14-19: Diploma in Engineering

- Started in September 2008
- Available at levels 1, 2 and 3 at partner institutions
  - **Foundation Diploma in Engineering**
  - **Higher Diploma in Engineering**
  - **Advanced Diploma in Engineering**
  - **Progression Diploma in Engineering**
- Provides an introduction to the industry
- Gives an overview of the different sectors
- Provides information about career opportunities and a foundation in engineering principles.
- For more information, please visit:
  - www.direct.gov.uk/diplomas
  - www.dcsf.gov.uk/14-19
  - www.qca.org.uk/diplomas
  - www.engineeringdiploma.com

Structure - at a glance

Foundation Diploma Level 1	600 glh	5 GCSEs at D – G
Higher Diploma Level 2	800 glh	7 GCSEs at A* – C
Advanced Diploma Level 3	1080 glh	3.5 A Levels at A* – E
Progression Diploma	720 glh	Consists of Principle Learning and Generic Learning only Equivalent to 2.5 A Levels

Advanced Diploma in Engineering: A Level – 3 Qualification

This will cover such interdependent themes as:

- engineering technology
- mathematical techniques and applications for engineers
- scientific principles and applications for engineers
- applications of computer aided design
- selection and management of engineering materials
- instrumentation and control engineering
- the relation between innovative engineering design and business success
- analytical methods in engineering
- engineering and the environment

An overview …

Advanced Diploma in Engineering (1080 glh)		
Principal Learning	**Generic Learning**	**Additional and Specialist Learning**
9 Compulsory Units (540 glh) At least 50% is applied learning	Functional skills in English, Maths, ICT at Level 2 (60 glh) Involves Personal, Learning and Thinking Skills Extended Project (120 glh) Work experience (minimum 10 days)	Optional Units (360 glh) Offers **Mathematics for Engineering (180 glh)** as Additional/Specialist Learning

UCAS Equivalencies

Components	UCAS Tariffs
Principal Learning and Extended Project	300 Points
Additional and/or Specialist Learning	120 Points
Generic Learning (PLTS or Functional Skills)	No extra points as it will be a standalone qualification.

Level 3: Principal Learning (Compulsory Units)

Unit Number	Title	GLH	Assessment
1	Investigating Engineering Business and the Environment	60	External
2	Applications of Computer Aided Designing	60	Internal
3	Selection and Application of Engineering Materials	60	Internal
4	Instrumentation and Control Engineering	60	Internal
5	Maintaining Engineering Plant, Equipment and Systems	30	Internal
6	Investigating Modern Manufacturing Techniques Used in Engineering	60	Internal
7	Innovative Design and Enterprise	60	Internal
8	**Mathematical Techniques and Applications for Engineers**	**60**	**External**
9	Principles and Application of Engineering Science	90	Internal

Unit-8: Mathematical Techniques and Applications for Engineers (60 glh)

Learning Outcomes

8.1 Know how to use **algebraic methods** to solve engineering problems.

8.2 Be able to use **trigonometric methods** to solve engineering problems.

8.3 Be able to use **statistical methods** to display engineering data.

8.4 Know how to apply **elementary calculus techniques** to solve engineering problems.

Need for More Maths in Context

- People involved with HE and engineering degrees believe that 60 glh at Advanced Diploma Level were not enough to give the level and depth of understanding for a pupil to succeed on an engineering degree.
- As a result of several stages of discussion among The Higher Education Academy: Engineering Subject Centre, The Royal Academy of Engineering and representatives from HE, a need for an Additional and Specialist Learning Unit in Mathematics was realised to support this Advanced Diploma in Engineering.
- Maths Task Group (MTG) was formed to achieve this goal. This group consists of representatives from Engineering Professors' Council, The Higher Education Academy: Engineering Subject Centre, The Royal Academy of Engineering, Institute of Mathematics and its Applications (IMA), Engineering Diploma Development Partnership (EDDP), Engineering Council UK, Mathematics in Education and Industry (MEI), University of Cambridge, and National Centre for Excellence in the Teaching of Mathematics (NCETM).
- After extended discussions over several months, MTG suggested an Additional and Specialist Learning unit called Mathematics for Engineering that consists of 10 mathematics topics that are very vital in engineering.

Additional and Specialist Learning (ASL) Unit

Mathematics for Engineers (180 glh)

Topic 1	Mathematical Models in Engineering
Topic 2	Models of Growth and Decay
Topic 3	Models of Oscillations
Topic 4	Functions
Topic 5	Geometry
Topic 6	Differentiation
Topic 7	Integration
Topic 8	Linear Algebra
Topic 9	Statistics and Probability
Topic 10	Algebraic Processes

WHAT YOU NEED TO COVER (Maths Task Group)

PS: Text in RED shows overlap with Unit – 8 in Principle Learning.

Mathematical models in engineering

- Learners should be able to identify appropriate models for given physical problems, and state assumptions they have made.

Models of growth and decay

- Learners should be able to define the exponential and natural logarithmic functions and understand the relationship between them. They should be able to solve equations in e^x and in $\ln x$. They should be able to solve simple problems in exponential growth and decay. They should be able to use log-linear and log-log graph paper.
- *Learners should be able to build a simple differential equation for a selected physical situation, identify suitable boundary and/or initial conditions, distinguish between general and particular solutions and solve, with guidance, a simple physical problem. They should be able to use a spreadsheet to implement Euler's method.*

Models of oscillations

- Learners should be able to sketch graphs of the three basic trigonometric functions and their reciprocals, and recognize the formulaic representation of shifting and scaling of the basic functions and be able to interpret the parameters in the expression $a\sin(\omega t+\phi)$ in terms of oscillatory motion. They should be able to find solutions of the equation $\sin(\omega t+\phi)=c$.
- They should be able to solve triangles using angle sum and the sine and cosine rules.
- They should be able to use simple trigonometric identities.

Functions

- Learners should be able to determine the domain and range of simple functions and their inverses. They should be able to form composite functions and find their inverses, using both box diagram and formula approaches, and determine the relevant domains and ranges. They should understand the meaning of the limit of a function.
- Learners should be able to identify quadratic functions and their graphs, and solve quadratic equations using factorization and completing the square. They should understand transformations of quadratic functions. They should have a basic understanding of cubics and higher-order polynomials.

Geometry

- Learners should be able to use the equation of a straight line in the forms $y=mx+c$, $y-y_1=m(x-x_1)$, and $ax+by+c=0$. They should know the conditions for two straight lines to be parallel or perpendicular to each other and be able to find the angle between two straight lines in other cases.
- Learners should be able to calculate the distance between two given points in 2D *and in 3D*. They should be able to calculate the shortest distance between a given point and a given straight line. *They should be able to interpret terms in the equation of a line in 3D. They should be able to find whether two lines in 3D intersect, or are parallel or are skew. They should be able to find the angle between two given lines. They should be able to determine the equation of a plane.*
- Learners should be able to find the equation of a circle in both standard and expanded form given its radius and the coordinates of its centre of a circle, and vice-versa. They should be able to find the equations of the tangent and normal at a given point. *They should be able to recognise the equations of a parabola, an ellipse and a hyperbola in standard form. They should be able to find the equations of the tangent and normal at a given point. They should be able to recognise the equation of a rectangular hyperbola in*

both standard forms.

Differentiation

- Learners should be able to calculate the average rate of change of a function given by a formula, or graphically, over an interval and estimate the instantaneous rate of change of a function given graphically. They should be able to calculate the derivative of a function at a given point using standard results and the rule for linear combinations of functions. They should be able to use differentiation to find the equations of the tangent and normal to a curve at a given point.
- Learners should be able to locate and classify the stationary points of a function using the first derivative test. They should be able to obtain the second derivative of a function and use it to classify the stationary points of a function and to locate points of inflection.

Integration

- Learners should be able to obtain the indefinite integral of a function by reversing the process of differentiation. They should be able to integrate simple functions using a table of integrals and the rule for linear combinations.
- Learners should be able to obtain definite integrals of simple functions using the standard notation. They should be able to demonstrate knowledge of, and use, the main properties of definite integrals.
- They should be able to use definite integration to find the area between the *x*-axis and a curve lying entirely above that axis. They should be able to find the area between a curve and the *x*-axis when part of, or all, the curve lies below that axis. They should be able to use definite integration to find the area between two intersecting curves.
- *They should be able to understand what a solid of revolution is and use definite integration to find its volume. They should be able to find the mean value and RMS value of a function over an interval. They should be able to use definite integration to find the position of the centroid of a plane area, using symmetry where appropriate.*
- They should be able to use a spreadsheet to perform numerical integration using rectangular and trapezoidal rules.
- *Learners should be able to carry out indefinite and definite integration by means of a simple substitution and by the method of parts. They should be able to carry out indefinite and definite integration of a fraction directly, or by means of partial fractions.*

Linear Algebra

- Learners should be able to identify basic quantities as vector or scalar. They should be able to represent vectors pictorially. They should be able to carry out the addition of two vectors pictorially. They should be able to carry out vector arithmetic on vectors in component form. They should be able to solve simple problems in geometry and in mechanics using vector methods. *They should be able to obtain the scalar product of two vectors in component form and use it to find the angle between them. They should be able to obtain the vector equation of a line in 2D and in 3D.*
- Learners should be able to *determine whether two simultaneous linear equations in two unknowns have a unique solution, no solutions or infinitely many solutions. They should be able to write a system of two linear equations in matrix form. They should be able to show knowledge of the basic features of matrices. They should be able to recognise when addition and multiplication of two matrices is possible and carry out the operations when it is. They should be able* to f*ind the determinant of 2x2 and 3x3 matrices (the latter by Sarrus' rule). They should be able to use simple properties of determinants. They should be able to use Cramer's rule to solve two simultaneous equations. They should be able to state the criterion for the existence of the inverse of a given matrix and find the inverse of a 2x2 matrix. They should be able to solve two simultaneous equations via the*

inverse of the matrix of coefficients.

Statistics and probability

- Learners should be able to summarise a set of data using a variety of pictorial methods and summarise a set of data with regard to average and dispersion using a variety of numerical methods. They should be able to demonstrate understanding of the effect of grouping data with regard to measures of average and dispersion. They should be able to calculate the main measures of average and of dispersion in a set of grouped data. They should be able to demonstrate understanding of what is meant by a random sample and how it might be taken.
- Learners should be able to give examples of outcomes and events from given simple experiments. They should be able to demonstrate understanding of probability as a measure of likelihood. They should be able to obtain the probability of an event by counting outcomes. They should be able to obtain the probability of a complementary event. They should be able to find the combined probability of two mutually exclusive events. They should be able to find the combined probability of two independent events. They should be able to find the probability of the union of two events. They should be able to use Venn diagrams to help solve simple problems in probability.

Algebraic processes

- Learners should be able to use the laws of direct, inverse and joint proportion.
- *Learners should be able to obtain partial fractions in the cases where the denominator of the original fraction (i) is a product of two or three linear factors, (ii) contains a repeated factor (iii) comprises a linear factor and an irreducible simple quadratic factor.*
- Learners should be able to distinguish between a sequence and a series. They should be able to solve problems involving arithmetic and geometric sequences and series. They should understand the concept of the sum of an infinite series and be able to find the sum of a geometric series. They should be able to carry out the expansion of $(a+bx)^s$ and approximate simple rational functions using binomial expansions.
- Learners should be able to *state and use the remainder theorem* and the factor theorem. They should be able to factorise cubic polynomials, making use of the factor theorem. They should be able to represent inequalities as intervals on the real line, including inequalities involving the modulus function. *They should be able to develop rules for manipulating inequalities and use them to solve simple examples. They should be able to convert to and from expressions involving the modulus function. They should be able to represent linear inequalities in two variables as regions of the plane; represent simultaneous inequalities.*
- *Learners should be able to identify real and imaginary parts of a complex number. They should be able to plot points representing given complex numbers on an Argand diagram. They should be able to carry out the addition and subtraction of two complex numbers. They should be able to obtain the conjugate of a complex number and understand their relationship geometrically on an Argand diagram. They should be able to carry out the multiplication and division of two complex numbers. They should be able to identify the modulus and argument of a complex number in polar form and convert to and from the Cartesian form.*

Learning Outcomes / Assessment Criteria

- MTG has suggested a number of LOs and ACs for this ASL Maths Unit
- This unit will be externally assessed by the awarding bodies.
- The main idea of assessment is that learners should be able to use and apply the mathematics they have learnt in solving problems in engineering contexts.
- All the learning objectives must all be assessed in every exam
- All the Assessment Criteria must be assessed over time and may be sampled in any given exam
- The proposed format of external exam is as follows:

Paper – 1	2 hours	Short answer type questions covering the whole range of mathematical skills and engineering context.
Paper – 2	1.5 hour	Pre-released Comprehension based questions involving step-by-step mathematical modelling covering an engineering context.

Suggested Delivery Plan for Unit – 8 and ASL Mathematics Unit

Semester 1 **Semester 2**

60 glh: 2 hours per week for 30 weeks	
30 glh **Algebra, Geometry & Trigonometry**	**30 glh** **Calculus, Statistics**
	180 glh: 4 hours per week for 45 weeks
	60 glh **Topics 1 – 4**

Year 1 **Year 2**

	120 glh **Topic 5 - 10**

Purpose of Exemplars

The exemplars are intended to:

- motivate mathematics teaching and learning
- provide support for teachers teaching contextualised mathematics for the first time
- help students gain fluency in the use of mathematics fro practical problem solving
- illustrate the applicability of the mathematics in the ASL unit
- exemplify valuable activities undertaken by engineers

These purposes suggest the following constraints on exemplars:

1. An exemplar should be simple in language and optimum in length.
2. The engineering should be authentic, linked to real-world engineers or companies wherever possible.
3. The context is likely to be interesting enough to enrich and enhance learning.
4. The real world context of the application should be well recognised by level 3 students of all ages.
5. It must have a clear problem statement that can be recognised by the teachers and the learners.
6. The problem that the mathematics is used to solve must be clear to the students.
7. The problem must be important enough to make sure students care about the solution.
8. It should illustrate mathematics from the ASL unit being used in industrial application.
9. It should indicate the branch of engineering in which the mathematics is being used.

Proposed format for an EXEMPLAR

<Company/Industry LOGO> (Provided by Industry)
<Name of the company/industry>
<Title of the Exemplar> (Provided by Industry/ Maths Task Group)

<Actual Problem Statement> (Provided by Industry)
<Importance of Exemplar in real life and some background> (Provided by Industry/ Maths Task Group)
<Information for Teachers> (Provided by Maths Task Group)
<Links with 9 units in the L3 diploma, maths topics in ASL unit, Learning Outcomes and Assessment Criteria> (Provided by Maths Task Group)

An industry could also provide some pictures, photographs, diagrams, video clips/animations, any useful numeric data, tables, charts, formulae, etc. or any other relevant information e.g. human interest to the case study, usage of any of the 10 topics in day to day job responsibilities, etc. to support the background of the exemplar.

Possible Support from Industries

We are committed to produce as many exemplars as possible in any engineering stream. Any support in exemplar development will be highly appreciated. If you have any further question, wish to add your suggestions, need more information or want to support this development with an engineering case study, please contact:

Dr Sapna Somani
Maths Coordinator, 14-19: Diploma in Engineering
The Royal Academy of Engineering
3 Carlton House Terrace
London SW1Y 5DG
Direct Tel.: 0207 766 0639
Mobile: 07878 633 730
sapna.somani@raeng.org.uk
www.raeng.org.uk