Figuring Outer Space

Curriculum Connections

ALBERTA, NORTHWEST TERRITORIES, NUNAVUT—Science 9: Space Exploration

Note: These curriculum connections are meant to be a quick reference guide only. If you have any suggestions for additional curriculum connections, or if you are aware of changes in your curriculum, please contact outreach@perimeterinstitute.ca.

Science 9 Curriculum Connections (2003, updated 2009, 2014)	Mathematics 9 Curriculum Connections (2007, updated 2016)
Activity 1: The Evolution of Stars	
Unit E: Space Exploration (Science and Technology Emphasis) **Outcomes for Science, Technology and Society (STS) and Knowledge** 1. Investigate and describe ways that human understanding of Earth and space has depended on technological development • describe, in general terms, the distribution of matter in star systems, galaxies, nebulae and the universe as a whole • identify evidence for, and describe characteristics of, bodies that make up the solar system; and compare their composition and characteristics with those of Earth 4. Identify issues and opportunities arising from the application of space technology, identify alternatives involved, and analyze implications • describe Canadian contributions to space research and development and to the astronaut program *(e.g., Canadarm)* **Skill Outcomes** (focus on problem solving) **Initiating and Planning** Ask questions about the relationships between and among observable variables, and plan investigations to address those questions • state a prediction and a hypothesis based on background information or an observed pattern of events *(e.g., predict the next appearance of a comet, based on past observations; develop a hypothesis about the geologic history of a planet or its moon, based on recent data)* **Performing and Recording** Conduct investigations into the relationships between and among observations, and gather and record qualitative and quantitative data • research information relevant to a given problem	***9: PATTERNS AND RELATIONS (Patterns)*** 1. Generalize a pattern arising from a problem-solving context, using a linear equation, and verify by substitution. [C, CN, PS, R, V]

• select and integrate information from various print and electronic sources or from several parts of the same source *(e.g., compile and compare information about two exploratory missions)* **Analyzing and Interpreting** Analyze qualitative and quantitative data, and develop and assess possible explanations • identify new questions and problems that arise from what was learned *(e.g., identify questions to guide further investigation, such as: "What limits the travelling distance and duration of space exploration?", "How old are the planets, and how did they form?")* **Communication and Teamwork** Work collaboratively on problems; and use appropriate language and formats to communicate ideas, procedures and results • receive, understand and act on the ideas of others *(e.g., take into account advice provided by other students or individuals in designing a model space suit or space vehicle)* • work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise *(e.g., write and act out a skit to demonstrate tasks carried out by astronauts on a mission)* **Attitude Outcomes** **Scientific Inquiry** Seek and apply evidence when evaluating alternative approaches to investigations, problems and issues *(e.g., seek accurate data that is based on appropriate methods of investigation; consider observations and ideas from a number of sources before drawing conclusions)* **Collaboration** Work collaboratively in carrying out investigations and in generating and evaluating ideas *(e.g., work with others to identify problems and explore possible solutions; share observations and ideas with other members of the group, and consider alternative ideas suggested by other group members; share the responsibility for carrying out decisions)*	
Activity 2: How to Find an Exoplanet	
Unit E: Space Exploration (Science and Technology Emphasis) **Outcomes for Science, Technology and Society (STS) and Knowledge** 1. Investigate and describe ways that human understanding of Earth and space has depended on technological development • investigate and illustrate the contributions of technological advances—including optical telescopes, spectral analysis and space travel—to a scientific understanding of space • identify evidence for, and describe characteristics of, bodies that make up the solar system; and compare their composition and characteristics with those of Earth	***9: STATISTICS AND PROBABILITY (Data Analysis)*** 3. Develop and implement a project plan for the collection, display and analysis of data by: • formulating a question for investigation • choosing a data collection method that includes social considerations

- describe and apply techniques for determining the position and motion of objects in space, including:
  - constructing and interpreting drawings and physical models that illustrate the motion of objects in space *(e.g., represent the orbit of comets around the Sun, using a looped-string model)*
  - describing the position of objects in space, using angular coordinates *(e.g., describe the location of a spot on a wall, by identifying its angle of elevation and its bearing or azimuth; describe the location of the Sun and other stars using altitude-azimuth coordinates, also referred to as horizon coordinates or local coordinates) [Note: A description of star positions based on right ascension and declination is not required.]*

3. Describe and interpret the science of optical and radio telescopes, space probes and remote sensing technologies

   - explain, in general terms, the operation of optical telescopes, including telescopes that are positioned in space environments
   - explain the role of radio and optical telescopes in determining characteristics of stars and star systems
   - describe and interpret, in general terms, the technologies used in global positioning systems and in remote sensing *(e.g., use triangulation to determine the position of an object, given information on the distance from three different points) [Note: This example involves the use of geometric approaches rather than mathematical calculations.]*

4. Identify issues and opportunities arising from the application of space technology, identify alternatives involved, and analyze implications

   - describe Canadian contributions to space research and development and to the astronaut program *(e.g., Canadarm)*

Skill Outcomes (focus on problem solving)

Initiating and Planning
Ask questions about the relationships between and among observable variables, and plan investigations to address those questions

- state a prediction and a hypothesis based on background information or an observed pattern of events *(e.g., predict the next appearance of a comet, based on past observations; develop a hypothesis about the geologic history of a planet or its moon, based on recent data)*

Analyzing and Interpreting
Analyze qualitative and quantitative data, and develop and assess possible explanations

- identify the strengths and weaknesses of different methods of collecting and displaying data *(e.g., compare Earth-based observations with those made from spacecraft)*
- selecting a population or a sample
- collecting the data
- displaying the collected data in an appropriate manner
- drawing conclusions to answer the question.

[C, PS, R, T, V]
[ICT: C1–3.5, C4–3.1, C6–3.1, C6–3.2, C7–3.1, C7–3.2, P1–3.4, P2–3.1]

• identify new questions and problems that arise from what was learned *(e.g., identify questions to guide further investigation, such as: "What limits the travelling distance and duration of space exploration?", "How old are the planets, and how did they form?")* **Communication and Teamwork** Work collaboratively on problems; and use appropriate language and formats to communicate ideas, procedures and results • receive, understand and act on the ideas of others *(e.g., take into account advice provided by other students or individuals in designing a model space suit or space vehicle)* • work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise *(e.g., write and act out a skit to demonstrate tasks carried out by astronauts on a mission)* **Attitude Outcomes** **Scientific Inquiry** Seek and apply evidence when evaluating alternative approaches to investigations, problems and issues *(e.g., seek accurate data that is based on appropriate methods of investigation; consider observations and ideas from a number of sources before drawing conclusions)* **Collaboration** Work collaboratively in carrying out investigations and in generating and evaluating ideas *(e.g., work with others to identify problems and explore possible solutions; share observations and ideas with other members of the group, and consider alternative ideas suggested by other group members; share the responsibility for carrying out decisions)*	
Activity 3: Take a Tour of the Milky Way	
Unit E: Space Exploration (Science and Technology Emphasis) **Outcomes for Science, Technology and Society (STS) and Knowledge** 1. Investigate and describe ways that human understanding of Earth and space has depended on technological development • identify different ideas about the nature of Earth and space, based on culture and science *(e.g., compare geocentric and heliocentric models [Note: knowledge of epicycles is not required]; describe Aboriginal views of space and those of other cultures; describe the role of observation in guiding scientific understanding of space)* • describe, in general terms, the distribution of matter in star systems, galaxies, nebulae and the universe as a whole • describe and apply techniques for determining the position and motion of objects in space, including: ○ constructing and interpreting drawings and physical models that illustrate the motion of objects in space *(e.g., represent the orbit of comets around the Sun, using a looped-string model)*	***9: PATTERNS AND RELATIONS (Patterns)*** 1. Generalize a pattern arising from a problem-solving context, using a linear equation, and verify by substitution. [C, CN, PS, R, V] ***9: SHAPE AND SPACE (Measurement)*** 4. Draw and interpret scale diagrams of 2-D shapes. [CN, R, T, V] [ICT: C6–3.4]

3. Describe and interpret the science of optical and radio telescopes, space probes and remote sensing technologies • explain the role of radio and optical telescopes in determining characteristics of stars and star systems **Skill Outcomes** (focus on problem solving) **Performing and Recording** Conduct investigations into the relationships between and among observations, and gather and record qualitative and quantitative data • research information relevant to a given problem **Analyzing and Interpreting** Analyze qualitative and quantitative data, and develop and assess possible explanations • test the design of a constructed device or system *(e.g., create and test a model device for remote manipulation of materials)* • identify new questions and problems that arise from what was learned *(e.g., identify questions to guide further investigation, such as: "What limits the travelling distance and duration of space exploration?", "How old are the planets, and how did they form?")* **Communication and Teamwork** Work collaboratively on problems; and use appropriate language and formats to communicate ideas, procedures and results • work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise *(e.g., write and act out a skit to demonstrate tasks carried out by astronauts on a mission)* **Attitude Outcomes** **Collaboration** Work collaboratively in carrying out investigations and in generating and evaluating ideas *(e.g., work with others to identify problems and explore possible solutions; share observations and ideas with other members of the group, and consider alternative ideas suggested by other group members; share the responsibility for carrying out decisions)*	

Activity 4: The History of the Universe	
Unit E: Space Exploration (Science and Technology Emphasis) **Outcomes for Science, Technology and Society (STS) and Knowledge** 1. Investigate and describe ways that human understanding of Earth and space has depended on technological development • describe, in general terms, the distribution of matter in star systems, galaxies, nebulae and the universe as a whole • identify evidence for, and describe characteristics of, bodies that make up the solar system; and compare their composition and characteristics with those of Earth 3. Describe and interpret the science of optical and radio telescopes, space probes and remote sensing technologies • explain, in general terms, the operation of optical telescopes, including telescopes that are positioned in space environments **Skill Outcomes** (focus on problem solving) **Performing and Recording** Conduct investigations into the relationships between and among observations, and gather and record qualitative and quantitative data • research information relevant to a given problem **Analyzing and Interpreting** Analyze qualitative and quantitative data, and develop and assess possible explanations • identify the strengths and weaknesses of different methods of collecting and displaying data *(e.g., compare Earth-based observations with those made from spacecraft)* • identify new questions and problems that arise from what was learned *(e.g., identify questions to guide further investigation, such as: "What limits the travelling distance and duration of space exploration?", "How old are the planets, and how did they form?")* **Communication and Teamwork** Work collaboratively on problems; and use appropriate language and formats to communicate ideas, procedures and results • work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise *(e.g., write and act out a skit to demonstrate tasks carried out by astronauts on a mission)* **Attitude Outcomes** **Collaboration** Work collaboratively in carrying out investigations and in generating and evaluating ideas *(e.g., work with others to identify problems and explore possible solutions; share observations and ideas with other members of the group, and consider alternative ideas suggested by other group members; share the responsibility for carrying out decisions)*	***9: PATTERNS AND RELATIONS (Patterns)*** 1. Generalize a pattern arising from a problem-solving context, using a linear equation, and verify by substitution. [C, CN, PS, R, V]

Activity 5: Crab Nebula Expansion

Unit E: Space Exploration (Science and Technology Emphasis)

Outcomes for Science, Technology and Society (STS) and Knowledge

1. Investigate and describe ways that human understanding of Earth and space has depended on technological development
   - identify different ideas about the nature of Earth and space, based on culture and science *(e.g., compare geocentric and heliocentric models [Note: knowledge of epicycles is not required]; describe Aboriginal views of space and those of other cultures; describe the role of observation in guiding scientific understanding of space)*
   - investigate and illustrate the contributions of technological advances—including optical telescopes, spectral analysis and space travel—to a scientific understanding of space
   - describe, in general terms, the distribution of matter in star systems, galaxies, nebulae and the universe as a whole
   - describe and apply techniques for determining the position and motion of objects in space, including:
     - constructing and interpreting drawings and physical models that illustrate the motion of objects in space *(e.g., represent the orbit of comets around the Sun, using a looped-string model)*
   - investigate predictions about the motion, alignment and collision of bodies in space *(e.g., investigate predictions about eclipses; identify uncertainties in predicting and tracking meteor showers)*
3. Describe and interpret the science of optical and radio telescopes, space probes and remote sensing technologies
   - explain, in general terms, the operation of optical telescopes, including telescopes that are positioned in space environments
   - explain the role of radio and optical telescopes in determining characteristics of stars and star systems

Skill Outcomes (focus on problem solving)

Performing and Recording

Conduct investigations into the relationships between and among observations, and gather and record qualitative and quantitative data

- select and integrate information from various print and electronic sources or from several parts of the same source *(e.g., compile and compare information about two exploratory missions)*
- organize data, using a format that is appropriate to the task or experiment *(e.g., maintain a log of observed changes in the night sky; prepare a data table to compare various planets)*

Analyzing and Interpreting

Analyze qualitative and quantitative data, and develop and assess possible explanations

9: PATTERNS AND RELATIONS (Patterns)

1. Generalize a pattern arising from a problem-solving context, using a linear equation, and verify by substitution. [C, CN, PS, R, V]

3. Model and solve problems, using linear equations of the form $ax = b$ [C, CN ,PS, V]

9: STATISTICS AND PROBABILITY (Data Analysis)

3. Develop and implement a project plan for the collection, display and analysis of data by:
   - formulating a question for investigation
   - choosing a data collection method that includes social considerations
   - selecting a population or a sample
   - collecting the data
   - displaying the collected data in an appropriate manner
   - drawing conclusions to answer the question.

   [C, PS, R, T, V]
   [ICT: C1–3.5, C4–3.1, C6–3.1, C6–3.2, C7–3.1, C7–3.2, P1–3.4, P2–3.1]

• identify new questions and problems that arise from what was learned *(e.g., identify questions to guide further investigation, such as: "What limits the travelling distance and duration of space exploration?", "How old are the planets, and how did they form?")* **Communication and Teamwork** Work collaboratively on problems; and use appropriate language and formats to communicate ideas, procedures and results • work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise *(e.g., write and act out a skit to demonstrate tasks carried out by astronauts on a mission)* **Attitude Outcomes** **Scientific Inquiry** Seek and apply evidence when evaluating alternative approaches to investigations, problems and issues *(e.g., seek accurate data that is based on appropriate methods of investigation; consider observations and ideas from a number of sources before drawing conclusions)* **Collaboration** Work collaboratively in carrying out investigations and in generating and evaluating ideas *(e.g., work with others to identify problems and explore possible solutions; share observations and ideas with other members of the group, and consider alternative ideas suggested by other group members; share the responsibility for carrying out decisions)*	
Activity 6: The Search for Exoplanets	
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• investigate predictions about the motion, alignment and collision of bodies in space *(e.g., investigate predictions about eclipses; identify uncertainties in predicting and tracking meteor showers)* 3. Describe and interpret the science of optical and radio telescopes, space probes and remote sensing technologies • explain, in general terms, the operation of optical telescopes, including telescopes that are positioned in space environments • explain the role of radio and optical telescopes in determining characteristics of stars and star systems **Skill Outcomes** (focus on problem solving) **Performing and Recording** Conduct investigations into the relationships between and among observations, and gather and record qualitative and quantitative data • select and integrate information from various print and electronic sources or from several parts of the same source *(e.g., compile and compare information about two exploratory missions)* • organize data, using a format that is appropriate to the task or experiment *(e.g., maintain a log of observed changes in the night sky; prepare a data table to compare various planets)* **Analyzing and Interpreting** Analyze qualitative and quantitative data, and develop and assess possible explanations • identify the strengths and weaknesses of different methods of collecting and displaying data *(e.g., compare Earth-based observations with those made from spacecraft)* • identify new questions and problems that arise from what was learned *(e.g., identify questions to guide further investigation, such as: "What limits the travelling distance and duration of space exploration?", "How old are the planets, and how did they form?")* **Communication and Teamwork** Work collaboratively on problems; and use appropriate language and formats to communicate ideas, procedures and results • work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise *(e.g., write and act out a skit to demonstrate tasks carried out by astronauts on a mission)* **Attitude Outcomes** **Scientific Inquiry** Seek and apply evidence when evaluating alternative approaches to investigations, problems and issues *(e.g., seek accurate data that is based on appropriate methods of investigation; consider observations and ideas from a number of sources before drawing conclusions)*	C6–3.2, C7–3.1, C7–3.2, P1–3.4, P2–3.1]

Collaboration Work collaboratively in carrying out investigations and in generating and evaluating ideas *(e.g., work with others to identify problems and explore possible solutions; share observations and ideas with other members of the group, and consider alternative ideas suggested by other group members; share the responsibility for carrying out decisions)*	

Figuring Outer Space

Curriculum Connections

BRITISH COLUMBIA AND YUKON—Science 10

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Science 10 Curriculum Connections (March 2018)	Mathematics 10 Curriculum Connections
Activity 1: The Evolution of Stars	
Curriculum Competencies **Questioning and predicting** • Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal interest • Make observations aimed at identifying their own questions, including increasingly complex 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) **Processing and analyzing data and information** • Construct, analyze and interpret graphs (including interpolation and extrapolation), models and/or diagrams • Use knowledge of scientific concepts to draw conclusions that are consistent with evidence • Analyze cause-and-effect relationships **Applying and innovating** • Consider the role of scientists in innovation **Communicating** • Communicate scientific ideas, claims, 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 **Content** • formation of the universe: – **components of the universe over time**	***Foundations of Mathematics and Pre-calculus 10*** **Big Ideas—Elaborations** • **proportional reasoning:** – comparisons of relative size or scale instead of numerical difference **Curricular Competencies—Elaborations** • **thinking strategies:** – using reason to determine winning strategies – generalizing and extending • **Think creatively:** – by being open to trying different strategies • **discussions:** – partner talks, small-group discussions, teacher-student conferences • **discourse:** – is valuable for deepening understanding of concepts ***Workplace Mathematics 10*** ***Big Ideas—Elaborations*** • **proportional reasoning:** – reasoning about comparisons of relative size or scale instead of numerical difference

• **astronomical data and collection methods** **Content—Elaborations** • **components of the universe over time:** changes to energy, matter, fundamental forces • *astronomical data and collection methods:* different types of data are collected and analyzed as evidence to support theories about the universe (e.g., radio telescopes, background microwave radiation, red and blue Doppler shift, Mars rover, SNOLAB, ISS, Canadarm/Dextre)	**Curricular Competencies—Elaborations** • **thinking strategies:** – using reason to determine winning strategies – generalizing and extending
Activity 2: How to Find an Exoplanet	
Curriculum Competencies **Questioning and predicting** • Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal interest • Make observations aimed at identifying their own questions, including increasingly complex 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) • Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data • Ensure that safety and ethical guidelines are followed in their investigations **Processing and analyzing data and information** • Seek and analyze patterns, trends, and connections in data, including describing relationships between variables (dependent and independent) and identifying inconsistencies • Construct, analyze and interpret graphs (including interpolation and extrapolation), models and/or diagrams • Analyze cause-and-effect relationships **Evaluating** • Evaluate the validity and limitations of a model or analogy in relation to the phenomenon modelled • Consider the changes in knowledge over time as tools and technologies have developed • Connect scientific explorations to careers in science **Applying and innovating** • Transfer and apply learning to new situations • Consider the role of scientists in innovation	***Foundations of Mathematics and Pre-calculus 10*** **Curriculum Competencies** **Understanding and solving** • **Visualize** to explore an illustrate mathematical concepts and relationships **Communicating and representing** • **Represent** mathematical ideas in concrete, pictorial, and symbolic forms ***Content*** • **functions and relations**: connecting data, graphs, and situations ***Big Ideas—Elaborations*** • **relations** – How can we use rate of change to make predictions? • **proportional reasoning** – Comparisons of relative size or scale instead of numerical difference • **situations** – Why are trends important? ***Curricular Competencies—Elaborations*** • **thinking strategies:** – using reason to determine winning strategies – generalizing and extending • **technology:** – organizing and displaying data – mathematical modelling

Communicating

- Formulate physical or mental theoretical models to describe a phenomenon
- Communicate scientific ideas, claims, 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

Content

- **astronomical data and collection methods**

Big Ideas—Elaborations

- **universe:**
  - How has the advancement of technology deepened our understanding of the universe?

- **other tools:**
  - manipulatives such as algebra tiles and other concrete materials
- **situational contexts:**
  - including real-life scenarios and open-ended challenges that connect mathematics with everyday life
- **inquiry:**
  - determining what is needed to make sense of and solve problems
- **Visualize:**
  - Visualization can be supported using dynamic materials (e.g., graphical relationships and simulations), concrete materials, drawings, and diagrams
- **Represent:**
  - Using models, tables, graphs, words, numbers and symbols
  - Connection meaning among various representations
  - using concrete materials and dynamic interactive technology
- **discussions:**
  - partner talks, small-group discussions, teacher-student conferences
- **discourse:**
  - is valuable for deepening understanding of concepts
- **reflect:**
  - share the mathematical thinking of self and others, including evaluating strategies and solutions, extending, posing new problems and questions

Content—Elaboration

- **functions and relations:**
  - connecting graphs and context

Workplace Mathematics 10

Content

- **surface area and volume**

	Big Ideas—Elaboration • **Proportional reasoning:** – reasoning about comparisons of relative size or scale instead of numerical difference • **Representing and analyzing data:** – How do we choose the most appropriate graph to represent a set of data? – How do graphs help summarize and analyze data? – Why are graphs used to represent data? – Why do we graph data? • **Thinking strategies:** – generalizing and extending • **technology:** – exploring and demonstrating mathematical relationships – organizing and displaying data – generating and testing inductive conjectures – mathematical modelling • **Visualize:** – Visualization can be supported using dynamic materials (e.g., graphical relationship, simulations), concrete materials, drawings, and diagrams • **Represent:** – Using models, tables, graphs, words, numbers, symbols
Activity 3: Take a Tour of the Milky Way	
Curriculum Competencies **Questioning and predicting** • Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal interest • Make observations aimed at identifying their own questions, including increasingly complex ones, about the natural world	***Foundations of Mathematics and Pre-calculus 10*** ***Curricular Competencies*** **Understanding and solving** • **Visualize** to explore and illustrate mathematical concepts and relationships

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)

Processing and analyzing data and information

- Seek and analyze patterns, trends, and connections in data, including describing relationships between variables (dependent and independent) and identifying inconsistencies
- Construct, analyze and interpret graphs (including interpolation and extrapolation), models and/or diagrams
- Use knowledge of scientific concepts to draw conclusions that are consistent with evidence

Evaluating

- 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 secondary sources
- Connect scientific explorations to careers in science

Applying and innovating

- Transfer and apply learning to new situations
- Generate and introduce new or refined ideas when problem solving
- Consider the role of scientists in innovation

Communicating

- Formulate physical or mental theoretical models to describe a phenomenon
- Communicate scientific ideas, claims, 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

Content

- formation of the universe:
  - **components of the universe over time**
- astronomical data and collection methods

Content—Elaborations

- **components of the universe over time:** changes to energy, matter, fundamental forces

Communicating and representing

- **Represent** mathematical ideas in concrete, pictorial, and symbolic forms

Big Ideas—Elaborations

- **proportional reasoning:**
  - comparisons of relative size or scale instead of numerical difference

Curricular Competencies—Elaboration

- **thinking strategies:**
  - generalizing and extending
- **situational contexts:**
  - including real-life scenarios and open-ended challenges that connect mathematics with everyday life
- **Think creatively:**
  - by being open to trying different strategies
- **Represent:**
  - Connecting meanings among various representations
- **discussions:**
  - partner talks, small-group discussions, teacher-student conferences
- **discourse:**
  - is valuable for deepening understanding of concepts

Workplace Mathematics 10

Big Ideas—Elaborations

- **Proportional reasoning:**
  - reasoning about comparisons of relative size or scale instead of numerical difference

Curricular Competencies—Elaborations

- **thinking strategies:**
  - generalizing and extending
- **Estimate reasonably:**

	– be able to defend the reasonableness of an estimated value or a solution to a problem or equation (e.g., measurement calculations, angle-size reasonableness, primary trigonometric ratio calculations) • **Visualize:** – create and use mental images to support understanding – Visualization can be supported using dynamic materials (e.g., graphical relationships, simulations), concrete materials, drawings, and diagrams
Activity 4: The History of the Universe	
Curriculum Competencies **Questioning and predicting** • Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal interest • Make observations aimed at identifying their own questions, including increasingly complex ones, about the natural world • Formulate multiple hypotheses and predict multiple outcomes **Planning and conducting** • Ensure that safety and ethical guidelines are followed in their investigations **Processing and analyzing data and information** • Seek and analyze patterns, trends, and connections in data, including describing relationships between variables (dependent and independent) and identifying inconsistencies • Use knowledge of scientific concepts to draw conclusions that are consistent with evidence • Analyze cause-and-effect relationships **Evaluating** • 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 secondary sources • Consider the changes in knowledge over time as tools and technologies have developed • Connect scientific explorations to careers in science	***Foundations of Mathematics and Pre-calculus 10*** ***Big Ideas—Elaborations*** • **proportional reasoning:** – comparisons of relative size or scale instead of numerical difference ***Curricular Competencies—Elaborations*** • **thinking strategies:** – generalizing and extending • **Think creatively:** – by being open to trying different strategies • **discussions:** – partner talks, small-group discussions, teacher-student conferences • **discourse:** – is valuable for deepening understanding of concepts ***Workplace Mathematics 10*** ***Big Ideas—Elaborations*** • **Proportional reasoning:**

• Critically analyze the validity of information in secondary sources and evaluate the approaches used to solve problems **Applying and innovating** • Transfer and apply learning to new situations • Generate and introduce new or refined ideas when problem solving • Consider the role of scientists in innovation **Communicating** • Formulate physical or mental theoretical models to describe a phenomenon • Communicate scientific ideas, claims, 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 ***Content*** • formation of the universe: – big bang theory – **components of the universe over time** • astronomical data and collection methods ***Big Ideas—Elaborations*** • **universe:** – What evidence supports the big bang theory? – How could you model the formation of the universe? – How has the advancement of technology deepened our understanding of the universe? • **Questioning and predicting:** – How would you investigate the age of the universe? ***Content—Elaborations*** • **components of the universe over time:** changes to energy, matter, fundamental forces • **astronomical data and collection methods:** different types of data are collected and analyzed as evidence to support theories about the universe (e.g., radio telescopes, background microwave radiation, red and blue Doppler shift, Mars rover, SNOLAB, ISS, Canadarm/Dextre)	– reasoning about comparisons of relative size or scale instead of numerical difference ***Curricular Competencies—Elaborations*** • **thinking strategies:** – generalizing and extending
Activity 5: Crab Nebula Expansion	
Curriculum Competencies **Questioning and predicting** • Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal interest	***Foundations of Mathematics and Pre-calculus 10*** ***Curricular Competencies***

- Make observations aimed at identifying their own questions, including increasingly complex ones, about the natural world

Planning and conducting

- Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data

Processing and analyzing data and information

- Seek and analyze patterns, trends, and connections in data, including describing relationships between variables (dependent and independent) and identifying inconsistencies
- Construct, analyze and interpret graphs (including interpolation and extrapolation), 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 the 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 secondary sources
- Consider the changes in knowledge over time as tools and technologies have developed
- Connect scientific explorations to careers in science

Applying and innovating

- Transfer and apply learning to new situations
- Consider the role of scientists in innovation

Communicating

- Formulate physical or mental theoretical models to describe a phenomenon
- Communicate scientific ideas, claims, 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

Content

- formation of the universe:
  - **components of the universe over time**

Communicating and representing

- **Represent** mathematical ideas in concrete, pictorial, and symbolic forms

Content

- functions and relations: connecting data, graphs, and situations

Big Ideas—Elaborations

- **relations:**
  - How can we tell if a relation is linear?
  - How can we use rate of change to make predictions?
- **proportional reasoning:**
  - comparisons of relative size or scale instead of numerical difference
- **indirect measurement**
  - using measurable values to calculate immeasurable values (e.g., calculating the height of a tree using distance from the tree and the angle to the top of the tree)
- **situations:**
  - Why are trends important?

Curricular Competencies—Elaborations

- **thinking strategies:**
  - generalizing and extending
- **Think creatively:**
  - by being open to trying different strategies
- **Visualize:**
  - Visualization can be supported using dynamic materials (e.g., graphical relationships and simulations), concrete materials, drawings, and diagrams
- **solve problems:**
  - Apply mathematics to solve the problem
- **discussions:**

- astronomical data and collection methods

Big Ideas—Elaborations

- **universe:**
  - How has the advancement of technology deepened our understanding of the universe?

Content—Elaborations

- **astronomical data and collection methods:** different types of data are collected and analyzed as evidence to support theories about the universe (e.g., radio telescopes, background microwave radiation, red and blue Doppler shift, Mars rover, SNOLAB, ISS, Canadarm/Dextre)

  - partner talks, small-group discussions, teacher-student conferences
- **discourse:**
  - is valuable for deepening understanding of concepts
- **Reflect:**
  - share the mathematical thinking of self and others, including evaluating strategies and solutions, extending, posing new problems and questions
- **Connect mathematical concepts:**
  - to develop a sense of how mathematics helps us understand ourselves and the world around us (e.g., daily activities, local and traditional practices, popular media and news events, social justice, cross-curricular integration)

Content—Elaborations

Functions and relations:

- understanding the meaning of a function

Workplace Mathematics 10

Curricular Competencies

- **Communicating and representing**
- **Represent** mathematical ideas in concrete, pictorial, and symbolic forms

Big Ideas—Elaborations

Proportional reasoning:

- reasoning about comparisons of relative size or scale instead of numerical difference
- **measuring:**
  - Why is it important to understand the components of a formula?

Curricular Competencies—Elaborations

- **thinking strategies:**
  - generalizing and extending

	Content—Elaborations • **conversions:** – using tools and appropriate units to measure with accuracy
Activity 6: The Search for Exoplanets	
Curriculum Competencies **Questioning and predicting** • Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal interest • Make observations aimed at identifying their own questions, including increasingly complex ones, about the natural world **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) • Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data • Ensure that safety and ethical guidelines are followed in their investigations **Processing and analyzing data and information** • Seek and analyze patterns, trends, and connections in data, including describing relationships between variables (dependent and independent) and identifying inconsistencies • Construct, analyze and interpret graphs (including interpolation and extrapolation), models and/or diagrams • Use knowledge of scientific concepts to draw conclusions that are consistent with evidence • Analyze cause-and-effect relationships **Evaluating** • Evaluate the validity and limitations of a model or analogy in relation to the phenomenon modelled • Consider the changes in knowledge over time as tools and technologies have developed • Connect scientific explorations to careers in science **Applying and innovating** • Transfer and apply learning to new situations • Generate and introduce new or refined ideas when problem solving • Consider the role of scientists in innovation	***Foundations of Mathematics and Pre-calculus 10*** ***Curricular Competencies*** **Understanding and solving** • **Visualize** to explore and illustrate mathematical concepts and relationships **Communicating and representing** • **Represent** mathematical ideas in concrete, pictorial, and symbolic forms **Content** • **functions and relations:** connecting data, graphs, and situations ***Big Ideas—Elaborations*** • **proportional reasoning:** – Comparisons of relative size or scale instead of numerical difference • **situations:** – Why are trends important? ***Curricular Competencies—Elaborations*** • **thinking strategies:** – generalizing and extending • **technology:** – mathematical modelling • **other tools:** – manipulatives such as algebra tiles and other concrete materials • **Model:** – use mathematical concepts and tools to solve problems and make decisions (e.g., in real-life and/or abstract scenarios)

Communicating

- Formulate physical or mental theoretical models to describe a phenomenon
- Communicate scientific ideas, claims, 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

Big Ideas—Elaborations

- **universe:**
  - How has the advancement of technology deepened our understanding of the universe?

Content—Elaborations

- astronomical data and collection methods

- **situational contexts:**
  - including real-life scenarios and open-ended challenges that connect mathematics with everyday life
- **Think creatively:**
  - generalizing and extending
- **inquiry:**
  - determining what is needed to make sense of and solve problems
- **Visualize:**
  - Visualization can be supported using dynamic materials (e.g., graphical relationships and simulations), concrete materials, drawings, and diagrams
- **Represent:**
  - Using concrete materials and dynamic interactive technology
- **discussions:**
  - Partner talks, small-group discussions, teacher-student conferences
- **discourse:**
  - Is valuable for deepening understanding of concepts
- **Connect mathematical concepts:**
  - to develop a sense of how mathematics helps us understand ourselves and the world around us (e.g., daily activities, local and traditional practices, popular media and news events, social justice, cross-curricular integration)

Content—Elaborations

- **functions and relations:**
  - Connecting graphs and context

Workplace Mathematics 10

Content

- **surface area and volume**

Big Ideas—Elaborations

	• **Proportional reasoning:** – Reasoning about comparisons of relative size or scale instead of numerical difference • **measuring:** – Why is it important to understand the components of a formula? • **Representing and analyzing data:** – Why are graphs used to represent data? – Why do we graph data? • **thinking strategies:** – generalizing and extending • **Represent:** – using models, tables, graphs, words, numbers, symbols

Figuring Outer Space

Curriculum Connections

MANITOBA—Senior 1 Science: Exploring the Universe

Note: These curriculum connections are meant to be a quick reference guide only. If you have any suggestions for additional curriculum connections, or if you are aware of changes in your curriculum, please contact outreach@perimeterinstitute.ca.

ELA = English Language Arts, MATH = Mathematics, TFS = Technology as a Foundation Skill Area, GLO = General Learning Outcome

Senior 1 Science Curriculum Connections (2000)	**Mathematics 9 Curriculum Connections** (2014)
Activity 1: The Evolution of Stars	
Senior 1, Cluster 4: Exploring the Universe ***Skills and Attitude Outcomes*** S1-0-1a Propose questions that could be tested experimentally. (ELA: S1: 3.1.2) GLO: C2 S1-0-1b Select and justify various methods for finding the answers to specific questions. (Math: S1: A-1) GLO: C2 S1-0-2a Select and integrate information obtained from a variety of sources. Include: print, electronic, specialists, other resource people. (ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 1.3.2, 4.3.4 S1-0-2c Summarize and record information in a variety of forms. Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources. (ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.3.1, 4.3.4 S1-0-4e Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise. (ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7 S1-0-5a Select and use appropriate methods and tools for collecting data or information. GLO: C2; TFS: 1.3.1 S1-0-5c Record, organize, and display data using an appropriate format. Include: labelled diagrams, graphs, multimedia (ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2 S1-0-6a Interpret patterns and trends in data, and infer and explain relationships. GLO: C2, C5 TFS: 1.3.1, 3.3.1 (ELA: S1: 3.3.1)	***Shape and Space (Transformations)*** 9.SS.4 Draw and interpret scale diagrams of 2-D shapes. [CN, R, T, V]

S1-0-7a Draw a conclusion that explains the results of an investigation. Include: cause and effect relationships, alternative explanations, supporting or rejecting the hypothesis or prediction. (ELA: S1: 3.3.4) GLO: C2, C5, C8 S1-0-7e Reflect on prior knowledge and experiences to develop new understanding. (ELA: S1: 4.2.1) GLO: C2, C3, C4 S1-0-8c Describe examples of how scientific knowledge has evolved in light of new evidence, and the role of technology in this evolution. GLO: A2, A5 S1-0-9a Appreciate and respect that science and technology have evolved from different views held by women and men from a variety of societies and cultural backgrounds. GLO: A4 ***Specific Learning Outcomes*** S1-4-07 Compare and contrast scientific and cultural perspectives on the origin and evolution of the universe. GLO: A1, A2, A4, D6 S1-4-08 Differentiate between the major components of the universe. Include: planets, moons, comets and asteroids, nebulae, stars, galaxies, black holes. GLO: D6, E1, E2 S1-4-09 Explain how various technologies have extended our ability to explore and understand space. GLO: A5, B1, B2, D6	
Activity 2: How to Find an Exoplanet	
Senior 1, Cluster 4: Exploring the Universe ***Skills and Attitude Outcomes*** S1-0-1a Propose questions that could be tested experimentally. (ELA: S1: 3.1.2) GLO: C2 S1-0-1b Select and justify various methods for finding the answers to specific questions. (Math: S1: A-1) GLO: C2 S1-0-1c Identify STSE issues which could be addressed. GLO: C4 S1-0-1d Identify stakeholders and initiate research related to an STSE issue. (ELA: S1: 3.1.4, 4.4.1) GLO: C4 S1-0-2a Select and integrate information obtained from a variety of sources. Include: print, electronic, specialists, other resource people. (ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 1.3.2, 4.3.4 S1-0-2b Evaluate the reliability, bias, and usefulness of information. (ELA: S1: 3.2.3, 3.3.3) GLO: C2, C4, C5, C8; TFS: 2.2.2, 4.3.4 S1-0-3b Identify probable mathematical relationships between variables. GLO: C2	***Statistics and Probability (Data Analysis)*** 9.SP.3 Develop and implement a project plan for the collection, display, and analysis of data by • formulating a question for investigation • choosing a data collection method that includes social considerations • selecting a population or a sample • collecting the data • displaying the collected data in an appropriate manner • drawing conclusions to answer the question [C, PS, R, T, V]

S1-0-4e Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise. (ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7 S1-0-5a Select and use appropriate methods and tools for collecting data or information. GLO: C2; TFS: 1.3.1 S1-0-5b Estimate and measure accurately using Système International (SI) and other standard units. Include: SI conversions. GLO: C2 S1-0-5c Record, organize, and display data using an appropriate format. Include: labelled diagrams, graphs, multimedia (ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2 S1-0-6a Interpret patterns and trends in data, and infer and explain relationships. GLO: C2, C5 TFS: 1.3.1, 3.3.1 (ELA: S1: 3.3.1) S1-0-7a Draw a conclusion that explains the results of an investigation. Include: cause and effect relationships, alternative explanations, supporting or rejecting the hypothesis or prediction. (ELA: S1: 3.3.4) GLO: C2, C5, C8 S1-0-7e Reflect on prior knowledge and experiences to develop new understanding. (ELA: S1: 4.2.1) GLO: C2, C3, C4 S1-0-8e Discuss how peoples of various cultures have contributed to the development of science and technology. GLO: A4, A5 S1-0-9a Appreciate and respect that science and technology have evolved from different views held by women and men from a variety of societies and cultural backgrounds. GLO: A4 ***Specific Learning Outcomes*** S1-4-02 Observe the motion of visible celestial objects and organize collected data. GLO: C2, C5, C6, D6 S1-4-05 Explain the apparent motion of the Sun, stars, planets, and the Moon as seen from Earth. Include: daily rising and setting, seasonal constellations, retrograde motion. GLO: D4, D6, E2 S1-4-08 Differentiate between the major components of the universe. Include: planets, moons, comets and asteroids, nebulae, stars, galaxies, black holes. GLO: D6, E1, E2 S1-4-09 Explain how various technologies have extended our ability to explore and understand space. GLO: A5, B1, B2, D6 S1-4-10 Investigate ways in which Canada participates in space research and in international space programs, and then use the decision-making process to address a related issue. GLO: A3, A4, B2, C4 S1-4-11 Evaluate the impact of space science and technologies in terms of their benefits and risks to humans. GLO: A3, B1, B2, B5	***Patterns and Relations (Patterns)*** 9.PR.2. Graph linear relations, analyze the graph, and interpolate or extrapolate to solve problems. [C, CN, ME, PS, R, T, V]

Activity 3: Take a Tour of the Milky Way	
Senior 1, Cluster 4: Exploring the Universe ***Skills and Attitude Outcomes*** S1-0-1a Propose questions that could be tested experimentally. (ELA: S1: 3.1.2) GLO: C2 S1-0-1b Select and justify various methods for finding the answers to specific questions. (Math: S1: A-1) GLO: C2 S1-0-2a Select and integrate information obtained from a variety of sources. Include: print, electronic, specialists, other resource people. (ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 1.3.2, 4.3.4 S1-0-4e Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise. (ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7 S1-0-4f Assume the responsibilities of various roles within a group and evaluate which roles are most appropriate for given tasks. (ELA: S1: 5.2.2) GLO: C2, C4, C7 S1-0-5a Select and use appropriate methods and tools for collecting data or information. GLO: C2; TFS: 1.3.1 S1-0-5c Record, organize, and display data using an appropriate format. Include: labelled diagrams, graphs, multimedia (ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2 S1-0-6a Interpret patterns and trends in data, and infer and explain relationships. GLO: C2, C5 TFS: 1.3.1, 3.3.1 (ELA: S1: 3.3.1) S1-0-7a Draw a conclusion that explains the results of an investigation. Include: cause and effect relationships, alternative explanations, supporting or rejecting the hypothesis or prediction. (ELA: S1: 3.3.4) GLO: C2, C5, C8 S1-0-7e Reflect on prior knowledge and experiences to develop new understanding. (ELA: S1: 4.2.1) GLO: C2, C3, C4 S1-0-8c Describe examples of how scientific knowledge has evolved in light of new evidence, and the role of technology in this evolution. GLO: A2, A5 ***Specific Learning Outcomes*** S1-4-05 Explain the apparent motion of the Sun, stars, planets, and the Moon as seen from Earth. Include: daily rising and setting, seasonal constellations, retrograde motion. GLO: D4, D6, E2	***Shape and Space (Transformations)*** 9.SS.4 Draw and interpret scale diagrams of 2-D shapes. [CN, R, T, V]

S1-4-08 Differentiate between the major components of the universe. Include: planets, moons, comets and asteroids, nebulae, stars, galaxies, black holes. GLO: D6, E1, E2 S1-4-09 Explain how various technologies have extended our ability to explore and understand space. GLO: A5, B1, B2, D6	
Activity 4: The History of the Universe	
Senior 1, Cluster 4: Exploring the Universe ***Skills and Attitude Outcomes*** S1-0-1a Propose questions that could be tested experimentally. (ELA: S1: 3.1.2) GLO: C2 S1-0-2a Select and integrate information obtained from a variety of sources. Include: print, electronic, specialists, other resource people. (ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 1.3.2, 4.3.4 S1-0-2c Summarize and record information in a variety of forms. Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources. (ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.3.1, 4.3.4 S1-0-4e Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise. (ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7 S1-0-5c Record, organize, and display data using an appropriate format. Include: labelled diagrams, graphs, multimedia (ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2 S1-0-7e Reflect on prior knowledge and experiences to develop new understanding. (ELA: S1: 4.2.1) GLO: C2, C3, C4 S1-0-8c Describe examples of how scientific knowledge has evolved in light of new evidence, and the role of technology in this evolution. GLO: A2, A5 S1-0-8d Describe examples of how technologies have evolved in response to changing needs and scientific advances. GLO: A5 S1-0-8e Discuss how peoples of various cultures have contributed to the development of science and technology. GLO: A4, A5 S1-0-9a Appreciate and respect that science and technology have evolved from different views held by women and men from a variety of societies and cultural backgrounds. GLO: A4 ***Specific Learning Outcomes*** S1-4-07 Compare and contrast scientific and cultural perspectives on the origin and evolution of the universe. GLO: A1, A2, A4, D6	***Shape and Space (Transformations)*** 9.SS.4 Draw and interpret scale diagrams of 2-D shapes. [CN, R, T, V]

S1-4-08 Differentiate between the major components of the universe. Include: planets, moons, comets and asteroids, nebulae, stars, galaxies, black holes. GLO: D6, E1, E2 S1-4-09 Explain how various technologies have extended our ability to explore and understand space. GLO: A5, B1, B2, D6	
Activity 5: Crab Nebula Expansion	
Senior 1, Cluster 4: Exploring the Universe ***Skills and Attitude Outcomes*** S1-0-1a Propose questions that could be tested experimentally. (ELA: S1: 3.1.2) GLO: C2 S1-0-1b Select and justify various methods for finding the answers to specific questions. (Math: S1: A-1) GLO: C2 S1-0-3b Identify probable mathematical relationships between variables. GLO: C2 S1-0-4e Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7 S1-0-5a Select and use appropriate methods and tools for collecting data or information. GLO: C2; TFS: 1.3.1 S1-0-5b Estimate and measure accurately using Système International (SI) and other standard units. Include: SI conversions. GLO: C2 S1-0-5c Record, organize, and display data using an appropriate format. Include: labelled diagrams, graphs, multimedia (ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2 S1-0-6a Interpret patterns and trends in data, and infer and explain relationships. GLO: C2, C5 TFS: 1.3.1, 3.3.1 (ELA: S1: 3.3.1) S1-0-6b Identify and suggest explanations for discrepancies in data. (ELA: S1: 3.3.3) GLO: C2 S1-0-7a Draw a conclusion that explains the results of an investigation. Include: cause and effect relationships, alternative explanations, supporting or rejecting the hypothesis or prediction. (ELA: S1: 3.3.4) GLO: C2, C5, C8 S1-0-7e Reflect on prior knowledge and experiences to develop new understanding. (ELA: S1: 4.2.1) GLO: C2, C3, C4 S1-0-8c Describe examples of how scientific knowledge has evolved in light of new evidence, and the role of technology in this evolution. GLO: A2, A5 S1-0-8d Describe examples of how technologies have evolved in response to changing needs and scientific advances. GLO: A5	***Statistics and Probability (Data Analysis)*** 9.SP.3 Develop and implement a project plan for the collection, display, and analysis of data by • formulating a question for investigation • choosing a data collection method that includes social considerations • selecting a population or a sample • collecting the data • displaying the collected data in an appropriate manner • drawing conclusions to answer the question [C, PS, R, T, V] ***Patterns and Relations (Patterns)*** 9.PR.2. Graph linear relations, analyze the graph, and interpolate or extrapolate to solve problems. [C, CN, ME, PS, R, T, V]

Specific Learning Outcomes S1-4-02 Observe the motion of visible celestial objects and organize collected data. GLO: C2, C5, C6, D6 S1-4-05 Explain the apparent motion of the Sun, stars, planets, and the Moon as seen from Earth. Include: daily rising and setting, seasonal constellations, retrograde motion. GLO: D4, D6, E2 S1-4-08 Differentiate between the major components of the universe. Include: planets, moons, comets and asteroids, nebulae, stars, galaxies, black holes. GLO: D6, E1, E2 S1-4-09 Explain how various technologies have extended our ability to explore and understand space. GLO: A5, B1, B2, D6	
Activity 6: The Search for Exoplanets	
Senior 1, Cluster 4: Exploring the Universe ***Skills and Attitude Outcomes*** S1-0-1a Propose questions that could be tested experimentally. (ELA: S1: 3.1.2) GLO: C2 S1-0-1b Select and justify various methods for finding the answers to specific questions. (Math: S1: A-1) GLO: C2 S1-0-2c Summarize and record information in a variety of forms. Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources. (ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.3.1, 4.3.4 S1-0-3b Identify probable mathematical relationships between variables. *Examples: relationship between current and resistance...* GLO: C2 S1-0-4e Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise. (ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7 S1-0-5a Select and use appropriate methods and tools for collecting data or information. GLO: C2; TFS: 1.3.1 S1-0-5b Estimate and measure accurately using Système International (SI) and other standard units. Include: SI conversions. GLO: C2 S1-0-5c Record, organize, and display data using an appropriate format. Include: labelled diagrams, graphs, multimedia (ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2 S1-0-6a Interpret patterns and trends in data, and infer and explain relationships. GLO: C2, C5 TFS: 1.3.1, 3.3.1 (ELA: S1: 3.3.1) S1-0-6b Identify and suggest explanations for discrepancies in data. GLO: C2	***Statistics and Probability (Data Analysis)*** 9.N.1 Demonstrate an understanding of powers with integral bases (excluding base 0) and whole-number exponents by • representing repeated multiplication using powers • using patterns to show that a power with an exponent of zero is equal to one • solving problems involving powers [C, CN, ME, PS, R] ***Shape and Space (Transformations)*** 9.SS.4. Draw and interpret scale diagrams of 2-D shapes. [CN, R, T, V]

S1-0-7a Draw a conclusion that explains the results of an investigation. Include: cause and effect relationships, alternative explanations, supporting or rejecting the hypothesis or prediction. (ELA: S1: 3.3.4) GLO: C2, C5, C8 S1-0-7e Reflect on prior knowledge and experiences to develop new understanding. (ELA: S1: 4.2.1) GLO: C2, C3, C4 S1-0-8c Describe examples of how scientific knowledge has evolved in light of new evidence, and the role of technology in this evolution. GLO: A2, A5 S1-0-8d Describe examples of how technologies have evolved in response to changing needs and scientific advances. GLO: A5 ***Specific Learning Outcomes*** S1-4-02 Observe the motion of visible celestial objects and organize collected data. GLO: C2, C5, C6, D6 S1-4-05 Explain the apparent motion of the Sun, stars, planets, and the Moon as seen from Earth. Include: daily rising and setting, seasonal constellations, retrograde motion. GLO: D4, D6, E2 S1-4-08 Differentiate between the major components of the universe. Include: planets, moons, comets and asteroids, nebulae, stars, galaxies, black holes. GLO: D6, E1, E2	

Figuring Outer Space

Curriculum Connections

NEW BRUNSWICK—Science 9: Space Exploration

Note: These curriculum connections are meant to be a quick reference guide only. If you have any suggestions for additional curriculum connections, or if you are aware of changes in your curriculum, please contact outreach@perimeterinstitute.ca.

Science 9 Curriculum Connections **(Atlantic Canada Science Curriculum, 2002)**	**Grade 9 Mathematics Curriculum Connections** **(Department of Education of New Brunswick, 2010)**
Activity 1: The Evolution of Stars	
SPACE EXPLORATION ***STSE*** ***Nature of Science and Technology*** 109-3 describe and explain the role of experimentation, collecting evidence, finding relationships, proposing explanations, and imagination in the development of scientific knowledge ***Social and Environmental Contexts of Science and Technology*** 112-6 provide examples of how Canadian research projects in science and technology are supported ***Skills*** ***Performing and Recording*** 209-4 organize data, using a format that is appropriate to the task or experiment ***Analysing and Interpreting*** 210-16 identify new questions and problems that arise from what was learned ***Communication and Teamwork*** 211-1 receive, understand, and act on the ideas of others 211-3 work co-operatively with team members to develop and carry out a plan, and troubleshoot problems as they arise 211-5 defend a given position on an issue or problem, on the basis of their findings	**GCO: Shape & Space (SS):** Describe and analyze position and motion of objects and shapes. SCO: SS4: Draw and interpret scale diagrams of 2-D shapes. [CN, R, T, V]

STSE

Nature of Science and Technology

109-3 describe and explain the role of experimentation, collecting evidence, finding relationships, proposing explanations, and imagination in the development of scientific knowledge

110-6 explain the need for new evidence in order to continually test existing theories

Social and Environmental Contexts of Science and Technology

112-6 provide examples of how Canadian research projects in science and technology are supported

Skills

Performing and Teamwork

209-4 organize data, using a format that is appropriate to the task or experiment

Communication and Teamwork

211-1 receive, understand, and act on the ideas of others

211-3 work co-operatively with team members to develop and carry out a plan, and troubleshoot problems as they arise

211-5 defend a given position on an issue or problem, on the basis of their findings

Knowledge

312-1 describe theories on the formation of the solar system

312-2 describe and classify the major components of the universe

312-3 describe theories on the origin and evolution of the universe

312-4 describe and explain the apparent motion of celestial bodies

312-5 describe the composition and characteristics of the components of the solar system

Attitude Outcome Statements

Appreciation of Science

422 appreciate the role and contribution of science and technology in our understanding of the world

424 appreciate and respect that science has evolved from different views held by women and men from a variety of societies and cultural backgrounds

Interest in Science

425 show a continuing curiosity and interest in a broad scope of science-related fields and issues

Collaboration 431 work collaboratively in carrying out investigations as well as in generating and evaluating ideas	
Activity 2: How to Find an Exoplanet	
STSE ***Nature of Science and Technology*** 109-3 describe and explain the role of experimentation, collecting evidence, finding relationships, proposing explanations, and imagination in the development of scientific knowledge ***Social and Environmental Contexts of Science and Technology*** 112-6 provide examples of how Canadian research projects in science and technology are supported ***Skills*** ***Performing and Recording*** 209-4 organize data, using a format that is appropriate to the task or experiment ***Analysing and Interpreting*** 210-16 identify new questions and problems that arise from what was learned ***Communication and Teamwork*** 211-3 work co-operatively with team members to develop and carry out a plan, and troubleshoot problems as they arise ***Knowledge*** 312-2 describe and classify the major components of the universe 312-4 describe and explain the apparent motion of celestial bodies ***Attitude Outcome Statements*** ***Appreciation of Science*** 422 appreciate the role and contribution of science and technology in our understanding of the world ***Interest in Science*** 425 show a continuing curiosity and interest in a broad scope of science-related fields and issues ***Scientific Inquiry*** 429 value accuracy, precision, and honesty 430 persist in seeking answers to difficult questions and solutions to difficult problems	**GCO: Patterns & Relations (PR):** Use patterns to describe the world and solve problems SCO: PR2: Graph linear relations, analyze the graph and interpolate or extrapolate to solve problems [C, CN, PS, R, T, V] **GCO: Statistics and Probability (SP):** Collect, display and analyze data to solve problems. SCO: SP4: Develop and implement a project plan for the collection, display and analysis of data by: • formulating a question for investigation • choosing a data collection method that includes • social considerations • selecting a population or a sample • collecting the data • displaying the collected data in an appropriate manner • drawing conclusions to answer the question. [C, PS, R, T, V]

Collaboration 431 work collaboratively in carrying out investigations as well as in generating and evaluating ideas ***Safety in Science*** 434 show concern for safety in planning, carrying out, and reviewing activities 435 become aware of the consequences of their actions	
Activity 3: Take a Tour of the Milky Way	
STSE ***Relationships Between Science and Technology*** 111-5 describe the science underlying particular technologies designed to explore natural phenomena, extend human capabilities, or solve practical problems ***Skills*** ***Performing and Recording*** 209-4 organize data, using a format that is appropriate to the task or experiment ***Analysing and Interpreting*** 210-16 identify new questions and problems that arise from what was learned ***Communication and Teamwork*** 211-1 receive, understand, and act on the ideas of others 211-3 work co-operatively with team members to develop and carry out a plan, and troubleshoot problems as they arise ***Knowledge*** 312-2 describe and classify the major components of the universe 312-3 describe theories on the origin and evolution of the universe ***Attitude Outcome Statements*** ***Appreciation of Science*** 422 appreciate the role and contribution of science and technology in our understanding of the world ***Interest in Science*** 425 show a continuing curiosity and interest in a broad scope of science-related fields and issues	**GCO: Shape & Space (SS):** Describe and analyze position and motion of objects and shapes. SCO: SS4: Draw and interpret scale diagrams of 2-D shapes. [CN, R, T, V]

Collaboration 431 work collaboratively in carrying out investigations as well as in generating and evaluating ideas	
Activity 4: The History of the Universe	
STSE ***Nature of Science and Technology*** 109-3 describe and explain the role of experimentation, collecting evidence, finding relationships, proposing explanations, and imagination in the development of scientific knowledge 110-6 explain the need for new evidence in order to continually test existing theories ***Skills*** ***Performing and Recording*** 209-4 organize data, using a format that is appropriate to the task or experiment ***Analysing and Interpreting*** 210-16 identify new questions and problems that arise from what was learned ***Communication and Teamwork*** 211-3 work co-operatively with team members to develop and carry out a plan, and troubleshoot problems as they arise ***Knowledge*** 312-1 describe theories on the formation of the solar system 312-2 describe and classify the major components of the universe 312-3 describe theories on the origin and evolution of the universe ***Attitude Outcome Statements*** ***Appreciation of Science*** 422 appreciate the role and contribution of science and technology in our understanding of the world ***Interest in Science*** 425 show a continuing curiosity and interest in a broad scope of science-related fields and issues ***Collaboration*** 431 work collaboratively in carrying out investigations as well as in generating and evaluating ideas	**GCO: Shape & Space (SS):** Describe and analyze position and motion of objects and shapes. SCO: SS4: Draw and interpret scale diagrams of 2-D shapes. [CN, R, T, V]

Activity 5: Crab Nebula Expansion	
STSE ***Nature of Science and Technology*** 109-3 describe and explain the role of experimentation, collecting evidence, finding relationships, proposing explanations, and imagination in the development of scientific knowledge ***Relationships Between Science and Technology*** 111-5 describe the science underlying particular technologies designed to explore natural phenomena, extend human capabilities, or solve practical problems ***Skills*** ***Performing and Recording*** 209-4 organize data, using a format that is appropriate to the task or experiment 210-9 calculate theoretical values of a variable ***Analysing and Interpreting*** 210-16 identify new questions and problems that arise from what was learned ***Communication and Teamwork*** 211-3 work co-operatively with team members to develop and carry out a plan, and troubleshoot problems as they arise ***Knowledge*** 312-2 describe and classify the major components of the universe 312-4 describe and explain the apparent motion of celestial bodies ***Attitude Outcome Statements*** ***Appreciation of Science*** 422 appreciate the role and contribution of science and technology in our understanding of the world ***Interest in Science*** 425 show a continuing curiosity and interest in a broad scope of science-related fields and issues ***Scientific Inquiry*** 429 value accuracy, precision, and honesty 430 persist in seeking answers to difficult questions and solutions to difficult problems	**GCO: Patterns & Relations (PR):** Use patterns to describe the world and solve problems SCO: PR2: Graph linear relations, analyze the graph and interpolate or extrapolate to solve problems [C, CN, PS, R, T, V] SCO: PR3 Model and solve problems using linear equations of the form: $ax = b$; $\frac{x}{a} = b$, $a \neq 0$; $ax + b = c$; $\frac{x}{a} + b = c$, $a \neq 0$; $ax = b + cx$; $a(x + b) = c$; $ax + b = cx + d$; $a(bx + c) = d(ex + f)$; $\frac{a}{x} = b$, $x \neq 0$ where a, b, c, d, e and f are rational numbers. [C, CN, PS, V] **GCO: Statistics and Probability (SP):** Collect, display and analyze data to solve problems. SCO: SP4: Develop and implement a project plan for the collection, display and analysis of data by: • formulating a question for investigation • choosing a data collection method that includes • social considerations • selecting a population or a sample • collecting the data • displaying the collected data in an appropriate manner • drawing conclusions to answer the question. [C, PS, R, T, V]

Collaboration 431 work collaboratively in carrying out investigations as well as in generating and evaluating ideas	
Activity 6: The Search for Exoplanets	
STSE ***Nature of Science and Technology*** 109-3 describe and explain the role of experimentation, collecting evidence, finding relationships, proposing explanations, and imagination in the development of scientific knowledge ***Relationships Between Science and Technology*** 111-5 describe the science underlying particular technologies designed to explore natural phenomena, extend human capabilities, or solve practical problems ***Skills*** ***Performing and Recording*** 209-4 organize data, using a format that is appropriate to the task or experiment 210-9 calculate theoretical values of a variable ***Analysing and Interpreting*** 210-16 identify new questions and problems that arise from what was learned ***Communication and Teamwork*** 211-3 work co-operatively with team members to develop and carry out a plan, and troubleshoot problems as they arise ***Knowledge*** 312-2 describe and classify the major components of the universe 312-4 describe and explain the apparent motion of celestial bodies ***Attitude Outcome Statements*** ***Appreciation of Science*** 422 appreciate the role and contribution of science and technology in our understanding of the world ***Interest in Science*** 425 show a continuing curiosity and interest in a broad scope of science-related fields and issues ***Scientific Inquiry*** 429 value accuracy, precision, and honesty	**GCO: Number (N)** **Develop number sense** SCO: N2: Demonstrate an understanding of operations on powers with integral bases (excluding base 0) and whole number exponents. [C, CN, PS, R, T] **GCO: Patterns & Relations (PR):** Use patterns to describe the world and solve problems **GCO: Statistics and Probability (SP)**: Collect, display and analyze data to solve problems. SCO: SP4: Develop and implement a project plan for the collection, display and analysis of data by: • formulating a question for investigation • choosing a data collection method that includes social considerations • selecting a population or a sample • collecting the data • displaying the collected data in an appropriate manner • drawing conclusions to answer the question. [C, PS, R, T, V]

430 persist in seeking answers to difficult questions and solutions to difficult problems ***Collaboration*** 431 work collaboratively in carrying out investigations as well as in generating and evaluating ideas ***Safety in Science*** 434 show concern for safety in planning, carrying out, and reviewing activities 435 become aware of the consequences of their actions	

Figuring Outer Space

Curriculum Connections

NEWFOUNDLAND AND LABRADOR—Grade 9 Science: Space

Note: These curriculum connections are meant to be a quick reference guide only. If you have any suggestions for additional curriculum connections, or if you are aware of changes in your curriculum, please contact outreach@perimeterinstitute.ca.

Grade 9 Science Curriculum Connections (revised January 2011)	Grade 9 Mathematics Curriculum Connections (2014)
Activity 1: The Evolution of Stars	
Unit 1: Space ***STSE*** ***Social and Environmental Contexts of Science and Technology*** 112-6 provide examples of how Canadian research projects in science and technology are supported. ***Skills*** ***Performing and Recording*** 209-4 organize data using a format that is appropriate to the task or experiment. 210-16 identify new questions and problems that arise from what was learned. ***Communication and Teamwork*** 211-1 receive, understand and act on the ideas of others. 211-3 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise. ***Knowledge*** 312-5 describe the composition and characteristics of the components of the solar system. 312-3 describe theories on the origin and evolution of the universe. 312-2 describe and classify the major components of the universe.	**Similarity and Transformations** ***Shape and Space (Transformations)*** 9SS4 Draw and interpret scale diagrams of 2-D shapes. [CN, R, T, V] *9SS4.2 Draw a diagram to scale that represents an enlargement or reduction of a given 2-D shape.*

Activity 2: How to Find an Exoplanet	
Unit 1: Space ***STSE*** ***Nature of Science and Technology*** 109-3 describe and explain the role of experimentation, collecting evidence, finding relationships, proposing explanations, and imagination in the development of scientific knowledge. ***Relationships Between Science and Technology*** 111-5 describe the science underlying particular technologies designed to explore natural phenomena, extend human capabilities, or solve practical problems. ***Social and Environmental Contexts of Science and Technology*** 112-6 provide examples of how Canadian research projects in science and technology are supported. ***Skills*** ***Initiating and Planning*** 208-8 select appropriate methods and tools for collecting data and information and for solving problems. ***Performing and Recording*** 209-3 use instruments effectively and accurately for collecting data. 209-4 organize data using a format that is appropriate to the task or experiment. ***Analyzing and Interpreting*** 210-3 identify strengths and weaknesses of different methods of collecting and displaying data. 210-16 identify new questions and problems that arise from what was learned. ***Communication and Teamwork*** 211-1 receive, understand and act on the ideas of others. 211-3 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise. 211-5 defend a given position on an issue or problem, based on their findings. ***Knowledge*** 312-4 describe and explain the apparent motion of celestial bodies. 312-2 describe and classify the major components of the universe.	**Probability and Statistics** ***Statistics and Probability (Data Analysis)*** GCO Collect, display and analyze data to solve problems. SCO 9SP3 Develop and implement a project plan for the collection, display and analysis of data by: • formulating a question for investigation • choosing a data collection method that includes social considerations • selecting a population or a sample • collecting the data • displaying the collected data in an appropriate manner • drawing conclusions to answer the question.

Activity 3: Take a Tour of the Milky Way	
Unit 1: Space ***STSE*** ***Nature of Science and Technology*** 109-13 explain the importance of using precise language in science and technology. ***Skills*** ***Analyzing and Interpreting*** 210-16 identify new questions and problems that arise from what was learned. ***Communication and Teamwork*** 211-1 receive, understand and act on the ideas of others. 211-3 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise. 211-5 defend a given position on an issue or problem, based on their findings. ***Knowledge*** 312-5 describe the composition and characteristics of the components of the solar system. 312-2 describe and classify the major components of the universe.	**Similarity and Transformations** ***Shape and Space (Transformations)*** 9SS4 Draw and interpret scale diagrams of 2-D shapes. [CN, R, T, V] *9SS4.2 Draw a diagram to scale that represents an enlargement or reduction of a given 2-D shape.*
Activity 4: The History of the Universe	
Unit 1: Space ***STSE*** ***Nature of Science and Technology*** 109-3 describe and explain the role of experimentation, collecting evidence, finding relationships, proposing explanations, and imagination in the development of scientific knowledge. ***Relationships Between Science and Technology*** 111-5 describe the science underlying particular technologies designed to explore natural phenomena, extend human capabilities, or solve practical problems. ***Skills*** ***Analyzing and Interpreting*** 210-16 identify new questions and problems that arise from what was learned.	***Similarity and Transformations*** ***Shape and Space (Transformations)*** 9SS4 Draw and interpret scale diagrams of 2-D shapes. [CN, R, T, V]

Communication and Teamwork 211-1 receive, understand and act on the ideas of others. 211-3 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise. 211-5 defend a given position on an issue or problem, based on their findings. ***Knowledge*** 312-1 describe theories on the formation of the solar system. 312-3 describe theories on the origin and evolution of the universe. 312-2 describe and classify the major components of the universe.	
Activity 5: Crab Nebula Expansion	
Unit 1: Space ***STSE*** ***Nature of Science and Technology*** 109-3 describe and explain the role of experimentation, collecting evidence, finding relationships, proposing explanations, and imagination in the development of scientific knowledge. ***Relationships Between Science and Technology*** 111-5 describe the science underlying particular technologies designed to explore natural phenomena, extend human capabilities, or solve practical problems. ***Skills*** ***Initiating and Planning*** 208-4 propose alternative solutions to a given practical problem, select one and develop a plan. 208-8 select appropriate methods and tools for collecting data and information and for solving problems. ***Performing and Recording*** 209-3 use instruments effectively and accurately for collecting data 209-4 organize data using a format that is appropriate to the task or experiment. ***Analyzing and Interpreting*** 210-3 identify strengths and weaknesses of different methods of collecting and displaying data. ***Communication and Teamwork*** 211-1 receive, understand and act on the ideas of others.	**Probability and Statistics** ***Statistics and Probability (Data Analysis)*** GCO Collect, display and analyze data to solve problems. SCO 9SP3 Develop and implement a project plan for the collection, display and analysis of data by: • formulating a question for investigation • choosing a data collection method that includes social considerations • selecting a population or a sample • collecting the data • displaying the collected data in an appropriate manner • drawing conclusions to answer the question. **Similarity and Transformations** ***Shape and Space (Transformations)*** 9SS4. Draw and interpret scale diagrams of 2-D shapes. [CN, R, T, V] **Linear Relations** ***Patterns and Relations (Patterns)*** 9PR1. Generalize a pattern arising from a problem solving context,

211-3 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise. 211-5 defend a given position on an issue or problem, based on their findings. ***Knowledge*** 312-4 describe and explain the apparent motion of celestial bodies. 312-5 describe the composition and characteristics of the components of the solar system. 312-2 describe and classify the major components of the universe.	using a linear equation, and verify by substitution. [C, CN, PS, R, V] *9PR1.5 Describe a context for a given linear equation.*
Activity 6: The Search for Exoplanets	
Unit 1: Space ***STSE*** ***Nature of Science and Technology*** 109-3 describe and explain the role of experimentation, collecting evidence, finding relationships, proposing explanations, and imagination in the development of scientific knowledge. ***Skills*** ***Initiating and Planning*** 208-8 select appropriate methods and tools for collecting data and information and for solving problems. ***Performing and Recording*** 209-3 use instruments effectively and accurately for collecting data. 209-4 organize data using a format that is appropriate to the task or experiment. ***Analyzing and Interpreting*** 210-3 identify strengths and weaknesses of different methods of collecting and displaying data. 210-13 test the design of a constructed device or system. ***Communication and Teamwork*** 211-1 receive, understand and act on the ideas of others. 211-3 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise. 211-5 defend a given position on an issue or problem, based on their findings. ***Knowledge*** 312-4 describe and explain the apparent motion of celestial bodies.	**Similarity and Transformations** ***Shape and Space (Transformations)*** 9SS4. Draw and interpret scale diagrams of 2-D shapes. [CN, R, T, V] **Powers and Exponent Laws** ***Number*** 9N2. Demonstrate an understanding of operations on powers with integral bases (excluding base 0) and whole number exponents. *9N2.2 Evaluate a given expression by applying the exponent laws.* *9N2.3 Determine the sum of two given powers, e.g., $5^2 + 5^3$, and record the process.* *9N2.4 Determine the difference of two given powers, e.g., $4^3 - 4^2$, and record the process.*

312-5 describe the composition and characteristics of the components of the solar system. 312-2 describe and classify the major components of the universe.	

Figuring Outer Space

Curriculum Connections

NOVA SCOTIA—Science 9: Space Exploration

Note: These curriculum connections are meant to be a quick reference guide only. If you have any suggestions for additional curriculum connections, or if you are aware of changes in your curriculum, please contact outreach@perimeterinstitute.ca.

Mathematical Processes: [C] Communication, [PS] Problem Solving, [CN] Connections, [ME] Mental Mathematics and Estimation, [T] Technology, [V] Visualization, [R] Reasoning

Science 9 Curriculum Connections (Learning Outcomes Framework, April 2012)	**Mathematics 9 Curriculum Connections** (June 2015)
Activity 1: The Evolution of Stars	
The Universe • describe and classify the major components of the universe (312-2) ***The Solar System*** • describe the composition and characteristics of the components of the solar system (312-5)	***Geometry (G)*** SCO G03 Students will be expected to draw and interpret scale diagrams of 2-D shapes. [CN, R, T, V] G03.02 Draw a diagram to scale that represents an enlargement or a reduction of a given 2-D shape.
Activity 2: How to Find an Exoplanet	
The Universe • describe and classify the major components of the universe (312-2) • describe and explain the apparent motion of celestial bodies (312-4) • provide and describe examples of how Canadian research projects and careers are supported through science and technology (112-6, 112-11) ***The Solar System*** • propose alternative solutions to space life, develop a plan and data, and defend, with a report, your group's position (208-4, 209-4, 211-3, 211-5)	***Patterns and Relations (PR)*** PR01 Students will be expected to generalize a pattern arising from a problem-solving context using a linear equation and verify by substitution. [C, CN, PS, R, V] PR02 Students will be expected to graph a linear relation, analyze the graph, and interpolate or extrapolate to solve problems. [C, CN, PS, R, T, V] PR02.02 Graph a given linear relation, including horizontal and vertical lines. PR02.07 Solve a given problem by graphing a linear relation and analyzing the graph.

Activity 3: Take a Tour of the Milky Way	
The Universe • describe and classify the major components of the universe (312-2) • describe and explain the apparent motion of celestial bodies (312-4) ***The Solar System*** • describe the composition and characteristics of the components of the solar system (312-5)	***Geometry (G)*** SCO G03 Students will be expected to draw and interpret scale diagrams of 2-D shapes. [CN, R, T, V] G03.02 Draw a diagram to scale that represents an enlargement or a reduction of a given 2-D shape.
Activity 4: The History of the Universe	
The Beginnings • describe theories on the formation of the solar system (312-1) • explain the need for new evidence in order to continually test existing theories about the composition and origin of our solar system and galaxies (110-6, 210-3) • describe theories on the origin and evolution of the universe (312-3) ***The Universe*** • describe and classify the major components of the universe (312-2)	***Geometry (G)*** SCO G03 Students will be expected to draw and interpret scale diagrams of 2-D shapes. [CN, R, T, V] G03.02 Draw a diagram to scale that represents an enlargement or a reduction of a given 2-D shape.
Activity 5: Crab Nebula Expansion	
The Universe • describe and classify the major components of the universe (312-2) • describe and explain the apparent motion of celestial bodies (312-4) ***The Solar System*** • describe the composition and characteristics of the components of the solar system (312-5)	***Number (N)*** SCO N03 Students will be expected to demonstrate an understanding of rational numbers by comparing and ordering rational numbers and solving problems that involve arithmetic operations on rational numbers. [C, CN, PS, R, T, V] N03.03 Solve a given problem involving operations on rational numbers in fraction or decimal form. ***Measurement (M)*** GCO: Students will be expected to use direct and indirect measurement to solve problems.

Activity 6: The Search for Exoplanets	
The Universe • describe and classify the major components of the universe (312-2) • describe and explain the apparent motion of celestial bodies (312-4) ***The Solar System*** • describe the composition and characteristics of the components of the solar system (312-5) • propose alternative solutions to space life, develop a plan and data, and defend, with a report, your group's position (208-4, 209-4, 211-3, 211-5)	***Number (N)*** N04 Students will be expected to explain and apply the order of operations, including exponents, with and without technology. [PS, T] ***Patterns and Relations (PR)*** PR01 Students will be expected to generalize a pattern arising from a problem-solving context using a linear equation and verify by substitution. [C, CN, PS, R, V] PR02 Students will be expected to graph a linear relation, analyze the graph, and interpolate or extrapolate to solve problems. [C, CN, PS, R, T, V] PR02.01 Describe the pattern found in a given graph. PR01.05 Write a linear equation representing the pattern in a given table of values, and verify the equation by substituting values from the table. ***Measurement (M)*** GCO: Students will be expected to use direct and indirect measurement to solve problems. M01.02 Solve a given problem involving application of one or more of the circle properties. ***Geometry (G)*** G01.03 Solve a given problem involving surface area. SCO G03 Students will be expected to draw and interpret scale diagrams of 2-D shapes. [CN, R, T, V]

Grade 9: Figuring Outer Space

Curriculum Connections

ONTARIO

Earth and Space Science: The Study of the Universe/Space Exploration

IP = Initiating and Planning, PR = Performing and Recording, AI = Analysing and Interpreting, C = Communicating

Science Curriculum Connections	Mathematics Curriculum Connections
Activity 1: The Evolution of Stars	
Earth and Space Science: The Study of the Universe/ Space Exploration[1] – **D1.1** assess, on the basis of research, and report on the contributions of Canadian governments, organizations, businesses, and/or individuals to space technology, research, and/or exploration (e.g., as part of the International Space Station mission; in the fields of telecommunications and satellite technology) [IP, PR, AI, C] (Academic) – **D2.1** use appropriate terminology related to the study of the universe, including, but not limited to: *celestial objects*, *orbital radius*, *retrograde motion*, and *satellite* [C] (Academic) – **D2.1** use appropriate terminology related to space exploration, including, but not limited to: *astronomical units*, *gravitational pull*, and *universe* [C] (Applied) – **D2.3** use a research process to compile and analyse information on the characteristics of various objects in the universe (e.g., planets, stars, constellations, galaxies) [PR, AI] (Applied) – **D2.5** compare and contrast properties of celestial objects visible in the night sky, drawing on information gathered through research and using an appropriate format (e.g., compare the size of planets; represent the distance of stars from Earth using scientific notation; compare star temperatures and colour) [PR, AI, C] (Academic) – **D3.1** describe observational and theoretical evidence relating to the origin and evolution of the universe (e.g., evidence supporting the big bang theory) (Academic) – **D3.1** describe the major components of the universe (e.g., planets, moons, stars, galaxies), the motion of the different types of celestial objects, and the distances between certain objects, using appropriate scientific terminology and units (e.g., astronomical units, light years) (Applied) – **D3.3** describe the major components of the solar system and the universe (e.g., planets, stars, galaxies), using appropriate scientific terminology and units (e.g., astronomical units, scientific notation, light years) (Academic)	***Number Sense and Algebra*** *Solving Problems Involving Proportional Reasoning* – solve problems involving ratios, rates, and directly proportional relationships in various contexts (e.g., currency conversions, scale drawings, measurement), using a variety of methods (e.g., using algebraic reasoning, equivalent ratios, a constant of proportionality; using dynamic geometry software to construct and measure scale drawings) (Applied) – solve problems requiring the expression of percents, fractions, and decimals in their equivalent forms (e.g., calculating simple interest and sales tax; analysing data) (Applied) *Manipulating Expressions and Solving Equations* – solve problems requiring the manipulation of expressions arising from applications of percent, ratio, rate, and proportion (Academic)

1. Where one heading follows another, separated by a "/", the first is the Academic heading, the second Applied.

Science Curriculum Connections	Mathematics Curriculum Connections
Activity 2: How to Find an Exoplanet	
Earth and Space Science: The Study of the Universe/ Space Exploration – **D1.2** assess some of the costs, hazards, and benefits of space exploration (e.g., the expense of developing new technologies, accidents resulting in loss of life, contributions to our knowledge of the universe), taking into account the benefits of technologies that were developed for the space program but that can be used to address environmental and other practical challenges on Earth (e.g., radiation monitors and barriers, sensors to monitor air and water quality, remote sensing technology, fire-resistant materials) [AI, C] (Academic) – **D1.2** assess the contributions of Canadians to space exploration (e.g., as astronauts; in research and development) [AI, C] (Applied) – **D2.1** use appropriate terminology related to the study of the universe, including, but not limited to: *celestial objects*, *orbital radius*, *retrograde motion*, and *satellite* [C] (Academic) – **D2.1** use appropriate terminology related to space exploration, including, but not limited to: *astronomical units*, *gravitational pull*, and *universe* [C] (Applied) – **D2.2** investigate patterns in the night sky (e.g., constellations) and the motion of celestial objects, (e.g., the sun, our moon, planets, stars, galaxies), using direct observation, computer simulations, and/or star charts, and record the information using a graphic organizer or other format [PR, AI, C] (Applied) – **D2.3** plan and conduct a simulation that illustrates the interrelationships between various properties of celestial objects visible in the night sky (e.g., set up flashlights of various intensities at different distances from an observation point to help illustrate why the brightness of a star viewed from Earth is a function of both its actual brightness and its distance from Earth) [IP, PR, AI] (Academic) – **D2.3** use a research process to compile and analyse information on the characteristics of various objects in the universe (e.g., planets, stars, constellations, galaxies) [PR, AI] (Applied) – **D3.1** describe the major components of the universe (e.g., planets, moons, stars, galaxies), the motion of the different types of celestial objects, and the distances between certain objects, using appropriate scientific terminology and units (e.g., astronomical units, light years) (Applied) – **D3.5** explain the causes of astronomical phenomena (e.g., the aurora borealis, solar eclipses, phases of the moon, comets) and how various phenomena can best be observed from Earth (e.g., solar eclipses should be viewed through a suitable solar filter or by projection, not with the naked eye) (Academic)	***Linear Relations*** *Using Data Management to Investigate Relationships* – design and carry out an investigation or experiment involving relationships between two variables, including the collection and organization of data, using appropriate methods, equipment, and/or technology (e.g., surveying; using measuring tools, scientific probes, the Internet) and techniques (e.g., making tables, drawing graphs) (Academic) – carry out an investigation or experiment involving relationships between two variables, including the collection and organization of data, using appropriate methods, equipment, and/or technology (e.g., surveying; using measuring tools, scientific probes, the Internet) and techniques (e.g., making tables, drawing graphs) (Applied) – describe trends and relationships observed in data, make inferences from data, compare the inferences with hypotheses about the data, and explain any differences between the inferences and the hypotheses (e.g., describe the trend observed in the data. Does a relationship seem to exist? Of what sort? Is the outcome consistent with your hypothesis? Identify and explain any outlying pieces of data. Suggest a formula that relates the variables. How might you vary this experiment to examine other relationships?) (Academic & Applied) *Connecting Various Representations of Linear Relations* – describe a situation that would explain the events illustrated by a given graph of a relationship between two variables (Academic)

Science Curriculum Connections	Mathematics Curriculum Connections
Activity 3: Take a Tour of the Milky Way	
Earth and Space Science: The Study of the Universe/ Space Exploration – **D2.1** use appropriate terminology related to the study of the universe, including, but not limited to: *celestial objects*, *orbital radius*, *retrograde motion*, and *satellite* [C] (Academic) – **D2.1** use appropriate terminology related to space exploration, including, but not limited to: *astronomical units*, *gravitational pull*, and *universe* [C] (Applied) – **D2.2** investigate patterns in the night sky (e.g., constellations) and the motion of celestial objects (e.g., the sun, our moon, planets, stars, galaxies), using direct observation, computer simulations, and/or star charts, and record the information using a graphic organizer or other format [PR, AI, C] (Applied) – **D3.1** describe the major components of the universe, the motion of the different types of celestial objects (e.g., planets, moons, stars, galaxies), and the distances between certain objects, using appropriate scientific terminology and units (e.g., astronomical units, light years) (Applied) – **D3.3** describe the major components of the solar system and the universe (e.g., planets, stars, galaxies), using appropriate scientific terminology and units (e.g., astronomical units, scientific notation, light years) (Academic)	***Number Sense and Algebra*** *Solving Problems Involving Proportional Reasoning* – solve problems involving ratios, rates, and directly proportional relationships in various contexts (e.g., currency conversions, scale drawings, measurement), using a variety of methods (e.g., using algebraic reasoning, equivalent ratios, a constant of proportionality; using dynamic geometry software to construct and measure scale drawings) (Applied) – solve problems requiring the expression of percents, fractions, and decimals in their equivalent forms (e.g., calculating simple interest and sales tax; analysing data) (Applied) *Manipulating Expressions and Solving Equations* – solve problems requiring the manipulation of expressions arising from applications of percent, ratio, rate, and proportion (Academic)
Activity 4: The History of the Universe	
Earth and Space Science: The Study of the Universe/ Space Exploration – **D1.1** research the challenges associated with space exploration, and explain the purpose of materials and technologies that were developed to address these challenges and how these materials and technologies are now used in other fields of endeavour (e.g., robotic arm technology developed for the space program is used in industry to handle hazardous chemicals; synthetic materials developed to protect astronauts are used in fire-fighting equipment) [IP, PR, AI, C] (Applied) – **D2.1** use appropriate terminology related to the study of the universe, including, but not limited to: *celestial objects*, *orbital radius*, *retrograde motion*, and *satellite* [C] (Academic) – **D2.1** use appropriate terminology related to space exploration, including, but not limited to: *astronomical units*, *gravitational pull*, and *universe* [C] (Applied) – **D2.3** use a research process to compile and analyse information on the characteristics of various objects in the universe (e.g., planets, stars, constellations, galaxies) [PR, AI] (Applied) – **D3.1** describe observational and theoretical evidence relating to the origin and evolution of the universe (e.g., evidence supporting the big bang theory) (Academic) – **D3.1** describe the major components of the universe, the motion of the different types of celestial objects (e.g., planets, moons, stars, galaxies), and the distances between certain objects, using appropriate scientific terminology and units (e.g., astronomical units, light years) (Applied) – **D3.3** describe the major components of the solar system and the universe (e.g., planets, stars, galaxies), using appropriate scientific terminology and units (e.g., astronomical units, scientific notation, light years) (Academic)	***Number Sense and Algebra*** *Solving Problems Involving Proportional Reasoning* – solve problems involving ratios, rates, and directly proportional relationships in various contexts (e.g., currency conversions, scale drawings, measurement), using a variety of methods (e.g., using algebraic reasoning, equivalent ratios, a constant of proportionality; using dynamic geometry software to construct and measure scale drawings) (Applied) – solve problems requiring the expression of percents, fractions, and decimals in their equivalent forms (e.g., calculating simple interest and sales tax; analysing data) (Applied) *Manipulating Expressions and Solving Equations* – solve problems requiring the manipulation of expressions arising from applications of percent, ratio, rate, and proportion (Academic)

Science Curriculum Connections	Mathematics Curriculum Connections
Activity 5: Crab Nebula Expansion	
Earth and Space Science: The Study of the Universe/ Space Exploration – **D2.1** use appropriate terminology related to the study of the universe, including, but not limited to: *celestial objects*, *orbital radius*, *retrograde motion*, and *satellite* [C] (Academic) – **D2.1** use appropriate terminology related to space exploration, including, but not limited to: *astronomical units*, *gravitational pull*, and *universe* (Applied) – **D2.2** use direct observation, computer simulation, or star charts to determine the location, appearance, and motion of well-known stars and other celestial objects that are visible in the night sky (e.g., the stars Polaris, Sirius, Betelgeuse; the planet Venus) [PR, AI] (Academic) – **D3.1** describe the major components of the universe, the motion of the different types of celestial objects (e.g., planets, moons, stars, galaxies), and the distances between certain objects, using appropriate scientific terminology and units (Applied) – **D3.3** describe the major components of the solar system and the universe, using appropriate scientific terminology and units (e.g., astronomical units, scientific notation, light years) (Academic)	***Linear Relations*** *Using Data Management to Investigate Relationships* – design and carry out an investigation or experiment involving relationships between two variables, including the collection and organization of data, using appropriate methods, equipment, and/or technology (e.g., surveying; using measuring tools, scientific probes, the Internet) and techniques (e.g., making tables, drawing graphs) (Academic) – carry out an investigation or experiment involving relationships between two variables, including the collection and organization of data, using appropriate methods, equipment, and/or technology (e.g., surveying; using measuring tools, scientific probes, the Internet) and techniques (e.g., making tables, drawing graphs) (Applied) – describe trends and relationships observed in data, make inferences from data, compare the inferences with hypotheses about the data, and explain any differences between the inferences and the hypotheses (e.g., describe the trend observed in the data. Does a relationship seem to exist? Of what sort? Is the outcome consistent with your hypothesis? Identify and explain any outlying pieces of data. Suggest a formula that relates the variables. How might you vary this experiment to examine other relationships? (Academic & Applied) ***Number Sense and Algebra*** *Manipulating Expressions and Solving Equations* – solve problems requiring the manipulation of expressions arising from applications of percent, ratio, rate, and proportion (Academic) *Manipulating Expressions and Solving Equations/Simplifying Expressions and Solving Equations* – simplify numerical expressions involving integers and rational numbers, with and without the use of technology (Academic & Applied) *Solving Problems Involving Proportional Reasoning* – solve problems involving ratios, rates, and directly proportional relationships in various contexts (e.g., currency conversions, scale drawings, measurement), using a variety of methods (e.g., using algebraic reasoning, equivalent ratios, a constant of proportionality; using dynamic geometry software to construct and measure scale drawings) (Applied)

Science Curriculum Connections	Mathematics Curriculum Connections
Activity 6: The Search for Exoplanets	
Earth and Space Science: The Study of the Universe/ Space Exploration – **D2.1** use appropriate terminology related to the study of the universe, including, but not limited to: *celestial objects*, *orbital radius*, *retrograde motion*, and *satellite* [C] (Academic) – **D2.1** use appropriate terminology related to space exploration, including, but not limited to: *astronomical units*, *gravitational pull*, and *universe (Applied)* – **D2.2** investigate patterns in the night sky (e.g., constellations) and the motion of celestial objects (e.g., the sun, our moon, planets, stars, galaxies), using direct observation, computer simulations, and/or star charts, and record the information using a graphic organizer or other format [PR, AI, C] (Applied) – **D2.3** plan and conduct a simulation that illustrates the interrelationships between various properties of celestial objects visible in the night sky (e.g., set up flashlights of various intensities at different distances from an observation point to help illustrate why the brightness of a star viewed from Earth is a function of both its actual brightness and its distance from Earth) [IP, PR, AI] (Academic)	***Number Sense and Algebra*** *Operating with Exponents* – substitute into and evaluate algebraic expressions involving exponents (i.e., evaluate expressions involving natural-number exponents with rational-number bases [e.g., evaluate $\left(\frac{3}{2}\right)^3$ by hand and 9.8^3 by using a calculator]) (Academic) *Manipulating Expressions and Solving Equations* – solve problems requiring the manipulation of expressions arising from applications of percent, ratio, rate, and proportion (Academic) ***Linear Relations*** *Understanding Characteristics of Linear Relations/Determining Characteristics of Linear Relations* – construct tables of values, scatter plots, and lines or curves of best fit as appropriate, using a variety of tools (e.g., spreadsheets, graphing software, graphing calculators, paper and pencil), for linearly related and non-linearly related data collected from a variety of sources (e.g., experiments, electronic secondary sources, patterning with concrete materials) (Academic & Applied) ***Measurement and Geometry*** *Solving Problems Involving Perimeter, Area, Surface Area, and Volume/Solving Problems Involving Perimeter, Area, and Volume* – solve problems involving the areas and perimeters of composite two-dimensional shapes (i.e., combinations of rectangles, triangles, parallelograms, trapezoids, and circles) (Academic & Applied) ***Linear Relations*** *Using Data Management to Investigate Relationships* – pose problems, identify variables, and formulate hypotheses associated with relationships between two variables. (Academic & Applied)

Figuring Outer Space

Curriculum Connections

PRINCE EDWARD ISLAND—Grade 9 Science

Note: These curriculum connections are meant to be a quick reference guide only. If you have any suggestions for additional curriculum connections, or if you are aware of changes in your curriculum, please contact outreach@perimeterinstitute.ca.

Mathematical Processes: [C] Communication, [PS] Problem Solving, [CN] Connections, [ME] Mental Mathematics and Estimation, [T] Technology, [V] Visualization, [R] Reasoning

Grade 9 Science Curriculum Connections (September 2018)	**Grade 9 Mathematics Curriculum Connections** (2010)
Activity 1: The Evolution of Stars	
Nature of Science NoS 1 Understand science as a unique way of knowing. ***Procedural Knowledge*** PK 5 Conduct investigations safely to collect data that can be used to answer questions or learn scientific concepts. PK 6 Analyze data to determine patterns, trends, and causal relationships.	***Patterns and Relations (PR)*** PR1 Generalize a pattern arising from a problem-solving context using linear equations and verify by substitution. ***Shape and Space (SS)*** SS4—Draw and interpret scale diagrams of 2-D shapes. [CN, R, T, V] A. Identify an example in print or electronic media, e.g., newspapers, the Internet, of a scale diagram and interpret the scale factor. B. Draw a diagram to scale that represents an enlargement or reduction of a given 2-D shape. C. Determine the scale factor for a given diagram drawn to scale. D. Determine if a given diagram is proportional to the original 2-D shape and, if it is, state the scale factor. E. Solve a given problem that involves a scale diagram by applying the properties of similar triangles.
Activity 2: How to Find an Exoplanet	
Nature of Science NoS 1 Understand science as a unique way of knowing.	***Patterns and Relations (PR)*** PR1 Generalize a pattern arising from a problem-solving context using linear equations and verify by substitution.

NoS 2 Evaluate, with support, if a reported idea or claim is scientifically reasonable. ***Procedural Knowledge*** PK 2 Compose written reports and arguments to effectively communicate scientific thinking. PK 5 Conduct investigations safely to collect data that can be used to answer questions or learn scientific concepts. PK 6 Analyze data to determine patterns, trends, and causal relationships. PK 7 Evaluate, with support, the strength of evidence resulting from a scientific investigation. ***Decisions and Perspectives*** DP 1 Examine the benefits and risks of scientific and technological developments.	
Activity 3: Take a Tour of the Milky Way	
Nature of Science NoS 1 Understand science as a unique way of knowing. ***Procedural Knowledge*** PK 6 Analyze data to determine patterns, trends, and causal relationships.	***Shape and Space (SS)*** SS4—Draw and interpret scale diagrams of 2-D shapes. [CN, R, T, V] A. Identify an example in print or electronic media, e.g., newspapers, the Internet, of a scale diagram and interpret the scale factor. B. Draw a diagram to scale that represents an enlargement or reduction of a given 2-D shape. C. Determine the scale factor for a given diagram drawn to scale. D. Determine if a given diagram is proportional to the original 2-D shape and, if it is, state the scale factor. E. Solve a given problem that involves a scale diagram by applying the properties of similar triangles.
Activity 4: The History of the Universe	
Nature of Science NoS 1 Understand science as a unique way of knowing. ***Procedural Knowledge*** PK 2 Compose written reports and arguments to effectively communicate scientific thinking. PK 6 Analyze data to determine patterns, trends, and causal relationships.	***Shape and Space (SS)*** SS4—Draw and interpret scale diagrams of 2-D shapes. [CN, R, T, V] A. Identify an example in print or electronic media, e.g., newspapers, the Internet, of a scale diagram and interpret the scale factor.

PK 7 Evaluate, with support, the strength of evidence resulting from a scientific investigation.	B. Draw a diagram to scale that represents an enlargement or reduction of a given 2-D shape. C. Determine the scale factor for a given diagram drawn to scale. D. Determine if a given diagram is proportional to the original 2-D shape and, if it is, state the scale factor. E. Solve a given problem that involves a scale diagram by applying the properties of similar triangles.
Activity 5: Crab Nebula Expansion	
Nature of Science NoS 1 Understand science as a unique way of knowing. NoS 2 Evaluate, with support, if a reported idea or claim is scientifically reasonable. ***Procedural Knowledge*** PK 5 Conduct investigations safely to collect data that can be used to answer questions or learn scientific concepts. PK 6 Analyze data to determine patterns, trends, and causal relationships. PK 7 Evaluate, with support, the strength of evidence resulting from a scientific investigation.	***Patterns and Relations (PR)*** PR2—Graph linear relations, analyse the graph and interpolate or extrapolate to solve problems. [C, CN, PS, R, T, V] A. Describe the pattern found in a given graph. B. Graph a given linear relation, including horizontal and vertical lines. C. Match given equations of linear relations with their corresponding graphs. D. Extend a given graph (extrapolate) to determine the value of an unknown element. E. Interpolate the approximate value of one variable on a given graph given the value of the other variable. F. Extrapolate the approximate value of one variable from a given graph given the value of the other variable. G. Solve a given problem by graphing a linear relation and analysing the graph. PR3 Model and solve problems using linear equations of the form: $ax = b$; $\frac{x}{a} = b$, $a \neq 0$; $ax + b = c$; $\frac{x}{a} + b = c$, $a \neq 0$; $ax = b + cx$; $a(x + b) = c$; $ax + b = cx + d$; $a(bx + c) = d(ex + f)$; $\frac{a}{x} = b$, $x \neq 0$; where *a, b c, d, e* and *f* are rational numbers.

	Statistics and Probability (SP) GCO: Collect, display and analyse data to solve problems. SP3—Develop and implement a project plan for the collection, display and analysis of data by: • formulating a question for investigation; • choosing a data collection method that includes social considerations; • selecting a population or a sample; • collecting the data; • displaying the collected data in an appropriate manner; • drawing conclusions to answer the question.
Activity 6: The Search for Exoplanets	
Nature of Science NoS 1 Understand science as a unique way of knowing. NoS 2 Evaluate, with support, if a reported idea or claim is scientifically reasonable. ***Procedural Knowledge*** PK 5 Conduct investigations safely to collect data that can be used to answer questions or learn scientific concepts. PK 6 Analyze data to determine patterns, trends, and causal relationships. PK 7 Evaluate, with support, the strength of evidence resulting from a scientific investigation.	***Number (N)*** N2—Demonstrate an understanding of operations on powers with integral bases (excluding base 0) and whole number exponents. ***Shape and Space (SS)*** SS4—Draw and interpret scale diagrams of 2-D shapes. [CN, R, T, V] A. Identify an example in print or electronic media, e.g., newspapers, the Internet, of a scale diagram and interpret the scale factor. B. Draw a diagram to scale that represents an enlargement or reduction of a given 2-D shape. C. Determine the scale factor for a given diagram drawn to scale. D. Determine if a given diagram is proportional to the original 2-D shape and, if it is, state the scale factor. E. Solve a given problem that involves a scale diagram by applying the properties of similar triangles. ***Statistics and Probability (SP)*** GCO: Collect, display and analyse data to solve problems. SP3—Develop and implement a project plan for the collection, display and analysis of data by: • formulating a question for investigation; • choosing a data collection method that includes social considerations;

	• selecting a population or a sample; • collecting the data; • displaying the collected data in an appropriate manner; • drawing conclusions to answer the question.

Figuring Outer Space

Curriculum Connections

SASKATCHEWAN—Science 9: Earth and Space Science; and Exploring Our Universe

Note: These curriculum connections are meant to be a quick reference guide only. If you have any suggestions for additional curriculum connections, or if you are aware of changes in your curriculum, please contact outreach@perimeterinstitute.ca.

Science 9 Curriculum Connections (2009)	Mathematics 9 Curriculum Connections (2009)
Activity 1: The Evolution of Stars	
EU9.1 Inquire into the motion and characteristics of astronomical bodies in our solar system and the universe. [SI] d. Create a physical and/or visual representation of the apparent motion of astronomical bodies, including retrograde motion, as seen from various locations within our solar system. f. Describe and explain the role of experimentation, collecting evidence, finding relationships, proposing explanations, and imagination in the development of scientific knowledge of the solar system and universe (e.g., explain how data provided by astronomy, radio astronomy, satellite-based astronomy, and satellite exploration of the sun, planets, moons, and asteroids contribute to our knowledge of the solar system). j. Classify the major components of the universe, including stars, quasars, black holes, nebulae, and galaxies, according to their distinguishing physical characteristics. **EU9.2** Analyze scientific explanations of the formation and evolution of our solar system and the universe. [SI] c. Construct and critique a visual representation of the life cycle of stars using appropriate scientific terminology and identify strengths and weaknesses of the representation. **EU9.4** Analyze human capabilities for exploring and understanding the universe, including technologies and programs that support such exploration. [DM, TPS] h. Provide examples of how Canadian research projects in space science and technology are supported by governments, universities, and private agencies.	**P9.1** Demonstrate understanding of linear relations including: • graphing • analyzing • interpolating and extrapolating • solving situational questions. [C, CN, PS, R, T, V]

Foundation 4: Attitudes **Interest in Science** Students will be encouraged to develop curiosity and continuing interest in the study of science at home, in school, and in the community. **Inquiry in Science** Students will be encouraged to develop critical beliefs concerning the need for evidence and reasoned argument in the development of scientific knowledge. **Collaboration** Students will be encouraged to nurture competence in collaborative activity with classmates and others, inside and outside of the school.	
Activity 2: How to Find an Exoplanet	
EU9.1 Inquire into the motion and characteristics of astronomical bodies in our solar system and the universe. [SI] j. Classify the major components of the universe, including stars, quasars, black holes, nebulae, and galaxies, according to their distinguishing physical characteristics. f. Describe and explain the role of experimentation, collecting evidence, finding relationships, proposing explanations, and imagination in the development of scientific knowledge of the solar system and universe (e.g., explain how data provided by astronomy, radio astronomy, satellite-based astronomy, and satellite exploration of the sun, planets, moons, and asteroids contribute to our knowledge of the solar system). g. Conduct an experiment, simulation, or demonstration to investigate the motion and/or characteristics of one or more astronomical bodies. k. Organize data about the characteristics of the major components of the solar system or universe using tables, spreadsheets, charts, and/or diagrams and draw conclusions about those characteristics specifically and the solar system and universe generally. l. State a prediction and a hypothesis about astronomical phenomenon based on background information or an observed pattern of events (e.g., predict the next visit of a comet based on past observations, predict the location of Venus or Mars over a period of days). **EU9.2** Analyze scientific explanations of the formation and evolution of our solar system and the universe. [SI] d. Explain the need for new evidence in order to continually test existing theories in science (e.g., explain the need for new evidence obtained from space-based telescopes and close-up observations by satellites, which can reinforce, adjust, or reject existing inferences based on observations from Earth).	SP9.2 Demonstrate an understanding of the collection, display, and analysis of data through aproject. [C, PS, R, T, V]

EU9.4 Analyze human capabilities for exploring and understanding the universe, including technologies and programs that support such exploration. [DM, TPS] f. Describe particular technologies designed to explore natural phenomena, extend human capabilities, or solve practical problems related to exploring and understanding the universe (e.g., quadrant, astrolabe, cross-staff, optical telescope, star chart, radio telescope, satellite, space-based telescope, unmanned probe, and robotics). **Foundation 4: Attitudes** **Appreciation of Science** Students will be encouraged to critically and contextually appreciate the role and contributions of science and technology in their lives and to their community's culture; and to be aware of the limits of science and technology as well as their impact on economic, political, environmental, cultural, and ethical events. **Interest in Science** Students will be encouraged to develop curiosity and continuing interest in the study of science at home, in school, and in the community. **Inquiry in Science** Students will be encouraged to develop critical beliefs concerning the need for evidence and reasoned argument in the development of scientific knowledge. **Collaboration** Students will be encouraged to nurture competence in collaborative activity with classmates and others, inside and outside of the school. **Safety** Students engaged in science and technology activities will be expected to demonstrate a concern for safety and doing no harm to themselves or others, including plants and animals.	
Activity 3: Take a Tour of the Milky Way	
EU9.1 Inquire into the motion and characteristics of astronomical bodies in our solar system and the universe. [SI] a. Pose questions about the characteristics of and relationships between astronomical bodies. b. Observe and identify movement patterns of the major visible bodies in the night sky. d. Create a physical and/or visual representation of the apparent motion of astronomical bodies, including retrograde motion, as seen from various locations within our solar system.	**P9.1** Demonstrate understanding of linear relations including: • graphing • analyzing • interpolating and extrapolating • solving situational questions. [C, CN, PS, R, T, V] SP9.2 Demonstrate an understanding of the collection, display, and analysis of data through aproject.

e. Compare the efficacy of various historical and contemporary models of planetary motion, including geocentric and heliocentric models, for explaining observed astronomical phenomena. EU9.2 Analyze scientific explanations of the formation and evolution of our solar system and the universe. **EU9.4** Analyze human capabilities for exploring and understanding the universe, including technologies and programs that support such exploration. [DM, TPS] **Foundation 4: Attitudes** **Appreciation of Science** Students will be encouraged to critically and contextually appreciate the role and contributions of science and technology in their lives and to their community's culture; and to be aware of the limits of science and technology as well as their impact on economic, political, environmental, cultural, and ethical events. **Interest in Science** Students will be encouraged to develop curiosity and continuing interest in the study of science at home, in school, and in the community. **Collaboration** Students will be encouraged to nurture competence in collaborative activity with classmates and others, inside and outside of the school.	[C, PS, R, T, V] SS9.3. Demonstrate understanding of similarity of 2-D shapes. [C, CN, PS, R, V]
Activity 4: The History of the Universe	
EU9.1 Inquire into the motion and characteristics of astronomical bodies in our solar system and the universe. [SI] k. Organize data about the characteristics of the major components of the solar system or universe using tables, spreadsheets, charts, and/or diagrams and draw conclusions about those characteristics specifically and the solar system and universe generally. **EU9.2** Analyze scientific explanations of the formation and evolution of our solar system and the universe. [SI] a. Describe scientific theories on the formation of the solar system, including planets, moons, asteroids, and comets. b. Describe scientific theories and models of the origin and evolution of the universe and the observational evidence that supports those theories (e.g., red shift of galaxies, cosmic microwave background radiation, and abundance of light elements). c. Construct and critique a visual representation of the life cycle of stars using appropriate scientific terminology and identify strengths and weaknesses of the representation.	**N9.2** Demonstrate understanding of rational numbers including: • comparing and ordering • relating to other types of numbers • solving situational questions. [C, CN, PS, R, T, V] SS9.3. Demonstrate understanding of similarity of 2-D shapes. [C, CN, PS, R, V]

EU9.4 Analyze human capabilities for exploring and understanding the universe, including technologies and programs that support such exploration. [DM, TPS] **Foundation 4: Attitudes** **Appreciation of Science** Students will be encouraged to critically and contextually appreciate the role and contributions of science and technology in their lives and to their community's culture; and to be aware of the limits of science and technology as well as their impact on economic, political, environmental, cultural, and ethical events. **Interest in Science** Students will be encouraged to develop curiosity and continuing interest in the study of science at home, in school, and in the community. **Inquiry in Science** Students will be encouraged to develop critical beliefs concerning the need for evidence and reasoned argument in the development of scientific knowledge. **Collaboration** Students will be encouraged to nurture competence in collaborative activity with classmates and others, inside and outside of the school.	
Activity 5: Crab Nebula Expansion	
EU9.1 Inquire into the motion and characteristics of astronomical bodies in our solar system and the universe. [SI] b. Observe and identify movement patterns of the major visible bodies in the night sky. c. Compare historical and modern explanations for the real and apparent motion, including real and apparent retrograde motion, of celestial bodies (e.g., sun, moon, planets, comets, and asteroids) and artificial satellites. f. Describe and explain the role of experimentation, collecting evidence, finding relationships, proposing explanations, and imagination in the development of scientific knowledge of the solar system and universe (e.g., explain how data provided by astronomy, radio astronomy, satellite-based astronomy, and satellite exploration of the sun, planets, moons, and asteroids contribute to our knowledge of the solar system). g. Conduct an experiment, simulation, or demonstration to investigate the motion and/or characteristics of one or more astronomical bodies. k. Organize data about the characteristics of the major components of the solar system or universe using tables, spreadsheets, charts, and/or diagrams and draw conclusions about those characteristics specifically and the solar system and universe generally.	**P9.1** Demonstrate understanding of linear relations including: • graphing • analyzing • interpolating and extrapolating • solving situational questions. [C, CN, PS, R, T, V] SP9.2 Demonstrate an understanding of the collection, display, and analysis of data through aproject. [C, PS, R, T, V] SP9.2 Demonstrate an understanding of the collection, display, and analysis of data through aproject. [C, PS, R, T, V]

l. State a prediction and a hypothesis about astronomical phenomenon based on background information or an observed pattern of events (e.g., predict the next visit of a comet based on past observations, predict the location of Venus or Mars over a period of days). **EU9.4** Analyze human capabilities for exploring and understanding the universe, including technologies and programs that support such exploration. [DM, TPS] **Foundation 4: Attitudes** **Appreciation of Science** Students will be encouraged to critically and contextually appreciate the role and contributions of science and technology in their lives and to their community's culture; and to be aware of the limits of science and technology as well as their impact on economic, political, environmental, cultural, and ethical events. **Interest in Science** Students will be encouraged to develop curiosity and continuing interest in the study of science at home, in school, and in the community. **Inquiry in Science** Students will be encouraged to develop critical beliefs concerning the need for evidence and reasoned argument in the development of scientific knowledge. **Collaboration** Students will be encouraged to nurture competence in collaborative activity with classmates and others, inside and outside of the school.	
Activity 6: The Search for Exoplanets	
EU9.1 Inquire into the motion and characteristics of astronomical bodies in our solar system and the universe. [SI] a. Pose questions about the characteristics of and relationships between astronomical bodies. b. Observe and identify movement patterns of the major visible bodies in the night sky. d. Create a physical and/or visual representation of the apparent motion of astronomical bodies, including retrograde motion, as seen from various locations within our solar system. g. Conduct an experiment, simulation, or demonstration to investigate the motion and/or characteristics of one or more astronomical bodies. **EU9.4** Analyze human capabilities for exploring and understanding the universe, including technologies and programs that support such exploration. [DM, TPS]	**N9.2** Demonstrate understanding of rational numbers including: • comparing and ordering • relating to other types of numbers • solving situational questions. [C, CN, PS, R, T, V] SP9.2 Demonstrate an understanding of the collection, display, and analysis of data through aproject. [C, PS, R, T, V] **SS9.2** Extend understanding of area to surface area of right rectangular prisms, right cylinders, right triangular prisms, to composite 3-D objects. [CN, PS, R, V]

Foundation 4: Attitudes **Appreciation of Science** Students will be encouraged to critically and contextually appreciate the role and contributions of science and technology in their lives and to their community's culture; and to be aware of the limits of science and technology as well as their impact on economic, political, environmental, cultural, and ethical events. **Interest in Science** Students will be encouraged to develop curiosity and continuing interest in the study of science at home, in school, and in the community. **Inquiry in Science** Students will be encouraged to develop critical beliefs concerning the need for evidence and reasoned argument in the development of scientific knowledge. **Collaboration** Students will be encouraged to nurture competence in collaborative activity with classmates and others, inside and outside of the school.	

Figuring Outer Space

Curriculum Connections

Next Generation Science Standards (NGSS): Grades 9–12

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Science Curriculum Connections **(April 2013)**
Activity 1: The Evolution of Stars
Earth and Space Science **HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.** [Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11- year sunspot cycle, and non-cyclic variations over centuries.] [Assessment Boundary: Assessment does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion.] **HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements.** [Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.] [Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.]
Activity 2: How to Find an Exoplanet
Earth and Space Science **HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.** [Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).] **HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.** [Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.] [Assessment Boundary: Mathematical representations for the gravitational attraction of bodies and Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus.]

Activity 3: Take a Tour of the Milky Way

Earth and Space Science

HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. [Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).]

HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. [Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.] [Assessment Boundary: Mathematical representations for the gravitational attraction of bodies and Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus.]

Activity 4: The History of the Universe

Earth and Space Science

HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. [Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).]

Activity 5: Crab Nebula Expansion

Earth and Space Science

HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. [Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).]

Activity 6: The Search for Exoplanets

Earth and Space Science

HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. [Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).]

HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. [Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.] [Assessment Boundary: Mathematical representations for the gravitational attraction of bodies and Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus.]