ME250 Laboratory Objectives

Lab #1 – Introduction to Basic Metrology Instruments and Measurements

Goal: Become familiar with manual metrology instruments and how to use them.

Learning Objectives:

Upon completion of this lab, the student shall be able to:

1. Identify basic metrology instruments
2. Properly use basic metrology instruments such as:
    a. Micrometers
    b. Calipers
    c. Gauge blocks
    d. Gauge pins
    e. Dial indicators
    f. Height gauge
3. Understand relative precision of measurements and sources of measurement errors.

Apparatus:

1. Dial and Digital Calipers, 6-inch
2. Micrometer, 1-inch
3. Height gauge, 18-inch
4. Dial indicator
5. Surface plate
6. Gauge pin
7. Gauge blocks
8. 1-2-3 block

Procedure:

Part A

In part A you will be required record measurements of given items. Before starting measurements, verify that the instruments are zeroed.

1. Select a pin gauge for your measurements.

2. Measure gauge pin using micrometers and record your result. Repeat each measurement 3 times.

3. Repeat the measurement on same gauge pin using calipers and record your result. Repeat each measurement 3 times

4. Using height gauge set the zero reference as the top of the surface plate. Place the same gauge pin on the surface plate and measure the diameter of the pin. Repeat the measurement 3 times and record your results.

5. Repeat steps 1 through 4 using a gauge block.

6. Repeat steps 1 through 4 using a 1-2-3 block measuring the 1" thickness.

Part B

In part B of the measurements you will be required to use gauge blocks and a dial indicator and perform a transfer measurement from the gauge blocks and verify the measurement of the 1-2-3 block.

7. Wring together two blocks that total 1-in.
8. Place wrung gauge blocks on surface plate next to 1-2-3 block.
9. Using the dial indicator attached to the height gauge, slowly approach the top of the gauge blocks until the dial needle moves.
10. Zero the dial.
11. Transfer the height stand with the dial indicator attached, sliding the stand on the surface plate, onto the 1-2-3 block.
12. Record the deviation shown on the dial indicator, plus or minus.

			Measurement		
	Item	**Instruments**	**1st reading**	**2nd reading**	**3rd reading**
PartA	Gauge pin (any size)	Micrometer			
	Gauge pin (same as above)	Caliper			
	Gauge pin (same as above)	Height gauge			
	Gauge block (any size)	Micrometer			
	Gauge block (same as above)	Caliper			
	Gauge block (same as above)	Height gauge			
	1-2-3 block (1" dim)	Micrometer			
	1-2-3 block (1" dim)	Calipers			
	1-2-3 block (1" dim)	Height gauge			
PartB	1-2-3 Block/Gauge block	Dial Indicator			

Analysis: (see appendix C for equations)

a. Calculate mean and 3-sigma of each measurement for the group. What is the accuracy and repeatability?

b. Calculate 3-sigma for each tool across all measurements for the group. What is the accuracy and repeatability?

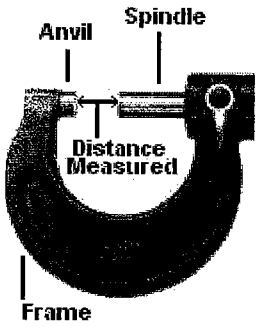
c. Rate the tools for relative measurement repeatability and accuracy.

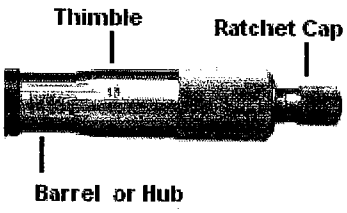
d. List the sources of error in the measurements.

e. Are these error sources random errors?

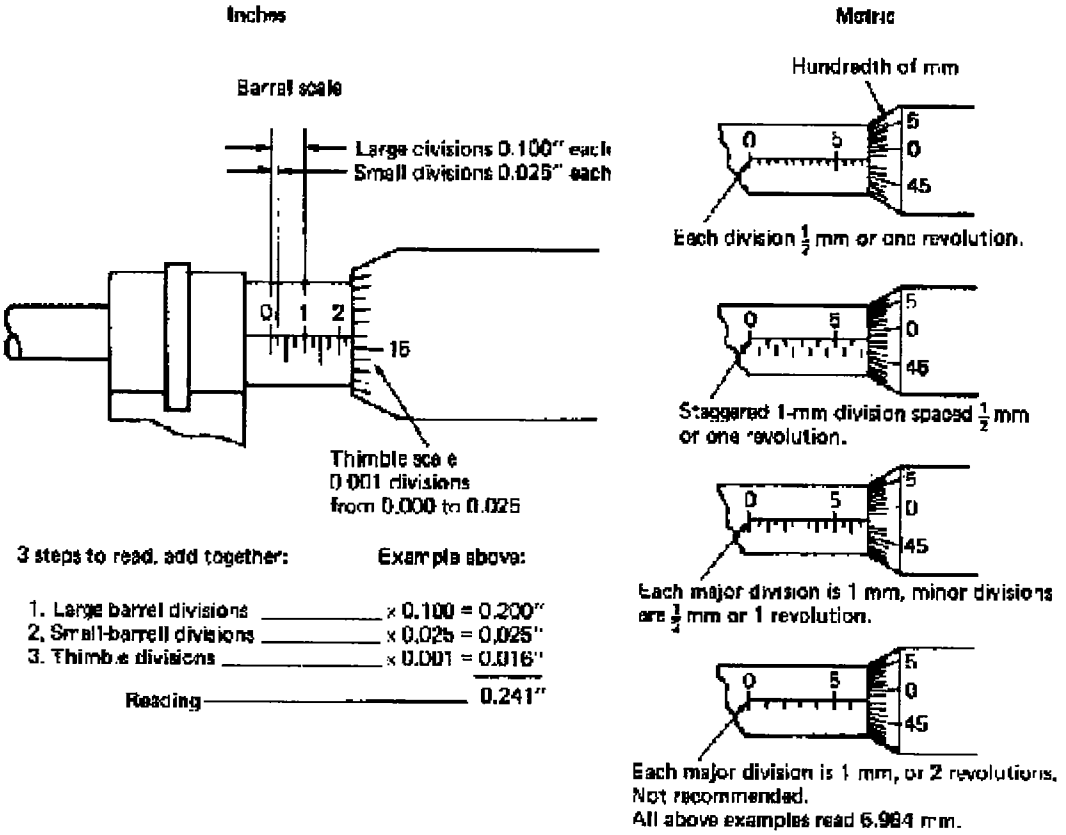
Appendix A: Basic Metrology tool references

Micrometer





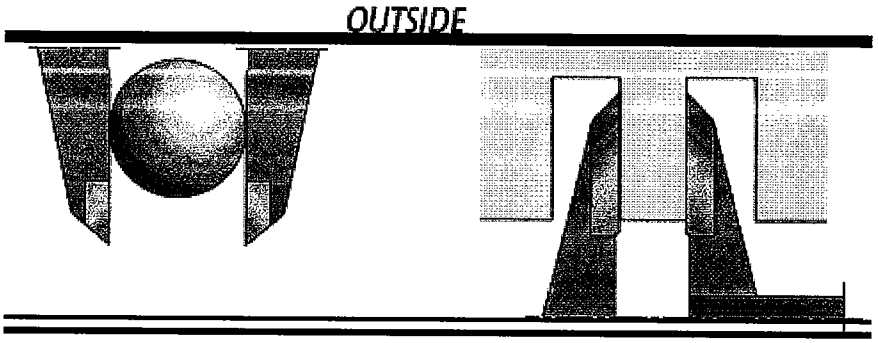
http://www.pastaffing.com/trainmic.asp



www-me.mit.edu/Lectures/MachineTools/measure/intro.html#3

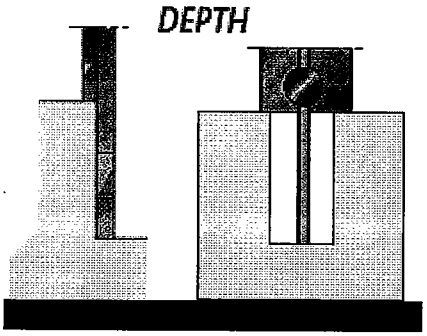
Calipers

Probably the most useful of tools, dial calipers offer **four measuring capabilities**: outside dimensions such as diameters measured with the large jaws, inside dimensions measured with the smaller jaws, depth measurements obtained with the extending rod, and step measurements taken with the front of the tool.



The ends of the jaws are beveled so that measurements in slots and grooves are possible. Don't use this area of the jaws for general measuring however, because it wears down quickly. Measure with the flat area of the jaws whenever possible.

The **depth measurement** is fine for small diameter holes and can extend all the way to 6 inches. If you need to span a larger diameter hole you can always get a depth bar attachment which will make your caliper function somewhat like a dial depth gage (see below).



Calipers have .001" graduations and are accurate to ± one graduation if none of the measuring surfaces have been worn, bent or damaged. They're perfect for all sorts of **quick measurement** and can be used as a preliminary source before moving on to more sensitive tools such as micrometers (.0001"), depth gages or dial indicators (.0005" and .0001").

Calipers should be frequently checked for **accuracy** using a gage block, or gage block combinations. To check for wear in the jaws do this: clean them and close them. Then hold them up to the light and if they're worn you'll see light shining through the gaps. At this point, measure with the unworn surfaces or have the calipers repaired. These jaws can be ground flat again.

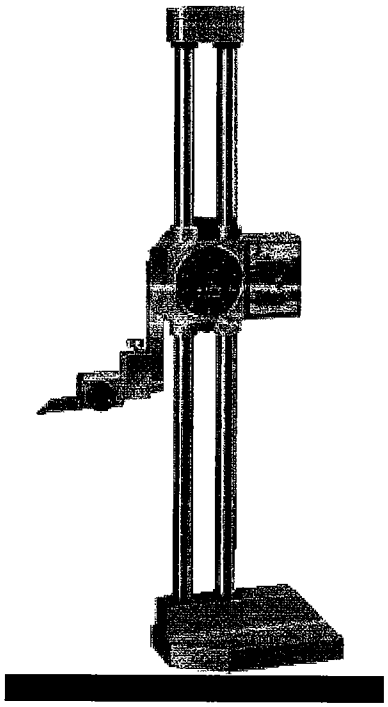
The most common dial calipers have a **measuring range** from zero to six inches. These are the most useful because they can be easily handled. However, 8-inch, 12-inch, and even longer calipers are available.

The inclusion of the dial makes for much easier reading because it eliminates the need to know how to read the vernier scale. The invention of the vernier scale is one

of the unsung innovations of the past, but reading the scale requires some training and a lot of practice if you want to be proficient at it. It's best to ask someone to **show** you how to do this.

http://www.longislandindicator.com/calipers.html

Height gage
and Scribing Gage



Using a height gage

- Height gages function like enormous calipers.
- Always approach your measured surface **from above** to get consistent readings.
- Check your height gage against a stack of gage blocks. Don't use test indicators to try and calibrate your height gage. You'll only introduce a new element of inaccuracy.
- You can expect an accuracy of .001" on height gages up to 12"
- When coming down on a test piece don't force it. You can actually lift the base of the gage off the surface without realizing it.
- You may encounter backlash on the main "drive" gear. This is normal even on new gages and may become exaggerated with wear and with age. It has no effect on the accuracy since the sole purpose of this gear is to move the measuring head up and down.
- Always use your height gage on a **flat surface**. We don't mean a flat table top. It has to be on a granite or metal surface plate.
- The bottom surface of the height gage should be treated like a very large gage block. It has to remain damage free and flat.

http://www.longislandindicator.com/heightgage.html

Appendix B: Practice instrument readings

Appendix C : Equations

Mean:

$$\bar{x} = \frac{\sum_{i=1}^{N} x_i}{N}$$

where:

x_i = value of data point
N = number of data points

Standard Deviation (s_x):

$$\sigma_x = \frac{[(\sum_{i=1}^{N} (x_i - \bar{x})^2]^{1/2}}{N-1}$$

Root Sum Square (RSS) for error measurement:

$$E_{RRS} = \frac{[(\sum_{i=1}^{N} (E_i)^2]^{1/2}}{N}$$

E_i = Individual error