7.4 Technological Implications

Compare the safety equipment worn by the two football players in Figure 7.13. Although the game has probably become much more physical during the same period of time, the chances of a serious injury have been significantly reduced by applying the principles of energy and momentum. Millions of dollars of basic research have gone into studying and improving sports equipment. In football equipment alone, imagine how many types of pads are designed on the principle of increasing the time interval of the collision in order to decrease the force on one part of the body. In addition to safety, new designs in sports equipment have resulted in materials that help athletes run faster, hit golf balls farther, and jump higher.

SECTION OUTCOMES

- Analyze and describe examples where energy- and momentum-related technologies were developed and improved over time.
- Describe and evaluate the design of technological solutions and the way they function using principles of energy and momentum.

Figure 7.13 Sports equipment has come a long way in the last fifty years.

Athletes choose to participate in sports but all citizens must avail themselves of transportation. As you learned in Chapter 5 when you read about and designed crumple zones for vehicles, a knowledge of energy and momentum is critical in auto safety. Go back to page 195 and look at Figure 5.18 of the race car accident. Do you have a better understanding of the reasons that the driver was able to walk away from the accident now than when you first saw the photograph? The research that goes into race cars is eventually applied to passenger vehicles. Modern vehicles have many safety features built into them today.

Safety in industry is also improving, from hard hats to steel toes of shoes for construction workers. The Canadian Standards Association (CSA) studies the materials and design of safety equipment for industry, the general public, and sports and then sets standards for each piece of equipment. For example, if you are shopping for a bicycle helmet, be sure that it has been approved by the CSA. In this section, you will read features, perform an experiment, and then choose a topic of interest in which to do in-depth research.

CAREERS IN PHYSICS

Science of the Sole

When the world's athletes take a run at the gold in the Olympics, few people know that a Canadian physicist is running in spirit right beside them. Dr. Benno Nigg, a professor at the University of Calgary and founder and chairperson of its Human Performance Laboratory, is a leading expert in biomechanics. Biomechanics is the science of how living things move. With biomechanics, scientists can determine how dinosaurs really walked, tens of millions of years ago. Biomechanics can also shed light on how humans walk, or, more importantly for athletes, how humans run.

It may sound strange, but there is a lot of physics in the design of running shoes. Dr. Nigg's work demands a precise application of forces, energy, and thermal physics. For example, the hardness of the shoe affects which kinds of muscle fibres are activated. This, in turn, will have an effect on the runner's fatigue. So an in-depth understanding of how the mechanical energy of the impact of the shoe is transmitted to the runner is vital. These discoveries are even now being used by athletics-wear companies to design the next generation of running shoe.

Dr. Nigg's interest in this kind of physics has taken him far. He has won awards from around the world, and is a member of the Olympic Order and the International Olympic Committee Medical Commission. He has consulted for all of the largest sportswear and equipment companies. If you look at the qualifications for researchers and technicians at any of these companies, you will see very quickly that almost every position requires a knowledge of biomechanics. This is truly a career that can bring an interest in sports and an interest in science together.

Dr. Nigg will tell you that, when he first entered the field, his main qualifications were a broad educational background and a deep interest in physics. He says these enabled him to go anywhere: "When you study physics, you open doors."

Dr. Benno Nigg

Going Further

According to Dr. Nigg, the best way to learn about biomechanics and the careers available is to get hands-on experience. Many students don't realize that very often university and corporate laboratories offer summer programs specifically aimed at high school students. Call a local university or an athletics-equipment manufacturer and see what they have to offer.

Web Link

www.mcgrawhill.ca/links/atlphysics

The Internet has a number of excellent resources that can help to explain some of the more difficult concepts and considerations involved in determining how runners run and what we can do to help them run faster. For example, Dr. Nigg's *Biomechanigg* page illustrates a number of these concepts. Go to the web site shown above to find out where to go next. Try to create your own method for measuring the forces involved in walking and running.

PHYSICS & SOCIETY

The Physics of Car Safety

TARGET SKILLS

- **Analyzing and interpreting**
- **Hypothesizing**

When a car stops suddenly, you keep going. This example of Newton's first law of motion has been responsible for many traffic injuries. Countless drivers and passengers have survived horrible crashes because they were wearing seat belts, and air bags have also played a major role.

To understand the physics behind the design of air bags, imagine that the car you are driving is suddenly involved in a head-on collision. At the instant of impact, the car begins to decelerate. Your head and shoulders jerk forward, and the air bag pops out of its compartment. The bag must inflate rapidly, before your head reaches the wheel, and then start to deflate as your head hits it. This causes your head to decelerate at a slower rate. In addition, the force of your impact with the air bag is exerted over a wider area of your body, instead of being concentrated at the impact site of your head with something small, such as the top of the steering wheel.

Physics is also involved in the design of car tires. The key consideration is the amount of tire area that stays in contact with the road during braking and turning; the more tire contact, the better your control of the car. Also important is having tires that resist "hydroplaning" on wet roads — at slow speeds, water skiers sink; at high speeds, they glide over the surface of the water. That's just what you do not want your car tires to do in the rain. Engineers used various physics principles to design tires with a centre groove that pumps water away from the surface as the tires roll over wet pavement.

Analyze

1. Air bags have come under increased scrutiny. Research the reasons for this debate.
2. To keep more rubber in contact with the road, tires could be made wider. The ultimate would be a single tire as wide as the car. What would be the disadvantage of this type of tire? What might limit the maximum width of a tire?

QUICK LAB

Safety First

TARGET SKILLS

- Initiating and planning
- Modelling concepts
- Conducting research

Part A Egg Drop Contest

How well can you design safety equipment for a raw egg? Work in pairs for this activity. With your partner, write down everything involving forces, impulse, momentum, and energy that might help you design your equipment. Brainstorm the shape and type of materials that will best protect your raw egg based on the principles of physics that you wrote down. The only restriction is that the total mass of your equipment cannot exceed 750 g.

As a class, decide on the height (between 3 m and 15 m) and a location from which you will drop your eggs. Obtain your materials, build your safety equipment for your egg, and carry out the contest. If there are several winners whose eggs were unbroken, your class might choose a higher location and have another contest among the winners of the first.

Analyze and Conclude

1. What physics principles seemed to be the most important in the design of your egg safety equipment?
2. What materials were used by the most successful contestants? What property of these materials do you think provided the most protection for the eggs?
3. Discuss a practical application for the principles that you learned while designing your egg safety equipment.

Part B Safety Equipment Poster

Your goal in this activity is to prepare a poster based on in depth research into one type of safety equipment. Work in small groups and assign different areas of research to each member of the group. Within the group, choose some type of safety equipment from the categories of sports, transportation, or industry. Include in your research and poster presentation information about the history of the product. For example, before the equipment was developed, what type of accidents or injuries were occurring? What stimulated the early developers of the equipment to pursue research into this area? Include scientific principles used by the researchers and developers of the equipment. How does your new knowledge of physics help you to understand the research? Finally describe the modern equipment and its capabilities. Include photographs of the equipment. Make your poster attractive and interesting for others to read.

7.4 Section Review

1. MC List at least five different types of safety equipment that were not mentioned in this section for which the principles of energy and momentum were pivotal in the design.
2. C Describe the safety equipment that most affects your life today.