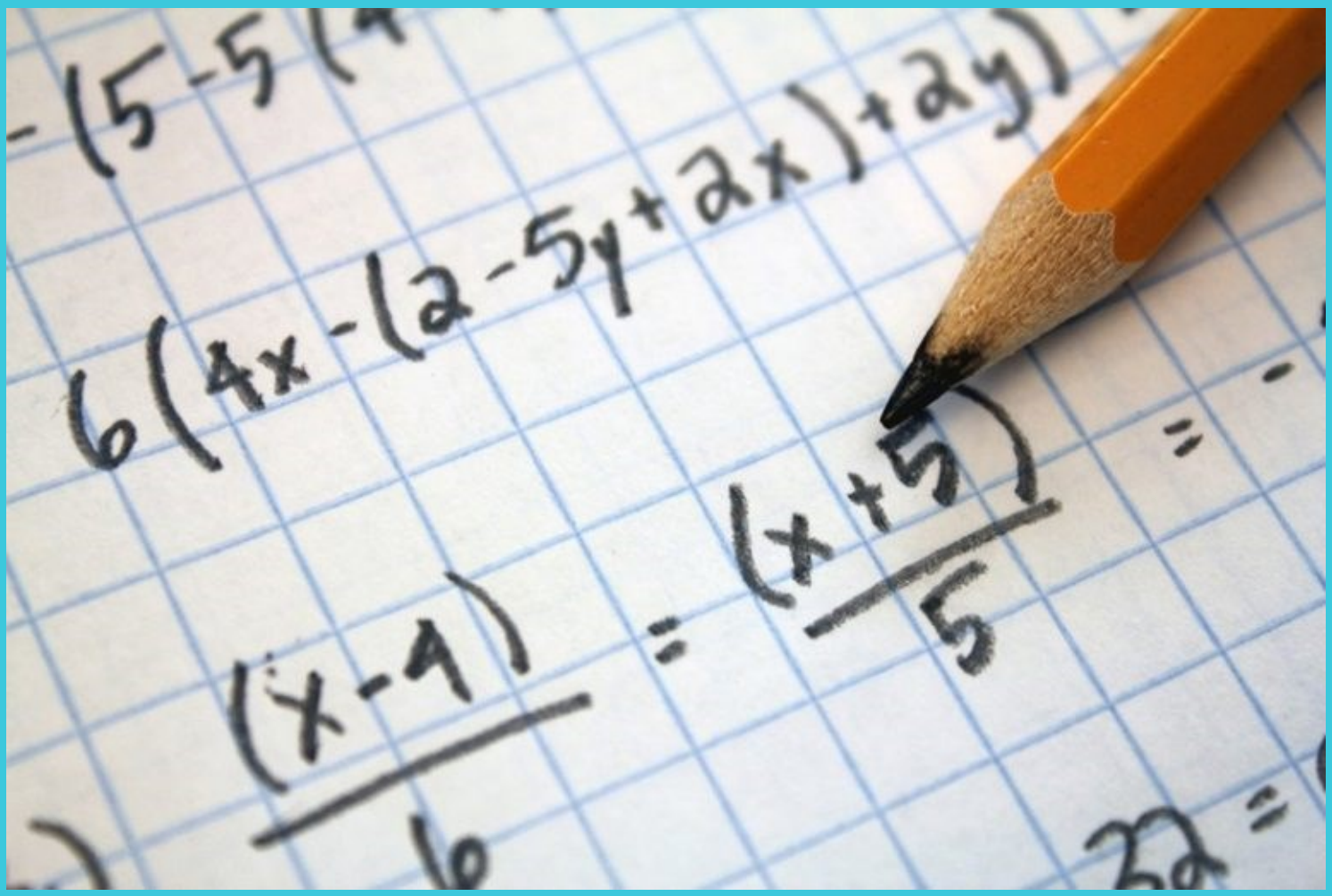

Simplifying and manipulating algebraic expressions

Pupil Name

Handbook Designed by Dr Kugan

Timetable

Timetable – Tutorials

Tutorial	Date	Time	Location
Baseline			
1			
2			
3			
4			
5 (Final Assignment)			
6 (Feedback)			

Timetable – Homework Assignments

Homework Assignment	Description	Due Date
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Tutorial 2		
Tutorial 3		
Tutorial 4		

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Course Rationale

The aim of the course is to thoroughly study the topic of 'simplifying and manipulating algebraic expressions', which forms a part of the GCSE mathematics curriculum. This content will be covered over four tutorials and assessments within each tutorial will test the understanding of this topic and tackle any misconceptions. This course will further prepare the students for exam questions leading to improved examination techniques when presented with challenging questions on this topic.

By the end of this course, each student will be able to:

- Collect like terms in any given algebraic expression,
- Expanding brackets of algebraic expression with a given single or double or both
- Factorise algebraic expressions into single or double brackets or both
- Simplify algebraic fractions into a single fraction—with all four operations

Subject Vocabulary (to be filled in by student)

Word	Definition	In a sentence

Tutorial 1 – Collecting 'Like Terms'

What is the Purpose of Tutorial 1?

- Objective 1: Definition of 'terms' and 'expressions'
- Objective 2: How to collect 'like terms: addition and subtraction
- Objective 3: How to collect 'like terms' : multiplication and division

1. Collecting 'like terms'

Keywords: terms, expressions, variables, unknowns, simplify

Objectives in this tutorial:

- Objective 1: Definition of 'like terms'
- Objective 2: How to collect 'like terms: addition and subtraction
- Objective 3: How to collect 'like terms' : multiplication and division

Starter: What do you notice in the following expression?

$$-4ab + 6ba^2 + 4b^2a - 3ba$$

Can this expression be simplified? Explain your answer.

Objective 1: Definition of 'like terms'

In algebra, a term is considered as either a single number or a variable, or numbers and a variables multiplied together. Such terms are separated by + or – signs.

Worked examples:

A) How many terms in the following expressions?

$$7n + 2 + m$$

1st term 2nd term 3rd term

Answer: 7n is made up of a number (or 'coefficient') multiplied by a variable which makes up 1 term; 2 is a number and also a constant (number, decimal or fraction) which is the 2nd term in the expression and m is the variable and the third term.

B) In the following expression, can you find the 'like terms'

$$2ab^2 - 7c^2 + 3abc - 4ab^2 + 8c^2 - ab$$

'Like terms'

$2ab^2$ and $4ab^2$ – are 'like terms' as these can be 'collected'

$7c^2$ and $8c^2$ – again are 'like terms' as each number is multiplied by c^2 and can be collected

Like Terms	Unlike Terms	Why are they Unlike Terms?
$2x + 19x$	$2x + 19a$	The variables are different.
$4w - 10w$	$4w - 10w^2$	The exponents are different.
$14.2r - 12r$	$12r - 12s$	The variables are different.
$32a^2 + 9a^2$	$32a^2 + 9a^3$	The exponents are different.
$8y + 5y$	$8y + 5$	One term is a constant and the other has a variable.

Practice 1: Definition of 'like terms'

State the number of terms in each of the following expressions:

(i) $2a - p$

(ii) $5 \times z + m \div 2$

(iii) $7z - z/a$

(iv) $p \div m \times q + r$

(v) $5x \div 3 + z + 5$

State whether the following statements are true or false:

State True or False:

(i) 8z has two terms 8 and z.

(ii) Expression 10 + k has two terms 10 and k.

(iii) xy and –yx are like terms.

(iv) a^2b and $-b^2a$ are like terms.

(v) m and –m are like terms.

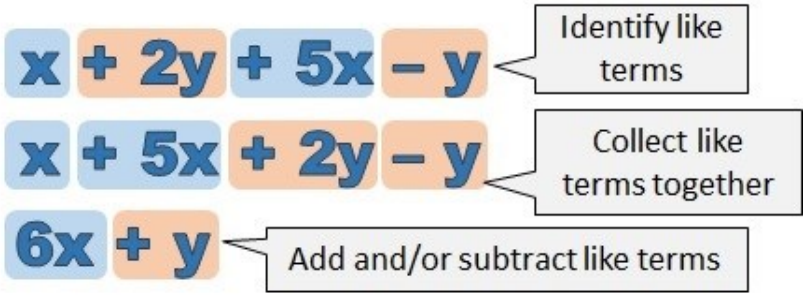
Assessment 1: Definition of 'like terms'

Which statement is **correct**?

A	Expression '$(c - 3m + 5) \div 2$' has 4 terms
B	Expression '$a \times b \times y \times z \div 11$ ' has two terms
C	–ba and 5ab are unlike terms.
D	$7b^2a$ and $-2ab^2$ are like terms.

Objective 2: How to collect 'like terms': addition and subtraction

Worked Example 1



Worked Example 2

Simplify the expression: **4w + 3 + 2w - 1**

$4w + 3 + 2w - 1$ (Now Group Like Terms)

$= \underbrace{4w + 2w} + \underbrace{3 - 1}$ (Combine Like Terms)

$= 6w + 2$

$= 6w + 2$ ✓

<u>Three Quick Steps:</u>

Step 1: Identify 'like terms' and group them on one side

Step 2: Collect/combine 'like terms'

Step 3: Write your answer in simplified version and check each term is different

Practice 2: How to collect 'like terms:' addition and subtraction

<u>Task 1:</u> State how many terms there are in each expression

<u>Task 2:</u> Simplify each expression by collecting like terms

A) $1z - 6t + 3z + 8t$

B) $17k + 12f - 6k - f$

C) $13h + 6d - 9d - 7h$

D) $12x^2 + 5x^2 + 4x$

E) $3c^2 + 5c - 5c^2$

F) $22jm + 3j + 3jm - j$

G) $15ac - 12c - 13ac$

H) $16x^2 + 13xy - 4x^2 - xy$

I) $17x^3 + 12x^2 - 3x^3 + 7x^2$

J) $15h^3 - 8h^2 - 17h^3 + 7h^2$

K) $34m^4 + 18u^2 - 3m^4 + 8$

Assessment 2: How to collect 'like terms': addition and subtraction

Which is correct?

The expression $7g^2h - 11h - 16hg^2 + 4gh$ can be simplified to:

A	$-9gh^2 + 4gh - 11h$	B	$9gh^2 + 4gh - 11h$	C	$-9g^2h + 4gh - 11h$	D	$-9g^2h + 4gh + 11h$

Objective 3: How to collect 'like terms': multiplication and division

Worked examples for multiplying

Simplify the following

A) $a \times a \times a = a^3$

B) $2a \times 4b$

$= 2 \times 4 \times a \times b$

STUDY TIP

$a + a + a = 3a$

Worked example for dividing

Simplify the following

A) $10a \div 2a$

$= 10 \div 2 = 5$ (as 'a' can be cancelled from the numerator and denominator)

B) $25b \div 5$

$= 5b$ (in this case 'b' can not be cancelled as it is not divided by the same term including 'b')

Worked example for multiplying and dividing expression

Simplify the following

A) $a^2 \times a^2 \div b$

$= a^{2+2} = a^4$ (as a rule of indices = for multiplying using indices ADD the powers with the **same** base,

for dividing SUBTRACT the powers with the **same** base

exponent

$= a^4 \div b$ → you can write this in a fraction for- $\frac{a^4}{b}$ mat as

base

(TIP: Always remember to write in alphabetical order 'ab' (a x b) rather than 'ba' (b x a)- although both

Practice 3: How to collect 'like terms': multiplication and division

Work out

A) $5z \times y$

B) $-6a^3b \div 3ab^2c$

C) $3pq^3 \times 4qr \times 4qr$

D) $8a^3k^4 \div 4dk^3 \div 2$

E) $12pq^3 \times 4q^2r \div 3pq^2$

Assessment 3: How to collect 'like terms': multiplication and division

Which is **correct**?

The expression $8xy^3 \times 4x^2 \div 2x^{-2}$ can be simplified to:

A	$16xy^3$	B	$4xy^3$	C	$16x^5y^3$	D	$4y^3x^0$

Plenary:

In your own words, what are the <u>three steps</u> to collect 'like terms' and give an example for each operation.

Tutorial 2– Expanding Algebraic Expressions

$3(x + 1)$	$7(x + y)$	$3(3x + 3)$	$5(x + 8)$	$8(2 + y)$
$x(x + 3)$	$12(x + 3)$	$4(9 + x)$	$7(4 + y)$	$17(2 + x)$
$2x(x + 2)$	$2y(x + y)$	$2(1 - x)$	$z(z + 5)$	$18(x + 1 - y)$
$9(2x + 4)$	$2x(x + 5)$	$3(1 - 2x)$	$8(8x + 5)$	$2(x + 7)$
$4y(y + 1)$	$x(x + 9)$	$4(3x + 4)$	$9(x)$	$12(x - 3)$

What is the Purpose of Tutorial 2?

- Objective 1: Expanding brackets using single brackets
- Objective 2: Expanding brackets using double brackets

2. Expanding Algebraic Expressions

Keywords: terms, expressions, variables, unknowns, simplify

Objectives in this tutorial:

- Objective 1: Expanding brackets using single brackets
- Objective 2: Expanding brackets using double brackets

Starter: What do you notice in the following expression?

$(4y \times 5y) - 2y(2y \times 4)$

How can this expression be simplified? Explain your answer.

Objective 1: Expanding brackets using single brackets

Worked example 1:

$$-3(x - 6)$$
$$= -3 \times x \boxed{+} -3 \times -6$$
$$= -3x + 18$$

Steps

- First, multiply −3 with x
- Then, multiply −3 with −6

TIP: Pay attention to the signs, there is an addition sign in the middle (orange box), however this could change if negative integers are involved

Worked example 2:

$$-5x(2x + 6y)$$
$$= -5x \times 2x + -5x \times 6y$$
$$= -10x^2 \boxed{+} -30xy$$
$$= -10x^2 - 30xy$$

Steps

- Multiply −5x with each term in the bracket

TIP: Pay attention to the signs, there is an addition sign in the middle (orange box), however this could change if negative integers are involved

Worked example 3:

$$5(x + 3) + 6(x - 4)$$
$$5x + 15 \boxed{+} 6x - 24$$
$$11x - 9$$

Steps

- Multiply the term in front of the bracket with each term inside the bracket,
- Simplify expression (by collecting 'like terms'

TIP: Pay attention to the signs, there is an addition sign in the middle (orange box), however this could change if negative integers are involved

Practice 1: Expanding brackets using single brackets

Complete the following by expanding out the brackets:

(i) $8(r + 4)$

(ii) $-7(t - 3)$

(iii) $4c(3c + 8d)$

(iv) $5(b + 8) - 3(3b + a)$

(v) $11(p + 3) - 10(p - 2)$

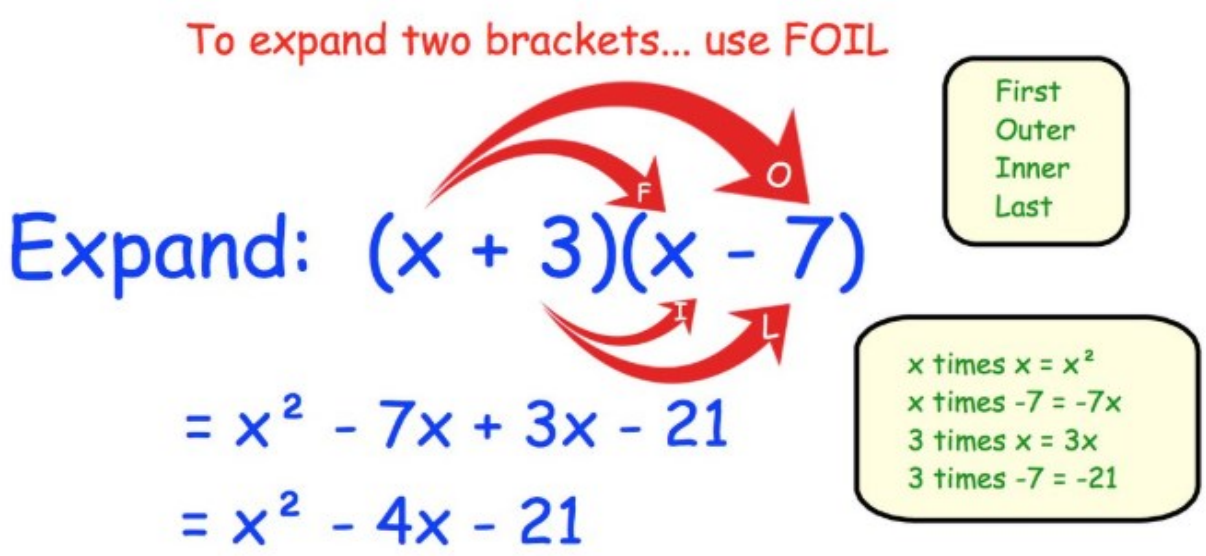
Assessment 1: Expanding brackets using single brackets

Which statement is **correct**?

A	$3(a + 4) + 4(a + 2) = 7a + 20$
B	$3(a + 4) = 3a + 12$
C	$5(a - 2) - 3(3a + 1) = 8a - 7$
D	$a(a + 8) = a^2 + 8$

Objective 2: Expanding brackets using double brackets

Worked example 1:



Worked example 2:

$$(5x+2)^2$$

$$(5x+2)(5x+2)$$

$$25x^2 + 10x + 10x + 4$$

$$25x^2 + 20x + 4$$

Steps

- Write out in full
- Use FOIL
- Simplify expression by collecting 'like terms'

Worked example 3:

$$\text{Eg. } (3n-4)^2$$

$$(3n-4)(3n-4)$$

$$9n^2 - 12n - 12n + 16$$

$$9n^2 - 24n + 16$$

Steps

- Write out in full
- Use FOIL
- Simplify expression by collecting 'like terms'
- Check the signs
- Remember:

  Negative × negative = positive

Practice 2: Expanding brackets using double brackets

Complete the following by expanding out the brackets:

1) $(a + 8)(a + 7)$

2) $(b + 12)(b + 4)$

3) $(c + 7)(c - 3)$

4) $(2d + 5)(d + 1)$

5) $(3e + 11)(4e - 11)$

6) $(3f - 7)(5f - 7)$

7) $(g + 8)^2$

8) $(3h - 12)^2$

9) $(x + 2)(2x^2 - x - 1)$

Assessment 2: Expanding brackets using double brackets

Which statement is **correct**?

A	$(x - 7)(x - 10) = x^2 - 17x - 70$
B	$(3m + 7)(2m - 5) = 6m^2 + 29m - 35$
C	$(n + 4)(n + 7) = n^2 + 11n + 28$
D	$3(3x - 2)(3x + 2) = 27x^2 + 18x - 4$

Plenary:

TASK A:

Expand these brackets then simplify your answer.

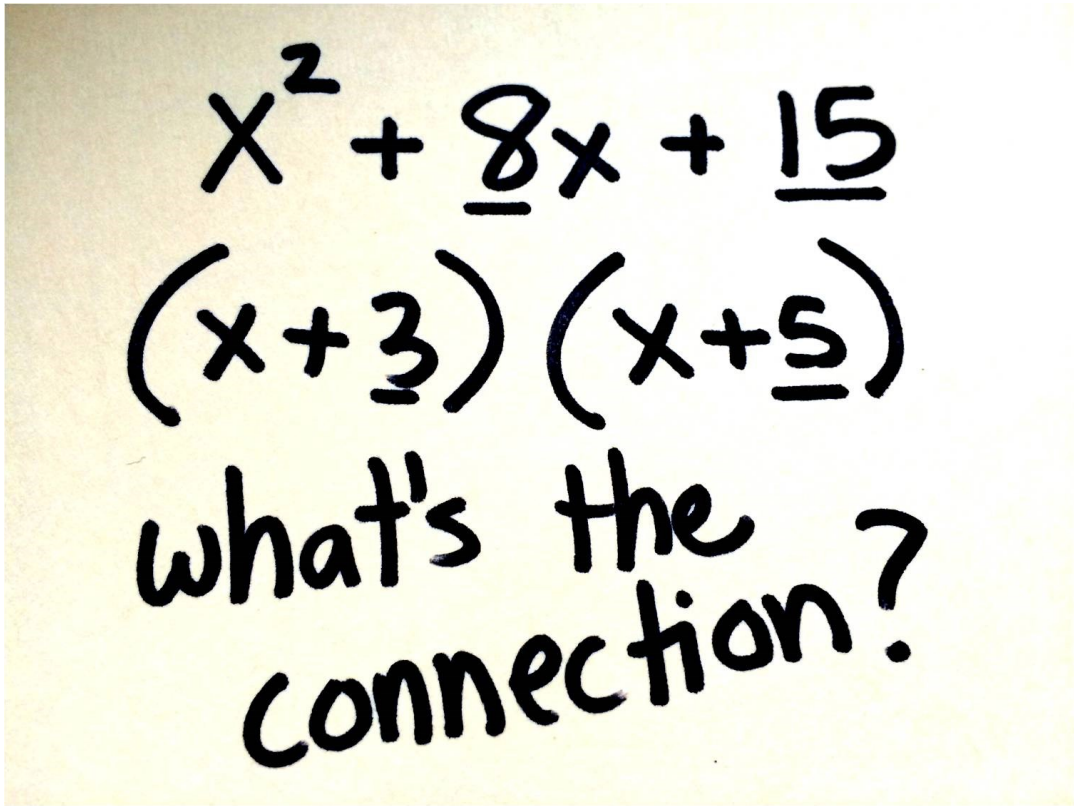
(a) $6(a+2)+3(a+3)$ **(b)** $11(b-2)+3(b+6)$

(c) $3(b+4)+6(b-3)$ **(d)** $6(c+3)+5(c+12)$

TASK B: Summarise the steps to expand single brackets. Give an example.

Which method do you use when multiplying out two brackets? Can you apply this when multiplying more than 2 brackets? If you use another method, share it.

Tutorial 3 – Factorisation of Algebraic Expressions



What is the Purpose of Tutorial 3?

- Objective 1: Factorising into single bracket expressions
- Objective 2: Factorising into double brackets expressions (quadratic)

3. Factorisation of Algebraic Expressions

Keywords: terms, expressions, variables, unknowns, simplify

Objectives in this tutorial:

- Objective 1: Factorising into single bracket expressions
- Objective 2: Factorising into double brackets expressions (quadratic)

Starter:

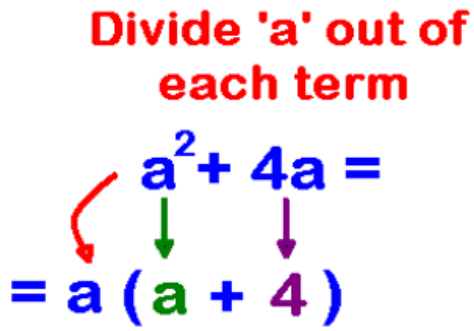
What does 'factorise' mean in algebra? What is the opposite of factorising?

What do you need to know to be able to factorise?

Discuss.

Objective 1: Factorising into single bracket expressions

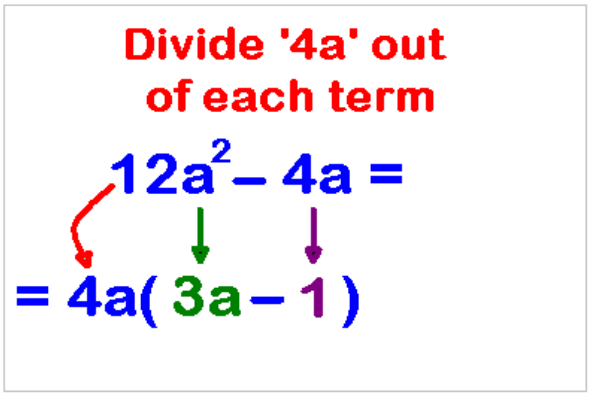
Worked example 1:



Steps

- Find the highest common factor (HCF) for the terms in the expression and place this in front of the brackets, i.e. 'a'
- In this case it is 'a', as 'a' is present within both terms

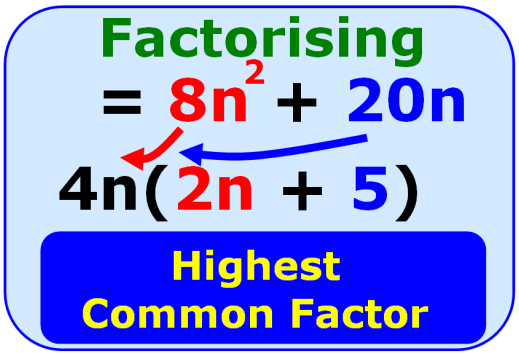
Worked example 2:



Steps

- Find the highest common factor for both terms in the expression and place this in front of the brackets i.e. '4a'
- In this case it is '4a', as '4a' is the highest factor which can be divided into each term in the expression
- Be careful on the signs

Worked example 3



Tip: To check that you have factorised properly, you could multiply out the brackets to check whether you obtain the original answer

BUT keep exam time in mind and go back if you have time to check your answers

Practice 1: Factorising into single brackets expressions

Complete the following by factorising each expression:

a) $3x + 3$

b) $4p - 8$

c) $6h + 9$

d) $16y + 28$

e) $4x + 2y + 10z$

f) $6p^2 + 9p$

g) $18m - 12m^2$

h) $5ab + 15a$

i) $6ab + 3bc$

j) $12ab - 8ac$

k) $4(x + 6) + 2(3x - 2)$

l) $2(2x + 9) - 4(3 + 2x)$

USE THIS SPACE TO SHOW WORKING OUT

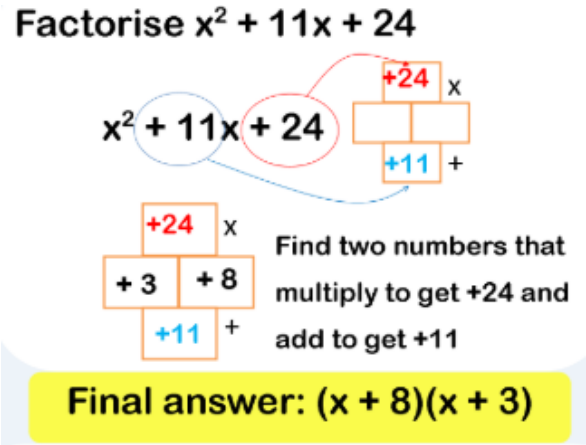
Assessment 1: Factorising into single brackets expressions

Which statement is **false**?

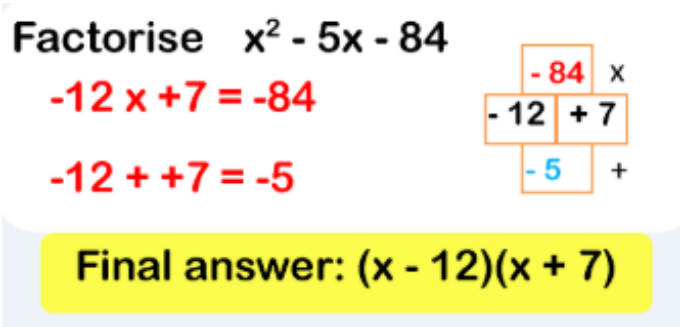
A	$x^2 + x = x(x + 1)$
B	$(3m + 7)(2m - 5) = 6m^2 + 29m - 35$
C	$x^2 + y^2 = (x + y)^2$
D	$2(x-1) = 2x - 2$

Objective 2: Factorising into double bracket expressions

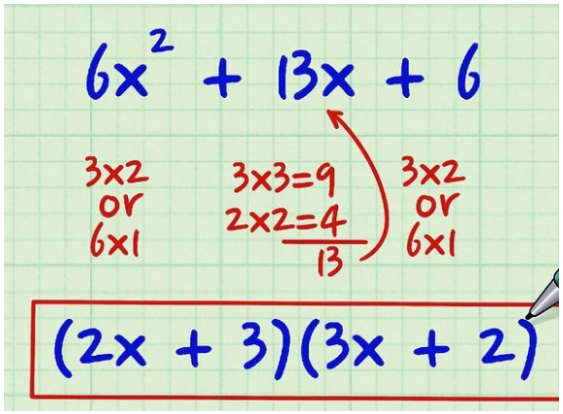
Worked example 1:



Worked example 2:



Worked example 3:

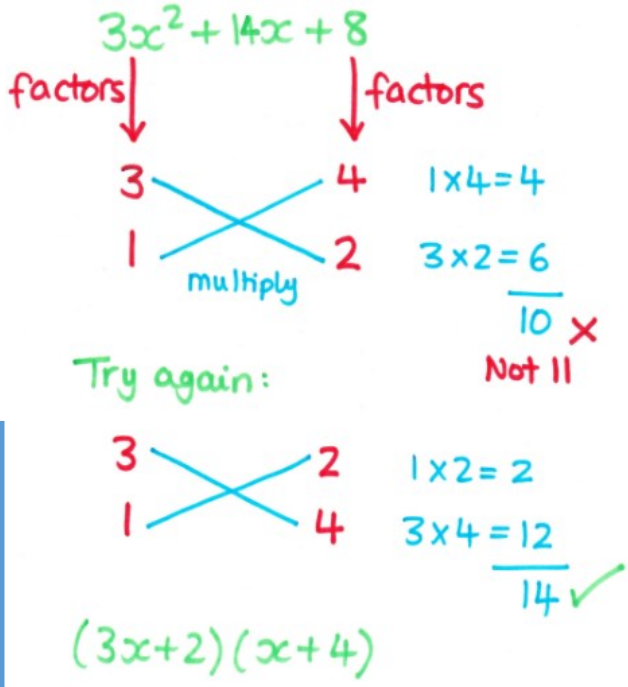


TIP: If the quadratic is in the form $x^2 - a^2$ then its factorised form is $(x - a)(x + a)$.

This is called the 'difference of TWO squares–

E.g. $(x-2)(x + 2) = x^2 + 2^2 = x^2 + 4$

Worked example 4:



Practice 2: Factorising into double brackets expressions

Complete the following by factorising each expression:

1) $x^2 + 2x - 8$

2) $3x^2 - x - 10$

3) $a^2 - 2ab + b^2$

4) $a^2 - b^2$

5) $(a - b)^2$

6) $(a + b)^2$

Assessment 2: Factorising into double brackets expressions

Factorise this quadratic: $x^2 + 13x + 12$. Show your working out and choose the correct answer below:

A	$(x + 2)(x + 6)$
B	$2(x + 6)(x - 2)$
C	$(x + 1)(x + 13)$
D	$(x + 12)(x + 1)$

Plenary:

Answer questions from 1 to 5.

1. For factorising into a single bracket expression, which 3-letter word is key? Explain.

2. What is the factorised form for the quadratic expression: $x^2 - a^2$

3. What is the method for factorising a quadratic expression. Give an example and explain on the white-board to the rest of the group.

4. Now you can factorise quadratic expression, can you apply this knowledge for cubic expression with an example? See the tip below

Difference of Cubes

$$a^3 - b^3 = (a - b)(a^2 + ab + b^2)$$

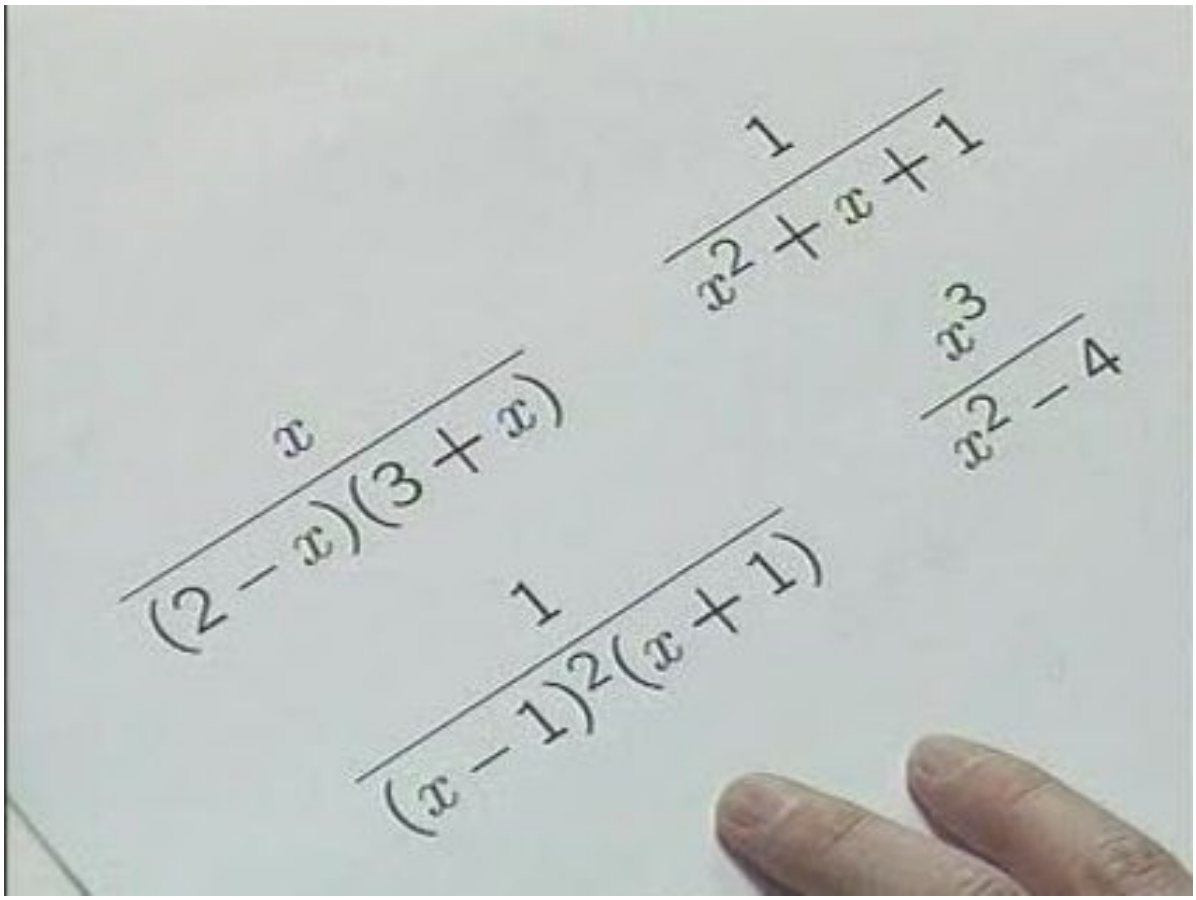
Sum of Cubes

$$a^3 + b^3 = (a + b)(a^2 - ab + b^2)$$

5. If you are solving for x, how many possible answers can we expect for

- Linear expression
- Quadratic expression
- Cubic expression

Tutorial 4 – Simplifying Algebraic Fractions



What is the Purpose of Tutorial 4?

- Objective 1: Simplifying algebraic fractions by expressing as a single fraction (addition and subtraction)
- Objective 2: Simplifying algebraic fractions by expressing as a single fraction (multiplication and division)

4. Simplifying Algebraic Fractions

Keywords: fractions, mixed fraction, improper fraction

Objectives in this tutorial:

- Objective 1: Simplifying algebraic fractions by expressing as a single fraction (addition and subtraction)
- Objective 2: Simplifying algebraic fractions by expressing as a single fraction (multiplication and division)

Starter:

When adding fractions, what is the 3-letter word that is important here. Explain why.

Recall all operations using fractions and give an example for each.

Objective 1: Simplifying algebraic fractions by expressing as a single fraction (addition and subtraction)

Worked example 1:

Simplify $\frac{2x}{9}+\frac{5x}{6}$

Solution:

$$\frac{2x}{9}+\frac{5x}{6} \quad \text{\{Lowest common denominator of 9 and 6 is 18\}}$$

$$=\frac{2\times 2x}{18}+\frac{3\times 5x}{18} \quad \text{\{Express denominators in LCD form\}}$$

$$=\frac{4x}{18}+\frac{15x}{18} \quad \text{\{Simplify the numerators\}}$$

$$=\frac{4x+15x}{18} \quad \text{\{Add the numerators\}}$$

$$=\frac{19x}{18}$$

Worked example 2:

Simplify $\frac{4x+3}{12}-\frac{2x+5}{8}$

Tips:

- Be careful of a **−ve sign** before a bracket.
- Factorise the final answer to discover whether any common factor exists which may be cancelled.
- Always reduce the final answer to its lowest terms.

Solution:

$$\frac{4x+3}{12}-\frac{2x+5}{8} \quad \text{\{Lowest common denominator of 12 and 8 is 24\}}$$

$$=\frac{2(4x+3)}{24}-\frac{3(2x+5)}{24} \quad \text{\{Express denominators in LCD form\}}$$

$$=\frac{8x+6-6x-15}{24} \quad \text{\{Simplify the numerators\}}$$

$$=\frac{2x-9}{24}$$

Worked example 3:

Simplify $\dfrac{9}{3x^2-3y^2}+\dfrac{x}{xy-x^2}$

Warning: Do not **reduce** through an addition or subtraction sign as shown here.

$$\frac{x+1}{x+2} \neq \frac{\cancel{x}+1}{\cancel{x}+2} \neq \frac{1}{2}$$

or

$$\frac{x+6}{6} \neq \frac{x+\cancel{6}}{\cancel{6}} \neq x$$

Solution:

$$\frac{9}{3x^2-3y^2}+\frac{x}{xy-x^2}$$ {Factorise the numerator and denominator}

$$=\frac{9}{3(x^2-y^2)}+\frac{x}{x(y-x)}$$ {Simplify fractions}

$$=\frac{3}{(x-y)(x+y)}+\frac{1}{y-x}$$ {Rewrite $y-x$ as $-(x-y)$}

$$=\frac{3}{(x-y)(x+y)}-\frac{1}{x-y}$$ {LCM $=(x-y)(x+y)$}

$$=\frac{3-1(x+y)}{(x-y)(x+y)}$$ {Subtract the numerators}

$$=\frac{3-x-y}{(x-y)(x+y)}$$

Practice 1: Simplifying algebraic fractions by expressing as a single fraction (addition and subtraction)

Simplify the following by expressing as a single fraction:

Simplify:

a. $\dfrac{3a}{4}-\dfrac{5a}{6}$

b. $\dfrac{7x}{8}-3x$

c. $\dfrac{7}{a^2}-\dfrac{8}{a}$

d. $\dfrac{2x+5}{14}-\dfrac{3x-4}{21}$

e. $\dfrac{3x+3}{8}-\dfrac{x-1}{4}$

f. $\dfrac{5}{a+b}-\dfrac{4}{a-b}$

Simplify $\dfrac{4}{x-y}+\dfrac{3}{y-x}$.

Simplify $\dfrac{6}{3x+3y}-\dfrac{x}{x^2-xy}$

Assessment 1: Simplifying algebraic fractions by expressing as a single fraction (addition and subtraction)

Factorise this quadratic expression and choose the following correct answer:

$$\frac{x+2}{3x} + \frac{x-3^1}{6x}$$

A	3x + 1/6x
B	x−1/2x
C	(x−1)/2x
D	(3x+1)/6x

Objective 2: Simplifying algebraic fractions by expressing as a single fraction (multiplication and division)

Worked example 1:

Multiplying first. Just as with multiplying ordinary fractions, you multiply the tops (numerators) together, then multiply the bottoms (denominators) together.

Example: $\frac{5}{7x} \times \frac{4}{3y}$

The answer is: $\frac{20}{21xy}$

Worked example 2:

Sometimes the multiplication can be made easier by cancelling.

Example: $\frac{x+2}{x+5} \times \frac{3x+15}{2x}$

This looks like it will take a while! Can you do any cancelling before you start multiplying, to make it quicker?

Yes! $\boxed{3x + 15 \text{ is } 3(x + 5)}$, so you can cancel:

Leave as factorised as possible!

$$\frac{x+2}{\cancel{x+5}} \times \frac{\cancel{3x+15}^{\,3}}{2x} = \frac{x+2}{1} \times \frac{3}{2x} = \frac{3(x+2)}{2x}$$

Worked example 3:

Now look at dividing algebraic fractions.

Example: $\frac{x}{x+1} \div \frac{7}{x}$

As with ordinary fractions you use a trick to divide. Turn the fraction on the right upside down and multiply instead:

$$\frac{x}{x+1} \times \frac{x}{7}$$

Then proceed as before. The answer is: $\frac{x^2}{7x+7}$

Worked example 4:

Example: $\frac{x^2-9}{x+4} \div \frac{x^2+2x-15}{7x+28}$

Again find the reciprocal of the fraction on the right and multiply. Can you do any cancelling before the multiplying?

$$\frac{x^2-9}{x+4} \times \frac{7x+28}{x^2+2x-15}$$ Yes!

$$\frac{(x+3)(x-3)}{x+4} \times \frac{7(x+4)}{(x-3)(x+5)} = \frac{(x+3)}{1} \times \frac{7}{(x+5)}$$

$$= \frac{7(x+3)}{x+5}$$

Practice 2: Simplifying algebraic fractions by expressing as a single fraction (multiplication and division)

Simplify the following algebraic fractions:

$\frac{2x}{3} \bullet \frac{y}{5}$ $\frac{x^2}{3y} \bullet \frac{2y}{3x}$ $\frac{x^2-4}{6} \bullet \frac{3y}{2x+4}$ $\frac{3x^2}{5} \div \frac{2x}{y} =$ $\frac{4x-8}{6} \div \frac{x-2}{3}$

USE THIS SPACE TO SHOW WORKING OUT

Assessment 2: Simplifying algebraic fractions by expressing as a single fraction (multiplication and division)

Simplify the following expression and choose the following correct answer:

$$\frac{10x}{x^2+3x} \div \frac{15x}{x^2-x-12}$$

A	$\frac{2x-4}{3x}$
B	$\frac{2(x-4)}{3x}$
C	$\frac{x-2}{3x}$
D	$\frac{2x-8}{3x}$

Plenary:

Answer questions from 1 to 3.

1. Why is HCF **not** used to add and/or subtract algebraic fractions?
2. Can you simplify through an addition or subtraction sign—give an example and explain.
3. How do you divide two algebraic fractions? Give an example.

Tutorial 5 – Feedback tutorial

What is the Purpose of Tutorial 5?

- To receive feedback on final assignments.
- To share examples of best practice with the other pupils in your group.
- To write targets for improvement in school lessons.

To reflect on the programme including what was enjoyed and what was challenging.

Final assignment feedback

What I did well…	What I could have improved on…

My target for future work is…

Reflecting on Uni Pathways

What did you most enjoy about Uni Pathways?

What did you find challenging about the programme?	How did you overcome these challenges?

Notes

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