4 Precision Measurement

Objective

The learner will be able to:

- Identify precision measuring tools
- Explain proper care of measuring tools
- Examine measuring techniques with micrometers
- Compare and contrast uses of various measuring instruments

Orienting Questions

- ✓ What is precision measurement?
- ✓ What makes precision measurement important to industry?
- ✓ Are precision measurement tools vital in today's machine shop?

Helpful Tips

- ✓ You can select the **HIGHLIGHTED TERMS** to read more about it.
- ✓ If needed, there are **CLOSED CAPTION** buttons CC on the YouTube videos that will enable you to read along while you watch. The Closed Caption buttons are located bottom right of the video screen.
- ✓ Take time and explore about the subject by selecting the **EXPLORE** links in each section of this module.

Commented [LCM1]: This will be added to the other 7 modules

LM July 25, 2013

INTRODUCTION

MEASUREMENT is the process by which size may be determined. **Figure 1** illustrates the different measurement system used in machining.

Measuring a piece of stock before machining can determine if there is enough material for the machining process or if there is too much material for the process. Measuring the part while machining or measuring between the machining processes helps verify the accuracy of the machining process by comparing it to a blueprint. Tolerances on the blueprint can affect the choice of measuring tool.

There are two systems of measurement used in industry:

- Inch (decimal)
- Metric

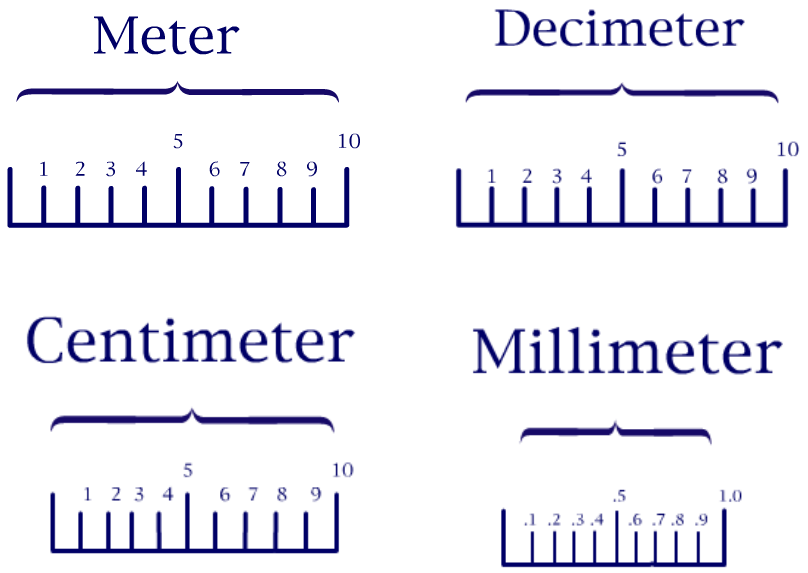


Figure 1: Metric System: Meter, Decimeter, Centimeter, and Millimeter
(Image by The Virtual Machine Shop, 2013)

INSTRUMENT CARE

Measuring instruments are very sensitive. Care must be taken when using and storing these instruments. If any of these instruments are neglected, accuracy of that tool will be affected greatly. Most measuring tools come with hard shell cases that will protect them from dust and debris. They should be stored in a case when not in use and cleaned on a regular basis to ensure the accuracy of that part and its appearance.

CALIBRATION OF MEASURING TOOLS

Measuring tools are very sensitive. Dropping or bumping these tools can cause inaccuracies in measurements that are taken. Most **CALIBRATION** of precision instruments can be done by the machinist or shop utilizing small tools that are provided by the manufacturer. **SMALL SPANNER WRENCHES** are the choice for most micrometers. **Figure 2** is an example of a Gage Block that can be used to measure calibration.

Explore… The Virtual Machine Shop: The Micrometer - 6: Adjusting

Figure 2: Gage Blocks (Image by Automation and Metrology Inc., 2013)

PRECISION FIXED GAGES

FIXED GAGES are used in both comparison measurement and precision measurement. In comparison, the fixed gage is compared to a feature to verify form. In precision measurement, fixed gages are measurement aides. Rather than only providing only a representation of a feature, precision gages provide a standard.

GAGE BLOCKS

GAGE BLOCKS, also known as Gauge Blocks, are very accurate hardened steel blocks that come in graduated sizes. They are used in calibrating measuring instruments and machining setups. Most shops have at least one set that is used for inspections of parts and tools. However, some shops have two sets with the second set used on the shop floor for machining setups. Gage blocks come in three grades:

- Grade 1(laboratory)
- Grade 2(Inspection)
- Grade 3(Shop)

Figure 3 shows the various shapes and sizes of gage blocks. **Figure 4** shows a representation of a gage block set.

Figure 3: Gage Blocks (Image by www.starrett-webber.com, 2013)

Remember to clean gage blocks after use and store them in a controlled environment so that corrosion does not occur. Gage blocks can be stacked based to represent the size or dimension that is to be checked. When stacking, it is necessary to wring them together. WRINGING, pronounced "ringing", is the process of displacing air between two precisely flat surfaces by rubbing them together. This results in the blocks sticking together. Otherwise they will simply fall apart if this is not performed.

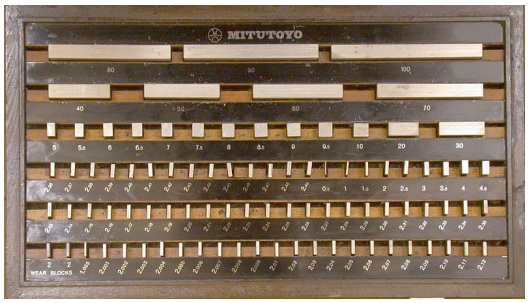


Figure 4: Gauge Block Metrics Set
(Image by McKechnie, Glenn., 26 March, 2005)

GAGE PINS

GAGE PINS (also known as Gauge Pins) are precisely-ground round cylinders and come in graduated sizes. They are used to check hole-sizes and can provide the machinist with an idea of how tighten the hole. This helps in determining the type of fit a hole has. The pins graduate in increments of .001(1 thousandths), .0005(5 ten thousandths), or .0001(1 ten thousandths). **Figure 5** shows the size designation that is etched on every gage pin.

Figure 5: Gage Pins (Image by Automation and Metrology Inc.)

READING MICROMETERS

MICROMETERS, sometimes referred to as “mics”, are the most common measuring device that is found in industry. Machinists are required to know how to use and maintain these precise instruments. It is also necessary to hold the micrometer in the proper position while measuring. For micrometers up to 4inches, it should be held and aligned with one hand. The common types of micrometer instruments are:

- Inside Micrometers
- Outside Micrometers
- Depth Micrometers

Measuring range of these mics is determined as follows:

- 0”-1”, Measures from 0 to 1 inches
- 1”-2”, Measures from 1 to 2 inches
- 2”-3” Measures from 2 to 3 inches

It is important to note that these sizes listed above represent minimum and maximum size ranges of just a few of the mics available. It is recommended that measuring outside of these ranges can result in inaccurate measurements. For example: If the part dimension to be checked measures 1.9999”, then it is not a wise choice to select a 2” to 3” micrometer. The micrometer that should be selected is the 1” to 2” mic.

Explore: Click on image below to watch video

(Note, select Closed Caption button CC on YouTube video if needed. Closed Caption button is located bottom right of video screen.)

Click the Picture to watch a video by Isstarrett on How to Read an Inch Micrometer

DISCRIMINATION, in measuring, is the degree to which a measuring instrument divides the units in which it measures. A micrometer with .001" graduations on its thimble can discriminate to one thousandth of an inch.

INCH AND METRIC OUTSIDE MICROMETERS

While inch and metric micrometers have some basic features that are exactly the same, they are read much differently. Inch and metric micrometers both consist of:

- Frame
- Anvil
- Spindle
- Sleeve
- Thimble
- Ratchet or Friction Stop

Active links: click terms to see more

Worth noting: It is important to be familiar with the parts of these micrometers – see figure 6 below for detail parts of an Outside Micrometer.

Now You Practice #1: Identify the parts of an Outside Micrometer
(Click on image below to begin interactive activity)

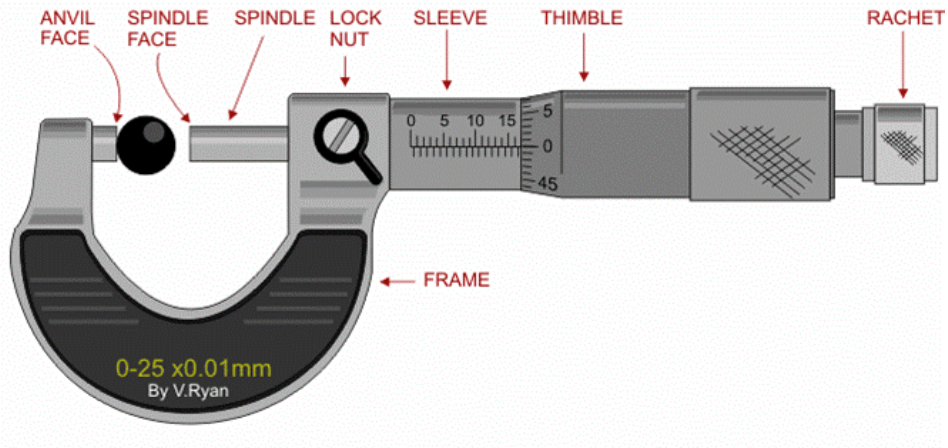


Figure 6: Outside Micrometer (Image by www.technologystudent.com)

Standard micrometers read in decimal parts of an inch. These micrometers are referred to as "inch mics". Each sleeve consists of a graduated scale broken into 10 numbered divisions equaling .100(100 thousandths). Each division is broken down further in 4 equal parts at .025(25 thousandths). The thimble is broken down into 25 equal parts with each division equaling .001(1 thousandths). The spindle screw is 1:40, which means that every time the thimble is rotated about the sleeve once it will have traveled .025(25 thousandths).

Metric micrometers have the same components; however they are graduated differently than inch micrometers. The sleeve is graduated in millimeters above the index line and .5(half) millimeters below the index line. The thimble is graduated in 50 parts that each equal .01(10 microns).

It is important to note that only the uncovered portion left exposed should be read by the machinist. Practice in holding the micrometer is important so that an inaccuracy of measurements doesn't call for all parts to be pulled for more in depth analysis.

ACTIVITY #1

Students will use 0 – 1" Micrometer provided in the tool kit to measure household item (such as nails, bolts, etc.) within the range to Micrometer record the measurement taken and bring the object and measurement recording to class.

DEPTH MICROMETERS

DEPTH MICROMETERS are used to measure depths of features such as holes, grooves, shoulders, and recesses. Comparing a depth micrometer (Figure 7 and Figure 8) to standard outside micrometer, it is easy to see that they are graduated in much the same. They are harder to read because of the sleeve numbers being backward.

Now You Practice #2: Identify the parts of a Depth Micrometer
(Click on image below to begin interactive activity)

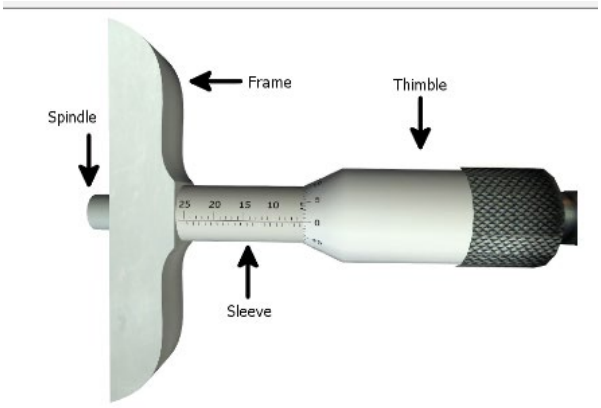
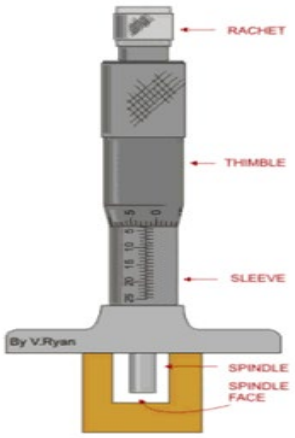


Figure 7: Depth Micrometer (Image by CA2VES Clemson University)

Now You Practice #3: Identify the parts of a Depth Micrometer
(Click on image below to begin interactive activity)



What you need to know:

This is a 90 Degree vertical orientation of a Depth Micrometer

Figure 8: Depth Micrometer (Image by www.technologystudent.com)

INSIDE MICROMETERS

INSIDE MICROMETERS has a micrometer head, tubular or solid measuring rods and are used to measure dimension accuracy of holes (see **Figure 9**). The Inside Micrometer comes in sets that can measure holes from 1-1/2" up to 12". These tools are used when close dimensions and tolerances must be maintained. They are checked with mics to qualify their accuracy. These precise instruments can measure a range of sizes from 1.5" to 12.0". They measure the same way as outside micrometers and discriminate in the same amount.

Explore: Inside Micrometer

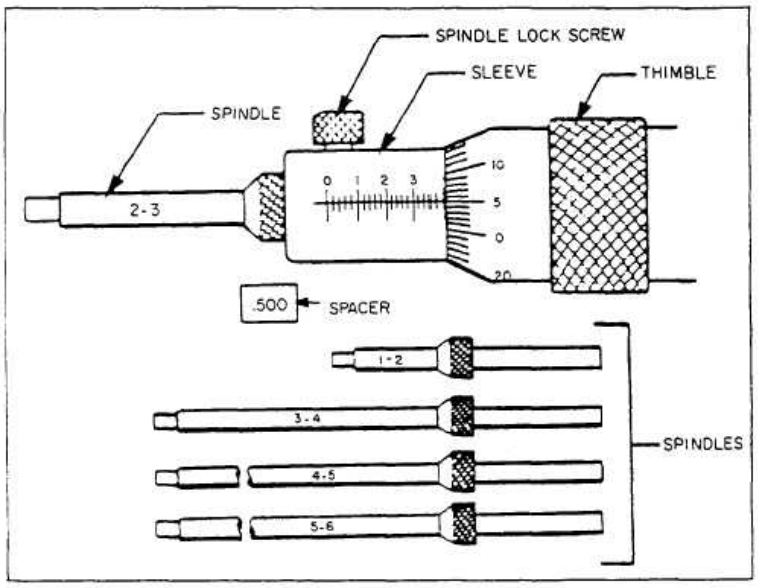


Figure 9: Inside Micrometer (image by navyaviation.tpub.com, 2013)

DIAL MEASUREMENT INSTRUMENTS

Dial based measuring tools are similar to Vernier measuring instruments, but instead of reading smaller graduations on the Vernier scale, they are read on a dial. The dial has a needle that makes revolutions as the scale is moved. Graduations on these dials range from .0001" (one ten thousandth of an inch) to .010" (ten thousandths of an inch) per revolution.

DIAL CALIPERS

DIAL CALIPERS **(Figure 10)** can be used to measure outside, steps, inside and depth. When reading a Dial Caliper **(Figure 11)**, it is important to remember that they are read similar to Vernier Calipers. First read the largest numbers on the main scale then the smaller .100" graduations on the beam and last, you will read the dial. Add the values per reading to get the sum of measurement. Dial Calipers are great for quick

measurements. However, they lack precision because the operator can manipulate the reading with more pressure. Dial Calipers are only accurate within .002" to .005". On the other hand, Digital Calipers **(Figure 12)** displays measurements in digital format and therefore, requires no additional measurement reading.

Figure 10: Dial and Digital Calipers
(Image by Machine Tool instructor: Mr. Ladell Humphries, 2013)

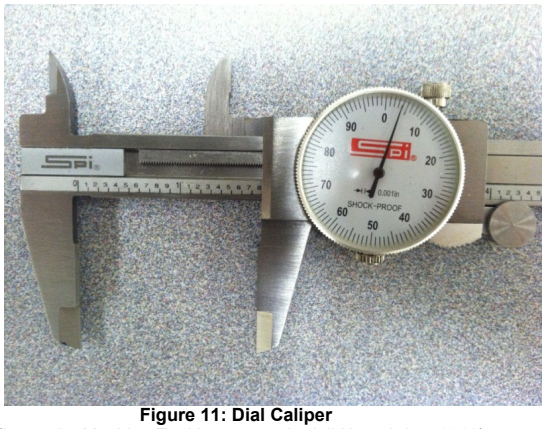


Figure 11: Dial Caliper
(Image by Machine Tool instructor: Ladell Humphries, 2013)

Figure 12: Digital Caliper
(Image by Machine Tool instructor: Ladell Humphries, 2013)

ACTIVITY #2

Using the same object chosen in Activity #1, Students will use 0 – 6" Dial Caliper provided in the tool kit to check the accuracy of their measurement and discriminate (see section on Reading Micrometer) the accuracy of the caliper. Note : this activity will engage students in Comparing and contrast uses of various measuring instruments.

DIAL INDICATORS

A **DIAL INDICATOR** is an instrument that displays small movements with a needle on a graduated face. Indicator graduations range from .00005" to .001" of an inch. The smallest graduation should be listed on the face of the dial. The contact is the part of the tool that touches the part and registers the movement on the dial face. There are two types of indicators that are most common:

- Plunger type – movement of contact is up and down **(Figure 13)**
- Test indicator – movement of contact is back and forth in a lever motion **(Figure 14 & 15)**

Dial indicators can have balanced graduations. These graduations are equally numbered on both sides of the zero mark, while a continuous dial is numbered in one direction. It is important to note that dial indicators do not measure dimensions but distance covered.

Figure 13: Dial Plunger Indicator
(Image by Machine Tool instructor: Ladell Humphries, 2013)

Figure 14: Test Indicator in a vertical view
(Image by Machine Tool instructor: Ladell Humphries, 2013)

Figure 15: a Test Indicator in a horizontal view
(Image by Machine Tool instructor: Ladell Humphries, 2013)

MAJOR CONCEPTS

KEY CONCEPTS

- Measurement is a critical component of machining. Without it, machinists cannot validate a part that has been completed. Machinists are required to analyze dimensions and tolerances that are located on blueprints. The level of accuracy and features of the part will dictate the selection of measuring instruments.
- Precision gages can be used to test parts as well as assuring the quality of work. They can also provide the machinist a way to compare parts to a predetermined standard of measurement.
- Micrometers are the most common precision measuring tool that is found in industry. Being proficient in the use and maintaining good hand position so that all of the controls on the micrometer are accessible with one hand. The ability to read the measurement and understand how to apply it to tolerances is key to producing quality parts.

KEY TERMS

Measurement

Gage Blocks

Wringing

Gage Pins

Micrometers

Discrimination (Ask the Instructor)

Depth micrometers

Inside micrometers

LABS

PHYSICAL LABS

MTT122 is a corequisite of MTT121

ASSESSMENTS

MODULE REINFORCEMENT

True or False: Read the following questions and determine whether the statement is true or false.

1. Industry only uses one system of measurement.
2. Measuring devices should be stored where they can be kept clean.
3. Fixed gages are only found in comparison measurement.
4. Micrometers are tools that are found only in laboratories.
5. Dial indicators can be used to measure distance covered.

Multiple Choice: Read the following questions or statements and select the best answer.

1. A _____ is an instrument that displays small movements with a needle on a graduated face.
    a. Dial caliper
    b. Micrometer
    c. Ruler

   d. Dial indicator
2. The inside micrometer comes in sets that can measure_____ to _____.
   a. 3”, 4”
   b. 1”, 24”
   c. .0005”, 6.0005”
   d. 11/2”, 12”
3. The sleeve of an inch micrometer is graduated in 10 numbered parts which equal _____.
   a. .010”
   b. .100”
   c. .025”
   d. .050”
4. When the thimble of an inch micrometer is rotated, one revolution, it moves _____.
   a. .0001”
   b. .00001”
   c. .0005”
   d. .0010”
5. _____ is the process of displacing air between two flat surfaces.
   a. Rubbing
   b. Wringing
   c. Pressing
   d. Setting

Answer Key

True or False	Multiple Choice
1. F 2. T 3. F 4. F 5. T 6.	1. A 2. D 3. B 4. D 5. B

ANSWER KEYS TO ACTIVITIES

ANSWER TO ACTIVITY #1

Students are to record object select using the Micrometer. Measurement must be recorded/written in decimal to the nearest thousandth of an inch (for example: 0.753)

ANSWER TO ACTIVITY #2

Students are to record object select using the Dial Caliper. Measurements must be written in decimals to the nearest thousandth of an inch (for example: 0.753). Review and discuss with students the difference in measuring outcomes between a Micrometer and a Dial Caliper.

DISCUSSION PROMPTS

DEPTH MICROMETER #1

Discuss the purpose and proper usage of a Depth Micrometer.

INSIDE MICROMETER #2

Examine **Figure 16** and identify the Inside Micrometer measuring instrument. Explain how you were able to identify the Inside Micrometer (keep in mind your explanation will give other students a different view on how to identify an instrument like the Inside Micrometer).

Figure 16: Micrometers ((Image by CA2VES Clemson University)

CRITICAL THINKING

PUTTING NEW KNOWLEDGE TO WORK

Job Description #1	Immediate Supervisor	Task	Result of Task
You are a Machinist…	…your immediate supervisor, **Mr. Humphries**,...	…has asked you to use the Outside Caliper and convert the measurement from centimeter (cm) to inches...	…this will enable you to explain conversion measurement and demonstrate use of the Outside Caliper.

Student Instructions:

1. Enter the Outside Caliper simulation exercise room by clicking on the link below: (Clemson: CA²VES, 2013)
   http://myweb.clemson.edu/~ca2ves/WebPlayer/MetrologyModules.html
2. Read instructions on screen in the simulation exercise room.
3. Verify completion by taking a screenshot of your completed measurement and score.
   Screenshot Tip:
4. Press the word “Print Scr” or “PRT SC” or “print scrn” located at the upper right hand side of your keyboard.
5. Open a new Word document.
6. Press “CTRL” and the letter “V” at the same time…this is a PASTE action or you can select “Paste” located at the upper left hand side of your Word Document screen.
7. Immediately below your screenshot explain your method/process on converting cm to inches. Explain how you were able to manipulate the simulated Outside Caliper.
8. Save your Screenshot document.
9. Upload your Screenshot document to the assigned class dropbox.
10. SMILE 

…You have completed two tasks and have successfully uploaded both screenshots documents to the assigned class dropbox.

RUBRIC SCALE

Grading Rubric for Instructors:

Two Tasks: Outside Micrometer and Caliper	Excellent (60 points max)	Good (50 points max)	Fair (40 points max)	Additional Practice Needed (25 points)
1. Completed simulation exercise and screenshot of completed measurements and scores.				
	Excellent (45 points max)	Good (35 points max)	Fair (25 points max)	Additional Practice Needed (10 point max)
2. Explained method/process to converting cm to inches				
3. Explained use of the simulated Outside Micrometer and Outside Caliper				
	Turned In On Time (5 points)	Turned in 1 day late (2 points)	Turned in 2 days late and gave reason to	Turned in 3 days late or Did Not Turn In after day

			instructor on tardiness (1 points)	**2 tardiness (0 point)**
3. Successfully uploaded Outside Micrometer and Caliper exercise documents to assigned class dropbox.				
Total				

ATTRIBUTION TABLE

Author/s	Title	Source	License
Automation and Metrology Inc.	**Figure 2:** Gage Blocks	http://www.auto-met.com/vermontgage/Black.htm	Author Contact: http://www.auto-met.com/orders/OrderLiterature.htm
Automation and Metrology Inc.	**Figure 5:** Gage Pins	http://www.auto-met.com/vermontgage/Black.htm	Author Contact: http://www.auto-met.com/orders/OrderLiterature.htm
CA2VES Center for Aviation and Automotive Technical Education Using Virtual E-Schools Clemson University	**Figure 7:** Depth Micrometer	http://myweb.clemson.edu/~ca2ves/	Copyright © 2013 Clemson University Contact: http://www.clemson.edu/centers-institutes/cucwd/centers/ca2ves/
CA2VES Center for Aviation and Automotive Technical Education Using Virtual E-Schools Clemson University	**Figure 16:** Micrometers	http://myweb.clemson.edu/~ca2ves/	Copyright © 2013 Clemson University Contact: http://www.clemson.edu/centers-institutes/cucwd/centers/ca2ves/
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Isstarrett	How to Read an Inch Micrometer	http://youtu.be/jNwiRLM3STA	Creative Commons

Ladell Humphries	Activities 1 and 2	Author	Creative Commons
Ladell Humphries	Critical Thinking	Author	Creative Commons
Ladell Humphries	**Figure 10:** Dial and Digital Calipers	Author	Creative Commons
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Ladell Humphries	**Figure 15:** Test Indicator in a horizontal view	Author	Creative Commons
McKechnie, Glenn	**Figure 4:** Gauge Block Metric Set	http://en.wikipedia.org/wiki/File:GaugeBlockMetricSet.jpg	GNU Free Documentation License, Version 1.2 or any later version
Navyaviation.tpub.com	**Figure 9:** Inside Micrometer	http://navyaviation.tpub.com/14003/css/14003_43.htm	Author Contact: http://www.tpub.com/copyright.htm
Ron Smith	Define Gage Pins linked to Gage Pins image	http://www.kanabco.com/vms/glossary/g/gage_pins.html	Author Contact: ronsmithut@yahoo.com
Ron Smith	**Figure 1:** Metric System: Meter, Decimeter, Centimeter, and Millimeter	Retrieved from http://www.kanabco.com/vms/measure_fundmentals/measure_fund_02.html)	Author Contact: ronsmithut@yahoo.com
Ron Smith	The Virtual Machine Shop:	http://www.kanabco.com/vms/measure_	Author Contact:

	The Micrometer - 6: Adjusting	mic_basic/measure_mic_basic_06.html Precision Fixed Gages	ronsmithut@yahoo.com
lsstarrett	Video: HD – How to Read an Inch Micrometer (YouTube.com)	http://youtu.be/jNwiRLM3STA	Author Contact: http://www.youtube.com/user/lsstarrett?feature=watch
www.starrett-webber.com	**Figure 3:** Gage Blocks	http://www.starrett-webber.com/	Author Contact: http://www.starrett.com/about/contact-us
technologystudent	**Figure 6:** Outside Micrometer	http://www.technologystudent.com/equip1/microm2.htm	Author Contact: CONTACT THE AUTHOR ? - techteacher@technologystudent.com
Three-quarter-ten	Micrometer caliper parts	http://commons.wikimedia.org/wiki/File:Micrometer_caliper_parts_0001.png	GNU Free Documentation License, Version 1.2 2 or any later version
V. Ryan	**Figure 6:** Outside Micrometer	http://www.technologystudent.com/equip1/microm1.htm	Author Contact: CONTACT THE AUTHOR ? - techteacher@technologystudent.com
V. Ryan	**Figure 8:** Depth Micrometer	http://www.technologystudent.com/equip1/microm2.htm	Author Contact: CONTACT THE AUTHOR ? - techteacher@technologystudent.com

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