APPENDIX 8: SPECIFIC LEARNING OUTCOMES

Cluster "0"—Skills and Attitudes Outcomes

Nature of Science

S4P-0-1a Explain the roles of theory, evidence, and models in the development of scientific knowledge.

S4P-0-1b Describe the importance of peer review in the evaluation and acceptance of scientific theories, evidence, and knowledge claims.

S4P-0-1c Relate the historical development of scientific ideas and technology to the form and function of scientific knowledge today.

S4P-0-1d Describe how scientific knowledge changes as new evidence emerges and/or new ideas and interpretations are advanced.

S4P-0-1e Differentiate between how scientific theories explain natural phenomena and how scientific laws identify regularities and patterns in nature.

Inquiry Skills

S4P-0-2a Select and use appropriate visual, numeric, graphical, and symbolic modes of representation to identify and represent relationships.

S4P-0-2b Propose problems, state hypotheses, and plan, implement, adapt, or extend procedures to carry out an investigation where required.

S4P-0-2c Formulate operational definitions of major variables or concepts.

S4P-0-2d Estimate and measure accurately using SI units.

S4P-0-2e Evaluate the relevance, reliability, and adequacy of data and data-collection methods.

Include: discrepancies in data and sources of error

S4P-0-2f Record, organize, and display data using an appropriate format.

Include: labelled diagrams, tables, graphs

S4P-0-2g Develop mathematical models involving linear, power, and/or inverse relationships among variables.

S4P-0-2h Analyze problems using vectors.

Include: Adding and subtracting vectors in straight lines, at right angles, and at non-orthogonal angles

S4P-0-2i Select and integrate information obtained from a variety of sources.

Include: print, electronic, specialists, or other resource people

Science, Technology, Society, and the Environment (STSE)

S4P-0-3a Analyze, from a variety of perspectives, the risks and benefits to society and the environment when applying scientific knowledge or introducing technology.

S4P-0-3b Describe examples of how technology has evolved in response to scientific advances, and how scientific knowledge has evolved as the result of new innovations in technology.

S4P-0-3c Identify social issues related to science and technology, taking into account human and environmental needs and ethical considerations.

S4P-0-3d Use the decision-making process to address an STSE issue.

S4P-0-3e Identify a problem, initiate research, and design a technological or other solution to address the problem.

Attitudes

S4P-0-4a Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment.

S4P-0-4b Work co-operatively with a group to identify prior knowledge, initiate and exchange ideas, propose problems and their solution, and carry out investigations.

S4P-0-4c Demonstrate confidence in their ability to carry out investigations in science and to address STSE issues.

S4P-0-4d Develop a sense of personal and shared responsibility for the impact of humans on the environment, and demonstrate concern for social and environmental consequences of proposed actions.

S4P-0-4e Demonstrate a continuing and more informed interest in science and science-related issues.

S4P-0-4f Value skepticism, honesty, accuracy, precision, perseverance, and open-mindedness as scientific and technological habits of mind.

Topic One: Mechanics

Topic 1.1: Kinematics

S4P-1-1 Derive the special equations for constant acceleration.

Include: $\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$; $\Delta \vec{d} = \vec{v}_1 \Delta t + \frac{1}{2} \vec{a} \Delta t^2$; $v_2^2 = v_1^2 + 2a\Delta d$

S4P-1-2 Solve problems for objects moving in a straight line with a constant acceleration.

Include: $\vec{v}_2 = \vec{v}_1 + \vec{a} \Delta t$; $\Delta \vec{d} = \vec{v}_1 \Delta t + \frac{1}{2} \vec{a} \Delta t^2$; $v_2^2 = v_1^2 + 2a\Delta d$; $\Delta \vec{d} = \left(\frac{\vec{v}_1 + \vec{v}_2}{2} \right) \Delta t$

S4P-1-3 Solve relative motion problems for constant velocities using vectors.

Topic 1.2: Dynamics

S4P-1-4 Solve vector problems for objects in equilibrium.

S4P-1-5 Calculate the forces acting on an object resting on an inclined plane.

Include: normal force, friction, components of the gravitational force (mg)

S4P-1-6 Calculate the components of $\vec{F}_{\text{gravity}}$ exerted on an object resting on an inclined plane.

S4P-1-7 Solve problems with $\vec{F}_{\text{friction}}$ for objects on a horizontal surface and on an inclined plane.

Include: coefficient of friction

S4P-1-8 Solve problems using $\vec{F}_{\text{net}} = m\vec{a}$ where $\vec{F}_{\text{net}} = \vec{F}_{\text{applied}} + \vec{F}_{\text{friction}}$ and using kinematics equations from above.

Include: $\vec{F}_{\text{applied}}$ at an angle to horizontal motion; combined mass systems; $\vec{F}_{\text{applied}}$ on an inclined plane; forces acting at various angles on a body

S4P-1-9 Perform an experiment to investigate forces acting on an object.

Topic 1.3: Momentum

S4P-1-10 Derive the impulse-momentum equation from Newton's second law.

S4P-1-11 Determine impulse from the area under a force-time graph.

Include: constant positive and negative force, uniformly changing force

S4P-1-12 Experiment to illustrate the Law of Conservation of Momentum in one and two dimensions.

S4P-1-13 Solve problems using the impulse-momentum equation and the Law of Conservation of Momentum.

S4P-1-14 Relate the impulse-momentum equation to real-life situations.

Examples: hitting a ball, catching a ball

Topic 1.4: Projectile Motion

S4P-1-15 Solve simple free-fall problems using the special equations for constant acceleration.

Include: horizontal and vertical components of motion of the curved path of a projectile (without air resistance)

S4P-1-16 Draw free-body diagrams for a projectile at various points along its path (with or without air resistance).

S4P-1-17 Calculate the horizontal and vertical components with respect to velocity and position of a projectile at various points along its path.

S4P-1-18 Solve problems for projectiles launched horizontally and at various angles to the horizontal to calculate maximum height, range, and overall time of flight of the projectile.

Topic 1.5: Circular Motion

S4P-1-19 Explain qualitatively why an object moving at a constant speed in a circle is accelerating toward the centre of the circle.

S4P-1-20 Discuss the centrifugal effects with respect to Newton's laws.

S4P-1-21 Draw free-body diagrams of an object moving in uniform circular motion.

S4P-1-22 Experiment to determine the mathematical relationship between period and frequency and one or more of the following: centripetal force, mass, and radius.

S4P-1-23 Derive an equation for the constant speed and acceleration of an object moving in a circle $\left(\vec{v} = \frac{2\pi r}{T},\ a = \frac{v^2}{R} \right)$.

S4P-1-24 Solve problems for an object moving with a constant speed in a circle using $a = \frac{v^2}{R}$, $\vec{v} = \frac{2\pi r}{T}$, and $\vec{F}_{\text{net}} = m\vec{a}$.

Topic 1.6: Work and Energy

S4P-1-25 Define work as the product of displacement and the component of force parallel to the displacement when the force is constant.

S4P-1-26 Determine work from the area under the force-position graph for any force.

Include: positive or negative force, uniformly changing force

S4P-1-27 Describe work as a transfer of energy.

Include: positive and negative work, kinetic energy, conservation of energy

S4P-1-28 Give examples of various forms of energy and describe qualitatively the means by which they can perform work.

S4P-1-29 Derive the equation for kinetic energy using $W = \vec{F}\ \Delta\vec{d}\cos\theta$ and kinematics equations.

S4P-1-30 Derive the equation for gravitational potential energy near the surface of the Earth ($E_p = mgh$).

S4P-1-31 Experiment to determine Hooke's Law $\left(\vec{F} = -k\vec{x} \right)$.

S4P-1-32 Derive an equation for the potential energy of a spring, using Hooke's law and a force-displacement graph.

S4P-1-33 Solve problems related to the conservation of energy.

Include: gravitational and spring potential, and kinetic energy

Topic 2: Fields

Topic 2.1: Exploration of Space

S4P-2-1 Identify and analyze issues pertaining to space exploration.

Examples: scale of the universe, technological advancement, promotion of global co-operation, social and economic benefits, allocation of resources shifted away from other pursuits, possibility of disaster

S4P-2-2 Describe planetary motion using Kepler's three laws.

Examples: relate Kepler's Third Law to objects other than planets, such as comets, satellites, and spacecraft

S4P-2-3 Outline Newton's Law of Universal Gravitation and solve problems using $F_g = \frac{Gm_1m_2}{r^2}$.

S4P-2-4 State the gravitational potential energy as the area under the force-separation curve and solve problems using $E_g = \frac{-Gm_1m_2}{r}$.

S4P-2-5 Solve problems for the escape velocity of a spacecraft.

Include: Law of Conservation of Energy, binding energy

Topic 2.2: Low Earth Orbit

S4P-2-6 Compare the Law of Universal Gravitation with the weight (mg) of an object at various distances from the surface of the Earth and describe the gravitational field as $g = \frac{Gm_{\text{Earth}}}{r^2}$.

S4P-2-7 Outline Newton's thought experiment regarding how an artificial satellite can be made to orbit the Earth.

S4P-2-8 Use the Law of Universal Gravitation and circular motion to calculate the characteristics of the motion of a satellite.

Include: orbital period, speed, altitude above a planetary surface, mass of the central body, and the location of geosynchronous satellites

S4P-2-9 Define microgravity as an environment in which the apparent weight of a system is smaller than its actual weight.

S4P-2-10 Describe conditions under which microgravity can be produced.

Examples: jumping off a diving board, roller-coaster, free fall, parabolic flight, orbiting spacecraft

S4P-2-11 Outline the factors involved in the re-entry of an object into Earth's atmosphere.

Include: friction and g-forces

S4P-2-12 Describe qualitatively some of the technological challenges to exploring deep space.

Examples: communication, flyby and the "slingshot" effect, Hohmann Transfer orbits (least-energy orbits)

Topic 2.3: Electric and Magnetic Fields

S4P-2-13 Compare and contrast the inverse square nature of gravitational and electric fields.

S4P-2-14 State Coulomb's Law and solve problems for more than one electric force acting on a charge.

Include: one and two dimensions

S4P-2-15 Illustrate, using diagrams, how the charge distribution on two oppositely charged parallel plates results in a uniform field.

S4P-2-16 Derive an equation for the electric potential energy between two oppositely charged parallel plates ($E_e = qE\Delta d$).

S4P-2-17 Describe electric potential as the electric potential energy per unit charge.

S4P-2-18 Identify the unit of electric potential as the volt.

S4P-2-19 Define electric potential difference (voltage) and express the electric field between two oppositely charged parallel plates in terms of voltage and the separation between the plates $\left(\varepsilon = \frac{\Delta V}{d}\right)$.

S4P-2-20 Solve problems for charges moving between or through parallel plates.

S4P-2-21 Use hand rules to describe the directional relationships between electric and magnetic fields and moving charges.

S4P-2-22 Describe qualitatively various technologies that use electric and magnetic fields.

Examples: electromagnetic devices (such as a solenoid, motor, bell, or relay), cathode ray tube, mass spectrometer, antenna

Topic 3: Electricity

Topic 3.1: Electric Circuits

S4P-3-1 Describe the origin of conventional current and relate its direction to the electron flow in a conductor.

S4P-3-2 Describe the historical development of Ohm's Law.

Include: contributions of Gray, Ohm, Joule, and Kirchoff

S4P-3-3 Investigate the relationships among resistance and resistivity, length, cross-section, and temperature.

Include: $R = \frac{\rho L}{A}$

S4P-3-4 Demonstrate the ability to construct circuits from schematic diagrams for series, parallel, and combined networks.

Include: correct placement of ammeters and voltmeters

S4P-3-5 Calculate the total resistance for resistors in series and resistors in parallel.

S4P-3-6 Calculate the resistance, current, voltage, and power for series, parallel, and combined networks.

Include: $P = IV$, $P = I^2R$, and $P = \frac{V^2}{R}$

Topic 3.2: Electromagnetic Induction

S4P-3-7 Define magnetic flux $(\Phi = B_{\perp}A)$.

S4P-3-8 Demonstrate how a change in magnetic flux induces voltage.

S4P-3-9 Calculate the magnitude of the induced voltage in coils using $V = \frac{N\Delta\Phi}{\Delta t}$.

S4P-3-10 Outline Lenz's Law and apply to related problems.

S4P-3-11 Describe the operation of an AC generator.

S4P-3-12 Graph voltage versus angle for the AC cycle.

S4P-3-13 Describe the operation of transformers.

S4P-3-14 Solve problems using the transformer ratio of $\frac{V_p}{V_s} = \frac{N_p}{N_s}$.

S4P-3-15 Describe the generation, transmission, and distribution of electricity in Manitoba.

Include: step-up and step-down transformers, power transfer, High Voltage Direct Current

Topic 4: Medical Physics

S4P-4-1 Describe the nuclear model of the atom.

Include: proton, neutron, nucleus, nuclear forces, stability, isotope, mass number, electron, ion

S4P-4-2 Define radioactivity as a nuclear change that releases energy.

Include: Becquerel units, radioactive decay, half life

S4P-4-3 Perform decay calculations using integer numbers of half life.

S4P-4-4 Describe the following types of radiation: alpha, beta, and electromagnetic radiation.

Include: particle radiation, wave radiation, electromagnetic spectrum, linear energy transfer

S4P-4-5 Compare and contrast sources and characteristics of ionizing radiation and non-ionizing radiation.

Include: NORM (Naturally Occurring Radioactive Materials), radon, background radiation, incandescent light bulb, hot objects

S4P-4-6 Describe various applications of non-ionizing radiation.

Examples: communications, microwave oven, laser, tanning bed

S4P-4-7 Describe various applications of ionizing radiation.

Examples: food irradiation, sterilization, smoke alarm

S4P-4-8 Describe the effects of non-ionizing and ionizing radiation on the human body.

Include: equivalency of sievert (Sv) and rem units, solar erythema (sunburn)

S4P-4-9 Research, identify, and examine the application of radiation to diagnostic imaging and treatment techniques.

Examples: nuclear medicine imaging techniques such as MRI, ultrasound, endoscopy, X-ray, CT scanning, PET, heavy isotopes such as Ba; nuclear medicine therapies such as brachitherapy, external beam, gamma knife