CHAPTER 14

Fields and Forces

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You cannot see electric energy, but the electric eel in the photograph can. It is not really an eel — it is actually a knife fish, or *Electrophorous electricus* — but it *is* electric. This fish can detect and generate an electric potential difference. Nearly half of the knife fish's body consists of specialized muscle cells that function like a series of electric cells. This living "battery" can generate an electric potential difference of up to 600 V. The electric shock caused by the knife fish can kill some small prey and often stuns large prey, which the knife fish then devours.

The pits along the side of the knife fish's head and body, called the "lateral line system," are specialized to detect electric fields. The knife fish uses its ability to generate and detect electric energy to navigate, detect enemies, kill or stun prey, and possibly even communicate with other knife fish. If water is polluted, it modifies the electric field generated by the knife fish. A university in France is studying the possibility of using the knife fish to monitor water quality. As you can see, there are even some areas of research in biology that require a basic understanding of physics.

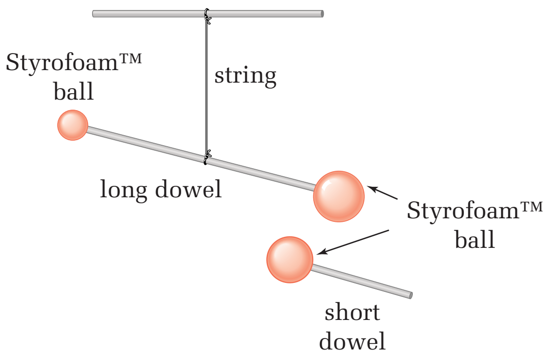
In this chapter, you will learn more about electric energy and fields and compare them with gravitational and magnetic energy and fields.

QUICK LAB

A Torsion Balance

TARGET SKILLS
- Hypothesizing
- Identifying variables
- Performing and recording

The torsion balance was an important tool in early studies of both gravitational force and the electrostatic force. As you know, Henry Cavendish was able to determine the universal gravitational constant, *G*, using a torsion balance. Charles Coulomb, unaware of Cavendish's balance, developed a very similar balance, which he used to develop the law now known as Coulomb's law. This lab will help you to understand the principles of the torsion balance, as well as to develop an appreciation of those who used it.



Attach a string (approximately 1.0 m long) to the centre of a thin wooden dowel (approximately 80 cm long) and suspend it from a retort stand or the ceiling. Wrap four Styrofoam™ balls with aluminum foil. Push one of the balls onto each end of the dowel. Make two probes by pushing one ball onto the end of each of two shorter-length wooden dowels. Charge one of the balls on the longer dowel on the suspended balance and also charge the ball on one of the probes. (Use either an ebonite rod and wool or an electrostatic generator to charge the balls.) Now, hold the charged "probe" ball in the vicinity of the "balance" ball and allow the system to reach equilibrium, with the torsion balance turned a small amount.

Experiment with different-sized charges by holding a charged probe in a fixed position near the "balance" ball, and observe the equilibrium position of the balance. Then, touch the charged probe ball to the uncharged probe ball to reduce (by approximately one half) the quantity of charge it carries. Then hold the probe ball in exactly the same position as before and observe the position of the balance.

Experiment with different types of string, a heavier dowel, protection from air currents, and any other variables that you think might affect the performance of the balance.

Analyze and Conclude

1. Describe the performance of the torsion balance.
2. How did the response of the balance change when you reduced the amount of charge on the probe?
3. How would you calibrate your balance if you wanted to obtain quantitative data?
4. What type of string and weight of dowel seemed to perform best?
5. Comment on the use of a torsion balance as a precision tool by early physicists.

Web Link

www.mcgrawhill.ca/links/atlphysics

To see an illustration of Charles Coulomb's torsion balance, go the the above Internet site and click on **Web Links**.