SI Physics - Full Discipline Demo

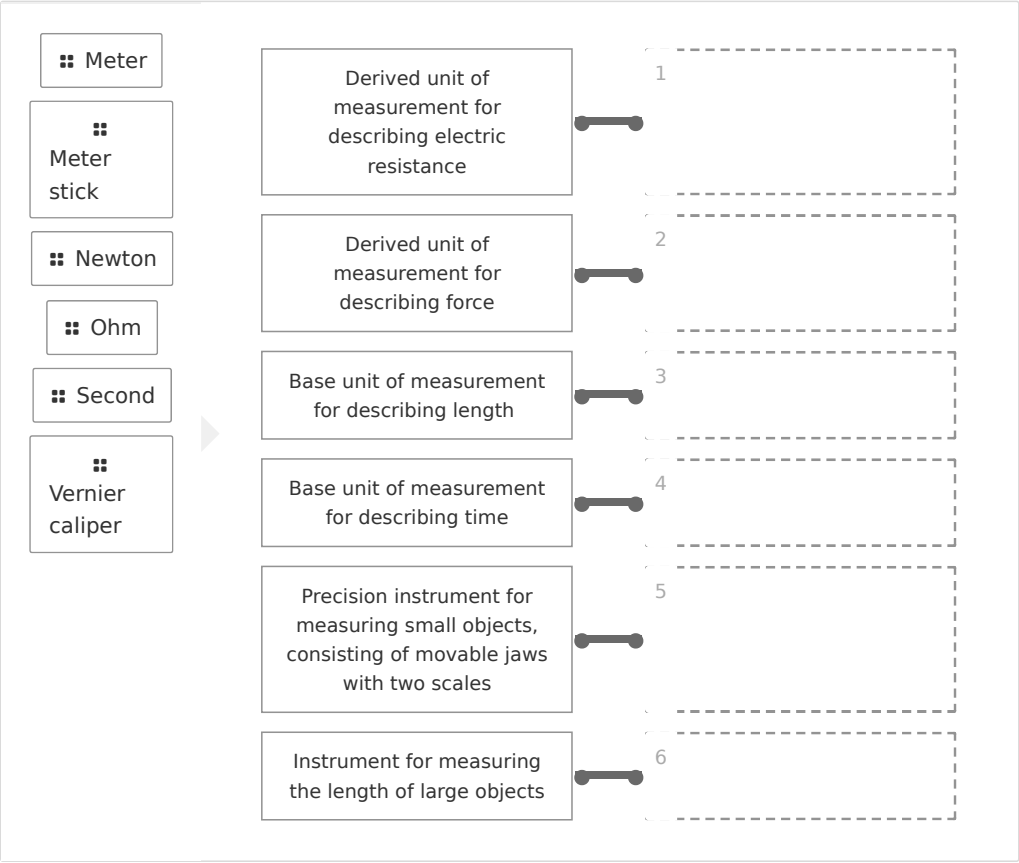
Measurement Techniques

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Physics - Full Discipline Demo
Course	SI Physics - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Match each term with the best description.



Correct answers:

1 Ohm 2 Newton 3 Meter 4 Second 5 Vernier caliper

6 Meter stick

Typesetting math: 100%

Identify each statement as true or false.

- Density is the ratio of the mass of an object to the volume it occupies.
- Density varies with the mass of an object.
- The height and radius of a cylinder must be known before calculating its volume.
- The units for expressing volume are m^2.

True	False
1	2

Correct answers:

1

The height and radius of a cylinder must be known before calculating its volume.

Density is the ratio of the mass of an object to the volume it occupies.

2 The units for expressing volume are m^2.

Density varies with the mass of an object.

Exploration

The _____ is an example of a base unit of measurement associated with a physical object.

- meter
- kilogram
- second
- All of the above ✔

Typesetting math: 100%

The ____ of the Vernier caliper is/are used to measure the exterior diameters and lengths of small objects.

- depth probe
- inner jaws
- outer jaws ✔
- All of the above

Multiple trials should be conducted when measuring objects with Vernier calipers in order to reduce random error.

- True ✔
- False

$V = \frac{4}{3}\pi r^3$ **is used to calculate the volume of a ____.**

- cube
- cylinder
- sphere ✔
- All of the above

The density of an object can be used to determine its composition.

- True ✔
- False

Exercise 1

Which of the quantities recorded in Data Tables 4 and 5 are base measures and which are derived measurements? Explain your answer.

Typesetting math: 100%

Length and mass are basic measurements recorded in the data tables. Volume and density are derived measurements recorded in Data Table 5 because they are computed from basic measurements.

Explain least count and zero error. Why were these computed before any measurements were taken with the Vernier calipers?

The least count is the smallest quantity that can be resolved by the calipers. The zero error refers to the degree of misalignment between the fixed and Vernier scales when the jaws of the calipers are closed. The least count must be calculated before measurements are taken because it determines the value of each mark on the Vernier scale. The zero error must be calculated initially because it relates how measurements taken with the device differs from the actual length of the object.

Why were multiple trials performed when measuring the marble and density cylinder? Use Data Tables 2, 3, and 4 to support your answer.

Multiple trials were performed to reduce random error. As noted in Data Tables 2, 3 and 4, slight variations existed in each of the measurements due to how firmly the calipers were closed and variation in determining the Vernier coincidence.

What are the material compositions of the marble and the density cylinder? Use Data Table 5 and Table 3 to explain your answer.

The marble is composed of glass, and the density cylinder is composed of acrylic. The density of the marble in Data Table 5 was calculated as 2.766 g/cm^3 and the reported density of glass in Table 3 is 2.70 g/cm^3. The density of the cylinder in Data Table 5 was calculated as 1.229 g/cm^3 and the reported density of acrylic in Table 3 is 1.18 g/cm3.

What is the height of a solid cylinder with a mass of 26.05 g, a diameter of 3.56 cm, and a density of 2.72 g/cm^3? Show all calculations in your answer.

$$V = \frac{m}{\rho}$$

$$V = \frac{26.05\ \text{g}}{2.72\ \text{g/cm}^3}$$

$$V = 9.58\ \text{cm}^3$$

$$V_{cylinder} = \pi r^2 h$$

$$h = \frac{9.58\ \text{cm}^3}{\pi(1.78\ \text{cm})^2}$$

$$h = 0.962\ \text{cm}$$

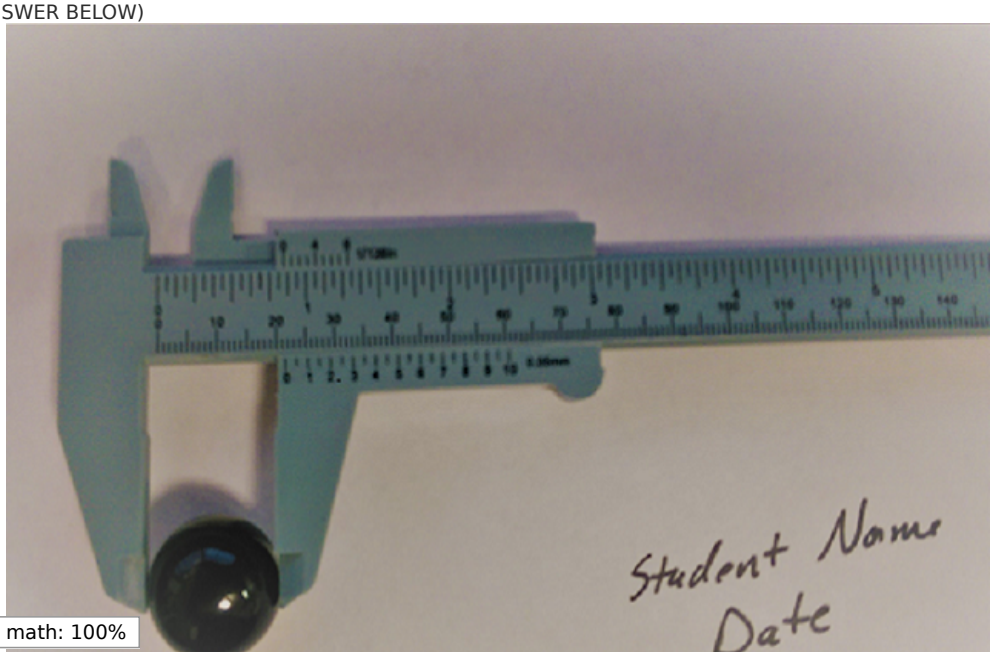
Data Table 1: Least Count and Zero Error of Vernier Calipers

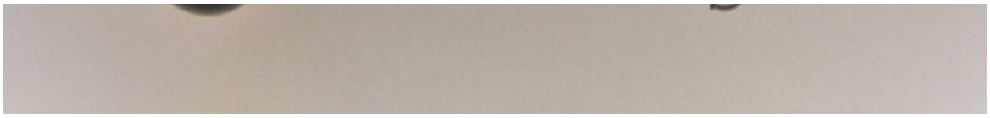
(SAMPLE ANSWER BELOW)

S (mm)	N	LC (mm)	ZE (mm)
1	20	0.05	0.00

Photo 1: Calipers Measuring Marble

(SAMPLE ANSWER BELOW)





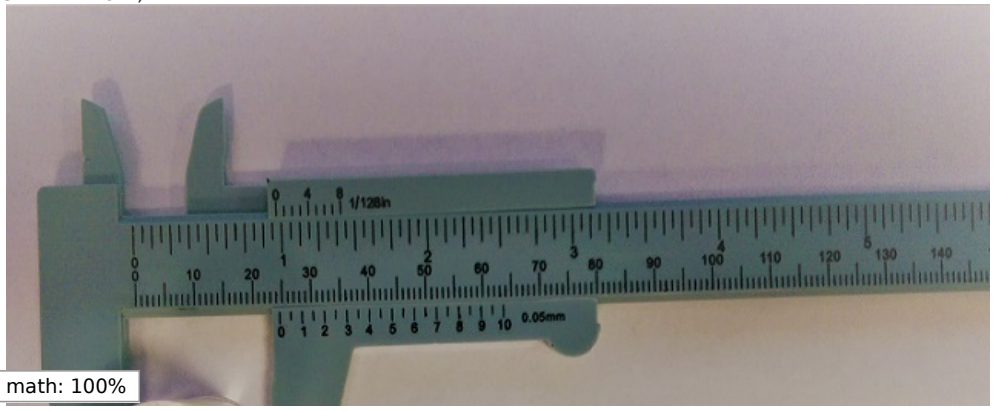
Data Table 2: Diameter of a Sphere

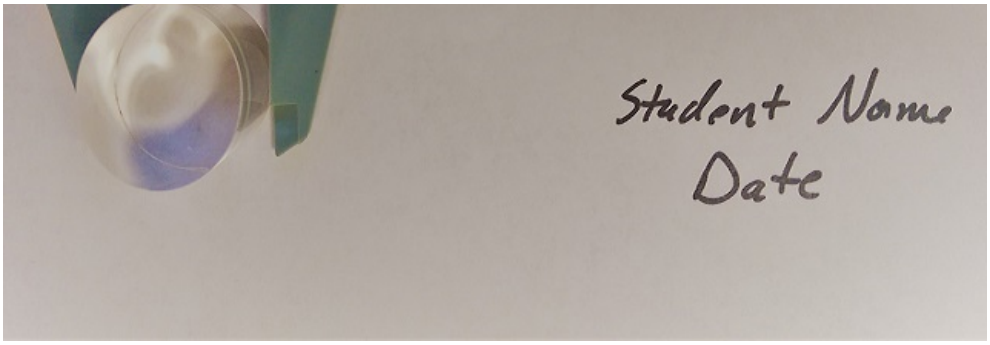
(SAMPLE ANSWER BELOW)

Trial	Main Scale (mm)	Vernier Coincidence	Diameter of Marble (mm)	Mean Diameter (cm)
1	21	15	21.75	2.185
2	21	15	21.75	
3	22	4	22.20	
4	21	14	21.70	

Photo 2: Calipers Measuring Diameter of Solid Cylinder

(SAMPLE ANSWER BELOW)





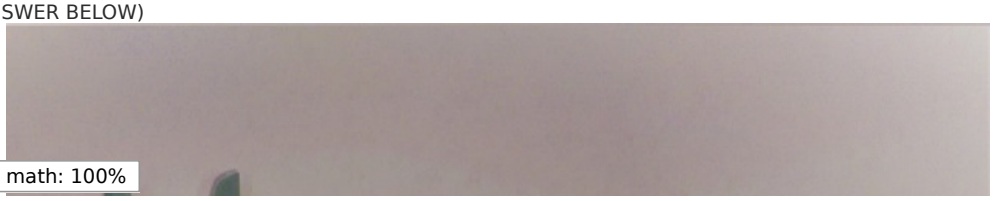
Data Table 3: Diameter of Solid Cylinder

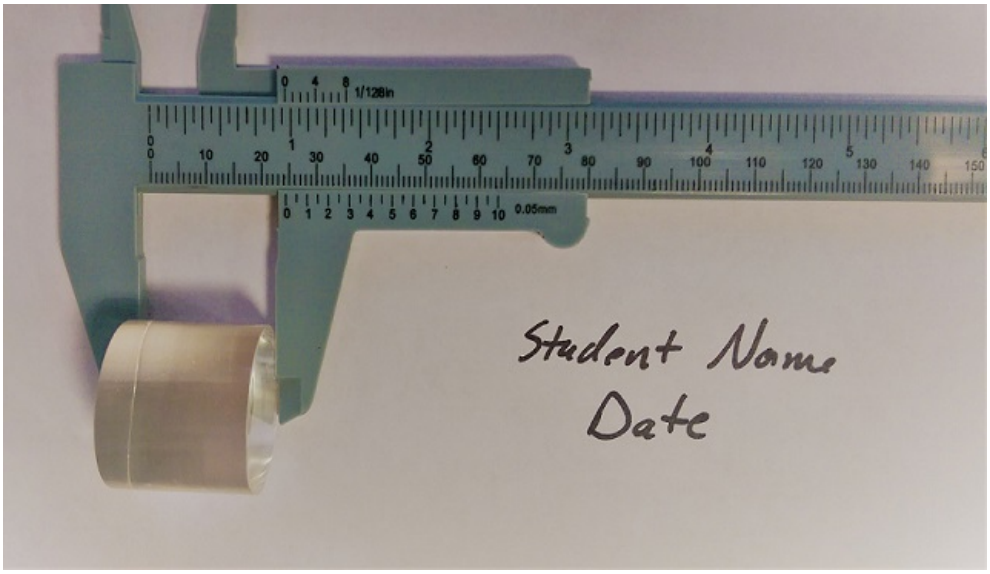
(SAMPLE ANSWER BELOW)

Trial	Main Scale (mm)	Vernier Coincidence	Diameter of Cylinder (mm)	Mean Diameter (cm)
1	24	13	24.65	2.464
2	24	12	24.60	
3	24	12	24.60	
4	24	14	24.70	

Photo 3: Calipers Measuring Height of Solid Cylinder

(SAMPLE ANSWER BELOW)





Data Table 4: Height of Solid Cylinder

(SAMPLE ANSWER BELOW)

Trial	Main Scale (mm)	Vernier Coincidence	Height of Cylinder (mm)	Mean height (cm)
1	24	16	24.80	2.480
2	24	16	24.80	
3	24	13	24.65	
4	24	19	24.95	

Data Table 5: Volume, Mass, and Density of Marble and Solid Cylinder
(SAMPLE ANSWER BELOW)

Object	Volume (cm^3)	Mass (g)	Density (g/cm^3)
Marble	5.462	15.11	2.766
Cylinder	11.826	14.53	1.229

Competency Review

Volume, density, and pressure are measured quantities of an object expressed with basic units.

- True
- False ✔

The divisions on the ____ scale of Vernier calipers indicate the smallest quantity that can be resolved by the instrument.

- fixed
- main
- Vernier ✔
- All of the above

Typical Vernier calipers consist of a _____ for measuring small objects.

- depth probe
- pair of inner jaws
- pair of outer jaws
- All of the above ✔

The volume of a solid object is calculated from measurements of its outer dimensions.

- True ✔
- False

Typesetting math: 100%

The volume of a sphere can be calculated using the formula ____.

- $V = a^3$
- $V = \frac{4}{3}\pi r^3$ ✔
- $V = \pi r^2 h$
- All of the above

Density is a calculated measure of the ratio of the ____ of an object to the volume it occupies.

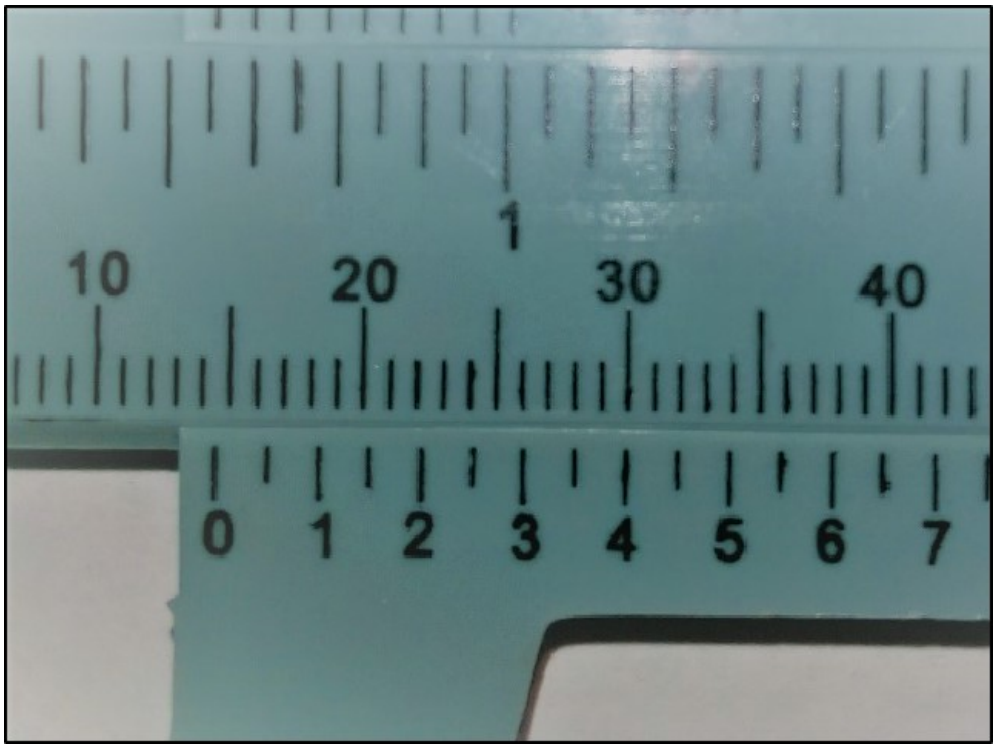
- mass ✔
- charge
- temperature
- All of the above

A Vernier calipers has a main scale with the smallest division of 1 mm and a Vernier scale with 20 marks. The least count is ____.

- 0.05 mm ✔
- 0.01 mm
- 0.50 mm
- 0.10 mm

Typesetting math: 100%

The Vernier coincidence in the photo indicates a length of ____.



- 10.35 mm
- 13.00 mm
- 14.30 mm ✔
- 15.35 mm

A solid cylinder has a height of 3.65 cm and a diameter of 3.28 cm. The volume of the cylinder is ____.

- 30.8 cm^2
- 30.8 cm^3 ✔
- 123 cm^3
- 123 g/ cm^3

Typesetting math: 100%

A solid sphere of unknown, uniform composition has a mass of 27.35 g and a volume of 10.13 cm^3. The densities of potential materials for composing the sphere are provided in the table. The sphere is most likely composed of ____.

Material	Density (g/cm^3)
Acrylic	1.18
Brass	8.55
Copper	8.94
Glass	2.70
Lead	11.34
Steel	8.05
Wood, Oak	0.77
Wood, Pine	0.48

- glass ✔
- acrylic
- lead
- steel

Extension Questions

The volume of a hollow cylinder is calculated with the formula $V = \pi h \left(R^2 - r^2\right)$ where: h = height, R = radius of the outer surface, and r = radius of the inner surface. Describe how a small, hollow cylinder would be measured using calipers to determine h, R, and r. (SAMPLE ANSWER BELOW)

The height could be measured by either tightening the outer jaws of the calipers over each end of the cylinder, or by placing the cylinder upright and inserting the depth probe. R should be measured with the outer jaws of the calipers, just as when measuring the diameter of a solid cylinder, and then dividing by 2 to find the radius. The inner radius, r, should be determine by measuring the inner diameter with the inner jaws of the calipers and then dividing this value by 2.