CHAPTER 17 Special Theory of Relativity

CHAPTER CONTENTS

The name of Albert Einstein has towered over the field of physics during the twentieth century and on into the twenty-first century. In the space of a few years, Einstein not only changed the world's way of thinking about electromagnetic radiation such as light, he also radically changed the commonly accepted picture of the universe with his two relativity theories — the special theory of relativity and the general theory of relativity.

The special theory of relativity, which you will be studying in this chapter, was not well received at first. The idea that fundamental measurements such as time, distance, and mass depended on the relative motion of the observer seemed absurd to many. In fact, Einstein was awarded the 1921 Nobel Prize for physics for his development of the concept of photons and the resulting explanation of the photoelectric effect, not for his theories of relativity.

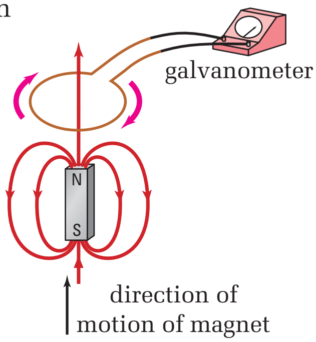
With the advent of high-energy physics, however, Einstein's theory of special relativity became essential to the understanding of the behaviours of all high-speed subatomic particles.

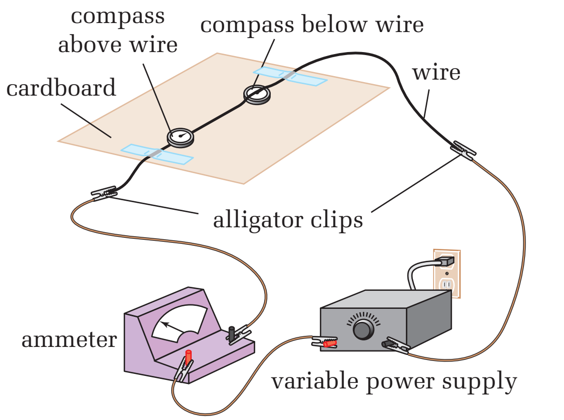
QUICK LAB Generating Electromagnetic Fields

TARGET SKILLS
- Predicting
- Performing and recording
- Analyzing and interpreting

One of the problems that led to Einstein's special theory of relativity came from an analysis of the way in which electric and magnetic fields spread out through space as electromagnetic waves. In Unit 6, you studied various characteristics of magnetic and electric fields; now, examine carefully the two diagrams and try to answer the questions that follow each of them. Discuss the answers with your classmates. Then, carry out the activity that follows these questions.

- Under what condition does a magnetic field generate an electric current?
- What determines the magnitude of the current?
- What determines the direction of the current?
- How do you know that an electric field must have been generated across the coil?

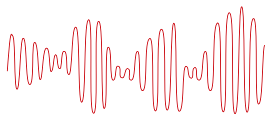




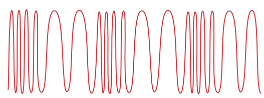
- What evidence is there that an electric current can generate a magnetic field?
- What affects the strength of the magnetic field?
- What affects the direction of the magnetic field?
- What kind of field is needed to produce an electric current?

Lab

Obtain a radio with a movable antenna. Turn on the radio and set it in the AM range. ("AM" refers to amplitude modulation, a process in which a signal is impressed on a radio carrier frequency by varying its amplitude, as shown in the diagram.) Turn on an induction coil and allow an arc (or spark) to pass between the points of the electrodes. Listen for the effect on the radio. Find the antenna orientation for which the effect is (a) greatest and (b) least. Repeat these steps with the radio tuned to an FM station. ("FM" stands for frequency modulation, in which the signal is impressed on the carrier wave through variations in its frequency, as shown.)



AM signal



FM signal

Analyze and Conclude

1. What evidence is there that radio waves (electromagnetic radiation) are travelling from the arc to the radio?
2. Is there any relationship between the orientation of the arc and the orientation of the antenna for maximum and minimum effects?
3. If there is a relationship in question 2, what does that indicate about the nature of the waves produced from the arc?
4. **(a)** What difference do you notice with the FM station? **(b)** Try to explain this difference.