

Scholars High School Physics: Foundations is a high-school-level course that does not assume specific physics experience. It is more advanced than our Middle School Physics courses but does not assume them as prerequisites.

The course focuses on the tools and language that physicists use to describe natural phenomena. This includes making measurements, analyzing data, building mathematical models, and testing those models against experimental results. We will model phenomena mathematically using algebra, and students should be ready to create and interpret graphs and simple diagrams as well. The course introduces many different phenomena, from elementary examples like levers and ramps to modern topics like the Kibble balance and gravitational lensing. The focus throughout is on the scientific process. After this course, students will be ready for courses focused on a systematic introduction to specific physics theories such as mechanics and electromagnetism.

This course is aimed at students with broad curiosity and a willingness to learn challenging new material, and is more difficult than a typical introductory physics course. Students will examine modern topics such as exoplanet detection, DNA wrapping in the nucleus, and sustainable energy, often using data published by professional scientists. We also study historical debates to learn about the nature of progress in physics.

Textbook(s): Scholars High School Physics: Foundations does not have a required textbook.

Sample Problems:

- ▶ Benjamin Franklin conducted an experiment in which he found that one teaspoon of oil, when poured out onto a pond, spread out to cover an area of half an acre over the surface of the water. Franklin assumed this layer was exactly one molecule thick. Franklin used the thickness of the layer to estimate the size of a molecule. What size did he come up with?
- ▶ If a pendulum clock on Earth keeps perfect time, will it run fast or slow on Mars, where $g \approx 3.72 \text{ m/s}^2$? By what factor?
- ▶ For each expression below, if each variable represents a length, decide whether the entire expression represents a length, an area, or a volume, and explain why.

$$\sqrt{abc(a + b + c)}$$

$$\frac{8\pi}{d} (r_1^3 - r_2^3)$$

$$\pi(R + r)\sqrt{(R - r)^2 + h^2}$$

- ▶ An approximation for the terminal velocity of a falling object is $v_{\text{terminal}} \approx \sqrt{\frac{2mg}{\rho A}}$. Find a similar equation for the distance an object falls before reaching terminal velocity.

Time Commitment: This 12-week course includes 1.5 in-class hours and 4-5 hours of homework and reading each week.

Grading: 64% short answer challenge problems, 32% writing problems that will get detailed feedback from a human grader, and 4% class participation.

Content:

Lesson	Scholars Topic
1	Designing Experiments
2	Measurement
3	Communication in Physics
4	Uncertainty
5	Working with Equations
6	Building and Using Models
7	Problem Solving
8	Estimation
9	Working with Graphs
10	Analyzing Nonlinear Data
11	Thought Experiments
12	Conservation Laws

Materials:

This course involves home experiments. Students should have access to the following materials at home. During class time, students only need a calculator, paper, and pen or pencil, except in lesson 9, during which they also need a ruler and graph paper during class.

- a stiff ruler (one that flexes some is fine, but it shouldn't be floppy)
- 10 or more sheets of graph paper
- coffee filters OR notebook paper and tape
- a way to draw circles several inches in diameter (e.g. a compass or a circular lid to trace)
- a scientific calculator (a graphing calculator is okay, but not required)
- a sturdy, large cardboard box and a stack of books, or other objects to build a simple ramp
- a stopwatch (a cell phone app is fine)
- a toy car, ball, or other object that rolls easily
- thin string, such as sewing thread or twine
- scissors
- rubber bands (any size)