Grade 11 Applied Mathematics (30S)
A Course for Independent Study
Field Validation Version
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**ACKNOWLEDGEMENTS**

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GRADE 11 APPLIED MATHEMATICS (30S)

Introduction
**Overview**

Welcome to Grade 11 Applied Mathematics! This course is a continuation of the concepts you have studied in previous years, as well as an introduction to new topics. It builds upon the topics you were introduced to in Grade 10 Introduction to Applied and Pre-Calculus Mathematics. You will put to use many of the skills that you have already learned to solve problems, and learn new skills along the way. This course helps you develop the skills, ideas, and confidence you will need to continue studying math in the future.

As a student enrolled in a distance learning course, you have taken on a dual role—that of a student and a teacher. As a student, you are responsible for mastering the lessons and completing the learning activities and assignments. As a teacher, you are responsible for checking your work carefully, noting areas in which you need to improve, and motivating yourself to succeed.

**What Will You Learn in This Course?**

In this course, problem solving, communication, reasoning, and mental math are some of the themes you will discover in each module. You will engage in a variety of activities that promote the practical application of symbolic math ideas to the world around you.

There are several areas that you will explore in this course, including linear and quadratic functions, logic and reasoning, geometry, trigonometry, statistics, and mathematical models.

**How Is This Course Organized?**

This course is divided into eight modules, organized as follows:

- Module 1: Quadratic Functions
- Module 2: Mathematics Research Project
- Module 3: Reasoning to Solve Problems
- Module 4: Geometry of Angles and Triangles
- Module 5: Trigonometry
- Module 6: Statistics
- Module 7: Mathematical Models
- Module 8: Scale Factors for 2-D and 3-D Shapes
The lessons in this course are organized as follows:

- **Lesson Focus**: The Lesson Focus at the beginning of each lesson identifies one or more specific learning outcomes (SLOs) that are addressed in the lesson. The SLOs identify the knowledge and skills you should have achieved by the end of the lesson.

- **Introduction**: Each lesson begins by outlining what you will be learning in that lesson.

- **Lesson**: The main body of the lesson consists of the content and processes that you need to learn. It contains information, explanations, diagrams, and completed examples.

- **Learning Activities**: Each lesson has a learning activity that focuses on the lesson content. Your responses to the questions in the learning activities will help you to practise or review what you have just learned. Once you have completed a learning activity, check your responses with those provided in the Learning Activity Answer Key found at the end of the applicable module. Do not send your learning activities to your tutor/marker for assessment.

- **Assignments**: Assignments are found throughout each module within this course. At the end of each module, you will mail or electronically submit all your completed assignments from that module to your tutor/marker for assessment. All assignments combined will be worth a total of 55 percent of your final mark in this course.

- **Lesson Summary**: Each lesson ends with a brief review of what you just learned.

- **Technology Appendix**: The appendix provides basic information to help you learn how to use certain technology software and applications to complete this course.

**What Resources Will You Need for This Course?**

You will require access to an email account if you plan to
- communicate with your tutor/marker by email
- use Blackboard Learn to submit your completed assignments

A valid email account is required for your Blackboard Learn profile. The website address for Blackboard Learn is https://bblearn.merlin.mb.ca/. You were issued a username and password when you registered for this course.

Please note that you do not need a textbook to complete this course. All of the content is included with this package.
Required Resources

To complete this course, you will require a graphing calculator or access to computer software applications for graphing and statistical analysis. To write your examinations, you will need access to the same resources that you used for the modules.

Contact your tutor/marker to make sure that the technology you are using is appropriate for the assignments and the examinations.

Before you write your midterm examination, you will be asked to specify one graphing app or graphing technology and, before you write your final examination, you will be asked to specify one graphing app or graphing technology and one statistics app or statistics technology. Make sure your tutor/marker has approved your choices prior to writing the examinations.

Optional Resources

- Access to the Internet will be helpful in completing this course. There are many online resources for this course and references are made to them in the lessons where they would be used. You can choose to use online resources to graph and solve linear and quadratic functions. Many statistical mathematics operations can be completed with the help of online sites. You can search for resources online to complete your research project. You may use spreadsheets for scale factors, the research project, or other modules.

- Access to a photocopier would be helpful because it would let you make a copy of your assignments before you send them to your tutor/marker. That way, if you and your tutor/marker want to discuss an assignment, you would each have a copy to reference, and you will have a copy to resubmit if your work goes missing.

Resource Sheet

When you write your midterm and final examinations, you will be allowed to take a resource sheet with you into the examination. This sheet will be one letter-sized page, 8½” by 11”, and can be handwritten or typewritten. Both sides of the page may be filled. It is to be submitted with your examination. The resource sheet is not worth any marks.
Creating your own resource sheet is an excellent way to review. It also provides you with a convenient reference and quick summary of the important facts of each module. Students are asked to complete a resource sheet for each module to help with studying and reviewing.

The lesson summaries are written for you to use as a guide, as are the module summaries at the end of each module. Refer to these when you create your own resource sheet.

After you complete each module resource sheet, summarize the sheets from all the modules to prepare your resource sheet. When preparing your Midterm Exam Resource Sheet, remember that the midterm examination is based on Modules 1 to 4. When preparing your Final Exam Resource Sheet, remember that the final examination is based on Modules 5 to 8.

Who Can Help You with This Course?

Taking an independent study course is different from taking a course in a classroom. Instead of relying on the teacher to tell you to complete a learning activity or an assignment, you must tell yourself to be responsible for your learning and for meeting deadlines. There are, however, two people who can help you be successful in this course: your tutor/marker and your learning partner.

Your Tutor/Marker

Tutor/markers are experienced educators who tutor Independent Study Option (ISO) students and mark assignments and examinations. When you are having difficulty with something in this course, contact your tutor/marker, who is there to help you. Your tutor/marker’s name and contact information were sent to you with this course. You can also obtain this information in the Who Is My Tutor/Marker? section of the distance learning website at www.edu.gov.mb.ca/k12/dl/iso/assistance.html.

Your Learning Partner

A learning partner is someone you choose who will help you learn. It may be someone who knows something about mathematics, but it doesn’t have to be. A learning partner could be someone else who is taking this course, a teacher, a parent or guardian, a sibling, a friend, or anybody else who can help you. Most importantly, a learning partner should be someone with whom you feel comfortable and who will support you as you work through this course.
Your learning partner can help you keep on schedule with your coursework, read the course with you, check your work, look at and respond to your learning activities, or help you make sense of assignments. You may even study for your examinations with your learning partner. If you and your learning partner are taking the same course, however, your assignment work should not be identical, and should be done independently.

One of the best ways that your learning partner can help you is by reviewing your midterm and final practice examinations with you. These examinations and their answer keys can be found at www.edu.gov.mb.ca/k12/dl/downloads/index.html. Your learning partner can administer your practice examination, check your answers with you, and then help you learn the things that you missed.

How Will You Know How Well You Are Learning?

You will know how well you are learning in this course by how well you complete the learning activities, assignments, and examinations.

Learning Activities

The learning activities in this course will help you to review and practise what you have learned in the lessons. You will not submit the completed learning activities to your tutor/marker. Instead, you will complete the learning activities and compare your responses to those provided in the Learning Activity Answer Key found at the end of each module.

Each learning activity has two parts: Part A has BrainPower questions and Part B has questions related to the content in the lesson.

Part A: BrainPower

The BrainPower questions are provided as a warm-up activity for you before trying the other questions. Each question should be completed quickly and without using a calculator, and most should be completed without using pencil and paper to write out the steps. Some of the questions will relate directly to content in the course. Some of the questions will review content from previous courses—content that you need to be able to answer efficiently.
Being able to do these questions in a few minutes will be helpful to you as you continue with your studies in mathematics. If you are finding it is taking you longer to do the questions, you can try one of the following:

- work with your learning partner to find more efficient strategies for completing the questions
- ask your tutor/marker for help with the questions
- search online for websites that help you practise the computations so you can become more efficient at completing the questions

None of the assignment questions or examination questions will require you to do the calculations quickly or without a calculator. However, it is for your benefit to complete the questions, as they will help you in the course. Also, being able to complete the BrainPower exercises successfully will help build your confidence in mathematics. BrainPower questions are like a warm-up you would do before competing in a sporting event.

**Part B: Course Content Questions**

One of the easiest and fastest ways to find out how much you have learned is to complete Part B of the learning activities. These have been designed to let you assess yourself by comparing your answers with the answer keys at the end of each module. There is at least one learning activity in each lesson. You will need a notebook or loose-leaf pages to write your answers.

Make sure you complete the learning activities. Doing so will not only help you to practise what you have learned, but will also prepare you to complete your assignments and the examinations successfully. Many of the questions on the examinations will be similar to the questions in the learning activities. Remember that you **will not submit learning activities to your tutor/marker**.

**Assignments**

Lesson assignments are located throughout the modules and include questions similar to the questions in the learning activities of previous lessons. The assignments have space provided for you to write your answers on the question sheets. **You need to show all your steps as you work out your solutions, and make sure your answers are clear (include units, where appropriate).**
Once you have completed all the assignments in a module, you will submit them to your tutor/marker for assessment. The assignments are worth a total of 55 percent of your final course mark. You must complete each assignment in order to receive a final mark in this course. **You will mail or electronically submit these assignments to the tutor/marker along with the appropriate cover page once you complete each module.**

The tutor/marker will mark your assignments and return them to you. Remember to keep all marked assignments until you have finished the course so that you can use them to study for your examinations.

### Midterm and Final Examinations

This course contains a midterm examination and a final examination.

- **The midterm examination** is based on Modules 1 to 4, and is worth 20 percent of your final course mark. You will write the midterm examination when you have completed Module 4. Due to the nature of the content of Module 2, it will not be assessed directly on the midterm examination.

- **The final examination** is based on Modules 5 to 8 and is worth 25 percent of your final course mark. You will write the final examination when you have completed Module 8.

In order to do well on the examinations, you should review all of the work that you have completed from Modules 1 to 4 for your midterm examination and Modules 5 to 8 for your final examination, including all learning activities and assignments. You can use your resource sheet to bring any formulas and other important information into the examination with you.

You will be required to bring the following supplies when you write both examinations: pens/pencils (2 or 3 of each), metric and imperial rulers, a graphing and/or scientific calculator, and your resource sheet.

For the **midterm examination**, graphing technology (either computer software or a graphing calculator) is **required** to complete the examination.

For the **final examination**, graphing and statistical applications technology (either computer software or a graphing calculator) are **required** to complete the examination.

Each examination is **2.5 hours** in duration.

The two examinations are worth a total of 45 percent of your final course mark. You will write both examinations under supervision.
Practice Examinations and Answer Keys
To help you succeed in your examinations, you will have an opportunity to complete a Midterm Practice Examination and a Final Practice Examination. These examinations, along with the answer keys, are found in the Student Downloads section of the distance learning website at www.edu.gov.mb.ca/k12/dl/downloads/index.html. If you do not have access to the Internet, contact the Independent Study Option office at 1-800-465-9915 to obtain a copy of the practice examinations.

These practice examinations are similar to the actual examinations you will be writing. The answer keys enable you to check your answers. Doing well on the practice questions will give you the confidence you need to do well on your examinations.

Requesting Your Examinations
You are responsible for making arrangements to have the examinations sent from the Independent Study Option office to your school or proctor (the person who supervises you as you write your examinations). Please make arrangements before you finish Module 4 to write the midterm examination. Likewise, you should begin arranging for your final examination before you finish Module 8.

To write your examinations, you need to make the following arrangements:

- **If you are attending school**, ask your school’s Independent Study Option (ISO) school facilitator to make arrangements for your examination. Do this at least **three weeks before** you are ready to write your examination. For more information on examination procedures, please contact your ISO school facilitator or visit the Grading and Evaluation section of the distance learning website at www.edu.gov.mb.ca/k12/dl/iso/assignments.html.

- **If you are not attending school**, check the Examination Request Form for options available to you. The form was sent to you with this course, and the information is also available on the website. **Three weeks before** you are ready to write the examination, fill in the Examination Request Form and mail, fax, or email it to
  
  ISO Office  
  555 Main Street  
  Winkler MB R6W 1C4  
  Fax: 204-325-1719  
  Toll-Free Telephone: 1-800-465-9915  
  Email: distance.learning@gov.mb.ca
How Much Time Will You Need to Complete This Course?

Learning through independent study has several advantages over learning in the classroom. You are in charge of how you learn and you can choose how quickly you will complete the course. You can read as many lessons as you wish in a single session. You do not have to wait for your teacher or classmates.

From the date of your registration, you have a maximum of 12 months to complete the course, but the pace at which you proceed is up to you. Read the following suggestions on how to pace yourself.

Chart A: Semester 1

If you want to start this course in September and complete it in January, you can follow the timeline suggested below.

<table>
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<th>Completion Date</th>
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<tr>
<td>Module 1</td>
<td>Middle of September</td>
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<td>Module 2</td>
<td>End of September</td>
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<td>Module 3</td>
<td>Middle of October</td>
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<tr>
<td>Module 4</td>
<td>End of October</td>
</tr>
<tr>
<td>Midterm Examination</td>
<td>End of October</td>
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<td>Module 5</td>
<td>Middle of November</td>
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<tr>
<td>Module 6</td>
<td>End of November</td>
</tr>
<tr>
<td>Module 7</td>
<td>Middle of December</td>
</tr>
<tr>
<td>Module 8</td>
<td>Middle of January</td>
</tr>
<tr>
<td>Final Examination</td>
<td>Middle of January</td>
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Chart B: Semester 2

If you want to start this course in January and complete it in June, you can follow the timeline suggested below.

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<th>Completion Date</th>
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<td>Module 1</td>
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<tr>
<td>Module 2</td>
<td>End of February</td>
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<tr>
<td>Module 3</td>
<td>Middle of March</td>
</tr>
<tr>
<td>Module 4</td>
<td>End of March</td>
</tr>
<tr>
<td>Midterm Examination</td>
<td>End of March</td>
</tr>
<tr>
<td>Module 5</td>
<td>Middle of April</td>
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<tr>
<td>Module 6</td>
<td>End of April</td>
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<tr>
<td>Module 7</td>
<td>Middle of May</td>
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<tr>
<td>Module 8</td>
<td>End of May</td>
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<tr>
<td>Final Examination</td>
<td>End of May</td>
</tr>
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Chart C: Full School Year (Not Semestered)

If you want to start this course in September and complete it in June, you can follow the timeline suggested below.

<table>
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<tr>
<th>Module</th>
<th>Completion Date</th>
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<td>Module 1</td>
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<td>Module 2</td>
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<td>Module 3</td>
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<tr>
<td>Module 8</td>
<td>Middle of May</td>
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<tr>
<td>Final Examination</td>
<td>End of May</td>
</tr>
</tbody>
</table>
Timelines

Do not wait until the last minute to complete your work, since your tutor/marker may not be available to mark it immediately and mailing and processing time may be required. It may take a few weeks for your work to be received, assessed, and returned to you or your school.

If you need this course to graduate by the end of the school year, remember to schedule and complete your final examination by **May 31**.

When and How Will You Submit Completed Assignments?

When to Submit Assignments

While working on this course, you will submit completed assignments to your tutor/marker at least nine times. Each time you submit assignments, you must include the applicable cover sheet, which you will find at the end of this Introduction.

The following chart shows you exactly what assignments you will be submitting at the end of each module. All of these assignments must be completed to earn a credit in this course.

<table>
<thead>
<tr>
<th>Submission</th>
<th>Assignments You Will Submit</th>
</tr>
</thead>
</table>
| 1          | **Module 1: Quadratic Functions**  
Module 1 Cover Sheet  
Module 1 Cover Assignment: Geometric Patterns  
Assignment 1.1: Quadratic Properties and Characteristics  
Assignment 1.2: Intercepts, Vertices, and Sketching  
Assignment 1.3: Applying Quadratic Functions |
| 2          | **Module 2: Mathematics Research Project**  
Module 2 Cover Sheet 1  
Module 2 Cover Assignment: Historical Mathematical Problems  
Assignment 2.1: Project Proposal |
| 3          | **Module 2: Mathematics Research Project**  
Module 2 Cover Sheet 2  
Assignment 2.2: Collecting and Assessing Data  
Assignment 2.3: Analyzing and Interpreting Data  
Assignment 2.4: Presentation of Your Research Project |
| 4          | **Module 3: Reasoning to Solve Problems**  
Module 3 Cover Sheet  
Module 3 Cover Assignment: Logic Puzzles  
Assignment 3.1: Inductive and Deductive Reasoning  
Assignment 3.2: Invalid Proofs and Spatial Reasoning |
Submission of Assignments (continued)

<table>
<thead>
<tr>
<th>Submission</th>
<th>Assignments You Will Submit</th>
</tr>
</thead>
</table>
| 5          | **Module 4: Geometry of Angles and Triangles**  
Module 4 Cover Sheet  
Module 4 Cover Assignment: Geometry in Tangrams  
Assignment 4.1: Polygons and Angles  
Assignment 4.2: Angle Properties of Parallel Lines and Transversals |
| 6          | **Module 5: Trigonometry**  
Module 5 Cover Sheet  
Module 5 Cover Assignment: Shape and Space  
Assignment 5.1: Solving Acute Triangles  
Assignment 5.2: Solving Obtuse Triangles  
Assignment 5.3: The Ambiguous Case |
| 7          | **Module 6: Statistics**  
Module 6 Cover Sheet  
Module 6 Cover Assignment: The Indigenous Identity Population in Canada  
Assignment 6.1: Measures of Central Tendency and Dispersion  
Assignment 6.2: z-Scores and the Normal Curve  
Assignment 6.3: Confidence Intervals |
| 8          | **Module 7: Mathematical Models**  
Module 7 Cover Sheet  
Module 7 Cover Assignment: Skyscraper Puzzles  
Assignment 7.1: Interpreting Rates Algebraically and Graphically  
Assignment 7.2: Linear Inequalities and Systems of Linear Inequalities  
Assignment 7.3: Optimizing Solutions to Linear Inequalities |
| 9          | **Module 8: Scale Factors for 2-D and 3-D Shapes**  
Module 8 Cover Sheet  
Module 8 Cover Assignment: Pattern Analysis  
Assignment 8.1: Finding and Using Scale Factors of 2-D Shapes and 3-D Objects  
Assignment 8.2: Scale Factors and Areas of 2-D Shapes  
Assignment 8.3: Scale Factors, Surface Area, and Volume of 3-D Shapes |

How to Submit Assignments

In this course, you have the choice of submitting your assignments either by mail or electronically.

- **Mail:** Each time you mail something, you must include the print version of the applicable cover sheet (found at the end of this Introduction).

- **Electronic submission:** Each time you submit something electronically, you must include the applicable Cover Sheet. You can use the Cover Sheets available on Blackboard Learn at https://bblearn.merlin.mb.ca/ or you can scan the Cover Sheet located at the end of this Introduction.

Complete the information at the top of each Cover Sheet before submitting it along with your assignments.
Submitting Your Assignments by Mail

If you choose to mail your completed assignments, please photocopy/scan all the materials first so that you will have a copy of your work in case your assignments go missing. You will need to place the applicable module cover sheet and assignments in an envelope, and address it to

   ISO Tutor/Marker  
   555 Main Street  
   Winkler MB  R6W 1C4

Your tutor/marker will mark your work and return it to you by mail.

Submitting Your Assignments Electronically

Assignment submission options vary by course. Sometimes assignments can be submitted electronically and sometimes they must be submitted by mail. Specific instructions on how to submit assignments were sent to you with this course. You can also obtain this information in the Grading and Evaluation section of the distance learning website at www.edu.gov.mb.ca/k12/dl/iso/assignments.html.

If you are submitting assignments electronically, make sure you have saved copies of them before you send them. That way, you can refer to your assignments when you discuss them with your tutor/marker. Also, if the original assignments are lost, you are able to resubmit them.

Your tutor/marker will mark your work and return it to you electronically.

The Independent Study Option office does not provide technical support for hardware-related issues. If troubleshooting is required, consult a professional computer technician.
What Are the Guide Graphics For?

Guide graphics are used throughout this course to identify and guide you in specific tasks. Each graphic has a specific purpose, as described below.

**Lesson Introduction:** The introduction sets the stage for the lesson. It may draw upon prior knowledge or briefly describe the organization of the lesson. It also lists the learning outcomes for the lesson. Learning outcomes describe what you will learn.

**Learning Partner:** Ask your learning partner to help you with this task.

**Learning Activity:** Complete a learning activity. This will help you to review or practise what you have learned and prepare you for an assignment or an examination. You will not submit learning activities to your tutor/marker. Instead, you will compare your responses to those provided in the Learning Activity Answer Key found at the end of the applicable module.

**Assignment:** Complete an assignment. You will submit your completed assignments to your tutor/marker for assessment at the end of a given module.

**Mail or Electronic Submission:** Mail or electronically submit your completed assignments to your tutor/marker for assessment.

**Tutor/Marker:** Contact your tutor/marker.

**Resource Sheet:** Indicates material that may be valuable to include on your resource sheet.

**Examination:** Write your midterm or final examination at this time.

**Note:** Take note of and remember this important information or reminder.
Getting Started

Take some time right now to skim through the course material, locate your cover sheets, and familiarize yourself with how the course is organized. Get ready to learn!

**Remember:** If you have questions or need help at any point during this course, contact your tutor/marker or ask your learning partner for help.

Good luck with the course!
GRADE 11 APPLIED MATHEMATICS (30S)

Module 1
Quadratic Functions
Module 1: Quadratic Functions

Introduction

In previous math courses, you learned about linear functions, which are functions that form a line when graphed. Module 1 will look at quadratic functions, which form a curved shape that can resemble an arch. A quadratic function can be used to describe the path of a rock as it is thrown in the air or the shape of an arch supporting a bridge. Quadratic functions can be used to model behaviour in our world. For example, they can model relationships that have a maximum value, such as the height of a football as it is thrown to a receiver compared to the time the football is in the air, or the expected revenue for an event compared to the price charged per ticket. You will start the module by exploring the characteristics of the shape of a quadratic function and finish the module by applying what you have learned to contexts in our world.

Assignments in Module 1

To obtain credit for Module 1, you will need to send the following four assignments to your tutor/marker when you have completed this module. Your evaluation for this module is based on these assignments.

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Assignment Number</th>
<th>Assignment Title</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cover Assignment</td>
<td>Geometric Patterns</td>
</tr>
<tr>
<td>2</td>
<td>Assignment 1.1</td>
<td>Quadratic Properties and Characteristics</td>
</tr>
<tr>
<td>4</td>
<td>Assignment 1.2</td>
<td>Intercepts, Vertices, and Sketching</td>
</tr>
<tr>
<td>5</td>
<td>Assignment 1.3</td>
<td>Applying Quadratic Functions</td>
</tr>
</tbody>
</table>
Resource Sheet

When you write your midterm examination, you are encouraged to take a Midterm Exam Resource Sheet with you into the examination. This sheet will be one letter-sized page, 8½ “ by 11”, and can be either handwritten or typewritten. Both sides of the sheet may be filled. You will submit it with your examination, but you do not receive any marks for it.

Many students have found that preparing a resource sheet is an excellent way to review. It provides you with a summary of the important facts of each module. You should complete a resource sheet for each module to help with your studying and reviewing. Lesson summaries and module summaries are included for you to use as guides.

You may use the list of instructions provided below to help you with preparing your resource sheet for the material in Module 1. On this sheet, you should record math terms and definitions, formulas, sample questions, or a list of places where you often make mistakes. You should also identify special areas that require extra attention or review by recording the page numbers.

After you have completed each module’s resource sheet, you may summarize the sheets from Modules 1 to 4 to prepare your Midterm Exam Resource Sheet. The midterm examination for this course is based on Modules 1 to 4.

Resource Sheet for Module 1

1. List all the important math terms, and define them if necessary.
2. List all the formulas and perhaps a sample problem that shows how the formula is used.
3. If necessary, write the solutions to some problems, showing in detail how you did the calculations.
4. Copy any questions that represent the key points of the lesson, and perhaps include the solutions as well.
5. Identify the problems you found most difficult, and copy the page numbers onto the resource sheet so that you can review them before writing the examination. You may also copy the problems and the solutions onto your resource sheet and later write them onto your Midterm Exam Resource Sheet.
6. Write any comments, ideas, shortcuts, or other reminders that may be helpful during an examination.
Lesson 1: Features of Quadratic Functions and Equations

Lesson Focus

In this lesson, you will

☐ differentiate between a quadratic equation and a quadratic function

☐ recognize a quadratic function given a table, an equation, or a graph

☐ recognize features of the graph of a quadratic function, including the vertex, axis of symmetry, and intercepts

☐ explain, using examples, why the graph of a quadratic function may have zero, one, or two $x$-intercepts

Lesson Introduction

In previous mathematics courses, you studied linear functions, which form a straight line when plotted on an $x$-$y$ plane. You learned to graph linear functions by finding the value of the slope and the $y$-intercept. As well, you learned of applications that can be modelled using linear functions. In this module, you will be studying quadratic functions. Unlike linear functions, the graphs of quadratic functions have a curved shape. In this lesson, you will be introduced to quadratic functions, quadratic equations, and their features.

Features of Quadratic Functions and Equations

You may remember from previous mathematics courses that linear functions can be represented as a function equation, a table of values, or a graph. An important property of linear functions is that when the change in the $x$-variable is a constant value, the change in the $y$-variable will also be a constant value. The table below shows a linear function as an equation, as a table, and as a graph. Take some time to recognize how all three forms are representing the same linear function.
The value of $x$ always increases by 1 in the table and the value of $y$ always increases by 2. The rate of change for this linear equation is a constant; it is \( \frac{2}{1} \).

The rate of change, commonly known as the slope, of any linear function is constant.

If you need help remembering linear functions, contact your tutor/marker or learning partner for assistance.

In this lesson, you will learn the properties of quadratic functions in terms of the function equation, table, and graph.

The first step is to distinguish between an equation and a function. You have already used linear equations, and solved them when you found solutions to equations such as $3x + 1 = 7$ or $2x - 3 = 5$. Notice that these equations have one variable ($x$) and that there are no exponents. These are linear equations.

If you add an exponent to these equations, $3x^2 + 1 = 7$ or $2x^2 - 3 = 5$, they still have one variable ($x$), but they no longer form a straight line. They are now quadratic equations.

**Quadratic Equation Defined**

A quadratic equation is an equation with one variable with the highest exponent being two. Some examples of quadratic equations are shown below.

\[
x^2 = 16
\]
\[
2a - a^2 = 0
\]
\[
n^2 = 4n - 4
\]
You can sometimes find values of the variable that make the left-hand side of the equation equal to the right-hand side. Values of the variable that make the equation true are called **roots** or **solutions**. Later in this module, you will learn some methods for solving quadratic equations to find their roots. For the equations given above, you can verify the roots that are shown by substituting the values for the variables given.

\[
\begin{align*}
    x^2 &= 16 \quad \text{roots are } x = 4 \text{ and } x = -4 \\
    2a - a^2 &= 0 \quad \text{roots are } a = 0 \text{ and } a = 2 \\
    n^2 &= 4n - 4 \quad \text{root is } n = 2
\end{align*}
\]

You may want to add the bolded definitions above to your resource sheet.

**Quadratic Function Defined**

A quadratic function is different from a quadratic equation because it has two variables. For example, \(x^2 = 4\) or \(x^2 - 7 = 0\) are quadratic equations, while \(y = x^2 - 4\) or \(x^2 - 7 = y\) are quadratic functions with two variables, \(x\) and \(y\). A quadratic function is a relationship between two variables, often \(x\) and \(y\), where the highest exponent of the range variable, \(y\), is one. The highest exponent of the domain variable, \(x\), is two. Usually function equations are written in the “\(y = \)” form with the range variable by itself on the left-hand side and all other terms on the right-hand side. Some examples of quadratic functions are shown below.

\[
\begin{align*}
    y &= x^2 - 16 \\
    b &= 2a - a^2 \\
    f(x) &= x^2 - 4x + 4
\end{align*}
\]

**Example 1**

Classify each item in the list as a linear equation, linear function, quadratic equation, quadratic function, or as neither linear nor quadratic.

a) \(5x + 2 = 7\)  
b) \(3n^2 + 5n - 1 = 0\)  
c) \(y = 2 - 3x + 2x^2\)  
d) \(y = 3x - 2\)  
e) \(f(n) = 4n^2\)  
f) \(y^2 = 1 - x^2\)
Solution:

a) $5x + 2 = 7$  
   linear equation (highest power is 1, only one variable)

b) $3n^2 + 5n - 1 = 0$  
   quadratic equation (highest power is 2, only one variable)

c) $y = 2 - 3x + 2x^2$  
   quadratic function (highest power is 2, two variables)

d) $y = 3x - 2$  
   linear function (highest power is 1, two variables)

e) $f(n) = 4n^2$  
   quadratic function (highest power is 2, two variables)

f) $y^2 = 1 - x^2$  
   neither linear nor quadratic (highest power of range variable, $y$, is more than 1)

Properties of Quadratic Functions

A quadratic function can be represented by using a table of values as well as by using a function equation. Some examples are shown below.

a) $y = x^2 - 16$  
   
<table>
<thead>
<tr>
<th>$x$</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y$</td>
<td>-16</td>
<td>-15</td>
<td>-12</td>
<td>-7</td>
<td>0</td>
</tr>
</tbody>
</table>

b) $b = 2a - a^2$  
   
<table>
<thead>
<tr>
<th>$a$</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>$b$</td>
<td>0</td>
<td>1</td>
<td>-3</td>
<td>-8</td>
<td></td>
</tr>
</tbody>
</table>

c) $f(x) = x^2 - 4x + 4$  
   
<table>
<thead>
<tr>
<th>$x$</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f(x)$</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

Notice that the value of $x$ always increases by 1 in the tables, but the value of $y$ does not increase by a constant amount like linear functions. The rate of change for a quadratic function is not a constant. However, for quadratic functions, although the change in $y$-values is not constant, the change in $y$-values forms a pattern. Notice that the $y$-values in the table for the first function go up by 1 ($-16$ to $-15$), then 3 ($-15$ to $-12$), then 5 ($-12$ to $-7$), and then 7 ($-7$ to 0). Can you determine mentally what the next value would be in the table for both $x$ and $y$? If you determined that the next $x$-value will be 5 and the next $y$-value will be 9, you are right!
Additionally, quadratic functions can be represented using graphs on an $x$-$y$ plane. Graphs for each of the quadratic functions are shown below.

\[ y = x^2 - 16 \]

\[ b = 2a - a^2 \]
You probably noticed that each graph has the same “U” shape. That is not a coincidence; every quadratic function will have this shape, which is called a parabola. Just like the shape of the graph of a linear function is always a line, the shape of the graph of a quadratic function is always a parabola.

The Anatomy of the Parabola

When you studied the graph of a linear function, you learned that one of the more important features is the slope. Since the slope of a parabola is not constant and will change, depending on where you are on the parabola, slope is not one of the features you will be studying in relation to a quadratic function. However, there are other things that you should know about a parabola.

First, a quadratic function creates a parabola that either opens up or opens down. Secondly, a parabola can be divided into two identical, symmetrical parts by drawing a specific vertical line, which is called its axis of symmetry. Since the axis of symmetry is vertical, its equation will be “x = a number.” Thirdly, the point where the axis of symmetry crosses the parabola is known as the vertex. The vertex is also the point on the parabola that is at the very bottom if the parabola opens up or the very top if the parabola opens down.
Finally, like a line, a parabola has $x$- and $y$-intercepts. The $y$-intercept is the value on the $y$-axis where the parabola crosses the $y$-axis. Therefore, $x = 0$ when the parabola crosses the $y$-axis. There will always be one $y$-intercept for a parabola. The $x$-intercepts are the values on the $x$-axis where the parabola crosses the $x$-axis. Therefore, $y = 0$ when the parabola crosses the $x$-axis. The shape and location of a quadratic function graph determines whether there will be zero, one, or two $x$-intercepts for a parabola.

Example 2
For each quadratic function shown below, write the equation of the axis of symmetry, the coordinates of the vertex, and the values of the $x$- and $y$-intercepts.

a)

b)
Solution:

a) The axis of symmetry equation is $x = 1$.
The coordinates of the vertex are $(1, -4)$.
The $y$-intercept is $-3$.
The $x$-intercepts are $-1$ and $3$.

b) The axis of symmetry equation is $x = 2$.
The coordinates of the vertex are $(2, 0)$.
The $y$-intercept is $-4$.
The $x$-intercept is $2$. 
The Number of $x$-Intercepts of a Parabola

The number of $x$-intercepts of a parabola depends on the location of the vertex and the direction of the opening. A quadratic function will have zero, one, or two $x$-intercepts. Due to the shape of the parabola, it is not possible for a quadratic function to have more than two $x$-intercepts.

Look carefully at the examples of parabolas shown below, which demonstrate zero, one, and two $x$-intercepts, and identify what conditions determine the number of $x$-intercepts. Then draw three different parabolas in your notebook that have zero, one, or two $x$-intercepts. Write a brief description under each parabola of the conditions that determine how many $x$-intercepts a parabola will have.

After you have written your descriptions, check your thinking by comparing your descriptions to the conditions outlined below.

**Example 3**

- **two $x$-intercepts**

- **one $x$-intercept**

- **no $x$-intercepts**
For a quadratic function, two x-intercepts can be found if the vertex is below the x-axis and the parabola opens up (as shown) or if the vertex is above the x-axis and the parabola opens down.

For a quadratic function, one x-intercept is found only when the vertex is on the x-axis.

For a quadratic function, no x-intercepts are found if the vertex is above the x-axis and the parabola opens up (as shown) or if the vertex is below the x-axis and the parabola opens down.

It is important that you understand the conditions that determine the number of x-intercepts for quadratic functions. You may want to record some of this on your resource sheet.

Learning Activity 1.1

Complete the following, and check your answers in the learning activity answer keys found at the end of this module.

**Part A: BrainPower**

The BrainPower questions are provided as a warm-up activity for your brain before trying the questions in Part B. Try to complete each question quickly, without the use of a calculator and without writing many steps on paper.

1. Solve: \(3x + 1 = 7\)
2. Solve: \(2x - 3 = 5\)
3. Find the length of side \(n\) of the right triangle shown below.

```
3  
/  
n |  
|  
|  
|  
|  
|  
|  
5
```

4. Solve: \(m^2 + 10 = 46\)
5. Is \(n = 2\) a root for the equation \(n^2 = 4n - 4\)?

*continued*
Learning Activity 1.1 (continued)

6. Use the values at the $x$-intercept and the $y$-intercept to determine the slope of the linear function shown below.

7. What is the domain of the function described by the set of ordered pairs \{(2, 4), (3, 5), (6, 8), (9, 7), (0, 1)\}?

8. What is the range of the function described by the set of ordered pairs \{(2, 4), (3, 5), (6, 8), (9, 7), (0, 1)\}?

Part B: Features of Quadratic Functions and Equations

Remember, these questions are similar to the ones that will be on your assignments and midterm examination. So, if you were able to answer them correctly, you are likely to do well on your assignments and midterm examination. If you were not able to answer them correctly, you need to go back to the lesson and learn the necessary concepts.

1. Classify the following as a quadratic equation, a quadratic function, or neither.
   a) $x^2 - 2x + 1 = 0$
   b) $y = 2x + 1$
   c) $c^2 = 36$
   d) $y = 2x^2 + 1$
   e) $7 = 3x - 5$
   f) $g(x) = 3x^2 + 2x - 1$

continued
Learning Activity 1.1 (continued)

2. Classify the following function graphs as quadratic or non-quadratic.

a)

b)

c)

d)

continued
Learning Activity 1.1 (continued)

3. Determine the type of function and the number of \( x \)-intercepts for each graph.

a) 

\[
\begin{array}{c}
\text{Graph a)} \\
\end{array}
\]

b) 

\[
\begin{array}{c}
\text{Graph b)} \\
\end{array}
\]

c) 

\[
\begin{array}{c}
\text{Graph c)} \\
\end{array}
\]

continued
Learning Activity 1.1 (continued)

4. For both of the quadratic functions shown below:
   a) find the equation of the axis of symmetry
   b) find the coordinates of the vertex
   c) find the values of the x-intercepts
   d) find the value of the y-intercept

Graph I

Graph II
Lesson Summary

In this lesson, you learned about the difference between a quadratic function and a quadratic equation. You learned to recognize a quadratic function when given either the function equation, table, or graph. You also learned about the important features related to the shape of the curve of a quadratic function, called a parabola. Those features include the axis of symmetry, the vertex, and the x- and y-intercepts. Finally, you learned that a parabola may have zero, one, or two x-intercepts.

You have now completed your first lesson and the first learning activity for the Grade 11 Applied Mathematics course. For the following Learning Activity 1.2, you are required to contact your tutor/marker. This is an excellent opportunity to introduce yourself to your tutor/marker and ask questions about any concerns you may have or points that need clarification.

Your tutor/marker is available if you need help learning any of the material. Also, your tutor/marker will be marking all of your assignments and examinations. Your tutor/marker’s contact information is on the cover sheet that came with this course. If, for any reason, you are unable to locate the contact information, contact the Independent Study Option at 1-800-465-9915, and they will provide you with the information you need.
Learning Activity 1.2 is the only one that doesn’t include a BrainPower section, although it still has two parts.

In this learning activity, you are required to contact your tutor/marker to discuss questions about your goals. Having this conversation with your tutor/marker has two important purposes. First, it introduces you to a very valuable resource—your tutor/marker. He or she is available to answer questions, explain concepts, and guide you through this course. You can discuss your math learning and progress. Feel free to contact your tutor/marker by telephone or email at any time during this course.

The second important purpose of this assignment is to help you to define and clarify your math goals. You may have a future career in mind and this course is getting you one step closer to it by completing a prerequisite for a future required course. There may be specific skills or topics you are interested in learning about and they are covered in this course.

If you are unsure of your math goals or why they are important, consider this:

- goals give you a sense of direction and purpose in taking this course
- goals help motivate you to learn and do your best, even when it’s tough
- when you accomplish your goals, you gain a great sense of achievement and success

Good goals need to be realistic and specific, and they should reflect what is important to you. They should give you direction and take you further down the path from where you have been to where you want to go.

<table>
<thead>
<tr>
<th>Math History</th>
<th>Math Goal</th>
<th>Math Goal</th>
<th>Math Destination</th>
</tr>
</thead>
</table>

Goals can be long term or short term, but they are the pathways that take you from where you were/are, closer to where you want to go.

continued
Learning Activity 1.2 (continued)

Part A: Contacting Your Tutor/Marker

Your first task is to contact your tutor/marker by telephone.
Fill in the following blanks using information provided with your course:
My tutor/marker’s name is ________________________________
I can phone my tutor/marker at 1-866-____________________
My tutor/marker’s email address is _________________________

Be ready to discuss the following topics and the reasons for your answers with your tutor/marker and learning partner. If you like, make some notes before you call in order to help you feel prepared. Feel free to add any other questions or comments that you may have.

1. I am taking this course by distance education because:

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

2. What I like about math and can do mathematically is (include favourite topic, skill, where you use math, etc.):

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

3. What I dislike about math or have difficulty doing is:

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

continued
Learning Activity 1.2 (continued)

4. Previous math experiences that influence the way I feel about math are:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

5. The next math course I would like to take is:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

6. What I am hoping this course will help me accomplish and learn for the future is:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

7. What I am doing and how I organize things to help me succeed in this course is:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

continued
Learning Activity 1.2 (continued)

During your telephone conversation, jot down a sentence or two in the spaces above about what you and your tutor/marker talk about. For example, if you are taking this course because it doesn’t fit into your schedule at school or because you travel with your basketball team, missing a large number of classes, state that in the space below question 1.

**Part B: Your Math Pathway**

Use the answers to the questions from the conversation with your tutor/marker as a starting point to fill in the following diagram. In the Math History box, jot down point-form notes about your prior experience and knowledge about math (questions 2, 3, and 4). In the Math Destination box, jot down what completing this course will help you accomplish in the future (questions 5 and 6).

In the Pathway box, write down what you will need to do to move along the pathway from your History to your Destination.

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<tr>
<th>Math History</th>
<th>Pathway</th>
<th>Math Destination</th>
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continued
**Learning Activity 1.2 (continued)**

For example, if you want to start your own business in the future, what skills will you need that will make you feel confident in your ability to do this? Will you be able to balance your finances and complete your taxes? Alternatively, your goal may be to find the right approach for you in acquiring the math skills that will prepare you for a post-secondary program of your choice. Your study plan may involve setting up a schedule to ensure you complete your assignments on time. You may need to find your calculator manual and learn how to use your scientific or graphing calculator in ways that will maximize its benefits towards helping you reach your destination. You may decide to set up regular appointments with your learning partner, research a topic on the Internet, or read a textbook about a certain math concept or skill. Your pathway is unique to you.

As you move through this course and work on achieving your goals, self-assessment is important as it helps you to determine whether the steps along your pathway are taking you in the right direction. As you complete each module, you will need to ask yourself: Am I doing my assignments? Are my note-taking skills improving? How often have I contacted my tutor/marker or worked with my learning partner? Have I found useful homework websites if necessary? Is my schedule working? What do I need to change or adjust so I can get to my destination?

Repeatedly going through this cycle of looking at where you have been, where you want to go, and where you currently are is recommended. At any time, you may want to revise your goals or set new ones as you evaluate your own progress and learning.

- Look back/history—reflect on what you know and how far you have come.
- Look around/pathway—assess if you are achieving your goals, determine if new learning or understanding has occurred, and check your progress.
- Look forward/destination—determine what you want to know and set goals to learn it.

Each time you go through these steps, you will become better at mathematics!

It is important that you keep this diagram handy so that you can revisit it at other points in this course.
Notes