Designing for the Advanced Manufacturing Lab

The Design Process

- 1) Concept Design **(A sketch not suitable for submission)**
- 2) Materials Selection
- 3) The Manufacturing Process (consider the way your parts will be machined. Think about how you might machine your parts! How would you hold your parts while machining them? What machining methods do you think you may need to employ? This is where having a basic understanding of manufacturing comes in handy. Try to consider potential problems and pit falls! Try to FOOL proof your parts, especially assembly parts.)
  - Lastly the Production Design and Drawings.
- 4) Drawings (fully define every part features, machinists can only build fully defined parts. They do not know the function or intent of a feature unless notation is used. Your drawings with dimensions and notes is their roadmap. If you let the machinist make design decisions on your parts you may be surprised with what you get!)
- 5) Dimensioning & Tolerances (each feature's dimension and tolerance does matter. Never tell a machinist it doesn't matter.)

The Manufacturing Process

Knowing how machine tools work, the tolerances they are capable of maintaining and the type of surface finish they generate is important in understanding what options are availably to you during the production processes.

Understanding these option will aid you in the design of parts that will improve performance, reliability and reduce required re-design and manufacture.

Once you have determined the function of a feature on a part you will know what type of finish and the degree of accuracy required to achieve the results you desire in that part(s).

There are 2 machine tools in the Advanced manufacturing Lab. They are: a CNC mill and a CNC lathe. Learn as much as possible about the capabilities of these machines. It will aid in your design and leave you with a better understanding of machine time.

To learn more about some of the machine tools in the shop and in industry visit these web pages :

http://www-me.mit.edu/Lectures/MachineTools/outline.html
http://web.mit.edu/2.670/www/Tutorials/Machining/Description.html
http://www.mmsonline.com/ *****
http://www.mmsonline.com/dp/zones/index.cfm?cat=TRN03&zone=TRN *****
http://www.dlricci.com/video.htm *****

Milling Machines

Milling is the process of removing material from a workpiece by moving the workpiece (fixed to the table/bed) past a fixed position, rotating multi or single tooth/flute milling cutter (tool bit). The cutting action of teeth around the center axis of the milling cutter provides a fastest and accurate approaches to machining. The machined surface may be flat, angular, or a multi dimensional curve or curve surface. The adjoining surfaces or edges (features) may also be milled to produce any combination of shapes and contours. The machine used for these applications is properly referred to as a milling machine tool or a machining center. Today live tooling lathes can now duplicate some of these operations. Eliminating the need for multiple set-ups.

The shop has both CNC and manual vertical mills.

Precision ±0.0005” or ±0.013 mm. These tolerances are operation and operator dependent and under ideal new equipment conditions.

Today milling machines are also used for drilling, reaming, boring, counter boring, counter sinking, tapping, grooving and chamfering holes. Know the difference between the operations above. They are different in their degree of accuracy and function. Learning these terms and use them in your drawings. It will clarify the requirements of a feature for the machinists working on your job.

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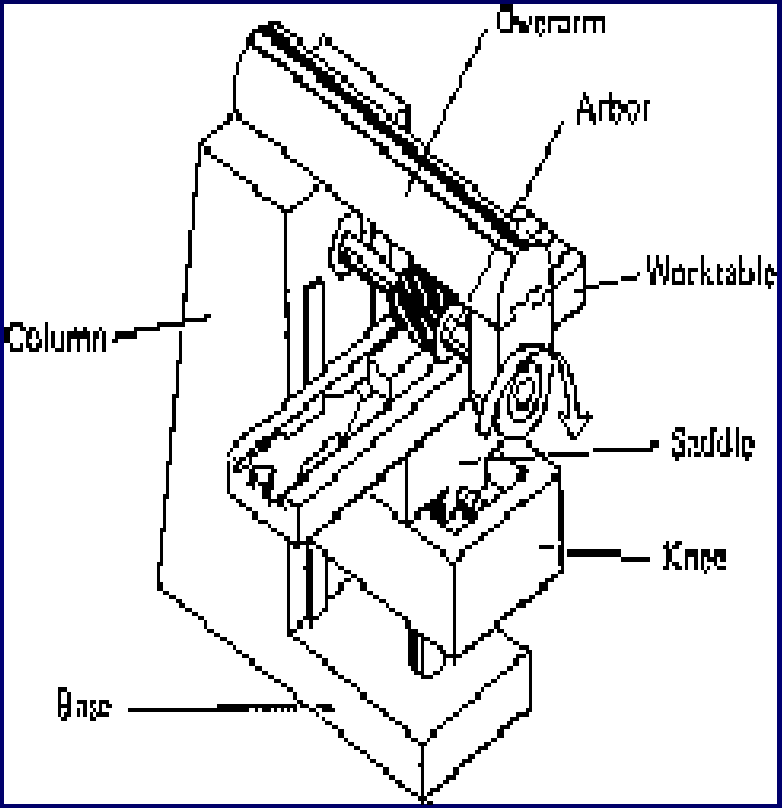
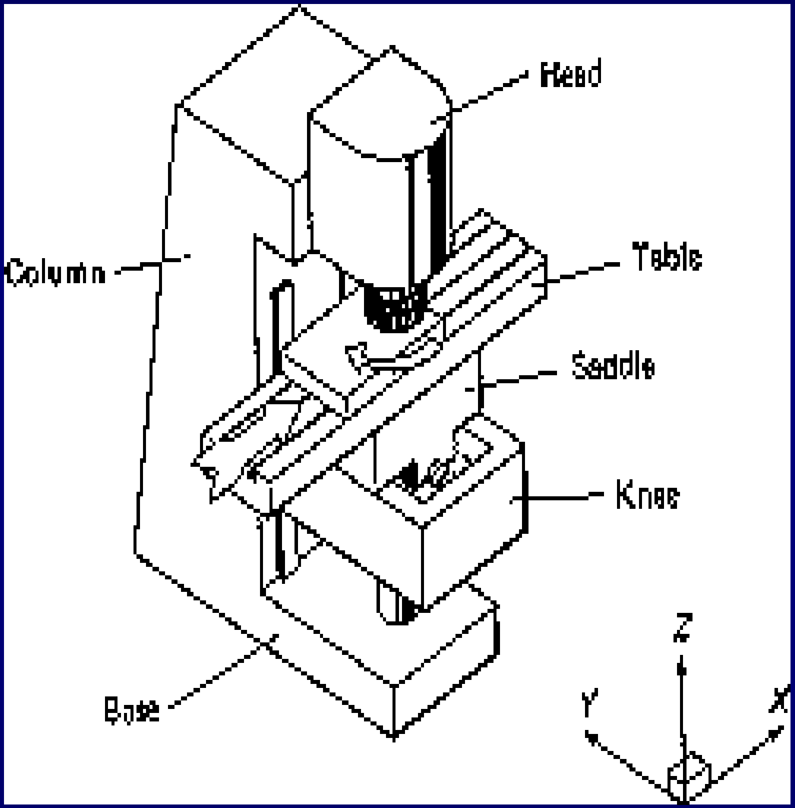
2 types of Milling Machines





Horizontal Milling Machine
Slab milling position

Vertical Milling Machine

The Functions of a Lathe

Operations commonly done with a lathe:

Turning…… cutting/machining (cylinder) the OD (outside diameter)

Boring……… cutting/machining (cylinder) the ID (inside diameter)

Facing……… cutting/machining a smooth surface on the end of a piece

Thread Cutting…… making threads on either the OD of ID

Taper Cutting…… turning/boring a conical OD or ID

Drilling…… clearing a hole thru (the center only) of a piece.

Grooving…… for O-rings, E-clips, snap rings, oil grooves, etc.

Turning/boring is the machining operation that produces *cylindrical* features on parts. To a greater extent, it is defined as machining external and internal surfaces. With the workpiece mounted in/on one of several types of head stocks the work piece then rotates about the centerline of the headstock . A single-point lathe tool-bit moves/feeds parallel to the axis of rotation of the workpiece and at a distance from the workpiece that will force contact between the work piece and the tool thereby allowing the tool bit to remove a portion of the outer or inner surface of the part.

Taper turning is similar with the exception that the cutter path is at an angle to the work piece axis. Similarly, in contour turning, the distance of the cutter from the work axis is varied to produce the desired shape. This is usually achieved by the use of templates on tracer lathes and G-code programs on CNC machines.

Various types of single flute lathe bits are used to generate the best result with respect to shape & type of material being used. Below…. Examples of Lathes.

Material Finishes

The machine shop uses or has access to the following processes.

- Sawing
- Drilling
- Milling
- Broaching
- Reaming
- Grinding
- Polishing

SURFACE ROUGHNESS AVERAGE OBTAINABLE BY COMMON PRODUCTION METHODS

PROCESS	ROUGHNESS HEIGHT RATING MICROINCHES 2000 1000 500 250 125 63 32 16 8 4 2 1 0.5
Flame Cutting	---------XXXX----------
Sawing	------------XXXXXXXXXX---------
Drilling	---------XXXXXXXXXXXXXX-----------
EDM	----------XXXXXXX--------
Milling	-----------------XXXXXXXXXXXXX----------
Broaching	-------XXXXXXXX--------
Reaming	-------XXXXXXXX--------
Laser	XXXXXXXXXXXXXX---------
Burnishing	---------XXXXXXX-------
Grinding	--------------XXXXXXXXXXXXXXXXX--------
Honing	-------XXXXXXXXXXXXX--------
Polishing	-------XXXXXXXX-----------------
Extruding	-------------XXXXXXX------
Investment Casting	------XXXX-----------------
Perm Mold Cast	------XXXX-----------------
Die Casting	------XXXXXX------

Engineering Drawings

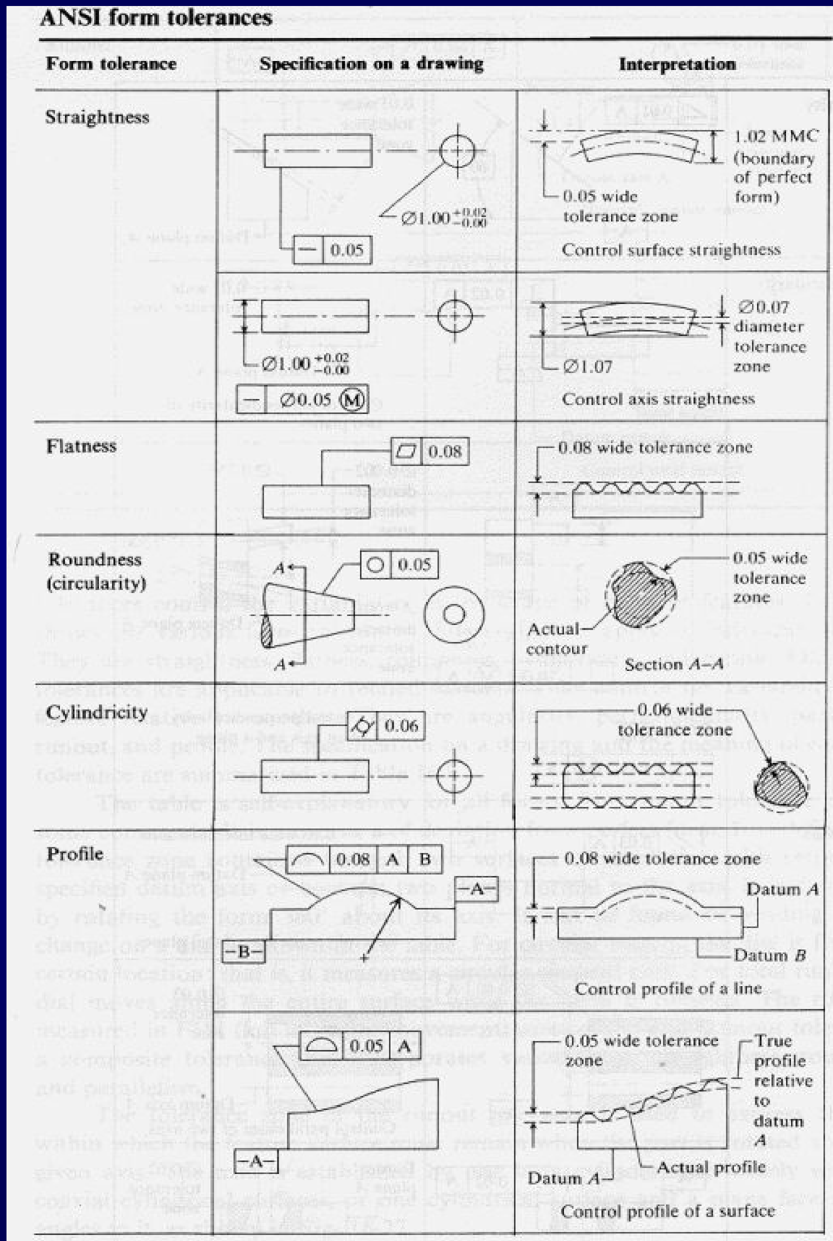
- Engineering drawing must be complete for all parts manufactured in the AML.
- Drawing must have at least one Datum and be drawn to ANSI/ASME Y14.5M-1994 Standard.
- Parts are to be dimensioned and toleranced based on function not manufacturing processes.
- Do Not tell me the tolerance does not matter! (It almost always does.)

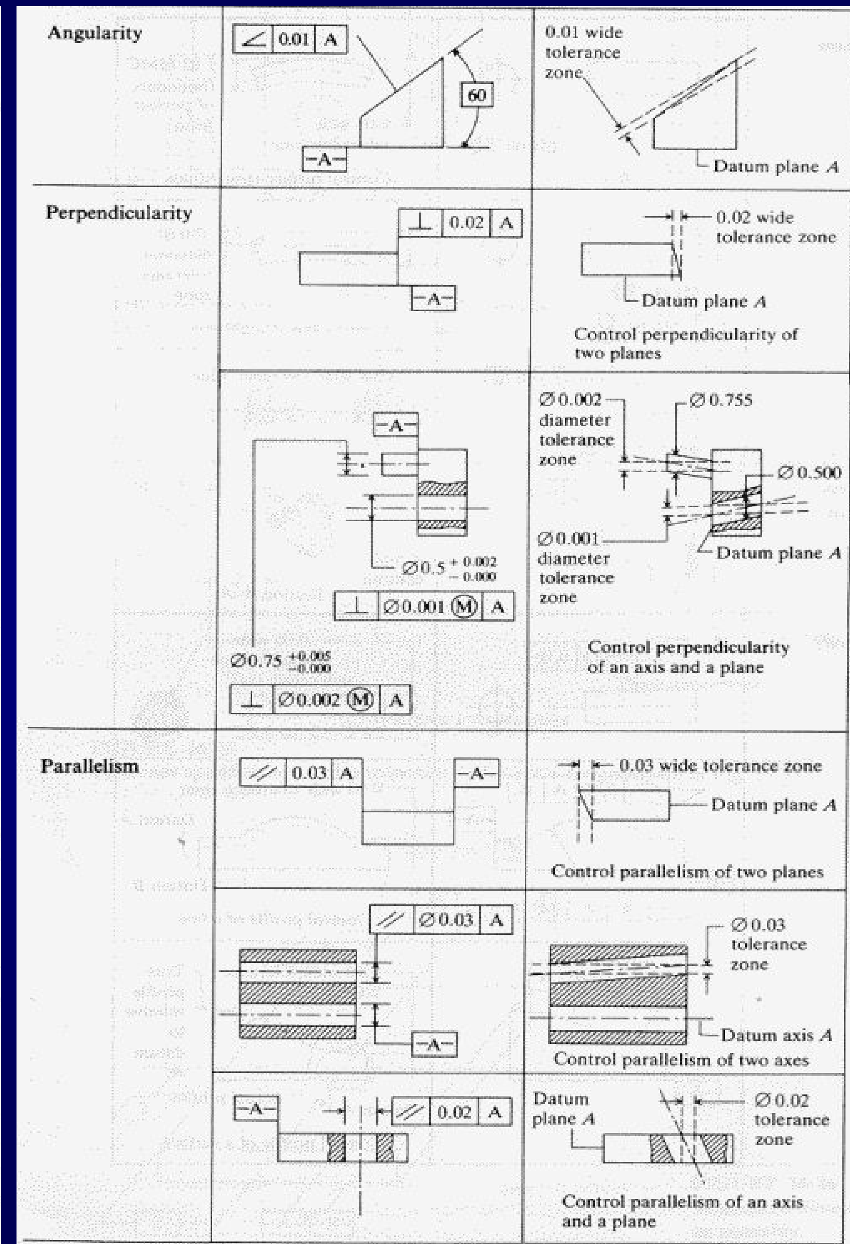
ANSI standard Y-14.1/14.5 symbols for geometric tolerancing & specs.

Type of Tolerance	Characteristic	Symbol
Form	Straightness	⏤
	Flatness	⏥
	Circularity	○
	Cylindricity	⌭
Profile	Line profile	⌒
	Surface profile	⌓
Orientation	Angle	∠
	Perpendicular	⊥
	Parallel	∥
Location	True Position	⌖
	Concentricity	◎
Runout	Circular runout	↗
	Total runout	⌰

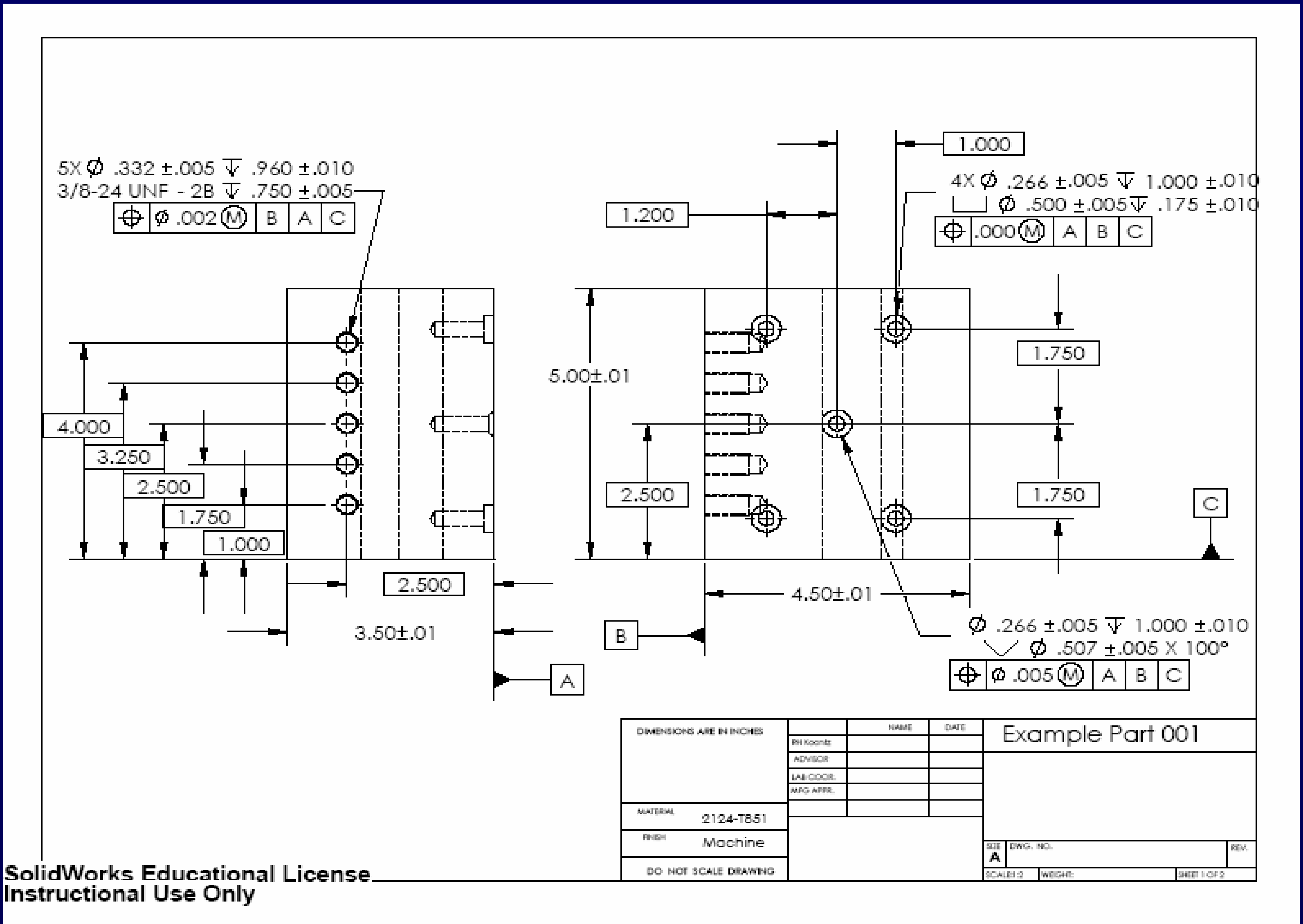
ANSI modification symbols	
MMC	Ⓜ
Regardless of feature size	Ⓢ
LMC	Ⓛ
Projected Tol Zone	Ⓟ
Diameter	Ø
Spherical Diameter	SØ
Radius	R
Spherical Radius	SR
Reference size	( )
Arc length	⌒

Feature Control GD&T Examples





Engineering Drawing Example



Manufacturing Steps

- STEP 1 (CONCEPT) The first step towards scheduling time in the advanced manufacturing lab (AML) is to schedule a meeting with Dr. Dolan to review a preliminary or conceptual design as well as proposed work. During this meeting, proposed use of the lab will be discussed as well as preliminary scheduling of manufacturing resources. This meeting initiates the communication between manufacturing and design and allows appropriate preparation for production by the AML.
- STEP 2 (DESIGN) Once the initial design concept has been finalized it will be important to keep the manufacturing apprised of your design as it develops.
- STEP 3 (MANUFACTURABILITY) Once approval has been given by Dr. Dolan to manufacture the part(s) a meeting should be scheduled with Mr. Koontz to discuss the manufacurability of the design. At this meeting you should bring engineering drawings of the part(s) to be manufactured. In addition a SolidWorks model may be needed along with any mating parts and/or assemblies if appropriate.
- Remember, several iterations may be required before a design meets the requirements for function and manufacturability (steps 2 to 3).
- STEP 4 (APPROVAL) A part will be scheduled for manufacture only after all of the individuals listed below have 'checked off' on the design.
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- **Design Engineer -** Person responsible for manufacturing the part.
- **Faculty Advisor –** Generally this will be the project advisor, can also be the research director if the part is for a research project.
- **Lab Coordinator –** Dr. Dolan
- **Production Engineer –** Ryan Koontz