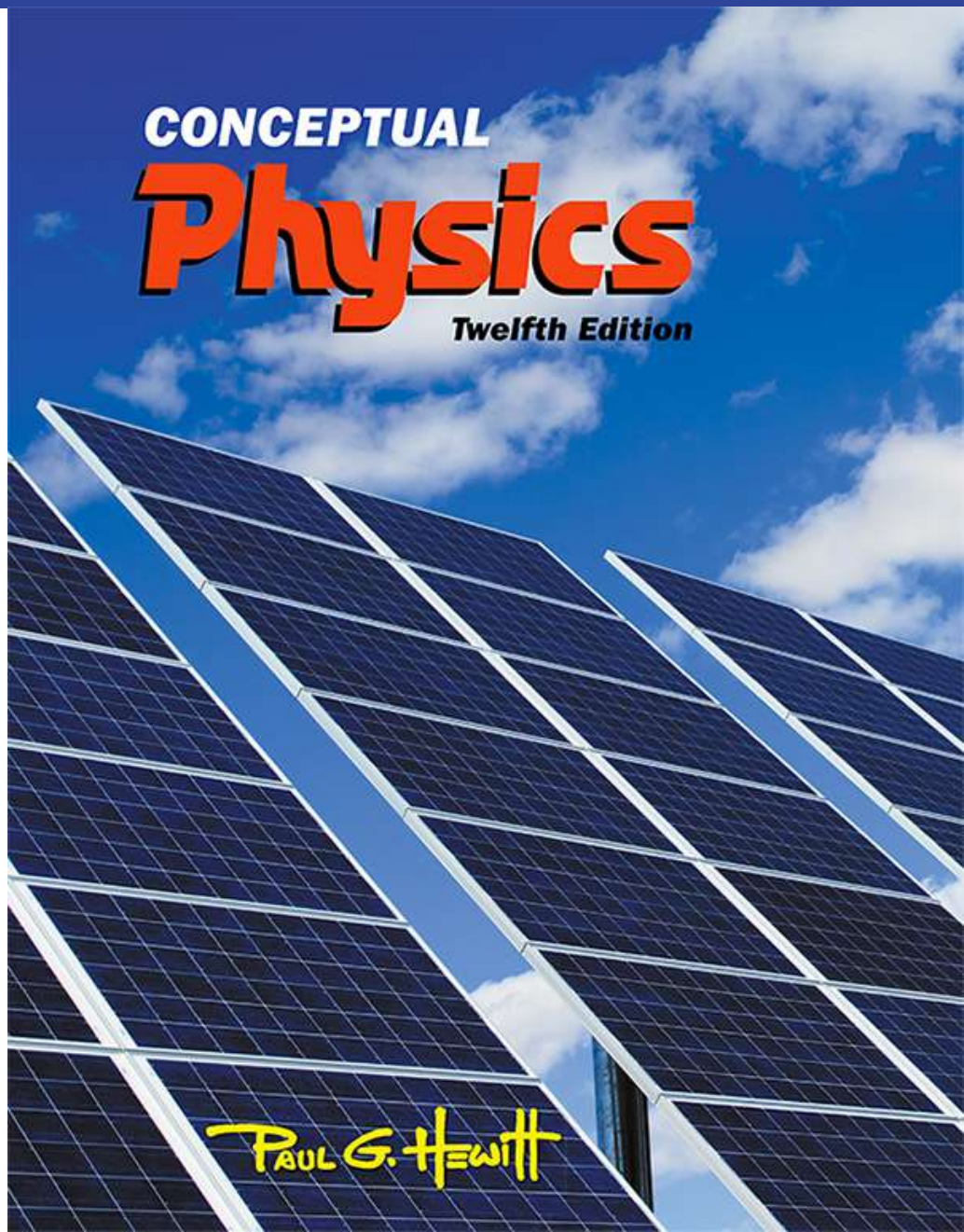
Lecture Outline

Chapter 1: About Science



This lecture will help you understand:

- What Science Is
- Scientific Measurements
- Mathematics—The Language of Science
- Scientific Methods
- The Scientific Attitude
- Science, Art, and Religion
- Science and Technology
- Physics—The Basic Science

What Science Is

- Science
  - is a body of knowledge.
  - is an ongoing human activity.
  - has beginnings that precede recorded history.

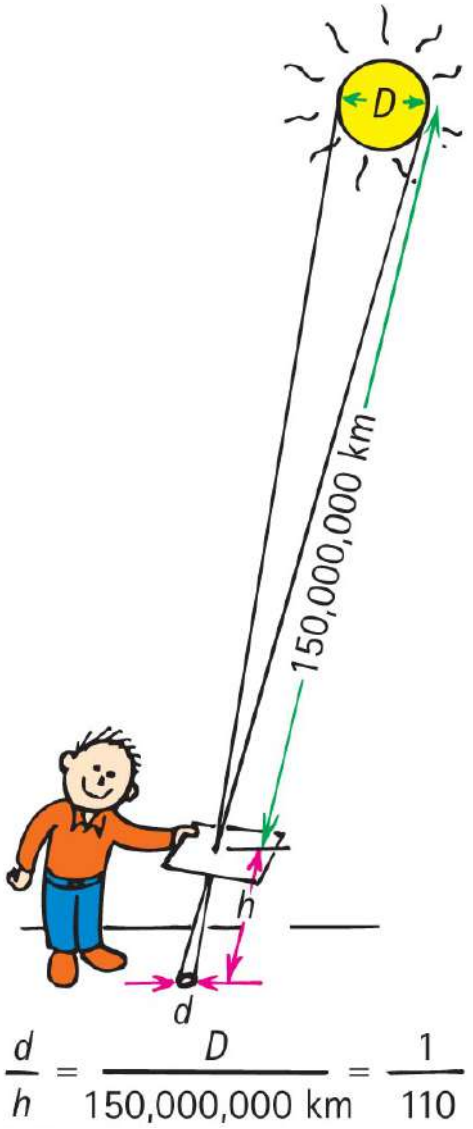
Scientific Measurements

- Measurements are a hallmark of good science.
- "I often say that when you can measure something and express it in numbers, you know something about it. When you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind. It may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the stage of science, whatever it may be."

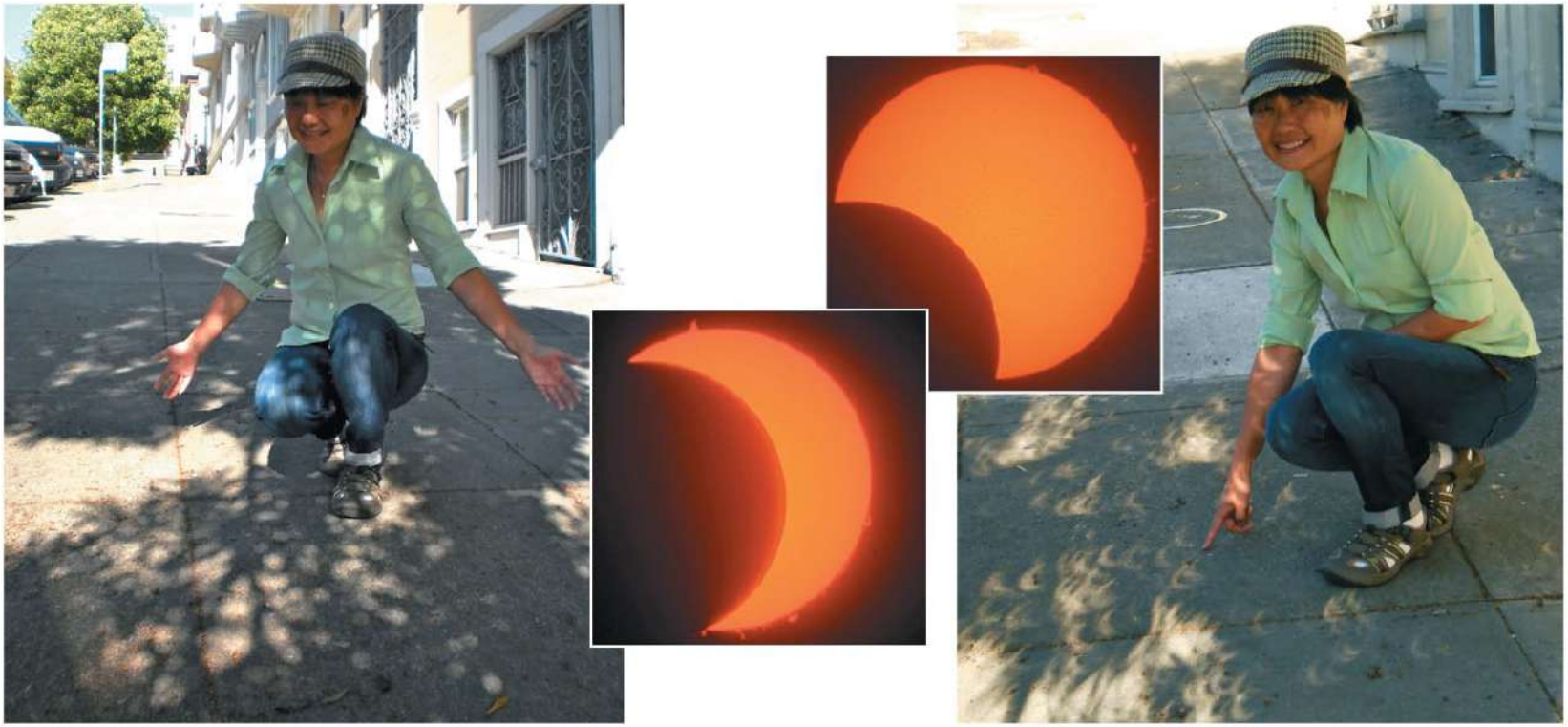
—Lord Kelvin

Scientific Measurements, Continued

- Measurements
  - relate to how much you know about something.
  - of pinhole images of the Sun nicely lead to a calculation of the Sun's diameter.



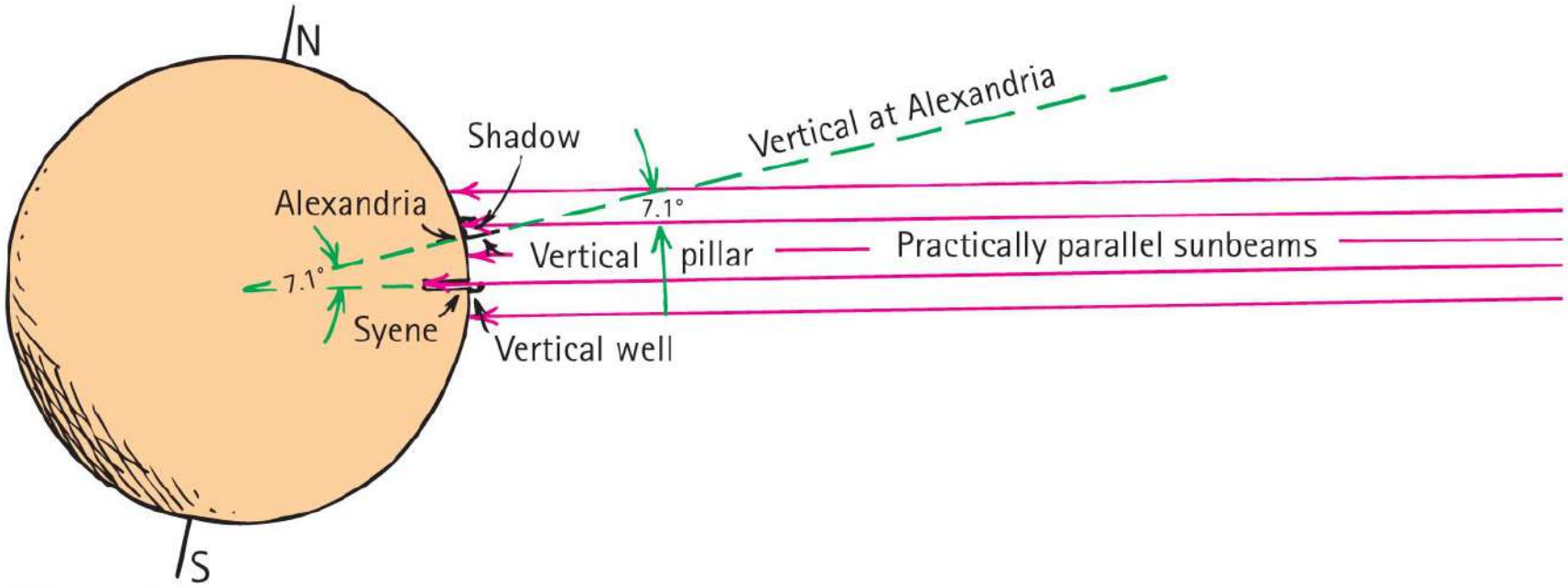
Scientific Measurements, Continued-1



- These round images of the Sun are crescent shaped during a partial solar eclipse.

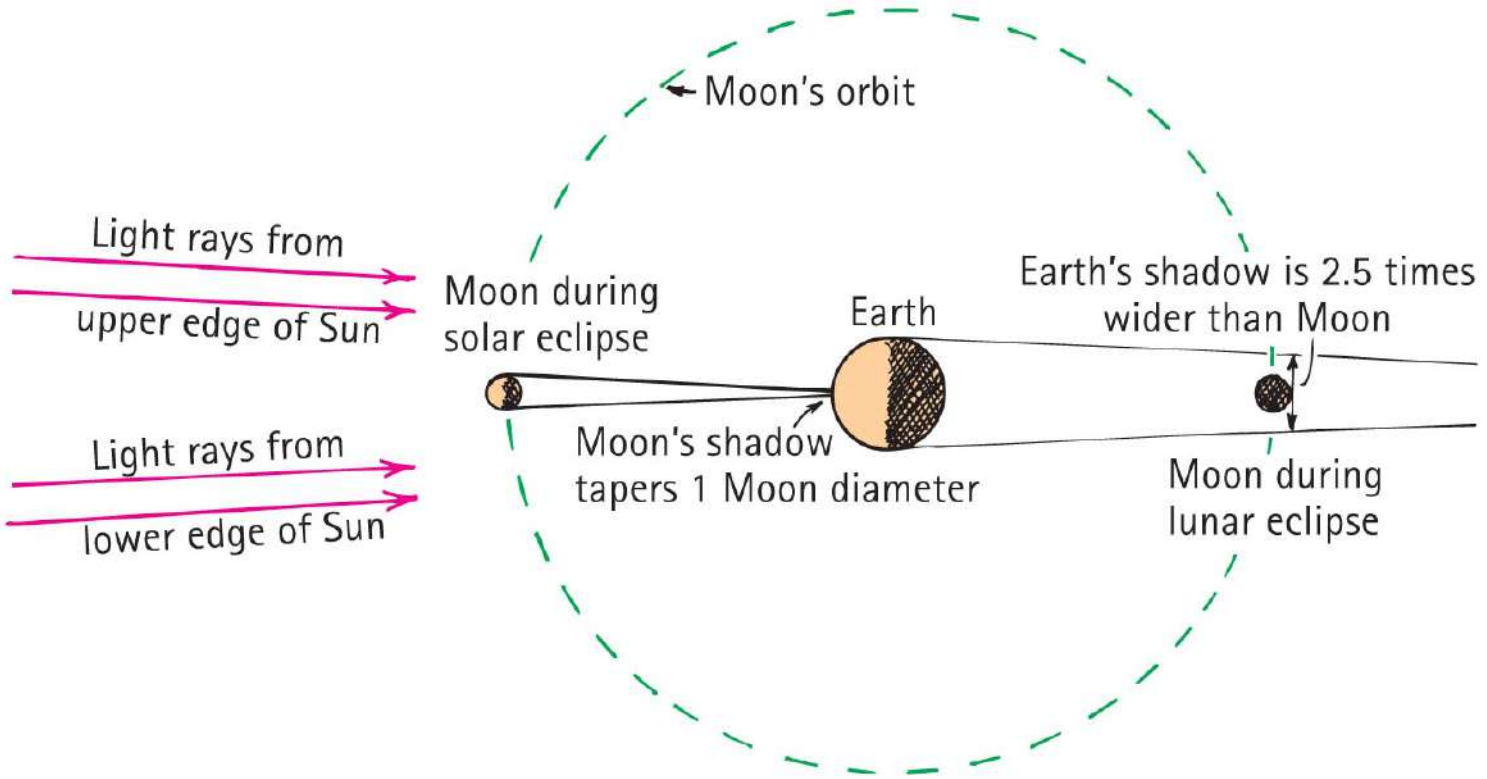
Some Early Scientific Measurements

- Eratosthenes—Diameter of Earth



Some Early Scientific Measurements, Continued

- Aristarchus—Distance and Size of the Moon



Mathematics—The Language of Science

- Integration of science and mathematics
  - Occurred some four centuries ago.
  - Ideas of science are unambiguous when expressed in mathematical terms.
  - Equations of science provide expressions of relationships between concepts
  - Equations are "guides to thinking."

Scientific Methods

- There is no *one* scientific method.
- In general, scientific methods refer to principles and procedures for the systematic pursuit of knowledge involving the recognition and formulation of a problem, the collection of data through observation and experiment, and the formulation and testing of hypotheses.

Scientific Methods—Common Steps

1. Recognize a question, a puzzle, or an unexplained fact.
2. Make a hypothesis (educated guess) to resolve the puzzle.
3. Predict consequences of the hypothesis.
4. Perform experiments or make calculations to test the predictions.
5. Formulate the simplest general rule that organizes the three main steps.

The Scientific Attitude

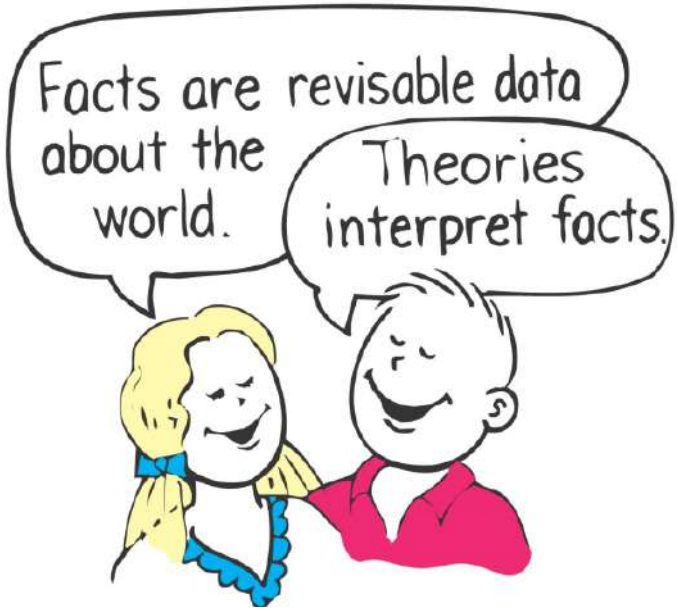
- The scientific attitude is one of
  - inquiry.
  - experimentation.
  - willingness to admit error.

The Scientific Attitude, Continued

- Scientists
  - are experts at changing their minds.
  - must accept experimental findings
    - test for erroneous beliefs
    - understand objections and positions of antagonists.

The Scientific Attitude, Continued-1

- **Fact** is a close agreement by competent observers who make a series of observations about the same phenomenon.
- A scientific **hypothesis** is an educated guess that is only presumed to be factual until supported by experiment.



The Scientific Attitude
CHECK YOUR NEIGHBOR

Which of these is a scientific **hypothesis**?

A. The Moon is made of green cheese.
B. Atomic nuclei are the smallest particles in nature.
C. A magnet will pick up a copper penny.
D. Cosmic rays cannot penetrate the thickness of your *Conceptual Physics* textbook.

The Scientific Attitude
CHECK YOUR ANSWER

Which of these is a scientific **hypothesis**?

A. **The Moon is made of green cheese.**
B. **Atomic nuclei are the smallest particles in nature.**
C. **A magnet will pick up a copper penny.**
D. **Cosmic rays cannot penetrate the thickness of your *Conceptual Physics* textbook.**

Explanation:
All are scientific hypotheses!
All have tests for proving wrongness, so they pass the test of being a scientific hypothesis.

The Scientific Attitude
CHECK YOUR NEIGHBOR, Continued

Which of these is *not* a scientific **hypothesis**?

A. Protons carry an electric charge.
B. Undetectable particles are some of nature's secrets.
C. Charged particles bend when in a magnetic field.
D. All of the above are scientific hypotheses.

The Scientific Attitude
CHECK YOUR ANSWER, Continued

Which of these is *not* a scientific **hypothesis**?

B. Undetectable particles are some of nature's secrets.

Explanation:
Choices A and C can be disproved by experiments.

Choice B has no test for wrongness, so it is *not* a scientific hypothesis.

The Scientific Attitude Law

- Law or principle
  - A hypothesis that has been tested repeatedly and has not been contradicted
- Theory
  - A synthesis of a large body of information that encompasses well-tested and verified hypotheses about certain aspects of the natural world

The Scientific Attitude
CHECK YOUR NEIGHBOR, Continued-1

Which of these often changes over time with further study?

A. Facts.
B. Theories.
C. Both of the above.
D. Neither of the above.

The Scientific Attitude
CHECK YOUR ANSWER, Continued-1

Which of these often changes over time with further study?

C. **Both of the above.**

Explanation:
Both can change. As we learn new information, we refine our ideas; likewise in science.

The Scientific Attitude
CHECK YOUR NEIGHBOR, Continued-2

A person who says, "that's only a theory" likely doesn't know that a scientific theory is a

A. guess.
B. number of facts.
C. hypothesis of sorts.
D. vast synthesis of well-tested hypotheses and facts.

The Scientific Attitude
CHECK YOUR ANSWER, Continued-2

A person who says, "that's only a theory" likely doesn't know that a scientific theory is a

D. vast synthesis of well-tested hypotheses and facts.

Explanation:
The word "theory" in everyday speech is different than its use in science.

In science, only a vast, experimentally verifiable body of knowledge is a theory.

Science, Art, and Religion

- Comparison of science, art, and religion by domain:
  - Science is of the natural order and involves the discovery and recording of natural phenomena.
  - Art is the interpretation and expression of human experience.
  - Religion involves faith and worship of a supreme being.

Science, Art, and Religion, Continued

- Similarities between art and in science
  - Knowledge of what is possible in human experience and in nature.
  - Knowledge of both affects our views and decisions about the world.
- Similarities between religion and in science
  - Both deal with unanswered questions.

The Scientific Attitude
CHECK YOUR NEIGHBOR, Continued-3

Between a pilot and a priest, who do you think should fly a commercial jet airplane? Who should perform a marriage? (Although the questions are no-brainers, they have a point.)

A. The pilot should fly and the priest should perform a marriage.
B. The priest should fly and the pilot should perform a marriage.
C. The pilot should do both.
D. The priest should do both.

The Scientific Attitude
CHECK YOUR ANSWER, Continued-3

Between a pilot and a priest, who do you think should fly a commercial jet airplane? Who should perform a marriage? (Although the questions are no-brainers, they have a point.)

A. The pilot should fly and the priest should perform a marriage.

Explanation:
The pilot and priest have different skills for different tasks, and each can do their thing well

Science and Technology

- *Science* is concerned with gathering and organizing knowledge.
- *Technology* is the use of scientific knowledge for practical purposes and to provide tools for further exploration.

Physics—The Basic Science

- Physical sciences include geology, astronomy, chemistry, and physics.
- Life sciences include biology, zoology, and botany.
- Physics underlies all the sciences.

The Scientific Attitude
CHECK YOUR NEIGHBOR, Continued-4

Although physics may be the most difficult science course in certain schools, when compared with the fields of chemistry, biology, geology, and astronomy, it is

A. the simplest.
B. still the hardest!
C. the central science, between chemistry and biology.
D. simple enough, but only for especially intelligent people.

The Scientific Attitude
CHECK YOUR ANSWER, Continued-4

Although physics may be the most difficult science course in certain schools, when compared with the fields of chemistry, biology, geology, and astronomy, it is

A. the simplest.

Explanation:
Your physics text has fewer terms than biology or chemistry texts. Physics is a much more basic science than other fields.