



Science

Science Grade 10

Curriculum Map

Topic B: Energy Flow in Technological Systems

Resources Included: *Science in Context*, *The Canadian Encyclopedia*, *Canada in Context*, *Historica Canada*, *CBC New in Review*

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On Behalf of THE ALBERTA LIBRARY

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(taken from Alberta Education's Program of Studies)

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Unit B: Energy Flow in Technological Systems

Outcomes for Science, Technology & Society (STS) & Knowledge

Students will:

1. Analyze and illustrate how technologies based on thermodynamic principles were developed before the laws of thermodynamics were formulated

- Illustrate, by use of examples from natural and technological systems, that energy exists in a variety of forms (*e.g., mechanical, chemical, thermal, nuclear, solar*)
- Describe, qualitatively, current and past technologies used to transform energy from one form to another, and that energy transfer technologies produce measurable changes in motion, shape or temperature (*e.g., hydroelectric and coal-burning generators, solar heating panels, windmills, fuel cells; describe examples of Aboriginal applications of thermodynamics in tool making, design of structures and heating*)
- Identify the processes of trial and error that led to the invention of the engine, and relate the principles of thermodynamics to the development of more efficient engine designs (*e.g., the work of James Watt; improved valve designs in car engines*)
- Analyze and illustrate how the concept of energy developed from observation of heat and mechanical devices (*e.g., the investigations of Rumford and Joule; the development of pre-contact First Nations and Inuit technologies based on an understanding of thermal energy and transfer*)

2. Explain and apply concepts used in theoretical and practical measures of energy in mechanical systems

- Describe evidence for the presence of energy; i.e., observable physical and chemical changes, and changes in motion, shape or temperature

- Define kinetic energy as energy due to motion, and define potential energy as energy due to relative position or condition
- Describe chemical energy as a form of potential energy (*e.g., energy stored in glucose, adenosine triphosphate [ATP], gasoline*)
- Define, compare and contrast scalar and vector quantities
- Describe displacement and velocity quantitatively
- Define acceleration, quantitatively, as a change in velocity during a

$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$$

time interval:

- Explain that, in the absence of resistive forces, motion at constant speed requires no energy input
- Recall, from previous studies, the operational definition for force as a push or a pull, and for work as energy expended when the speed of an object is increased, or when an object is moved against the influence of an opposing force
- Define gravitational potential energy as the work against gravity
- Relate gravitational potential energy to work done using $E_p = mgh$ and $W = Fd$ and show that a change in energy is equal to work done on a system: $\Delta E = W$
- Quantify kinetic energy using $E_k = 1/2 mv^2$ and relate this concept to energy conservation in transformations (*e.g., for an object falling a distance "h" from rest: $mgh = Fd = 1/2 mv^2$*)
- Derive the SI unit of energy and work, the joule, from fundamental units
- Investigate and analyze one-dimensional scalar motion and work done on an object or system, using algebraic and graphical techniques (*e.g., the relationships among distance, time and velocity; determining the area under the line in a force - distance graph*)

3. Apply the principles of energy conservation and thermodynamics to investigate, describe and predict efficiency of energy transformation in technological systems

- Describe, qualitatively and in terms of thermodynamic laws, the energy transformations occurring in devices and systems (*e.g., automobile, bicycle coming to a stop, thermal power plant, food chain, refrigerator, heat pump, permafrost storage pits for food*)
- Describe how the first and second laws of thermodynamics have changed our understanding of energy conversions (*e.g., why heat engines are not 100% efficient*)
- Define, operationally, "useful" energy from a technological perspective, and analyze the stages of "useful" energy transformations in technological systems (*e.g., hydroelectric dam*)
- Recognize that there are limits to the amount of "useful" energy that can be derived from the conversion of potential energy to other forms in a technological device (*e.g., when the potential energy of gasoline is converted to kinetic energy in an automobile engine, some is also converted to heat; when electrical energy is converted to light energy in a light bulb, some is also converted to heat*)
- Explain, quantitatively, efficiency as a measure of the "useful" work compared to the total energy put into an energy conversion process or device
- Apply concepts related to efficiency of thermal energy conversion to analyze the design of a thermal device (*e.g., heat pump, high efficiency furnace, automobile engine*)
- Compare the energy content of fuels used in thermal power plants in Alberta, in terms of costs, benefits, efficiency and sustainability
- Explain the need for efficient energy conversions to protect our environment and to make judicious use of natural resources (*e.g., advancement in energy efficiency; Aboriginal perspectives on taking care of natural resources*)

Skill Outcomes

Skill Outcomes (focus on problem solving)

Initiating and Planning

Students will:

Ask questions about observed relationships, and plan investigations of questions, ideas, problems and issues

- Design an experiment, identifying and controlling major variables (*e.g., design an experiment involving a combustion reaction to demonstrate the conversion of chemical potential energy to thermal energy*)
- Formulate operational definitions of major variables (*e.g., predict or hypothesize the conversion of energy from potential form to kinetic form, in an experiment using a pendulum or free fall*)

Performing and Recording

Students will:

Conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information

- Carry out procedures, controlling the major variables and adapting or extending procedures (*e.g., perform an experiment to demonstrate the equivalency of work done on an object and the resulting kinetic energy; design a device that converts mechanical energy into thermal energy*)
- Compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data (*e.g., use a computer-based laboratory to compile and organize data from an experiment to demonstrate the equivalency of work done on an object and the resulting kinetic energy*)
- Use library and electronic research tools to collect information on a given topic (*e.g., compile information on the energy content of fuels*)

used in Alberta power plants; trace the flow of energy from the Sun to the lighting system in the school, identifying what changes are taking place at each stage of the process)

- Select and integrate information from various print and electronic sources or from several parts of the same source (*e.g., create electronic documents, containing multiple links, on using alternative energy sources, such as wind or solar, to generate electricity in Alberta; relate the importance of the development of effective and efficient engines to the time of the Industrial Revolution and to present-day first-world economics*)

Analyzing and Interpreting

Students will:

Analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- Compile and display evidence and information, by hand or using technology, in a variety of formats, including diagrams, flow charts, tables, graphs and scatterplots (*e.g., plot distance - time, velocity - time and force - distance graphs; manipulate and present data through the selection of appropriate tools, such as scientific instrumentation, calculators, databases or spreadsheets*)
- Identify limitations of data or measurement (*e.g., recognize that the measure of the local value of gravity varies globally; use significant digits appropriately*)
- Interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables (*e.g., interpret a graph of changing kinetic and potential energy from a pendulum during one-half of a period of oscillation; calculate the slope of the line in a distance - time graph; analyze a simple velocity - time graph to describe acceleration; calculate the area under the line in a force - distance graph*)
- Compare theoretical and empirical values and account for discrepancies (*e.g., determine the efficiency of thermal energy conversion systems*)

- State a conclusion based on experimental data, and explain how evidence gathered supports or refutes the initial hypothesis (*e.g., explain the discrepancy between the theoretical and actual efficiency of a thermal energy conversion system*)
- Construct and test a prototype of a device or system, and troubleshoot problems as they arise (*e.g., design and build an energy conversion device*)
- Propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each and select one as the basis for a plan (*e.g., assess whether coal or natural gas should be used to fuel thermal power plants in Alberta*)
- Evaluate a personally designed and constructed device on the basis of self-developed criteria (*e.g., evaluate an energy conversion device based on a modern or traditional design*)

Communication and Teamwork

Students will:

Work as members of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results

- Represent large and small numbers using appropriate scientific notation
- Select and use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate ideas, plans and results (*e.g., use appropriate Système international (SI) units, fundamental and derived units; use advanced menu features within a word processor to accomplish a task and to insert tables, graphs, text and graphics*)
- Work cooperatively with team members to develop and carry out a plan and to troubleshoot problems as they arise (*e.g., develop a plan to build an energy conversion device, seek feedback, test and review the plan, make revisions, and implement the plan*)

Attitude Outcomes

Interest in Science

Students will be encouraged to:

Show interest in science-related questions and issues, and pursue personal interests and career possibilities within science-related fields (e.g., apply concepts learned in the classroom to everyday phenomena related to energy; show interest in a broad scope of science-related fields in which energy plays a significant role)

Mutual Respect

Students will be encouraged to:

Appreciate that scientific understanding evolves from the interaction of ideas involving people with different views and backgrounds (e.g., appreciate Aboriginal technologies of the past and present that use locally-available materials and apply scientific principles; recognize that science and technology develop in response to global concerns, as well as to local needs)

Scientific Inquiry

Students will be encouraged to:

Seek and apply evidence when evaluating alternative approaches to investigations, problems and issues (e.g., assess problem using a variety of criteria; respect alternative solutions; honestly evaluate limitations of their designs; be persistent in finding the best possible answer or solution to a question or problem)

Collaboration

Students will be encouraged to:

Work collaboratively in carrying out investigations and in generating and evaluating ideas (e.g., select a variety of strategies, such as group brainstorming, active listening, paraphrasing and questioning, to find the best possible solution to a problem; work as a team member when assigning and performing tasks; accept responsibility for problems that arise)

Stewardship

Students will be encouraged to:

Demonstrate sensitivity and responsibility in pursuing a balance between the needs of humans and a sustainable environment (e.g., recognize that their choices and actions, and the choices and actions that technologists make, can have an impact on others and on the environment)

Safety

Students will be encouraged to:

Show concern for safety in planning, carrying out and reviewing activities (e.g., demonstrate concern for self and others in planning and carrying out experimental activities and the design of devices; select safe methods for collecting evidence and solving problems)

Section 1: General Reference

[Alternative and Renewable Energy](#): *Science In Context*: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.

[Coal](#): *Science in Context*: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.

[Conservation Laws](#): *Science in Context*: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.

[Energy](#): *Science in Context*: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.

[Energy in Canada](#): *The Canadian Encyclopedia: Overview and links to articles about Oil and Gas, Nuclear Energy, General Energy, Electric and Coal.*

[Energy Efficiency](#): *Science in Context*: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.

[Energy Transfer](#): *Science in Context*: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.

[Force](#): *Science in Context*: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.

[Gravity](#): *Science in Context*: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.

[Hydroelectric](#): *Science in Context*: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.

[Kinetic Energy](#): *Science in Context*: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.

[Laws of Motion](#): *Science in Context*: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.

[Nuclear Energy](#): *Science in Context*: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.

[Potential Energy](#): *Science in Context*: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.

[Solar Energy](#): *Science in Context*: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.

[Thermodynamics](#): *Science in Context*: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.

[Velocity](#): *Science in Context*: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.

[Wind Energy](#): *Science in Context*: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.

[Work](#): *Science in Context*: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.

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CBC News in Review

"[The Oil Sands and the Environment](#)." *CBC News in Review*. Feb. 2008. Web. 14 Nov. 2015.

Section 4: Websites

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"[Conservation Laws](#)." *LightandMatter.com*. *Science in Context*. Web. 12 Nov. 2015.

"[Fuel Cells](#)." *National Geographic Society*. *Science in Context*. Web. 12 Nov. 2015.

"[Heat Transfer Between Metal and Water](#)." *Gale Science in Context*. Detroit: Gale, 2010. *Science in Context*. Web. 16 Nov. 2015.

Brief Description: Interactive webpage which allows the user to study heat transfer between water and different metals.

"[Hydropower](#)." *National Geographic Society*. *Science in Context*. Web. 12 Nov. 2015.

"[The Law of Momentum Conservation](#).' The Physics Classroom." *Gale Science in Context*. Detroit: Gale, 2015. *Science in Context*. Web. 13 Nov. 2015.

Brief Description: Geared towards high school students and explains Newton's third law of motion, dealing with forces. An interactive quiz allows users to test their understanding.

"[Nuclear Power: Risking a Comeback](#)." *National Geographic Society*. *Science in Context*. Web. 13 Nov. 2015.

"[Nuffield Foundation. Practical Physics: Introducing Energy](#)." *Gale Science in Context*. Detroit: Gale, 2015. *Science in Context*. Web. 16 Nov. 2015.

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["Solid Oxide Fuel Cells."](#) *U.S. Department of Energy (DOE): Office of Fossil Energy. Science in Context.* Web. 12 Nov. 2015.

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Section 5: Experiments

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