Chapter 5

Polynomials

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5.1. Definitions

Polynomials are algebraic expressions that generally have more than one term.

• A monomial has one term. For example, \( 2x, -5x^2, 8 \)

• A binomial has two terms. For example, \( 2x + 8, 3x - 5x^2 \)
Algebra

• A trinomial has three terms. For example, 
  \(-5x^2 + 3x + 9\), \(4x^4 - 2x^2 + 4x\)

• The exponent of the variable in a term defines the degree of that term. For example, \(2x^2\) has a degree of 2.

• The degree of a polynomial equation or expression is determined by the highest degree of the variable in any of its terms.
  
  \(4x^4 - 2x^2 + 4x\) has a degree of 4.
  \(5x^2 + 3x + 9\) has a degree of 2.
  \(-5x^2\) has a degree of 2.
  \(2x^2y\) has a degree of 2.
  \(8\) has a degree of 0.
  (The degree of a constant is zero.)
  \(2x\) has a degree of 1.
  (The degree of a variable without an exponent shown is one.)

• If the variable does not have an exponent, an invisible “1” is present. \((x^1 = x)\) Equations with terms having the highest degree of one are called linear equations because the graphs of these equations form straight lines. If at least one variable in one term has an exponent greater than one, the equation is non-linear. Equations containing the degree of 2 are called quadratic equations and the graphs of these equations form curved lines.
5.2. Addition of polynomials

Addition of polynomials is performed by combining and adding like terms.

- Example: Add \((y^2 - 3y + 4)\) and \((y - 3y^2 + y^3)\).

\[(y^2 - 3y + 4) + (y - 3y^2 + y^3)\]

Remove parentheses and group like terms.

\[= y^3 + y^2 - 3y^2 - 3y + y + 4\]

Add like terms.

\[= y^3 - 2y^2 - 2y + 4\]

Therefore:

\[(y^2 - 3y + 4) + (y - 3y^2 + y^3) = y^3 - 2y^2 - 2y + 4\]

- Example: Add \(2y(y^2 - 2y + 2)\) and \(3(y - 4y^2 + 2y^3)\).

\[2y(y^2 - 2y + 2) + 3(y - 4y^2 + 2y^3)\]

Multiply \(2y\) and \(3\) into the parentheses and group like terms.

\[= 2y^3 - 4y^2 + 4y + 3y - 12y^2 + 6y^3\]

\[= 2y^3 + 6y^3 - 4y^2 - 12y^2 + 4y + 3y\]

Add like terms.

\[= 8y^3 - 16y^2 + 7y\]

Therefore:

\[2y(y^2 - 2y + 2) + 3(y - 4y^2 + 2y^3) = 8y^3 - 16y^2 + 7y\]
5.3. Subtraction of polynomials

To subtract polynomials, distribute the negative sign into the parentheses by multiplying it with each term, and combine like terms.

- Example: Subtract \((y^2 - 3y + 4)\) and \((y - 3y^2 + y^3)\).

Use parenthesis as a reminder that the entire second polynomial is subtracted.

\[(y^2 - 3y + 4) - (y - 3y^2 + y^3)\]

Distribute the negative sign into parentheses by multiplying it with each term.

\[= y^2 - 3y + 4 - y + 3y^2 - y^3\]

Note that each sign of each term after the minus sign changes to the opposite sign.

Combine like terms.

\[= -y^3 + y^2 + 3y^2 - 3y - y + 4\]

\[= -y^3 + 4y^2 - 4y + 4\]

Therefore:

\[(y^2 - 3y + 4) - (y - 3y^2 + y^3) = -y^3 + 4y^2 - 4y + 4\]
5.4. Multiplication of polynomials

Multiplication of polynomials, including multiplying monomials, multiplying a monomial with a polynomial, multiplying two binomials and multiplying polynomials with polynomials, is described in this section.

- To multiply monomials, multiply the numerical coefficients with each other and multiply the variables with each other.

- Example: Multiply the monomials:
  $$(6x)(-3x^2) = (6)(-3)(x)(x^2) = -18x^3$$

- Example: Multiply the monomials:
  $$(-5x^2y)^2 = (-5x^2y)(-5x^2y) = (-5)(-5)(x^2)(x^2)(y)(y) = 25x^4y^2$$

- To multiply a monomial with a polynomial, use the distributive property to multiply the monomial with each term in the polynomial.

- Example: Multiply the monomial and polynomial:
  $$6(4x + 8) = (6)(4x) + (6)(8) = 24x + 48$$

- Example: Multiply the monomial and polynomial:
  $$-10x(2x^2 - 6x - 2)$$
  $$= (-10x)(2x^2) + (-10x)(-6x) + (-10x)(-2)$$
  $$= -20x^3 + 60x^2 + 20x$$
Algebra

• To multiply two binomials, use the distributive property to multiply each term in one binomial with each term in the other binomial. In other words, multiply the first term in the first binomial with each term in the second binomial, next multiply the second term in the first binomial with each term in the second binomial, then combine like terms.

• Example: Multiply the binomials:

\[(2x + 6)(3x + 4)\]
\[= (2x)(3x) + (2x)(4) + (6)(3x) + (6)(4)\]
\[= 6x^2 + 8x + 18x + 24\]
\[= 6x^2 + 26x + 24\]

Note that this technique is often called the FOIL method because the First, Outer, Inner and Last terms are multiplied with each other.

• To multiply polynomials with polynomials, use the distributive property to multiply each term in the first polynomial with each term in the second polynomial. In other words, multiply the first term in the first polynomial with each term in the second polynomial, then multiply the second term in the first polynomial with each term in the second polynomial, then multiply the third term in the first polynomial with each term in the second polynomial, and so on. Finally, combine like terms.
Polynomials

- Example: Multiply the polynomials:

\[(2x - 4)(x^2 + 2x - 5)\]
\[= (2x)(x^2) + (2x)(2x) + (2x)(-5) + (-4)(x^2)\]
\[+ (-4)(2x) + (-4)(-5)\]
\[= 2x^3 + 4x^2 - 10x - 4x^2 + 8x + 20\]
\[= 2x^3 + 4x^2 - 4x^2 - 10x + 8x + 20\]
\[= 2x^3 - 18x + 20\]

5.5. Division of polynomials

Division of polynomials, including division of monomials, division of polynomials by monomials, and division of polynomials by polynomials, is described in this section.

- To divide monomials, write the division in the form of a fraction, then divide numerical coefficients with each other and divide like variable bases with each other.

- Example: Divide \(6x \div (-3x^2)\):

\[
\frac{6x}{-3x^2} = \frac{6x}{-3xx} = \frac{2}{-x} = -\frac{2}{x}
\]

- To divide polynomials by monomials, use the distributive property and divide the monomial into each term of the polynomial, or multiply one-over the monomial with each term of the polynomial.
Algebra

• Example: Divide \((4x + 8) \div 6\):

Multiply one-over the monomial with each term in the polynomial.

\[
(4x + 8) \div 6 = (1/6)(4x + 8)
\]

\[
= (1/6)(4x) + (1/6)(8) = 4x/6 + 8/6 = \frac{2}{3}x + \frac{4}{3}
\]

• Example: Divide \((2x^2 - 6x - 2) \div -2x\):

Multiply one-over the monomial with each term in the polynomial.

\[
(2x^2 - 6x - 2) \div -2x = (-1/2x)(2x^2 - 6x - 2)
\]

\[
= (-1/2x)(2x^2) + (-1/2x)(-6x) + (-1/2x)(-2)
\]

\[
= \frac{-2x^2}{2x} + \frac{6x}{2x} + \frac{2}{2x} = -x + 3 + 1/x
\]

• To divide polynomials by polynomials, use the long division format. To do this, divide the first term in the divisor into the first term in the dividend, then multiply the divisor by the first term in the quotient and write the product under the dividend. Next, subtract like terms and bring down the next term. Repeat this long division procedure until there are no more terms to bring down.
Polynomials

• Example: Divide \((-10x + 8 + 8x^2) \div (2x - 4)\):

Arrange the terms with the largest degrees first, and write in long division format.

\[
\begin{array}{c|cc}
& 8x^2 & -10x + 8 \\
\hline
2x - 4 & | & 8x^2 & -10x + 8 \\
\hline
& 8x^2 & -16x \\
\hline
& 6x + 8
\end{array}
\]

Divide the first term in the divisor into the first term in the dividend, \(8x^2 + 2x = 4x\).

\[
\begin{array}{c|cc}
& 8x^2 & -10x + 8 \\
\hline
2x - 4 & | & 8x^2 & -10x + 8 \\
\hline
& 8x^2 & -16x \\
\hline
& 6x + 8
\end{array}
\]

Multiply the divisor with the first term in the quotient, \(4x(2x - 4) = 8x^2 - 16x\) and write the product under the dividend.

\[
\begin{array}{c|cc}
& 8x^2 & -10x + 8 \\
\hline
2x - 4 & | & 8x^2 & -10x + 8 \\
\hline
& 8x^2 & -16x \\
\hline
& 6x + 8
\end{array}
\]

Subtract like terms and bring down the next term.

\[
\begin{array}{c|cc}
& 8x^2 & -16x \\
\hline
2x - 4 & | & 8x^2 & -10x + 8 \\
\hline
& 8x^2 & -16x \\
\hline
& 6x + 8
\end{array}
\]

Find the second term in the quotient by dividing \(2x\) into \(6x\), \(6x \div 2x = 3\).
\[
\begin{array}{c}
\frac{4x + 3}{2x - 4} \div \frac{8x^2 - 10x + 8}{8x^2 - 16x} = 6x + 8 \\
\end{array}
\]

Multiply the divisor with the second term in the quotient, \(3(2x - 4) = 6x - 12\) and write the product under the dividend.

\[
\begin{array}{c}
\frac{4x + 3}{2x - 4} \div \frac{8x^2 - 10x + 8}{8x^2 - 16x} = 6x + 8 \\
\end{array}
\]

Subtract like terms and, because there is no next term to bring down, write the remainder as a fraction of the difference over the divisor.

\[
\begin{array}{c}
\frac{4x + 3}{2x - 4} \div \frac{8x^2 - 10x + 8}{8x^2 - 16x} = 6x + 8 \\
\end{array}
\]

Therefore, \((-10x + 8 + 8x^2) + (2x - 4) = 4x + 3 + \frac{20}{2x - 4}\)

where, \(\frac{20}{2x - 4} = \frac{20}{2(x - 2)} = \frac{10}{x - 2}\).

Therefore, the final answer is \(4x + 3 + (10/(x-2))\).
Polynomials

• Example: Divide \((x^2 + 4) \div (x + 4)\):

Arrange the terms with the largest degrees first (fill in missing terms using zero), and write in long division format.

\[
\begin{array}{c}
\text{x + 4} \\
\hline
x^2 + 0x + 4
\end{array}
\]

Divide the first term in the divisor into the first term in the dividend, \(x^2 + x = x\).

\[
\begin{array}{c}
x \\
\hline
x + 4 \\
x^2 + 0x + 4
\end{array}
\]

Multiply the divisor with the first term in the quotient, \(x(x + 4) = x^2 + 4x\) and write the product under the dividend.

\[
\begin{array}{c}
x \\
\hline
x + 4 \\
x^2 + 0x + 4 \\
x^2 + 4x
\end{array}
\]

Subtract like terms and bring down the next term.

\[
\begin{array}{c}
x \\
\hline
x + 4 \\
x^2 + 0x + 4 \\
x^2 + 4x \\
- 4x + 4
\end{array}
\]

Find the second term in the quotient by dividing \(x\) into \(-4x\), \(-4x + x = -4\).
Algebra

\[
\begin{align*}
\frac{x - 4}{x + 4} & \frac{x^2 + 0x + 4}{x^2 + 4x} \\
& -4x + 4 \\
& -4x - 16
\end{align*}
\]

Multiply the divisor with the second term in the quotient, \(-4(x + 4) = -4x - 16\) and write the product under the dividend.

\[
\begin{align*}
\frac{x - 4}{x + 4} & \frac{x^2 + 0x + 4}{x^2 + 4x} \\
& -4x + 4 \\
& -4x - 16 \\
& 20
\end{align*}
\]

Subtract like terms and, because there is no next term to bring down, write the remainder as a fraction of the difference over the divisor.

\[
\begin{align*}
\frac{x - 4}{x + 4} & \frac{x^2 + 0x + 4}{x^2 + 4x} \\
& -4x + 4 \\
& -4x - 16 \\
& 20
\end{align*}
\]

Therefore, \((x^2 + 4) ÷ (x + 4) = x - 4 + \frac{20}{x + 4}\).
5.6. Factoring polynomials with a common monomial factor

When solving equations or simplifying expressions, it is often beneficial to factor polynomials containing a common monomial factor in each term.

- The factored form of a number is an expression of the number as a product of numbers that, when multiplied together, equal the number. Similarly, the factored form of a polynomial is an expression of the polynomial as a product of monomials and/or polynomials that, when multiplied together, equal the polynomial.

- When factoring a polynomial with a common monomial factor, factor out the greatest common factor.

- For example, factor the following:

  \[ 6 = (2)(3) \]
  Where 2 and 3 are both factors of 6.

  \[ 2a + 2b = 2(a + b) \]
  Where 2 is the greatest common factor.

  \[ 2x + 5x = x(2 + 5) = 7x \]
  Where x is the greatest common factor.

  \[ 2x^2 + 4x^2y = 2x^2(1 + 2y) \]
  Where \(2x^2\) is the greatest common factor.

  \[ 12x^4 - 6x^3 + 3x^2 = 3x^2(4x^2 - 2x + 1) \]
  Where \(3x^2\) is the greatest common factor.
5.7. Factoring polynomial expressions with the form $ax^2 + bx + c$

When solving equations or simplifying expressions containing trinomials in the form $ax^2 + bx + c$, it is generally beneficial to factor the trinomial.

- Factoring a trinomial in the form $ax^2 + bx + c$ results in two binomials. Factoring a trinomial is the reverse of multiplying two binomials.

- Recall the steps involved in multiplying binomials.

Multiply binomials $(x + 2)(x + 3)$.

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

$$= x^2 + (2+3)x + (2)(3) = x^2 + 5x + 6$$

Multiply binomials $(4x + 2)(5x + 3)$.

$$(4x + 2)(5x + 3)$$

$$= (4x)(5x) + (4x)(3) + (2)(5x) + (2)(3)$$

$$= 20x^2 + 12x + 10x + 6 = 20x^2 + 22x + 6$$
Polynomials

*Compare the factored binomial form with the trinominal form*

- If $m$ and $n$ represent numbers, compare the factored binominal form and the trinominal form of this simple expression:

$$(x + m)(x + n) = x^2 + nx + mx + mn \quad \text{(factored form)}$$

$$= x^2 + (m+n)x + mn \quad \text{(trinominal form)}$$

The coefficient $(m+n)$ is the sum of the numbers in the last terms of each binominal. The trinominal has the form, $ax^2 + bx + c$, where $a = 1$, $b = (m+n)$ and $c = mn$.

- If $p$, $q$, $m$ and $n$ represent numbers, compare the factored binominal form and the trinominal form of this more complicated expression:

$$(px + m)(qx + n) = pqx^2 + pnx + qmx + mn \quad \text{(factored form)}$$

$$= pqx^2 + (pn+qm)x + mn \quad \text{(trinominal form)}$$

The coefficient $(pn+qm)$ results from the sum of the products of the first and last terms of each binominal. The sum of the outer product $(px)(n)$ and the inner product $(m)(qx)$ is $(pn+qm)x$. The trinominal has the form, $ax^2 + bx + c$, where $a = qp$, $b = (qm+pn)$ and $c = mn$. 

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Algebra

- To factor a trinomial:

1. Write the factored format \((\quad)(\quad)\).

2. Find sets of two values that, when multiplied together, equal the first term of the trinomial.

3. Find sets of two values that, when multiplied together, equal the last term of the trinomial.

4. Choose the above sets such that the sum of the outer product and the inner product of the binomial is equal to the second term (the first degree term) of the trinomial. (Remember to be careful of negative signs.)

5. Multiply the resulting binomials to check that the original trinomial is obtained.

- Example: Factor the trinomial \(x^2 + 5x + 6\).

Write the factored format \((\quad)(\quad)\).

Find sets of two values that, when multiplied together, equal the first term of the trinomial.
The only set is: \(x \) and \(x\).
\((x\quad)(x\quad)\)

Find sets of two values that, when multiplied together, equal the last term of the trinomial.
The possible sets are 2 and 3 or 1 and 6
Set 1: \((2)(3)\)
Set 2: \((1)(6)\)
Polynomials

Choose these sets such that the sum of the outer product and the inner product of the binomial is equal to the second term of the trinomial.
The second term of the trinomial is 5x.
Therefore: Outer product + inner product must equal 5x.
Set 1: \(3x + 2x = 5x\)
Set 2: \(6x + -1x = 5x\)

Because there are no negative signs in the original trinomial, Set 2 is eliminated.
Therefore, the Set 1 binomial, \((x + 2)(x + 3)\), must be the factored binomial.

Multiply the chosen binomial set to check that it produces the original trinomial.
\((x + 2)(x + 3) = x^2 + 3x + 2x + 6 = x^2 + 5x + 6\)

Therefore, the factored form of \(x^2 + 5x + 6\) is \((x + 2)(x + 3)\).

- Example: Factor the trinomial \(x^2 + 3x - 18\).

Write the factored format \((\quad)(\quad)\).

Find sets of two values that, when multiplied, equal the first term of the trinomial.
The only set is \(x\) and \(x\).
\((x \quad)(x \quad)\)

Find sets of two values that, when multiplied, equal the last term of the trinomial.
The possible sets are 6 and -3, -6 and 3, 9 and -2, -9 and 2, 18 and -1, -18 and 1.
( + 6)( - 3)  
( - 6)( + 3)  
( + 9)( - 2)  
( - 9)( + 2)  
( + 18)( - 1)  
( - 18)( + 1)  

Choose these sets such that the sum of the outer product and the inner product of the binomial is equal to the second term of the trinomial.
The second term of the trinomial is 3x.
Therefore: Outer product + inner product must equal 3x.

(x + 6)(x - 3) outer product = -3x, inner product = 6x, sum = 3x  
(x - 6)(x + 3) outer product = 3x, inner product = -6x, sum = -3x  
(x + 9)(x - 2) outer product = -2x, inner product = 9x, sum = 7x  
(x - 9)(x + 2) outer product = 2x, inner product = -9x, sum = -7x  
(x + 18)(x - 1) outer product = -1x, inner product = 18x, sum = 17x  
(x - 18)(x + 1) outer product = 1x, inner product = -18x, sum = -17x

The set that has the sum of the outer product and inner product equal to 3x is (x + 6)(x - 3). Therefore this set must be the factored binomial.
Multiply the chosen binomial set to check that it produces the original trinomial.
Polynomials

\[(x + 6)(x - 3) = x^2 - 3x + 6x - 18 = x^2 + 3x - 18\]

Therefore, the factored form of \(x^2 + 3x - 18\) is \((x + 6)(x - 3)\).

- Example: Factor the trinomial \(20x^2 + 22x + 6\).

Write the factored format \((\quad)(\quad)\).

Find sets of two values that, when multiplied, equal the first term of the trinomial. The possible sets are 2x and 10x, 20x and 1x, 5x and 4x.

\[(2x \quad)(10x \quad)\]
\[(20x \quad)(1x \quad)\]
\[(5x \quad)(4x \quad)\]

Find sets of two values that, when multiplied, equal the last term of the trinomial. The possible sets are 2 and 3, 1 and 6.
\[(\quad 2)(\quad 3)\]
\[(\quad 1)(\quad 6)\]

Choose these sets such that the sum of the outer product and the inner product of the binomial is equal to the second term of the trinomial.

The second term of the trinomial is 22x.

Therefore, the sum of the outer product and the inner product must equal 22x. From the above possible sets:

\[(2x \quad)(10x \quad)\]
\[(20x \quad)(1x \quad)\]
\[(5x \quad)(4x \quad)\]
\[(\quad 2)(\quad 3)\]
\[(\quad 1)(\quad 6)\]
Algebra

Make all possible combinations of the inner and outer products.

\[(2x + 2)(10x + 3)\] outer product = 6x, inner product = 20x, sum = 26x  
\[(20x + 2)(1x + 3)\] outer product = 60x, inner product = 2x, sum = 62x  
\[(5x + 2)(4x + 3)\] outer product = 15x, inner product = 8x, sum = 23x  
\[(2x + 1)(10x + 6)\] outer product = 12x, inner product = 10x, sum = 22x  
\[(20x + 1)(1x + 6)\] outer product = 120x, inner product = 1x, sum = 121x  
\[(5x + 1)(4x + 6)\] outer product = 30x, inner product = 4x, sum = 34x

Because there are no negative signs in the original trinomial, negative numbers are not included. The set that has the sum of the outer product and the inner product equal to 22x is \((2x + 1)(10x + 6)\); therefore, this set must be the factored binomial.

Multiply the chosen binomial set to check that it produces the original trinomial.

\[(2x + 1)(10x + 6) = 20x^2 + 12x + 10x + 6 = 20x^2 + 22x + 6\]

Therefore, the factored form of \(20x^2 + 22x + 6\) is \((2x + 1)(10x + 6)\).
Polynomials

Special Binomial Products to Remember

• The difference of two squares, \(x^2 - y^2\), factors to \((x + y)(x - y)\) because the sum of the inner and outer products will always equal zero. For example:

\[
(x + y)(x - y) = x^2 - xy + xy - y^2 = x^2 - y^2
\]

\[
(x + 3)(x - 3) = x^2 - 3x + 3x - 3^2 = x^2 - 3^2 = x^2 - 9
\]

• Example: Factor the difference of two squares \(4x^2 - 25\).

What squared equals \(4x^2\)?

\[
(2x)(2x) = 4x^2
\]

What squared equals \(25\)?

\[
(5)(5) = 25
\]

Therefore, \(4x^2 - 25 = (2x + 5)(2x - 5)\).

Check by multiplying the resulting binomials.

\[
(2x + 5)(2x - 5) = 4x^2 - 10x + 10x - 25
\]

\[
= 4x^2 + (10-10)x - 25 = 4x^2 + 0x - 25 = 4x^2 - 25
\]

• The sum of two squares, \(x^2 + y^2\), cannot be further factored.

• The binomial squared has the following form:

\[
(x + y)^2 = x^2 + 2xy + y^2 \text{ because,}
\]

\[
(x + y)(x + y) = x^2 + xy + xy + y^2 = x^2 + 2xy + y^2
\]

\[
(x - y)^2 = x^2 - 2xy + y^2 \text{ because,}
\]

\[
(x - y)(x - y) = x^2 - xy - xy + y^2 = x^2 - 2xy + y^2
\]

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• Example, factor $x^4 - 81$.

Using the difference of two squares (discussed previously):

$$x^4 - 81 = (x^2 + 9)(x^2 - 9)$$

Also, $(x^2 - 9)$ can be further factored using the difference of two squares:

$$x^2 - 9 = (x + 3)(x - 3)$$

Therefore, the factored form of $x^4 - 81$ is $(x^2 + 9)(x + 3)(x - 3)$.

To check, multiply $(x^2 + 9)(x + 3)(x - 3)$.

First multiply $(x + 3)(x - 3) = x^2 - 3x + 3x - 3^2 = x^2 - 9$

Then multiply $(x^2 + 9)(x^2 - 9) = x^4 - 9x^2 + 9x^2 - 9^2 = x^4 - 81$

Note: Factoring more complicated polynomials in the form $ax^2 + bx + c$ may require first factoring out a common monomial factor or require more than one factoring event.

• Example: Factor $2x^2 + 10x + 12$.

Factor out the common monomial factor, 2.

$$2x^2 + 10x + 12 = 2(x^2 + 5x + 6)$$

Factor the trinomial $(x^2 + 5x + 6)$.

Find sets of two values that, when multiplied, equal the first term of the trinomial.

Find sets of two values that, when multiplied, equal the last term of the trinomial.
Polynomials

Possible binomial sets are (there are no negative signs in the trinomial):
(x + 2)(x + 3)
(x + 6)(x + 1)

Choose the above sets such that the sum of the outer product and the inner product of the binomial is equal to the second term (the first degree term) of the trinomial. (Note that in this case the terms are positive.)
(x + 2)(x + 3) outer product = 3x, inner product = 2x, sum = 5x
(x + 6)(x + 1) outer product = 1x, inner product = 6x, sum = 7x

Because the second term of the trinomial is 5x, choose (x + 2)(x + 3).

Multiplying the monomial factor 2 results in
(2)(x + 2)(x + 3).

Multiply the resulting factors to check that the original trinomial is produced.

\[ (2)(x + 2)(x + 3) = (2)(x^2 + 3x + 2x + 6) \]
\[ = (2)(x^2 + 5x + 6) = 2x^2 + 10x + 12 \]

Therefore, the factored form of \(2x^2 + 10x + 12\) is
(2)(x + 2)(x + 3).