Pre-requisite mathematics knowledge for the Level 2 Entry Engineering Maths Summer School

As preparation for the Level 2 entry Maths Summer School (MSS) participants should revise and familiarise themselves with the following topics which will have appeared in their earlier mathematics learning. While many of these topics may be revisited during the first week of the Summer School, some level of familiarity will be assumed since these topics are first encountered much earlier in mathematics education.

This list is broken into two halves, the first half covers materials from the Engineering Maths 1 & 2 units, and are specific for students applying for Year 2 direct entry. The second half covers typical mathematics topics that appear across all of engineering.

Links have been provided to online resources to aid you with any topics of which you may like to refresh your knowledge. For the later general materials you will find many other resources online, for the specific Year 2 direct entry materials more tailored links are provided to assist you. The links are found in the footnotes and are accessible via the numbered superscripts in the main text.

Year 2 Entry Engineering pre-requisites

Exponentials and logarithms

- Definition of logarithms¹
- Definition of exponentials²
- Appreciate the relationship between exponentials and logarithms³
- Use the three logarithm laws⁴
- Sketch and identify basic logarithm and exponential graphs⁵

Vectors in 2D & $3D^6$

- Definition of a vector
- Work with vectors in 2D and 3D including the topics of:
 - magnitude⁷
 - scalar product⁸
 - angles between vectors
- Convert from Cartesian [Rectangular] form to Polar form and vice versa⁹
- 1 Logarithms
- ²The exponential constant e
- 3 Taking logs
- ⁴The logarithm laws
- ⁵Graphs of logs and exponentials
- ⁶Introduction to vectors
- 7 Forces as vectors 8 The scalar product
- ⁹Polar coordinates

Complex numbers

- Basic algebra of complex numbers, like addition, subtraction, multiplication and division¹⁰
- Conversion between Cartesian (rectangular) format and polar format¹¹¹²
- Perform mutliplication and division of complex numbers in polar format¹³
- Represent complex numbers on an Argand diagram¹⁴

Differentiation ¹⁵

- Differentiation of standard functions, like ax^n , $\sin(ax+b)$, $\ln(ax+b)$ and e^{ax+b}
- Use the chain rule for differentiation
- Use differentiation to find stationary/turning points of functions
- Calculate second derivatives to classify stationary/turning points¹⁶
- Use differentiation in real-world problems to determine rates of change, or optimize a variable.

Integration

- Appreciation of integration as anti-differentiation¹⁷
- Integrate standard functions¹⁸, like ax^n , sin(ax + b), $\frac{a}{ax+b}$ and e^{ax+b}
- Calculate definite integrals with given limits¹⁹
- Appreciate usage of integration to find areas under graphs, to solve real-world problems²⁰

General engineering maths pre-requisites

Numerical skills

- Calculating percentages²¹
- Reversing percentage calculations, e.g. calculating original quantities after percentage reductions
- Orders of operations: i.e. BODMAS or BIDMAS or PEDMAS (depending on when you learnt it)

Algebra skills

- Working with brackets
 - Expanding brackets²², e.g. $(x+1)(ax^2+bx+c)$
 - Factorising into brackets, spotting common factors
- Using algebraic formulae, like Pythagoras' theorem
- Simplifying by grouping 'like' terms

- ¹⁸Integration using a table of anti-derivatives
- 19 Calculating definite integrals 20 Finding areas with integration
- ²¹Percentages at Mathcentre

¹⁰Complex number algebra

¹¹Polar format for complex numbers

¹²also see topic inside Vectors

 $^{^{13}\}mathrm{Multiplication}$ and division of complex numbers in polar format

¹⁴Argand diagrams

 $^{^{15}}$ Differentiation (many topics)

¹⁶Maxima and minima

¹⁷Integration as anti-differentiation

 $^{^{22}\}mathrm{Expanding}$ brackets – Grid Method or Expanding brackets - Traditional method

Fractions

- Reducing fractions to lowest forms²³
- Multiplication, division, addition and subtraction of fractions
- Relationship between fractions and negative powers (see Powers)

Linear equations

- Identifying linear equations
- Re-arranging to make a variable the subject
- Solving linear equations

More general equations

- Rules for re-arranging equations: changing sides, dividing through, squaring and square-rooting
- Substitution methods
- Making a variable the subject
- Simultaneous linear equations²⁴
 - Formulating simultaneous equations from text questions
 - Solving simultaneous equations

Powers

- Simplifying powers and rationalising denominators of fractions²⁵
- The standard power laws
 - Multiplication and division using positive, negative and fractional indices
 - Expanding brackets with powers, e.g. $(ab)^n = a^n b^n$
 - Powers of powers, e.g. $(a^m)^n = a^{mn}$
 - Fractional powers as roots, $a^{m/n} = \sqrt[n]{a^m}$

Simple graphs

- Equations of straight lines²⁶
- Graphs of quadratics²⁷
- Recognising maxima and minima of graphs

Quadratics

- Working with quadratics
 - Completing the square
 - Factorising quadratics
 - Using the 'quadratic formula'
 - Identifying graphs of quadratics (see also Simple graphs)

 $^{26}\mathrm{Straight}$ line equations

²³Reducing fractions

 $^{^{24}}Simultaneous$ linear equations (all methods) and Simultaneous linear equations - elimination method $^{25}Rationalise$ fractions with surds - see Section 5

 $^{^{27}\}ensuremath{\mathrm{Quadratic}}$ sketching - Khan Academy - one method (see other nearby videos too)

Trigonometry²⁸

- Basic graphs of sine and cosine
 - Amplitude
 - Translations vertically and horizontally
- The $\sin^2(x) + \cos^2(x) = 1$ identity
- The tan(x) = sin(x)/cos(x) identity
 Using sine, cosine and tangent in right-angled triangles, i.e. SOH-CAH-TOA

Trigonometric equations & hyperbolics functions

- Solve problems of the form $A\sin(mx+a) = b$ and similar
- The reciprocal trignometric functions (cosec, sec, cot)²⁹
- Working with the compound angle formulae³⁰, e.g. $\sin(A+B)$
- Using trigonometric identities³¹, like $\cos(2A) = 2\cos^2(A) 1$
- (Nice to know, but optional) Hyperbolic functions³²:
 - Evaluate sinh, cosh and tanh functions
 - Use hyperbolic identities

Links to revision resources

If you would like to look up some revision notes on any of the above topics then you should find a very wide range of resources, especially videos online. For the latter general engineering mathematics there are many very high quality resources.

Furthermore, since many of these topics will be revisited in the first week of the Maths Summer School (MSS) you will find a lot of the topics have at least summary notes available here, in the MSS Week 1 algebra notes. This is the default advice for initial revision.

Some topics above do not explicitly appear in the Week 1 notes, for those you will find some useful links provided via the superscripts/footnotes embedded in this document.

As a final bonus, here are a few of the most popular websites which specifically offer maths learning resources (though YouTube is also excellent):

- https://www.mathcentre.ac.uk/students/topics (UK academic consortium outputs)
- http://www.mathtutor.ac.uk (UK academic consortium outputs)
- https://www.khanacademy.org/math (in-house developed materials)
- https://www.examsolutions.net/maths (links to mostly YouTube videos)

²⁸Trigonometry topics

²⁹Reciprocal trigonometric functions (in 5 lessons)

³⁰Addition formulae

³¹Double angle formula (you don't need the tan formulae)

³²Hyperbolic functions and identities