**Area of Learning: MATHEMATICS — Geometry Grade 12**

**BIG IDEAS**

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| **Diagrams** are fundamental to investigating, communicating, and discovering properties and relations in geometry. |  | Finding **invariance amidst** **variation** drives geometric investigation. |  | Geometry involves creating, testing, and refining **definitions**. |  | The **proving process** begins with conjecturing, looking for counter-examples, and refining the conjecture, and the process may end with a written proof. |  | **Geometry** stories and applications vary across cultures and time. |

**Learning Standards**

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| **Curricular Competencies** | **Content** |
| *Students are expected to do the following:*Reasoning and modelling* Develop **thinking strategies** to solve puzzles and play games
* Engage in **spatial reasoning** in a dynamic environment
* Explore, **analyze**, and apply mathematical ideas using **reason**, **technology**, and **other tools**
* **Estimate reasonably** and demonstrate **fluent, flexible, and strategic thinking** about number
* **Model** with mathematics in **situational contexts**
* **Think creatively** and with **curiosity and wonder** when exploring problems

Understanding and solving* Develop, demonstrate, and apply conceptual understanding of mathematical ideas through play, story, **inquiry**, and problem solving
* **Visualize** to explore and illustrate geometric concepts and relationships
* Apply **flexible and strategic approaches** to **solve problems**
* Solve problems with **persistence and a positive disposition**
* Engage in problem-solvingexperiences **connected** with place, story, cultural practices, and perspectives relevant to local First Peoples communities, the local community, and other cultures
 | *Students are expected to know the following:** geometric **constructions**
* **parallel and perpendicular** lines:
	+ **circles as tools** in constructions
	+ perpendicular bisector
* **circle geometry**
* **constructing tangents**
* transformations of 2D shapes:
	+ **isometries**
	+ **non-isometric transformations**
* **non-Euclidean geometries**
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**Area of Learning: MATHEMATICS — Geometry Grade 12**

**Learning Standards (continued)**

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| **Curricular Competencies** | **Content** |
| Communicating and representing* **Explain, justify,** and evaluate geometric ideas and **decisions** in **many ways**
* **Represent** mathematical ideas in concrete, pictorial, and symbolic forms
* Use geometric vocabulary and language to contribute to **discussions** in the classroom
* Take riskswhen offering ideas in classroom **discourse**

Connecting and reflecting* **Reflect** on geometric thinking
* **Connect mathematical concepts** with each other, other areas, and personal interests
* Use **mistakes** as **opportunities to advance learning**
* **Incorporate** First Peoples worldviews, perspectives, **knowledge**, and **practices** to make connections with mathematical concepts
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|  **MATHEMATICS – Geometry Big Ideas – Elaborations Grade 12** |
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| * **Diagrams:**

*Sample questions to support inquiry with students:** + How would we describe a specific geometric object to someone who cannot see it?
	+ What properties can we infer from a diagram?
	+ What behaviours can we infer from a dynamic diagram?
* **invariance amidst variation:**
	+ Invariance amidst variation can be more easily experienced using current technology and dynamic diagrams. For example, the sum of the angles in planar triangles is invariant no matter what forms a triangle takes.

*Sample questions to support inquiry with students:** + How do we construct geometric shapes that maintain properties under variation?
	+ What properties change and stay the same when we vary a square, parallelogram, triangle, and so on?
	+ How can the Pythagorean theorem be restated in terms of variance and invariance?
* **definitions:**
	+ are seldom the starting point in geometry

*Sample questions to support inquiry with students:** + How does variation help to refine our definitions of shapes?
	+ How would we define a square (or a circle) in different ways? When would one definition be better to work with than another?
	+ How can the definition of a shape be used in constructing the shape?
	+ How can we modify a definition of a shape to define a new shape?
* **proving process:**

*Sample questions to support inquiry with students:** + Can we make a conjecture about the diagonals of a polygon? Can we find a counter-example to our conjecture?
	+ How can one conjecture about a *specific* shape lead to making another more *general* conjecture about a family of shapes?
	+ How can we be sure that a proof is complete?
	+ Can we find a counter-example to a conjecture?
	+ How can different proofs bring out different understandings of a relationship?
* **Geometry:**
	+ Geometry is more than a list of axioms and deductions. Non-Western and modern geometry is concerned with shape and space and is not always axiomatic. It is not always about producing a theorem; rather, it is about modelling mathematical and non-mathematical phenomena using geometric objects and relations. Today geometry is used in a multitude of disciplines, including animation, architecture, biology, carpentry, chemistry, medical imaging, and art.

*Sample questions to support inquiry with students:** + Can we find geometric relationships in local First Peoples art or culture?
	+ Can we make geometric connections to story, language, or past experiences?
	+ What do we notice about and how would we construct common shapes found in local First Peoples art?
	+ How has the notion of “proof” changed over time and in different cultures?
	+ How are geometric ideas implemented in modern professions?
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|  **MATHEMATICS – Geometry Curricular Competencies – Elaborations Grade 12** |
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| * **thinking strategies:**
	+ using reason to determine winning strategies
	+ generalizing and extending
* **spatial reasoning:**
	+ being able to think about shapes (real or imagined) and mentally transform them to notice relationships
* **analyze:**
	+ examine the structure of and connections between geometric ideas (e.g., parallel and perpendicular lines, circle geometry, constructing tangents, transformations)
* **reason:**
	+ inductive and deductivereasoning
	+ predictions, generalizations, conclusions drawn from experiences (e.g., with puzzles, games, and coding)
* **technology:**
	+ graphing technology, dynamic geometry, calculators, virtual manipulatives, concept-based apps
	+ can be used for a wide variety of purposes, including:
		- exploring and demonstrating geometrical relationships
		- organizing and displaying data
		- generating and testing inductive conjectures
		- mathematical modelling
* **other tools:**
	+ paper and scissors, straightedge and compass, ruler, and other concrete materials
* **Estimate reasonably:**
	+ be able to defend the reasonableness of an estimated value or a solution to a problem or equation (e.g., congruencies, angles, lengths)
* **fluent, flexible, and strategic thinking:**
	+ being able to generate a family of shapes and apply characteristics across the family
* **Model:**
	+ use mathematical concepts and tools to solve problems and make decisions (e.g., in real-life and/or abstract scenarios)
	+ take a complex, essentially non-mathematical scenario and figure out what mathematical concepts and tools are needed to make sense of it
* **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
	+ refers to creative and innovative mathematical thinking rather than to representing math in a creative way, such as through art or music
* **curiosity and wonder:**
	+ asking questions to further understanding or to open other avenues of investigation
* **inquiry:**
	+ includes structured, guided, and open inquiry
	+ noticing and wondering
	+ determining what is needed to make sense of and solve problems
* **Visualize:**
	+ create and use mental images to support understanding
	+ Visualization can be supported using dynamic materials (e.g., graphical relationships and simulations), concrete materials, drawings, and diagrams.
* **flexible and strategic approaches:**
	+ deciding which mathematical tools to use to solve a problem
	+ choosing an effective strategy to solve a problem (e.g., guess and check, model, solve a simpler problem, use a chart, use diagrams, role-play)
* **solve problems:**
	+ interpret a situation to identify a problem
	+ apply mathematics to solve the problem
	+ analyze and evaluate the solution in terms of the initial context
	+ repeat this cycle until a solution makes sense
* **persistence and a positive disposition:**
	+ not giving up when facing a challenge
	+ problem solving with vigour and determination
* **connected:**
	+ through daily activities, local and traditional practices, popular media and news events, cross-curricular integration
	+ by posing and solving problems or asking questions about place, stories, and cultural practices
* **Explain and justify:**
	+ use geometrical arguments to convince
	+ includes anticipating consequences
* **decisions:**
	+ Have students explore which of two scenarios they would choose and then defend their choice.
* **many ways:**
	+ including oral, written, visual, gestures use of technology
	+ communicating effectively according to what is being communicated and to whom
* **Represent:**
	+ concretely, diagrammatically, symbolically, including using models, tables, graphs, words, numbers, symbols
* **discussions:**
	+ partner talks, small-group discussions, teacher-student conferences
* **discourse:**
	+ is valuable for deepening understanding of concepts
	+ can help clarify students’ thinking, even if they are not sure about an idea or have misconceptions
* **Reflect**
	+ share the geometric thinking of self and others, including evaluating strategies and solutions, finding counter-examples, extending, posing new problems and questions, proving results
* **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)
* **mistakes:**
	+ range from calculation errors to misconceptions
* **opportunities to advance learning:**
	+ by:
		- analyzing errors to discover misunderstandings
		- making adjustments in further attempts
		- identifying not only mistakes but also parts of a solution that are correct
* **Incorporate:**
	+ by:
		- collaborating with Elders and knowledge keepers among local First Peoples
		- exploring the [First Peoples Principles of Learning](http://www.fnesc.ca/wp/wp-content/uploads/2015/09/PUB-LFP-POSTER-Principles-of-Learning-First-Peoples-poster-11x17.pdf) (e.g., Learning is holistic, reflexive, reflective, experiential, and relational [focused on connectedness, on reciprocal relationships, and a sense of place]; Learning involves patience and time)
		- making explicit connections with learning mathematics
		- exploring cultural practices and knowledge of local First Peoples and identifying mathematical connections
* **knowledge:**
	+ local knowledge and cultural practices that are appropriate to share and that are non-appropriated
* **practices:**
	+ [Bishop’s cultural practices](http://www.csus.edu/indiv/o/oreyd/ACP.htm_files/abishop.htm): counting, measuring, locating, designing, playing, explaining
	+ [Aboriginal Education Resources](http://www.aboriginaleducation.ca/)
	+ [*Teaching Mathematics in a First Nations Context*,](http://www.fnesc.ca/resources/math-first-peoples/) FNESC
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|  **MATHEMATICS – Geometry Content – Elaborations Grade 12** |
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| * **constructions:**
	+ angles, triangles, triangle centres, quadrilaterals
* **parallel and perpendicular:**
	+ angle bisector
* **circles as tools:**
	+ constructing equal segments, midpoints
* **circle geometry:**
	+ properties of chords, angles, and tangents to mobilize the proving process
* **constructing tangents:**
	+ lines tangent to circles, circles tangent to circles, circles tangent to three objects (e.g., points [PPP], three lines [LLL])
* **isometries:**
	+ transformations that maintain congruence (translations, rotations, reflections)
	+ composition of isometries
	+ tessellations
* **non-isometric transformations:**
	+ dilations and shear
	+ topology
* **non-Euclidean geometries:**
	+ perspective, spherical, Taxicab, hyperbolic
	+ tessellations
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