Recruiting Diploma in Engineering graduates

A guide for Higher Education Version 1.1

The Diploma IN ENGINEERING

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What is the Diploma in Engineering?

The Diploma is a new applied qualification developed with employers to provide learners with subject specific skills and knowledge alongside employability skills and a self managed project. The Diploma is available at 3 levels:

Foundation: equivalent to 5 GCSE grades at D-G
Higher: equivalent to 7 GCSE grades at A*-C
Advanced: equivalent to 3.5 A levels

There is also a Progression Diploma available at Advanced Level, which comprises the Principal Learning, Functional Skills and extended project, and is equivalent to 2.5 A levels.

Pre-16, the Foundation and Higher diplomas are studied alongside the compulsory elements of the curriculum (eg Science, citizenship, and physical education).

Diploma components

Principal Learning which is subject specific (referred to as lines of learning) and represents approximately half the Diploma study time. See Appendix 3 for the units which Diploma in Engineering students will study.

Generic Learning which covers the personal learning and thinking skills (PLTS – see Appendix 4 for the elements of PLTS covered in the Diploma), the functional skills (guaranteeing literacy, numeracy and ICT skills) and a project.

Additional and Specialist Learning (ASL) which allows students to broaden their learning experience, or focus on a specific area of their chosen subject. For Engineering students, additional and specialist learning can include specially reconfigured BTEC units, newly created qualifications (eg the ABC Awards qualifications in Building Services Engineering), the new Maths for Engineering qualification from OCR, or GCSEs and A levels.

How is the Diploma in Engineering different to other qualifications?

The emphasis of the Diploma in Engineering is on applying engineering concepts to real life examples, and at least 50% of the learning must be applied.

A wide range of study and life skills (identified as essential by employers and admissions tutors) are developed by students and assessed by tutors.

A key factor of the Diploma in Engineering is transferability. Students are not forced to make life choices too early, the different qualifications have been written to ensure students can transfer between diplomas and other qualifications and maintain choice of progression. The employability skills developed on the Diploma in Engineering could be used for all kinds of careers and further learning and do not restrict an individual to a career in engineering. The ASL aspect of the Diploma allows for real personalised study for students, facilitating choice and progression. Because the Diploma pre-16 at Foundation and Higher Level does not fill the curriculum, students will also continue to study those compulsory elements of the Key Stage 4 curriculum which also build transferable skills, such as Personal, Social and Health Education.

How does the teaching philosophy differ?

Teaching of the Diploma in Engineering is focused on 'application of concept' and experiential learning. This enables students to grasp both the theory of engineering and see its relevance to the real world.

The wider Diploma programme incorporates essential life skills such as those specified as Personal Learning and Thinking Skills. It is not possible to gain a passing grade in a Diploma without completing all of the elements (Principal Learning and Project, Additional and Specialist Learning, Functional Skills, Personal Learning and Thinking Skills and work experience).

It is not designed to give students practical engineering skills, or measure their competence in engineering tasks, but rather to enable them to understand engineering concepts and 'language', and test their understanding in applied environments.

The Diploma in Engineering is designed to be delivered in a different environment to straightforward 'academic' qualifications. As a result, current students are already reporting their enjoyment of a more 'mature' learning environment, and one which is closer to that of university or work-based learning. They feel they have more responsibility for their own learning, and enjoy more opportunities to relate to tutors and teachers as adults.

Teachers and tutors are bringing their own engineering experience and skills in the workplace into the Diploma, and providing students with real world examples of application of the theory. This in turn gives students more insight into the world of engineering and its application.

Employer engagement is a key element of Diploma development and delivery, with business involved at every stage. Employers have helped define the content of curriculum, and have a key role to play in making the learning 'come alive'. Significant numbers of employers have been and continue to be involved, providing projects, assisting with curriculum delivery, creating work experience placements, and supplying resources.

What grades can Diploma students achieve?

At Foundation Level, the grades are: A*, A, B, and U.
At Higher Level, the grades are: A*, A, B, C, and U.
At Advanced Level, the grades are A*, A, B, C, D, E, and U.

Only the student's performance in the Principal Learning and Project influences their grade, with their performance in Additional and Specialist Learning being reported separately. Diploma students must complete all elements to receive the grade.

Diploma students who fail to complete all the elements receive a Progress Statement which details their achievements so far, and indicates which are still required in order for them to receive their Diploma grade at a later date.

Progression Diploma students need only complete the Principal Learning and Project to receive their grade.

The Diploma and the UCAS application system

Advanced Diploma students will be applying for university courses with Diplomas, just as they have with GCSE and A level. Results for Diploma students will be known from the same date as GCSE and A level results in August, although Diploma students can additionally complete their programme at other points through the year. The Advanced Diploma results will normally be released on the same day as A level results, however for some students, elements of their diploma may have study time tables that do not match GCE study and it will be appropriate for these students to be awarded their diplomas at different points. This also applies where an element of the diploma (such as a functional skill) needs to be retaken.

On the UCAS system, the Advanced Diploma grade will be recorded in the application in a single field, with the ASL component being reported separately, with a separate tariff. This means that a student who takes the Progression Diploma plus an additional A level, and an Advanced Diploma student who takes an A level as their ASL will present identical UCAS forms. It is in the personal statement that individuals will be able to present the context in which they have studied their Diploma including details of their extended project and work experience. This supports the diversity and choice which is available to Diploma students.

UCAS tariff points

Progression Diploma, and Principal Learning and Extended Project UCAS tariff points:

Grade	Tariff points
A*	350
A	300
B	250
C	200
D	150
E	100

Additional and Specialist Learning may also attract UCAS tariff points. For example, **the Maths for Engineering Unit from OCR attracts 90 UCAS tariff points.**

Advanced Diplomas as a whole are allocated points under the UCAS system as follows (illustration only):

			Principal Learning & Extended Project					
		UCAS tariff points	**E**	**D**	**C**	**B**	**A**	**A***
			100	**150**	**200**	**250**	**300**	**350**
Additional & Specialist Learning (ASL)	E	**40**	140	190	240	290	340	390
	D	**60**	160	210	260	310	360	410
	C	**80**	180	230	280	330	380	430
	B	**100**	200	250	300	350	400	450
	A	**120**	220	270	320	370	420	470
	A*	**140**	240	290	340	390	440	490

The ASL illustration shown is for standard A level grades and allocation – other selections for ASL could have a different UCAS point tariff.

The structure of the diploma allows for qualifications from a higher level to be used as ASL. There are a number of level 4 courses, many of which attract CAT points, that can be used as ASL. In these cases the Tariff score will not fully reflect the learner's experience and achievement.

Students personal statements will emphasise where this higher level of study has been included.

What will a Diploma graduate have that makes them stand out?

Students…

- have the opportunity to make an informed choice on progression, having experienced elements of engineering, thus aiding retention and reducing the likelihood of poor choices;
- understand the skills they have developed and are encouraged to reflect on them;
- complete a rigorous programme of study that meets strict criteria identified as essential by professional institutions, further education and higher education;
- undertake a range of learning within the programme, and must achieve in all these areas in order to receive a Diploma grade, improving their all round study and life skills;
- manage areas of their own learning, primarily a project they agree with their tutor;
- experience real work through work related learning supported by employers;
- undertake work experience linked to their studies; and
- complete the Functional Skills assessments, these are contextualised assessments for Maths, English and ICT demonstrating the skills can be used in real situations.

OCR Level 3 Certificate in Mathematics for Engineering (NDAQ ref 500/4136/8)

"The Maths for Engineering qualification gives the Advanced Diploma students an edge when competing with the highest achieving A level students. Not only will advanced diploma students have spent two years studying an authentic engineering curriculum before they even register for an engineering degree course at university, but the contextualised maths module will have given them a fluency in engineering problem solving that their A level maths colleagues won't have. Able, well-taught diploma students should have no problems accessing the very best degree courses on the strength of their problem solving skills alone."
Professor Matthew Harrison Director, education programmes, The Royal Academy of Engineering

Mathematics is an integral part of the study of engineering regardless of which branch of engineering is chosen. Many in the engineering community believe that additional mathematics material should be available for those students studying the Advanced Diploma in Engineering to prepare them for progression onto engineering degree courses at university. Many also appreciate that teachers in schools and colleges need more real engineering examples to underpin the essential mathematics and also to excite interest in engineering. In response to these challenges, the engineering and maths communities joined together in May 2007 to form a Maths Task Group.

Maths Task Group

- Engineering Professors Council (EPC)
- The Higher Education Academy: Engineering Subject Centre
- The Royal Academy of Engineering
- Institute of Mathematics and its Application (IMA)
- Engineering Diploma Development Partnership (EDDP)
- Engineering Council UK (ECuk)
- Mathematics in Education and Industry (MEI)
- University of Cambridge
- National Centre for Excellence in the Teaching Mathematics (NCETM)

The task group has developed a specialist mathematics unit, accredited by OCR, available for any Level 3 learner wishing to develop his or her mathematical skills and knowledge beyond those already incorporated in the principal learning, through problems set in real life contexts, especially in engineering. A consensus is emerging that students thinking of studying engineering at university should take this unit as an ASL qualification along with the Advanced Diploma in Engineering at Level 3.

The qualification is 180 GLH in size, and attracts 90 UCAS Tariff points (50% more than any other 180GLH unit) at grade A. This learning needs to be considered in conjunction with the 60 GLH Mathematics unit within the Advanced Diploma, giving 240GLH of intensive, engineering-specific mathematics study.

It is worth mentioning in passing that the benefit of offering the specific mathematics unit from the Advanced Diploma in Engineering to a wider audience has been identified, and the 60 GLH diploma mathematics unit has been accredited as a stand alone qualification. This enables learners not studying the Advanced Diploma in Engineering to study this qualification, but this is only advised where the learner has already studied the specific 60GLH Mathematics unit within the principal learning of the Advance Diploma in Engineering, which is also available as a stand-alone unit from OCR.

The syllabus of the Maths for Engineering unit is based on a foundation year course taught at Loughborough University over many years. The Loughborough course is designed for students without A level Mathematics who wish to go on to study engineering to degree level.

Experts in mathematics, engineering and industry have joined together to produce a range of exemplars demonstrating high level mathematics being applied in real world situations. These exemplars support practitioners in contextualising the mathematics unit. The additionality of the unit provides real context and depth of mathematical understanding for the student.

Assessment of the unit

The assessment takes the form of two papers.

- Paper 1- A 2 hours paper consisting of standard A level type questions covering the whole range of mathematical skills and engineering context.
- Paper 2- 1.5 hour paper The questions which will be unseen will be comprehension based questions involving step by step mathematical modelling covering a particular engineering context This context will be based around a pre-released engineering scenario. Thus ensuring that all students are familiar with the context and terminology in this area of engineering.

The topic summary for the units is included as APPENDIX 6.

Interviewing Diploma in Engineering Students

The Diploma Transcript (the certificate presented to students completing the diploma) summarises grades and completion of the various elements of the Diploma, and the UCAS application form will also contain extensive information about their Diploma achievements.

However, neither of these will reflect the full range of the student's experience.

To support higher and further education in appraising Diploma graduates, this document suggests questions that admissions tutors could use to highlight the unique experience of Diploma Students. These questions can be used where selection is via interview, or equally can highlight the detail admissions tutors can expect to find within the personal statement.

Line of Learning

Why did you choose to study the Diploma in Engineering?

Why is engineering important to the UK?

How do you think your study of the Diploma in Engineering will help you with this course?

Personal Learning and Thinking Skills

(see appendix 4 for PLTS content)

Tell me about when you worked as part of a team and the role that you played in that team?

Which parts of the course did you feel you had to manage yourself? How well do you think you did this?

During your studies, when did you have to think creatively?

Do you think you are different now to when you started studying the course? If so, how are you different and why?

Give me an example of when you worked independently.

Give me an example of when you had to choose the direction you wanted your studies to go in.

Tell me about your diploma group and how they worked together?

Project

What is the title of your project?

What was it was about and why you chose to do it?

What would you do differently if you could do this project again?

Work Experience

Where did you go for your work experience?

Why did you choose that company?

What was the best thing about your time there?

Tell me about any things you learned in the course that you saw being used during your work experience?

(Employers who take Diploma students on work experience will be encouraged to provide a short commentary on the experience, which recruiters may ask about.)

Additional and Specialist Learning

Which qualifications did you chose for ASL and why?

(How) do you think they added to your understanding of engineering?

APPENDIX 1

Diploma in Engineering Equivalencies

Other qualifications	…are equivalent to the Diploma in Engineering at…	Diploma in Engineering grades achievable	Diploma students also have…	Qualifications Diploma students may have studied AS PART of the Diploma in Engineering	Qualifications Diploma students may have studied OUTSIDE the Diploma in Engineering
5 GCSE grades D-G	**Foundation Level**	A*, A, B, ungraded	Level 1 Functional Skills in numeracy, literacy, IT A project based on the line of learning	• GCSEs • BTEC qualifications • City & Guilds qualifications • OCR Nationals • Vocationally Related Qualifications (VRQs)	GCSEs NVQ
7 GCSE grades A*-C	**Higher Level**	A*, A, B, C, ungraded	Level 2 Functional Skills in numeracy, literacy, IT A project based on the line of learning	• GCSEs • BTEC qualifications • City & Guilds qualifications • OCR Nationals • VRQs	GCSEs NVQ
3.5 A levels	**Advanced Level**	A*, B, C, D, E, ungraded	Level 2 Functional Skills in numeracy, literacy, IT An extended project based on a particular area of engineering	• A levels • BTEC qualifications • City & Guilds qualifications • OCR Nationals • VRQs • Level 4 courses	A levels
2.5 A levels	**Progression Diploma**	A*, B, C, D, E, ungraded	Level 2 Functional Skills in English, ICT and mathematics		
	Extended Advanced Diploma	Coming 2011			

APPENDIX 2

Diplomas in the Qualifications and Credit Framework in England

Qualification Levels England	**Vocational Qualifications**	**Academic/Applied Qualifications**
Levels 8-7	Graduate apprenticeship	Doctorate Masters degree Post-graduate certificates and diplomas
Level 6	Graduate apprenticeship	Honours degree Management certificates and diplomas
Levels 4-5	NVQ 4 - 5 Higher apprenticeship	Foundation degree (Fd) HNC/HND Management certificates and diplomas
Level 3	NVQ 3 Advanced apprenticeship	National certificate or diploma **Progression/Advanced Diploma** A levels
Level 2	NVQ 2 Apprenticeship	**Higher Diploma** GCSEs A*-C
Level 1	NVQ 1 Apprenticeship	**Foundation Diploma** GCSEs D-G

APPENDIX 3

Diploma in Engineering Unit Titles

(These unit titles are from the AQA awarding body version of the Diploma in Engineering, and may vary slightly with other awarding bodies)

Foundation Unit 1: Introducing the world of engineering
Foundation Unit 2: Practical engineering and communication skills
Foundation Unit 3: Using Computer Aided Engineering
Foundation Unit 4: Routine maintenance operations
Foundation Unit 5: Introduction to engineering materials
Foundation Unit 6: Introduction to electronics
Foundation Unit 7: Engineering the future

Higher Unit 1: The engineered world
Higher Unit 2: Engineering design
Higher Unit 3: Engineering applications of computers
Higher Unit 4: Producing engineering solutions
Higher Unit 5: Construct electronic and electrical systems
Higher Unit 6: Manufacturing engineering
Higher Unit 7: Maintenance
Higher Unit 8: Innovation, enterprise and technological advance

Advanced Unit 1: Engineering business and the environment
Advanced Unit 2: Applications of Computer Aided Designing
Advanced Unit 3: Selection and application of engineering materials
Advanced Unit 4: Instrumentation and control engineering
Advanced Unit 5: Maintaining engineering systems and products
Advanced Unit 6: Production and manufacturing
Advanced Unit 7: Innovative design and enterprise
Advanced Unit 8: Mathematical techniques and applications for engineers
Advanced Unit 9: Scientific principles and applications for engineers

APPENDIX 4

Personal Learning and Thinking Skills

Personal Learning and Thinking Skills elements

1. **Independent Enquirer**
   - 1.1. identify questions to answer and problems to resolve
   - 1.2. plan and carry out research, appreciating the consequences of decisions
   - 1.3. explore issues, events or problems from different perspectives
   - 1.4. analyse and evaluate information, judging its relevance and value
   - 1.5. consider the influence of circumstances, beliefs and feelings on events
   - 1.6. support conclusions, using reasoned arguments and evidence

2. **Creative Thinker**
   - 2.1. generate ideas and explore possibilities
   - 2.2. ask questions to extend your thinking
   - 2.3. connect your own and others' ideas and experiences
   - 2.4. question your own and others' assumptions
   - 2.5. try out alternatives or new solutions and follow ideas
   - 2.6. adapt ideas as circumstances change

3. **Reflective Learner**
   - 3.1. assess yourself and others, identifying opportunities and achievements
   - 3.2. set goals with success criteria for their development and work
   - 3.3. review progress, acting on the outcomes
   - 3.4. invite feedback and deal positively with praise, setbacks and criticism
   - 3.5. evaluate experiences and learning to inform future progress
   - 3.6. communicate your learning in relevant ways for different audiences

4. **Team Worker**
   - 4.1. collaborate with others to work towards common goals
   - 4.2. reach agreements, managing discussions to achieve results
   - 4.3. adapt behaviour to suit different roles and situations
   - 4.4. show fairness and consideration to others
   - 4.5. take responsibility, showing confidence in yourself and your contribution
   - 4.6. provide constructive support and feedback to others

5. **Self Manager**
   - 5.1. seek out challenges or new responsibilities and show flexibility when priorities
   - 5.2. work towards goals, showing initiative, commitment and perseverance
   - 5.3. organise time and resources, prioritising actions
   - 5.4. anticipate, take and manage risks
   - 5.5. deal with competing pressures, including personal and work-related demands
   - 5.6. respond positively to change, seeking advice and support when needed

6. **Effective Participator**
   - 6.1. discuss issues of concern, seeking resolution where needed
   - 6.2. present a persuasive case for action
   - 6.3. propose practical ways forward, breaking these down into manageable steps
   - 6.4. identify improvements that would benefit others as well as yourself
   - 6.5. try to influence others, negotiating and balancing diverse views to reach workable solutions
   - 6.6. act as an advocate for views and beliefs that may differ from your own

APPENDIX 5

Diploma Quotes from Universities and Professional Institutions

The following quotes have been taken from an interview with Professor Matthew Harrison based on his involvement with the first year of delivery for the Diploma in Engineering.

“The Royal Academy of Engineering, a vocal supporter of the Diploma in Engineering from the beginning, has conducted its own research on how well the qualification has fared in the first few months since its launch. The headline message is ‘so far so good’, but there is no room for complacency.”

“The Diploma in Engineering is an authentic engineering course.”

“Learning extends well beyond the grounding in basic engineering defined by the Principal Learning requirements. There is an individual project, periods of work-based learning and real depth of investigations through optional Additional and Specialist Learning. Because of this authenticity and rigour (the Diploma in Engineering is not an easy course), university admissions officers have declared their intention to accept the Level 3 diploma for direct admission to engineering degree courses……. This is very welcome, but it is worth stating that the diploma is as much about preparing young people for work (perhaps through the apprenticeship route) as preparing them for higher education.”

The article is in the Summer 2009 edition of the E&Te magazine pg 4. The magazine can be downloaded free from the IET web site at:
http://www.theiet.org/education/supportteachers/ete/

Quotes from Higher Education

"Studying the Diplomas will give you skills that are valuable for university and the future." Professor Michael Arthur, Vice Chancellor, **University of Leeds**

"We have had extensive input into the Engineering Diploma, with the goal of ensuring that it will be a suitably rigorous qualification for entry into higher education." "The engineering diploma is an interesting new qualification combining practical and theoretical learning in innovative ways." Geoff Parkes, Director of Undergraduate Admissions at **Cambridge University**

“Our admissions policy at Aston reflects my high opinion of the Diploma. We are accepting all of the relevant Diploma subjects onto our courses, including engineering and business programmes. As a recognised leader in these areas, I believe that Diploma students will add to the strength of our graduates and go on to become future industrial leaders…Aston University is the lead sponsor for a new 14-19 Aston University Engineering Academy, which is being built on the Aston Science Park for September 2012. This will play a crucial role in delivering the Engineering Diploma to young people in the Birmingham area over the next five years. The aim of this project is to encourage talented teenagers into engineering in the future and tackle the current engineering skills shortage.” Professor Alison Halstead of **Aston University**

“When we looked at the Engineering Diploma, we saw a qualification that is a good match for our courses. No qualification will be a perfect match to a particular degree course as there is only so much that students can cover in the two years of the sixth form, but students with the Engineering Diploma should be well equipped to come to Loughborough. They’ll have covered areas like material science and manufacturing processes which most of our other students will not have”. Dr Jon Petzing, Admissions Tutor for Mechanical & Manufacturing Engineering at **Loughborough University**.

This new qualification covers many aspects of engineering, and will provide university students with real understanding of what engineering is about…we are pleased that the Diploma has some strong material on control systems. This is a very important area of engineering, especially for the electronics that we focus on here in York, and A-Level students often have little or no knowledge of control systems”. Dr Stuart Porter, Undergraduate Admissions Tutor at the **University of York**.

Appendix 6

Advanced Diploma in Engineering Unit-8: Mathematical Techniques and Applications for Engineers (60 glh)

Learning Outcomes

- Know how to use algebraic methods to solve engineering problems.
- Be able to use trigonometric methods to solve engineering problems.
- Be able to use statistical methods to display engineering data.
- Know how to apply elementary calculus techniques to solve engineering problems.

Learning Outcomes

Learning outcomes	Assessment criteria	Content
The learner will: 1 understand the idea of mathematical modelling	The learner can: 1.1 identify the assumptions made in establishing a specific mathematical model 1.2 describe and use the modelling cycle	This learning outcome is concerned with the construction of abstract mathematical models from given real life situations in engineering. Techniques to analyse and deduce results from the models are covered in other LOs Fundamental laws of physics including Newton's laws of motion, Hooke's law, Newton's law of cooling, Ohm's law, Kirchhoff's law, Lenz's law, Boyle's law Particular situations are: Projectiles; simple dynamic models involving a spring and a damper; simple electronic circuits involving a resistor, capacitor and inductor; flow of liquid through pipes and tanks, linear and circular movement of objects under the influence of forces and friction; problems involving elasticity, stress and strain; heating and cooling of liquids
2 be familiar with a range of models involving change, and growth and decay.	2.1 use mathematical functions related to growth and decay	This learning outcome is concerned with recognising particular characteristics of mathematical models associated with rates of change and applying appropriate techniques for their analysis and solution. This will include knowledge of exponential functions and the laws of logs. Content includes: e^{kt}, k^x where k is + or –, whole number or fraction.

Learning outcomes	Assessment criteria	Content
	2.2 solve problems involving exponential growth and decay	$\log a + \log b = \log (ab)$ $\log (ab) = \log a + \log b$ *if both* $a > 0$ *and* $b > 0$ $\log a - \log b = \log \left(\frac{a}{b}\right)$ $\log \left(\frac{a}{b}\right) = \log a - \log b$ *if both* $a > 0$ *and* $b > 0$ $n \log a = \log \left(a^n\right), \log\left(a^n\right) = n \log a$ *if* $a > 0$ such as $e^x + e^{-x} = k$ $\ln x + \ln x^y = k$, $\ln x + \ln x^y = k$, $\ln x^y + \ln x^z = k$ The force F on the taut side of a drive belt is given approximately by $F = ke^{\mu\theta}$ where θ is the angle of lap Introduction to the basic formulae involving growth and decay: $y = a(1+r)^x$, $y = a(1-r)^x$, $y = ae^{kx}$ Solution and graphical interpretation of these equations Content includes radioactive decay, discharge of a battery, charging capacitor, changing sound intensity, liquid heating up in a warm room, compound interest

Learning outcomes	Assessment criteria	Content
	2.3 set up and solve a differential equation to model a physical situation	Solution of first order linear differential equations requiring direct integration, separation of variable and integrating factor techniques. Standard solutions to second order linear differential equations with constant coefficients. Applying initial conditions to find particular solutions. Work done in isothermal expansion content includes: Mixing of solutions Capstan Ventilation of lecture room Belt drive RL and RC circuits $\frac{dF}{d\theta} = \mu F$ $\frac{dI}{dt} = -\frac{R}{L}I$ $\frac{dQ}{dt} + \frac{1}{RC}Q = 0$

Learning outcomes	Assessment criteria	Content
3 understand the use of trigonometry to model situations involving oscillations	3.1 solve problems in engineering requiring knowledge of trigonometric functions.	This learning outcome is concerned with the analysis and solution of models which require the application of trigonometry. Standard trigonometric functions and identities Power factor correction Projectile motion Navigation Identify frequency, phase angle and amplitude in the oscillation involving, such as $y = 2\cos 3(t - 0.25\pi)$ Find the solutions of: $2\cos 3(t - 0.25\pi) = 1$ in the interval $-\pi \leq t < \pi$
	3.2 relate trigonometrical expressions to situations involving oscillations.	Oscillations in mechanical and electrical contexts Mathematical representation of frequency, period, amplitude and phase. Harmonics, resonance, bandwidth. Relationship between time domain and frequency domain Amplitude, angular frequency, phase angle

Learning outcomes	Assessment criteria	Content
4 understand the mathematical structure of a range of functions and be familiar with their graphs	4.1 identify and describe functions and their graphs	Plot and analyse functions of the form $F(x) = ax + b$, $1/(ax + b)$, Ae^{ax}, $A\log_n x$, Ax^n $f(x) = ax^n + b$, where a and b are real numbers and n is an integer. Composite functions, of the form if $f(x) = x^2$, $g(x) = x+1$ then $f(g(x)) = (x+1)^2$, $g(f(x)) = x^2+1$ Poles, zeros and asymptotes. Inverse functions, of the form if $f(t) = 2t$, $f^{-1}(t) = 0.5t$, $f(x) = 2(x+3)$: inverse function is $0.5x - 3$ Types of functions to be considered include: linear, rational, composite etc. step functions, ramp function, modulus function, odd and even functions. Velocity-time graphs

Learning outcomes	Assessment criteria	Content
	4.2 analyse functions represented by polynomial equations	Solve quadratic equations using factorisation, completing the square and the standard formula x $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ Formats are $x^2 - 6x + 16 \equiv (x-3)^2 + 7$; $x^2 + 4x - 5 \equiv (x+2)^2 - 9$ $x^2 - 7x + 6 \equiv (x-1)(x-6)$ $x^2 - 6x + 9 \equiv (x-3)^2$ Plot and analyse functions of the form $F(x) = ax^3 + bx^2 + cx + d$ Factorisation of polynomial functions. Polynomial division. Factor theorem, Remainder theorem. Formats are $y = -x^2 + 6x - 5$, projectile path. $y = x^2 + 4$; $y = x^2 - 4$; $y = (x-4)^2$; $y = (x+4)^2$; $y = 3x^2$; $y = (3x+2)^2$ $y = x^3 - 4x$; $y = x^3 - 4x^2$ - Cubic splines $y = x^3 - x^2 + 6x - 6$; $y = (x-2)^3$; $y = (x+2)^3$ Radiation heat loss, deflection of a beam.

Learning outcomes	Assessment criteria	Content
5 know how 2-D and 3-D coordinate geometry is used to describe lines, planes and conic sections within engineering design and analysis	5.1 use equations of straight lines, circles, conic sections, and planes	Determine the equation of a straight line in the form $y=mx+c$, and $ax+by=c$ Determine the equation of a plane in the form $ax+by+cz = d$. General equation of a conic section $Ax^2+Bxy+Cy^2+Dx+Ey+F=0$ Particular cases for a circle, ellipse, parabola, hyperbola and rectangular hyperbola, in the forms $(x-4)^2+(y-b)^2=r^2$, $\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$, $y^2=4ax$, $\frac{x^2}{a^2}-\frac{y^2}{b^2}=1$, $xy=c^2$. Ideal Gas Law Data from an experiment to verify Ohm's law or Hooke's law Stress-strain and Resistance-temperature graphs Linear thermal expansion Velocity of an object with constant acceleration Architecture and Structures, roofs of stadiums, power station cooling towers, suspension bridge cables Hyperboloidal gear sets Car head lamp reflectors, satellite dishes

Learning outcomes	Assessment criteria	Content
	5.2 calculate distances	Distance between two points in 2-D and 3-D space; distance between a point and a line or a plane
	5.3 describe relationships between lines in 3-D	Determine the line formed by the intersection of two planes Determine lines normal to a plane Determine the angle attained by two lines in 3-D space Find a general point on a line Find the angle between two lines

Learning outcomes	Assessment criteria	Content
6 know how to use differentiation and integration in the context of engineering analysis and problem solving	6.1 calculate the rate of change of a function	Elementary rules of differentiation. If $y = x^n$ then $\frac{dy}{dx} = nx^{n-1}$ If $y = f(x) + g(x)$ then $\frac{dy}{dx} = f'(x) + g'(x)$ Standard derivatives. Product rule, quotient rule function of a function rule. Specifically in the following formats: $2e^x$, $\sin x + \ln x$, $3\sin x - 2e^{-x}$, $x \sin 2x$, $\frac{e^x}{x^2+1}$ Equation of the tangent and normal to the curve in the form $y = x^2 - x + 2$ at $x = 3, 0, -0.5$ $P = I^2R$; find rate of change of P with respect to I EMF in search coil. $E = -N\frac{d\phi}{dt}$
	6.2 use derivatives to locate and classify stationary points of a function of one variable	Use the principle, $\frac{dy}{dx} = 0$, to determine stationary points. Use the second derivate, $\frac{d^2y}{dx^2}$, to determine maxima, minima and points of inflection. Maximum power transmitted by a belt

		Maximum volume of a box from a fixed amount of material and fixed volume of box using the minimum amount of material. Open box, closed box. Rectangular and cylindrical boxes
	6.3 find definite and indefinite integrals of functions	Elementary rules of integration: $\int x^n = \frac{x^{n+1}}{n+1}, \; n \neq -1$ If $y = f(x)$ and $g(x)$ then $\int y dx = \int f(x)dx + \int g(x)dx$ Standard integrals. Integration by parts, integration by partial fractions. Integrals of the form $\int \frac{f'(x)}{f(x)}dx$ and $\int f(x).f'(x)dx$ Relationship between acceleration, velocity and displacement for linear and angular motion Tension and energy in a stretched spring Mean value of a half sine wave, a full sine wave, RMS value of a half sine wave, a full sine wave Magnitude of the magnetic field at point due to the current in a straight wire

Learning outcomes	Assessment criteria	Content
		Energy stored in an inductor after a certain time under varying voltage Reaction time in a second-order chemical reaction
	6.4 use integration to find areas and volumes	Use $\int_a^b f(x)dx$ to determine the area between a curve and the x axis and the limits $x = a$ and $y = b$ Use $\int_a^b f(x) - g(x)dx$ to determine the area between the curves and the limits $x = a$ and $x = b$ Use $\int_a^b \pi y^2 dx$ and $2\pi\int_a^b xydx$ to determine volumes of revolution. Use standard integrals to determine the centroid of a uniform lamina.

Learning outcomes	Assessment criteria	Content
7 understand the methods of linear algebra. Know how to use algebraic processes	7.1 solve engineering problems using vector methods	Vector representation, scalar and vector quantities. Components of a vector, vectors in space, direction cosine, addition of vectors, scalar product, vector product, angle between two vectors Resultant of vectors. Resolving a vector into two perpendicular components Forces on a robot manipulator Work done against force. Find the work done in moving an object in a straight line
	7.2 use matrices to solve two simultaneous equations in two unknowns	Matrix notation, square matrix, rectangular matrix, row and column vectors. Addition, subtraction and multiplication of matrices. Determinants and the inverse of a square matrix Use of matrices to represent simultaneous equation. Solution of simultaneous equations using the matrix inverses and Cramer's rule
	7.3 solve problems involving arithmetic and geometric sequences and series	Identification of arithmetic and geometric series. Determination of individual terms within and summation of arithmetic and geometric series Summation of infinite series and convergence Definition and use of Binomial series

Learning outcomes	Assessment criteria	Content
		Simple interest. Compound interest. Interest on borrowed sum, total interest paid Discounted cash flow Discharging a capacitor
	7.4 use inequalities	Plotting linear inequalities on a graph. Construction of linear programmes from given situations involving up to three variables Solution of linear programmes involving two variables using graphical techniques for example machine utilisation, mixtures, production planning
	7.5 manipulate complex numbers use complex numbers to solve engineering problems	Definition of a complex number with reference to real and imaginary parts Representation of a complex number in graphical form, in the form $a + bj$, polar form and exponential form. Complex number arithmetic AC linear circuits. Complex impedance of resistor, capacitor or inductor

Learning outcomes	Assessment criteria	Content
8 understand how to describe engineering situations using statistics and use probability as a measure of likelihood	8.1 summarise a set of data	Concept of discrete and continuous data. Frequency distributions, density functions and cumulative frequency Construction of box plots, bar charts, histograms, pie charts, frequency tables. Standard statistical measures – mean, median, mode, range standard deviation content includes discrete and continuous distributions Construct a box plot from the data in a table Mean and standard deviation of data Dimensional variations of mass produced components
	8.2 describe a random sample and how it might be taken	Defining a realistic population, determination of an appropriate sample size Types of sampling Inference of population statistics from sample statistics. Simple hypothesis testing
	8.3 use methods of probability to help solve engineering problems	Basic probability theory. Exclusive and non-exclusive events, dependent and independent events, laws of addition and multiplication, conditional probability. Use Binomial and Poisson distributions. Mean and standard deviation of a distribution

Learning outcomes	Assessment criteria	Content
		Use of the Normal and exponential continuous distribution functions to determine probabilities including in Series and Parallel connections Defects in batches Selection with and without replacement Reliability
9 construct rigorous mathematical arguments and proofs in engineering contexts	9.1 use precise statements, logical deduction and inference 9.2 manipulate mathematical expressions 9.3 construct extended arguments to handle substantial problems	Learners will be expected to construct and present clear mathematical arguments, consisting of logical deductions and precise statements involving correct use of symbols and connecting language. In particular terms such as 'equals', 'identically equals', 'therefore', 'because', 'implies', 'is implied by', 'necessary', 'sufficient', and notations such as ⇨, ⇦, ⇔, should be understood and used accurately. In addition, learners are expected to know about mathematical proof: Proof by contradiction Disproof by counter-example.

Learning outcomes	Assessment criteria	Content
10 comprehend translations of common realistic engineering contexts into mathematics	10.1 read critically and comprehend substantial mathematical arguments or examples of applications	Learners will be able to read critically, comprehend substantial mathematical arguments, and reason and draw conclusions by considering a specific engineering context. Learners will communicate their understanding.