

Adult Basic Education

Mathematics

Mathematics 3104A

Quadratic Functions, Graphs and Equations

Curriculum Guide

Prerequisites: Math 1104A, Math 1104B and Math 1104C
Math 2104A, Math 2104B and Math 2104C

Credit Value: 1

Required Mathematics Courses [Degree and Technical Profile]

Mathematics 1104A

Mathematics 1104B

Mathematics 1104C

Mathematics 2104A

Mathematics 2104B

Mathematics 2104C

Mathematics 3104A

Mathematics 3104B

Mathematics 3104C

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To the Instructor

I. Introduction to Mathematics 3104A

This course is an introduction to quadratic functions, equations and graphs. Quadratics, in particular, is an essential and fundamental component of post-secondary Math courses.

Students will learn to work with quadratics in many different forms:

1. functions
2. graphs
3. tables of values
4. written description
5. ordered pairs

They will learn to translate between these different ways of presentation.

Quadratic functions can be used to represent real-life situations such as maximizing area, profit or height. Students will also learn different ways to solve quadratic equations.

II. Prerequisites

Students taking this course should have prerequisite skills to identify quadratics, graph functions and find their domain and range. Students should also be able to complete the square and solve quadratic equations by factoring. There are exercises, (with solutions) for each **Section** of the textbook in **Prerequisites** in the *Teacher's Resource Book*. The instructor may use these problems to determine the student's ability. In the Study Guide, students are often directed to see their instructor for **Prerequisite** exercises. The instructor, however, must ensure that the student has mastered these concepts before beginning a particular unit.

III. Textbook

Most of the concepts are introduced, developed and explained in the **Examples**. The instructor must insist that the student carefully studies and understands each **Example** before moving on to the **Exercises**. In the Study Guide, the student is directed to see the instructor if there are any difficulties.

To the Instructor

There are four basic categories included in each section of the textbook which require the student to complete questions:

1. **Investigate**
2. **Discussing the Ideas**
3. **Exercises**
4. **Communicating the Ideas**

Investigate: This section looks at the thinking behind new concepts. The answers to its questions are found in the back of the text.

Discussing the Ideas: This section requires the student to write a response which clarifies and demonstrates understanding of the concepts introduced. The answers to these questions are not in the student text but are in the *Teacher's Resource Book*. Therefore, in the Study Guide, the student is directed to see the instructor for correction. This will offer the instructor some perspective on the extent of the student's understanding. If necessary, reinforcement or remedial work can be introduced. Students should not be given the answer key for this section as the opportunity to assess the student's understanding is then lost.

Exercises: This section helps the student reinforce understanding of the concepts introduced. There are three levels of **Exercises**:

- A:** direct application of concepts introduced;
- B:** multi-step problem solving and some real-life situations;
- C:** problems of a more challenging nature.

The answers to the **Exercises** questions are found in the back of the text.

Communicating the Ideas: This section helps confirm the student's understanding of a particular lesson by requiring a clearly written explanation. The answers to **Communicating the Ideas** are not in the student text, but are in the *Teacher's Resource Book*. In the Study Guide students are asked to see the instructor for correction.

IV. Technology

It is important that students have a **scientific** calculator and its manual for their individual use. Ensure that the calculators used have the word "scientific" on it as there are calculators designed for calculation in other areas such as business or statistics which would not have the functions needed for study in this area.

To the Instructor

A graphing calculator should be **available** to the students since the text provides many opportunities for its use. The *Teacher's Resource Book* suggests many opportunities to use a graphing calculator. These suggestions are outlined where there is the heading *Integrating Technology*. In the Study Guide, students are directed to see the instructor when a graphing calculator is required. The *Teacher's Resource Book* contains a module called **Graphing Calculator Handbook** which will help the instructor and student get acquainted with some of the main features of the TI-83 Plus graphing calculator.

Graphing software such as *Graphmatica* or *Winplot* can also be used if the students don't have access to a graphing calculator but do have access to a computer. The textbook doesn't offer the same guidance for graphing with these tools as it does for a graphing calculator but each software program does have a HELP feature to answer questions.

V. Curriculum Guides

Each new ABE Mathematics course has a Curriculum Guide for the instructor and a Study Guide for the student. The Curriculum Guide includes the specific curriculum outcomes for the course. Suggestions for teaching, learning, and assessment are provided to support student achievement of the outcomes. Each course is divided into units. Each unit comprises a **two-page layout of four columns** as illustrated in the figure below. In some cases the four-column spread continues to the next two-page layout.

Curriculum Guide Organization: The Two-Page, Four-Column Spread

Unit Number - Unit Title		Unit Number - Unit Title	
Outcomes	Notes for Teaching and Learning	Suggestions for Assessment	Resources
Specific curriculum outcomes for the unit.	Suggested activities, elaboration of outcomes, and background information.	Suggestions for assessing students' achievement of outcomes.	Authorized and recommended resources that address outcomes.

To the Instructor

VI. Study Guides

The Study Guide provides the student with the name of the text(s) required for the course and specifies the sections and pages that the student will need to refer to in order to complete the required work for the course. It guides the student through the course by assigning relevant reading and providing questions and/or assigning questions from the text or some other resource. Sometimes it also provides important points for students to note. (See the *To the Student* section of the Study Guide for a more detailed explanation of the use of the Study Guides.) The Study Guides are designed to give students some degree of independence in their work. Instructors should note, however, that there is much material in the Curriculum Guides in the *Notes for Teaching and Learning* and *Suggestions for Assessment* columns that is not included in the Study Guide and instructors will need to review this information and decide how to include it.

VII. Resources

Essential Resources

Addison Wesley Mathematics 11 (Western Canadian edition)
ISBN:0-201-34624-9

Mathematics 11 Teacher's Resource Book (Western Canadian edition) ISBN: 0-201-34626-5

Math 3104A Study Guide

Recommended Resources

Mathematics 11 Independent Study Guide (Western Canadian edition) ISBN: 0-201-34625-7

Center for Distance Learning and Innovation: <http://www.cdli.ca>
Winplot: <http://math.exeter.edu/rparris/winplot.html>
(Free graphing software)

Graphmatica (Evaluation software available on CD-ROM contained in *Teacher's Resource Book*)

CD Rom accompanying *Teacher's Resource Book*
This CD contains selected solutions from the text and self test
solutions from the *Independent Study Guide*.

To the Instructor

Other Resources

Math Links: <http://mathforum.org>

<http://spot.pcc.edu/~ssimonds/winplot>

(Free videos concerning Winplot)

<http://www.pearsoned.ca/school/math/math/>

<http://www.ed.gov.nl.ca/edu/sp/mathlist.htm>

(Math Companion 3204 Supporting Document)

VIII. Recommended Evaluation

Written Notes	10%
Assignments	10%
Test(s)	30%
Final Exam (<i>entire course</i>)	<u>50%</u>
	100%

The overall pass mark for the course is 50%.

Quadratic Functions, Graphs and Equations

Unit 1 - Quadratic Functions and Graphs

Outcomes	Notes on Teaching and Learning
1.1 Use technology to graph and analyze a quadratic function.	Students will begin their study of quadratics with the example of a stone thrown straight up from a cliff that falls to the beach below. Using a TI-83 Plus graphing calculator, students will follow the steps outlined in Graphing a Function on page 84. This will guide them through the graphing and analysis of the quadratic function that describes the path of the stone.
1.1.1 Use a graphing calculator to graph a quadratic function.	
1.1.2 Use the TRACE feature to display the coordinates of a point.	
1.1.3 Display a table of values using TBLSET and TABLE.	This preliminary exercise will serve as a tour or review of many of the common calculator functions that will be used throughout this course. Additional information on these features are in the Graphing Calculator Handbook which is included in the <i>Teacher's Resource Book</i> .
1.1.4 Enlarge a graph using the ZOOM feature.	
1.1.5 Use the CALC menu to find zeros and the maximum point.	This and other similar exercises throughout the text serve to educate students or remind them of the capabilities of a graphing calculator. Its use, however, should not be to the detriment of the student's understanding of the math concepts or logic behind problem-solving.
1.1.6 State the effect of varying the initial velocity on the graph of a function.	The lack of a graphing calculator will not prevent progress in this course but it is a tool that helps the student meet the objectives.
	The Centre for Distance Learning and Innovation (www.cdli.ca) provides an excellent resource for students and instructors. Many of the topics have MLO (multimedia learning objectives) which will lead the student step-by-step through a math problem. There is also a Math 3204 Public Exam Review.
	The instructor must obtain a user name and password in order to access the CDLI website.

Unit 1 - Quadratic Functions and Graphs

Suggestions for Assessment

Study Guide questions 1.1 to 1.2 will meet the objectives of Outcome 1.1.

Resources

Mathematics 11, Mathematics and Technology, Graphing a Function, pages 84 - 87

Mathematics 11, Teacher's Resource Book, Chapter 2, page 4

Graphing Calculator Handbook, Teacher's Resource Book, pages 19 - 24

Independent Study Guide, Chapter 2, pages 31 - 40

Unit 1 - Quadratic Functions and Graphs

Outcomes

1.2 Identify and graph a quadratic function, and from the graph determine, specific information.

1.2.1 Define the following terms and where appropriate use an example to support the definition:

- (i) quadratic function
- (ii) parabola
- (iii) quadratic equation
- (iv) axis of symmetry
- (v) roots of the quadratic equation
- (vi) zeros of the quadratic equation
- (vii) domain
- (viii) range
- (ix) vertex
- (x) x -intercepts

Notes for Teaching and Learning

Note: Assign review questions from **Prerequisites**, *Teacher's Resource Book*, Chapter 2, page 5.

The vertex, x -intercepts, y -intercept, and axis of symmetry may be easily determined from the graph of a quadratic function. Students should also be able to see this significant information in a table of values. The symmetry of the graph can be seen in y - values that are repeated around the vertex, which has a unique y - value. Intercepts are recognizable as having one coordinate that is 0. Information about the domain and range can also be gathered from the table of values.

In any example that uses a table of values, the instructor should encourage the students to take a few minutes to identify key information in the table before proceeding to the graph.

Note: In Example 1, on pages 89 and 90 of *Mathematics 11*, the minimum value can be estimated from the graph that accompanies the table of values or may be found by using the **TRACE** or **CALC** features of the graphing calculator.

Students should be reminded that definitions may be found on the referenced pages or in the glossary in the textbook. To ensure understanding, students can provide definitions in their own words, supported with an example when appropriate.

Unit 1 - Quadratic Functions and Graphs

Suggestions for Assessment

See the *Teacher's Resource Book*, Chapter 2, on pages 5 to 8 for supplementary material that can be used for practice, review or further assessment.

See the *Independent Study Guide* on pages 31 to 40 for questions that can be used for assessment, review or practice.

Resources

Mathematics 11, Section 2.1
Graphs of Quadratic Functions, pages 84 - 87

Mathematics 11, Teacher's Resource Book, Chapter 2, page 5 - 8

Independent Study Guide, Chapter 2, pages 31 - 40

Unit 1 - Quadratic Functions and Graphs

Outcomes

1.2.2 From the quadratic graph, find the following information:

- (i) vertex coordinates (h, k)
- (ii) axis of symmetry $(x = h)$
- (iii) x -intercepts $(x, 0)$
- (iv) y -intercept $(0, y)$
- (v) maximum or minimum value
- (vi) domain and range

1.2.3 Given the zeros of a quadratic function, find the quadratic function.

1.2.4 Given a word problem and its associated quadratic function, find specific information.

Notes for Teaching and Learning

The instructor should remind students that because the axis of symmetry is a vertical line, it will always be written in the form, $x = \text{constant}$.

In Level 1, students learned to solve a quadratic function by factoring. In this unit, they will learn to solve the same function by graphing. This outcome will also require them to use inverse operations to turn roots which are given in the form $x = a$, $x = b$ into a function of the form $f(x) = (x - a)(x - b)$.

Unit 1 - Quadratic Functions and Graphs

Suggestions for Assessment

Study Guide questions 1.3 to 1.5 will meet the objectives of Outcome 1.2.

The answers to questions found in **Discussing the Ideas** are not found in the text. Students will bring these answers to the instructor for correction. This will provide an opportunity to assess the students' progress and understanding.

Question 3 on page 95 of *Mathematics 11* is a question similar to **Discussing the Ideas** in that it requires the student to think beyond a definition or a concept and asks them to demonstrate a deeper level of understanding. Answers in the back of the text for this type of question may consist of the sentence **“Explanations may vary”**. This will require a student to go to the instructor for correction. Students should be encouraged to use correct terminology in the answers. Instructors should ensure that the students have correctly and fully understood the examples and concepts of the section before proceeding to the **Exercise** questions.

See the *Teacher’s Resource Book*, Chapter 2, pages 5 to 8, for supplementary material that can be used for practice, review or further assessment.

Resources

Mathematics 11, Section 2.1, Graphs of Quadratic Functions, pages 88 - 97

Mathematics 11 , Teacher’s Resource Book, Chapter 2, pages 5 - 8

Independent Study Guide, Chapter 2, pages 31 - 40

www.cdli.ca
Math 3204, Unit 01,
Section 04

Unit 1 - Quadratic Functions and Graphs

Outcomes

1.3 Given a word problem, determine the quadratic function, and through its graph, find specific information.

1.3.1 State the significance of the vertex of a quadratic function.

1.3.2 State the significance of the x -intercepts.

Notes for Teaching and Learning

Note: Assign review questions 1 to 3 in **Prerequisites, Teacher's Resource Book**, Chapter 2, page 10.

In this section, students will develop quadratic functions from word problems. **Example 1** on page 101 deals with finding a maximum area when given a perimeter. Students will be asked to describe area as a function of width and will probably need a more familiar example before understanding what this means. The teaching notes of the *Teacher's Resource Book* on page 11 use the example of the amount of money earned being a function of the hours worked. Students may also need to review writing an expression representing one variable in terms of another.

In **Example 2** on page 103 of the textbook, students may need to start by creating a table listing the selling price, the number of canoes sold, and the revenue generated. Students should notice that the revenue increases and then decreases, indicating that there will be an optimum selling price that will maximize revenue.

Unit 1 - Quadratic Functions and Graphs

Suggestions for Assessment

Study Guide questions 1.6 and 1.7 will meet the objectives of Outcome 1.3.

See the *Teacher's Resource Book*, Chapter 2, pages 10 to 13, for supplementary material that can be used for practice, review or further assessment.

The *Independent Study Guide*, pages 31 to 40, provides questions that can be used for assessment, review or practice.

Resources

Mathematics 11, Section 2.2,
Modeling Real Situations
Using Quadratic Functions,
pages 101 - 107

Mathematics 11, Teacher's Resource Book, Chapter 2,
pages 10 - 13

Independent Study Guide,
Chapter 2, pages 31 - 40

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Unit 1 - Quadratic Functions and Graphs

Outcomes

1.4 Describe how parameter changes in the equation $y = x^2$ affect its graph:

- (i) $y = ax^2$
- (ii) $y = a(x - p)^2$
- (iii) $y = a(x - p)^2 + q$

1.4.1 Given a parabola with equation: $y = a(x - p)^2 + q$, state:

- a) the coordinates of the vertex
- b) the equation of the axis of symmetry
- c) the y -intercept.

1.4.2 Write the equation of a parabola when given the vertex and the y -intercept.

1.4.3 Determine the equation of a parabola when given its graph.

Notes for Teaching and Learning

Note: Assign review questions in **Prerequisites, Teacher's Resource Book**, Chapter 2, page 14.

In this section, students will develop the ability to predict graphical information from the function. This objective is concentrating on how the basic quadratic graph is shifted left, right, up and down, made wider or more narrow.

The students are asked to compare a variety of related quadratic functions. Because of the number of functions they will be asked to graph, it is recommended that students use a graphing tool. Otherwise, a suggestion made by the *Teacher's Resource Book* is to provide the students with grid paper and the basic graph of a question on a transparency. Students can then graph each of the remaining functions and lay the transparency over their graphs to determine how changes in the function have led to changes in the graph.

Unit 1 - Quadratic Functions and Graphs

Suggestions for Assessment

Study Guide questions 1.8 to 1.11 will meet the objectives of Outcome 1.4.

See *Teacher's Resource Book*, Chapter 2, pages 14 to 16, for questions that can be used to assess the student's understanding of the objectives of this section.

See the *Independent Study Guide*, pages 31 - 40, for questions that can be used for assessment, review or practice.

Resources

Mathematics 11,
Section 2.3,
Graphing, $y = a(x - p)^2 + q$
pages 109 - 119

Mathematics 11, Teacher's Resource Book, Chapter 2,
pages 14 - 16

Independent Study Guide,
Chapter 2, pages 31 - 40

Unit 1 - Quadratic Functions and Graphs

Outcomes

1.5 Using the method of completing the square, change the quadratic function from the form, $y = ax^2 + bx + c$ to the standard form, $y = a(x - p)^2 + q$

1.5.1 Change the quadratic function from the form $y = ax^2 + bx + c$ to the standard form $y = a(x - p)^2 + q$.

1.5.2 Given a quadratic equation $y = ax^2 + bx + c$, state whether the function has a maximum or minimum value of y and determine what it is.

1.5.3 Find the value of x for which the maximum or minimum value occurs.

1.5.4 Given the general equation of a quadratic, state the domain and range.

Notes for Teaching and Learning

Note: Assign review questions from **Prerequisites, Teacher's Resource Book**, Chapter 2, page 17.

Example 1 on page 122 in *Mathematics 11* works through the steps of completing the square. The important points are demonstrated in each step:

- i) Remove a common factor from the x^2 and x terms. These two terms will be the first two terms in a perfect square trinomial.
- ii) Take half of the coefficient of the x -term and square it.
- iii) Add and subtract this number inside the brackets.
- iv) In order to move the subtracted term outside the bracket, it must first be multiplied by the common factor.

Instructors should encourage students not to change fractions to decimals. When students take one-half of the x -coefficient, which may sometimes be an odd number, it will ultimately be easier to work with in a fraction form. In the quadratic function, $y = x^2 + 3x + 4$, taking one half of x -coefficient will result in $\frac{1}{2}(3) = \frac{3}{2}$. The instructor should show the students that when it is time to factor the quadratic function, which has now become

$$y = (x^2 + 3x + \frac{9}{4}) + \frac{7}{4}, \text{ its factored form will be}$$

$$y = (x + \frac{3}{2})^2 + \frac{7}{4}. \text{ Note the } \frac{3}{2} \text{ in the factored equation is the same as one half of the } x\text{- coefficient.}$$

Unit 1 - Quadratic Functions and Graphs

Suggestions for Assessment

Study Guide questions 1.12 and 1.13 will meet the objectives of Outcome 1.5.

See *Teacher's Resource Book*, Chapter 2, pages 17 to 19, for questions that can be used to assess the student's understanding of the concepts of this section.

See the *Independent Study Guide*, pages 31 to 40, for questions that can be used for assessment, review or practice.

Resources

Mathematics 11,
Section 2.4,
Graphing $y = a(x - p)^2 + q$
pages 122 - 126

Mathematics 11, Teacher's Resource Book, Chapter 2,
pages 17 - 19

Independent Study Guide,
Chapter 2, pages 31 - 40

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Unit 1 - Quadratic Functions and Graphs

Outcomes

1.6 Solve maximum and minimum problems involving quadratic functions.

Notes for Teaching and Learning

Note: Assign review questions from **Prerequisites, Teacher's Resource Book**, Chapter 2, page 20.

If the shape of the quadratic graph is known, the maximum or minimum value can be easily determined. In word problems however, neither the graph nor the function are given. Since many students have difficulty with word problems, some review work before beginning this section would be worthwhile. See Chapter 2, Quadratic Functions, page 20, *Teacher's Resource Book*, for review material and page 21 for Supplementary Material that can be assigned after the students have read the indicated pages and studied the **examples** on pages 127 to 129 of *Mathematics 11*.

Unit 1 - Quadratic Functions and Graphs

Suggestions for Assessment

Study guide questions 1.14 to 1.15 will meet the objectives of Outcome 1.6.

See *Teacher's Resource Book*, Chapter 2, on pages 21 to 23, for questions that can be used to assess the student's understanding of the concepts of this section.

See *Independent Study Guide*, on pages 31 to 40, for questions that can be used for assessment, review or practice.

Masters 2.4 to 2.5 contain a written test and Masters 2.6 to 2.10 have a multiple choice test, which could be used for an assessment.

Resources

Mathematics 11, Section 2.5, Maximum and Minimum Problems, pages 127 - 131

Mathematics 11, Teacher's Resource Book, Chapter 2, pages 20 - 23
Masters 2.4 - 2.10

Independent Study Guide, Chapter 2, pages 31 - 40

Unit 2 - Quadratic Equations

Outcomes

2.1 Use the quadratic formula to solve quadratic equations.

2.2.1 Use the method of completing the square to solve a quadratic equation of the form
 $y = ax^2 + bx + c$.

2.2.2 Use the quadratic formula to solve a quadratic equation of the form
 $y = ax^2 + bx + c$.

Notes for Teaching and Learning

Note: Assign review questions from **Prerequisites, Teacher's Resource Book**, Chapter 4, page 5.

The derivation of the quadratic formula is done on page 234 of *Mathematics 11* and follows the method of completing the square. The students have been instructed to use this method to solve quadratic equations in **Investigate** on page 226. However, as a method of solving equations, completing the square will be used infrequently. Factoring and the quadratic formula are the most commonly used methods. When completing the square is used, if necessary, students will change any fraction under the root sign to a decimal, thereby avoiding the need to rationalize a denominator.

Students will find memorization of the quadratic formula easier than its derivation. However, going through the derivation with the student will give the instructor the opportunity to note any weaknesses. The opportunity for a student to practise derivations should be encouraged as it shows that the rules for numbers are exactly the same as the rules for variables.

When solving quadratic equations two solutions are calculated. Sometimes however, one must be discounted due to the constraints of the situation described by the quadratic equation. One familiar situation involves an object that is thrown. The independent variable of the equation is time. Any negative solution for time would not be accepted as time cannot be negative.

The method used in this section is the quadratic formula. Students should be reminded that they have learned other techniques such as graphing, factoring and completing the square. Students could use a second method to verify the original answers or they could substitute the roots back into the equation.

Unit 2 - Quadratic Equations

Suggestions for Assessment

Study Guide questions 2.1 to 2.4 will meet the objectives of Outcome 2.1.

See *Teacher's Resource Book*, Chapter 4, on pages 5 to 7, for questions that can be used to assess the student's understanding of the concepts of this section.

See the *Independent Study Guide*, on pages 53 to 59, for questions that can be used for assessment, review or practice.

Resources

Mathematics 11, Section 4.1, Solving Quadratic Equations by Using a Formula, pages 226 - 235

Mathematics 11, Teacher's Resource Book, Chapter 4, pages 5 - 7

Independent Study Guide, Chapter 4, pages 53 - 59

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Unit 2 - Quadratic Equations

Outcomes

2.2 Use the discriminant to determine the nature of the roots of a quadratic equation and solve related problems.

2.2.1 Define the discriminant of a quadratic equation.

2.2.2 State the three (3) possible cases describing roots of a quadratic equation.

2.2.3 Define imaginary numbers.

2.2.4 Match the type of discriminant to a type of graph.

Notes for Teaching and Learning

Note: Assign review questions from **Prerequisites, Teacher's Resource Book**, Chapter 4, page 9.

The outcome of the discriminant $b^2 - 4ac$ will indicate one of three possibilities:

- i) a positive answer will mean the roots are real and unequal,
- ii) an answer of 0 will mean the roots are real and equal,
- iii) a negative answer will mean the roots are imaginary or complex.

The instructor should remind students that real numbers include negative and positive whole numbers, zero, all fractions and rational decimals that come from fractions (identified by a repeating patterns or termination) and irrational decimals that can come from irreducible radicals (identified by the fact they don't repeat or end). On a graph, real roots are x -intercepts, those points where the graph touches or crosses the x -axis.

A graph which neither touches nor crosses the x -axis will have a negative discriminant value and imaginary (ie. $\pm 2i$) or complex (ie. $3 \pm 5i$) roots.

Unit 2 - Quadratic Equations

Suggestions for Assessment

Study Guide questions 2.5 to 2.8 will meet the objectives of Outcome 2.2.

See *Teacher's Resource Book*, Chapter 4, on pages 9 to 11, for questions that can be used to assess the student's understanding of the concepts of this section.

See the *Independent Study Guide*, on pages 31 to 40, for questions that can be used for assessment, review or practice.

Masters 4.5 to 4.7 contain written and multiple choice questions. Since only Sections 4.1 and 4.2 were studied, the instructor will have to choose the relevant questions.

Resources

Mathematics 11, Section 4.2, The Nature of the Roots of a Quadratic Equation, pages 240 - 247

Mathematics 11, Teacher's Resource Book, Chapter 4, pages 9 - 12
Masters 4.5 - 4.7

Independent Study Guide, Chapter 4, pages 31 - 40