

MATHEMATICS 10C
POLYNOMIALS

**High School collaborative venture with
Harry Ainlay, Jasper Place, McNally, Queen Elizabeth,
Ross Sheppard and Victoria Schools**



EDMONTON PUBLIC SCHOOLS

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2009 - 2010

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Mathematics 10C

Polynomials

STAGE 1 Desired Results



Big Idea:

Through a deeper understanding of multiplication and division, students will develop higher-level and abstract thinking skills.

Implementation note:

Post the BIG IDEA in a prominent place in your classroom and refer to it often.



Enduring Understandings:

Students will understand ...

- the relationship between factoring and multiplication.
- that multiplication and factoring can be represented in a variety of ways.
- the connection between whole numbers and polynomials with respect to multiplication and factoring.



Essential Questions:

- What is the difference between concrete, pictorial and symbolic representations?
- What is factoring and how does it relate to multiplying?

Implementation note:

Ask students to consider one of the essential questions every lesson or two. Has their thinking changed or evolved?



Knowledge:

Enduring Understanding	Specific Outcomes	Description of Knowledge
<i>Students will understand...</i> <ul style="list-style-type: none">• The relationship between factoring and multiplication.	*AN 1 *AN 4 *AN 5	<i>Students will know ...</i> <ul style="list-style-type: none">• that factoring and multiplying are inverse operations.
<i>Students will understand...</i> <ul style="list-style-type: none">• that multiplication and factoring can be represented in a variety of ways.	*AN 1 *AN 4 *AN 5	<i>Students will know ...</i> <ul style="list-style-type: none">• the different strategies and representations for multiplication and factoring
<i>Students will understand...</i> <ul style="list-style-type: none">• the connection between whole numbers and polynomials with respect to multiplication and factoring.	*AN 1 *AN 4 *AN 5	<i>Students will know ...</i> <ul style="list-style-type: none">• the strategies that work for whole numbers also work for polynomial operations and vice versa.

*AN =Algebra and Number



Skills:

Enduring Understanding	Specific Outcomes	Description of Skills
<p><i>Students will understand...</i></p> <ul style="list-style-type: none"> The relationship between factoring and multiplication. 	<p>*AN 1 *AN 4 *AN 5</p>	<p><i>Students will be able to...</i></p> <ul style="list-style-type: none"> determine the prime factors, GCF and LCM for whole numbers. determine the GCF for polynomials.
<p><i>Students will understand...</i></p> <ul style="list-style-type: none"> that multiplication and factoring can be represented in a variety of ways. 	<p>*AN 1 *AN 4 *AN 5</p>	<p><i>Students will be able to...</i></p> <ul style="list-style-type: none"> multiply polynomials concretely, pictorially and symbolically. factor polynomials concretely, pictorially and symbolically.
<p><i>Students will understand...</i></p> <ul style="list-style-type: none"> the connection between whole numbers and polynomials with respect to multiplication and factoring. 	<p>*AN 1 *AN 4 *AN 5</p>	<p><i>Students will be able to...</i></p> <ul style="list-style-type: none"> determine prime factors, GCF and LCM for whole numbers. determine the GCF for polynomials. multiply polynomials concretely, pictorially and symbolically. factor polynomials concretely, pictorially and symbolically.

*AN =Algebra and Number

Implementation note:

Teachers need to continually ask themselves, if their students are acquiring the knowledge and skills needed for the unit.



Poly Productions Inc. or Polynomial Funk-Shuns CD

Teacher Notes

There are two transfer tasks to evaluate student understanding of the concepts relating to slope. The teacher (or the student) will select one for completion. Photocopy-ready versions of the two transfer tasks are included in this section.

Implementation note:

Students must be given the transfer task & rubric at the **beginning** of the unit. They need to know how they will be assessed and what they are working toward.

Each student will:

- demonstrate an understanding of the multiplication of polynomial expressions concretely, pictorially and symbolically.
- demonstrate an understanding of common factors and trinomial factoring concretely, pictorially and symbolically.

Teacher Notes for **Poly Productions Inc.** Transfer Task

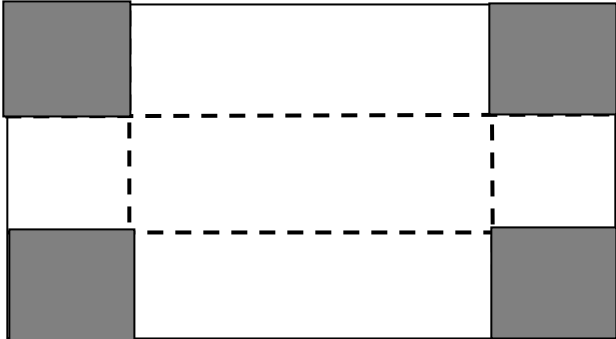


Glossary

net – a set of polygons in a plane, all connected by certain edges such that when "folded up" form a polyhedron

revenue – money that comes into a business from the sale of goods or services

Teachers may want to guide students with the following net diagram.



The following charts could be used to assist students in the completion of this task

	Net Diagram	Maximum Number of Balls
Original Dimensions		

Net Diagram

Calculations of Areas

Increased Dimensions		Base Wasted Material Area of the Sides Total Area
----------------------	--	--

Teacher Notes for Rubric

- *No score is awarded for the **Insufficient/Blank** column , because there is no evidence of student performance.*
- ***Limited** is considered a pass. The only failures come from **Insufficient/Blank**.*
- *When work is judged to be **Limited** or **Insufficient/Blank**, the teacher makes decisions about appropriate intervention to help the student improve.*

Implementation note:

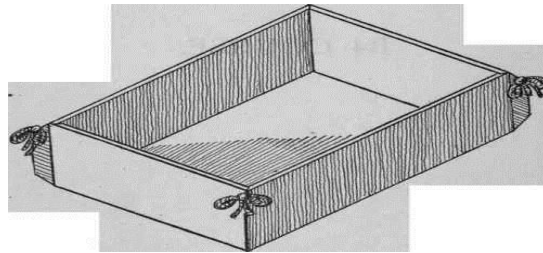
Teachers need to consider what performances and products will reveal evidence of understanding?
 What other evidence will be collected to reflect the desired results?



Poly Productions Inc. - Student Assessment Task

Golf, a game of Scottish origin, is one of the most popular sports in the world. The standard golf ball used in the United States is a minimum of 4.26 cm in diameter; the British ball is slightly smaller.

You work for Poly Productions Inc. and you have been asked to design an open box that would accommodate various sizes of golf balls. A polynomial can represent the area of material needed to create an open box based on the change in size of the diameter of the golf ball.



Begin with a golf ball with a 5 cm diameter and a piece of paper 15 cm by 25 cm. Your job is to create an open-topped box that will fit a maximum number of golf balls.

- Draw a labelled net diagram showing all dimensions of each part of your box.
- Determine the maximum number of balls that will fit in the box

To accommodate the same number of golf balls, if you change the diameter of the golf ball, the area of the material you start with would need to change as well. Determine a polynomial that would represent the area of material required if the diameter of the ball is changed by a value of x .

- Draw a labelled net diagram showing all new dimensions of each part of your box.
- Find the area of the base of your box.
- Find the area of the wasted material.
- Find the area of the sides.
- Find the total area of the material (this will be your polynomial that represents the material needed).

Poly Productions Inc. will now produce various customized box sizes. Based on the 5 cm golf ball box, the cost per box can be represented by $6x^2 + 39x + 45$, where x represents the change in the size of the golf ball.

The cost per box = (number of balls) (ball size) (cost of the sheet)

- Factor the expression $6x^2 + 39x + 45$ to determine the size of the ball and the cost in terms of x .
- If you are asked to produce a box that will hold golf balls with a diameter of 6 cm, determine the cost per box (in cents)?



Mathematics 10C

Polynomials

Rubric

Level Criteria	Excellent 4	Proficient 3	Adequate 2	Limited* 1	Insufficient / Blank*
Performs Calculations	Performs precise and explicit calculations.	Performs focused and accurate calculations.	Performs appropriate and generally accurate calculations.	Performs superficial and irrelevant calculations.	No score is awarded because there is no evidence of student performance.
Presents Data	Presentation of data is insightful and astute .	Presentation of data is logical and credible .	Presentation of data is simplistic and plausible .	Presentation of data is vague and inaccurate .	No data is presented.
Explains Choice	Shows a solution for the problem; provides an insightful explanation.	Shows a solution for the problem; provides a logical explanation.	Shows a solution for the problem; provides explanations that are complete but vague .	Shows a solution for the problem; provides explanations that are incomplete or confusing .	No explanation is provided.
Communicates findings	Develops a compelling and precise presentation that fully considers purpose and audience; uses appropriate mathematical vocabulary, notation and symbolism.	Develops a convincing and logical presentation that mostly considers purpose and audience; uses appropriate mathematical vocabulary, notation and symbolism.	Develops a predictable presentation that partially considers purpose and audience; uses some appropriate mathematical vocabulary, notation and symbolism.	Develops an unclear presentation with little consideration of purpose and audience; uses inappropriate mathematical vocabulary, notation and symbolism.	No findings are communicated.



Glossary

accurate – free from errors

astute – shrewd and discerning

appropriate – suitable for the circumstances

compelling – convincing and persuasive

complete – including every necessary part

convincing – impressively clear or definite

credible – believable

explicit – expressing all details in a clear and obvious way

focused – concentrated on a particular thing

incomplete – partial

inaccurate – not correct

inappropriate – not suitable

insightful – a clear perception of something

irrelevant – not relevant or important

logical - based on facts, clear rational thought, and sensible reasoning

precise - detailed and specific

plausible – believable

predictable - happening or turning out in the way that might have been expected

simplistic – lacking detail

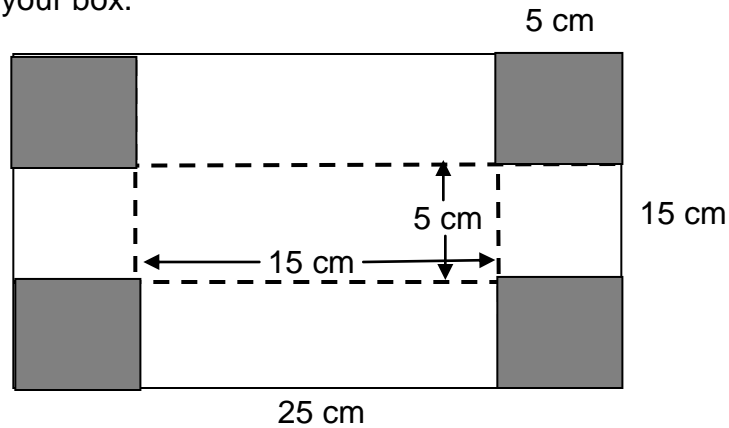
superficial - having little significance or substance

unclear – ambiguous or imprecise

vague - not clear in meaning or intention

Possible Solution to Poly Productions Inc.

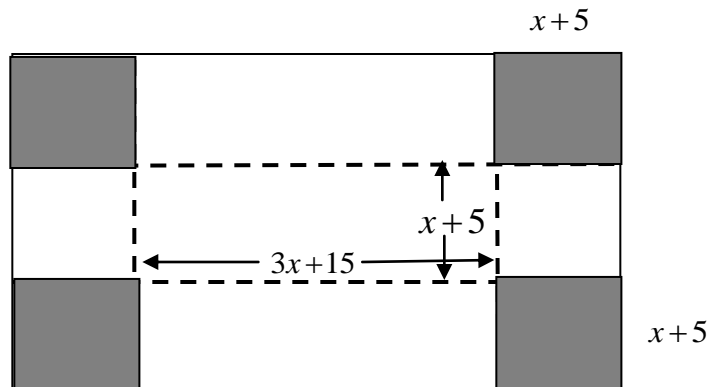
- Draw a labelled net diagram showing all dimensions of each part of your box.



- Determine the maximum number of balls that will fit in the box

3

- Draw a labelled net diagram showing all new dimensions of each part of your box.



- Find the area of the base of your box.

$$\text{Area of Base} = (15 + 3x)(x + 5) = (3x + 15)(x + 5) = 3x^2 + 30x + 75$$

- Find the area of the wasted material

$$\text{Wasted Area} = 4(x + 5)^2 = 4x^2 + 40x + 100$$

- Find the area of the sides.

$$\text{Area of sides} = 2(x + 5)^2 + 2(x + 5)(3x + 15) = 8x^2 + 80x + 200$$

Find the total area of the material (this will be your polynomial to represent the material)

$$\begin{aligned}\text{Total Area} &= (3x+15)(x+5) + 4(x+5)^2 + 2(x+5)^2 + 2(x+5)(3x+15) \\ &= 15x^2 + 150x + 375\end{aligned}$$

The cost per box = (number of balls)(ball size)(cost of the sheet)

- Factor the expression to determine the size of the ball and cost

$$= 3(x+5)(2x+3)$$

- If you are asked to produce a box that will hold a golf ball with a diameter of 6 cm. What will be the cost per box?

First find the value of x

$$x+5=6$$

$$x=1$$

Then calculate the cost per box

$$\begin{aligned}\text{The cost per box} &= (\text{number of balls})(\text{ball size})(\text{cost of the sheet}) \\ &= 3((1)+5)(2(1)+3) \\ &= 90 \text{ cents}\end{aligned}$$



Glossary

liner notes - printed information about a recording that appears on the cover or as part of the packaging

Teacher Notes for **Rubric**

- *No score is awarded for the **Insufficient/Blank** column , because there is no evidence of student performance.*
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- *When work is judged to be **Limited** or **Insufficient/Blank**, the teacher makes decisions about appropriate intervention to help the student improve.*

Implementation note:

Teachers need to consider what performances and products will reveal evidence of understanding? What other evidence will be collected to reflect the desired results?



Polynomial Funk-Shuns CD - Student Assessment Task

Part A

- Use algebra tiles to create a polynomial perfect square as a CD cover. You may use one variable, two variables or three variables.
- Construct a 12 cm by 12 cm image of your design.
- On a 12 cm by 12 cm page, create liner notes that include:
 - the polynomial dimensions and polynomial area.
 - a grid demonstrating how the dimensions multiply to the area.
 - a colour legend that communicates the names of each piece of your design.

Part B

The band would like to include some notes about polynomial functions in the liner notes for their album.

- $x^2 + 6x + 9$, $x^2 - 9$, $x^2 - 6x + 9$, and $2x^2 + 12x + 18$ form a “family” of rectangle-able polynomials. Factor all four, sketch them, and show the factors in a grid. Use words to describe their similarities and differences. Present your notes on a 12 cm by 12 cm page.
- Create another “family” of four polynomial rectangles and present them in the same manner as the previous one. Explain what makes your polynomials a family.



Mathematics 10C

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STAGE 3 Learning Plans

Lesson 1

Activating Prior Knowledge (GCF and LCM)



STAGE 1

BIG IDEA:

Through a deeper understanding of multiplication and division students will develop higher – level and abstract thinking skills, thus enabling them to represent real – life problems.

ENDURING UNDERSTANDINGS:

Students will understand ...

- the relationship between factoring and multiplication.
- that multiplication and factoring can be represented in a variety of ways.

ESSENTIAL QUESTIONS:

- What is factoring and how does it relate to multiplying?

KNOWLEDGE:

Students will know ...

- that factoring and multiplying are inverse operations.
- the different strategies and representations for multiplication and factoring.

SKILLS:

Students will be able to...

- determine prime factors, GCF and LCM for whole numbers.

Implementation note:

Each lesson is a conceptual unit and is not intended to be taught on a one lesson per block basis. Each represents a concept to be covered and can take anywhere from part of a class to several classes to complete.



Lesson Summary

Students will review:

- Prime Factors
- Greatest Common Factors
- Lowest Common Multiples



Lesson Plan

Pre-assessment

In groups of three, students complete five pre-assessment mini-posters.

- Show how 5 is a prime number.
- Show how 12 a composite number.
- Show as many methods as you know to find the greatest common factor between 12 and 18.
- Show as many methods as you know to find the least common multiple between 12 and 18.
- Show how 36 is a perfect square.

Have the groups post their mini-posters on larger displays with titles: Prime, Composite, GCF, LCM, and Perfect Square. These collections of understanding can serve as references throughout the unit. As well, the class can add more algebraic applications to these poster collages throughout the unit.

Ideas that the teacher might expect: factor trees, rectangular arrays and/or lists.

Investigation

Locker Problem

(<http://lpsl.coe.uga.edu/mile3/resa/gpsinaction/lessonplans/LockersProblemLessonPlan.pdf>)

Follow the link to a problem in which factorability is important. The teacher can use this problem as an opening set, allowing pairs of students to get as far as they can with the problem and leaving it “unfinished” with an option to come back to the problem as their knowledge changes. Alternatively, this problem could come after the above pre-assessment, thus inviting students to think about factorability as they work on the problem. The locker problem also fits well into the Algebra and Number, Outcome 1.

Learning Plan

Begin with examples using numbers such as 16, 24, and 36. Facilitate discussion and investigation about the numbers and guide students to group the numbers, discover factors, greatest common factors and lowest common multiples.

Possible Prime Factorization Methods:

- Factor Tree.
- Lists.
- Rectangular Array.

Possible GCF Methods:

- Factor Tree.
- Factor Rainbows (Pearson pg 136).
- Look for the largest factor of one number that also divides into the other number.
- List prime factors for both numbers and multiply factors common to both to get the GCF.

Possible LCM Methods:

- List all multiples of both numbers until the same number occurs in both lists.
- List multiples of one number while checking to see if other number divides into any of these.

Algebra Tile Methods

- Ask students to build tile rectangles for numbers 24 and 18
- How many ways can they construct these?
- In which rectangles can a common length be found?



Resources

Math 10 (McGraw Hill: sec 5.2)

Foundations and Pre-calculus Mathematics 10 (Pearson: sec 3.1)

algebra tiles
poster materials



Assessment

Written formative assessments will be utilized. Students should be given the opportunity to solve various factoring and multiple problems involving whole numbers with a strategy of their choice.



Glossary

common factor – a term that exactly divides at least two given terms

common multiple – a non-zero multiple that two or more terms have in common

factor – a term that exactly divides a given term

greatest common factor (GCF) – the largest or most complex factor that a set of terms have in common

least common multiple (LCM) - the smallest or least complex multiple that a set of terms have in common

prime factorization - the expression of a natural number greater than one, as a unique product of prime numbers

Glossary hyperlinks redirect you to the Learn Alberta Mathematics Glossary (<http://www.learnalberta.ca/content/memg/index.html>). Some terms can be found in more than one division. Some terms have animations to illustrate meanings.

Lesson 2

Feel the Math (Multiplying)



STAGE 1

BIG IDEA:

Through a deeper understanding of multiplication and division students will develop higher – level and abstract thinking skills, thus enabling them to represent real – life problems.

ENDURING UNDERSTANDINGS:

Students will understand ...

- the connection between whole numbers and polynomials with respect to multiplication and factoring.

ESSENTIAL QUESTIONS:

- What is the difference between concrete, pictorial and symbolic?

KNOWLEDGE:

Students will know ...

- the strategies that work for whole numbers also work for polynomial algebra.

SKILLS:

Students will be able to...

- multiply polynomials concretely, pictorially and symbolically.
- factor polynomials concretely, pictorially and symbolically.



Lesson Summary

- Prior Knowledge
 - Prime Factors
 - Greatest Common Factors
 - Squares and Cubes
 - Multiplying and Dividing Monomials
 - Collecting Like Terms
- Students will now be introduced to multiplying binomials with algebra tiles (concretely)
- Students may also be introduced to multiplying binomials/trinomials symbolically.



Lesson Plan

Begin with two-digit multiplication using a grid.

Calculate: 23×32

\times	20	+	3
30	600		90
+			
2	40		6

$$600 + 90 + 40 + 6 = 736$$

$$\therefore 23 \times 32 = 736$$

Then, progress to one variable monomial multiplication with algebra tiles. Next, follow with binomial multiplication using positive terms, then by negative terms. You may want to connect multiplication to an area model. Finally, you may progress to abstract multiplication including multiplication of binomials with trinomials.

Multiplying

Given the dimensions $x+2$ and $2x+3$. Find the area using algebra tiles. Sketch on board. Provide the symbolic representation of $2x^2 + 7x + 6$.

Present the following grid:

\times	$2x$	+	3
x	$2x^2$		$3x$
+			
2	$4x$		6

Differentiated Instruction

- *Include difference of squares.*
- *Incorporate multiplications involving more than one variable.*



Resources

Foundations and Pre-calculus Mathematics 10 (Pearson: sec 3.5, 3.6, 3.7)
Math 10 (McGraw Hill: sec 5.1)

Algebra Tile Tutorial

<http://mathbits.com/MathBits/AlgebraTiles/AlgebraTilesMathBitsNew07ImpFree.html>

Algebra Tutorial (YouTube)

<http://www.youtube.com/watch?v=LKEdmHtiyU8>

Smart Board Algebra Tile Template

[http://education.smarttech.com/ste/en-](http://education.smarttech.com/ste/en-US/Ed+Resource/Lesson+activities/Notebook+Activities/Browse+Notebook/New+Zealand/Secondary/8-9/Maths/Algebra+Tiles.htm)

[US/Ed+Resource/Lesson+activities/Notebook+Activities/Browse+Notebook/New+Zealand/Secondary/8-9/Maths/Algebra+Tiles.htm](http://education.smarttech.com/ste/en-US/Ed+Resource/Lesson+activities/Notebook+Activities/Browse+Notebook/New+Zealand/Secondary/8-9/Maths/Algebra+Tiles.htm)



Assessment

Written formative assessments will be utilized. Students should be given the opportunity to solve various multiplication problems with a strategy of their choice (e.g. algebra tiles or distributive property).



Glossary

binomial – a polynomial with two terms

distributive property – multiplying a sum or difference by a number is the same as multiplying each term in the bracket by the factor outside and then combining the products

monomial – a polynomial with only one term

polynomial – an expression that has one or more terms that are added or subtracted

term – part of a mathematical expression that is associated with another by a plus or minus sign

trinomial – a polynomial with three terms

Lesson 3

See the Math (Factoring)



STAGE 1

BIG IDEA:

Through a deeper understanding of multiplication and division students will develop higher – level and abstract thinking skills, thus enabling them to represent real – life problems.

ENDURING UNDERSTANDINGS:

Students will understand ...

- the relationship between factoring and multiplication.
- that multiplication and factoring can be represented in a variety of ways.

ESSENTIAL QUESTIONS:

- What is the difference between concrete, pictorial and symbolic?
- What is factoring and how does it relate to multiplying?

KNOWLEDGE:

Students will know ...

- that factoring and multiplying are inverse operations.
- the different strategies and representations for multiplication and factoring.

SKILLS:

Students will be able to...

- determine the GCF for polynomials.
- factor polynomials concretely, pictorially and symbolically.



Lesson Summary

- Prior Knowledge
 - Prime Factors
 - Greatest Common Factors
 - Squares and Cubes
 - Multiplying and Dividing Monomials
 - Collecting Like Terms
- Students will now be introduced to factoring binomials and trinomials with algebra tiles (concretely).
- Students will also be introduced to factoring binomials/trinomials symbolically.



Lesson Plan

Ask students to multiply two binomials together then ask students to *undo* the operation. Students can use algebra tiles, pictorial representations, or algebra.

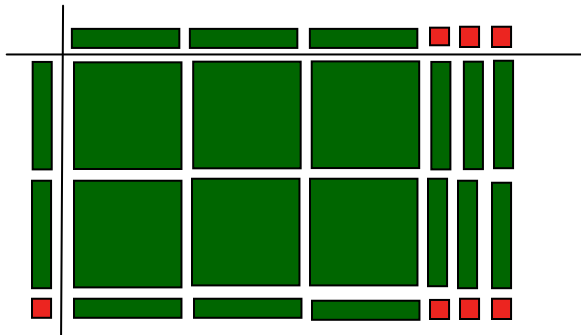
Write examples such as $4x+6$, x^2+5x+6 , $3x^2+8x+4$ on board. Ask students to identify factors using algebra tiles or pictorial representations.

Sample Lesson

1. Teacher: You are a factory worker. You've been requested to fill an order. You need one x^2 tile, five x tiles and six unit tiles. Form a rectangle out of the pieces.

Ask students to record answers on board. Discuss the possibilities. What are the similarities and differences? Orientation doesn't matter but encourage standard form. For displaying algebra tiles, standard form constitutes beginning with the x^2 tiles, followed by the x tiles, and finally the unit tiles as you move from left to right and from top to bottom.

Example



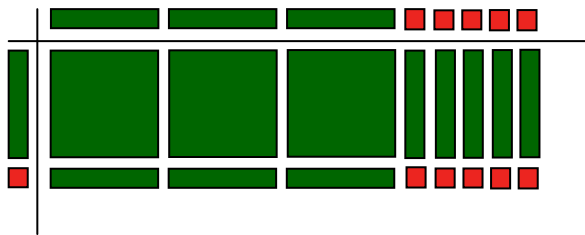
2. A new order comes in:
Build a rectangle out of $2x^2 + 11x + 5$.
Discuss answers. How many possibilities are there? Focus on the fact that the constant is a prime number so there is only one way to arrange the unit tiles (1x5).
3. Build $2x^2 + 9x + 9$.
Point out that this time the constant is not prime. Record and discuss answers.
4. Build $2x^2 + 10x + 12$.
Record answers on board (sketch). Discuss dimensions of each possibility.
($x+3$)($2x+4$) and ($2x+6$)($x+2$).

Ask if there is a better answer.

- Is there a more efficient way to organize the tiles?
- Which form would a mathematician prefer?
- Break the rectangle into two equal rectangles. ($x+2$)($x+3$)
- Discuss the efficiency of stacking the rectangles on top of each other. [$2(x+2)(x+3)$]. This can lead into a discussion about common factors.

Bridging the Gap into Factoring

(concretely) Build $3x^2 + 8x + 5$
 (pictorially) Sketch
 (symbolically) Create a grid showing dimensions.



x	3x	+	5
x	$3x^2$		$5x$
+			
1	$3x$		5

The factors of the polynomial $3x^2 + 8x + 5$ are $(3x+5)(x+1)$.
 Provide multiple examples.



Resources

Math 10 (McGraw Hill: sec 5.2, 5.3, 5.4)

Foundations and Pre-calculus Mathematics 10 (Pearson: sec 3.1, 3.3, 3.5, 3.6, 3.8)

Algebra Tile Tutorial

<http://mathbits.com/MathBits/AlgebraTiles/AlgebraTilesMathBitsNew07ImpFree.html>

Algebra Tutorial (YouTube)

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[US/Ed+Resource/Lesson+activities/Notebook+Activities/Browse+Notebook/New+Zealand/Secondary/8-9/Maths/Algebra+Tiles.htm](http://education.smarttech.com/ste/en-US/Ed+Resource/Lesson+activities/Notebook+Activities/Browse+Notebook/New+Zealand/Secondary/8-9/Maths/Algebra+Tiles.htm)



Assessment

Written formative assessments will be utilized. Students should be given the opportunity to solve various factoring problems with a strategy of their choice (e.g. algebra tiles or decomposition).



Glossary

difference of squares – a binomial that is the difference of two terms which are perfect squares

factoring a polynomial – expressing a polynomial as a list of factors, all of which, multiply to give the original polynomial

factored fully – decomposing a polynomial into factors which cannot be factored further

multiple (of a number) – a term that is the product of a given term and another term, or is a term that can be exactly divided by a given term

perfect square trinomial – A trinomial whose two binomial factors are identical