Introduction to Machining

Description
Machining is the process of using cutting tools to remove some amount of a piece of material (metal, wood, plastics, ceramic, etc.) to precisely shape it for an intended use. This use of the physical action of cutting tools is also known as *subtractive manufacturing*.

The primary machines used in machining are the engine lathe (metal lathe), milling machine (both horizontal and, most typically, vertical), drill press, and abrasive grinders. These and other machines can be either manual or automated. Most automated machines have CNC (computer numerical control) and are capable of producing very intricate, precise, and complex parts with a high degree of repeatable accuracy for any number of applications.

Machinists are people trained in the operation of such machinery and processes. Machinists work in prototyping new parts, on production lines, and in repair and maintenance facilities. Machinists provide a necessary and vital service to all industries, from very large organizations such as Bombardier, NASA, and Boeing Corporation, to small, independent shops.

In this activity plan, students will learn what is meant by the term machining, be exposed to several machines and their uses and to trades related to machining.

Lesson Objectives
Students will be able to:

- Briefly describe the meaning of *machining*
- List and describe several machining-related trades
- Identify basic machining equipment by name and list some of the operations done on those pieces of equipment

Assumptions
The student will:

- Have an understanding of metals, forms and shapes of metals, and metallurgy
- Have at least a grade 9 numeracy level
- Know how to measure both in ISO and SAE systems using scales, Vernier calipers, height gauges, and micrometers
- Know the basic principles and methods of layout

Estimated Time
1–2 hours
Facilities
Senior secondary metal shop as per BC Technology Educators’ Best Practices Guide

Recommended Number of Students
20, based on BC Technology Educators’ Best Practices Guide

Personal Protective Equipment
• Welding coat
• Welding gloves
• Welding helmet

Tools
• Machine lathe with 3- and 4-jaw chucks
• Vertical milling machine
• Milling vise
• Horizontal mill*
• Gear head drill press
• Drill press vise
• Belt grinder
• Surface grinder*
• Indexing head*
• Rotary table*
• CNC mill/router/lathe*
• CNC plasma table*
• Tool post grinder*
• Boring head*
• Broaching kit*
• Taping head*
• Layout tools
• Measuring tools

* optional
Tooling

- Twist drills: straight, stepped, and MT shank; centre drills
- Mill bits: face mill, end mill, roughing mill, chamfer mill, fillet mill, radius mill, bullnose mill, taper mill, ball nose mill, woodruff/keying mill, planing mill, slotting mill, forming cutter, gear hob cutters
- Broaching kit
- Boring bars
- Hole saws

Terminology

Machine Lathe
- Boring, reaming
- Turning to a diameter
- Facing off
- Center drilling
- Knurling
- Parting off
- Tapering
- Filing, Sanding, Polishing
- Threading (likely optional)

Vertical Milling Machine
- Face milling
- End milling
- Slot milling
- Boring head
- Indexing head

Drill Press
- Twist drills; fractional, metric, number, letter
- Hole saws
- Indexable carbide insert
- Boring head
- Boring
- Reaming
- Countersinking
- Threading
- Internal
- External
- Tap
- Die
Split die
Button die
Dienut
Plug tap
Taper tap
Bottoming tap
Tandem tap

**Carbide tooling**: tooling made of tungsten and carbide initially in a powdered form that is pressed into the desired shape and then sintered to fuse it together. Tungsten carbide tooling is much more heat resistant and much longer wearing than HSS and is formed into various cutting tool shapes such as endmills, drill bits, brazed lathe tool bits, and mountable inserts of many shapes for milling, drilling, and turning operations. The cost tends to be higher than equivalent HSS tooling. Such tooling may be coated in ceramics such as titanium nitride to improve wear and speed abilities.

**Centre drill**: a short, rigid drill used to locate holes for later drilling or holding on a centre in a lathe.

**Face off**: a process performed on a lathe in which irregularities on the face of an object are removed so that the face is at a 90-degree angle (right angle) to the object’s sides.

**Gear head drill press**: a drill press in which rotational and downward forces cause the attached tooling to cut into the material being processed. The gear head allows for high-torque drilling operations with a variety of rotational speeds useful for cutting metals and other materials. The table may be slotted for holding materials and fixtures and movable in the x, y, and z planes.

**HSS tooling**: tooling made of carbon tool steel, often with alloying of tungsten and vanadium that resists tool edge breakdown due to heat caused by rapid motion. Found in endmills, drill bits, lathe tool bits, etc. Such tooling may be coated in ceramics such as titanium nitride to improve wear and speed abilities.

**Machine lathe**: a machine tool used to rotate and remove/shape material.

**Surface grinder**: a machine used for precision grinding of materials to accuracies up to about 0.0001". A horizontal spindle holds an abrasive wheel and a magnetic chuck holds the work piece.

**Tap**: hand tool used to create screw threads in metal. A tap makes an internal thread inside a hole (for example, a nut).

**Die**: hand tool used to create screw threads in metal. A die makes an external thread on a round rod (for example, a bolt).

**Knurl**: a process where a pattern of straight, crossed, or angled lines is cut or rolled into a metal surface, resulting in a series of small ridges or beads that aid in gripping

**Chamfer**: to cut away the (usually right-angled) corner or edge to make a sloping edge.
**Vertical milling machine**: a machine that uses rotating cutters to remove precise amounts of material as the material is fed into the cutter.

**Materials**
Mild steel and/or aluminum and/or bronze bar stock or heavy plate for machine demonstration purposes

**Resources**
Facing off on a lathe
https://www.youtube.com/watch?v=5tXpKS3lfy0&noredirect=1

**Teacher-led Activity**
The teacher will pre-set the machinery with tooling and stock to do a brief demonstration of a few processes on each machine. Carbide and HSS tooling, aluminum, and mild steel could be used to demonstrate material properties and tooling characteristics. Machining and related trades could be described during these demonstrations.

Students are to take notes. Key terminologies under a heading for each machine could be included in fill-in-the-blank formatted note sheets. Safety features and procedures should be stressed at each of these teaching stations.

**Evaluation**
Consider co-creating the evaluation criteria with your students at the beginning of the activity.

A short written quiz at the start of the second period could be used to evaluate student understanding, to review main ideas, and to maintain student focus on the subject. Students will have the opportunity to study and assimilate the material covered.

Have students build a study sheet from their notes (one side of one sheet of paper only, handwritten) and use this when writing their quiz.

**Optional Extension Activity**
The teacher could integrate the demonstrations with a pre-demonstration of the processes necessary to complete a future mandatory project.