

Experiment 3

The Slide Rule

Reading Analog Scales and Performing Calculations

Objectives

In this experiment you will learn to

- read values from nonuniform analog scales;
- estimate values between marked divisions;
- use a slide rule for multiplication and division;
- determine squares, square roots, cubes, and cube roots;
- use the reciprocal, logarithm, sine, and tangent scales;
- determine the proper decimal point by estimation; and
- report answers with a reasonable number of significant figures.

Equipment

- Sterling slide rule with scales $A, B, C, CI, D, K, S, L, T$
- Pencil
- This laboratory sheet

Group Work and Individual Reports

Work in groups of approximately four or five students. You are encouraged to help one another learn how to operate the slide rule. However, **each student must make his or her own scale readings, perform the calculations, and submit an individual laboratory report.**

Introduction

Before electronic calculators became common, scientists and engineers routinely performed numerical calculations with slide rules. A slide rule does not perform arithmetic by counting. Its principal scales are logarithmic, so multiplication and division can be performed by adding and subtracting distances along the scales.

A slide rule is also an excellent exercise in reading an analog instrument. Unlike a digital display, an analog scale normally requires the observer to determine the value of the marked divisions and then estimate between them.

The Sterling slide rule used in this experiment has the following scales:

Scale	Principal use
A, B	Squares and square roots
C, D	Multiplication and division
CI	Reciprocals and convenient multiplication/division
K	Cubes and cube roots
S	Sines
L	Common logarithms
T	Tangents

The transparent movable window is the **cursor**. The line on the cursor is called the **hairline**. The movable center portion is the **slide**; the stationary portion is the **body** or **stock**.

Part I: Reading an Analog Scale

Examine the D scale. Notice that the numbered marks are **not equally spaced**. The distance from 1 to 2 is much greater than the distance from 8 to 9 because the scale is logarithmic.

The value of the smallest marked division also changes along the scale. Therefore, before reading a value, first determine what the nearby divisions represent.

Move the cursor to each position assigned by your instructor. Read the value indicated by the hairline as accurately as the scale permits.

Reading	Value on D scale
1	
2	
3	
4	
5	

Question 1. Why can you not assume that every small division on the D scale has the same numerical value?

Question 2. If the hairline falls between two marked divisions, what should you do?

Part II: Multiplication with the C and D Scales

To multiply $a \times b$:

1. Find a on the D scale.
2. Move the slide so that the left index (1) of the C scale is directly above a .
3. Move the cursor to b on the C scale.
4. Read the product on the D scale beneath the hairline.

If b lies beyond the end of the D scale, use the **right index** (10) of the C scale instead.

The slide rule generally does **not** determine the decimal point. You must estimate the size of the answer mentally.

Use the slide rule to calculate:

Calculation	Slide-rule result	Estimated order of magnitude
2.37×4.16		
6.42×1.73		
23.7×4.16		
0.0642×173		

Question 3. Compare the first and third calculations. Why are the slide-rule settings essentially the same even though the answers differ by a factor of ten?

Part III: Division

To divide a/b :

1. Find a on the D scale.
2. Move b on the C scale directly above a .
3. Read the answer on the D scale beneath whichever index of C lies on the D scale.
4. Determine the decimal point by estimation.

Calculation	Slide-rule result
$8.35/2.17$	
$14.6/3.72$	
$0.638/4.25$	
$572/8.64$	

Part IV: Reciprocals — the CI Scale

The CI scale is the inverse of the C scale and runs in the opposite direction. Use the C and CI scales to find:

Quantity	Slide-rule result
$1/2.5$	
$1/4.0$	
$1/7.5$	

Part V: Squares and Square Roots — the A and D Scales

The A scale consists of two logarithmic cycles placed end to end. Numbers on A correspond to the squares of numbers directly below them on D .

To square a number, place the cursor on the number on D and read its square on A . To find a square root, locate the number on the appropriate half of A and read the square root on D .

Quantity	Slide-rule result
3.25^2	
7.40^2	
$\sqrt{2.00}$	
$\sqrt{37.5}$	

Part VI: Cubes and Cube Roots — the K Scale

The K scale contains three logarithmic cycles and is used with the D scale for cubes and cube roots.

Quantity	Slide-rule result
2.50^3	
$\sqrt[3]{8.00}$	
$\sqrt[3]{50.0}$	

Part VII: Common Logarithms — the L Scale

Remove the slide and reverse it so that the S, L, T scales are visible. The L scale gives the fractional part (mantissa) of the common logarithm corresponding to the position on the logarithmic scale.

Quantity	Slide-rule result
$\log_{10}(2.0)$	
$\log_{10}(5.0)$	
$\log_{10}(8.0)$	

Part VIII: Trigonometric Functions — the S and T Scales

The S scale is used to find sines, and the T scale is used to find tangents. Angles are read in degrees.

Quantity	Slide-rule result
$\sin 30^\circ$	
$\sin 45^\circ$	
$\sin 60^\circ$	
$\tan 30^\circ$	
$\tan 45^\circ$	

Part IX: Physics Applications

Use the slide rule for all numerical calculations.

- 1. Density.** A metal sample has mass $m = 47.3$ g and volume $V = 6.12$ cm³. Calculate its density.

$$\rho = \frac{m}{V} = \text{_____ g/cm}^3$$

- 2. Constant acceleration.** A toy car travels $x = 0.850$ m from rest in $t = 1.63$ s. Using

$$a = \frac{2x}{t^2},$$

find its acceleration.

$$a = \underline{\hspace{2cm}} \text{ m/s}^2$$

3. Vector components. A force of magnitude $F = 37.5 \text{ N}$ acts at an angle of 32.0° above the $+x$ -axis. Find its rectangular components.

$$F_x = F \cos \theta = \underline{\hspace{2cm}} \text{ N}$$

$$F_y = F \sin \theta = \underline{\hspace{2cm}} \text{ N}$$

Questions

4. A calculator displays many digits. Why would it usually be inappropriate to report six or eight significant figures from a measurement made with a slide rule?

5. What skill is required to place the decimal point correctly in a slide-rule answer?

6. What did you find most difficult about reading the analog scales on the slide rule?

7. Give one other laboratory instrument in which the user must read a scale and estimate between marked divisions.

Conclusion

In one or two sentences, describe what using a slide rule teaches that is less obvious when using a digital calculator.
