Mathematical techniques and applications for engineers

Level 3 Certificate in Mathematical techniques and applications for engineers H865

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1 About this Qualification

This booklet contains the specification for OCR's Level 3 Certificate in Mathematical techniques and applications for engineers for teaching from September 2008.

The aim in preparing this specification has been to promote the teaching and learning of mathematics appropriate to engineering, post GCSE, in schools and colleges.

The broad objectives in designing the scheme have been to include a sufficient range of applied mathematical topics to allow schools and colleges to deliver a course to suit the requirements of potential students of engineering, construction, manufacturing and the sciences.

This stand-alone qualification, together with OCR's Level 3 Certificate in Mathematics for Engineering, is part of the Additional and Specialist Learning for the Diploma in Construction and the built environment and the Diploma in Manufacturing.

The specification has been designed to develop the knowledge and understanding required to enable progression to qualifications along the vertical and horizontal planes in the National Qualifications Framework.

For example a candidate achieving a Level 3 Certificate in Mathematical techniques and applications for engineers may:

- undertake additional Level 3 qualifications part-time or full-time in further education, eg OCR Level 3 Certificate in Mathematics for Engineers, OCR Level 3 Principal Learning in Manufacturing.
- progress onto a full Diploma qualification.
- undertake Level 4 qualifications and above, part-time or full-time in further or higher education, eg Beng.
- progress into employment at technician level.

1.1 The Level 3 Certificate

The Level 3 Certificate is a 'stand-alone' qualification and can be used as Additional Specialist Learning for the Diploma in Manufacturing, Diploma in Construction and the Built Environment.

From September 2008 the Level 3 Certificate is made up of **one** mandatory externally assessed component.

1.2 Qualification Title and Level

This qualification is shown on a certificate as:

- OCR Level 3 Certificate in Mathematical techniques and applications for engineers.

This qualification is Level 3 in the National Qualification Framework (NQF).

1.3 Aims

The aims of this specification are to enable candidates to:

- provide learners with the opportunity to study the theory of mathematics and then apply this theory in a variety of engineering contexts;
- develop their understanding of mathematics and mathematical processes in a way that promotes confidence and fosters enjoyment;
- develop abilities to reason logically and recognise incorrect reasoning, to generalise and to construct mathematical proofs;
- extend their range of mathematical skills and techniques and use them in engineering problems;
- develop an understanding of how different areas of mathematics can be connected to solve engineering problems;
- use mathematics as an effective means of communication within an engineering context;
- take increasing responsibility for their own learning and the evaluation of their own mathematical development.

1.4 Prior Learning/Attainment

This qualification is available to anyone who is capable of reaching the required standards. It has been developed free from any barriers that restrict access or progression thereby supporting equality and diversity.

It is advisable that anyone embarking upon this course should previously have studied GCSE Mathematics at Higher tier or be fully familiar with such mathematical content. It is recommended that the teaching of this qualification should be integrated with the teaching of OCR Level 3 Certificate in Mathematics for Engineering.

All centre staff involved in the assessment or delivery of this qualification should understand the requirements and match them to the needs and capabilities of individual learners before entering them as candidates for this qualification. There is no requirement for learners to achieve any qualification before progressing onto this qualification although, as a general guide, learners with qualification profiles comparable to Level 2 of the National Qualifications Framework (NQF) will normally be at a level suitable for entry onto a programme leading to this qualification. Individuals should be considered equally for entry whether they hold certificates easily recognisable against the NQF or present more varied profiles for consideration.

2 Profile of the qualification

2.1 Profile of the qualification

Title	OCR Level 3 Certificate in Mathematical techniques and applications for engineers			
OCR code	H865			
Level	This qualification has been accredited onto the National Qualifications Framework (NQF) at Level 3.			
QAN	500/4709/7 (Qualification Accreditation Number)			
Age group approved	Pre-16	16-18	18+	19+
		✓	✓	✓
This qualification is suitable for	• Learners studying in preparation for employment in the engineering, construction, manufacturing or sciences sector at technician level • Learners wishing to gain a Level 3 qualification to support further study in FE and HE in the engineering, construction, manufacturing or sciences sector • Learners wishing to gain a Level 3 qualification to support further study in FE and HE in any other sector or subject area.			
Entry requirements	There are no formal entry requirements for this qualification.			
Qualification structure	Please refer to section 1.1. To achieve this qualification, learners must complete the component.			
External assessment	This qualification is externally assessed.			
Grading	Components are graded as a* - e			
Funding	Information not yet available			
Performance figures	Information not yet available			
Last session date*	June 2013	**Revised date:**		

*OCR will inform centres of changes to these dates. All centre records must be updated accordingly.

3 Component Content

The information contained in this component is structured in the same way as the Principal Learning units. This will help centre staff and learners to understand fully the requirements of this qualification. This component contains 8 distinct sections. Some cover mandatory requirements, others provide advice and guidance. The 8 sections are described below.

Component level

This section indicates whether the unit is at level 1, 2 or 3 on the National Qualifications Framework.

Component size

This section indicates the size of the component in terms of the guided learning hours needed for its completion (see section 5.5).

Component overview

This section provides an overview of the component.

Learning outcomes

This section indicates the learning outcomes that a learner will achieve when meeting the assessment criteria associated with the component.

Assessment criteria

This section indicates the criteria that a learner will be assessed against.

For this externally assessed component the learner's skills, knowledge and understanding will be assessed through one examination.

Exemplification

This section provides guidance about the underpinning knowledge, understanding and/or skills which the learner will need in order to be able to undertake the assessment for the component and to meet the requirements of the assessment criteria.

Form of assessment

This section indicates whether the component will be internally or externally assessed. It specifies the mandatory requirements in relation to the assessment of the component.

Approaches to learning

This section provides additional guidance for tutors on the variety of methods that can be used to develop knowledge, understanding and skills through a range of learning strategies.

Component level	Component size
Level 3	60 Guided Learning Hours

Component overview

Mathematics in its simplest form can be defined as the study of measurements, numbers and quantities. Engineering has been defined as the knowledge required, and the process applied to conceive, make, build, operate, sustain or recycle something of significant technical content for a specified purpose, a concept, a model, a product, a device, a process or a system.

The aim of this qualification is to link the above statements together to provide learners with the opportunity to study the theory of mathematics and then apply this theory in a variety of engineering contexts and through work in other engineering units.

It is intended that learners will develop further knowledge and understanding of:

- Algebra
- Geometry and Trigonometry
- Calculus
- Statistics

From this knowledge and understanding of the theory will come the development of the ability to solve problems in the context of engineering.

The learning outcomes provided can broadly be defined as a very general statement, which lead to a set of detailed intentions for the future. The assessment criteria attempt to describe in the clearest terms possible, exactly what a learner will be able to do at the end of the learning experience.

Just as a learning outcome describes events so assessment criteria describe an activity that learners will be able to do to demonstrate their competence.

Where appropriate, practical engineering examples are included to assist the understanding and application of certain mathematical techniques.

This qualification, together with OCR's Level 3 Certificate in Mathematics for Engineering, is part of the Additional and Specialist Learning for the Diploma in Construction and the built environment and the Diploma in Manufacturing.

This component is also part of OCR's Level 3 Principal Learning in Engineering qualification.

Learning outcomes	Assessment criteria	Exemplification
The learner will: develop knowledge and understand 1 Algebra Algebraic brackets Binomial expressions Algebraic factorisation Algebraic fractions Algebraic equations Simultaneous equations Transposition of formulae Transposition of formulae containing a square root or power Transposition of formulae containing two like terms Quadratic equations – solution by (a) factorisation (b) completing the square (c) formula Partial fractions	The learner can 1.1 State and apply the rule that when algebraic brackets are removed, every term within the bracket is multiplied by the quantity outside the bracket	$5(3 + x) = 15 + 5x$
	1.2 State and apply the rule for a binomial expression, which means that the contents of one bracket are multiplied by the contents of a second bracket	$(x + 3)(x + 2) = x^2 + 5x + 6$
	1.3 State and apply the rule that a factor of an algebraic expression is a letter or number that can be taken from the expression, the remainder of the expression being placed in brackets	$bx + by = b(x + y)$
	1.4 State and apply the rule for factorisation that gives a result with two brackets	$x^2 + 5x + 6 = (x + 3)(x + 2)$
	1.5 State and apply the rule that the principle of the lowest common multiple (LCM) is applied	$(x + 2)/ 5 + (x + 4)/3$ gives a common multiple of 15 leading to a solution of $(8x + 26)/15$
	1.6 State and apply the rule that an equation is a statement that two algebraic expressions are equal and the process of finding the unknown is called solving the equation	$5(x – 3) – 7(6 – x) = 12 – 3(8 – x)$ leading to a solution that $x = 5$

Learning outcomes	Assessment criteria	Exemplification
	1.7 State that when two equations contain two unknowns such as $2x + 5y = 10$ and $x + 2y = 3$, such that only one value of x and y exist that will satisfy both equations, are called simultaneous equations	
	1.8 Solve simultaneous equations by the elimination method and the substitution method	Solve practical engineering problems using simultaneous equations in the area of (a) mechanics using the distance travelled by an object is $s = ut + \frac{1}{2} at^2$ (b) electrical engineering using Kirchhoff's laws (c) fluid mechanics using $p_1 - rg(d - d_1)$ and $p_2 - rg(d - d_2)$ etc
	1.9 State that transposition of formulae means that we change the subject of a given formula, using the same rules as for the solution of equations	
	1.10 Transpose formulae that are used in engineering	(a) given $R = R_1 + R_2$ find R_2 (b) given $F = ma$ find m (c) given $PV = RT$ find T (d) given $v = u + at$ find t
	1.11 Transpose formulae used in engineering that contain a root or a power	(a) given $E = mv^2/2g$ find v (b) given $T = 2\pi \sqrt{(K^2/gh)}$ find K and g

Learning outcomes	Assessment criteria	Exemplification
	1.12 Transpose formulae used in engineering that contain two like terms	Given $Mv + mu = MV + mU$ find M or m
	1.13 Solve quadratic equations using the factorisation method	Given $x^2 + 6x + 8 = 0$ leads to $(x + 2)(x + 4) = 0$ so $(x + 2) = 0$ or $(x + 4) = 0$ so $x = -2$ or $x = -4$
	1.14 Solve a quadratic equation of the type $ax^2 + bx + c = 0$ using the rules for completing the squares (i) rewrite the equation in the form $ax^2 + bx = c$ (ii) divide both sides of the equation by the value of "a" (iii) add to each side of the equation the square of one-half the value of "b" (iv) take the square root of each side of the equation and solve the resulting equation for "x"	Apply quadratic equations to engineering applications in the area of (a) bending moment (M) of beams $M = 0.3x^2 + 0.35x - 2.6$ (b) displacement S of a particle $S = 1.9t + 4.3t^2$ (c) fabrication of steel boxes when the volume of the box is $2(x - 4)(x - 4)$ and "x" is a required dimension (d) fluids going through two pipes to fill a reservoir at different time (e) power P when the power developed in an electronic circuit is $P = 10i - 8i^2$ (f) sag L metres in a cable when $L = (12/x) + x$ where "x" is the distance between cable supports (g) acid dissociation constant K is $K = x^2/v(1 - x)$ where "x" is the degree of ionisation
	1.15 Solve a quadratic equation of the type $ax^2 + bx + c = 0$ using the formula $x = [- b \pm \sqrt{(b^2 - 4ac)}]/ 2a$	

Learning outcomes	Assessment criteria	Exemplification
	1.16 State and apply the rule that will split up a single fraction whose denominator has factors into two partial fractions	$5/(x^2 + x - 6)$ resolves into $1/(x - 2) - 1/(x + 3)$
2 Geometry and trigonometry The learner will develop knowledge and understand Degrees and radians Length of arc of a circle Area of sector of a circle Solution of a right-angled triangle Graphs of trigonometrical functions $y = \sin x$, $y = \cos x$ and $y = \tan x$ Values of $\sin x$, $\cos x$ and $\tan x$ for angles between 0^0 and 360^0 Sine rule Cosine rule Area of a triangle Complementary angles Ratios of 30^0, 45^0 and 60^0 Reciprocal of sine, cosine and tangent Trigonometrical identities Solid trigonometry with three-dimensional problems	2.1 Define the terms angle and radian 2.2 State and apply the formula that 1 radian = $360^0/2\pi$ degrees and that 1 degree = $2\pi/360$ radians 2.3 State and apply the formula that the length of an arc of a circle $S = xr$ radians and $S = \pi x^0 r/180$ where r is the radius of the circle and x^0 is the subtended angle	(a) A wheel is rotating at the rate of 54 revolutions per minute. Determine the angular speed in radians per minute (b) A shaft is rotating at 100 revolutions per minute. Express this in radians per second (c) A water main is 500 mm diameter, and is more than half full of water. The angle subtended at the centre by the horizontal surface of the water is $(2/3)\pi$ radians. Calculate (i) the length of the surface that is wet (ii) the depth of the water (d) The braking surface of a brake lining has a cross-section in the form of an arc of a circle of radius 120 mm, and the angle subtended by the arc is 120^0. Calculate the length of the arc

Learning outcomes	Assessment criteria	Exemplification
	2.4 Explain what is meant by the term "solution of a triangle"	
	2.5 State and apply the formula that the sine of an angle is the ratio of the side opposite to the hypotenuse in a right-angled triangle	(a) A triangular template is being made for use in a workshop. The hypotenuse of the right - angled triangle is 150 mm. One angle is 23^0. Determine the value of the third angle and the lengths of the other two sides
	2.6 State and apply the formula that the cosine of an angle is the ratio of the side adjacent to the hypotenuse in a right-angled triangle	(b) Surveying – From two points A and B, 100 m apart, in a straight line with a tower, the angles of elevation of the top of the tower are 20 and 35^0 respectively. Determine the height of the tower
	2.7 State and apply the formula that the tangent of an angle is the ratio of the opposite side to the adjacent side in a right-angled triangle	(c) Two pulleys A and B of diameter 100 and 70 mm respectively, are connected by an open belt. The centre distance between the pulleys is 140 mm. Calculate (i) the length of the belt assuming it does not sag (ii) the rotational speed of pulley B if pulley A is rotating at 210 rev/min
		(d) A single phase load takes a current of 5 amperes on a 240 volt 50 hertz supply at a lagging power factor of 0.8. Calculate the capacitance of a capacitor to correct the power factor to unity
		(e) An engineering factory is supplied with a 2000 volt single phase 50 hertz supply, and takes a load current of 400 amperes at 0.6 power factor lagging. Calculate the capacitance of a capacitor that will alter the power factor to (i) unity, (ii) 0.9 lagging and (iii) 0.9 leading

Learning outcomes	Assessment criteria	Exemplification
	2.8 Plot a graph of y = sin x, y = cos x and y = tan x for a range of angles from 0^0 to 360^0 2.9 Determine the sine, cosine and tangent of any angle between 0^0 and 360^0 from a graph or by using a calculator	(a) An alternating e.m.f. is represented by v = 25 sin x. Determine the value of v when x equals (i) 30^0 ,(ii) 60^0, (iii) 90^0, (iv) 180^0 (v) 210^0, and (vi) 270^0 (b) The instantaneous value of an alternating current is given by i = 5 sin 314.2t amperes. Determine (i) peak value (ii) frequency (iii) periodic time (iv) the current after 12 milliseconds, and (v) sketch a sine wave showing the position of the current calculated in part (iv) (c) An oscillating mechanism has a maximum displacement of 3 m and a frequency of 60 Hz. At time t = 0 the displacement is 75 m. Express the displacement in the general form A sin (wt ± x) where A = maximum displacement, w = angular velocity, x = lagging or leading angle in radians
	2.10 State and apply the sine rule for a triangle that a/sin A = b/sin B = c/sin C where A, B and C are angles within the triangle and a, b and c are the lengths of the three sides	(a) A workshop 10 m wide has a span roof which slopes at 30^0 on one side and 45^0 on the other. Calculate the length of the roof slopes (b) An e.m.f. of 20 volts lags another e.m.f. of 40 volts by 60^0. Determine the magnitude of the total e.m.f. and its phase angle

Learning outcomes	Assessment criteria	Exemplification
	2.11 State and apply the cosine rule for a triangle that $a^2 = b^2 + c^2 - 2bc.\ \cos A$, $b^2 = a^2 + c^2 - 2ac.\ \cos B$ and $c^2 = a^2 + b^2 - 2ab.\ \cos C$ where A, B and C are angles within the triangle and a, b, and c are the lengths of the three sides	(a) A jib crane consisting of a tie AB and a strut BC is fixed to two points CA fastened to a vertical post. Point C is at ground level. AB =10 m, BC = 15 m and CA = 12 m. Sketch the jib crane and calculate the height of the point B above ground level and the horizontal distance of point B from the wall (b) In a reciprocating engine the lengths of the crank AC and the connecting rod AB are 1 m and 4.8 m respectively. Calculate the value of angle ABC when the angle ACB is 86^0 (c) Two quantities are represented by vectors of lengths 25 and 50, which act at the same point. The angle between the vectors is 60^0. Calculate the resultant quantity and the angle it makes with the larger of the original quantities

Learning outcomes	Assessment criteria	Exemplification
	2.12 For a triangle state and apply the formulae for the area of a triangle (a) Area = ½bh where b is the length of the base and h is the perpendicular height (b) Area = ½bc sin A where b and c are the lengths of two sides and A is the angle opposite the third side (c) Area = $\sqrt{}$ [s(s - a)(s - b)(s – c)] where a, b, and c are the lengths of the sides of the triangle and s = ½(a + b + c) 2.13 State and apply the formula that (a) sin A = cos (90 – A) (b) cos A = sin (90 – A) 2.14 State and apply (a) tan 45^0 = 1 (b) sin 45^0 = 1/ $\sqrt{2}$ and (c) cos 45^0 = 1/ $\sqrt{2}$ 2.15 State and apply (a) sin 60^0 = $\sqrt{3}/2$ (b) cos 60^0 = ½ (c) tan 60^0 = $\sqrt{3}$ (d) sin 30^0 = ½ (e) cos 30^0 = $\sqrt{3}/2$ (f) tan 30^0 = $1/\sqrt{3}$	(a) The plan of a building plot is a quadrilateral ABCD in which AB = 50 m, BC = 60 m, CD = 32 m, DA =42 m and the diagonal BD = 66 m. Calculate the area of the plot of land (b) An iron casting has a uniform triangular cross- section with the following dimensions: length of base of triangle = 400 mm, height of triangle = 75 mm. Determine the cross-sectional area of the casting (c) A copper bar with a uniform cross-section is in the form of a regular hexagon with sides 15 mm long. Calculate the cross sectional area of the bar

Learning outcomes	Assessment criteria	Exemplification
	2.16 State and apply that (a) the reciprocal of sine is the cosecant (cosec), ie 1/sin x = cosecant x (b) the reciprocal of cosine is the secant (sec), ie 1/ cos x = secant x (c) the reciprocal of tangent is cotangent (cot), ie1/ tan x = cotangent x. 2.17 Prove from first principles that (a) tan A = sin A / cos A (b) cot A = cos A / sin A (c) $\sin^2 A + \cos^2 A = 1$ (d) $1 + \cot^2 A = \text{cosec}^2 A$ (e) $\tan^2 A + 1 = \sec^2 A$	(a) Given that tan x = 4/3, find the value for sin x and cos x (b) Using complementary angle, find a value for (i) $\sin 40^0/\cos 50^0$ (ii) $\sec 20^0/\text{cosec } 70^0$ (c) Show that the identity $\sin^2 x + \cos^2 x = 1$ is true when $x = 125^0$ (d) Prove that tan x = sec x/cosec x (e) Prove that $\sin^2 x (\text{cosec}^2 x + \sec^2 x) = 1/\cos^2 x$

Learning outcomes	Assessment criteria	Exemplification
	2.18 State that a plane is a flat surface, defined as a surface containing all of the straight lines passing through a fixed point and also intersecting a straight line in space 2.19 Deal with problems in three dimensions by drawing suitable triangles in different planes and then calculating dimensions as required	(a) A solid block of material is 67.5 mm x 45.8 mm x 23.6 mm. Determine (i) its longest dimension and (ii) the angle the longest dimension makes with the base of the block (b) A solid pyramid has a square base of side 45 mm with a perpendicular height of 60 mm. Calculate (i) the length of the diagonal of the base ii) the length of one of the sloping sides, and (iii) the angle that the sloping side edge makes with the base (c) A television mast is held vertical by a number of cables fastened to its top and pegged to the ground. Two of these cables are inclined at 38^0 to the vertical and pegged 50 m from the bottom of the mast. Calculate (i) the length of each cable (ii) the height of the mast (iii) the distance between the two pegs if the angle between the two cables is 80^0

Learning outcomes	Assessment criteria	Exemplification
3 Calculus The learner will develop knowledge and understand The gradient of a curve Differentiation from first principles Differentiation of algebraic functions Maximum and minimum turning points Differentiation of sine and cosine Differentiation of the exponential function Differentiation of the logarithmic function Indefinite integrals Definite integrals Area under a curve Integrals of sin x and cos x	3.1 Determine gradients to a simple curve using a graphical method eg $y = a.x^2$ where "a" is a constant and determine the gradient of a curve using a numerical method 3.2 Derive dy/dx for the functions $y = a.x^n$, $n = 0$, $n = 1$, $n = 2$, $n = 3$ from first principles 3.3 State and apply the rule to differentiate simple algebraic functions	Solve problems in the area of mechanics using the formula for distance (s) travelled by a body in t seconds is given by $s = t^3 - 5t^2 - 3t$. Express the velocity in terms of time t. velocity = ds/dt and acceleration = d^2s/dt^2
	3.4 Given a graph of $y = x^3 - 3x - 1$, identify the maximum and minimum turning points and then determine the co-ordinates of the turning points by differentiating the equation twice. If d^2y/dx^2 is positive for a value of x the turning point is at a minimum value for y. If d^2y/dx^2 is negative for a value of x the turning point is at a maximum value for y	Given that the surface area S of a cylindrical water tank is given by $S = 2\pi(r^2 + 6750/r)$. Calculate the dimensions of the tank so that its total surface area is a minimum

Learning outcomes	Assessment criteria	Exemplification
	3.5 Draw a graph and then find the derivation of sin x and cos x	
	3.6 Differentiate functions of the form (a) $y = \sin x$ (b) $y = a. \sin x$ (c) $y = a. \sin bx$ (d) $y = \cos x$ (e) $y = a. \cos x$ (f) $y = a. \cos bx$ (g) $y = a. \cos x + b. \sin x$, where "a" and "b" are constants	Given that an alternating voltage is given by $v = 20 \sin 50t$ where v is in volts and t in seconds. Calculate the rate of change of voltage at a given time
	3.7 State and apply the rule for differentiating an exponential function eg (a) If $y = a. e^{bx}$ then $dy/dx = ba. e^{bx}$ (b) If $y = a. e^{-bx}$ then $dy/dx = -ba. e^{-bx}$ 3.8 State and apply the rule for differentiating a logarithmic function eg (a) If $y = \ln x$ then $dy/dx = 1/x$ (b) If $y = \ln 3x$ then $dy/dx = 1/x$ (c) If $y = 4. \ln 2x$ then $dy/dx = 4/x$	Laws (a) linear expansion $l = l_0. e^{ab}$ (b) tension in belts $T_1 = T_0. e^{\mu a}$ (c) biological growth $y = y_0. e^{kt}$ (d) discharge of a capacitor $q = Q. e^{-t/RC}$ (e) radioactive decay $N = N_0. e^{-wt}$ (f) atmospheric pressure $p = p_0. e^{-h/c}$ (g) decay of current in an inductive circuit $i = I. e^{-Rt/L}$ (h) growth of current in a capacitive circuit $i = I(1 - e^{-t/RC})$

Learning outcomes	Assessment criteria	Exemplification
	3.9 Define indefinite integration as the reverse process to differentiation and state that an indefinite integral does not reveal a calculated value	
	3.10 Recognise the symbol $\int$ for integration and then state and apply the rule to integrate simple algebraic functions eg If $y = a x^n$ then $\int ax^n \, dx = a (x^{n+1}/ n + 1) +$ constant C. The term dx indicates the variable that is the subject of the integration process and $n \neq -1$	(a) Integrate $x^3 + 3x^2 + x$ with respect to x (b) Integrate $x^{1.4} + 1/x^3$ with respect to x (c) Integrate $6t^4 + \sqrt{t}$ with respect to t
	3.11 State and apply the rule for a definite integral and also state that in all calculations for definite integrals the constant C will disappear when an upper and lower limit are given	(a) Calculate a value for the definite integral $_2\int^4 6x \, dx$ $_2\int^4 6x \, dx = [6x^2/2 + C]^4_2 = [3x^2 + C]^4_2$. The numerical values of 2 and 4 mean that x = 2 and x = 4. When x = 4, integral $=3x^2 + C = 48 + C$ When x = 2, integral $= 3x^2 + C = 12 + C$ So $_2\int^4 6x \, dx = (48 + C) – (12 + C)$ $= 48 + C – 12 – C$ $= 36$ ie $_2\int^4 6x \, dx = 36$ (b) Integrate $_0\int^2 4x \, dx$ (c) Integrate $_0\int^3 2t^2 \, dt$ (d) Integrate $_1\int^2 (3x + 2) \, dx$ (e) Integrate $_1\int^4 (2x^3 + x^2) \, dx$

Learning outcomes	Assessment criteria	Exemplification
	3.12 State and apply that the interpretation of a definite integral is that it represents the area between the function f(x) and the x axis between the limits given	(a) Find the area between the curve y = x and the x axis between the values x = 0 and x =10 Equation: y = x Area under the curve = $\int_0^{10} x\,dx = [\,x^2/2\,]_0^{10}$ $= 10^2/2 - 0 = 50$ units A check on y = x can be made by plotting a graph of x against y (b) Find the area under the curve y = (x – 3)(x – 2) from x = 2 and x = 3 (c) The brakes are applied to a train and the velocity (v) at any time (t) seconds after applying the brakes is given by v = (18 – 3.5t) metres per second. Calculate the distance travelled in 6 seconds if distance (d) = $\int_{t1}^{t2} v\,dt$ (d) The force (F) newtons acting on a body at a distance x metres from a fixed point is given by F = $4x + 3x^2$. Calculate the work done (W) = $\int_{x1}^{x2} F\,dx$ when the body moves from the position where x = 2 metres to that where x = 5 metres.

Learning outcomes	Assessment criteria	Exemplification
	3.13 State and apply that (a) $\int \sin x \, dx = -\cos x + C$ (b) $\int \cos x \, dx = \sin x + C$	(a) Integrate the following with respect to x (i) sin 2x (ii) cos 3x (iii) cos (2x +Ø) (b) Evaluate the following integrals all between the limits of 0 and π/2 (i) sin x (ii) cos x (iii) sin 3x (iv) cos 3x (v) 3 cos 5x (vi) sin x + cos x (vii) 4 sin 5x + 3 cos 4x (viii) cos 4x – 5 sin x (ix) $2x^3$ + cos 4x – 3 sin 4x (x) sin 4x + 2 cos 6x + √x

Learning outcomes	Assessment criteria	Exemplification
4 Statistics The learner will develop knowledge and understand Data Handling Histograms Frequency polygon Cumulative frequency Arithmetic mean, mode and median Percentiles and quartiles Distribution curves Standard deviation Probability Expectation Dependent events without replacement Independent events with replacement Addition law of probability Multiplication law of probability	4.1 Explain what is meant by the term "data handling" 4.2 Explain what is meant by the term "histogram" and construct a histogram from given data 4.3 Explain what is meant by the term "frequency polygon" and construct a frequency polygon from a histogram	Collection and analysis of data – involves populations and samples The number of castings per box in a sample of 21 boxes was as follows: Number in box 70 71 72 73 74 75 Number of boxes 2 6 3 1 4 5 Draw a histogram and a frequency polygon from the information.
	4.4 Explain what is meant by the term "cumulative frequency" and construct a cumulative frequency curve from given data 4.5 Construct a table showing a tally diagram and then draw a (a) histogram (b) frequency polygon and (c) cumulative frequency diagram	The diameters of 30 components were measured in millimetres with a micrometer, with the following results: 5.8 6.2 6.0 6.2 5.9 6.1 5.9 5.7 6.1 5.5 5.8 5.9 6.2 6.1 6.0 6.0 5.9 6.0 6.0 5.9 6.0 6.1 5.9 6.1 6.2 6.3 6.3 6.3 6.3 6.2 Construct a table showing a tally diagram and then draw a (i) histogram (ii) frequency polygon and (iii) cumulative frequency diagram

Learning outcomes	Assessment criteria	Exemplification
	4.6 Explain and apply the following terms to a set of data (a) arithmetic mean (b) mode and (c) median	(a) The tensile strength for a sample of 15 tin specimens are: 34.16 34.75 34.04 34.36 34.15 34.94 34.16 34.25 34.55 34.85 34.35 34.44 34.84 34.04 34.28 Determine the mean, mode and median (b) The diameter of 100 spindles was measured giving the frequency distribution shown Diameter 10 10.2 10.4 10.6 10.8 11.00 11.2 Frequency (No of spindles) 4 8 15 28 32 10 3 Draw a cumulative frequency diagram and from it determine the median

Learning outcomes	Assessment criteria	Exemplification
	4.7 Explain and apply the following terms to a set of data (a) percentiles (b) quartiles	(a) The values of mass obtained by weighing 200 components are shown:. Mass kg 93 94 95 96 97 98 99 Frequency 7 30 42 46 40 25 10 Plot a cumulative frequency curve and find the median and the upper and lower quartiles (b) In a study exercise components were assembled by a group of technicians. The times taken in seconds are shown: 56 61 68 59 74 69 73 76 68 80 79 57 76 89 96 74 97 66 74 86 63 77 98 53 69 78 70 74 87 66 83 78 77 78 72 88 54 90 63 75 94 84 86 65 80 73 60 67 75 52 Construct a histogram and a frequency polygon to represent the data. Determine the (a) median (b) lower quartile and (c) the upper quartile
	4.8 Explain what is mean by the terms (a) distribution curve (b) positive skew (c) negative skew 4.9 Explain and apply the following terms to a set of data (a) variance (b) standard deviation	(a) Calculate the standard deviation for a set of test scores: 80% 70% 65% 40% 55% 50% (b) A random sample of components were taken from a production line, measured on dimensions nominally 6 +/- 0.5 units and put into categories as follows: Variation x 5.6 5.8 6.0 6.2 6.4 Frequency f 2 8 19 15 6 Calculate the arithmetic mean and standard Deviation

Learning outcomes	Assessment criteria	Exemplification
	4.10 Explain and apply the following terms to data (a) probability (b) expectation (c) dependent events without replacement (d) independent events with replacement 4.11 State and apply the addition law of probability and the multiplication law of probability	(a) Determine the probability of selecting at random (i) a drill for use on bricks (ii) a drill for use in wood, from a box of drills containing 25 brick drills and 40 wood drills (b) The probability of an engineering system failing in one year due to excessive temperature is 1/25, due to excessive vibration is 1/30 and due to excessive humidity is 1/55. Determine the probabilities that over one year the system fails due to excessive (i) temperature and vibration assuming that the failure modes are independent (ii) vibration or humidity assuming that the failures are mutually exclusive (c) A batch of 30 castings contains 5 which are defective. If a casting is chosen at random and inspected for quality and then a second casting is chosen at random, determine the probability of having exactly one poor quality casting, both with and without replacement

Form of assessment

This component is externally assessed. The application of mathematical principles and the analytical nature of this component make external assessment the most suitable form of assessment.

The examination paper will include questions on:

- Algebra
- Calculus
- Geometry and Trigonometry
- Statistics

Questions will, wherever possible, be presented in an engineering context.

In line with other similar specifications it will not be possible to test every part of the detailed assessment criteria at each session. It is anticipated, however, that over a period of 5 years all content will be covered at least once.

Approaches to applied learning

At first the content of this component looks extensive but it needs a closer inspection to realise that everything that a presenter needs to know when teaching the component is provided in the assessment criteria.

It is intended that the basic facts are taught, ideally by a mathematics specialist presenter together with an abundance of worked examples. The learner having been provided with sufficient mathematical tools should then, possibly with some assistance, be able to carry out theoretical calculations. It is essential to present wherever possible mathematical techniques in the context of practical engineering examples

With so wide a range of subject content areas ie Algebra, Geometry and Trigonometry, Calculus and Statistics, the order in which they have been presented is not necessarily the order in which they should be taught. This matter is left to the discretion of the presenter taking into account the wants and needs of the learner.

Presenters are reminded that this component is assessed by an external test so it is important that all of the learning outcomes are covered taking into account the nature of the test.

Resources for teaching aspects of Mathematics can be found in the teacher and trainer resources produced by the Quality Improvement Agency (QIA) National Teaching and Learning Change Programme 'Improving learning in Mathematics'.

4 Scheme of Assessment

4.1 Level 3 Certificate Scheme of Assessment

Level 3 Certificate in Mathematical techniques and applications for engineers (H865)

100% of the total marks
2 hr written paper
60 marks

- *This question paper consists of a number of questions of different lengths and mark allocations.*
- *Candidates answer all questions.*
- *This component is externally assessed.*

4.2 Assessment Availability

Two examination sessions will be offered each year, in January and June. The first examination series will be held in January 2010.

5 Technical Information

5.1 Making Entries

Candidates must enter for:

- Level 3 Certificate in Mathematical techniques and applications for engineers (entry code H865).

5.2 Grading

The Level 3 Certificate in Mathematical techniques and applications for engineers is awarded on the scale A*-E. Grades are awarded on certificates. However, results for candidates who fail to achieve the minimum grade (E) will be recorded as unclassified (U) and this is not certificated.

5.3 Enquiries about results

Under certain circumstances, a centre may wish to query the result issued to one or more candidates. Enquiries about Results for this qualification must be made immediately following the series in which the relevant component was taken (by the Enquiries about Results deadline).

Please refer to the *JCQ Post-Results Services* booklet and the *OCR Admin Guide (14-19 Qualifications)* for further guidance about action on the release of results. Copies of the latest versions of these documents can be obtained from the OCR website.

5.4 Qualification Re-sits

Candidates may enter for the full qualifications an unlimited number of times.

5.5 Guided Learning Hours

Level 3 Certificate in Mathematical techniques and applications for engineers requires **60** guided learning hours in total.

5.6 Arrangements for Candidates with Particular Requirements

For candidates who are unable to complete the full assessment or whose performance may be adversely affected through no fault of their own, teachers should consult the *Access Arrangements and Special Consideration Regulations and Guidance Relating to Candidates who are Eligible for Adjustments in Examinations*. In such cases advice should be sought from OCR as early as possible during the course.

5.7 Disability Discrimination Act

This qualification has been reviewed to identify whether any of the competences required by the subject present a barrier to candidates with a disability. Where this was the case, such competencies were included only where essential to the subject.

Reasonable adjustments may be made for candidates with a disability in order to enable them to access assessments. Applications should be made on an individual basis to OCR, however, centres are encouraged to consider first the access arrangements set out in Section A of the JCQ document *Regulations and Guidance Relating to Candidates who are Eligible for Adjustments in Examinations*. Information on reasonable adjustments can be found within Section B, Chapter 9, of the above-mentioned JCQ publication. In such cases advice must be sought from OCR as early as possible during the course.

Candidates who are unable to access part of the assessment, even after exploring all possibilities through reasonable adjustments, may still be able to receive an award based on the parts of the assessment they have taken.

6 Other Specification Issues

6.1 Key Skills Mapping

This specification provides opportunities for the development of the Key Skills of *Communication, Application of Number, Information Technology, Working with Others, Improving Own Learning and Performance* and *Problem Solving* at Levels 2 and/or 3. However, the extent to which this evidence fulfils the Key Skills criteria at this level will be totally dependent on the style of teaching and learning adopted for the qualification.

The following table indicates where opportunities *may* exist for at least some coverage of the various Key Skills criteria at Levels 2 and/or 3 for the qualification.

Communication	*Application of number*	*IT*	*Working with others*	*Improving own learning and performance*	*Problem solving*
✓	✓			✓	✓

6.2 Spiritual, Moral, Ethical, Social, Legislative, Economic and Cultural Issues

Candidates are required to examine arguments critically and so to distinguish between truth and falsehood. They are also expected to interpret results of exercises and there are times, particularly in statistical work, when this inevitably raises moral, ethical, social and cultural issues. Such issues are not assessed in examination questions.

6.3 Sustainable Development, Health and Safety Considerations and European Developments

There may be opportunities for candidates to address these issues during the course of their study, however this has not been addressed by the specification. Such issues are not assessed in examination questions.

6.4 Avoidance of Bias

OCR has taken great care in preparation of this specification and assessment materials to avoid bias of any kind.

6.5 Language

This specification and associated assessment materials are in English only.

6.6 Mode of delivery

OCR does not specify the mode of study or specify a time limit for the achievement of this qualification other than the expiry dates for entry and certification laid down by the regulatory authorities and detailed in the Profile of the Qualification (section 2.1).

Centres are free to deliver this qualification using any mode of delivery that meets the needs of their learners. Whatever mode of delivery is used, centres must ensure that learners have appropriate access to the resources appropriate to the task and as required by the qualification.

Centres should consider the learners' complete learning experience when designing learning programmes. This is particularly important in relation to learners studying part time alongside real work commitments where they may bring with them a wealth of experience that should be utilised to maximum effect by tutors, teachers and assessors.

6.7 Progression from this Qualification

This qualification is designed to enable candidates to progress either directly to employment, or to proceed to further qualifications. For example, candidates achieving this qualification as part of a Diploma may progress to Higher Education or to employment within the engineering, manufacturing or construction sector.

7 Further Support and Information

7.1 General enquiries

For general enquiries relating to any of OCR's qualifications, please contact the OCR Customer Contact Centre:

For queries relating to vocational qualifications:
Telephone: 02476 851 509
Fax: 02476 421 944
Email: vocational.qualifications@ocr.org.uk

For queries relating to general qualifications:
Telephone: 01223 553 998
Fax: 01223 552 627
Email: general.qualifications@ocr.org.uk

(The teams in both our contact centres can help you with your queries relating to Diplomas, Principal Learning and Project.)

Alternatively, you could visit OCR's website at www.ocr.org.uk for further information on OCR qualifications.

7.2 OCR Training Events

Information on OCR's training events for centres can be found on our website by going to www.ocr.org.uk, or by contacting:

OCR Training
Customer Support Division
Progress House
Westwood way
Coventry
CV4 8JQ

Telephone: 02476 496 398
Fax: 02476 496 399
Email: training@ocr.org.uk

7.3 OCR Publications

OCR's *Publications Catalogue* (A410) lists all the qualifications that OCR offers, and contains more detail on how to order publications. It is available to download from the OCR website at www.ocr.org.uk or to order from the OCR Customer Contact Centre by telephoning 02476 851 509, or 01223 553 998.

If you would like to order any OCR Publications, please contact:

OCR Publications
PO Box 5050
Annesley
Nottingham
NG15 0DL

Telephone: 0870 770 6622
Fax: 0870 770 6621
Email: publications@ocr.org.uk

OCR Support Materials prepare extra resources to help you deliver our qualifications. These support materials can be ordered from OCR Publications and more information about the materials can be obtained from support.materials@ocr.org.uk

7.4 OCR Diplomas

OCR diplomas will be introduced into centres between 2008 and 2014. Designed principally, although not exclusively, for 14 to 19 year olds, each diploma explores a range of widely applicable skills and knowledge within the context of one employment sector. At the heart of the diploma is the concept of applied learning – acquiring knowledge and skills through tasks or contexts that have many of the characteristics of real work.

Each diploma has three components:

Principal learning

Generic learning

Additional and specialist learning

For a full list of the Diploma work related sectors please refer to www.qca.org.uk