

**Introduction to**

**A-Level Maths**

**Bridging Unit**

“What is infinity + infinity?

…To infinity and beyond!”



**SUMMER 2021**

**Elizabeth Woodville School**

**A-Level Mathematics**

**INTRODUCTION TO A LEVEL MATHS AT EWS**

Thank you for considering studying Mathematics in the sixth form at EWS. In A2 Mathematics you will sit three exams: Paper 1 – Core/Pure, Paper 2 – Core/Pure/Mechanics and Paper 3 – Core/Pure/Statistics. All exams have an equal weighing and are 2 hours in duration. These exams will take place at the end of the course, summer 2023.

The Mathematics Faculty is committed to ensuring that you make good progress throughout your A2 course. In order that you make the best possible start to the course, we have prepared this booklet of key algebra topics that you will need to be confident with prior to starting A-Level.

It is vitally important that you spend some time working through the questions in this booklet over the summer - you will need to have a good knowledge of these topics before you commence your course in September. You should have met all the topics before at GCSE. Work through the introduction to each chapter, making sure that you understand the examples. Then tackle the exercise – not necessarily every question, but enough to ensure you understand the topic thoroughly. The answers are given at the back of the booklet. At the end of each section, there are some extra ideas you may wish to investigate further! Extra reward points will be given in September for any of these that are completed.

We will test you during the second week of the course starting to check how well you know the topics. You will be expected to gain 90% of the marks, so it is important that you have looked at all the booklet before then. If you do not pass this test, you will be given one re-test, failure to pass a second time will result in a conversation regarding your suitability to continue with A-level Maths. A mock test is provided at the back of this booklet.

From September, students will be expected to prepare themselves with research ***prior*** to lessons in order for them to access subject content.

We hope that you will use this introduction to give you a good start to you’re A level work and that it will help you enjoy and benefit from the course more.

NB: The Maths faculty highly recommend the Casio fx-991EX (‘Classwiz’) calculator. Available at around £25, this is a sensible option for A-level Maths.

Many thanks and good luck,

**Miss H. Gilligan & Ms S. Christopher**

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# Chapter 1: REMOVING BRACKETS

To remove a single bracket, we multiply every term in the bracket by the number or the expression on the outside:

**Examples**

1) 3 (*x* + 2*y*) = 3*x* + 6*y*

2) -2(2*x* - 3) = (-2)(2*x*) + (-2)(-3)

= -4*x* + 6

To expand two brackets, we must multiply everything in the first bracket by everything in the second bracket. We can do this in a variety of ways, including

\* the smiley face method

\* FOIL (Fronts Outers Inners Lasts)

\* using a grid.

**Examples**:

1) (*x* + 1)(*x* + 2) = *x*(*x* + 2) + 1(*x* + 2)

or

(*x* +1)(*x* + 2) = *x*2 + 2 + 2*x* + *x*  = *x*2 + 3*x* +2

or

|  |  |  |
| --- | --- | --- |
|  | *x* | 1  (*x* +1)(*x* + 2) = *x*2 + 2*x* + *x* + 2 = *x*2 + 3*x* +2 |
| *x* | *x*2 | *x* |
| 2 | 2*x* | 2 |

2) (*x* - 2)(2*x* + 3) = *x*(2*x* + 3) - 2(2*x* +3) = 2*x*2 + 3*x* – 4*x* - 6

= 2*x*2 – *x* – 6

or

(*x* - 2)(2*x* + 3) = 2*x*2 – 6 + 3*x* – 4*x* = 2*x*2 – *x* – 6

or

(2*x* +3)(*x* - 2) = 2*x*2 + 3*x* - 4*x* - 6 = 2*x*2 - *x* - 6

|  |  |  |
| --- | --- | --- |
|  | *x* | -2 |
| 2*x* | 2*x*2 | -4*x* |
| 3 | 3*x* | -6 |

**EXERCISE A** Multiply out the following brackets and simplify.

1. 7(4*x* + 5)
2. -3(5*x* - 7)
3. 5*a* – 4(3*a* - 1)
4. 4*y* + *y*(2 + 3*y*)
5. -3*x* – (*x* + 4)
6. 5(2*x* - 1) – (3*x* - 4)
7. (*x* + 2)(*x* + 3)
8. (*t* - 5)(*t* - 2)
9. (2*x* + 3*y*)(3*x* – 4*y*)
10. 4(*x* - 2)(*x* + 3)
11. (2*y* - 1)(2*y* + 1)
12. (3 + 5*x*)(4 – *x*)

**Two Special Cases**

**Perfect Square: Difference of two squares:**

(*x* + *a*)2  = (*x + a*)(*x + a*)= *x*2 + 2*ax* + *a*2 (*x - a*)(*x + a*) = *x*2 – *a*2

(2*x* - 3)2  = (2*x* – 3)(2*x* – 3) = 4*x*2 – 12*x* + 9 (*x* - 3)(*x* + 3) = *x*2 – 32

= *x*2 – 9

**EXERCISE B** Multiply out

1. (*x* - 1)2

2. (3*x* + 5)2

3. (7*x* - 2)2

4. (*x* + 2)(*x* - 2)

5. (3*x* + 1)(3*x* - 1)

6. (5*y* - 3)(5*y* + 3)

# 

# [Read](https://meiassets.blob.core.windows.net/amsp-uploads/uploads/files/Mind-Trick.pdf) minds with maths! Have a go at this number trick and then not only impress friends and family but discover how it is done and create your own tricks.

[Read](https://nrich.maths.org/6485) more about how algebra was developed thousands of years ago and how visualisations were used even then!

[Read](https://mathigon.org/course/sequences/pascals-triangle) more about Pascal’s triangle, interact with it and find out more about it’s heritage and who really discovered it first!

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# [Discover](https://meiassets.blob.core.windows.net/amsp-uploads/uploads/files/GCSE-Problem-Solving-Problem-19.pdf) and use algebra to prove why something is true. There is a [solution](https://meiassets.blob.core.windows.net/amsp-uploads/uploads/files/GCSE-Problem-Solving-Problem-19-Solution.pdf) if you need it.

[Discover](https://nrich.maths.org/5961) the history of negative numbers and how they were thought of as making dark of mathematics!

[Discover](https://nrich.maths.org/762/) more expansions linking to geometrical representations. You’ll find a [hint](https://nrich.maths.org/762/clue) and a potential [solution](https://nrich.maths.org/762/solution) from other students to help you too.

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# [Watch](https://www.youtube.com/watch?v=w-I6XTVZXww) more mathematical hocus pocus in this video - you will be astounded! The result you’ll discover is used in many areas of physics, including string theory, so it’s not hocus pocus after all!

# [Watch](https://www.youtube.com/watch?v=ZMkIiFs35HQ) this video to find how there are actually patterns in prime numbers and how simple algebra can show this – with brackets of course!

# [Watch](https://www.youtube.com/watch?v=0iMtlus-afo) this video and encounter the almost endless amount of number patterns contained within Pascal’s triangle.Chapter 2: LINEAR EQUATIONS

When solving an equation, you must remember that whatever you do to one side must also be done to the other. You are therefore allowed to

* add the same amount to both side
* subtract the same amount from each side
* multiply the whole of each side by the same amount
* divide the whole of each side by the same amount.

If the equation has unknowns on both sides, you should collect all the letters onto the same side of the equation.

If the equation contains brackets, you should start by expanding the brackets.

A linear equation is an equation that contains numbers and terms in *x*. A linear equation does not contain any  terms.

**Example 1**: Solve the equation 64 – 3*x* = 25

**Solution**: There are various ways to solve this equation. One approach is as follows:

Step 1: Add 3*x* to both sides (so that the *x* term is positive): 64 = 3*x* + 25

Step 2: Subtract 25 from both sides: 39 = 3*x*

Step 3: Divide both sides by 3: 13 = *x*

So the solution is *x* = 13.

**Example 2**: Solve the equation 6*x* + 7 = 5 – 2*x*.

**Solution:**

Step 1: Begin by adding 2*x* to both sides 8*x* + 7 = 5

(to ensure that the *x* terms are together on the same side)

Step 2: Subtract 7 from each side: 8*x* = -2

Step 3: Divide each side by 8: *x* = -¼

**Exercise A**: Solve the following equations, showing each step in your working:

1) 2*x* + 5 = 19 2) 5*x* – 2 = 13 3) 11 – 4*x* = 5

4) 5 – 7*x* = -9 5) 11 + 3*x* = 8 – 2*x* 6) 7*x* + 2 = 4*x* – 5

**Example 3**: Solve the equation 2(3*x* – 2) = 20 – 3(*x* + 2)

Step 1: Multiply out the brackets: 6*x* – 4 = 20 – 3*x* – 6

(taking care of the negative signs)

Step 2: Simplify the right hand side: 6*x* – 4 = 14 – 3*x*

Step 3: Add 3x to each side: 9*x* – 4 = 14

Step 4: Add 4: 9*x* = 18

Step 5: Divide by 9: *x* = 2

**Exercise B:** Solve the following equations.

1) 5(2*x* – 4) = 4 2) 4(2 – *x*) = 3(*x* – 9)

3) 8 – (*x* + 3) = 4 4) 14 – 3(2*x* + 3) = 2

**EQUATIONS CONTAINING FRACTIONS**

When an equation contains a fraction, the first step is usually to multiply through by the denominator of the fraction. This ensures that there are no fractions in the equation.

**Example 4**: Solve the equation 

**Solution**:

Step 1: Multiply through by 2 (the denominator in the fraction): 

Step 2: Subtract 10: *y* = 12

**Example 5**: Solve the equation 

**Solution**:

Step 1: Multiply by 3 (to remove the fraction) 

Step 2: Subtract 1 from each side 2*x* = 14

Step 3: Divide by 2 *x* = 7

When an equation contains two fractions, you need to multiply by the lowest common denominator.

This will then remove both fractions.

**Example 6**: Solve the equation 

**Solution**:

Step 1: Find the lowest common denominator: The smallest number that both 4 and 5 divide into is 20.

Step 2: Multiply both sides by the lowest common denominator 

Step 3: Simplify the left hand side: 

5(*x* + 1) + 4(*x* + 2) = 40

Step 4: Multiply out the brackets: 5*x* + 5 + 4*x* + 8 = 40

Step 5: Simplify the equation: 9*x* + 13 = 40

Step 6: Subtract 13 9*x* = 27

Step 7: Divide by 9: *x* = 3

**Example 7**: Solve the equation 

**Solution**: The lowest number that 4 and 6 go into is 12. So we multiply every term by 12:



Simplify 

Expand brackets 

Simplify 

Subtract 10*x* 

Add 6 5*x* = 24

Divide by 5 *x* = 4.8

**Exercise C**: Solve these equations

1)  2) 

3)  4) 

**Exercise C (continued)**

5)  6) 

7)  8) 

**Forming equations**

**Example 8**: Find three consecutive numbers so that their sum is 96.

**Solution**: Let the first number be *n*, then the second is *n* + 1 and the third is *n* + 2.

Therefore *n* + (*n* + 1) + (*n* + 2) = 96

3*n* + 3 = 96

3*n* = 93

*n* = 31

So the numbers are 31, 32 and 33.

**Exercise D:**

1) Find 3 consecutive even numbers so that their sum is 108.

2) The perimeter of a rectangle is 79 cm. One side is three times the length of the other. Form an equation and hence find the length of each side.

3) Two girls have 72 photographs of celebrities between them. One gives 11 to the other and finds that she now has half the number her friend has.

Form an equation, letting *n* be the number of photographs one girl had at the **beginning**.

Hence find how many each has **now**.

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# [Read](https://www.mathscareers.org.uk/linear-equations/) how solving linear equations is an important part of many jobs – including those involving computer graphics, economics and genetics.



# [Discover](https://www.youtube.com/watch?v=xtRhnB0kNLw) the type of maths that is used when making blockbuster movies and how to do it.



[Watch](https://www.youtube.com/watch?v=ILWbaWrjgU4) this animated history of operational research about its origins in the first and second world wars - when maths was used not only to improve operations but to save lives!

# Chapter 3: SIMULTANEOUS EQUATIONS

An example of a pair of simultaneous equations is 3*x* + 2*y* = 8 ➀

5*x* + *y* = 11 ➁

In these equations, *x* and *y* stand for two numbers. We can solve these equations in order to find the values of *x* and *y* by eliminating one of the letters from the equations.

In these equations it is simplest to eliminate *y*. We do this by making the coefficients of *y* the same in both equations. This can be achieved by multiplying equation ➁ by 2, so that both equations contain 2*y*:

3*x* + 2*y* = 8 ➀

10*x* + 2*y* = 22 2×➁ = ➂

To eliminate the *y* terms, we subtract equation ➂ from equation ➀. We get: 7*x* = 14

i.e. *x* = 2

To find y, we substitute *x* = 2 into one of the original equations. For example if we put it into ➁:

10 + *y* = 11

*y* = 1

Therefore the solution is *x* = 2, *y* = 1.

**Remember**: You can check your solutions by substituting both x and y into the original equations.

**Example**: Solve 2*x* + 5*y* = 16 ➀

3*x* – 4*y* = 1 ➁

**Solution**: We begin by getting the same number of *x* or *y* appearing in both equation. We can get 20*y* in both equations if we multiply the top equation by 4 and the bottom equation by 5:

8*x* + 20*y* = 64 ➂

15*x* – 20*y* = 5 ➃

As the signs in front of 20*y* are different, we can eliminate the *y* terms from the equations by ADDING:

23*x* = 69 ➂+➃

i.e. *x* = 3

Substituting this into equation ➀ gives:

6 + 5*y* = 16

5*y* = 10

So… *y* = 2

The solution is *x* = 3, *y* = 2.

**Exercise**:

Solve the pairs of simultaneous equations in the following questions:

1) *x* + 2*y* = 7 2) *x* + 3*y* = 0

3*x* + 2*y* = 9 3*x* + 2*y* = -7

3) 3*x* – 2*y* = 4 4) 9*x* – 2*y* = 25

2*x* + 3*y* = -6 4*x* – 5*y* = 7

5) 4*a* + 3*b* = 22 6) 3*p* + 3*q* = 15

5*a* – 4*b* = 43 2*p* + 5*q* = 14

# 

# Below are some problems which involve the use of simultaneous equations that you may like to try:

# [Rudolff’s Problem](https://nrich.maths.org/278)

* [Matchless](https://nrich.maths.org/5674)
* [Training Schedule](https://nrich.maths.org/7366) (use spreadsheet for this one!)

# Chapter 4: FACTORISING

**Common factors**

We can factorise some expressions by taking out a common factor.

**Example 1**: Factorise 12*x* – 30

**Solution**: 6 is a common factor to both 12 and 30. We can therefore factorise by taking 6 outside a bracket:

12*x* – 30 = 6(2*x* – 5)

**Example 2**: Factorise 6*x*2 – 2*xy*

**Solution**: 2 is a common factor to both 6 and 2. Both terms also contain an *x*.

So we factorise by taking 2*x* outside a bracket.

6*x*2 – 2*xy* = 2*x*(3*x* – *y*)

**Example 3**: Factorise 9*x*3*y*2 – 18*x*2*y*

**Solution**: 9 is a common factor to both 9 and 18.

The highest power of *x* that is present in both expressions is *x*2.

There is also a *y* present in both parts.

So we factorise by taking 9*x*2*y* outside a bracket:

9*x*3*y*2 – 18*x*2*y* = 9*x*2*y*(*xy* – 2)

**Example 4**: Factorise 3*x*(2*x* – 1) – 4(2*x* – 1)

**Solution**: There is a common bracket as a factor.

So we factorise by taking (2*x* – 1) out as a factor.

The expression factorises to (2*x* – 1)(3*x* – 4)

**Exercise A**

Factorise each of the following

1) 3*x* + *xy*

2) 4*x*2 – 2*xy*

3) *pq*2 – *p*2*q*

4) 3*pq* - 9*q*2

5) 2*x*3 – 6*x*2

6) 8*a*5*b*2 – 12*a*3*b*4

7) 5*y*(*y* – 1) + 3(*y* – 1)

**Factorising quadratics**

**Simple quadratics: Factorising quadratics of the form **

The method is:

Step 1: Form two brackets (*x* … )(*x* … )

Step 2: Find two numbers that multiply to give *c* and add to make *b*. These two numbers get written at the other end of the brackets.

**Example 1**: Factorise *x*2 – 9*x* – 10.

**Solution**: We need to find two numbers that multiply to make -10 and add to make -9. These numbers are -10 and 1.

Therefore *x*2 – 9*x* – 10 = (*x* – 10)(*x* + 1).

**General quadratics: Factorising quadratics of the form **

The method is:

Step 1: Find two numbers that multiply together to make *ac* and add to make *b*.

Step 2: Split up the *bx* term using the numbers found in step 1.

Step 3: Factorise the front and back pair of expressions as fully as possible.

Step 4: There should be a common bracket. Take this out as a common factor.

**Example 2**: Factorise 6*x*2 + *x* – 12.

**Solution**: We need to find two numbers that multiply to make 6 × -12 = -72 and add to make 1. These two numbers are -8 and 9.

Therefore, 6*x*2 + *x* – 12 = 6*x*2 - 8*x* + 9*x* – 12

= 2*x*(3*x* – 4) + 3(3*x* – 4) (the two brackets must be identical)

= (3*x* – 4)(2*x* + 3)

**Difference of two squares: Factorising quadratics of the form **

Remember that  = (*x + a*)(*x – a*).

Therefore: 



Also notice that: 

and 

**Factorising by pairing**

We can factorise expressions like  using the method of factorising by pairing:

 = *x*(2*x* + *y*) – 1(2*x* + *y*) (factorise front and back pairs, ensuring both brackets are identical)

= (2*x* + *y*)(*x* – 1)

**Exercise B**

Factorise

1) 

2) 

3) 

4)  (factorise by taking out a common factor)

5) 

6) 

7) 

8) 

9) 

10) 

11) 

12) 

13) 

14) 

# 

# [Read](https://mathigon.org/course/divisibility/distribution-of-primes) about the amazing properties of prime numbers. Generate large primes for yourself and find out how you can make money from solving prime number problems.

# [Explore](https://mathigon.org/timeline) the history of mathematics with this interactive historical timeline -in particular look for at Al-Khwarizmi.



# [Discover](https://nrich.maths.org/2049) how you can use place value and factorising to explore number tricks by attempting this nrich problem.

# [Discover](https://nrich.maths.org/2286) how you can use factorising quadratics and apply it to higher powers by this neat trick shown in this nrich task.



# [Watch](https://www.youtube.com/watch?v=xH2xlihr7q0&list=PLf_vCuiTnETpNb36p_sUUIxSYGFqZC4iN&index=44) this video by James Grime. See if you can work out why the trick works.

[Watch](https://www.youtube.com/watch?v=LkIK8f4yvOU#action=share) how you can apply difference of two squares to a fun numerical problem.

# Chapter 5: CHANGING THE SUBJECT OF A FORMULA

We can use algebra to change the subject of a formula. Rearranging a formula is similar to solving an equation – we must do the same to both sides in order to keep the equation balanced.

**Example 1**: Make *x* the subject of the formula *y* = 4*x* + 3.

**Solution**: *y* = 4*x* + 3

Subtract 3 from both sides: *y* – 3 = 4*x*

Divide both sides by 4; 

So  is the same equation but with *x* the subject.

**Example 2**: Make *x* the subject of *y* = 2 – 5*x*

**Solution**: Notice that in this formula the *x* term is negative.

*y* = 2 – 5*x*

Add 5*x* to both sides *y* + 5*x* = 2 (the *x* term is now positive)

Subtract *y* from both sides 5*x* = 2 – *y*

Divide both sides by 5 

**Example 3**: The formula  is used to convert between ° Fahrenheit and ° Celsius.

We can rearrange to make *F* the subject.



Multiply by 9  (this removes the fraction)

Expand the brackets 

Add 160 to both sides 

Divide both sides by 5 

Therefore the required rearrangement is .

**Exercise A**

Make *x* the subject of each of these formulae:

1) *y* = 7*x* – 1 2) 

3)  4) 

**Rearranging equations involving squares and square roots**

**Example 4**: Make *x* the subject of 

**Solution**: 

Subtract  from both sides:  (this isolates the term involving *x*)

Square root both sides: 

Remember that you can have a positive or a negative square root. We cannot simplify the answer any more.

**Example 5**: Make *a* the subject of the formula 

**Solution**: 

Multiply by 4 

Square both sides 

Multiply by *h*: 

Divide by 5: 

**Exercise B:**

Make *t* the subject of each of the following

1)  2) 

3)  4) 

5)  6) 

**More difficult examples**

Sometimes the variable that we wish to make the subject occurs in more than one place in the formula. In these questions, we collect the terms involving this variable on one side of the equation, and we put the other terms on the opposite side.

**Example 6**: Make *t* the subject of the formula 

**Solution**: 

Start by collecting all the t terms on the right hand side:

Add *xt* to both sides: 

Now put the terms without a *t* on the left hand side:

Subtract *b* from both sides: 

Factorise the RHS: 

Divide by (*y + x*): 

So the required equation is 

**Example 7**: Make *W* the subject of the formula 

**Solution**: This formula is complicated by the fractional term. We begin by removing the fraction:

Multiply by 2*b*: 

Add 2*bW* to both sides:  (this collects the W’s together)

Factorise the RHS: 

Divide both sides by *a* + 2*b*: 

**Exercise C**

Make *x* the subject of these formulae:

1)  2) 

3)  4) 

# 

# [Read](https://www.mathscareers.org.uk/10-reasons-for-studying-algebra/) – Ten key reasons why developing algebraic skills is so important!

[Read](https://plus.maths.org/content/101-uses-quadratic-equation) about how the rearrangement of algebraic expressions can be used in many real life contexts including proving the quadratic formulae!



# [Discover](https://www.geogebra.org/m/A49Ug8ed) more about the graphs of a function and its inverse by exploring this GeoGebra activity

[Discover](https://nrich.maths.org/6843&part=) how trigonometry was developed to become the study of algebraic ratios from numeric beginnings by comparing the merkhet (not comparing the meerkat!)



[Watch](https://www.youtube.com/watch?v=AAGCdLS2VEI) and learn how maths, in particular the correct use of brackets, influences music, poetry and even rap!

[Play](https://meiassets.blob.core.windows.net/amsp-uploads/uploads/files/Helices.pdf) with Lego, visit Paris and do maths all at the same time? It is possible through Helices!

# Chapter 6: SOLVING QUADRATIC EQUATIONS

A quadratic equation has the form .

There are two methods that are commonly used for solving quadratic equations:

\* factorising

\* the quadratic formula

Note that not all quadratic equations can be solved by factorising. The quadratic formula can always be used however.

**Method 1: Factorising**

Make sure that the equation is rearranged so that the right hand side is 0. It usually makes it easier if the coefficient of *x*2 is positive.

**Example 1** : Solve *x*2 –3*x* + 2 = 0

Factorise (*x* –1)(*x* – 2) = 0

Either (*x* – 1) = 0 or (*x* – 2) = 0

So the solutions are *x* = 1 or *x* = 2

Note: The individual values *x* = 1 and *x* = 2 are called the **roots** of the equation.

**Example 2**: Solve *x*2 – 2*x* = 0

Factorise: *x*(*x* – 2) = 0

Either *x* = 0 or (*x* – 2) = 0

So  *x* = 0 or *x* = 2

**Method 2: Using the formula**

Recall that the roots of the quadratic equation  are given by the formula:



**Example 3**: Solve the equation 

**Solution**: First we rearrange so that the right hand side is 0. We get 

We can then tell that *a* = 2, *b* = 3 and *c* = -12.

Substituting these into the quadratic formula gives:

 (this is the *surd form* for the solutions)

If we have a calculator, we can evaluate these roots to get: *x* = 1.81 or *x* = -3.31

**EXERCISE**

1) Use factorisation to solve the following equations:

a) *x*2 + 3*x* + 2 = 0 b) *x*2 – 3*x* – 4 = 0

c) *x*2  = 15 – 2*x*

2) Find the roots of the following equations:

a) *x*2 + 3*x* = 0 b) *x*2 – 4*x* = 0

c) 4 *– x*2 = 0

3) Solve the following equations either by factorising or by using the formula:

a) 6*x*2  - 5*x* – 4 = 0 b) 8*x*2 – 24*x* + 10 = 0

4) Use the formula to solve the following equations to 3 significant figures. Some of the equations can’t be solved.

a) *x*2 +7*x* +9 = 0 b) 6 + 3*x* = 8*x*2

c) 4*x*2 – *x* – 7 = 0 d) *x*2 – 3*x* + 18 = 0

e) 3*x*2 + 4*x* + 4 = 0 f) 3*x*2 = 13*x* – 16



[Read](https://plus.maths.org/content/101-uses-quadratic-equation) about the history of Quadratic equations and how there are 101 uses for them!



[Discover](https://mathigon.org/course/circles/conic-sections) what is meant by a conic section and what on earth quadratics have to do with them.



[Watch](https://www.bbc.co.uk/programmes/p058y4cy) this video if you have ever been told that there are no solutions to a particular quadratic equation – because there are! They are not real though - welcome to imaginary maths! You can try a question for yourself [here.](https://meiassets.blob.core.windows.net/amsp-uploads/uploads/files/NA8__2_.pdf)**Chapter 7: INDICES**

**Basic rules of indices**

. 4 is called the **index** (plural: indices), **power** or **exponent** of *y*.

There are 3 basic rules of indices:

1)  e.g. 

2)  e.g. 

3)  e.g. 

**Further examples**



 (multiply the numbers and multiply the *a*’s)

 (multiply the numbers and multiply the *c*’s)

 (divide the numbers and divide the *d* terms i.e. by subtracting the powers)

**Exercise A**

Simplify the following:

1)  = (Remember that )

2)  =

3)  =

4) =

5)  =

6)  =

7)  =

8)  =

**More complex powers**

**Zero index:**

Recall from GCSE that

.

This result is true for any non-zero number *a*.

Therefore 

**Negative powers**

A power of -1 corresponds to the reciprocal of a number, i.e. 

Therefore 



 (you find the reciprocal of a fraction by swapping the top and bottom over)

This result can be extended to more general negative powers: .

This means:







**Fractional powers:**

Fractional powers correspond to roots: 

In general:



Therefore:

  

A more general fractional power can be dealt with in the following way: 

So 





**Exercise B:**

Find the value of:

1) 

2) 

3) 

4) 

5) 

6) 

7) 

8) 

9) 

10) 

11) 

12) 

Simplify each of the following:

13) 

14) 

15) 



[Read](https://mathigon.org/applications) how maths is used in different careers. For indices and exponential growth check out Population Dynamics, Epidemics Analysis and [Carbon Dating](https://mathigon.org/course/exponentials/carbon-dating) in particular.



[Discover](https://www.youtube.com/watch?v=5JCm5FY-dEY&t=4s) the power of indices! Here you will see how they could be used to knock down very tall buildings!!



[Watch](https://www.youtube.com/watch?v=y8acoaakvPM) this Numberphile video and learn how to impress friends and family by finding the fifth root of a number in the blink of an eye.**Practice Booklet Test**

This is the test that Year 12 mathematicians sat last September. Your test will ask similar questions to this one.

**You may NOT use a calculator**

If *ax*2 + *bx* + *c* = 0 then *x* **= **

1. Expand and simplify

(a) (2*x* + 3)(2*x* – 1) (b) (*a* + 3)2 (c) 4*x*(3*x* – 2) – *x*(2*x* + 5)

2. Factorise

(a) *x*2 – 7*x* (b) *y*2 – 64 (c) 2*x*2 + 5*x* – 3 (d) 6*t*2 – 13*t* + 5

3. Simplify

(a)  (b) + 

4. Solve the following equations

(a) +  = 4 (b) *x*2 – 8*x* = 0 (c) *p*2 + 4*p* = 12

5. Write each of the following as single powers of *x* and / y

(a)  (b) (*x*2*y*)3 (c) 

6. Work out the values of the following, giving your answers as fractions

(a) 4-2 (b) 100 (c) 

7. Solve the simultaneous equations 3*x* – 5y = -11

5*x* – 2y = 7

8. Rearrange the following equations to make *x* the subject

(a) *v*2 = u2 + 2a*x* (b) V = π*x*2h (c) y = 

9. Solve 5*x*2 – *x* – 1 = 0 giving your solutions in surd form

**SOLUTIONS TO THE EXERCISES**

**CHAPTER 1:**

Ex A

1) 28*x* + 35 2) -15*x* + 21 3) -7*a* + 4 4) 6*y* + 3*y*2 5) 2*x* – 4

6) 7*x* – 1 7) *x*2 + 5x + 6 8) *t*2 – 7*t* + 10 9) 6*x*2 + *xy* – 12*y*2

10) 4*x*2 + 4*x* – 24 11) 4*y*2 – 1 12) 12 + 17*x* – 5*x*2

Ex B

1) *x*2 – 2*x* + 1 2) 9*x*2 + 30*x* + 25 3) 49*x*2 – 28*x* + 4 4) *x*2 – 4

5) 9*x*2 -1 6) 25*y*2 – 9

**CHAPTER 2**

Ex A

1) 7 2) 3 3) 1½ 4) 2 5) -3/5 6) -7/3

Ex B

1) 2.4 2) 5 3) 1 4) ½

Ex C

1) 7 2) 15 3) 24/7 4) 35/3 5) 3 6) 2 7) 9/5 8) 5

Ex D

1) 34, 36, 38 2) 9.875, 29.625 3) 24, 48

**CHAPTER 3**

1) *x* = 1, *y* = 3 2) *x* = -3, *y* = 1 3) *x* = 0, *y* = -2 4) *x* = 3, *y* = 1

5) *a* = 7, *b* = -2 6) *p* = 11/3, *q* = 4/3

**CHAPTER 4**

Ex A

1)  *x*(3 + *y*) 2) 2*x*(2*x* – *y*) 3) *pq*(*q* – *p*) 4) 3*q*(*p* – 3*q*) 5) 2*x*2(*x* - 3) 6) 4*a*3*b*2(2*a*2 – 3*b*2)

7) (*y* – 1)(5*y* + 3)

Ex B

1) (*x* – 3)(*x* + 2) 2) (*x* + 8)(*x* – 2) 3) (2*x* + 1)(*x* + 2) 4) *x*(2*x* – 3) 5) (3*x* -1 )(*x* + 2)

6) (2*y* + 3)(*y* + 7) 7) (7*y* – 3)(*y* – 1) 8) 5(2*x* – 3)(*x* + 2) 9) (2*x* + 5)(2*x* – 5) 10) (*x* – 3)(*x* – *y*)

11) 4(*x* – 2)(*x* – 1) 12) (4*m* – 9*n*)(4*m* + 9*n*) 13) *y*(2*y* – 3*a*)(2*y* + 3*a*) 14) 2(4*x* + 5)(*x* – 4)

**CHAPTER 5**

Ex A

1)  2)  3)  4) 

Ex B

1)  2)  3)  4)  5)  6) 

Ex C

1)  2)  3)  4) 

**CHAPTER 6**

1) a) -1, -2 b) -1, 4 c) -5, 3 2) a) 0, -3 b) 0, 4 c) 2, -2

3) a) -1/2, 4/3 b) 0.5, 2.5 4) a) -5.30, -1.70 b) 1.07, -0.699 c) -1.20, 1.45

d) no solutions e) no solutions f) no solutions

**CHAPTER 7**

Ex A

1) 5*b*6 2) 6*c7* 3) *b*3*c*4 4) -12*n*8 5) 4*n*5 6) *d*2 7) *a*6 8) -*d*12

Ex B

1) 2 2) 3 3) 1/3 4) 1/25 5) 1 6) 1/7 7) 9 8) 9/4 9) ¼ 10) 0.2 11) 4/9 12) 64

13) 6*a*3  14)  *x* 15) *xy*2

**SOLUTIONS TO PRACTICE BOOKLET TEST**

1) a) 4*x*2 + 4*x* – 3 b) *a*2 + 6*a* + 9 c) 10*x*2 -13*x*

2) a) *x*(*x* – 7) b) (*y* + 8)(*y* – 8) c) (2*x* - 1)(*x* + 3) d) (3*t* - 5)(2*t* – 1)

3) a)  b) 

4) a) h = 5 b) *x* = 0 or *x* = 8 c) p = -6 or p = 2

5) a) *x-*4 b) *x*6*y*3 c) *x*7

6) a)  b) 1 c) 

7) *x* = 3, *y* = 4

8) a)  b)  c) 

9) 