Science

Science Grade 12

Curriculum Map

Topic C: Electromagnetic Energy

Resources Included: *Academic One File, Global Issues in Context, Histor!ca The Canadian Encyclopedia, Science in Context, Canada in Context*

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User Guide

Curricular Topic

(taken from Alberta Education's Program of Studies)

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Topic C: Electromagnetic Energy

Themes
Diversity and Energy

Overview
Electrical energy transmission and transformation technologies, based on field theory and on an understanding of electromagnetic radiation (EMR), play an important role in meeting human needs. These technologies are also useful in furthering our understanding of the universe. In this unit, students investigate the functioning of these technologies, the principles of field theory and the properties of EMR. This unit provides a foundation for further studies of electromagnetism.

Focusing Questions
How can field theory be used to explain the function of electrical devices in the home and in the workplace? How are the specific properties of the electromagnetic spectrum applied to medical, communication and remote-sensing technologies? How do imaging technologies reveal the structure and the history, and shape our understanding, of the universe?

General Outcome 1

***Students will* explain field theory and analyze its applications in technologies used to produce, transmit and transform electrical energy.**

Specific Outcomes for Knowledge
Students will:

- define a field as a property of space around a mass, an electric charge or a magnet that causes another mass, electric charge or magnet introduced in to this region to experience a force
- compare the interaction between static electric charges with the interaction between magnetic poles and with the interaction between two masses at a distance
- compare the basic properties (source, direction and strength) of vector fields (gravitational, electric and magnetic), as determined by a test object

- describe gravitational and electric field strength at a given distance from a mass or a point charge, using the equations $|\vec{g}| = Gm / r^2$ and $|\vec{E}| = kq / r^2$
- describe the effect of a conductor moving through a magnetic field and inducing an electrical current
- describe the relationships, for up to three resistors, among power, current, voltage and resistance for series and parallel circuits, using the equations $V = IR$, $P = VI$, $P=I^2R$, $R_T = R_1 + R_2 + R_3$, and $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$
- describe electrical energy in kilowatt hours and joules, using the equation $E_e = Pt$ for electrical energy and the equation $P = VI$ for power
- distinguish between alternating current (AC) and direct current (DC) in terms of electron flow and electric field
- describe the operation of a transformer, in terms of the relationship among current, voltage and the number of turns in the primary and secondary coils, using the equation $N_p / N_s = V_p / V_s = I_s / I_p$
- describe the advantage of AC over DC for transmitting and using electrical energy
- compare the general design and function of a DC electric motor and a generator
- describe, in terms of design and electrical energy, the functioning of safety technologies; *e.g., circuit fuses and breakers, polarized plugs and ground wiring.*

Specific Outcomes for Science, Technology and Society (STS) (Science and Technology Emphasis)

Students will:

- explain that the goal of technologies, based on the application of field theory, is to provide solutions to practical problems
  - describe, in general terms, examples of technological devices based on electrical current and describe their impact on daily life; *e.g., light bulbs, electrical devices and electromagnets in the home, the workplace and in industry*
  - describe, in general terms, examples of technological devices based on electric and magnetic fields and describe their impact on daily life; *e.g., telephones, cellular telephones, CD players, photocopiers, electrostatic filters*

and scrubbers

- explain that technological development may involve the creation of prototypes, the testing of prototypes and the application of knowledge from related and interdisciplinary fields
  - *explain the significance of a simple electric generator or motor in society*
  - *investigate the use of nanotubes in the production of wires to transmit electricity.*

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning
***Students will* formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues**

- evaluate and select appropriate instruments for measuring current, voltage and resistance
- design an experiment and identify specific variables to measure current, voltage and resistance

Performing and Recording
***Students will* conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information**

- investigate the interactions between static electric charges, between magnetic poles and between two masses
- construct an electric circuit to measure current, voltage and resistance, using a voltmeter or an ammeter
- construct a simple electric generator or a DC motor
- draw diagrams to represent fields *(e.g., gravitational, electric or magnetic fields),*using field lines
- *investigate the effects of a conductor moving through a magnetic field by manipulating variables such as current, velocity and magnetic field strength*

Analyzing and Interpreting
***Students will* analyze data and apply mathematical and conceptual models to develop and assess possible solutions**

- test and evaluate a self-constructed, simple electric generator or motor in terms of design, ruggedness and ability to perform a specific function
- calculate the values for $|\vec{g}|$ and $|\vec{E}|$ using the corresponding field-strength equations

- calculate the resistance of series and parallel circuits for a maximum of three resistors
- calculate values for power, current, voltage and resistance
- calculate the value of E_e, *P, t, I, V,* using the related equations
- calculate current voltage and the number of turns in the primary and secondary coils of electrical transformers

Communication and Teamwork
***Students will* work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results**

- *work cooperatively in designing and constructing a simple electric generator or motor and troubleshoot problems as they arise*
- *present research and defend a position, using multimedia capabilities, on the effect of high-voltage power lines in their community*

General Outcome 2

***Students will* describe the properties of the electromagnetic spectrum and their applications in medical technologies, communication systems and remote-sensing technologies used to study the universe.**

Specific Outcomes for Knowledge
Students will:

- describe the range of the electromagnetic spectrum from long, low-frequency radio waves through microwaves, infrared (IR) rays, visible light rays and ultraviolet (UV) radiation to very short, high-frequency waves, such as X-rays and gamma rays
- compare and contrast, to each other, the various constituents of the electromagnetic spectrum, on the basis of source, frequency, wavelength and energy, and their effect on living tissue; *e.g., UV radiation on human skin and photosynthetic organisms; gamma radiation on living cells; visible light on plants, phytoplankton and humans; artificial illumination on the growth of plants*
- recognize that Earth's atmosphere absorbs certain frequencies of EMR
- investigate and describe, qualitatively, the phenomena of reflection, refraction, diffraction and polarization of visible light
- compare and contrast the properties of radiation, from any region of the electromagnetic spectrum, with those of visible

light; i.e., wavelength, frequency, speed, reflection, refraction, diffraction, penetrability

- investigate and describe the relationships of the variables in the universal wave equation $v = f\lambda$
- explain, in general terms, the design of telescopes that are used to gather information about the universe through the collection of as much EMR as possible; i.e., reflecting and refracting optical and radio telescopes
- explain that nuclear fusion in the sun, represented by the equation ${}_{1}^{2}H + {}_{1}^{2}H \rightarrow {}_{2}^{3}He + {}_{0}^{1}n$ produces a wide spectrum of EMR
- describe, in general terms, how a spectroscope can be used to determine the composition of incandescent objects or substances, and the conditions necessary to produce emission (bright line) and absorption (dark line) spectra, in terms of light source and temperature
- describe technologies used to study stars
    - spectroscopes used to analyze the distribution of energy in a star's continuous emission spectrum can be used to estimate the surface temperature of the star
    - Doppler-shift technology used to measure the speed of distant stars provides evidence that the universe is expanding
- describe, in general terms, the evolution of stars and the existence of black holes, white dwarves and neutron stars.

Specific Outcomes for Science, Technology and Society (STS) (Science and Technology Emphasis)

Students will:

- explain that the goal of technology is to provide solutions to practical problems
    - identify examples of technologies that apply EMR to solve medical, communication, industrial and environmental problems; *e.g., use of UV radiation to kill bacteria; diagnostic use of MRIs and X-rays; use of radio waves, microwaves, fibre optics and infrared light in communications; use of remote-sensing technologies, including telescopes, space probes and satellites, in the study of the universe*
    - *describe how lenses and/or laser surgery are used to*

correct vision problems
    - *describe technologies developed to protect astronauts from high-energy radiation*
- explain that scientific knowledge may lead to the development of new technologies, and new technologies may lead to or facilitate scientific discovery
    - explain, in general terms, how EMR-detection technologies have advanced scientific knowledge of our universe and the structure of matter
- explain how the appropriateness, risks and benefits of technologies need to be assessed for each potential application from a variety of perspectives, including sustainability
    - *assess the value to society of studying the structure and the history of the universe and the expense of building telescopes, such as the Hubble, or launching space probes*
    - *conduct a risk-benefit analysis regarding the use of radiation treatment for cancer or the frequency of use of EMR in medical diagnostics.*

Specific Outcomes for Skills (Science and Technology Emphasis)

Initiating and Planning
***Students will* formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues**

- design an experiment, identifying specific variables, to investigate the reflection, refraction or polarization of visible light
- calculate values for any of the variables in the universal wave equation
- *define a question regarding the frequency and duration of exposure to EMR from use of video terminals, cellular telephones and other devices*
- *state the qualitative relationship among optical density (refractive index), angle of incidence and total internal reflection*
- *evaluate and select appropriate instruments, such as a prism, a diffraction grating, a light meter or a spectroscope, for problem solving and inquiry*

Performing and Recording
***Students will* conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information**

- investigate the reflection, refraction or polarization of visible

light
- create data tables from investigations into polarization, reflection or refraction of visible light or draw diagrams to illustrate these phenomena
- create a summary table or a diagram of spectral lines observed from gas discharge tubes
- *record observations of the colour changes of an incandescent object, such as a light bulb, as temperature is changed*

Analyzing and Interpreting
***Students will* analyze data and apply mathematical and conceptual models to develop and assess possible solutions**
- observe and analyze the various spectra of an artificial light source, using a spectroscope, prism or diffraction grating
- *assess the bias, reliability and validity of electronically accessed information on exposure to EMR emitted by video terminals, cellular telephones and other devices*
- *propose solutions to reduce human exposure to EMR, emitted by such devices as radio telephones, laptop computers and video terminals, and identify the strengths and weaknesses of each solution*
- *pose new questions, such as "What is the relationship between the polarization of light and the ability of insects to use this property to navigate?" or "How are emission and absorption spectra used in determining the spectral classification of stars?"*

Communication and Teamwork
***Students will* work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results**
- *present multiple perspectives on the value of studying the structure and history of the universe and the expense of building telescopes or launching space probes*
- *use appropriate communication technology to elicit information on recent advances in the study of the universe*
- *participate in a variety of electronic group formats when developing criteria to assess telescopes designed to study the universe*
- *select and use multimedia capabilities for presenting research on the effect of locating a communications tower in a community*
- *take and defend a position in support for or against the location of a communications tower in their local community*

Section 1: General Topic Reference

Astronomy and Cosmology: *Science in Context: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.*

Electric Fields and Forces: *Science in Context: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.*

Electricity: *Canada in Context: Topic/definition page contains links to reference, biographies, news and magazine articles, academic journals, images, videos, audio, critical essays and websites.*

Electromagnetic Spectrum: *Science in Context: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.*

Electromagnetism: *Science in Context: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.*

Light: *Science in Context: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.*

Origins of the Universe: *Science in Context: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.*

Reflection, Refraction, Diffraction, and Wave Interference: *Science in Context: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.*

Space Exploration: *Science in Context: Topic/definition page contains links to featured content, reference, biographies, images, news, videos, academic journals, magazine articles, and websites.*

Telescope: *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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