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Cambridge **TECHNICALS LEVEL 3**

ENGINEERING

MAPPING MEI RESOURCES TO CAMBRIDGE TECHNICALS IN ENGINEERING LEVEL 3

Version 1

ROYAL ACADEMY OF **ENGINEERING**

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CONTENTS

INTRODUCTION

The Royal Academy of Engineering contracted Mathematics in Education and Industry (MEI) to provide contextualised examples of mathematics applied to problems in engineering. The aim of the work was to provide support for the learning outcomes/aims across level 3 engineering programmes. A total of 43 resources were developed. This was broken down into 13 small resources, 15 medium resources and 5 large resources.

This document provides a mapping of these resources to the Cambridge Technicals in Engineering.

The mapping shows how these resources could be used to support the delivery of selected units and learning outcomes in terms of their mathematical content in the context of solving engineering problems.

The MEI resources can be accessed at the following web link:

http://integralmaths.org.uk

Free subscriptions are available to the MEI resources which is explained at the following web link:

http://www.mei.org.uk/engineering

To find out more about the Cambridge Technicals in Engineering go to the following web link:

http://www.ocr.org.uk/qualifications/vocational-education-and-skills/cambridge-technicals-engineering-level-3-certificate-extended-certificate-foundation-diploma-diploma-05822-05825/

DESCRIPTION OF MEI RESOURCES

Resource no:	Resource title:	Resource description:	Mathematics content:
1	AC Electricity	The resource is about the use of AC electricity to manage the supply of electricity to the national grid.	• Mathematical modelling • Trigonometry and co-ordinates • Graphs • Degrees and radians • Angular motion • Algebra
2	Air Tracking of a Ground Object	This resource describes how digital devices, such as computers, convert physical measurements that can take any value into equivalent digital measurements.	• 2D and 3D coordinate geometry • Linear algebra • Translation of engineering contexts into maths
3	Analogue to Digital Conversion in Distance Measuring	This resource describes how digital devices, such as computers, convert physical measurements that can take any value into equivalent digital measurements.	• Algebra • Evaluate expressions • Work in index form
4	Bending Metal	When a metal sheet is bent the inner side is compressed and the outer side is stretched. The amount of stretch depends upon how the bend is made. For a sharp crease in a metal sheet, the stretching can be extreme and can tear the outer side of the metal, weakening the product. Bending a pipe in such a manner not only weakens it structurally, it also constricts the pipe making it less effective for carrying fluids. The resource is about how metal sheets and pipes can be bent so that their strength and performance are preserved.	• Trigonometry and coordinate geometry • Degrees and radians • Algebra • Ratio and proportion • Perimeter, area and volume
5	Bio-Production Engineering	The resource is about producing useful compounds through biological activity using bioreactors. The yield of the material depends on many parameters, including the biological population size in the reactor. Mathematical modelling can help predict behaviour so that an efficient production process can be constructed. In this resource the focus is on using exponential functions to model the growth of a population of bacteria.	• Mathematical modelling • Change, growth and decay • Differentiation and integration • Translation of engineering contexts into maths
6	Capstans	The resource explores how the use of a capstan can take advantage of the force due to friction to reduce significantly the amount of effort needed to control an object.	• Trigonometry and coordinate geometry • Degrees and radians • Algebra • Changing the subject • Graphs – plotting and interpreting • Logarithms • Exponential growth and decay
7	Car Speedometers	This resource shows the method used to convert between miles per hour and kilometres per hour.	• Converting between units
8	Circuit Board Manufacture	This resource uses component edge clearance to calculate the area of a circuit board using binomial expressions.	• Algebra • Multiplying out brackets • Binomial expressions

Resource no:	Resource title:	Resource description:	Mathematics content:
9	Dormer Window Extension	This resource is about using mathematics to determine lengths and angles for a building project, working from two-dimensional drawings.	• Trigonometry and coordinate geometry • Pythagoras' theorem • Sine, cosine, tangent • Solving right angled triangles • Interpreting drawings • Calculating lengths and angles • Algebra • Units, and unit conversions • Area and volume • Estimation
10	Foam Cushioning	This resource looks at various ways of storing natural gas efficiently, and considers safety issues that can result. This requires the application of differentiation to analyse changes in the specific capacity per gram of activated carbon at different pressures.	• Mathematical modelling • Change, growth and decay • Mathematical functions and graphs • Differentiation and integration
11	Gas Compression and Expansion	This resource is about calculating the energy used or made available when the volume of a gas is changed.	• Area • Definite and indefinite integrals • Definite integrals and area
12	Heat Loss from Buildings	Heat transfer is important for many aspects of engineering with typical problems being either the effective transfer of heat from one region to another or the exact opposite; prevention of heat transfer. The resource is about designing a building to be as energy efficient as possible.	• Algebra • Perimeter, area and volume • Scale drawings • Using formulae • Graphs and tables • Using graphs
13	Irrigation Channels	Open channels are often used to transport water for irrigation, industrial and power generation purposes. Such channels often have a cross section that is parabolic in shape; this provides good strength and stability and has low wear. The resource investigates the characteristics of a parabolic channel.	• Algebra • Perimeter, area and volume • Calculus • Estimating area under curve • Integrating polynomial function
14	Light Sensing	Light sensing explores the use of light dependent resistors to measure the amount of light available, and to use this information to control devices such as light meters.	• Algebra • Index form • Using indices • Changing the subject • Linear equations • Simultaneous equations • Substitution • Plotting data • Drawing graphs • Extracting information from graphs • Straight line graphs – gradient, intercept and equation • Using laws of logarithms

Resource no:	Resource title:	Resource description:	Mathematics content:
15	Metal Bar Manufacture	This resource looks at the methods used to ensure that metal bars remain to the correct specification in the production line.	• Statistics • Data collection • Sampling • Organising and describing data • Mode, median and mean
16	Microphone Sensitivity	This resource explores the use of polar coordinates to provide plots for the sensitivity of directional microphones that are more readily understood than the equivalent Cartesian plots.	• Trigonometry and coordinate geometry • Graphs of y = sin x, y = cos x, y = tan x • Algebra • Cartesian and polar coordinates and graphs - conversions
17	Natural Gas Storage	This resource looks at various ways of storing natural gas efficiently, and considers safety issues that can result. This requires the application of differentiation to analyse changes in the specific capacity per gram of activated carbon at different pressures.	• Calculus • Differentiation and outcome as a gradient • Product, quotient and chain rules
18	Non-Destructive Weld Inspection	This resource is about using a radioactive source and photographic film to inspect welds to check there are no defects. In order to determine the exposure time for the film, the activity measured in GBq (giga-becquerels) of the radioactive source is required. This activity changes with time as the source decays. The resource investigates how the strength of a radioactive source changes with time.	• Algebra • Decimal places and significant figures • Interpreting answers to degrees of accuracy • Laws of logarithms • Graphs and tables • Exponential growth and decay • Forming algebraic expressions from description in words
19	Optimal Gutter Design	This resource uses calculus to consider how an optimal design for gutters can be produced that ensures they are large enough to cope with the expected flow of water, whilst requiring the least possible amount of material to construct the gutter.	• Calculus • Differentiation and outcome as a gradient • Turning points – maximum, minimum and stationary points of inflection • Second derivatives
20	Power Demand Planning	One important area of civil engineering is electrical power production. In order to plan for future building, which may take many years to prepare, design and construct, demand forecasts are often used to indicate the quantity and size of new power stations required. This resource is about using information from past and present demand to predict future power requirements.	• Mathematical modelling • Algebra • Rules for sequences • Changing the subject • Graphs and tables • Laws of logarithms • Exponential growth and decay • Algebra • Forming algebraic expressions from description in words
21	Predicting Performance of Power Lines	The resource is about predicting changes in the sag of power lines for a range of weather conditions, including the effect of ice build-up in winter months.	• Mathematical modelling • Functions and graphs • Differentiation and integration • Linear algebra • Mathematical arguments and proofs

Resource no:	Resource title:	Resource description:	Mathematics content:
22	Producing a Calibration curve for a Distance Measuring Device	This resource considers how data collected from a distance measuring device may be calibrated to obtain an estimate of the distance.	• Algebra • Linear, simultaneous and quadratic equations • Plotting data
23	Profiling Power Lines	The resource is about ensuring power lines are safe by calculating the extent to which they will sag under their own weight and under normal loads, so that the cables are always at a safe distance above the ground.	• Decimal places and significant figures – accuracy • Effects of accumulated errors • Estimation • Algebra • Linear, quadratic and simultaneous equations • Substitutions • Graphs – e.g. linear, quadratic, trigonometric, exponential • Gradients and tangents • Differentiation • Turning points – maximum, minimum and stationary points of inflection
24	Regenerative Braking	The resource is about designing a system for storing and reusing kinetic energy in a car.	• Mathematical modelling • Functions and graphs • Differentiation and integration • Translating realistic engineering situations into mathematics
25	Resistor Production	The resource is about using statistical data to help adjust a production process for resistors so that the resistances produced are close to the intended resistance, which means they can be sold for a higher price.	• Statistics • Graphs – pie charts, bar charts, vertical line diagrams, frequency • Using graphs to extract information • Probability
26	Resistor Use	The resource is about assessing the impact component tolerances can have on the performance of a design and the probability that component variability will lead to an unacceptable product.	• Statistics • Extracting numerical information from data sets • Probability • Laws of probability • Independent and mutually exclusive events
27	Risk Engineering	This resource uses probability as a tool to investigate how risks of threatening events such as floods or earthquakes may be analysed by engineers at the stage when a building or other structure is being designed.	• Statistics • Probability • Relative frequency • Laws of probability • Tree diagrams • Independent and mutually exclusive events
28	RMS Values	The resource is about using RMS values, which are a measure of the average of a varying quantity and are especially useful when a quantity can be both positive and negative, such as current, but its physical effect depends only on the absolute value. An example is the resistive heating caused by an alternating current. This activity describes why RMS values are a useful average and shows how they may be calculated.	• Trigonometry to model oscillations • Functions and graphs • Differentiation and integration • Linear algebra

Resource no:	Resource title:	Resource description:	Mathematics content:
29	Satellite Dishes	This resource considers why satellite receiver dishes have the shape they do. It considers why the shape of a parabola is relevant, and how the size of the dish may be reduced in some applications.	• Functions and graphs • 2-D and 3-D coordinate geometry – lines, planes and conic sections • Differentiation and integration • Translating realistic engineering situations into mathematics
30	Simple Gears and Transmission	The resource is about using gears and transmission to convert the speed of rotation and turning force from a motor into a new speed and turning force that match what is required for a particular piece of equipment.	• Trigonometry and coordinate geometry • Angular motion - revolutions per second, revolutions per minute and radians per second • Algebra • Fractions • Ratio and proportion • Percentages • Scale drawings • Simplifying expressions – indices • Changing the subject
31	Smoothing Noisy Data in Distance Measurement	This resource describes how data collected from a distance measuring device may be smoothed using statistical methods to provide a reliable estimate of distance.	• Algebra • Evaluating expressions • Percentages • Data collection and sampling • Describing data sets • Extracting information from data
32	Standard Values	This resource considers a problem found in producing components of varying sizes or values for use in manufacturing engineered products, namely 'how does a component manufacturer design a sensible set of standard sizes or values to offer?'	• Algebra • Percentages • Index form • Decimal places, significant figures and levels of accuracy • Simplifying expressions – indices • Changing the subject • Graphs and tables • Laws of logarithms
33	Statistical Process Control	This resource explores how statistical methods may be used to test whether a manufacturing process is working as intended or has drifted away from the specified values for the product.	• Statistics • Frequency graphs • Algebra • Extracting information from data

Resource no:	Resource title:	Resource description:	Mathematics content:
34	Surveying	This resource is about how surveyors can establish and keep track of key locations on a construction site.	• Trigonometry and coordinate geometry • Pythagoras' theorem • Sine, cosine and tangent • Algebra • Scale drawings • Decimal places and significant figures – accuracy • Plotting data • Cartesian and polar coordinates – conversion
35	Surveying Pylon Height	The resource is about finding the height of a pylon to ensure safe clearance for a flight path. Only indirect surveying methods are available as the pylon is carrying power lines and the original design specifications are not available.	• Mathematical modelling • Trigonometry and coordinate geometry • Sine, cosine, tangent • Solving right angled triangles • Algebra • Scale drawings • Decimal places, significant figures and levels of accuracy • Indentifying accumulated errors • Substitution • Changing the subject
36	Synchronous AC Motors	This resource looks at how the inductance of a coil affects the relationship between current and voltage, and at the impact it has on the power consumed by a device.	• Trigonometry and coordinate geometry • Graphs of $y = \sin x$, $y = \cos x$ and $y = \tan x$ • Calculus • Using the chain rule • Differentiating trigonometric functions
37	Temperature Sensing	The resource is about the way a refrigerator uses a temperature sensor to keep food products within a fixed temperature range, low enough to preserve the food as long as possible, but not so low that the liquids in the refrigerator freeze.	• Algebra • Evaluating expressions • Percentages • Changing the subject • Substitutions • Plotting data • Graphs and tables • Extracting information from graphs • Laws of logarithms • Exponential growth and decay
38	The AC Transformer	AC electricity is generated in power stations as it is more easily transformed from high voltage electricity that is more efficient for long-distance transmission, to a lower voltage that is more suitable for use in homes and workplaces. This resource considers the mathematics underpinning transformer design.	• Mathematical modelling • Algebra • Ratio and proportion • Using decimal places to express numerical answers • Changing the subject

Resource no:	Resource title:	Resource description:	Mathematics content:
39	The Band Brake	The resource is about how vehicle braking systems rely on friction to dissipate energy and slow the vehicle down. Usually this friction is generated by pressing one object against another. The resource considers how hard you need to press two objects together to generate a given braking force.	• Mathematical modelling • Trigonometry and coordinate geometry • Degrees and radians – conversion • Algebra • Exponential growth and decay
40	The Vane Anemometer	This resource analyses the wind drag on the cups of a vane anemometer, and considers how the resulting information may be used to calibrate the instrument.	• Mathematical modelling • Linear algebra • Algebraic processes • Arguments and proofs • Translating realistic engineering situations into mathematics
41	Thermal Expansion of Solids	This resource considers the problems that thermal expansion of solids can produce for engineers, and ways in which these can be analysed to produce an optimal rail design.	• Mathematical modelling • Algebra • Standards form • Using appropriate units • Converting between units • Graphs and tables • Straight line graphs - gradients
42	Wind Power	This resource investigates how the capacity of a wind turbine to produce power at close to its maximum value is affected by the speed of the wind.	• Probability • Graphs and tables • Extracting information from graphs and data • Area under curves (integration) • Algebra • Percentages • Translating realistic engineering situations into mathematics
43	Wind Vectors	The resource is about using vectors to work out relative positions and velocities of a ship and a helicopter that needs to land on the ship. The speed and direction of the wind is taken into account.	• Trigonometry and coordinate geometry • Pythagoras' theorem • Sine, cosine and tangent • Solving trigonometric functions • Vectors • Scale drawings • Algebra • Using decimal places to express numerical answers • Changing the subject • Solving linear equations • Substitution • Cartesian and polar coordinates – conversion

MAPPING OF MEI RESOURCES TO CAMBRIDGE TECHNICALS IN ENGINEERING LEVEL 3 UNITS

MEI resources	Cambridge Technicals in Engineering Level 3 units																				
Resource number and title	**Unit 1**	**Unit 2**	**Unit 3**	**Unit 4**	**Unit 5**	**Unit 6**	**Unit 7**	**Unit 8**	**Unit 9**	**Unit10**	**Unit 11**	**Unit 12**	**Unit 13**	**Unit 14**	**Unit 15**	**Unit 16**	**Unit 17**	**Unit 18**	**Unit 19**	**Unit 20**	**Unit 21**	**Unit 22**	**Unit 23**
1 AC Electricity	LO1 LO4			LO2																			
2 Air Tracking of a Ground Object	LO1 LO2	LO2																					LO1 LO5
3 Analogue to Digital Conversion in Distance	LO1			LO6			LO3							LO2	LO1								
4 Bending Metal	LO1 LO2 LO4	LO4							LO3		LO3												
5 Bio-Production Engineering	LO3 LO5																						LO2 LO3 LO5
6 Capstans	LO1 LO2 LO3 LO4	LO2	LO6							LO1					LO1								
7 Car Speedometers	LO1	LO2	LO1												LO1								
8 Circuit Board Manufacture	LO1					LO2																	
9 Dormer Window Extension	LO1 LO2 LO4								LO1	LO1													
10 Foam Cushioning	LO2 LO5	LO5																					LO2 LO3 LO5
11 Gas Compression and Expansion	LO5	LO5													LO4								
12 Heat Loss from Buildings	LO1	LO6																					
13 Irrigation Channels	LO1 LO5	LO5										LO4											
14 Light Sensing	LO1	LO3		LO1	LO3		LO2							LO3									
15 Metal Bar Manufacture	LO6								LO2		LO3						LO2	LO2					
16 Microphone Sensitivity	LO1 LO4				LO3		LO2							LO3									
17 Natural Gas Storage	LO5	LO6																					
18 Non-Destructive Weld Inspection	LO1 LO3																		LO4				
19 Optimal Gutter Design	LO5	LO5										LO4											
20 Power Demand Planning	LO1 LO3																						
21 Predicting Performance of Power Lines	LO1 LO5																						LO2 LO5
22 Producing a Calibration curve for a Distance	LO1	LO1	LO1											LO3									
23 Profiling Power Lines	LO1 LO2 LO5									LO1													

MEI resources	Cambridge Technicals in Engineering Level 3 units																					
Resource number and title	**Unit 1**	**Unit 2**	**Unit 3**	**Unit 4**	**Unit 5**	**Unit 6**	**Unit 7**	**Unit 8**	**Unit 9**	**Unit10**	**Unit 11**	**Unit 12**	**Unit 13**	**Unit 14**	**Unit 15**	**Unit 16**	**Unit 17**	**Unit 18**	**Unit 19**	**Unit 20**	**Unit 21**	**Unit 22**	**Unit 23**
24 Regenerative Braking	LO5	LO2	LO1																				LO2 LO3 LO5
25 Resistor Production	LO6																	LO2	LO1				
26 Resistor Use	LO6	LO3			LO1	LO1		LO1															
27 Risk Engineering	LO6																						
28 RMS Values	LO4 LO5			LO4	LO2	LO1	LO3																LO1 LO2 LO3
29 Satellite Dishes	LO2 LO5		LO3							LO1													LO1 LO2 LO3 LO5
30 Simple Gears and Transmission	LO1 LO4	LO1							LO1														
31 Smoothing Noisy Data in Distance Measurement	LO1 LO6	LO3					LO3	LO1															
32 Standard Values	LO1 LO3				LO1				LO2		LO2												
33 Statistical Process Control	LO1 LO6																	LO2	LO1				
34 Surveying	LO1 LO4								LO1	LO1													
35 Surveying Pylon Height	LO1 LO4								LO1	LO1													
36 Synchronous AC Motors	LO4 LO5			LO3	LO2		LO2	LO1															
37 Temperature Sensing	LO1 LO2						LO2							LO1 LO3									
38 The AC Transformer	LO1			LO4	LO2										LO2								
39 The Band Brake	LO1 LO4	LO2	LO5																				
40 The Vane Anemometer	LO1	LO1	LO1				LO2							LO3									LO2 LO5
41 Thermal Expansion of Solids	LO1 LO2	LO6																					
42 Wind Power	LO1 LO5 LO6	LO5																					LO2 LO5
43 Wind Vectors	LO1 LO4	LO2	LO1																				

The small print

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