VIRGINIA PENINSULA®
COMMUNITY COLLEGE

College Physics I Laboratory Manual

A modern guide to experimental reasoning at VPCC

Why This Manual Exists

- Physics is an experimental science
- Students need structured support to learn evidence-based reasoning
- Manual designed to teach how physicists think, not how to plug numbers

Goals of the Laboratory Course

By the end of this course, you should be able to:

- Make careful and honest physical measurements
- Recognize and interpret experimental uncertainty
- Use graphs and models to extract physical meaning from data
- Explain experimental results clearly in words and diagrams
- Identify limitations of models and measurements
- Revise experimental approaches when evidence is unclear

The goal of laboratory work is experimental reasoning, not numerical perfection.

Core Philosophy

- Real data → real variation
- Uncertainty is information
- Models are tools, not answers
- Reasoning outweighs calculation

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What Makes This Manual Different

- Not a “recipe book”
- Prompts emphasize interpretation
- Students learn to justify choices, not follow steps
- Reflection built into every lab

Each lab contains:

- a clear explanation of why the experiment matters,
- structured tasks and checkpoints,
- prompts that guide interpretation rather than rote calculation,
- and reflection questions that support learning.

These features are intentional. They are meant to slow you down, focus your attention on reasoning, and make experimental thinking visible.

Structure of the Manual

- Front matter: expectations, goals, safety
- Ten labs + two practicals
- Integrative revision module
- Seven appendices

The Role of the Appendices

The appendices are an essential part of this manual, not optional reference material.

They provide guidance on:

- measurement and uncertainty (Appendix A),
- statistical reasoning (Appendix B),
- graphs, slopes, intercepts, and units (Appendix C),
- linearization and model testing (Appendix D),
- scientific communication (Appendix E),
- and the appropriate use of PASCO Capstone software (Appendix F).

You are expected to refer to the appendices throughout the course.

The Idea Behind the Labs

- Labs gradually reduce procedural guidance
- Students transition from "guided tasks" → "independent experimental design"
- Emphasis on thinking like a physicist

How to Decide What Goes in a Table

A data table should answer this question:

What quantities did we measure or determine, and how do they relate to each other?

For this lab:

- Each row represents one measurement.
- Each column represents one quantity.

Start with a column labeled:

- Measured Length (units)

Record every individual measurement in this column.

When to Add a Column

You add a new column when you:

- calculate a new quantity from measured data,
- want to compare two quantities row-by-row,
- or need to make your reasoning visible.

Execution: How Labs Are Built

- Each lab includes:
  - Why the experiment matters
  - Structured tasks and checkpoints
  - Prompts that slow students down
  - Reflection questions
- Appendices provide the “how” without cluttering the lab narrative

Why This Lab Matters

Physics is an experimental science. Every experimental result begins with a measurement, and every measurement involves some uncertainty.

In this laboratory you will not only measure a length, but also learn how physicists:

- read measuring instruments,
- record data honestly,
- expect and interpret variation,
- and decide what result to report.

This lab sets the standards and habits that will be used throughout the semester.
How carefully you learn these skills now will matter later, when experiments become more complex.

Example: Lab 1 (Measurement)

- Teaches foundational habits
- Students learn:
  - Estimated digits
  - Repetition
  - Honest data recording
  - Statistical meaning
- Sets tone for the entire course

Part A — Learning to Read a Measuring Device

Before measuring anything, examine the measuring instrument you are using (meter stick or ruler).

1. Identify the smallest marked division on the scale.
2. Decide which digits can be read directly from the markings.
3. Decide which digit must be estimated.

Important idea

Every physical measurement contains one estimated digit. That estimate is not a guess — it is a reasonable judgment made between marks on the scale.

If two careful people report slightly different last digits, both can be correct.

Checkpoint (discuss with your group):
Which digit in your measurement will be estimated, and why?

Example: Lab 2 (Motion)

- Students choose representations
- Graphs become arguments
- Reduced procedural guidance
- Focus on model justification

What You Are Learning

By the end of this lab, you should be able to:

- Record motion data using electronic sensors
- Organize data effectively in tables and graphs
- Interpret slopes of graphs as physical quantities
- Decide which graphical representation best answers a given question

Explain differences between measurements using experimental reasoning

Example: Lab 3 (Projectile Motion)

- Students must:
  - Predict before measuring
  - Determine launch speed experimentally
  - Compare prediction vs measurement
- Teaches model assumptions and limitations

What You Are Learning

By the end of this lab, you should be able to:

- Design a method to measure an unknown quantity experimentally
- Use measured quantities to make a quantitative prediction
- Test that prediction using experimental data
- Evaluate agreement and disagreement using uncertainty and model assumptions
- Explain results clearly using evidence, not just equations

Practical Assessments

- Practical 1: foundations of measurement, graphing, uncertainty
- Practical 2: design, revise, and communicate an experiment
- Evaluates reasoning, not memorization

Purpose of Practical 1

Practical 1 is an opportunity for you to demonstrate the experimental skills you have developed in the first part of the course. This practical does not test how fast you can calculate or how well you can memorize formulas. Instead, it assesses your ability to:

- make careful measurements,
- interpret data using graphs,
- reason about uncertainty,
- and explain results clearly in words.

These are the core skills used by experimental physicists and are more important than arriving at a single “correct” number.

Benefits for Students

- Builds scientific habits early
- Encourages independence and confidence
- Reduces fear of “wrong answers”
- Supports transfer to later STEM courses
- Makes experimental thinking visible

Benefits for Instructors

- Clear expectations reduce confusion
- Appendices standardize reasoning across sections
- Labs encourage meaningful discussion
- Students arrive better prepared for advanced work

Potential Difficulties

- Students unused to open-ended tasks may feel uncertain
- Requires consistent reinforcement of expectations
- Some may resist writing explanations instead of equations
- Data variation may challenge students who expect perfection

Interested?

- This manual builds experimental thinkers. It teaches students not just what physics is, but how physicists know. A modern, evidence-centered approach to laboratory learning.

If interested to get a copy, please contact me at KuchinaE@VPCC.edu