Physical Science 21 (2018)

Course Overview

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Overview

The purpose of this document is to provide an introduction to the *Physical Science 21 (2018)* course and supplementary resource packages that were developed by a committee of teachers representing various school divisions. The entire course package consists of this course overview and five supplementary resource packages, namely:

- *Physical Science 21 (2018) Resource Package – Career Exploration*
- *Physical Science 21 (2018) Resource Package – Student Directed Study*
- *Physical Science 21 (2018) Resource Package – Heat*
- *Physical Science 21 (2018) Resource Package – Foundations of Chemistry*
- *Physical Science 21 (2018) Resource Package – Properties of Waves*

The following individuals participated in the development of the *Physical Science21 (2018)* course and resource packages.

• Talena Scott	Chinook S.D. #211
• Manjula Rawal	Northern Lights S.D. #113
• Darren Forbes	Regina S.D. #4
• Melanie Mayer	Regina R.C.S.S.D. #81
• Michael Graham	South East Cornerstone S.D. #209
• Dawn Pratt	Saskatoon Tribal Council
• Danette Senterre	Saskatchewan Polytechnic
• Camille Hounjet	Sun West S.D. #207
• Dean Elliott	Science Consultant – Ministry of Education
• Fatma-Zohra Henni	Consultant, Math & Science, French – Ministry of Education

School divisions wishing to receive copies of this course should submit a request to the ministry at curriculum@gov.sk.ca. The necessary documents will be sent back to the school division so they can submit an application through Blackboard. Once approval is received from the Ministry of Education, the school division may start using this course.

If a student is being considered for *Physical Science 21 (2018)*, or any other modified course of study, the student and the parents/caregivers of the student must be consulted prior to being enrolled in a Locally Modified Course of Study. Consult *Policy and Procedures for Locally Modified Courses of Study* for further information.

Introduction

Science is a required area of study in Saskatchewan's Core Curriculum. Students require *Science 10* and a 20-level science course in order to meet graduation requirements. A modified course (e.g., *Physical Science 21*) can be used to fulfill the 20-level science requirement.

The *Physical Science21 (2018)* course and resource package was developed to reflect the structure of the renewed *Physical Science 20* curriculum. Therefore, teachers should use *Physical Science 20*, which is available at http://www.curriculum.gov.sk.ca, to assist with unit planning and instruction for *Physical Science 21 (2018)*.

Using this Resource Package

This resource package is divided into five themes that will guide student learning and support meeting *Physical Science21 (2018)* learning outcomes. Each of the themes is divided into individual lessons. Lessons can be used together to support a learning theme or be used individually at the teacher's discretion. When looking at lessons within each theme, the following headings, as seen in the handouts provided, indicate the various stages of learning:

- **What Do You Know…**
  - activate students prior knowledge
- **Did You Know…**
  - engage students with content of lesson
- **Show What You Know….**
  - follow-up student learning related to the "Did You Know…" and/or "What Do You Know…" handout
- **Practice What You Know…**
  - engage students in hands on activity and/or research
- **Check What You Know…**
  - assess student learning (formative and/or summative)

Some outcomes are addressed in more than one of the suggested lessons within a learning theme; therefore teachers need not use all of the suggested lessons. Teachers may request an electronic version of this course package from their school division office so that they can modify the instructional documents to meet diverse needs.

Learning Theme Correlation

The table below show which outcomes each of the five learning themes support.

Theme	CE1	SDS1	HT1	HT2	FC1	FC2	FC3	PW1	PW2	PW3
Career Exploration	X									
Student Directed Study		X								
Heat			X	X						
Foundations of Chemistry					X	X	X			
Properties of Waves								X	X	X

General Suggestions for Teaching Physical Science 21 (2018)

Students in *Physical Science 21 (2018)* may be capable of completing the same activities as students in *Physical Science 20*, but may require appropriate adaptations to meet individual learning needs. For example, students may need additional time to complete a particular activity, may require more guidance while performing the activity or may require additional assistance with reading through a lab and interpreting the procedure to carry out the steps of the investigation.

Students in modified courses, such as *Physical Science 21 (2018)*, often experience success with assignments when given some guidance, or a template. For example, doing a complete lab write-up beginning with a blank sheet of paper may be too much of a challenge. However, if a student is provided a partial lab write-up and required to fill in information as they carry out the investigation, they will likely experience more success with the task.

Incorporating educational videos into lessons may facilitate the learning of some concepts in any course. Teachers need to pay attention to student learning styles when using video, particularly in a modified course. Some suggestions for use of video would be to watch the video in short clips as well as provide the students with sufficient guidance (including handouts) to assist them with gathering important information from the video.

Adaptive Dimension

In order to meet the variety of students' needs, flexibility is required within the school program to enable schools and teachers to adapt instructional materials, methods, and the environment to provide the most appropriate educational opportunities for all students. The Adaptive Dimension is used to:

- help students achieve curriculum outcomes
- maximize student learning and independence

- lessen discrepancies between achievement and ability
- promote a positive self-image and feeling of belonging
- promote a willingness to become involved in learning
- provide opportunities for all students to be engaged in learning.

The intent of the Adaptive Dimension applies to all programs and courses of instruction. The key variables of instruction are differentiated--the content (what students will learn), the learning processes (how students will interact with the content), the learning products (how students will demonstrate learning and mastery of content) and the instructional setting or environment.

Whenever possible, students should learn a regular curricula and be supported through the Adaptive Dimension. Some students may not be able to complete a particular regular provincial course even though adaptations to curriculum materials and topics, instruction, and environment have been made. This may require the development of a modified course (e.g., *Physical Science 21*) to meet student needs to which the Adaptive Dimension may be applied.

Broad Areas of Learning

There are three Broad Areas of Learning that reflect Saskatchewan's Goals of Education. Science education contributes to student achievement of the Goals of Education through helping students achieve knowledge, skills and attitudes related to these Broad Areas of Learning.

Lifelong Learners

Students who are engaged in constructing and applying science knowledge naturally build a positive disposition towards learning. Throughout their study of science, students bring their curiosity about the natural and constructed world, which provides the motivation to discover and explore their personal interests more deeply. By sharing their learning experiences with others, in a variety of contexts, students develop skills that support them as lifelong learners.

Sense of Self, Community, and Place

Students develop and strengthen their personal identity as they explore connections between their own understanding of the natural and constructed world and perspectives of others, including scientific and Indigenous perspectives. Students develop and strengthen their understanding of community as they explore ways in which science can inform individual and community decision making on issues related to the natural and constructed world. Students interact experientially with place-based local knowledge to deepen their connection to and relationship with nature.

Engaged Citizens

As students explore connections between science, technology, society and the environment, they experience opportunities to contribute positively to the environmental, economic and social sustainability of local and global communities. Students reflect and act on their personal responsibility to understand and respect their place in the natural and constructed world, and make personal decisions that contribute to living in harmony with others and the natural world.

Cross-curricular Competencies

The Cross-curricular Competencies are four interrelated areas containing understandings, values, skills and processes which are considered important for learning in all areas of study. These competencies reflect the Common Essential Learnings and are intended to be addressed in each area of study at each grade.

Developing Thinking

Learners construct knowledge to make sense of the world around them. In science, students develop understanding by building and reflecting on their observations and what is already known by themselves and others. By thinking contextually, creatively and critically, students develop deeper understanding of various phenomena in the natural and constructed world.

Developing Identity and Interdependence

This competency addresses the ability to act autonomously in an interdependent world. It requires the learner to be aware of the natural environment, of social and cultural expectations and of the possibilities for individual and group accomplishments. Interdependence assumes the possession of a positive self-concept and the ability to live in harmony with others and with the natural and constructed world. In science, students examine the interdependence among living things within local, national and global environments and consider the impact of individual decisions on those environments.

Developing Literacies

Literacies are multi-faceted and provide a variety of ways, including the use of various language systems and media, to interpret the world and express understanding of it. Literacies involve the evolution of interrelated knowledge, skills and strategies that facilitate an individual's ability to participate fully and equitably in a variety of roles and contexts – school, home, and local and global communities. In science, students collect, analyze and represent their ideas and understanding of the natural and constructed world in multiple forms.

Developing Social Responsibility

Social responsibility is how people positively contribute to their physical, social, cultural and educational environments. It requires the ability to participate with others in accomplishing shared or common goals. This competency is achieved by using moral reasoning processes, engaging in communitarian thinking and dialogue and taking social action. Students in science examine the impact of scientific understanding and technological innovations on society.

Aim and Goals

The aim of K-12 science education is to enable all Saskatchewan students to develop scientific literacy. Scientific literacy today embraces Euro-Canadian and Indigenous heritages, both of which have developed an empirical and rational knowledge of nature. A Euro-Canadian way of knowing about the natural and constructed world is called science, while First Nations and Métis ways of knowing nature are found within the broader category of Indigenous knowledge.

Diverse learning experiences based on the outcomes in this curriculum provide students with many opportunities to explore, analyze, evaluate, synthesize, appreciate and understand the interrelationships among science, technology, society and the environment (STSE) that will affect their personal lives, their careers and their future.

Goals are broad statements identifying what students are expected to know and be able to do upon completion of the learning in a particular area of study by the end of Grade 12. The four goals of K-12 science education are to:

- **Understand the Nature of Science and STSE Interrelationships** – Students will develop an understanding of the nature of science and technology, their interrelationships and their social and environmental contexts, including interrelationships between the natural and constructed world.
- **Construct Scientific Knowledge** – Students will construct an understanding of concepts, principles, laws and theories in life science, in physical science, in earth and space science and in Indigenous knowledge of nature and then apply these understandings to interpret, integrate and extend their knowledge.
- **Develop Scientific and Technological Skills** – Students will develop the skills required for scientific and technological inquiry, problem solving and communicating, for working collaboratively, and for making informed decisions.
- **Develop Attitudes that Support Scientific Habits of Mind** – Students will develop attitudes that support the responsible acquisition and application of scientific, technological and Indigenous knowledge to the mutual benefit of self, society and the environment.

Inquiry

Inquiry learning provides students with opportunities to build knowledge, abilities and inquiring habits of mind that lead to deeper understanding of their world and human experience. Inquiry is more than a simple instructional method. It is a philosophical approach to teaching and learning, grounded in constructivist research and methods, which engages students in investigations that lead to disciplinary and interdisciplinary understanding.

Inquiry builds on students' inherent sense of curiosity and wonder, drawing on their diverse backgrounds, interests and experiences. The process provides opportunities for students to become active participants in a collaborative search for meaning and understanding.

Secondary students who are engaged in inquiry in science should be able to:

- identify questions and concepts that guide scientific investigations.
- design and conduct scientific investigations.
- use technology and mathematics to improve investigations and communications.
- formulate and revise scientific explanations and models using logic and evidence.
- recognize and analyze alternative explanations and models.
- Communicate and defend a scientific argument.

(NRC, 1996, pp. 175, 176)

Creating Questions for Inquiry in Science

Inquiry focuses on the development of questions to initiate and guide the learning process. Students and teachers formulate questions to motivate inquiries into topics, problems and issues related to curriculum content and outcomes.

Well-formulated inquiry questions are broad in scope and rich in possibilities. Such questions encourage students to explore, observe, gather information, plan, analyze, interpret, synthesize, problem solve, take risks, create, conclude, document, reflect on learning and develop new questions for further inquiry.

> *Good science inquiry provides many entry points – ways in which students can approach a new topic – and a wide variety of activities during student work.*
>
> *(Kluger-Bell, 2000, p.48)*

In science, teachers and students can use the four learning contexts of Scientific Inquiry, Technological Problem Solving, STSE Decision Making, and Cultural Perspectives (see Learning Contexts section of this document for further information) as curriculum entry points to begin their inquiry. The process may evolve into interdisciplinary learning opportunities reflective of the holistic nature of our lives and an interdependent global environment.

Developing questions evoked by student interests has the potential for rich and deep learning. These questions are used to initiate and guide the inquiry and give students direction for investigating topics, problems, ideas, challenges or issues under study.

Essential questions that lead to deeper understanding in science should:

- center on objects, organisms and events in the natural world;
- connect to science concepts outlined in the curricular outcomes;
- lend themselves to empirical investigation; and,
- lead to gathering and using data to develop explanations for natural phenomena.

(NRC, 2000, p. 24)

The process of constructing questions for deep understanding can help students grasp the important disciplinary or interdisciplinary ideas that are situated at the core of a particular curricular focus or context. These broad questions lead to more specific questions that can provide a framework, purpose and direction for the learning activities in a lesson, or series of lessons, and help students connect what they are learning to their experiences and life beyond school.

Questions give students some initial direction for uncovering the understandings associated with a unit of study. Questions can help students grasp the big disciplinary ideas surrounding a focus or context and related themes or topics. They provide a framework, purpose and direction for the learning activities in each unit and help students connect what they are learning to their experiences and life beyond the classroom. Questions also invite and encourage students to pose their own questions for deeper understanding.

Outcomes and Indicators

Outcomes are statements of what students are expected to know and be able to do by the end of a grade or secondary level course in a particular area of study. Therefore, all outcomes are required. The outcomes provide direction for assessment and evaluation, and for program, unit and lesson planning. Critical characteristics of an outcome include the following:

- focus on what students will learn rather than what teachers will teach;
- specify the skills and abilities, understandings, knowledge and/or attitudes students are expected to demonstrate;
- are observable, assessable and attainable;
- are written using action-based verbs and clear professional language (educational and subject-related);
- are developed to be achieved in context so that learning is purposeful and interconnected;
- are grade and subject specific;
- are supported by indicators which provide the breadth and depth of expectations; and,
- have a developmental flow and connection to other grades where applicable.

Indicators are representative of what students need to know and/or be able to do in order to achieve an outcome. When teachers are planning for instruction, they must comprehend the set of indicators to understand fully the breadth and the depth of learning related to a particular outcome. Based on this understanding of the outcome, teachers may develop their own indicators that are responsive of students' interests, lives and prior learning. These teacher-developed indicators must maintain the intent of the outcome.

The outcomes and indicators in this locally modified course have been adapted from the renewed *Physical Science 20* outcomes and indicators. The modified outcomes and indicators are also identified in each of the resource packages that accompany this course. Further information about learning contexts and the Foundations of Scientific Literacy is available in the *Physical Science 20* curriculum document.

Outcomes at a Glance

Career Exploration
PS21-CE1 Explore physical science related occupations in Saskatchewan and Canada.

Student-Directed Study
PS21-SDS1 Explore one or more topics of personal interest relevant to *Physical Science 21* in depth.

Heat
PS21-HT1 Investigate the effect of heat on matter during temperature changes and changes of state using kinetic molecular theory.
PS21-HT2 Observe the heat involved in chemical reactions through experimentation.

Foundations of Chemistry
PS21-FC1 Provide examples of the five basic types of chemical reactions.
PS21-FC2 Construct an understanding of the mole as a unit for measuring the amount of substance.
PS21-FC3 Use stoichiometry to determine the relative amounts of substances consumed and produced in chemical reactions.

Properties of Waves
PS21-PW1 Investigate the properties and characteristics of waves in one or more media (e.g., springs, ropes, air and water).
PS21-PW2 Examine, using physical materials and ray diagrams, how waves reflect from a variety of barriers.
PS21-PW3 Examine, using physical materials and ray diagrams, how waves refract from a variety of barriers.

Legend

PS21-FC1a

PS21	Course name
FC	Unit of study
1	Outcome number
a	Indicator
[CP, DM, SI, TPS]	Learning context(s) that best support this outcome
(A, K, S, STSE)	Foundation(s) of Scientific Literacy that apply to this indicator

Outcomes and Indicators

Career Exploration	
All outcomes contribute to the development of all K-12 science goals.	
Outcomes	**Indicators**

PS21-CE1 Explore physical science related occupations in Saskatchewan, Canada and the world.
 	
[CP, DM]
	a. Participate in events such as a career fair or job shadow that relate to a physical science career. (K, S)
	b. Explore connection between topics in *Physical Science 21* and occupations of personal interest. (S, A, STSE)
	c. Examine the roles, responsibilities, educational qualifications and personal and professional qualities common to people involved in physical-science related jobs. (S, A)
	d. Reflect upon personal suitability or non-suitability for a specific physical-science related occupation considering criteria such as:
	    a. initial and continuing educational requirements;
	    b. duties and skills required for this occupation;
	    c. the work environment, including typical hours and shifts worked and typical locations;
	    d. current wages received in Saskatchewan and how these compare to the rest of Canada;
	    e. physical, mental and emotional stresses related to this occupation;
	    f. workplace hazards and safety considerations;
	    g. other occupations with which they interact;
	    h. professional and/or licensing requirements in Canada and Saskatchewan; and
	    i. future trends impacting the occupation. (K, S, A, STSE)
	e. Interview or connect with others to discuss physical science related occupations. (K, S, A)
	f. Communicate research findings related to physical science occupations through a display, brochure, video, presentation software, website or orally. (K, S, A, STSE)

Student-Directed Study	
All outcomes contribute to the development of all K-12 science goals.	
Outcomes	**Indicators**
PS21-SDS1 Explore one or more topics of personal interest relevant to *Physical Science 21* in depth. [DM, SI, TPS]	a. Plan a scientific investigation related to a topic of study in *Physical Science 21* that may include a testable question, a hypothesis, an experimental design that will test the hypothesis and detailed procedures for making observations. (STSE, S). b. Carry out an experiment following established scientific protocols to investigate a question of interest related to one or more of the topics of *Physical Science 21*. (S, A, K, STSE) c. Assemble and reflect on a portfolio that demonstrates an understanding of a physical science topic of interest to the student. (S, A) d. Design, construct and evaluate the effectiveness of a device, model or technique that demonstrates the scientific principles underlying a concept related to *Physical Science 21*. (STSE, S) e. Debate an issued related to physical science, including developing materials to support the arguments for and against a position. (A, K, S) f. Share the results of student-directed research through a display, presentation, performance, demonstration, song, game, commercial, fine art representation, video or research paper. (S) g. Use a tool (e.g., rubric, checklist, self-evaluation form or peer-evaluation form) to assess the process and products involved in a student-directed study. (S, A) h. Provide examples of applications of the properties and characteristics of waves or electromagnetic radiation in various technologies (e.g., ultrasound, sonar, Doppler Effect, sonic booms, satellite dishes, microwaves, mobile phones, wireless routers, Bluetooth, radio waves, X-rays, radar and remote controls). (STSE, K) i. Explore wave-related phenomena such as natural vibrations, forced vibrations, resonance and harmonics in the context of musical instruments and human hearing. (STSE, S, K)

Heat	
All outcomes contribute to the development of all K-12 science goals.	
Outcomes	**Indicators**
PS21-HT1 Investigate the effect of heat on matter	a. Distinguish between heat and temperature using the kinetic molecular theory of matter. (K)

during temperature changes and changes of state using kinetic molecular theory. [CP, DM, SI]	b. Explore the importance of heat and fire for First Nations and Métis peoples, and how they use their understanding of heat transfer to solve practical problems related to cooking and shelter. (STSE, K, A) c. Measure the specific heat capacity of various metals using a calorimeter to demonstrate the concept of a closed system and the law of conservation of energy. (S, K) d. Determine the latent heat of fusion and/or latent heat of vaporization of various substances using a calorimeter. (S, K) e. Measure some physical properties of water, such as density at various temperatures, specific heat capacity and latent heat of fusion and latent heat of vaporization. (S, K) f. Compare-the heat capacities of some common materials, including water, and explain how heat capacity can influence choices of materials used in the development of technologies related to clothing, food and shelter. (STSE, S, K) g. Interpret a heating or cooling curve for water, or other substances. (S, K) h. Use appropriate technologies such as temperature probes and calorimeters safely when collecting data. (S, A) i. Calculate the quantity of heat ($Q = mc\Delta T$), specific heat capacity, latent heat of fusion ($Q = mH_f$) and latent heat of vaporization ($Q = mH_v$) during changes of state. (S, K) j. Observe the amount of heat exchanged and final temperature reached when mixing two known quantities of known substances, compare to expected results. (S, K, STSE, A) k. Examine applications of heat transfer such as heating a drum skin, using heat to make copper tools, energy control in buildings, heat pumps and insulated and moisture wicking clothing. (STSE, S, K) l. Explore, qualitatively and/or quantitatively, the expansion and contraction of matter during heat transfer or temperature change. (S, K) m. Investigate effects of the thermal expansion and contraction of matter in technological applications such as road, bridge and building design, plumbing, power line construction and industrial engineering. (STSE, A) n. Discuss how water differs from other substances in terms of phase change, density, and specific heat capacity. (STSE, K)

PS21-HT2 Observe the heat involved in chemical reactions through experimentation. [SI, TPS]	a. Distinguish between endothermic and exothermic chemical reactions, including those that occur in solutions. (K) b. Outline the historical development of thermodynamics, including significant discoveries and inventions, and the contributions of engineers and scientists such as Carnot, Maxwell, Boltzmann, Lord Kelvin and Gibbs. (STSE) c. Measure, using a thermometer or temperature probe, and record the temperature change in an exothermic and/or endothermic chemical reaction. (S, K) d. Compare and explain why the actual heat of reaction differs from the theoretical heat of reaction, with reference to sources of error. (S, K) e. Discuss the importance of analyzing the quantities of heat involved in chemical reactions. (STSE) f. Calculate the molar heat of reaction associated with dissolving ionic compounds in a solution. (S, K) g. Compare the quantity of heat involved in the use of various commercially available cold and/or heat packs. (STSE, S, K) h. Evaluate the effectiveness of a cold pack and/or heat pack given the goal of having no excess reactants remaining at reaction completion. (STSE, S, K) i. Compare the fuel consumed and heat energy output of various combustion reactions involving common fuels (e.g., methane, propane, octane and ethanol). (STSE, S)

Foundations of Chemistry	
All outcomes contribute to the development of all K-12 science goals.	
Outcomes	**Indicators**
PS21-FC1 Provide examples of the five basic types of chemical reactions. [DM, SI]	a. Perform and observe synthesis, decomposition, combustion, single-replacement and double-replacement (including acid base neutralization) reactions. (S, K) b. Represent synthesis, decomposition, combustion, single-replacement and double-replacement (including acid base neutralization) reactions using atomic models, other manipulatives, skeleton equations, balanced chemical equations and International Union of Pure and Applied Chemistry (IUPAC) nomenclature. (S) c. Explain the importance of skeleton equations, balanced equations and IUPAC nomenclature in communicating

	understanding of chemical reactions. (S, K, A) d. Understand the feasibility of single-replacement reactions based on the activity series of metals and/or non-metals. (S, K) e. Distinguish between the products of complete and incomplete combustion reactions. (K, STSE) f. Participate in an investigation to observe the difference between a complete and incomplete combustion reaction. (S) g. Select and apply proper techniques for handling and disposing of lab materials, as outlined in Workplace Hazardous Materials Information System (WHMIS 1998 and WHMIS 2015) standards, and interpret *Materials Safety Data Sheets* (MSDS) and *Safety Data Sheets* (SDS). (K, STSE, A) h. Analyze and compare the fuel consumed and carbon output of various combustion reactions (e.g., methane, propane, octane and ethanol). (STSE, S) i. Describe how the outcomes of various chemical reactions may benefit or harm living organisms and affect the environment. (K, STSE) j. Research how industrial, mining and/or agricultural processes involve chemical reactions. (STSE, S, K, A)
PS21-FC2 Construct an understanding of the mole as a unit for measuring the amount of substance. [DM, SI]	a. Pose questions about how to measure quantities of substances that are not readily countable. [S] b. Relate counting by weighing to the sale of a granular product such as grain or gravel, the purchase of bulk foods, rolled coin deposits at the bank and purchasing propane for a barbeque. (K) c. Provide examples to demonstrate the size of the Avogadro constant (6.02×10^{23}) in relation to common items such as coins, water drops, sand grains and marbles. (K) d. Explain why chemists use the mole to represent the amount of a substance. (K, STSE) e. Outline how individuals such as Avogadro-and Dalton have contributed to modern understanding of the composition of compounds. (STSE, A) f. Celebrate mole day on 10/23 or 6/02 by bringing a multiple of a mole of substance to school, consuming a mole of a substance and creating and/or sharing cartoons, articles, pictures or songs relevant to the mole. (A) g. Calculate the molar mass of various molecular and ionic compounds. (S)

	h. Perform molar conversions, including mass to mole, and their inverse operations. (S) i. Research the use of solutions in industrial, mining and agricultural processes. (STSE, S, K)
PS21-FC3 Use stoichiometry to determine the relative amounts of substances consumed and produced in chemical reactions. [SI]	a. Pose questions about how to determine the amount of material required to produce a finished product. (S) b. Determine the relative numbers of moles of each substance in a variety of chemical reactions using balanced chemical equations. (K, S) c. Relate the use of the mole to the coefficients in a balanced chemical equation, and compare this to mass as measurable quantities. (K, A, STSE) d. Perform stoichiometric calculations to predict the mass of reactants and products in chemical reactions, using the correct units. (S) e. Perform experiments to support stoichiometric hypotheses using appropriate instruments to collect data accurately and precisely. (S, A) f. Communicate results of experiments. (S, A) g. Apply the concepts of limiting and excess reagents to a simple chemical reaction. (S, K) h. Compare the theoretical and actual yield for a variety of chemical reactions. (S, K) i. Predict how to maximize the yield of a particular chemical process. (STSE, S) j. Discuss the economic impact of the yield of chemical reactions with respect to maximizing product and profit and minimizing waste production. (STSE, A) k. Research how the reactants used and products formed through chemical reactions in industrial, mining and/or agricultural processes can affect human health and/or the health of the environment. (STSE, A)

Properties of Waves	
All outcomes contribute to the development of all K-12 science goals.	
Outcomes	**Indicators**
PS21-PW1 Investigate the properties and characteristics of waves in one or more media (e.g., springs, ropes, air and	a. Pose questions about the nature and prevalence of waves in the world around us (e.g., What are waves? Where do we find waves in the world around us? Do all waves exhibit the same properties and behaviours? Why are waves important to study?). (S, STSE, A)

water). [SI]	b. Examine Indigenous understanding of waves, including waves as carriers of energy. (STSE, K) c. Recognize that scientists understand waves as the transmission of energy originating from a vibrating source that determines the frequency and amplitude of the wave. (K) d. Communicate information about the properties and characteristics of waves using appropriate terminology (e.g., medium, pulse, vibration, cycle, periodic motion, frequency, period, amplitude, phase and wavelength). (S, K) e. Explore questions about properties of waves (e.g., What controls the frequency of a wave? What controls the speed of a wave? What happens when two or more waves meet?). (S, A) f. Identify characteristics of transverse and longitudinal waves, [e.g., crests (positive pulse), troughs (negative pulse), compressions, rarefactions and the relationship between direction of vibration and energy transfer]. (K) g. Describe the relationship between rectilinear propagation and the nature of the medium as they affect the speed of a wave. (S, K) h. Trace the historical developments of technologies used to measure the speed of light and/or sound. (STSE) i. Solve problems related to speed, period, frequency and wavelength using the universal wave equation ($v = \lambda f$) and the period-frequency relationship (T = 1/f). (S, K) j. Illustrate constructive and destructive interference in waves, including standing waves, using point-source and straight-source waves. (S, K) k. Observe and describe diffraction of waves through single and double slits and diffraction gratings. (S, K)
PS21-PW2 Examine, using physical materials and ray diagrams, how waves reflect from a variety of barriers. [DM, SI]	a. Investigate the behaviour of waves as they strike parallel, oblique, and curved barriers. (S, K) b. Compare the characteristics of specular (regular) and diffuse reflection of waves. (S, K) c. Demonstrate the application of the law of reflection when a wave strikes a straight barrier and when a wave encounters the boundary between two different media. (S, K) d. Provide examples of wave and particle reflection in everyday situations such as echoes, reverberation, room acoustics, radar, sonar, parabolic microphones, ultrasound, water waves, satellite dishes, billiard balls and ball-based sports. (STSE, K, A)

	e. Investigate image formation in plane, concave and convex mirrors, including constructing ray diagrams. (S, K) f. Identify the properties, such as type (real or virtual), attitude/orientation (upright or inverted), magnification (smaller, larger or same size) and position (relative to the mirror surface or vertex), of images formed in plane, concave and convex mirrors. (K) g. Describe the implications of wave-based technologies in furthering scientific understanding of phenomena such as Earth's internal structure, the topography of the ocean floor and the rock cycle. (STSE, K)
PS21-PW3 Examine, using physical materials and ray diagrams, how waves refract from a variety of barriers. [DM, SI]	a. Pose questions about how waves behave when they travel from one medium to another. (S) b. Observe behaviour of waves, such as partial reflection and refraction, the critical angle and total internal reflection, at a boundary between different media. (S, K) c. Relate refraction to the change in the speed and direction of waves at a boundary between different media. (S, K) d. Observe image formation in converging and diverging lenses, including constructing ray diagrams. (S, K) e. Identify the properties, such as type (real or virtual), attitude/orientation (upright or inverted), magnification (smaller, larger, or same size) and position (relative to the optical center) of images formed in converging and diverging lenses. (K) f. Explore applications related to total internal reflection. (STSE, S, K)

Assessment and Evaluation of Student Learning

Assessment and evaluation require thoughtful planning and implementation to support the learning process and to inform teaching. All assessment and evaluation of student achievement must be based on the outcomes in the provincial curriculum.

Assessment involves the systematic collection of information about student learning with respect to:

- achievement of provincial curriculum outcomes;
- effectiveness of teaching strategies employed; and,
- student self-reflection on learning.

Evaluation compares assessment information against criteria based on curriculum outcomes for the purpose of communicating to students, teachers, parents/caregivers and others about student progress and to make informed decisions about the teaching and learning process.

There are three interrelated purposes of assessment. Each type of assessment, systematically implemented, contributes to an overall picture of an individual student's achievement.

Assessment for learning involves the use of information about student progress to support and improve student learning, inform instructional practices, and:

- is teacher-driven for student, teacher and parent use;
- occurs throughout the teaching and learning process, using a variety of tools; and,
- engages teachers in providing differentiated instruction, feedback to students to enhance their learning and information to parents in support of learning.

Assessment as learning actively involves student reflection on learning, monitoring of her/his own progress, and:

- supports students in critically analyzing learning related to curricular outcomes;
- is student-driven with teacher guidance; and,
- occurs throughout the learning process.

Assessment of learning involves teachers' use of evidence of student learning to make judgements about student achievement and:

- provides opportunity to report evidence of achievement related to curricular outcomes;
- occurs at the end of a learning cycle, using a variety of tools; and,
- provides the foundation for discussions on placement or promotion.

Key Resources

Many resources that were reviewed and recommended for *Physical Science 20* are also suggested for use in *Physical Science 21 (2018)*. It should be noted that the teacher may need to adapt and modify the resources to meet the diverse needs of the students. For further information (including order numbers) for these resources refer to the *Physical Science 20* tab at www.curriculum.gov.sk.ca.

- *Chemistry 11* (2011) – McGraw-Hill Ryerson / Nelson
- *Chemistry , Matter and Change* (2017) – McGraw-Hill Ryerson / Nelson
- *Conceptual Chemistry (5th ed.)* (2014) – Pearson Education Canada
- *Conceptual Physics (12th ed.)* (2014) – Pearson Education Canada
- *Glencoe Physics: Principles & Problems* (2017) – McGraw-Hill Ryerson / Nelson
- *Pearson Chemistry* (2014) – Pearson Education Canada
- *Pearson Physics* (2009) – Pearson Education Canada
- *PhysicsSource 11* (201) – Pearson Education Canada

References

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