Student-based Performance Standards

Science 30

Alberta Provincial Diploma Examinations

Alberta

Classification: Public

This document was written primarily for:

Students	✓	
Teachers	✓	of Science 30
Administrators	✓	
Parents		
General Audience		
Others		

Alberta Education, Government of Alberta

Science 30 Performance Standards

Distribution: This document is posted on the Alberta Education website.

Copyright 2019, the Crown in Right of Alberta, as represented by the Minister of Education, Alberta Education, Provincial Assessment Sector, 44 Capital Boulevard, 10044 108 Street NW, Edmonton, Alberta T5J 5E6, and its licensors. All rights reserved.

Classification: Public

Contents

Please note that if you cannot access one of the direct website links referred to in this document, you can find diploma examination-related materials on the Alberta Education website.

Classification: Public

Introduction

The *Science 30 Student-based Performance Standards* document is designed to be a tool for the classroom teacher. **This document is not the program of studies.** Rather, it is intended to provide teachers with examples of behaviours exhibited by students at the acceptable standard and at the standard of excellence for this course. These lists of behaviours are neither prescriptive nor exhaustive. This document should be used in conjunction with the program of studies.

The relative number of behaviours described in each unit is not an indication of the time required. Teachers should be guided by the program of studies, which indicates that each of the four units should be allotted 25% of the time in the course. In addition, the described behaviours span the range of cognitive levels (Remembering/Understanding, Applying, and Higher Mental Activities). Details about cognitive levels can be found in the *Science 30 Information Bulletin*.

Some of the described behaviours cannot be adequately assessed in a paper-and-pencil format, especially if the assessment instrument is exclusively machine-scored. However, they are part of the program of studies and should be assessed as part of the school-awarded mark in Science 30.

The statements in this document reflect specific knowledge, skills, and STS outcomes in the Science 30 Program of Studies.

The skills of collaboration, teamwork, and scientific communication are present in every unit of the program of studies. It is assumed that Science 30 students at both the acceptable standard and the standard of excellence would display the behaviours associated with these skill outcomes throughout the course. Therefore, behaviours associated with these outcomes have not been described repeatedly throughout this document.

Many of the standards in this document are related to laboratory activities that are best experienced directly by the student. Some of these could be replaced by teacher demonstrations, multimedia presentations, or digital simulations, but direct student participation in laboratory activities should be maximized, with substitutes used only when direct experiences are not possible for safety or environmental reasons.

Experimental design is an integral part of all four units in Science 30, and several of the related standards are found in each and every unit of the course.

For more information, contact

Stan Bissell
Science 30 Exam Manager
780-422-5730 or Stan.Bissell@gov.ab.ca

or Mark Haak
Science 30 Examiner
780-422-3337 or Mark.Haak@gov.ab.ca

Classification: Public

General Outcome A1

Students will analyze how the human circulatory system facilitates interaction between blood cells and the external environment and investigate cardiovascular health.

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• identify the chambers and major associated vessels of the mammalian heart on a diagram, model, or dissected heart, and describe their functions	• explain how a given heart defect would impair the typical functioning of the heart
• relate the structure of valves in the heart and veins to how they work to direct the flow of blood in the circulatory system	• compare the function or components of the mammalian circulatory system to a circulatory system of another organism or to analogies of the circulatory system
• explain what happens during each stage of the rhythmic contraction of the heart by describing the position of the heart valves (open or closed) and condition of the ventricles and atria (relaxed or contracting)	
• relate the rhythmic contraction and relaxation of the heart chambers to systolic and diastolic blood pressures	• explain what happens during each stage of the rhythmic contraction of the heart by describing the position of the heart valves (open or closed) and condition of the ventricles and atria (relaxed or contracting)
• use a digital blood pressure cuff, or manual sphygmomanometer and stethoscope, to measure blood pressure	• compare blood pressure and heart rate readings with the typical resting values for a healthy adult
• measure heart rate when resting and after exercise	
• order the sequence of blood flow through the chambers and major associated vessels of the mammalian heart beginning at any location in the circulatory system	• compare circulation in the pulmonary pathway with circulation in the systemic pathway
• identify capillaries as the site of oxygen exchange in pulmonary and systemic tissues	
• compare arteries, arterioles, veins, venules, and capillaries in terms of structure	
• compare arteries, arterioles, veins, venules, and capillaries in terms of function	
• compare arteries, arterioles, veins, venules, and capillaries in terms of direction of blood flow	

Classification: Public

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• compare arteries, arterioles, veins, venules, and capillaries in terms of relative blood pressure • compare arteries, arterioles, veins, venules, and capillaries in terms of relative oxygen and carbon dioxide content of the blood that they carry • state that the role of blood is to transport substances including nutrients, wastes, gases, and hormones; to defend against pathogens; and to distribute thermal energy • rank the four major blood components according to their proportion in whole blood • describe the role of plasma, red blood cells, white blood cells, and platelets • state that plasma and platelets work together to clot blood • state that plasma carries dissolved carbon dioxide and some oxygen • state that red blood cells contain hemoglobin and that hemoglobin carries oxygen and some carbon dioxide	
• identify possible symptoms in a person who lacks sufficient levels of one of the main blood components (e.g., unable to clot blood with a low platelet count)	• evaluate given symptoms of a person who lacks sufficient levels of one of the main blood components to determine the blood component that is lacking
• identify variables in experiments where the responding variable is either blood pressure or heart rate	• design an experiment in which the responding variable is either blood pressure or heart rate
• follow a procedure in an experiment where exercise is the manipulated variable and the responding variable is blood pressure and/ or heart rate	• evaluate and suggest improvements to experiments that are designed to determine the effects of exercise, emotion, caffeine, and other factors on blood pressure and heart rate
• identify human blood cells by their colour, size, shape, and relative number when observing a prepared blood slide using a light microscope or an electronic image	• analyze microscopic images of a person's blood where the relative number of blood cells is atypical and make an inference about the person's health (e.g., a person may be suffering from an infection where an elevated white blood cell count is observed)

Classification: Public

General Outcome A2

Students will analyze the defense mechanisms used by the human body to protect itself from pathogens found in the external environment.

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• define *pathogen* and provide some examples of pathogens	
• list structures and processes that restrict entry of pathogens into the body	• distinguish between non-specific defense mechanisms (e.g., skin, tears, stomach acid) and specific defense mechanisms (e.g., antibodies are produced against a particular pathogen)
• describe situations that would increase the likelihood of pathogens entering the body	
• describe the role of macrophages, B cells, helper T cells, killer T cells, suppressor T cells, and memory cells	
• identify a type of white blood cell from a diagram or simulation showing the action of that type of white blood cell	
• order a sequence of events in an immune response	• compare an immune response after exposure to a new pathogen with an immune response after exposure to a pathogen to which immunity has already been acquired
	• explain how the immune response would be affected if a particular immune cell is missing or not functioning
• contrast autoimmune disorders with infectious diseases	• explain why autoimmune disorders are often difficult to treat
• identify a disorder as being autoimmune given a description of the disorder	• explain how a vaccination results in immunity to a specific pathogen
• describe the relationship between antigens and antibodies	• predict relative antibody levels after vaccination or exposure to a pathogen
	• interpret graphs of antibody levels after vaccination or exposure to a pathogen
• identify manipulated, responding, and controlled variables in an experimental design	• design or interpret a study on the immune system
• use simulations to model the spread of a pathogen in a population with partial immunity against that pathogen	• interpret data from vaccination programs to draw conclusions about the efficacy of particular vaccines in a population

Classification: Public

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
	• evaluate sources of information on vaccination safety

Classification: Public

General Outcome A3

Students will apply the principles of heredity and molecular genetics to explain how human diseases can arise from inherited traits, the risks and benefits of genetic technology, and the need for ethical considerations in the application of scientific knowledge.

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• identify the process of mitosis, meiosis, or fertilization from a diagram showing stages of the process	
• order a sequence of stages showing chromosome behaviour in either mitosis or meiosis	
• perform a simulation of mitosis or meiosis to demonstrate the behaviour of chromosomes	
• define *haploid* and *diploid*	
• define *dominant* and *recessive*	
• distinguish between genotype and phenotype	• explain how genotype determines phenotype
• write genotypes for given phenotypes by representing dominant alleles with upper case letters and recessive alleles with lower case letters (e.g., *HH*, *Hh*, or *hh*)	
• represent X-linked alleles with appropriate symbols (e.g., X^BX^b, X^BY)	
• analyze a genotype to determine phenotype	
• state that a person could be a carrier for a genetic disease, but not express that disease	• explain how a person could be a carrier for a genetic disease, but not express that disease
• interpret the results of monohybrid crosses from given Punnett squares	• relate the representation of alleles in a Punnett square to the processes of meiosis and fertilization
• determine the probabilities of genotypes and phenotypes occurring in offspring for dominant and recessive autosomal or X-linked traits	• compare autosomal recessive, autosomal dominant, X-linked recessive, X-linked dominant, and Y-linked patterns of inheritance
• express genotype or phenotype probabilities as a fraction, percentage, or decimal between 0 and 1	• analyze genotypic or phenotypic ratios to determine the genotype or phenotype of the parents
	• analyze pedigree charts to determine the pattern of inheritance

Classification: Public

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• describe the phenotypes of individuals in a given pedigree chart	• analyze pedigree charts to determine the phenotypes and genotypes of individuals when the inheritance pattern of the trait is known • construct pedigree charts from descriptions of the incidence of a trait in a family
• state that chromosomes are composed of DNA and that genes are regions of DNA • describe the relationship between genes, DNA, and amino acids • describe how genetic information is coded for by the sequence of bases in DNA molecules • identify the three components of a nucleotide • use the letters A, T, C, and G to represent nitrogen bases • describe nitrogen base pairing in DNA • match nitrogen bases with complementary bases • describe the molecular structure of DNA, including the double helix shape and the complementary nature of the two strands • draw or construct a model of a DNA nucleotide • construct a model of DNA to show the general structure and arrangement of bases • outline the process of DNA replication • perform a simulation to demonstrate replication • use a table of DNA triplets matched with amino acids to determine the amino acids that are coded for in a given gene sequence • determine a possible sequence of nitrogen bases for a given sequence of amino acids • determine whether a given mutation will result in a new amino acid being produced • list the roles of proteins in the human body • classify proteins based on their role (e.g., structural, regulatory, transport, defensive, energy)	

Classification: Public

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• state that enzymes and hormones are types of regulatory proteins • state that hemoglobin is a type of transport protein • state that an antibody is a type of defensive protein	
• relate genetic disorders to DNA mutations	• explain how the consequences of mutations in DNA can be positive, negative, or neutral for an organism
• describe how GMOs can be developed through genetic engineering by inserting new DNA sequences into their genomes	• analyze risks and benefits of developing and using specific GMOs • research and present information on a particular GMO • explain how genetic engineering could be used to meet societal needs
• relate genetic engineering to gene therapy	• analyze examples of genetic technologies to determine intended and unintended consequences
• outline the general process of genetic engineering • outline the general process of gene therapy	• analyze risks and benefits of developing and using specific GMOs and gene therapies from social, cultural, environmental, ethical, and economic perspectives
• describe the potential for gene therapy to cure genetic diseases • state that plasmids are rings of DNA that can be transferred between bacteria	
• identify the process of plasmid transfer or transformation of DNA fragments from a diagram	• explain how plasmid transfer and transformation of DNA fragments contribute to antibiotic resistance in bacteria
• distinguish between social, cultural, environmental, ethical, and economic perspectives on genetic technologies	
• describe factors that promote the development of antibiotic resistance in bacteria	• explain how natural selection can lead to the development of antibiotic resistance in bacteria or the development of pesticide resistance in insects

Classification: Public

General Outcome B1

Students will analyze the sources of acids and bases and their effects on the environment.

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• state that acids can be modelled as proton donors and that bases are proton acceptors	• analyze reaction equations or equilibrium equations to classify proton donors and acceptors
• identify the conjugate base of an acid and the conjugate acid of a base	• compare strong acids and weak acids in terms of proton transfer
• state that equilibrium arrows represent reactions occurring simultaneously in two directions in a solution that is in equilibrium	• differentiate between acid concentration and acid strength
• rank acids according to strength using a table of relative acid strength	• compare the results of diagnostic tests performed on strong acids and weak acids
• define *pH* in terms of hydronium ion concentration	
• describe the logarithmic nature of the pH scale and compare the relative hydronium ion concentration of two solutions given their pH (e.g., the $[H_3O^+(aq)]$ of a solution with a pH of 4 is 1 000 times greater than the $[H_3O^+(aq)]$ of a solution with a pH of 7)	
• calculate the pH of a solution given the hydronium ion concentration	
• calculate the hydronium ion concentration given the pH of a solution	

Classification: Public

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• measure the pH of a solution using a pH meter or pH paper • explain how acid–base indicators can be used to differentiate between acid and base solutions • relate the colour of an acid–base indicator in solution, including intermediate colours, with the pH range of the solution • use a table of acid–base indicators to predict the colour of an indicator in a solution of known pH • use a dichotomous key to classify unknown solutions as acidic, basic, neutral ionic, or neutral molecular • predict observations expected from diagnostic tests on known solutions • describe how diagnostic tests can be used to differentiate between neutral molecular solutions, acidic solutions, basic solutions, and neutral ionic solutions • given the results of diagnostic tests on various solutions, classify these solutions as either neutral ionic solutions, acidic solutions, basic solutions, or neutral molecular solutions	• select an appropriate acid–base indicator for a particular diagnostic test being performed on an acid or base
• follow a procedure to test solutions for conductivity, pH, and reactivity with metals	• design an experiment where unknown solutions can be classified as acidic, basic, neutral ionic, or neutral molecular
• perform a series of tests with acid–base indicators and record resulting colour changes	• given the results of acid–base indicator colour changes for a particular solution, use a table of acid–base indicators to analyze and determine the pH range in which that solution falls • evaluate and suggest improvements to experiments that classify solutions according to conductivity, pH, and reactivity with metals
• outline the steps in a titration of a strong monoprotic acid with a strong monoprotic base	• evaluate sources of error in a titration procedure
• pipette a precise volume of acid for a titration trial	• relate the number of titration trials to the reliability of the titration

Classification: Public

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• identify the equipment used in a titration	• compare results of multiple titration trials and identify trials that are appropriate for calculating concentration
• determine the volume of titrant used in a trial by reading from a burette	
• use data from a titration to calculate the concentration of an acid, calculate the concentration of a titrant, or calculate the average volume of titrant used in an acid–base titration	• analyze data or graphs to draw conclusions about the buffering capacity of soil or water samples
• define *buffer system* and describe the properties of a buffer solution	• interpret a graph of a titration of a monoprotic acid and identify the buffering region
• contrast the impact of acid deposition in areas with soils that have different buffering capacities	
• relate the process of buffering to the importance of pH regulation in living organisms	• distinguish between sources of acid-forming emissions that are the result of human activities and those that are the result of natural events
• list sources of sulfur oxide (SO_x) and nitrogen oxide (NO_x) emissions	
• state that SO_x and NO_x gases combine with water to produce the acids that result in acid deposition	
• outline chemical reactions for the formation of acids involved in acid deposition	
• explain the difference between the terms *acid deposition* and *acid rain*	• explain the relationship between the buffering capacity of an area and the impact of acid deposition on that area
• identify the acids that are involved in acid deposition (i.e., sulfurous acid, sulfuric acid, nitrous acid, and nitric acid)	
• describe the process that results in rain being naturally acidic	
• list potential impacts of acid deposition on the environment, including metal leaching	• analyze the impacts of acid deposition on the biotic and abiotic components of a particular environment
• match common acids and bases with their household or industrial uses	

Classification: Public

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• indicate the prevailing wind direction on a map of Alberta, Canada, or North America	• apply knowledge of prevailing wind direction to predict the location on a map that would be most affected by acid deposition
• state that the prevailing wind direction in Alberta, Canada, and North America is from west to east	• analyze strategies or processes to reduce the impact of acid deposition
• relate prevailing wind direction to the impact of acid deposition in a particular area	
• identify manipulated, responding, and controlled variables in experimental designs of diagnostic tests, titrations, or buffering capacity investigations	• design an experiment to compare the buffering capacity of different soil or water samples

Classification: Public

General Outcome B2

Students will analyze the sources of organic compounds and their effects on the environment.

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• classify carbon compounds that contain up to three carbon atoms in the parent chain as either halogenated hydrocarbons, alcohols, carboxylic acids, or esters from given structural diagrams • name halogenated hydrocarbons, alcohols, carboxylic acids, and esters that contain up to three carbon atoms in the parent chain using IUPAC nomenclature • draw halogenated hydrocarbons, alcohols, carboxylic acids, and esters that contain up to three carbon atoms in the parent chain using either molecular model representations, expanded, condensed, or line structural diagrams • identify benzene rings and the functional groups of halogenated hydrocarbons, alcohols, and carboxylic acids in structural diagrams of molecules	
• list some common uses of esters, such as artificial flavourings, fragrances, and polymers • list some common uses of alcohols, such as fuels, solvents, and disinfectants • match halogenated hydrocarbons, alcohols, carboxylic acids, and esters with their common uses • state that hydrocarbons (including benzene), CFCs, PCBs, dioxins, and furans are environmental pollutants • match CFCs, PCBs, dioxins, and furans with their sources and their associated hazards • identify structural diagrams of CFCs, PCBs, dioxins, and furans • describe the process by which CFCs deplete the ozone layer • describe the impact of banning the use of CFCs	• classify halogenated hydrocarbons, alcohols, carboxylic acids, and esters according to their properties • investigate the properties of alcohols, carboxylic acids, and esters • describe how hydrocarbons (including benzene), CFCs, PCBs, dioxins and furans affect living systems globally

Classification: Public

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• outline how photochemical smog is produced • list some constituents of photochemical smog, including NO_x and O_3 • describe conditions that may increase the production of photochemical smog • identify some health effects and environmental impacts of photochemical smog	
• describe potential strategies or identify technologies that can reduce photochemical smog	• evaluate potential strategies or identify technologies that can reduce photochemical smog
• state that PCBs, DDT, dioxins and furans, and other POPs biomagnify in the food chain	• explain, using the properties of persistence and fat solubility, how PCBs, DDT, dioxins and furans, and other POPs biomagnify in the food chain
• explain why the use of DDT has been banned in many countries	• contrast the hazard of ground-level ozone with the role of ozone in the upper atmosphere
• identify alternatives or technologies that can reduce the release of POPs into the environment	• compare the concentration of POPs that biomagnify in organisms at lower and higher levels of a food chain
• describe the effects of POPs that biomagnify on organisms at higher levels in a food chain	• analyze case studies where biomagnification has occurred
• identify possible sources of organic waste, such as fertilizer or manure, that affect biological oxygen demand • evaluate pesticides in terms of their persistence, toxicity, volatility, target specificity, or resistance development • relate increased emissions of carbon dioxide, methane, and CFCs to climate change • identify strategies or technologies that can reduce emissions of human-produced greenhouse gases into the environment	

Classification: Public

General Outcome B3

Students will analyze, from a variety of perspectives, the risks and benefits of using chemical processes in meeting human needs and assess technologies for reducing the impact of chemical compounds on the environment.

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• identify strategies or technologies to reduce pollutants outlined in general outcome B1 or B2	• evaluate strategies, technologies, or alternatives that can address an environmental issue outlined in general outcome B1 or B2 from a variety of perspectives
• describe how the concentration of a substance affects the safe use of or exposure to that substance	
• match WHMIS 2015 pictograms to the hazards they represent	
• select an appropriate WHMIS 2015 pictogram for a substance given a description of that substance's potential hazards	
• identify potential risks of using a product from consumer product labelling information	
	• evaluate the safety of a given laboratory procedure
• describe how to safely handle, store, and dispose of strong acids and bases used in a titration	
• identify manipulated, responding, and controlled variables in experiments that test the effectiveness of a pesticide or pollution-reduction strategy	• design or interpret experiments that test the effectiveness of a pesticide or pollution-reduction strategy
• relate levels of organic waste in a body of water to biological oxygen demand and dissolved oxygen levels	• analyze and draw conclusions from water-quality data (e.g., pH, BOD, dissolved O_2)
	• evaluate alternatives to chemical pesticides, such as biological controls or using genetically modified crops to resist pest insects
	• explain how resistance to a pesticide could develop in an insect population and identify factors that could promote pesticide resistance

Classification: Public

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
	• compare pesticide resistance to antibiotic resistance in bacteria • research and assess methods to reduce acid deposition and photochemical smog

Classification: Public

General Outcome C1

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

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• define *vector field*	• contrast the properties of electric, magnetic, and gravitational fields
• list the properties of a vector field • select the appropriate test object for a particular field	• describe the role of a test object in determining the direction of a field at a point in space
• describe the attraction and/or repulsion that one object exerts on another when the objects are electric charges, magnetic poles of bar magnets, and masses • draw a diagram showing the field lines (including direction) around a mass, a charged object, or a bar magnet • recognize that Earth's magnetic field can be modelled as being produced by a bar magnet • use iron filings or a compass to determine and plot the field lines around a bar magnet • draw a diagram showing the expected field produced by two charged objects or produced by two poles of bar magnets • identify attraction and repulsion from diagrams showing field lines	
• identify the graph shape that corresponds to the electric or gravitational field strength formula • observe and record the interaction between static electric charges and between the poles of bar magnets	• explain the relationship between graph shape and the electric or gravitational field strength formula
• calculate electric field strength when given charge and radius	• determine how changing the radius or charge proportionally affects the electric field strength
• calculate gravitational field strength when given mass and radius	• determine how changing the radius or mass proportionally affects the gravitational field strength
• identify a graph showing the relationship between electric or gravitational field strength and distance	• plot a graph of the relationship between electric field strength and distance

Classification: Public

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• describe the relationship between electric or gravitational field strength and distance as inverse squared	• plot a graph of the relationship between gravitational field strength and distance
• define *electromagnetic induction*	
• measure and record the electrical current produced when a conductor is moved through a magnetic field	
• identify a diagram of a setup that would produce electrical current through electromagnetic induction	
• define *power*, *voltage*, *current*, and *resistance*	
• describe how changing the voltage, current, or resistance in a circuit affects the other values	• construct circuits with up to three resistors in series or parallel from a circuit diagram
• calculate the current, voltage, or power for a circuit by selecting an appropriate formula, and re-arranging that formula if necessary	• compare current, voltage, and resistance in series circuits with current, power, and voltage in parallel circuits
• calculate the total resistance of a circuit with up to three resistors arranged in series	• analyze circuit diagrams showing up to three resistors in series or parallel
• construct circuits with up to three resistors in series or parallel from a circuit diagram	
• follow a procedure to construct circuits with up to three resistors in series or parallel	• design an experiment to confirm the relationships of the formula $V = IR$
	• explain the relationship between graph shape and the formula $V = IR$
• measure the current and voltage for a constructed circuit	
• recognize standard circuit symbols	
• draw circuit diagrams using standard circuit symbols	
• describe how an ammeter and voltmeter should be arranged in a circuit to provide readings of current and voltage	
• identify the correct arrangement of an ammeter and voltmeter in a constructed circuit or in a circuit diagram	• analyze constructed circuits or circuit diagrams to troubleshoot circuits that are not operating
• convert energy in joules to kilowatt hours and kilowatt hours to joules	• analyze an electrical power bill to calculate the cost of energy given the price per kilowatt hour and the electricity consumption
• calculate energy in joules or kilowatt hours	

Classification: Public

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• describe how a transformer operates • state that a transformer works with AC and not with DC • contrast the properties of AC and DC • compare step-up transformers with step-down transformers • classify a transformer as step-up or step-down from a schematic diagram of the transformer	
• calculate the number of turns, voltage, or current on the primary or secondary coils of a transformer	• relate electromagnetic induction to the function of transformers
• identify manipulated, responding, and controlled variables in experiments that investigate the current, voltage, or resistance of a circuit	• design an experiment where the responding variable is current, voltage, or resistance for an electrical circuit
• follow a procedure to investigate the current, voltage, or resistance in a circuit • list some circuit safety technologies • describe how a circuit safety technology works to prevent electrocution • identify the most appropriate placement of circuit safety technologies	
	• compare the design, operation, input, and output of a simple electric generator with a simple electric motor • construct and test a simple electric generator or DC motor • evaluate the design of a simple electric generator or DC motor

Classification: Public

General Outcome C2

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.

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• recognize and label a wavelength on a diagram of a wave • define *wave frequency* • state that all types of EMR have a speed of 3.00×10^8 m/s in the vacuum of space, and recognize that the speed of EMR in the vacuum of space is represented by the symbol *c* • order types of EMR according to wavelength, frequency, or relative energy per photon	
• distinguish between non-ionizing EMR and ionizing EMR • state that ionizing EMR can cause mutations in DNA • classify constituents of the EMR spectrum according to source, frequency, wavelength, relative energy per photon, atmospheric penetrability, or ionizing ability	• evaluate the safety of exposure to a particular frequency of EMR
• contrast visible EMR with other types of EMR in terms of frequency, wavelength, and relative energy per photon • list types of EMR that do not penetrate Earth's atmosphere because they are absorbed • state that some frequencies of ultraviolet EMR are absorbed by Earth's ozone layer and do not reach Earth's surface, while other frequencies of ultraviolet EMR can penetrate Earth's atmosphere • list examples of medical, communication, or other applications of EMR technologies	• explain the relationship between graph shape and the universal wave equation formula
• describe the phenomena of reflection, refraction, polarization, and diffraction	• predict the path of a reflected light ray given an incident ray and a normal line in a diagram

Classification: Public

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• identify the phenomena of reflection, refraction, diffraction, and polarization from given diagrams • draw diagrams to illustrate the phenomena of reflection, refraction, polarization, and diffraction	• predict the path of a refracted light ray given an incident ray and a normal line in a diagram
• describe applications of reflection, refraction, polarization, and diffraction • select the types of EMR that must be studied outside Earth's atmosphere using space-based telescopes and those that can be effectively studied within Earth's atmosphere using ground-based telescopes • compare the basic properties of reflecting and refracting telescopes • explain why astronauts or equipment outside Earth's atmosphere require shielding from EMR • describe how the information from EMR-detection technologies has advanced knowledge of the universe • calculate wavelength, frequency, or speed of EMR or other types of waves (e.g., sound) using the universal wave equation • identify the energy released in fusion reactions in the Sun and other stars as a source of a wide spectrum of EMR • identify manipulated, responding, and controlled variables in experiments that investigate properties of EMR or the phenomena of reflection, refraction, polarization, or diffraction • follow a procedure to investigate a property of EMR or the reflection, refraction, or polarization of EMR	• compare the phenomena of reflection, refraction, polarization, and diffraction
• interpret data from investigations of the reflection, refraction, or polarization of EMR	• design an experiment to investigate reflection, refraction, or polarization of EMR • evaluate and suggest improvements to experiments that investigate reflection, refraction, or polarization of EMR
• state that a spectroscope can be used to measure the wavelength of EMR emitted from an object	

Classification: Public

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• explain that spectra can be used to determine the composition of incandescent objects or substances	• compare emission (bright-line) spectra with absorption (dark-line) spectra, including the conditions necessary to produce each type of spectrum
• draw diagrams of bright-line spectra produced by high-voltage gas discharge tubes	• compare spectral lines produced from discharge tubes of various gases
• relate the wavelength of EMR measured by a spectroscope to the colour of visible light emitted by a star and to the star's relative surface temperature	• analyze the spectral lines from EMR emitted by a celestial body and determine the composition of the elements in that body by comparing to reference spectra
• use a spectroscope, prism, or diffraction grating to observe spectra of artificial light sources	• use a spectroscope, prism, or diffraction grating to compare spectra of artificial light sources
• explain how the Doppler effect can be used to determine the velocity of celestial objects	
• state that stars begin their life cycle in a nebula	
• outline the stages in the evolution of stars of small, intermediate, and large mass	• classify a telescope as reflecting or refracting from descriptions or diagrams showing their design
• contrast stars that emit different colours of visible light in terms of their relative surface temperature	
• identify the end stage of evolution in the life cycle of small-mass, intermediate-mass, and large-mass stars	• compare spectra that have been red shifted with spectra that have been blue shifted
• rank black holes, white dwarves, and neutron stars according to the mass of the star that produced those celestial bodies	• use evidence of Doppler-shift in EMR observed from distant galaxies to support the idea that the universe is expanding
• identify nebulae, black holes, white dwarves, and neutron stars from images and diagrams	• evaluate the advantages and disadvantages of space exploration

Classification: Public

General Outcome D1

Students will explain the need for balancing the growth in global energy demands with maintaining a viable biosphere.

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• recognize graphical representations of exponential growth in global energy consumption	• differentiate between the total energy consumption in contemporary society and the total energy consumption of pre-contact or pre-industrial societies
• plot data of population, total energy consumption, and per capita energy consumption over time	• research and present strategies that could help lower per capita energy consumption
• calculate per capita energy consumption given population and total energy consumption data	• analyze data or graphs showing energy consumption to draw conclusions, extrapolate, or make predictions
• describe how a per capita measurement can be useful	
• recognize that Canada has high per capita energy consumption compared to other countries	
• list factors that affect energy consumption, such as GDP, lifestyle, level of industrialization, geography, and climate	
• identify the factors that result in Canada's high per capita energy consumption	
• define *sustainable development*	
• relate increased efficiency to sustainable development and to per capita energy use	
• identify practices that promote sustainable development	
• define *renewable energy*	
• classify energy sources as renewable or non-renewable	
• identify environmental impacts of using various renewable and non-renewable sources of energy production	• research and compare energy production by source for different countries or regions
• match sources of energy production with their environmental impacts	• debate the advantages and disadvantages of developing an energy source in an environmentally sensitive area
	• assess a given energy policy, proposed energy-producing technology, or strategy to reduce energy consumption

Classification: Public

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• describe an Aboriginal perspective of an interconnected environment	• evaluate a policy decision according to the degree to which it balances resources extraction with environmental impact

Classification: Public

General Outcome D2

Students will describe the Sun as Earth's main source of energy and explain the functioning of some conventional and alternative technologies that convert solar, nuclear, tidal, and other energy sources into useable forms.

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• calculate heat of combustion using Hess's Law given a balanced combustion reaction equation • compare the heat of combustion for different fuel sources	
• state that a very high proportion of solar energy received by Earth creates wind and drives the water cycle and that a very small proportion of solar energy received by Earth is captured by photosynthesis	• analyze diagrams, charts, or graphs of Earth's solar radiation budget and identify the proportion that corresponds to energy that creates wind and drives the water cycle and the proportion that corresponds to energy captured by photosynthesis
• state the three different forms of fossil fuels (coal, oil, and natural gas) and provide some examples of their uses • list some types of biomass that are used to generate heat or fuel vehicles • trace the energy pathway for the transformation of renewable and non-renewable sources of energy from their original source of energy (e.g., the chemical potential energy in coal originated from radiant solar energy) • outline the energy transformation pathway to electrical and thermal energy for renewable and non-renewable energy-generating technologies (e.g., in a coal-fired power plant the chemical potential energy of coal is transformed into thermal energy when it is burned, and the thermal energy is transformed into the kinetic energy of high-pressure steam, which is transformed into the kinetic energy of a spinning turbine)	
• classify sources of energy according to those that originate with radiant solar energy and those that do not originate with radiant solar energy	• debate the feasibility of replacing fossil fuels with biofuels or hydrogen fuel

Classification: Public

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• explain how a wind turbine, hydroelectric dam, biomass-burning plant, geothermal power plant, and hydrogen fuel cell work to produce electrical or thermal energy	• evaluate advantages and disadvantages of using a particular renewable energy-generating technology from various perspectives (e.g., economic, environmental, societal)
• describe the emissions that are reduced or eliminated when a renewable energy technology replaces a technology that relies on fossil fuels	• assess the suitability or feasibility of a renewable or non-renewable energy-generating technology for a particular location or situation
• contrast active solar heating with passive solar heating	
• contrast fission and fusion reactions	• determine a missing product for a given incomplete nuclear process
• identify examples of fission or fusion from a given diagram of the process	
• write and balance given nuclear reaction equations	• explain the balancing of nuclear reaction equations using conservation of nucleons and conservation of charge
• define *radioactive decay*	
• classify a nuclear decay as either alpha, beta, or gamma decay given a nuclear equation representing the nuclear decay	• compare alpha, beta, or gamma decay in terms of their source and the radiation emitted
• relate radioactive decay to geothermal energy	
• calculate the mass change for a particular nuclear change using a table of nuclide masses	• determine the mass–energy change for a given nuclear change
• calculate the energy change for a particular nuclear change using the formula $\Delta E = \Delta mc^2$ given the mass change	
• calculate the percent efficiency of an energy transformation in a device given the input and output energies	
• state that some input energy is transformed into thermal energy during an energy transformation and relate this concept to efficiency	
• identify the major components of a nuclear fission power plant and describe how the plant operates to produce electricity	

Classification: Public

Behaviours of a student functioning at the **acceptable standard** include, but are not limited to, the following:	Behaviours of a student functioning at the **standard of excellence** include, but are not limited to, the following:
• describe the current limitations of using nuclear fusion to generate energy on a large scale • identify the major components of a coal-fired power plant and describe how the plant operates to produce electricity • identify where phase changes occur during the energy transformations in nuclear or combustion power plants • rank nuclear, chemical, and phase changes according to the energy released by those changes	
• select the fuel from a list that would provide the greatest energy per gram or per mole	• compare the advantages and disadvantages of producing electricity from nuclear fission reactions with the advantages and disadvantages of producing electricity from burning fossil fuels
• draw diagrams of the relative locations of the Sun, Earth, and the Moon for low tides and high tides	• compare the energy transformations that occur when producing electricity from tidal sources to the energy transformations that occur when producing electricity from hydroelectric sources
• describe the relative positions of the Sun, Earth, and the Moon that would produce the greatest and least tidal variation on Earth • describe how a tidal barrier dam operates to produce electricity • describe how a hydroelectric dam operates to produce electricity	

Classification: Public