Mathematics

Unit Reference Number	L/618/6106
Unit Title	Mathematics
Unit Level	3
Number of Credits	10
Total Qualification Time (TQT)	100
Guided Learning Hours (GLH)	40
Mandatory / Optional	Mandatory
Sector Subject Area (SSA)	14.1 Foundations for learning and life
Unit Grading Structure	Pass / Fail

Unit Aims

This unit will develop learners' knowledge and understanding of the mathematical techniques commonly used to solve a range of engineering problems. Learners will be able to use mathematical formulas to solve practical problems commonly found within engineering studies.

Learning Outcomes, Assessment Criteria and Indicative Content

Learning Outcomes – The learner will:	Assessment Criteria – The learner can:	Indicative contents
1. Understand the application of algebra relevant to engineering problems.	1.1 Demonstrate application of algebra i.e. • binomial expansion • factorisation • using the principle of the lowest common multiple (LCM) 1.2 Simplify and solve algebraic equations. 1.3 Demonstrate how to solve linear simultaneous equations with two unknowns using graphical interpretation and algebraic method: elimination method, substitution method. 1.4 Demonstrate how to solve quadratic equations i.e.	• Learners should understand the rules of algebra to simplify and solve mathematical problems for example: • algebraic division • the remainder and factor theorems • $(x+3)(x+2)=x^2+5x+6$ • $(a+b)^4=a^4+4a^3b+6a^2b^2+4ab^3+b^4$ • $bx+by=b(x+y)$ • $\frac{x+2}{5}+\frac{x+4}{3}=\frac{8x+26}{15}$

	sketching of quadratic graphs using the formula
	$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
		Using an LCM of 15
		• Learners should be taught to simplify and solve equations for example: $5(x-3)-7(6-x)=12-3(8-x)$ leading to a solution that $x=5$
		• Engineering problems are often described using simultaneous equations. Learners should be taught to solve simultaneous equations graphically and by calculation for example:
		  o electrical engineering problems using Kirchhoff's laws forces in a mechanical system using $0.7F_1 + 0.5F_2 = 9$ and $0.3F_1 + 0.4F_2 = 5$, state that when two equations contain two unknowns
		  o such as $3x+7y=10$and $x+4y=6$, such that only one value of x and y exist that will satisfy both equations, are called simultaneous equations
		• Engineering problems can often be described using quadratic equations. Learners should be taught to solve quadratic equations for example:
		  o bending moment (M) of beams $M = 0.4x^2+0.47x-3.2$
		  o fabrication of steel boxes when the volume of the box is, $2(x-4)(x-4)$ where "x" is a required dimension
		  o equations of motion $v = u+at$
		$v^2 = u^2 + 2as$

2. Be able to use geometry and graphs in the context of engineering problems.	2.1 Demonstrate how to use co-ordinate geometry including straight line equations and curve sketching.	• Straight line equations i.e.
		  o equation of a line through two points
		  o gradient of parallel lines

	2.2 Demonstrate graphical transformation.	o gradient of perpendicular lines o mid-point of a line o distance between two points • curve sketching i.e. o graphs of $y = kx^n$ o graphical solution of cubic functions • The behaviour of engineering systems can be described using straight line equations. Learners should be taught how to solve problems using straight line equations for example: ○ force vs displacement for a linear spring or spring buffer ○ electrical problems using Ohm's law ○ Learners should be taught to sketch mathematical functions in order to visualise (and sometimes to solve) problems for example: $y = -3x^2$ $f(x) = x(x-1)(2x+1)$ $m(x) = (2-x)^3$ *Learners can be taught to use spreadsheets to plot and solve cubic functions using trend lines. ○ Graphical transformations i.e. ○ translation by addition ○ transformation by multiplication ○ Learners should be taught graphical transformations for example: ○ translation in the *y* direction by adding a whole number to the whole function ○ translation in the *x* direction by adding a whole number to *x* ○ multiplying the whole function by a whole

		number ○ multiplying x by a whole number
3. Understand exponentials, logarithms and trigonometry related to engineering problems.	3.1 Demonstrate problem solving using exponentials and logarithms. 3.2 Demonstrate problem solving with arcs, circles and sectors. 3.3 Demonstrate problem solving involving right-angled triangles.	• Many engineering systems and devices can be characterised, and problems solved using exponentials and logarithms for example: • Voltage and current growth in capacitor circuits (RC circuits) • Voltage and current decay in capacitor circuits (RC circuits) • Stress-strain curves for certain engineering materials • Learners should be taught how to solve problems involving exponential growth and decay including use of the exponential and logarithmic functions and the log laws. ○ $y = e^{ax}$ ○ $y = e^{-ax}$ ○ $e^{y}=x$ ○ $\ln x=y$ • Learners should be taught both how to produce and interpret sketch graphs showing exponential growth and decay. • Problem solving with arcs, circles and sectors i.e. ○ the formula for the length of an arc of a circle ○ the formula for the area of a sector of a circle ○ the co-ordinate equation of a circle $(x-a)^2+(y-b)^2=r^2$ to determine: centre of the circle

		o radius of the circle
		
		• Problem solving involving right-angled triangles i.e.
		  ○ what is meant by the term “solution of a triangle”
		  ○ Pythagoras’ Theorem
		  ○ use of sine, cosine and tangent rule for right-angled triangles
		  ○ the formulae for the area of a right-angled triangle

4. Understand calculus relevant to engineering problems	4.1 Demonstrate problem solving involving differentiation.
	4.2 Differentiate functions of the form:
	
	• $y = x^n$
	• $y = \sin ax$
	• $y = \cos ax$
	• $y = \tan ax$
		• Problem solving involving differentiation i.e.
		  ○ determine gradients of a simple curve using graphical methods
		  ○ the rule to differentiate simple algebraic functions
		  ○ determine the maximum and minimum turning points and the co-ordinates of the turning points by differentiating the equation twice
		• Learners should be taught to solve problems involving differentiation for example:
		  ○ given that an alternating voltage $v = 20\sin 50t$ where v is in volts and t in seconds, calculate the rate of change of voltage at a given time
		  ○ differentiate displacement to get velocity
		  ○ differentiate velocity to get acceleration, where possible problems should be presented in an engineering context.

Assessment

To achieve a 'pass' for this unit, learners must provide evidence to demonstrate that they have fulfilled all the learning outcomes and meet the standards specified by all assessment criteria.

Learning Outcomes to be met	Assessment criteria to be covered	Type of assessment
All 1 to 3	All AC under LO 1 to 3	Coursework – The assessment focuses on breadth, challenge and application. Learners will draw on and extend the skills they have learned during the teaching of the unit.

Indicative Reading list

- Croft, A. & Davison, R. (2015) *Mathematics for Engineers*. 4th ed. Prentice Hall
- Attwood, G. et al (2017) *Edexcel AS and A-level Pure Mathematics*. Pearson Education
- Beveridge, C. (2016) *AS and A-level Maths for Dummies*. John Wiley