



BASICS OF ENGINEERING MEASUREMENTS

(AGE 2340)

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Course Contents



- Chapter 1:*** Basic Concepts of Measurement Methods
- Chapter 2:*** Uncertainty Analysis
- Chapter 3:*** Electrical Devices and Measurements
- Chapter 4:*** Measurements of Length, Time and Mass
- Chapter 5:*** Temperature Measurements
- Chapter 6:*** Pressure and Velocity Measurements
- Chapter 7:*** Flow Measurements
- Chapter 8:*** Strain and Force Measurements
- Chapter 9:*** Power and Energy Measurements

Chapter 4:

Measurements of Length, Time and Mass

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Chapter 4:

Measurements of Length, Time and Mass

4.1 Length Measurements

4.2 Time Measurements

4.3 Mass Measurements

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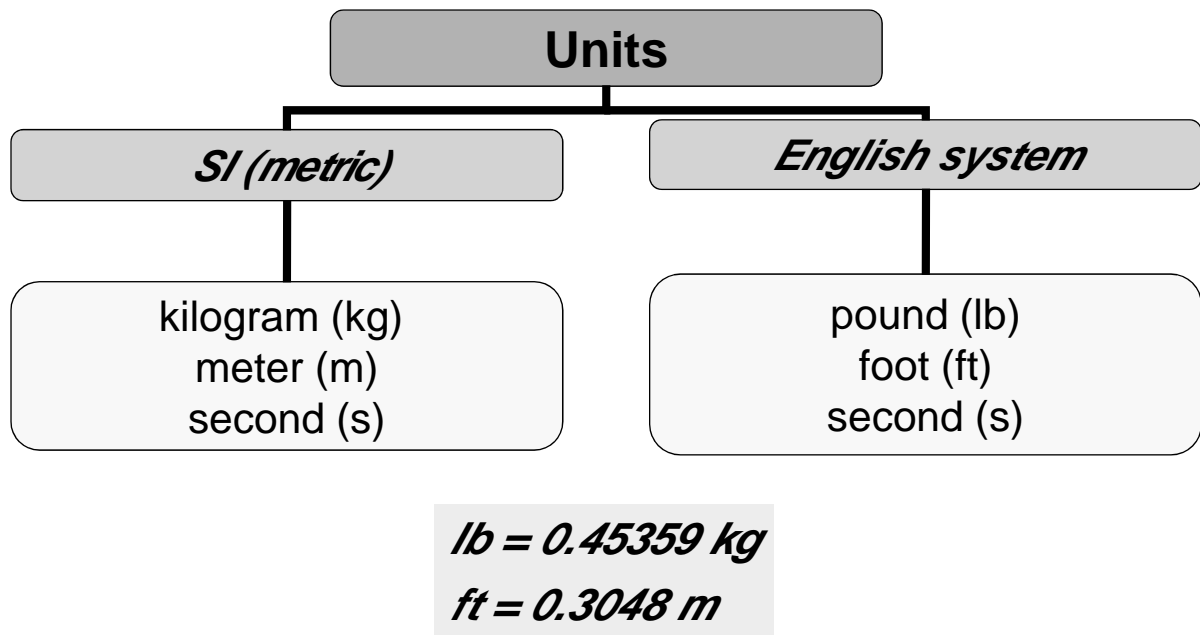
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Units & Dimensions



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Standards of Length, Mass, and Time

Length: (m)

The meter (m) was redefined as the distance traveled by light in vacuum during a time of $1/299\,792\,458$ second.

Mass: (kg)

The kilogram (kg), is defined as the mass of a specific platinum–iridium alloy cylinder kept at the International Bureau of Weights and Measures at Sèvres, France.

Time: (s)

The second (s) is now defined as 9 192 631 770 times the period of vibration of radiation from the cesium atom.

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Conversion of Units

Length

	m	cm	km	in.	ft	mi
1 meter	1	10^2	10^{-3}	39.37	3.281	6.214×10^{-4}
1 centimeter	10^{-2}	1	10^{-5}	0.393 7	3.281×10^{-2}	6.214×10^{-6}
1 kilometer	10^3	10^5	1	3.937×10^4	3.281×10^3	0.621 4
1 inch	2.540×10^{-2}	2.540	2.540×10^{-5}	1	8.333×10^{-2}	1.578×10^{-5}
1 foot	0.304 8	30.48	3.048×10^{-4}	12	1	1.894×10^{-4}
1 mile	1 609	1.609×10^5	1.609	6.336×10^4	5 280	1

Conversion of Units

Mass

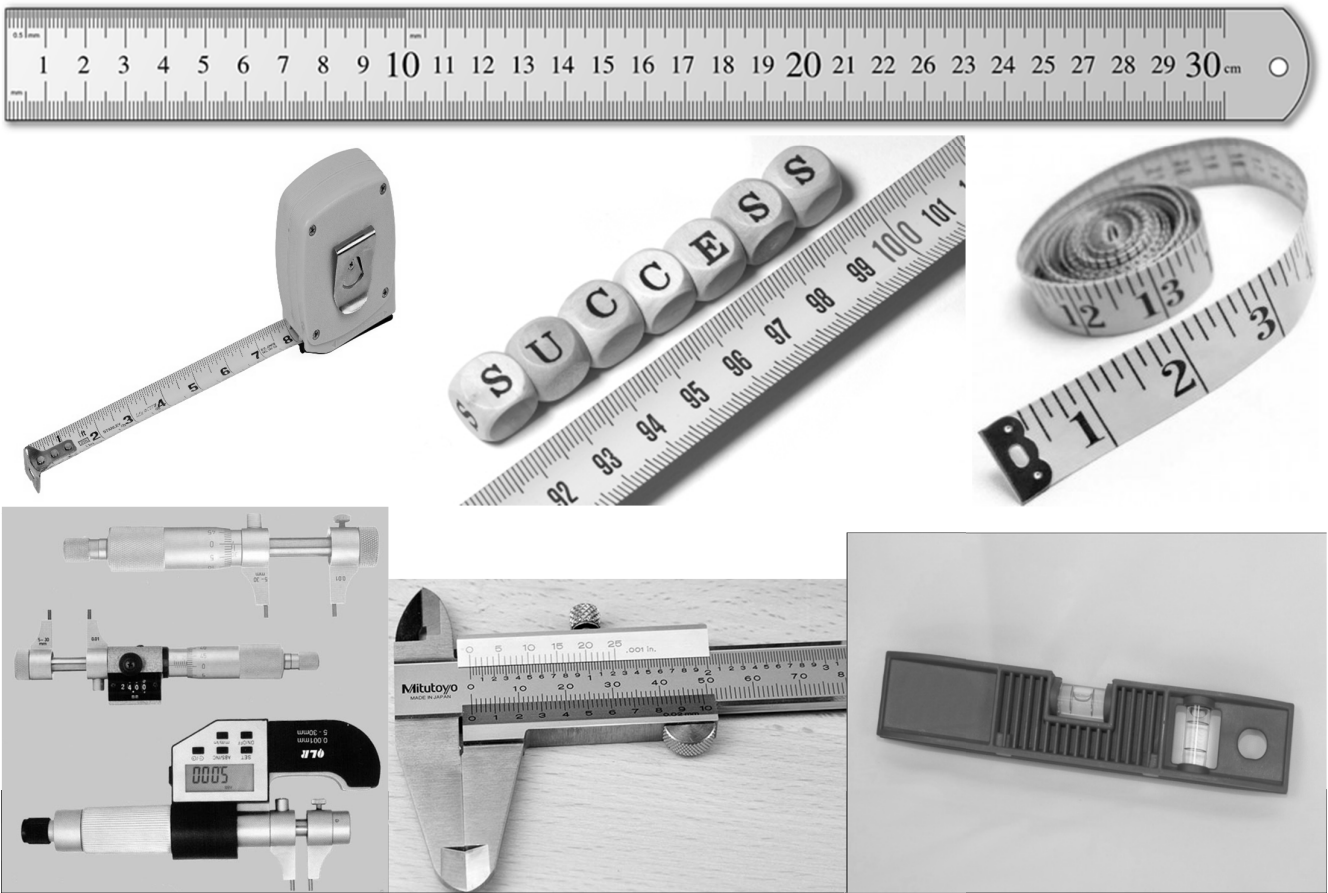
	kg	g	slug	u
1 kilogram	1	10^3	6.852×10^{-2}	6.024×10^{26}
1 gram	10^{-3}	1	6.852×10^{-5}	6.024×10^{23}
1 slug	14.59	1.459×10^4	1	8.789×10^{27}
1 atomic mass unit	1.660×10^{-27}	1.660×10^{-24}	1.137×10^{-28}	1

Note: 1 metric ton = 1 000 kg.

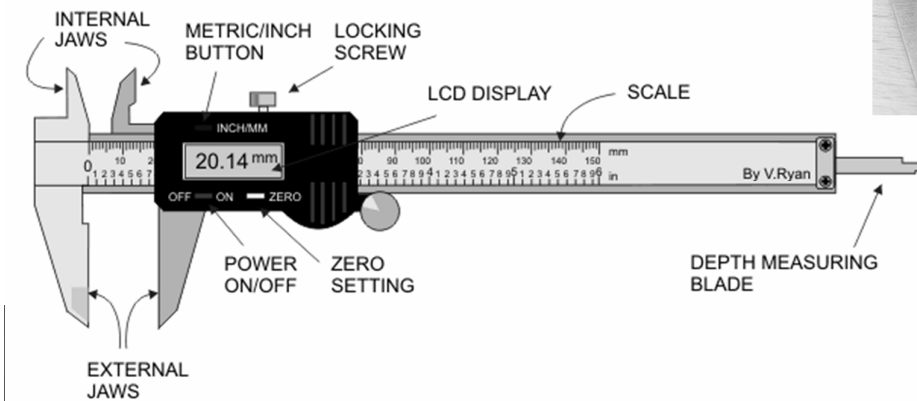
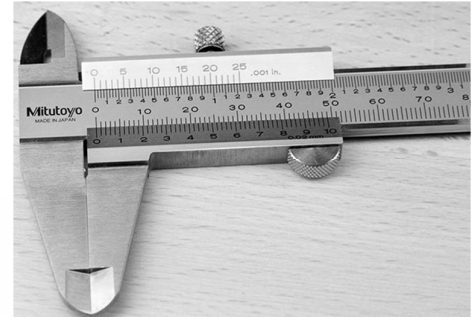
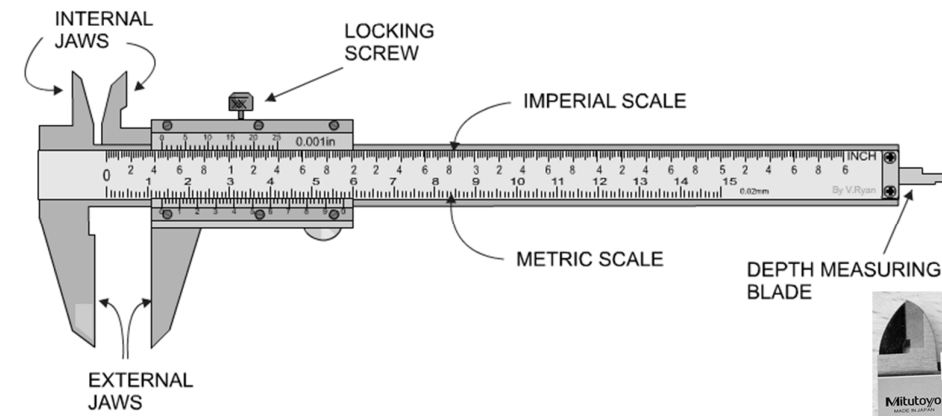
Conversion of Units

Time	s	min	h	day	yr
1 second	1	1.667×10^{-2}	2.778×10^{-4}	1.157×10^{-5}	3.169×10^{-8}
1 minute	60	1	1.667×10^{-2}	6.994×10^{-4}	1.901×10^{-6}
1 hour	3 600	60	1	4.167×10^{-2}	1.141×10^{-4}
1 day	8.640×10^4	1 440	24	1	2.738×10^{-5}
1 year	3.156×10^7	5.259×10^5	8.766×10^3	365.2	1

Linear Measurement Instruments



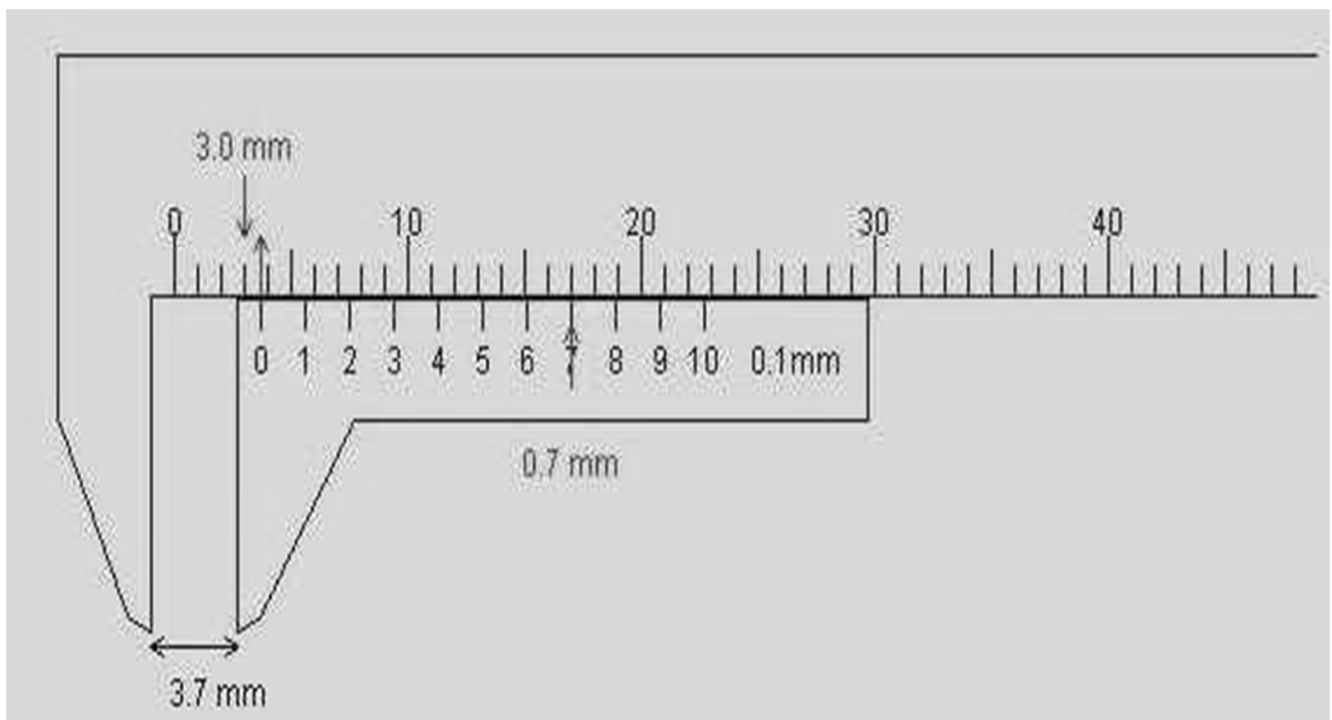
Vernier Caliper



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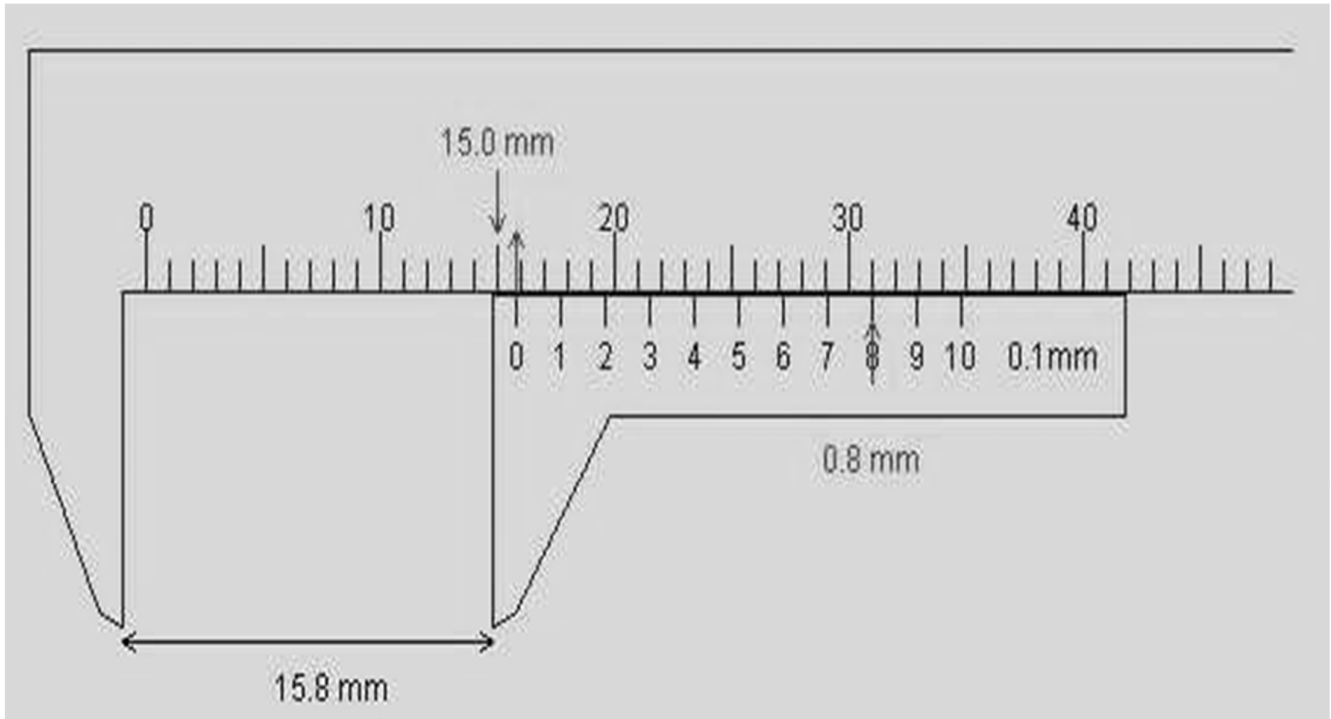
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Vernier Caliper

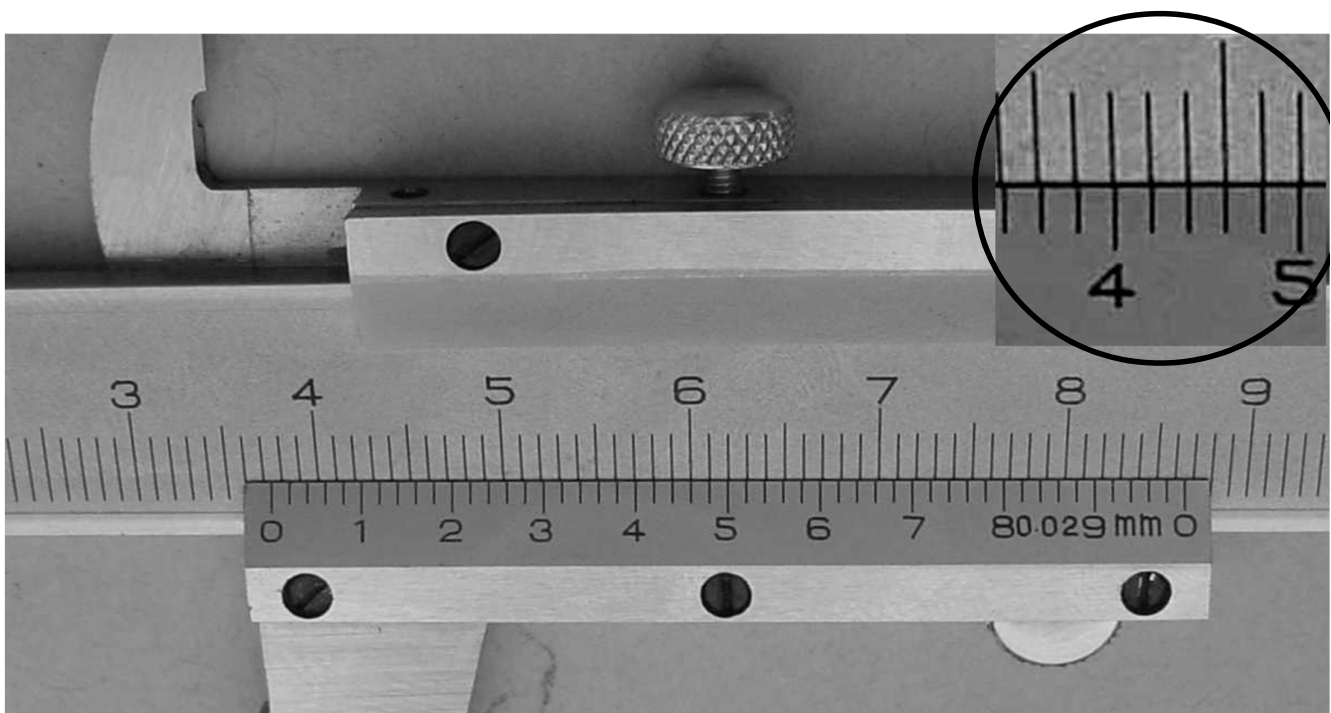


The reading here is **3.7 mm** or **0.37 cm**.

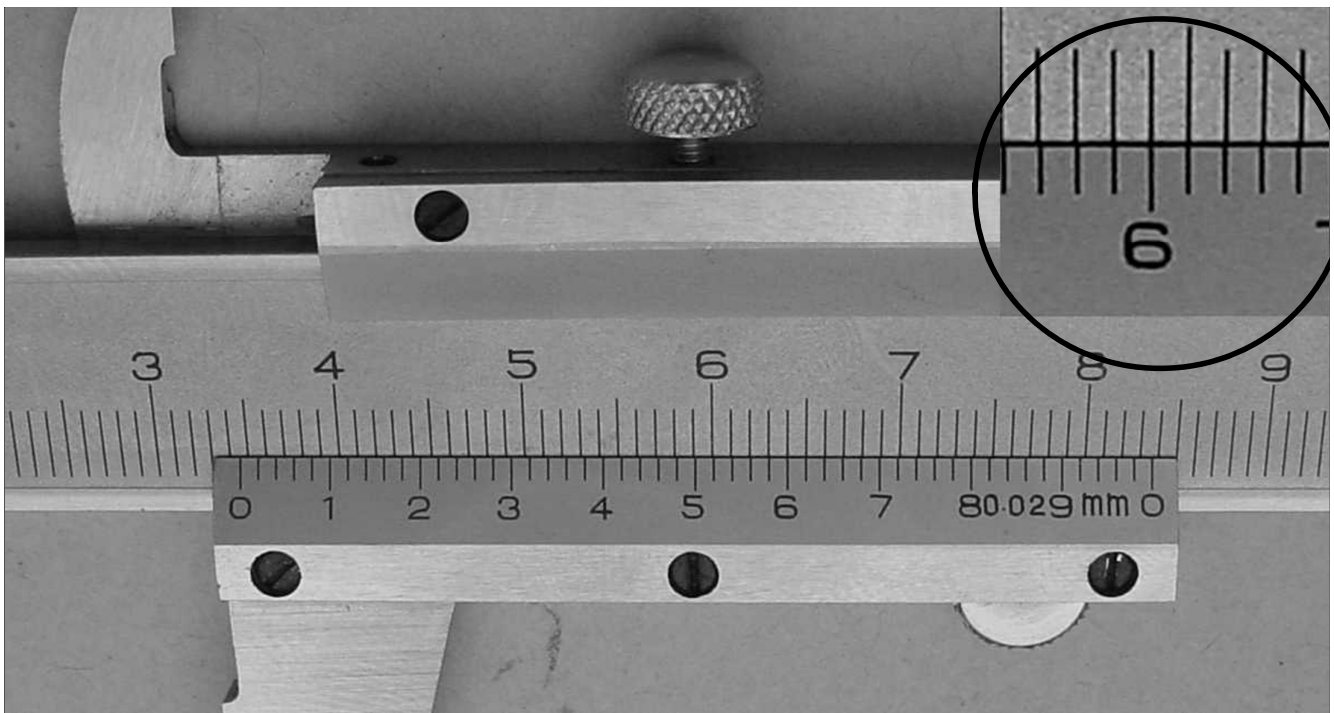
Vernier Caliper



*The reading here is **15.8mm** or **1.58 cm**.*



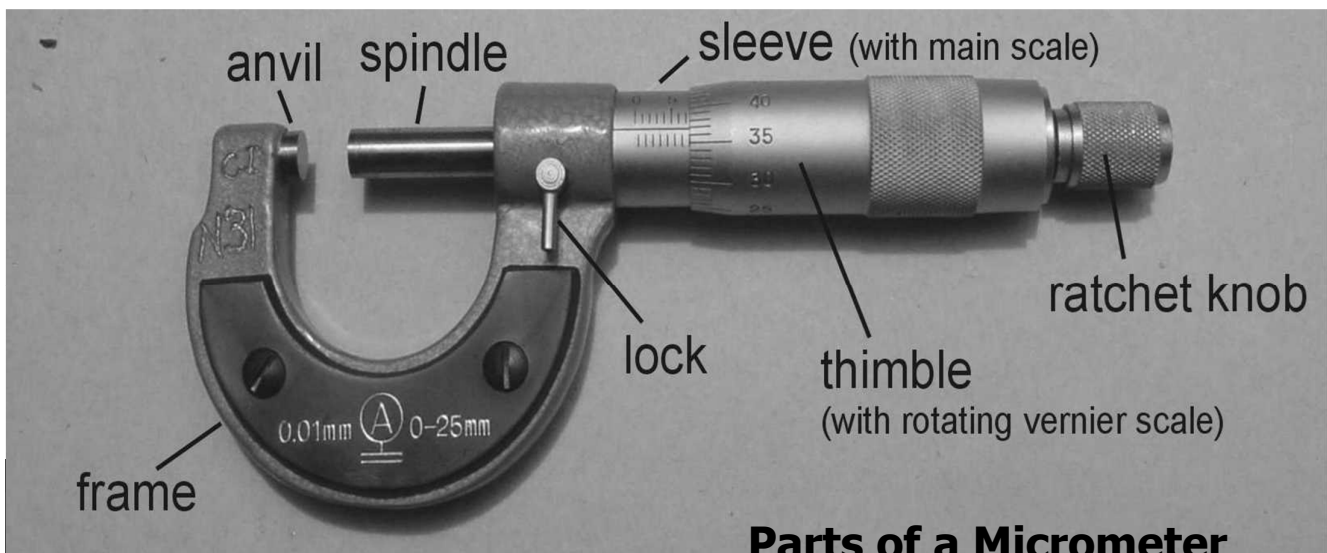
In figure 4 above, the first significant figures are taken as the main scale reading to the left of the vernier zero, i.e. 3.7 cm. The remaining digits are taken from the vernier scale reading that lines up with any main scale reading, (i.e. 0.46 mm or 0.046 cm) on the vernier scale. Thus the reading is **3.746 cm.**



In figure above, the first significant figures are taken as the main scale reading to the left of the vernier zero, i.e. 3.4 cm. The remaining digit is taken from the vernier scale reading that lines up with any main scale reading, (i.e. 0.60 mm or 0.060 cm) on the vernier scale. Therefore the reading is 3.460 cm.

Micrometer

- A *micrometer* allows a measurement of the size of a body. It is one of the most accurate mechanical devices in common use.



Parts of a Micrometer

Micrometer



OUTSIDE MICROMETER



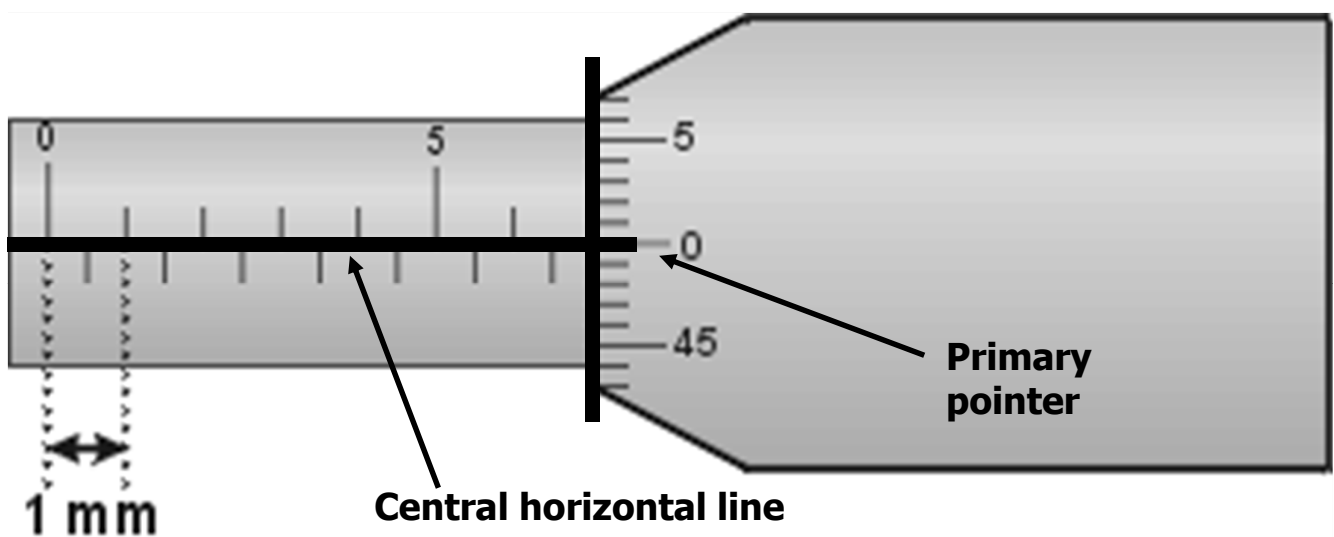
INSIDE MICROMETER

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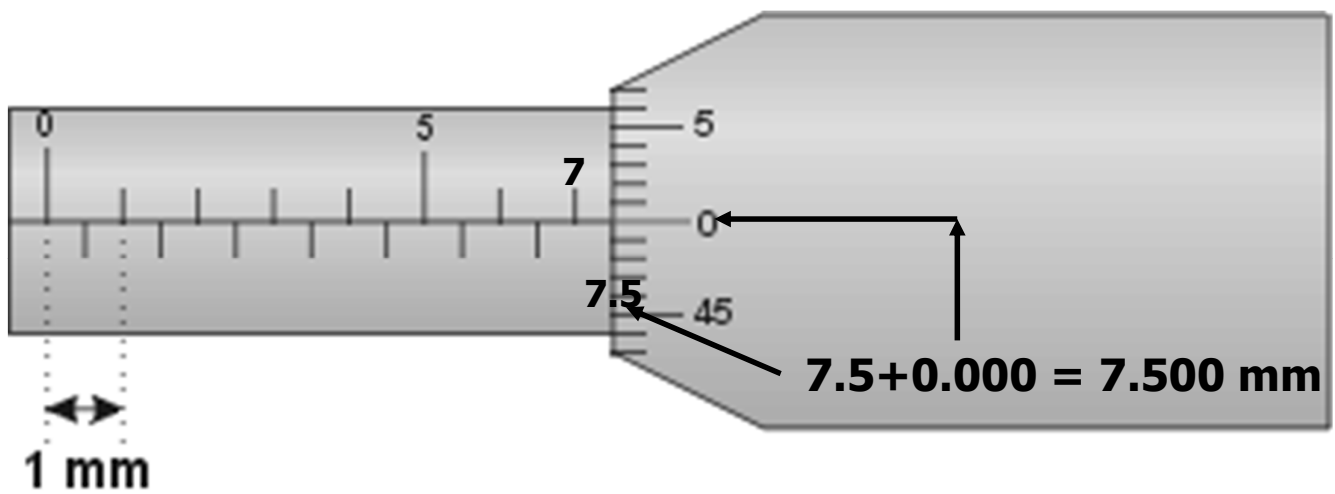
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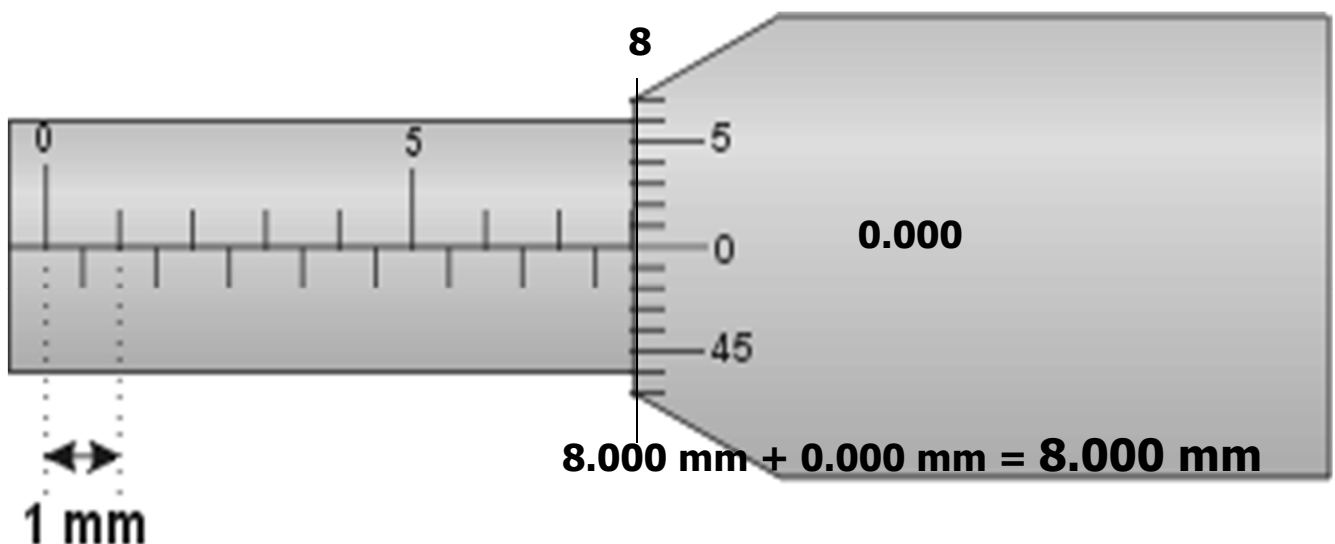


- 1) The line labeled 0 is the primary pointer. When it lines up with the central horizontal line on the cylinder, as shown, then the distance between the measuring rods is exactly an integral or half-integral number of millimeters.
- 2) The left-hand side of the thimble has markings all around it.
- 3) In this case, then, the distance between the measuring rods is 7.000 mm. The upward line on the cylinder corresponding to 7 mm is barely visible under the thimble.



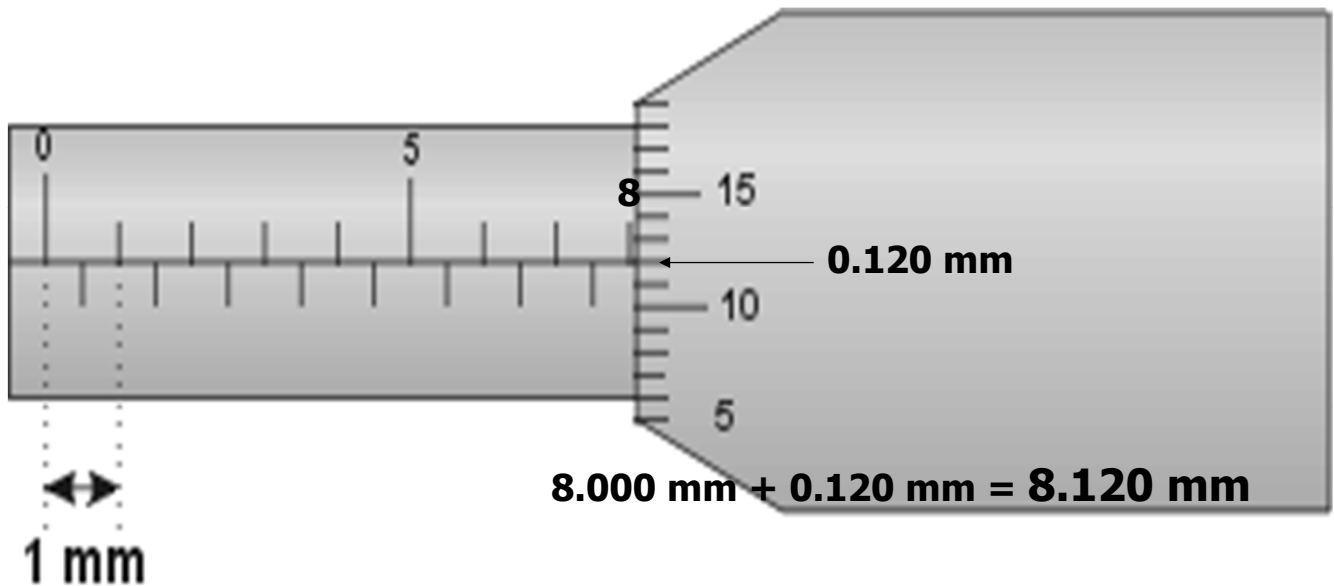
- 1) If we rotate the thimble one complete revolution so it moves to the right, it will look as shown.
- 2) Now the distance between the measuring rods is **7.500 mm**. The downward line on the cylinder corresponding to 7.5 mm is barely visible.
- 3) Note that this is all consistent with the fact that the markings on the cylinder correspond to fifty divisions for a complete revolution. Thus the numbers on the thimble correspond to *hundredths* of a millimeter.

Micrometer



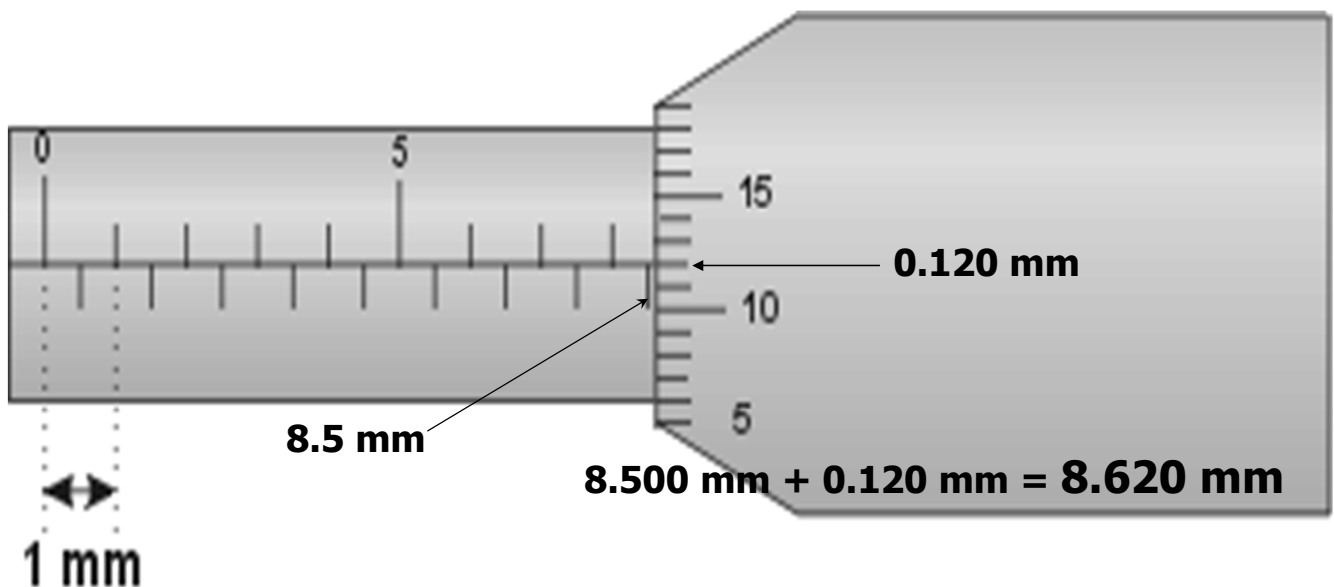
- One more complete revolution takes the distance to **8.000 mm**, as shown.

Micrometer



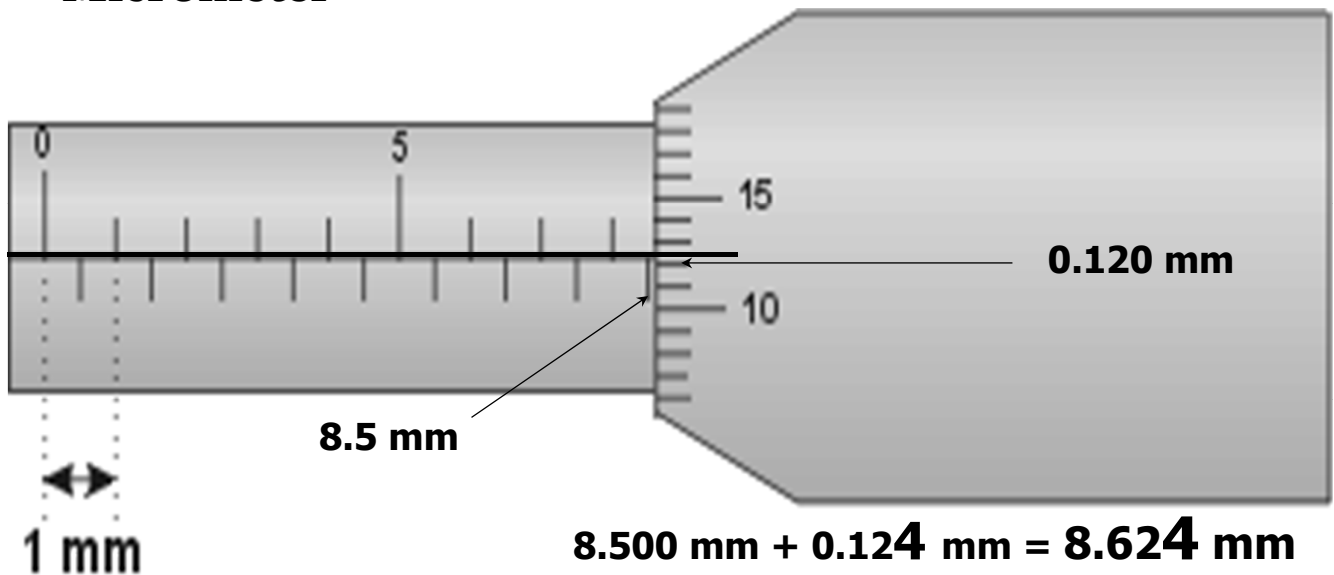
- Now turn the thimble just a little bit more, and end up with the situation shown.
- We have increased the distance by 0.120 mm from 8.000, so the distance between the measuring rods is now **8.120 mm**.

Micrometer

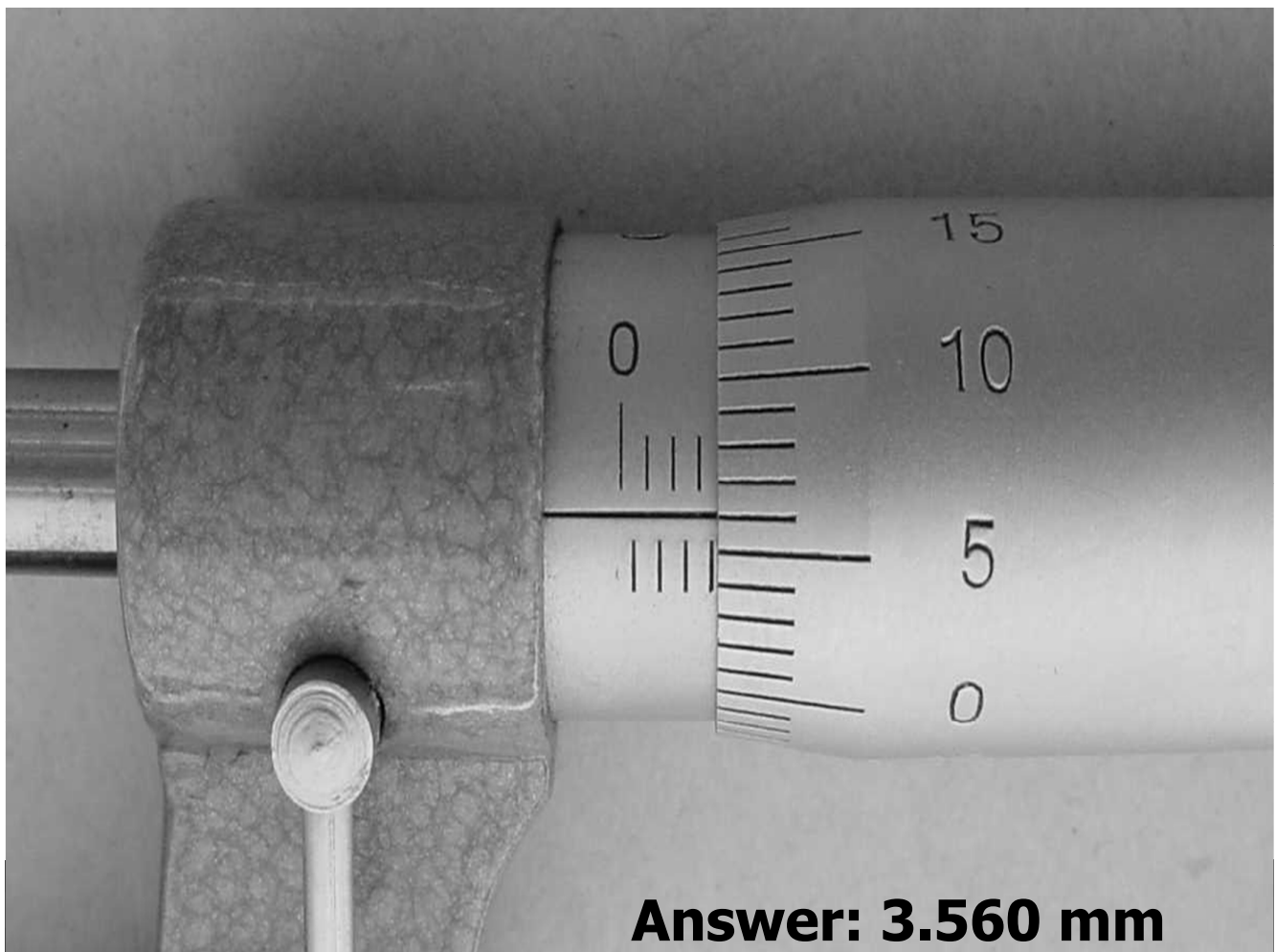


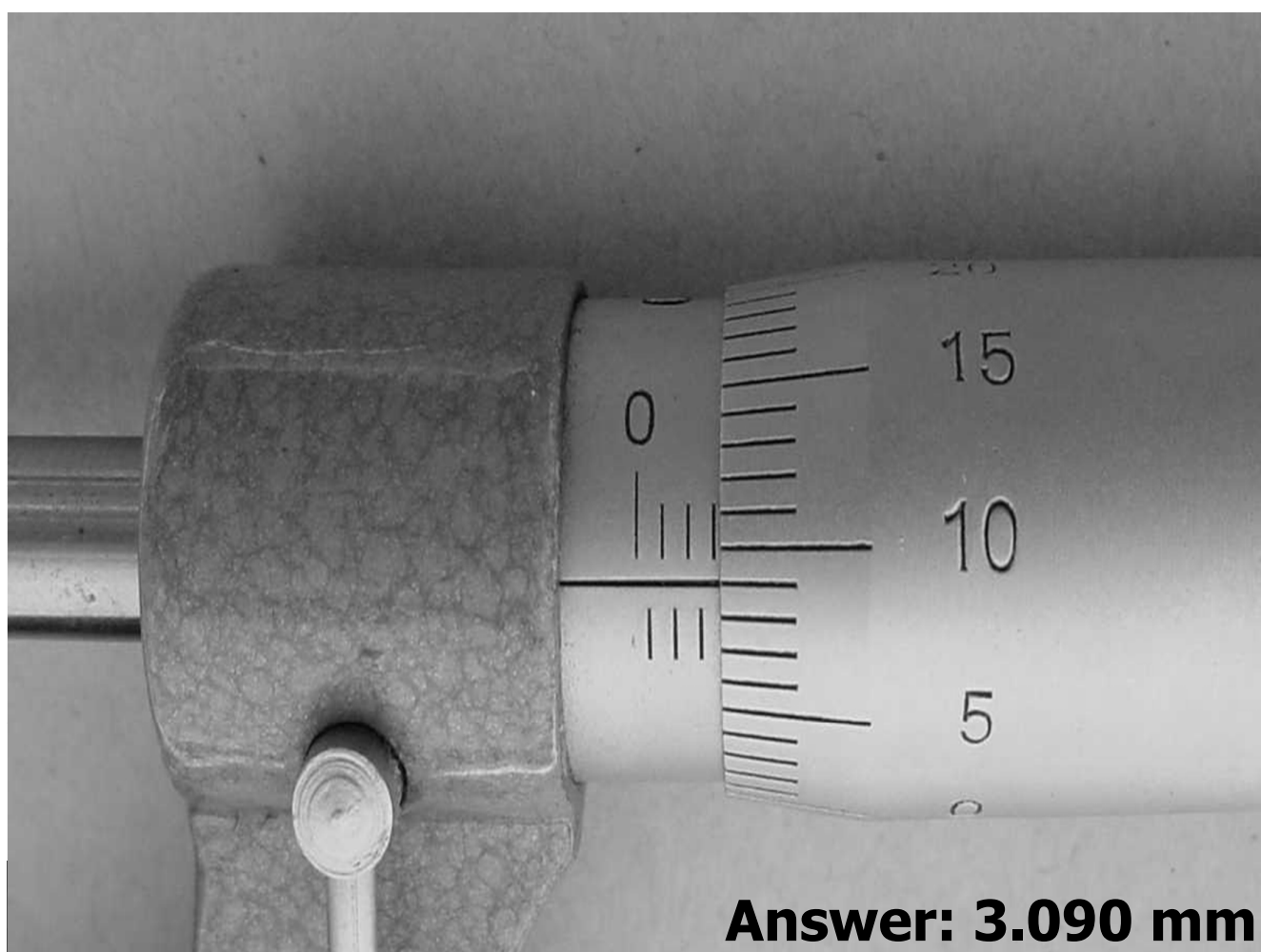
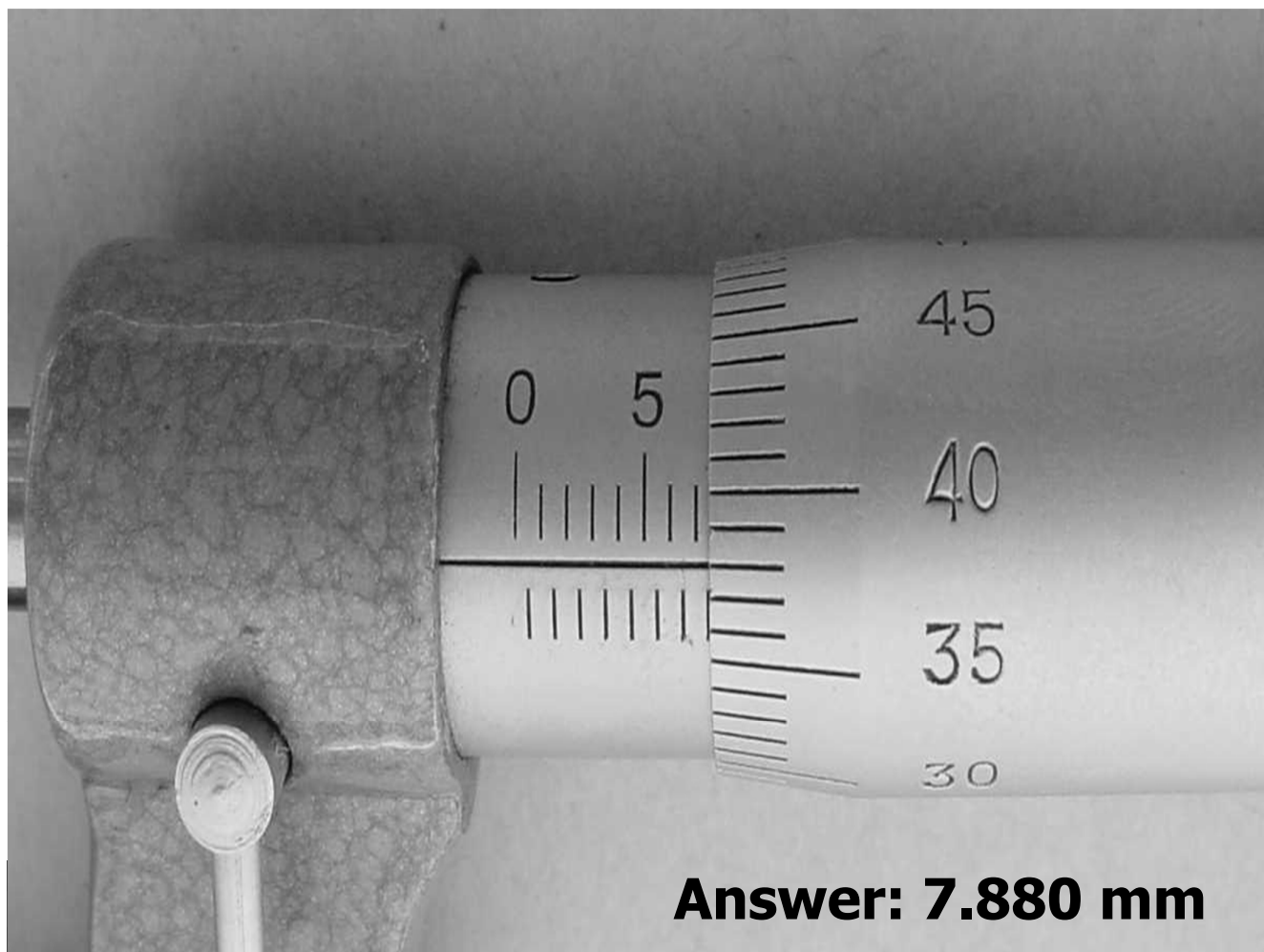
- If we give the thimble one complete further rotation, we end up with the micrometer as shown above.
- Now the distance is 0.120 mm greater than 8.500 mm, so the distance is **8.620 mm**.

Micrometer



- Finally, if we turn the thimble a tiny bit further, it might end up like the figure above.
- Now the distance is greater than 8.620 mm, but clearly less than 8.630 mm. We might estimate this reading to be **8.624 mm**.





Micrometer

Mass Measurements

Mass: (kg)

Kg = 1000 g.

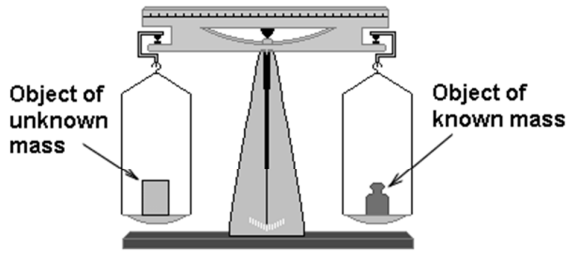
Ton = 1000 kg.

lb = 0.4536 kg

lb = 12 ounce

Slug = 14.6 kg

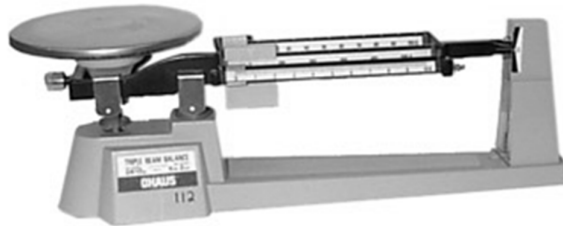
Mass Measurements



**Electronic
Mass Balance**



Triple Beam Balance



**Lever
Balance**



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Time Measurements

Time: (sec)

hr = 60 min.

min = 60 sec.



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Thank You