BIG IDEAS

Measurement of motion depends on our frame of reference.	Forces can cause **linear and circular motion**.	Forces and energy interactions occur within **fields**.	**Momentum** is conserved within a closed and isolated system.

Learning Standards

Curricular Competencies	Content
Students are expected to be able to do the following: **Questioning and predicting** • Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal, local, or global interest • Make observations aimed at identifying their own questions, including increasingly abstract ones, about the natural world • Formulate multiple hypotheses and predict multiple outcomes **Planning and conducting** • Collaboratively and individually plan, select, and use appropriate investigation methods, including field work and lab experiments, to collect reliable data (qualitative and quantitative) • Assess risks and address ethical, cultural, and/or environmental issues associated with their proposed methods • Use appropriate SI units and appropriate equipment, including digital technologies, to systematically and accurately collect and record data • Apply the concepts of accuracy and precision to experimental procedures and data: – significant figures – uncertainty – scientific notation	*Students are expected to know the following:* • frames of reference • relative motion within a stationary reference frame • postulates of special relativity • **relativistic effects** within a moving reference frame • **static equilibrium** • **uniform circular motion:** – centripetal force and acceleration – **changes to apparent weight** • **First Peoples knowledge and applications of forces in traditional technologies** • **gravitational field** and Newton's law of universal gravitation • gravitational potential energy • **gravitational dynamics and energy relationships** • **electric field** and Coulomb's law • electric potential energy, electric potential, and electric potential difference • **electrostatic dynamics and energy relationships** • **magnetic field** and **magnetic force** • **electromagnetic induction** • **applications of electromagnetic induction** • **impulse** and momentum • conservation of momentum and energy in **collisions** • **graphical methods** in physics

Learning Standards (continued)

Curricular Competencies	Content
Processing and analyzing data and information • Experience and interpret the local environment • Apply First Peoples perspectives and knowledge, other ways of knowing, and local knowledge as sources of information • Seek and analyze patterns, trends, and connections in data, including describing relationships between variables, performing calculations, and identifying inconsistencies • Construct, analyze, and interpret graphs, models, and/or diagrams • Use knowledge of scientific concepts to draw conclusions that are consistent with evidence • Analyze cause-and-effect relationships **Evaluating** • Evaluate their methods and experimental conditions, including identifying sources of error or uncertainty, confounding variables, and possible alternative explanations and conclusions • Describe specific ways to improve their investigation methods and the quality of their data • Evaluate the validity and limitations of a model or analogy in relation to the phenomenon modelled • Demonstrate an awareness of assumptions, question information given, and identify bias in their own work and in primary and secondary sources • Consider the changes in knowledge over time as tools and technologies have developed • Connect scientific explorations to careers in science • Exercise a healthy, informed skepticism and use scientific knowledge and findings to form their own investigations to evaluate claims in primary and secondary sources • Consider social, ethical, and environmental implications of the findings from their own and others' investigations • Critically analyze the validity of information in primary and secondary sources and evaluate the approaches used to solve problems • Assess risks in the context of personal safety and social responsibility	

Learning Standards (continued)

Curricular Competencies	Content
Applying and innovating • Contribute to care for self, others, community, and world through individual or collaborative approaches • Co-operatively design projects with local and/or global connections and applications • Contribute to finding solutions to problems at a local and/or global level through inquiry • Implement multiple strategies to solve problems in real-life, applied, and conceptual situations • Consider the role of scientists in innovation **Communicating** • Formulate physical or mental theoretical models to describe a phenomenon • Communicate scientific ideas and information, and perhaps a suggested course of action, for a specific purpose and audience, constructing evidence-based arguments and using appropriate scientific language, conventions, and representations • Express and reflect on a variety of experiences, perspectives, and worldviews through **place**	

Big Ideas – Elaborations

- **Measurement of motion:**
  Sample questions to support inquiry with students:
  - When are measurements considered to be relative?
  - How is vector addition/subtraction different from scalar addition/subtraction?
  - What are the implications of the theory of special relativity?
- **linear and circular motion:**
  Sample questions to support inquiry with students:
  - Under what conditions do forces not cause linear or circular motion?
  - Why do you feel a sideways sliding motion when you speed around a corner in a vehicle?
  - Why must the “orbiting electron” model of the atom be false?
- **fields:**
  Sample questions to support inquiry with students:
  - Why is gravity considered to be a fundamental force?
  - Explain the similarities and differences between electrostatic force and gravitational force.
  - How are electric fields similar to magnetic and gravitational fields?
  - How can a conductor and a magnet be used to generate electricity?
  - What is the relationship between the moon orbiting Earth and an apple falling to the ground?
- **Momentum:**
  Sample questions to support inquiry with students:
  - Why would you consider an inelastic or an elastic collision to be more dangerous?
  - Why does it appear that energy is not conserved during some collisions?
  - Why are cars designed with crumple zones and airbags?
  - How does a ballistic pendulum demonstrate conservation laws?

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Curricular Competencies – Elaborations

- **Questioning and predicting:**
  Sample opportunities to support student inquiry:
  - Predict the age of a sibling who travels to Mars at half the speed of light and returns a few years later.
  - Observe a variety of ways in which a seesaw can be kept parallel to the ground.
  - Generate a hypothesis about the factors that can be used to increase the magnitude of a field.
  - Observe the motion of a ballistics pendulum when different masses are used.

- **Planning and conducting:**
  Sample opportunities to support student inquiry:
  - Collaboratively plan a way to determine the upstream angle needed to land a motorized boat directly across a body of moving water in the local area.
  - Determine the effect of the impulse delivered by a bumper car as it hits a wall at different angles.
- **Processing and analyzing data and information:**
  Sample opportunities to support student inquiry:
  - Construct vector diagrams and derive equations that use vector addition or subtraction to determine a resultant.
  - Use the relativistic mass of a particle in a particle accelerator to determine the radius of curvature needed to keep it within the walls of the device.
  - How do First Peoples traditional hunting methods apply the principles of relative motion?
  - What effect does velocity have on apparent weight (e.g., horizontal circles, vertical circles)?
  - Visually represent the electric fields around a variety of point charges and plates.
- **Evaluating:**
  Sample opportunities to support student inquiry:
  - Identify sources of random and systematic error in lab experiments.
  - Compare an experimental result with a theoretical result and calculate % error or difference and suggest an explanation for any discrepancies.
  - Evaluate the validity of the representation of special relativity in science fiction movies.
  - Critically analyze the findings that suggest the existence of gravitational waves.
  - What are the social, ethical, and environmental implications of the application of electromagnetic induction technologies (e.g., magnetic levitation [mag-lev] trains, hydroelectric dams, high-voltage power lines)?
  - Determine whether a collision is elastic or inelastic and identify ways of improving the quality of the data collected.
  - Assess the safety features in vehicles designed to protect passengers during a collision.
- **Applying and innovating:**
  Sample opportunities to support student inquiry:
  - Co-operatively design a waterwheel to contribute to aeration of a local waterway.
  - Why are roads designed with banked curves?
  - Apply static equilibrium to design and build a deadfall trap that could be used in a survival situation.
  - How did the discovery of the electron and the development of the cathode ray tube (CRT) form the basis of new technologies (e.g., particle accelerators, smartphones)?
  - Investigate methods of providing inexpensive and easily available electricity to rural areas or as part of disaster relief.
  - Collaboratively generate possible prevention methods for common sports injuries based on an understanding of force, momentum, and impulse.
  - How do G-suits save pilots' lives?

Curricular Competencies – Elaborations

- **Communicating:**
  Sample opportunities to support student inquiry:
  - Visually represent an effect of special relativity.
  - Model how activities such as kite-boarding, Ultimate Frisbee, or soccer are affected by relative motion.
  - Demonstrate the difference between a beam in static, translational, and rotational equilibrium.
  - Visually represent how Inukshuks and cairns demonstrate an application of centre of gravity.
  - Present the effects of prolonged cell phone use in the most effective way for a specific audience (e.g., peers, parents).
  - Present an evidence-based argument for the requirement of wearing boxing gloves during a boxing match.
- **place:** Place is any environment, locality, or context with which people interact to learn, create memory, reflect on history, connect with culture, and establish identity. The connection between people and place is foundational to First Peoples perspectives.

Content – Elaborations

- **relativistic effects:** for example, changes in time, length, and mass
- **static equilibrium:**
  - translational: sum of all forces equals zero (vertical and horizontal)
  - rotational: sum of all torques equals zero, location of centre of gravity of a uniform body
- **uniform circular motion:** both horizontal and vertical circles
- **changes to apparent weight:** vertical and horizontal circles (e.g., on a string, upside down on a roller coaster, on a Ferris wheel, right-side up over a hill, centrifuges)
- **First Peoples knowledge and applications of forces in traditional technologies:** for example, Salmon wheel, canoe paddle design, deadfall traps
- **gravitational field:**
  - vector field
  - interacts with mass through gravitons
  - attractive only
- **gravitational dynamics and energy relationships:** satellite motion, orbit changes, launch velocity, escape velocity

- **electric field:**
  - vector field
  - interacts with positive/negative elementary charge
  - attractive or repulsive
  - single point charges (non-uniform field) and parallel plates (uniform field)
- **electrostatic dynamics and energy relationships:**
  - relationships between force, charge, and distance on a single point charge:
    - 1D and 2D with other charges
    - in orbits
    - between parallel plates
  - application of law of conservation of energy and the principle of work and energy (e.g., cathode ray tube, mass spectrometer, particle accelerator)
- **magnetic field:**
  - vector field
  - induced by moving charges
  - interacts with polarity (north/south)
  - attractive or repulsive
  - permanent magnets, straight wires, and solenoids
- **magnetic force:**
  - acting on a moving charge or current carrying wire within a magnetic field
  - right-hand rules
- **electromagnetic induction:**
  - Faraday's law
  - Lenz's law
  - current induced by a change in magnetic flux
  - moving a bar, wire, coil, single charge within a changing magnetic field (strength, polarity, or area)
- **applications of electromagnetic induction:** back electromotive force (EMF), direct current (DC) motors, generators, transformers
- **impulse:**
  - relation to Newton's second law
  - in a closed and isolated system
- **collisions:**
  - elastic, inelastic, and completely inelastic
  - multiple objects in 1D and 2D
  - ballistic pendulums

Content – Elaborations

- **graphical methods:**
  - graphing a linear, exponential, and inverse relationship given a physical model (e.g., electric and gravitational forces and fields versus distance)
  - determining the linear regression that results from exponential and inverse relationships
  - calculating the slope of a line of best fit, including significant figures and appropriate units
  - interpolating and extrapolating data from a constructed graph
  - calculating and interpreting area under the curve on a constructed graph (e.g., impulse)

