-bits and other cutterbased tools are only made to withstand certain cutting conditions. As such it is critical for the life of the tool and the efficiency of the machining process that the tools are run within their working parameters.

### Lathe

The metal lathe is a machine tool that has been used in industry since the time of the industrial revolution over 200 years ago. The material removal process of turning on a lathe is accomplished by revolving a mounted workpiece at high speeds against a movable and hard cutter which cuts away the material it touches. The tool bit can be precisely controlled allowing the operator to cut the workpiece into the desired shape.

Lathes are produced in a variety of sizes and formats ranging from those that are used by jewelers and instrument makers, to machines that turn large cylindrical shapes, such as shafts used in heavy industries such as mining and marine. The size of a lathe is specified by the maximum diameter that it can turn (**Swing**) and the maximum length of workpiece that can be accommodated between centers (**Distance Between Centers**). Other important specifications include HP of motor, Spindle Bore, Spindle Taper, Tailstock Taper, Cross Slide Travel, Tailstock Quill Travel, Spindle Speeds, and Threading ranges.

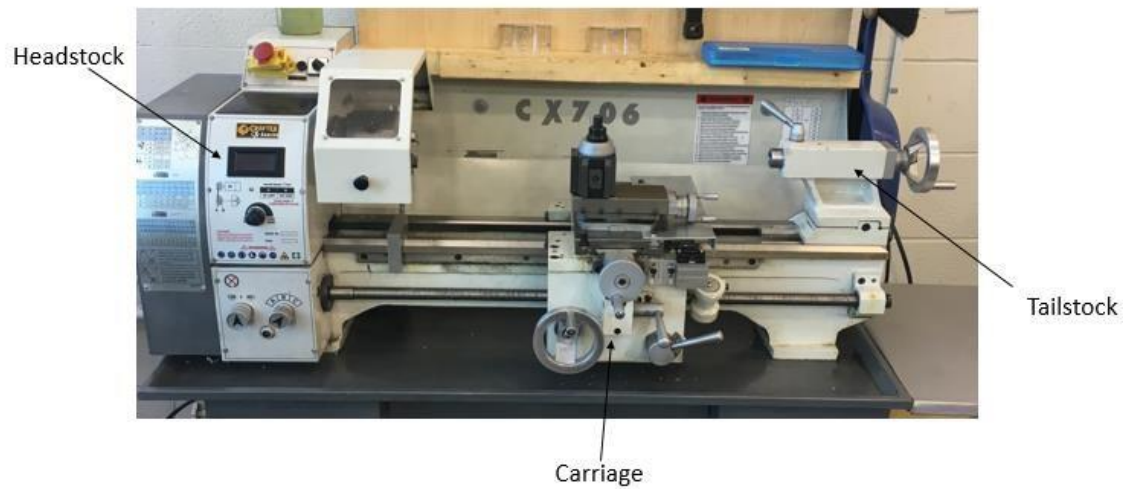
The main variables to consider when turning are:

- Desired Diameter and Depth of Cut
- The type of material – For specific properties and tool selection
- The coolant selected – Specific to the type of material and tool
- Machine and work-holding – Setup rigidity
- Tool Type and Material

### Cutting Speed

Considering these factors, there is still a level of understanding that is required before the correct values can be found. This comes with experience, however there is a simple equation that may be used as a starting guideline for the correct rotation speed of the cutter (mill) or rotational speed of the workpiece (lathe).

$$\text{RPM} = 4 \times \text{CS} / \text{Dia.}$$



### Examples:

**Turning a ½" steel rod in the lathe**

$$\begin{aligned} \text{CS (steel)} &= 80 \text{ SFPM} \\ \text{Piece Diameter} &= \frac{1}{2}'' \\ \text{RPM} &= 4 \times \text{CS} / \text{DIA.} \\ &= 4 \times 80 / .5 \\ &= 640 \text{ RPM} \end{aligned}$$

**Turning a 2" piece of aluminium in the lathe**

$$\begin{aligned} \text{CS (Aluminium)} &= 300 \text{ SFPM} \\ \text{Piece Diameter.} &= \frac{1}{4}'' \\ \text{RPM} &= 4 \times \text{CS} / \text{DIA.} = 4 \times \\ &300 / .25 \\ &= 4800 \text{ RPM} \end{aligned}$$

*Figure 1 : Lathe (found in MTC)*

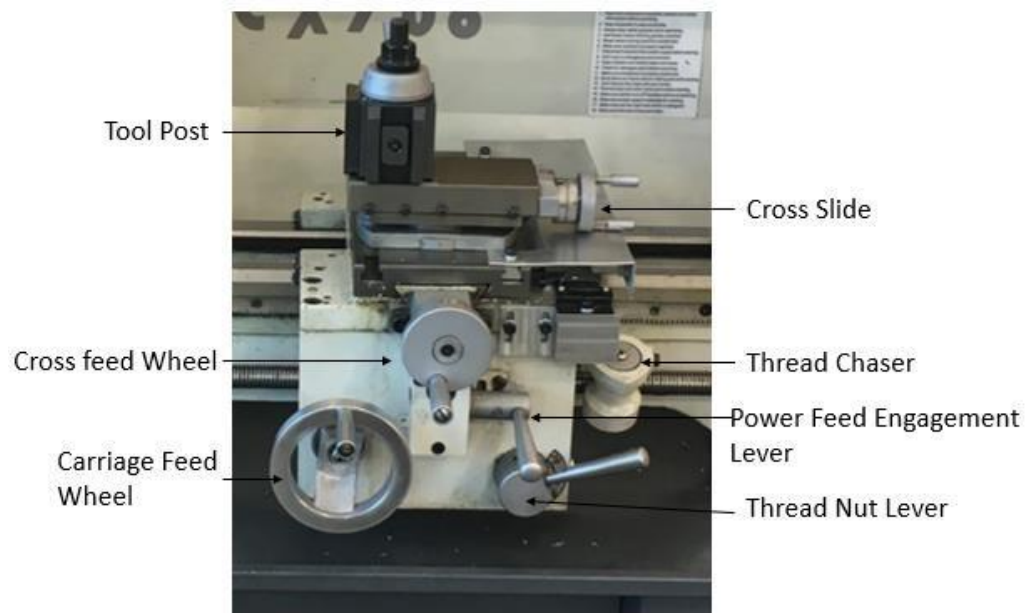


Figure 2 : Lathe Carriage

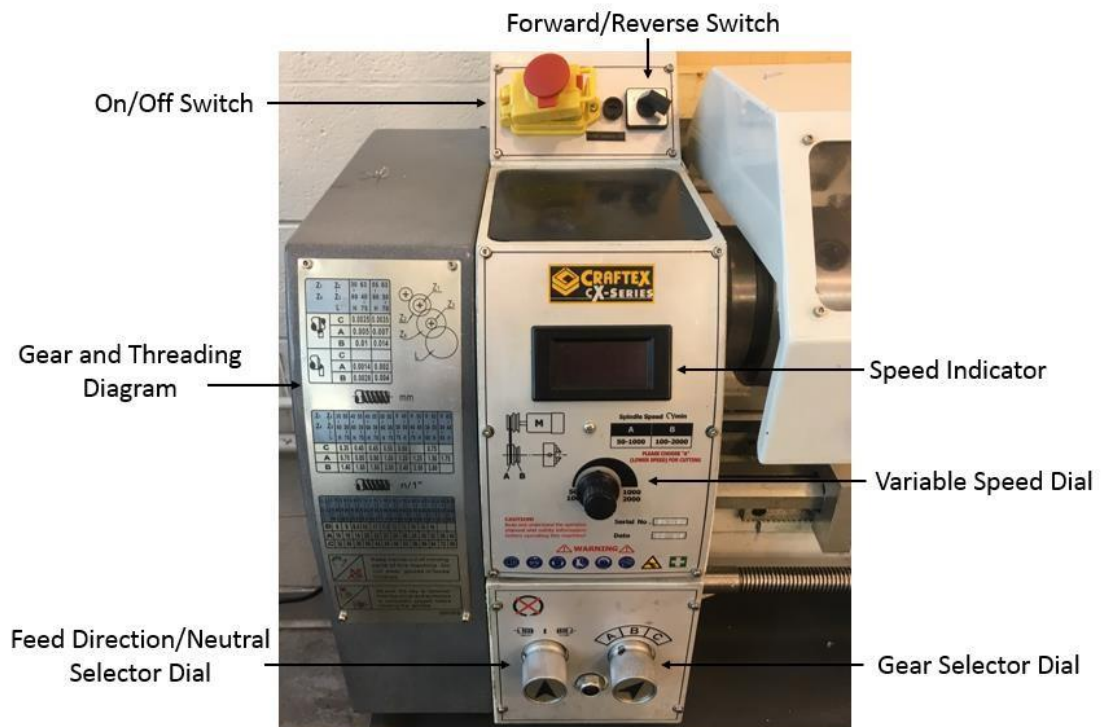
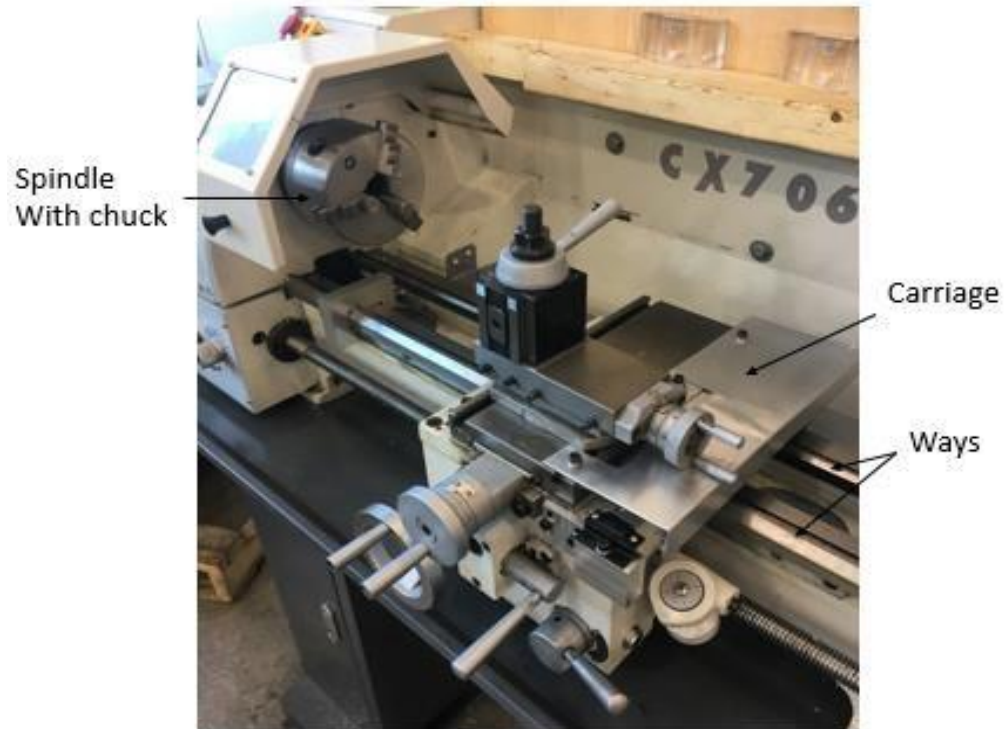


Figure 3 : Lathe Headstock



*Figure 4 : Lathe Bed*



*Figure 5 : Tailstock*

The following definitions will be in reference to the Figures above.

**Lathe Bed:** The bed of the lathe is the main foundation of the lathe that supports the other parts of the lathe. It must be rigid and precisely machined to achieve proper accuracy while working.

**The Ways:** The Ways are the precision finished bearing surfaces of the bed on which the Headstock, Tailstock and the Carriage are mounted and aligned parallel to the axis of the spindle through the length of the bed. The *Outer Ways* are the bearing surfaces on which the carriage rides and the *Inner ways* are used to align the tailstock and the headstock.

**Headstock:** The headstock is an assembly that consists of the headstock casting, the main spindle, the drive and speed selection mechanism and the gears to drive the **leadscrew**. The **main spindle** provides the mounting for a chuck or a faceplate. Its center is bored out through its length to allow a workpiece to pass through and the end where the chuck is mounted has an internal taper in which to insert a center. The main spindle controls the speed of the workpiece when it revolves.

**Tailstock:** The tailstock is a cast and machined unit that provides bearing support for longer workpieces or with a drill chuck, may be used for drilling. The tailstock consists of a mounting base that aligns it with the main spindle axis, a movable spindle and locking mechanisms.

**Tailstock Quill:** The tailstock spindle has a tapered hole on its end to receive a center for workpiece support or a drill chuck for drilling the workpiece. Its movement is controlled with handwheel with a micrometer ring and can be locked in position with a locking lever.

**Carriage:** The carriage of a lathe is an assembly that is moved along the ways of the lathe to control the position of the tool bits. These movements, powered either by hand or using the power feeds of the lathe, advance the cutting bit into the workpiece to remove material. The carriage has the following parts; the Apron, the Saddle, the Cross Slide, the Compound Slide, and the Toolpost.

**Apron:** The apron is the front section (overhanging the bed of the lathe) where the carriage handwheel, the cross slide handwheel and the levers for the power feed engagement and threading are located.

**Saddle:** The saddle is the H shaped piece with the bearing surfaces that rest on the ways of the bed. It also has the dovetails that the cross slide runs on.

**Cross Slide:** The cross slide moves perpendicular to the axis of the lathe bed on ways on the saddle. A handwheel with a micrometer collar allows for precise movements (to .001") of the tool.

**Compound slide:** The compound is mounted on the cross slide and can be rotated to any angle to allow the tool to advance at any angle.

**Toolpost:** The toolpost is mounted on the compound rest and holds the tool bit holders.

**Quick Change Gearbox:** The quick-change gearbox allows the various feed rates to be quickly set up for the carriage and cross slide power feeds and the feeds for thread cutting. On the Gardner Lathe, the feed rates / thread pitches are set using Selector Knobs A and B.

**Lead Screw:** This is the threaded shaft that runs along the bed of the lathe on the operator's side from the headstock to the end of the bed. This shaft, when rotating, is engaged by *half-nuts* to drive the carriage when cutting threads. A *thread-chaser* is used to indicate when the *half-nuts* are to be engaged for cutting a particular thread. The leadscrew only rotates when the main spindle is turning, as it is connected to the main spindle through the change gears and the quick-change gearbox. Charts on the headstock indicate the threads/inch screw threads or the pitch in metric that various gear combinations produce, the proper gear combinations can then be determined.

**Power Feed:** This is a slotted shaft that runs along the bed of the lathe from the headstock to the end of the bed, usually below the leadscrew. When rotating, will transmit the power to drive the carriage feed and the cross feed. It only rotates when the main spindle is turning. The rate of feed is set by the change gears/ quick change gearbox. Feed rates are expressed as inches/revolution of the main spindle (or mm/rev. in metric).

## Terminology

**Backlash:** Backlash is a term used to identify the space of no contact on a gear train when switching from reverse to forward. As a general rule the more backlash a system the harder it is to control the precision of the instrument and therefore is something to be avoided.

**Chatter:** Chatter occurs when the tool bit or the workpiece is vibrating during machining leaving a patterned finish rather than a smooth finish and making a loud "chattering" noise. The simplest and, usually, the most effective way to remove chatter is to make the tool clamping or piece clamping more rigid to try and mitigate vibration. Chatter is bad because the constant vibration of the tool will significantly decrease tool life as well as affect the overall precision of the work.

**Coolant:** Coolant is a liquid that is applied either as a light mist or a flow of liquid at the area of contact between the tool bit and the piece. It performs several functions, the primary function being to dissipate the heat generated from the cutting. Coolant also cools the workpiece and provides lubrication during cutting to reduce tool wear. Coolant is not required on all materials and the type of coolant varies depending on the material being machined. It can produce a better surface finish on some materials.

## Possible Lathe Operations

**Facing Cut:** A facing cut is a cut that is done across the face of the workpiece using the cross slide to move the tool bit either using the power feed or by hand feeding.

**Turning Cut:** Turning is a cut made parallel to the axis of the bed of the lathe using the carriage power feed or by hand using the carriage handwheel.

**Boring:** Boring is an internal cut that hollows out the end of the workpiece and can be a very precise cut.

**Drilling:** Drilling is done by using a drill bit held in a drill chuck inserted into the tailstock spindle or using taper-shank drill bits inserted either directly into the tailstock spindle.

**Parting:** Parting separates the workpiece from the stock. It is used when repetitive parts are made or for parts that would be difficult to hold by conventional means during machining. It is usually the last machining operation that is performed on the part. When parting the piece must always be supported with a live center and the speed must be dropped drastically.

**Grooving:** This type of cut leaves a groove in the part and is performed using the cross slide of the lathe to move the tool bit in to the required depth of cut; ie; an O ring groove or a groove for a retaining ring (circlip).

**Threading:** Threading is done by taking a series of cuts using a thread form tool to reach the final depth and profile of the thread required. The turning speed is usually reduced to less than 120 RPM and lighter cuts are taken, with the compound used to advance the cutting bit on each successive cut. Threads may be inch or metric, internal or external, left hand or right hand depending how the lathe leadscrew is set. Tapered threads such as pipe threads require the use of a taper turning attachment.

**Knurling:** This operation puts a patterned roughness into a round workpiece to provide a raised gripping surface. The knurling tool is rolled against the workpiece as it slowly revolves and is fed along the length to be knurled using the leadscrew. The federate is set by the selection of the screw pitch set on the quick-change gearbox.

## Apparatus and Equipment Overview

The following equipment and materials will be used in this lab:

- 1 x lathe
- 1 x lathe accessories
- 1 x Delrin cylinder

## Pre-Lab Preparation

Before arriving at the lab, students should review the lab manual and familiarize themselves with the lab set up and procedures. Students need to complete a computer simulation from

<https://makerepo.com/jboud030/655.tour-virtuel-virtual-lathe> before the lab.

## Review Questions

Name 2 operations on a lathe.

Turning, Facing

What is a live center used for?

A tool used to support the free end as well as to adjust your equipment accordingly

Coolant is used for what purpose?

Helps reduce the heat generated during cutting, which can extend the life of your cutting tool

What is the RPM you should use for a 1/2in workpiece made of stainless steel?

Between 200 and 400 depending on SFM of metal  
 $4 \times \text{SFM} / 0.5$

What is backlash?

Backlash is the grinding between mechanical components causing reverse motion leading to inaccuracy and loss of control

## General Rules and Safety

1. Following the completion of basic training, students will be permitted to use the Brunsfield Centre's workshop, and only those whom have already completed basic training will have access. Basic training will however grant limited access to the space as students will not have access to the mill, lathe, and welding area without having completed subsequent trainings for the respective equipment.
2. It is important to never work alone in the shop and to always have a supervisor on duty in the space. If working alone there is no one to help in the case of an accident or injury which makes it very dangerous.
3. Safety glasses must always be worn within the workshop. Safety glasses must be worn even if a face shield or welding helmet is being used overtop of them. Never approach anyone actively working the workshop without wearing safety glasses.
4. Proper footwear must be worn when working in the workshop to avoid hazardous situations (e.g. sparks, sharp metal, hot chips from operations) where the inappropriate footwear would cause greater levels of risk/harm. Closed-toed shoes must be worn. Not flip flops, crocs, mesh-toed running shoes and/or similar style or type of footwear. Steeltoed or similar footwear is recommended when working on larger, heavier projects.
5. Clothing that is long, baggy and/or loose must be rolled up. Strings on the front of a hoodie and hanging jewelry must be tucked under a shirt or taken off. Rings must not be worn inside of the machine shop. Long hair must also be tied back and up. These rules are in place to avoid the danger of having machinery grab and pull you into them causing severe harm.



6. No food or drink should be brought into the workshop. There are many chemicals, coolants and other contaminants that can be harmful if ingested.
7. The Bruntsfield centre is a serious workspace and must be treated as one. Pranks, roughhousing, and general fooling around while within the workshop will not be tolerated. Any behavior deemed unprofessional and to this way by a supervisor will be met with an immediate suspension of shop privileges.
8. All persons within the MTC and Bruntsfield Centre must always be of good health both physically and mentally as well as not being under the influence of any drugs and or alcohol.
9. A first aid kit is located within the Bruntsfield office (Room A139). Any injury severe or small should be reported to a supervisor and an incident report should be filled. In the case a supervisor is not present, contact the nearest designated first aider (a list of first aiders can be found on the main door).
10. An emergency spill kit is available in the Bruntsfield Centre. The spill kit can be used to clean and or contain hazardous materials that get spilled in the shop. A supervisor must be advised whenever the spill kit is used.
11. There are fire extinguishers and emergency stops located throughout the Bruntsfield Centre. There is one fire extinguisher located at each of the main entrance doors, and one near the designated welding area. There are three emergency stops located at the main entrances and in the office. Students should be familiar with the location of each fire extinguisher. If an individual is not familiar with these locations, they should request the information from a supervisor their first time in the workshop.
12. Students are responsible for knowing their own limited knowledge of facilities and equipment, and to ask for assistance from a supervisor when encountering any unfamiliar equipment or processes (i.e. if you're not sure: Ask). Supervisors are there to help with any matter pertaining to the workshop and would much rather take the time to explain something many times then having someone get injured or equipment break because of improper use of the space.
13. Before working with unfamiliar materials and chemicals, become familiar with the product's handling procedures. MSDS (Material Safety Data Sheets) info can be obtained by using the Google search engine and typing "MSDS" followed by the product name and/or asking a supervisor to see the MSDS.
14. Students as well as supervisors are entitled to a safe working environment. Safety is everyone's responsibility, thus anyone witnessing any unsafe behavior or working practices must advise a supervisor immediately.
15. Any damaged equipment must be reported to a supervisor immediately to ensure shop safety and that the issue related to the equipment is correctly addressed. A supervisor must also be notified in the case of a broken tool to ensure that the tool was being used properly as to avoid the breakage of future tools.
16. Students are responsible for keeping the workshop clean and tidy. It is required that students clean up any work areas or machines that have been used after you have finished. The floor must be kept free of debris and tripping hazards. All tools must be put back in their proper places after use. Unplug all power tools while not in use.

# Procedure

## 1. Setup:

- a. Insert the live center into the tail stock.
- b. Select a right hand turning tool and adjust the tool height so that the tip of the cutting tool is the same height as the tip of the live center.
- c. Now rotate the tool so that there is a rake angle of 5-10 degrees.

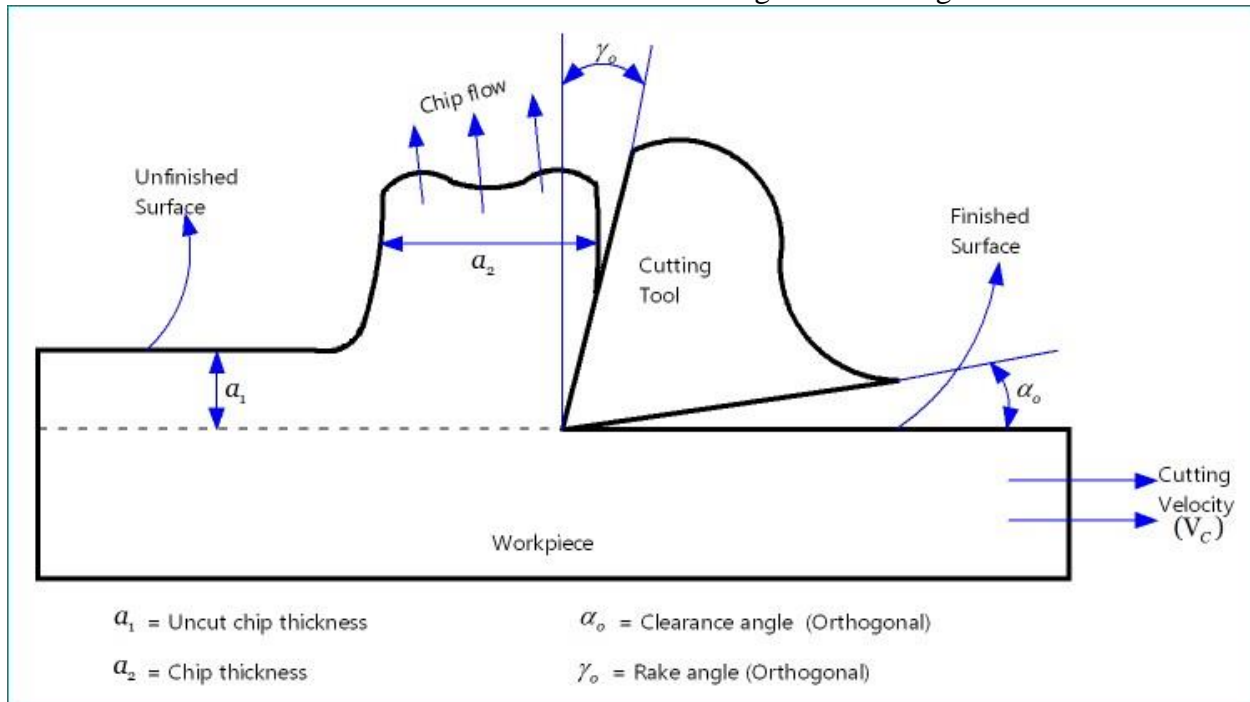


Figure 6 : Cutting tool diagram

2. Face one end of the stock.
3. Now measure the diameter of the stock and subtract the final diameter (0.3"). The difference is how much you want to remove. Note: The digital readout displaces a linear distance, or radius. The measurements are taken from the diameter.
  - a. The depth of cut should be 50 thou.
4. Now we can drill the hole with the appropriate drill bit.
5. Repeat step 1 for the parting tool, but there should be NO rake angle.
6. Using the parting tool, cut off the part at the correct length.
7. Repeat for each person in the group.

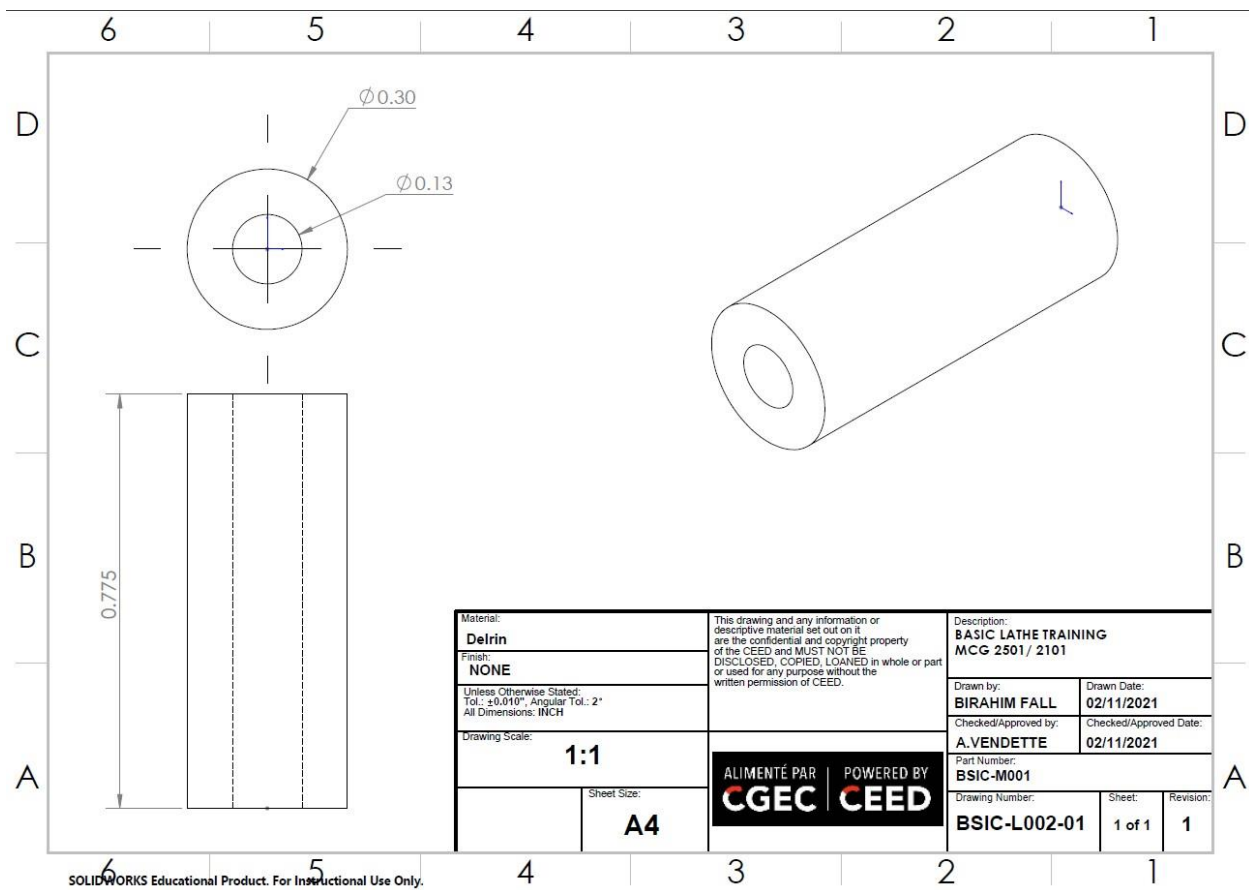


Figure 7 : Drawing of the turned part