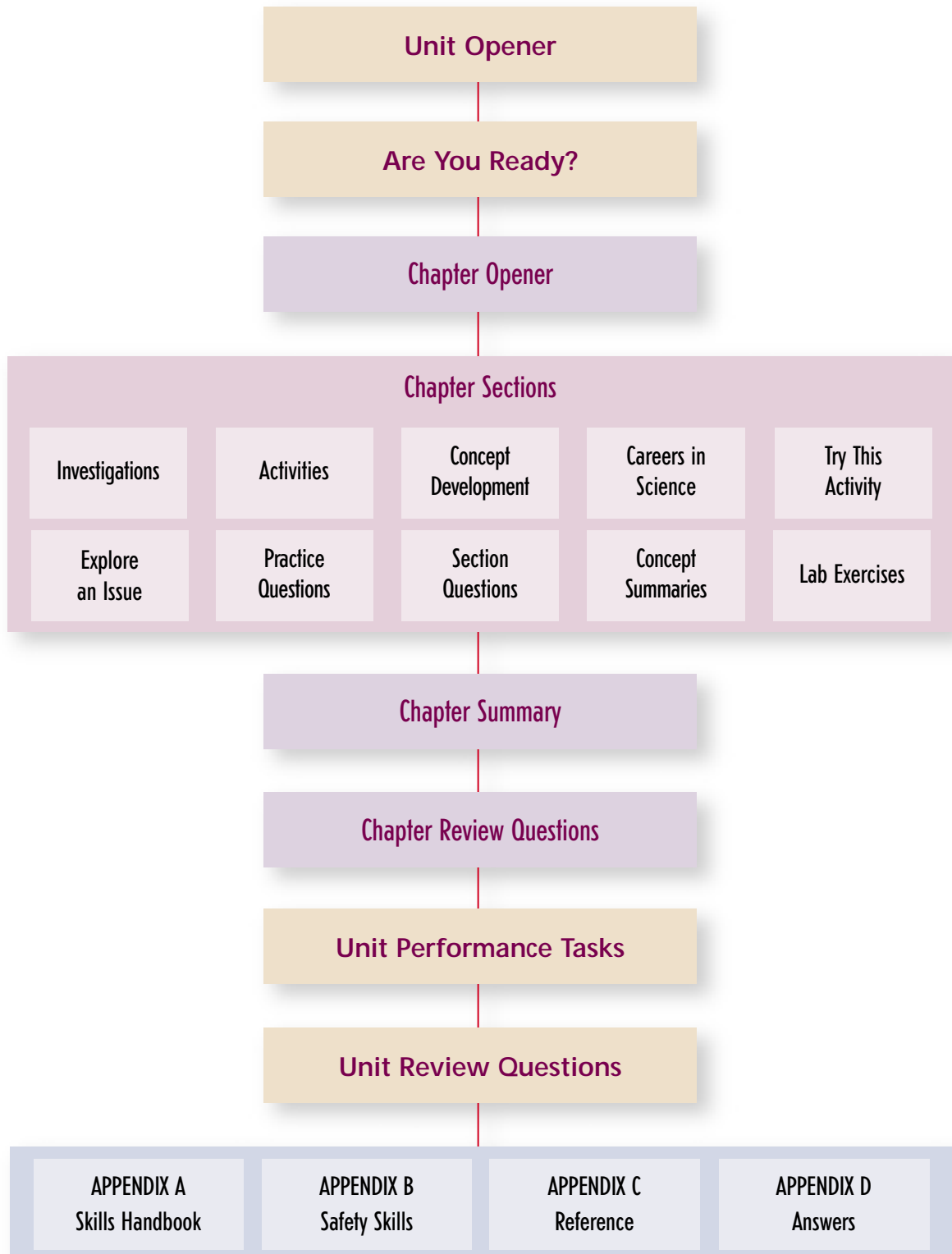


How is *Nelson Physics 11* organized into an understandable format for Grade 11 students?

Unit and Chapter Framework

The student text is organized into five units with up to four chapters in each unit.



Consistent column width and use of margin space throughout the text makes it easy to read.

5.1 The Consumption of Energy

We will begin this chapter by looking at the amount of energy we consume and the effects of the growth in energy demands.

Our Daily Energy Consumption

How much energy (in joules) do you think you have consumed from your physical activities in the past 24 hours? From your study of energy in Chapter 4, you know that it takes 9.8 J of energy (in the form of work) to raise a 1-kg object a vertical distance of 1 m. As your body is not very efficient, for every joule of energy you transform, your body may need to consume 4 J, 5, or even 10 J. It usually takes about 200 J to raise your body from a sitting to standing position and about 2×10^6 J (2 MJ) to climb a set of stairs. Before you begin reading the next paragraph, estimate an answer to the question above.

If your estimate is less than 10^7 J (10 kJ), you will need to review your work on energy. Your food intake in a day provides about 10 MJ of energy for your activities.

When you compare the energy consumed from your activities to the daily energy consumption of the average Canadian, which is about 10^7 J (10 MJ or 1000 MJ), you will notice that there is a huge amount of other energy you are responsible for consuming. This includes the energy you use to cook your food, the energy that lights and heats your home and school, and perhaps the energy that provides transportation. More indirectly, you are also responsible for the energy used to make your clothes, books, furniture, CD players, and other appliances, as well as the energy to build and light your streets, to remove your sewage and garbage — the list is ever increasing.

The energy we consume about 1000 MJ (per person per day) is about 100 times as much as the amount we need to survive (about 10 MJ). Of course, much of the consumed energy is beyond our control, but we should be aware of the entire energy situation. Consider, for example, Figure 1. Are we, as individuals, responsible for the energy consumed to illuminate vacant offices at night?

It is interesting to compare our current consumption of energy (1000 MJ per person per day) with that of people in different eras. As civilization progressed, the amount of energy consumed per capita, that is, per person, increased appreciably (Table 1). Simultaneously, the world's population has grown, so the effect is that we are now consuming a vast amount of energy.



Figure 1 This skyline of Toronto, Ontario, after business hours.

Table 1 Daily Average Energy Consumption per Person

Activity	Era	Type of energy use	Energy consumption per day (MJ)
Survival	pre Stone Age	energy from food only	10
Domesticity	Stone Age	energy from wood fires for cooking and heating	22
	medieval	energy from animal manure, wind, water, and coal	100
Industrial	19th century	energy mainly from coal but iron production and steam engines	300
	20th century	energy from fossil fuels and nuclear sources used for electricity, transportation, industry, agriculture, and so on	1000 (in Canada)

Make a Summary

Draw a map of your area of the province and show the approximate location of your home and school as well as several other features, such as electrical generating stations, garbage dumps, bodies of water, rivers, and recycling depots. On your map, show how electricity is generated and distributed to your home and school. Add alternative ways that electrical energy could be generated in the future. Use as many of the concepts and key words from this chapter as possible.

Reflect on Learning

Devise your answers to the Reflect on Your Learning questions at the beginning of this chapter.

- How has your thinking changed?
- What new questions do you have?

Chapter 5 Summary

Key Expectations

- In this chapter, you learned how to
- analyze, in qualitative and quantitative terms, simple situations involving work, gravitational potential energy, kinetic energy, thermal energy, and heat, using the law of conservation of energy. (5.3)
 - apply quantitatively the relationships among power, energy, and time in a variety of contexts. (5.2)
 - analyze, in quantitative terms, the relationships among percent efficiency, input energy, and useful output energy for several energy transformations. (5.1, 5.2, 5.3, 5.4)
 - communicate the procedures, data, and conclusions of investigations involving work, mechanical energy, power, thermal energy, and heat, and the law of conservation of energy, using appropriate means (e.g., oral and written descriptions, numerical and/or graphical analysis, tables, diagrams). (5.2)
 - analyze, using their own or given criteria, the economic, social, and environmental impact of various energy sources (e.g., wind, tidal flow, falling water, the Sun, thermal energy, and heat) and energy transformation technologies (e.g., hydroelectric power plants and energy transformations produced by other renewable sources, fossil fuel, and nuclear power plants) used around the world. (5.3, 5.4)

Key Terms

- doubling time
- energy transformation
- technology
- energy converter
- energy resource
- renewable energy
- resource
- non-renewable energy
- resource
- hydrocarbon
- bitumen
- nuclear fusion
- solar energy
- passive solar heating
- hydraulic energy
- wind energy
- tidal energy
- wave energy
- biomass energy
- geothermal energy
- nuclear fission
- fuel cell
- atmosphere
- heat pump
- cogeneration
- local consumption

Key Terms are bolded as they appear in the body of the text and are defined in the side margin. They are repeated in the Chapter Summary and in the Glossary at the end of the text.

Practice

Understanding Concepts

- For this question, assume one significant digit.
 - What is the daily energy consumption of the average Canadian?
 - Estimate Canada's current population.
 - Use your answers in (a) and (b) to estimate Canada's total energy consumption per day, and per year.
- What fuel source replaced wood as the human lifestyle changed from nomadic to agricultural?
 - What fuel replaced the one you named in (a)?
 - What fuel replaced the one you named in (b)?
- Refer to the data in Table 1, starting with the Stone Age.
 - Plot a graph of daily average energy consumption per capita (in megajoules) as a function of year, starting at 6000 B.C. (Assume that the Stone Age value cited in the table applies to 6000 B.C.)
 - Compare the shape of this graph to the shape of the graph you drew in question (b) of the chapter opening activity.
- Why might two countries of similar technological levels have very different per capita energy consumptions? List several reasons.
- It is known that population growth rates are lowest among the most technologically advanced countries. Suggest reasons why this is so. What consequences does this have in terms of energy consumption?

Making Connections

- Describe reasons why Canadians, on average, consume much more energy per capita than people living in Mexico.

The Effects of Growth

Let us look at one of the most enlightening and frightening aspects of energy consumption. Frequently we hear news reports indicating the rate of growth per annum of some factors in our society. Using "a" to represent annum or "year," we have these examples:

- The population increase in Latin America is 2.3%^a.
- The total energy consumption in Africa is increasing at 4.2%^a.
- Consumption of oil for heating is decreasing at 3%^a.
- Consumption of natural gas in Canada is increasing at 6.7%^a.

To analyze the impact of growth rates, we will use the following example. Suppose that a town's annual budget for public transportation is \$100 000. However, with the projected increase in salaries, cost of energy, and population growth, an average growth in expenses of 8% is expected. The effect of this growth after several years is evident in Table 2.

Table 2 shows that at the seemingly low growth rate of 8%^a, the original value has approximately doubled in 9 years, and after 45 years the value is greater by a factor of 32 times! This rapid growth may appear marvellous in the case of salaries. But what about energy consumption? If our energy consumption were to increase at 8%^a, after the average period of work expectancy (45 years), our energy use would be 32 times greater! You can now appreciate why scientists and politicians should be concerned about growth in energy consumption.

Another interesting fact emerges from Table 2. At a growth rate of 8%^a, the time required for an amount to double, called the doubling time, is 9 years. The product of the two numbers is $8\% \times 9 = 72\%$. This percentage can be used

Answers
1. (a) 1×10^7 J
(b) 3×10^7 J
(c) daily 2×10^{10} J
yearly

Table 2 Effects upon Budget of a Growth of 8%^a

Year	Budget
0	\$100 000.00
1	\$108 000.00 ($\$100 000 \times 1.08$)
2	\$116 640.00 ($\$108 000 \times 1.08$)
3	\$125 971.20 ($\$116 640 \times 1.08$)
4	\$136 027.89 ($\$125 971.20 \times 1.08$)
5	\$146 909.12 ($\$136 027.89 \times 1.08$)
6	\$158 661.85 ($\$146 909.12 \times 1.08$)
7	\$171 354.80 ($\$158 661.85 \times 1.08$)
8	\$185 063.18 ($\$171 354.80 \times 1.08$)
9	\$199 868.34 ($\$185 063.18 \times 1.08$)

doubling time: the time required for an amount to double
Using Energy in Our Society 163

Using a graphic organizer such as a concept map in the Chapter Summary, students have the opportunity to summarize key terms and concepts to consolidate understanding.

SUMMARY Newton's First Law of Motion

- Galileo's real and virtual experiments led the way for Newton to formulate his three laws of motion.
- The net force acting on an object, \vec{F}_{net} , is the vector sum of all the forces acting on the object.
- Newton's first law of motion, often called the law of inertia, states that if the net force acting on an object is zero, the object will maintain its state of rest or uniform velocity.
- The first law of motion is observed and applied in many situations, including the need for restraint systems in automobiles.

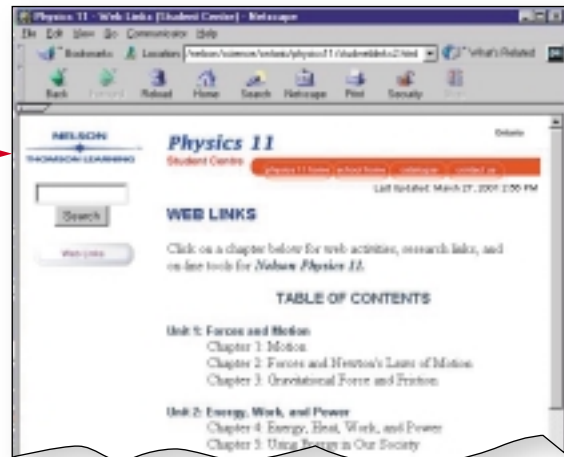
Section 2.2 Questions

Concept/Skill Summary

A point-form summary of the major concepts or skills presented in the section is intended to aid in study. It could be a summary of the steps required to solve a particular class of problems.

Technology

The Nelson Science Web site (www.science.nelson.com) includes "Work the Web" links along with other resources for students, parents, and teachers.



Web Questions appear periodically throughout the student text. These questions provide students with the opportunity to extend learning by doing further research and engaging in interactive activities on the Internet related to lessons presented in the text. Links to *Explore an Issue* lessons help students to further understand the issue by pointing them to Web sites supporting alternative positions.

- A communication satellite has small engines aboard that are used to keep the satellite within its proper space. Use at least one of Newton's laws to explain the use of the engines.
- Find out about the asteroid impact in the Yucatan Peninsula in Mexico about 65 million years ago, which is believed to have caused the extinction of dinosaurs and numerous other species. Also find out about the chances that an asteroid or a huge meteor could crash into Earth in the future. Follow the links for Nelson Physics 11, 3.2.
 - How does an asteroid impact relate to gravitational forces?
 - What might possibly be done to prevent an asteroid impact in the future?
 - How do the research scientists apply their knowledge of local gravitational fields to determine the shape of the impact crater?

- Practice**
- Understanding Concepts**
- Compare and contrast starting friction and kinetic friction, giving an example of each.
 - Give examples of friction you have experienced, besides the ones already given, that are
 - sliding
 - rolling
 - fluid
 - What type of friction is air resistance? Give two examples of it.

Controlling Friction

About 4500 years ago, the Egyptians built enormous pyramids using huge stone blocks that were difficult to move by sliding. The Egyptians placed logs beneath the blocks to push them and move them. By doing this, people were taking advantage of the fact that rolling friction is much less than sliding friction. Modern technology uses the same principles as the Egyptians, though in a more sophisticated way. We try to reduce undesirable friction for many reasons. For instance, all machines have moving parts that experience friction during operation. Friction can wear out the machines, reduce efficiency, and cause unwanted heat. (If you rub your hands together vigorously, you can feel the heat produced by friction.) Excess friction in machines can be overcome by making surfaces smooth, using materials with little friction, lubricating with grease or oil, and using bearings.

Bearings function on the principle of the rolling logs used by the Egyptians to move stones. A bearing is a device containing many rollers or balls that reduce friction while supporting a load (Figure 3). Bearings change sliding friction into rolling friction, reducing friction by up to 100 times.

Ways of reducing undesirable friction in other situations are also common. The wax applied to skis mentioned earlier reduces sliding friction. A layer of air between a hovercraft and the water reduces fluid friction in a manner similar to the use of air pucks and the linear air track in a physics laboratory (Figure 4(a)). A human joint is lubricated by *synovial fluid* between the layers of cartilage lining the joint. The amount of lubrication provided by synovial fluid increases when a person moves, giving an excellent example of the efficiency of the human body (Figure 4(b)). In fact, our lubrication systems work so well that it is difficult for technologists to design artificial joints that function to the same standard.

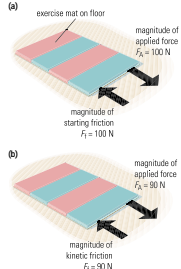


Figure 2
 (a) Starting friction must be overcome before an object begins moving.
 (b) Kinetic friction occurs with a moving object. In general, kinetic friction between two surfaces is less than starting friction between the same surfaces.



Figure 1
 To reduce the friction between skis and the snow, skiers choose a wax that is designed for use within a specific temperature range. At temperatures of, say, -10°C , the ski wax is more slippery than the wax used at higher temperatures.

3.3 The Effects of Friction

Friction is part of everyday life. Removing a fried egg from a frying pan is easier if the pan has a non-stick surface. You find running easier on a dry sidewalk than on a skating rink. Skiers can choose different waxes for their skis, depending on the air temperature and characteristics of the snow (Figure 1). Cars need friction to speed up, slow down, and go around corners.

Static and Kinetic Friction

Friction resists motion and acts in a direction opposite to the direction of motion. It occurs because of the electrical forces between the surfaces where two objects are in contact. No one would put on a pair of ice skates to try to glide along a concrete sidewalk. The friction between the sidewalk and the skate blades would prevent any skating.

One type of friction, called **static friction**, is the force that tends to prevent a stationary object from starting to move. ("Static" comes from the Greek word *statikos*, which means "causing to stand.") The maximum static friction is called the **starting friction**. It is the amount of force that must be overcome to start a stationary object moving. See Figure 2(a).

In certain circumstances static friction is useful; in others, it is not. A person trying to turn a stubborn lid on a jam jar appreciates the extra friction that comes with using a rubberized cloth between the lid and the hand. However, someone attempting to move a heavy filing cabinet across a floor does not appreciate static friction.

Once the force applied to an object overcomes the starting friction, the object begins moving. Then, moving or kinetic friction replaces static friction. **Kinetic friction** is the force that acts against an object's motion in a direction opposite to the direction of motion. For horizontal motion, if the applied force has the same magnitude as the kinetic friction, the moving object will maintain uniform velocity. See Figure 2(b).

Different types of kinetic friction have different names, depending on the situation. *Sliding friction* affects a toboggan; *rolling friction* affects a bicycle; and *fluid friction* affects a boat moving through water and an airplane flying through air.

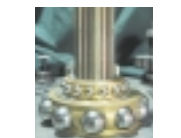
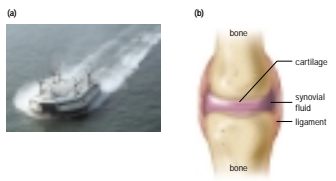


Figure 3
 Ball bearings are used to reduce friction in a wheel.

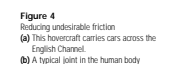


Figure 4
 Reducing undesirable friction
 (a) The hovercraft carries cars across the English Channel.
 (b) A typical joint in the human body

Additional investigations and activities that

offer students the opportunity to use computer interface laboratory technology are included in the teacher support materials. For each investigation or activity, sample data is provided.


Materials
 Densim track and cart
 Motion sensor, computer interface, and computer

Caution
 After giving the cart a push, make sure you keep your hand out of the space between the motion sensor and the cart. When the cart starts back down the ramp, make sure you step it before it reaches the motion sensor.

Procedure
 1. Set up the apparatus as shown in the picture at the beginning of this investigation. The software automatically steps up to each step, shows a graph of velocity vs. time, and shows the results. As you see how the motion changes, you'll see how the motion sensor for motion sensor data.

Investigation 4.1 (Computer Interface)
Testing the Law of Conservation of Energy

Any energy transformation can be tested to determine if the Law of Conservation of Energy holds. The only check for this investigation involves the motion of a cart on a track.



The cart shown in the photograph is given a push. The motion sensor on the left end of the track monitors the motion of the cart as it rolls to the top of the track, stops, and then returns to its starting position, where it is caught before it reaches the motion sensor. This relatively simple setup allows a system being together many of the concepts and skills related to the study of motion. These include position, velocity, acceleration, gravitational field strength, motion, gravitational potential energy, kinetic energy, and total mechanical energy. The skills include using scientific technology and using the software tools available to analyze the data. The purpose of this investigation is to test the Law of Conservation of Energy for a low friction cart on an incline.

Question
 Make a question for this activity.

Hypothesis/Prediction
 Write your own hypothesis and prediction.


Design
 The basic design of this investigation is simple. A cart given a push up an incline to gain some kinetic energy. As the cart rolls up the incline its speed and kinetic energy decrease. However, about the cart is increasing its height above its starting position, its gravitational potential energy is increasing. As the cart rolls back to its starting point the process is reversed, the height and gravitational potential energy decrease and the speed and kinetic energy increase. The motion sensor determines the position of the cart every time a second. The software for the computer can analyze information to determine the cart's velocity and acceleration at any instant. The calculator available as part of the software allows you to determine the kinetic energy, the gravitational potential energy, and the sum of these two energies (total mechanical energy) at any instant throughout the motion experienced by the cart.

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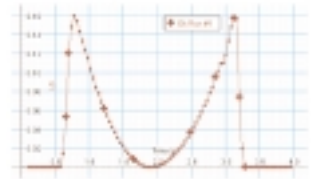
Investigation 4.1 (Computer Interface)
 Testing the Law of Conservation of Energy

Sample Results:

Graph of velocity vs. time for cart on incline

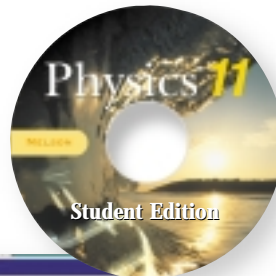


Graph of Kinetic Energy vs. time for cart on incline



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Investigation 4.1 (Computer Interface)
 Testing the Law of Conservation of Energy



The **Student CD-ROM** not only includes all of the student text, but also additional computer animations.

