Pearson BTEC Level 3 National Diploma in Civil Engineering

Unit 15: Further Mathematics for Construction

Level 3 – 60 GLH

Unit type: Internal

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www.edulibrary.co.uk

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Please read this handbook in conjunction with departmental and unit pages on Microsoft Office Teams (including the Programme Handbook)

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1 INTRODUCTION

1.1 Purpose of the Unit Handbook

This unit handbook aims to provide learners with guidance and support to develop and use skills to apply rules of transposition of formulae, arithmetical methods, calculus and statistics to construction problems.

1.2 Introduction to the Unit

Many of the buildings and structures that we encounter in our daily lives are the result of projects that civil engineers and building services engineers have worked on. They use a range of mathematical techniques and formulae to find out important physical properties of the buildings and structures. These could include finding the centre of gravity of an irregular shaped, precast cladding unit so that it can be safely lifted, using arithmetic or trigonometric techniques to determine areas of sites, or calculating the root mean square value of an alternating electric current to make sure the supply is suitable.

In this unit, you will investigate relevant aspects of pure mathematics and explore how you can solve complex practical problems. You will learn how to solve applied mathematical problems involving statistical data, structural properties for beams and columns, complex measurements, trigonometric identities, rates of change and decay, differentiation of maxima and minima, numerical integration, and complex areas or volumes by definite and indefinite integration. These mathematical skills are transferable and will be used to support your study of other topics in the BTEC Nationals in Construction programme, for example in surveying, electrical systems or structural analysis.

As a civil engineer or building services engineer, you will need to understand and develop the skills required to solve contextual problems using mathematical methods. This unit will prepare you for progression to higher education to study in the construction, civil engineering or building services engineering sectors at Higher National or degree level. It will also prepare you for an apprenticeship or employment in a range of construction

disciplines as a technician, and will help you work with professionals as part of a team working on cutting-edge products and systems.

1.3 Unit Content

Learning aim A: Examine how algebraic and trigonometric techniques can be used to solve a construction problem

A1 Transposition techniques

Rearrangement of formulae to determine new subjects and their use in evaluating data.

• Mathematical formulae to transpose, to include:

o linear, quadratic and cubic expressions

o trigonometric functions, to include sine, cosine, tangent ratios

o logarithmic functions

o binomial theorem applied to errors.

A2 Trigonometric techniques

Application of trigonometric techniques to 2D scenarios to solve construction problems involving the calculation of dimensions, angles, regular areas and irregular areas.

• Trigonometric functions, to include sine, cosine, tangent ratios.

• The sine rule, including ambiguous case.

• The cosine rule.

• Area rules for triangles.

A3 Construction-related problems

Typical problems that transposition and trigonometric techniques will solve.

• Application of properties of sections: o simple shapes, regular shapes, irregular shapes, to include:

– cross-sectional area

– location of centroid

– section modulus

– moment of inertia

– radius of gyration.

• Application of trigonometry to determine dimensions in 2D and 3D:

o in surveying

o in setting out

o other practical contexts, to include calculating heights, lengths etc.

Learning aim B: Examine how calculus can be used to solve a construction problem

B1 Differential calculus

Application of differentiation techniques to algebraic (polynomial), trigonometric (sine, cosine), logarithmic and exponential functions, for solving construction engineering problems.

• Standard differential calculus methods:

o polynomial equations of the form $s = 5t^2 - 3t + 4$

o trigonometric (sine, cosine) equations of the form $y = \sin^2 4x$

o logarithmic equations of the form $v = 8\log_e(5x)$

o exponential equations of the form $y = 2e^{(3x + 5)}$

• Differentiation by standard results, e.g. $y = ax^n$, where $dy/dx = nax^{(n - 1)}$

• Derivatives of algebraic (powers) ax^n

• Derivatives of trigonometric (sine, cosine) sinax, cosax

• Derivatives of logarithmic functions, for example logeax

• Derivatives of exponential functions, for example e^{ax}

• Product rule, e.g. $dy/dx = vdu/dx + udv/dx$

• Quotient rule, e.g. $dy/dx = vdu/dx – udv/dx / v^2$

• Function of a function (chain rule) method.

• Second order derivatives:

• second derivative of algebraic (polynomial), e.g. $y = ax^n$, where $d^2y/dx^2 = n(n - 1)ax^{(n - 2)}$

• second derivative of trigonometric (sine, cosine) functions

o the location of stationary values, to include turning points, points of inflection.

B2 Integral calculus

Application of indefinite and definite integration techniques to algebraic (polynomial), trigonometric and exponential functions, in order to solve construction problems.

• Routine functions integrated in one step without the need for manipulation, using standard integral calculus methods, to include:

o polynomial, e.g. $\int(x2 - 3x + 4)dx$

o trigonometric (sine, cosine), e.g. $\int(\sin 5\theta - 3\cos 4\theta)d\theta$

o reciprocal, e.g. $\int(3/x)dx$

o exponential, e.g. $\int(e^{3t})dt$

• Integration of common functions by standard results, e.g. ax^n , sinax, cosax, 1/x, e^{ax}

• Indefinite integrals, constant of integration, initial conditions.

• Definite integrals – limits and square bracket notation.

B3 Numerical integration

Application of the formulae for irregular areas and volumes for numerical integration.

• Trapezoidal rule:

o for comparison of methods in terms of complexity and accuracy.

• Mid-ordinate rule:

o for comparison of methods in terms of complexity and accuracy.

• Simpson's rule:

o area under a curve determined using Simpson's rule for comparison with values obtained using calculus.

• Numerical integration using a spreadsheet.

• Arithmetical calculation of various properties of sections, including:

o cross-sectional area

o location of centroid

o neutral axis

o moment of inertia

o section modulus

o radius of gyration.

Learning aim C: Investigate the use of statistical methods to solve a construction problem

C1 Statistical methods

How statistics are used in a construction context to convey relevant information that is in a useful format, appropriate to the audience.

• Presentation of data:

o histograms

o bar charts

o pie charts

o frequency graphs

o cumulative frequency graphs.

• Sampling distributions:

o normal distribution tables

o confidence limits

o significance testing.

C2 Use of statistical methods in construction contexts

How statistics are used in a construction context to solve problems.

• Measures of central tendency:

o mean

o mode

o median.

• Measures of dispersion:

o range

o variance

o standard deviation.

• Cumulative frequency:

o quartiles, deciles and percentiles

o interquartile range.

• Types of data:

o discrete data

o continuous data

o grouped data

o ungrouped data.

2 TEACHING AND LEARNING METHODS

Delivery will be through lectures, group workshops and tutorials. It is expected that learners undertake problem solving, further reading and research to support the guidance provided during taught sessions. Reading materials will be provided via the virtual learning environment (VLE) to support teaching but learners are encouraged to familiarise themselves with college library and online databases. Prior to each assessment, there will be series of formative feedback tutorial sessions/revision. These sessions will provide the opportunity for learners to receive constructive feedback on work/tasks prior to assessment.

3. LECTURE PROGRAMME

Week	Date	Lecture Duration (Hours)	Learning Aim	Session Aim
1	05/09/2023	1.5	LA A	- Unit introduction - Transposition techniques (1)
2	12/09/2023	1.5	LA A	- Transposition techniques (2)
3	19/09/2023	1.5	LA A	- Trigonometric techniques (1)
4	26/09/2023	1.5	LA A	- Trigonometric techniques (2)
5	03/10/2023	1.5	LA A	- Construction-related problems – Transposition and trigonometric techniques (1)
6	10/10/2023	1.5	LA A	- Construction-related problems – Transposition and trigonometric techniques (2)
7	17/10/2023	1.5	LA A	- **Issue Assignment 1**
8	24/10/2023	1.5	LA A	- **Student Support/Independent Study**
	31/10/2023			- **STUDY REVIEW WEEK**
9	07/11/2023	1.5	LA A	- **Student Support/Independent Study** - **Submit Assignment 1**
10	14/11/2023	1.5	LA B	- Differential calculus (1) – Standard differential calculus methods
11	21/11/2023	1.5	LA B	- Differential calculus (2) – Standard differential calculus methods

				- **Give feedback: Assignment 1**
12	28/11/2023	1.5	LA B	- Differential calculus (3) – Product rule
13	05/12/2023	1.5	LA B	- Differential calculus (4) – Quotient rule
14	12/12/2023	1.5	LA B	- Differential calculus (5) – stationary values.
15	19/12/2023	1.5	LA B	- Integral calculus (1) - Standard integral calculus method (1)
HOLIDAY	26/12/2023			
HOLIDAY	02/01/2024			
16	09/01/2024	1.5	LA B	- Integral calculus (2) – Standard integral calculus method (2)
17	16/01/2024	1.5	LA B	- Integral calculus (3) – Definite integrals
18	23/01/2024	1.5	LA B	- Numerical integration (1) – Irregular areas
19	30/01/2024	1.5	LA B	- Numerical integration (2) – Irregular volumes
20	06/02/2024	1.5	LA B	- **Issue Assignment 2**
	13/02/2024			- **STUDY REVIEW WEEK**
21	20/02/2024	1.5	LA B	- **Student Support/Independent Study**
22	27/02/2024	1.5	LA B	- **Submit Assignment 2** - **Student Support/Independent Study**
23	05/03/2024	1.5	LA C	- Statistical methods – presentation of data - Statistical methods – types of data
24	12/03/2024	1.5	LA C	- Statistical methods – measures of central tendency

				- **Give feedback: Assignment 2**
25	19/03/2024	1.5	LA C	- Statistical methods – measures of dispersion
HOLIDAY	26/03/2024			
HOLIDAY	02/04/2024			
26	09/04/2024	1.5	LA C	- Statistical methods – cumulative frequency
27	16/04/2024	1.5	LA C	- Statistical methods – sampling distributions - **Issue Assignment 3**
28	23/04/2024	1.5	LA C	- **Student Support/Independent Study**
29	30/04/2024	1.5	LA C	- **Student Support/Independent Study**
30	07/05/2024	1.5	LA C	- **Submit Assignment 3**
31	14/05/2024	1.5	LA C	- **Give Assignment 3 feedback**
32	21/05/2024	1.5	LA C	- **Student support for assignment non-submissions.**
	28/05/2024			- **STUDY REVIEW WEEK**
33	04/06/2024	1.5	LA C	- **Student support for assignment non-submissions.**
34	11/06/2024	1.5	LA C	- **Give Assignment 3 Resubmission feedback**
35	18/06/2024	1.5	LA C	- **Give Assignment 3 Resubmission feedback** - **End of unit**

4. ASSESSMENT SCHEDULE

4.1 Detailed Description of the Assessment Scheme

The unit will comprise three summative assessments.
Summative assessment One 15.1 will cover learning aim A.
Summative assessment Two 15.2 will cover learning aim B.
Summative assessment Three 15.3 will cover learning aim C.

NB: There will be ample opportunities for assessment resubmissions. Resubmission dates will be communicated in due course.

4.2 Learning Aim and Assessment Criteria

Learning aim A: Examine how algebraic and trigonometric techniques can be used to solve a construction problem

Pass	Merit	Distinction
A.P1 Demonstrate, using simple algebraic and trigonometric techniques, the calculation for a given construction problem.	A.M1 Demonstrate, using advanced algebraic and trigonometric techniques, the calculation for a given construction problem.	A.D1 Demonstrate, using complex algebraic and trigonometric techniques, the calculation for a given construction problem.

Learning aim B: Examine how calculus can be used to solve a construction problem

Pass	Merit	Distinction
B.P2 Demonstrate, using simple differential calculus techniques, the solution for a given construction problem. B.P3 Demonstrate, using simple integral calculus techniques, the solution for a given construction problem.	B.M2 Demonstrate, using advanced differential calculus, solutions for each type of given routine function, for a given construction problem. B.M3 Demonstrate, using advanced integral calculus and numerical integration, the solution for a given construction problem.	B.D2 Demonstrate, using complex differential and integral calculus techniques, the solution for a given construction problem, validating results achieved by numerical integration.

B.P4 Demonstrate, using simple numerical integration techniques, the solution for a given construction problem.		

Learning aim C: : Investigate the use of statistical methods to solve a construction problem

Pass	Merit	Distinction
C.P5 Demonstrate simple techniques to present grouped and ungrouped statistical data related to a given construction problem. C.P6 Demonstrate, using simple statistical analysis methods, the outcome of a given construction problem.	C.M4 Demonstrate, using advanced statistical analysis and assessment techniques, the outcome of a given construction problem.	C.D3 Demonstrate, using complex statistical analysis and assessment techniques, the outcome of a given construction problem.

4.3 Marking Standards

The controlled assessments will be marked in accordance with the Pearson standards. It will also meet requirements set by the Regulated Qualifications Framework (RQF). Learners are expected to make reasonable attempts towards problem solving. A coherent, well-balanced and organised approach to tasks with clear notations and evidence will be rewarded.

5. LEARNING RESOURCES

The library offers services and resources needed for this unit. The following resources have been provided to assist your studies in this Unit:

- Access to specialist databases.
- Class notes and lecture slides.
- Library electronic services.
- Links to online journal articles.
- Open-access computers and printers.
- Reprographic services.
- Staff expertise and advice.
- Librarian and team of learning support staff.

Pearson BTEC National Construction Student Book. Authors: Simon Topliss, Mike Hurst, Simon Cummings. Sohrab Donyavi

Weblinks:

https://edulibrary.co.uk/further-mathematics-for-construction

http://www.mathsisfun.com/index.htm

http://www.mathcentre.ac.uk/students/topics

Above are some examples of websites. Further useful resources may be found at
http://qualifications.pearson.com/en/support/published-resources.html#step1

If you have any queries about how to access any of these learning resources, please ask the Unit Leader.