1 What is Science?
   a. *Science—the study of nature's rules*
      i) Investigators throughout human history painstakingly discovered these rules. These rules, which are surprisingly few in numbers, explain most of the phenomena we experience daily.
      ii) To know nature’s rules (the connections between things) itself is a fascinating experience.
   b. *Science—both the methods and the knowledge*
      i) Science is a body of knowledge (e.g., why is sky so blue? Sunset so red?).
      ii) Science is a way of thinking to produce that knowledge.

2 The Basic Science—Physics
   a. *Natural philosophy* is the objective study of nature and the physical universe that was regnant before the development of modern science. Forms of science historically developed out of natural philosophy. Our notions of science and scientists date only to the 19th century. Before then, the word "science" simply meant knowledge and the label of scientist did not exist. Isaac Newton's 1687 scientific work is known as *The Mathematical Principles of Natural Philosophy* (which contains Newton’s laws of motion).
   b. The study of science branch into life sciences (living things) and the physical sciences (nonliving things). The life sciences branch into areas such as biology, zoology, and botany. The physical sciences branches into areas such as geology, astronomy, chemistry, and physics.
   c. Physics is the most basic of all the sciences. It’s about the nature of basic things such as motion, forces, energy, matter, heat, sound, light, and the composition of atoms.
   d. Physics supports chemistry, which in turn supports biology. That’s why physics is the most basic science.

3 The Goal of Studying Physics – Physics Worldview
   a. *Goal:* to comprehend the course of events in the whole world – to create a *worldview*. Once you get it, your world will never be the same again. You will never walk down a street, ride in a car, or look in a mirror without involuntarily seeing an extra dimension.
   b. *Worldview:* a shared set of ideas that represents the current explanations of how the material world operates. The physics worldview is dynamic. Ideas/models are constantly being proposed, debated, and tested against the material world. The models supported by the experimental facts will eventually survive.
   c. *Common sense:* is a personal worldview and, like the physics world view, is built on a large experimental base. The difference is in part due to different ranges of experience. Our observations are limited by the *ranges of human sensations* while physicists use *instruments* to extend our sensations. That’s why some ideas in physics might appear to be contrary to common sense.

4 Scientific Method
   a. The Italian physicist *Galileo Galilei* and the English philosopher *Francis Bacon* are usually credited as the principal founders of the *scientific method*.
   b. Scientific method is extremely effective in gaining, organizing, and applying new knowledge.
   c. Scientific method generally includes the following:
      i) Observing.
      ii) Recognizing a problem.
      iii) Developing a hypothesis
      iv) Predicting the consequences of the hypothesis.
v) Developing and performing experiments to test predictions.

vi) Formulating the simplest general rule that organizes hypothesis, prediction, and experimental outcome.

vii) Refining the hypothesis based on experimental results and testing new hypothesis.

viii) Publishing results for peer review.

d. The scientific method is only a guide to good science practice. Most discoveries happen by trial and error, experimentation, or accidental discovery.

e. The attitude to inquiry, to experiment, and to be humble before the facts is the key to have scientific success.

5 Einstein’s View of Science

a. Creative leap & consequences: a scientist makes a creative leap in attempting to explain some phenomena. The leap is intuitive and it is not scientific. The scientific process begins when the scientist takes the ideas, or axioms, and develops consequences based on it. A powerful axiom has a large number of consequences. The final task is to test these consequences against the material world.

b. Imagination: The knowledge is a good thing, but it is not enough. Such knowledge is the springboard for the creative leap. It is the "shoulders of giants" on which Newton and then Einstein had to stand in order to make their own new contribution.

6 The Scientific Attitude

a. Fact — is not immutable and absolute, but is a close agreement by competent observers who make a series of observations of the same phenomenon.

b. Hypothesis — is an educated guess that is only presumed to be factual until demonstrated by experiment.

c. Laws or Principles — when hypotheses are tested over and over again and not contradicted, they may become known as laws or principles. If there is any evidence that contradicts a hypothesis, law or principle, then the hypothesis, law or principle must be changed or abandoned.

d. Scientific Theory — is a synthesis of a large body of information that encompasses well-tested and verified hypotheses about certain aspects of the natural world. The criterion of a theory is not whether it is true or untrue, but rather whether it is useful or non-useful. A theory is useful even though the ultimate causes of the phenomena it encompasses are unknown. The theories of science are not fixed, but rather they undergo change — redefinition and refinement. The refinement of theories is strength of science, not a weakness.

e. Concept — is the intellectual framework that is part of a theory. A concept encompasses the overriding idea that underlines various phenomena. To think conceptually is to employ a generalized way of looking at things.

f. Appealing to authority, popularity, personal preferences, or selecting partial facts can lead to distorted conclusions.

g. A scientific attitude accompanies a search for order, for uniformities, and for lawful relations among the events of nature.

7 Scientific Hypotheses Must Be Testable

a. It is more important that there be a means of proving a scientific hypothesis wrong than that there be a means of proving it correct.

b. Albert Einstein: “No number of experiments can prove me right; a single experiment can prove me wrong.”
c. A hypothesis that has no test for its possible wrongness lies outside the domain of science.

d. For example, “Atoms are the smallest particles of matter.” is a scientific hypothesis, while “The observation of the observer creates the world which the observer sees.” is not a scientific hypothesis.

8 Criteria of Scientific Models and Physics Laws

a. **Criteria of scientific models:** (1) If an idea is very general, having many consequences, it can replace many separate ideas. (2) The simplicity of an idea is valuable. Even a model earns wide acceptance it is still tentative. Experimental results can never prove an idea; they can only disapprove it.

b. **Criteria of a physics law:** (1) It must account for the known data. (2) It must make predictions that can be tested. (3) It must have a scientific basis.

9 Science, Technology, and Society

a. The comparison between science and technology:

<table>
<thead>
<tr>
<th>Item</th>
<th>Science</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target</td>
<td>questions about nature</td>
<td>problems about human life</td>
</tr>
<tr>
<td>Goal</td>
<td>answering theoretical questions (knowing)</td>
<td>solving practical problems (doing)</td>
</tr>
<tr>
<td>Method</td>
<td>discovering facts and relationships between observable phenomena in nature</td>
<td>developing tools, technique, and procedures</td>
</tr>
<tr>
<td>Result</td>
<td>establishing theories which interpret them</td>
<td>putting the findings of science to use</td>
</tr>
<tr>
<td>Motivation</td>
<td>scientists’ curiosity</td>
<td>engineers’ problem solving urge</td>
</tr>
</tbody>
</table>

b. The development of science can change people’s worldview. The development of technology can directly impact people’s life. The needs of people and the funding provided by the society can affect the direction of scientific and technological development.

c. It is the responsibility of all of us to see that science and technology are wisely used to promote the general well being of human life.