Unit 4002: Engineering Mathematics

Unit Code: **A/651/0708**

Level: **4**

Credits: **15**

Introduction

The mathematics that is delivered in this unit is directly applicable to the engineering and manufacturing industry, and it will help to increase students' knowledge of the broad underlying principles within this discipline.

The aim of this unit is to develop students' skills in the mathematical principles and theories that underpin the engineering curriculum. Students will be introduced to mathematical methods and statistical techniques in order to analyse and solve problems within an engineering and manufacturing context.

On successful completion of this unit, students will be able to employ mathematical methods within a variety of contextualised examples, interpret data using statistical techniques, and use analytical and computational methods to evaluate and solve engineering and manufacturing sector problems.

Learning Outcomes

By the end of this unit students will be able to:

LO1 Apply a variety of mathematical methods to a range of engineering and manufacturing sector problems

LO2 Investigate applications of statistical and probability techniques to interpret, organise, and present data

LO3 Use analytical and computational methods for solving engineering and manufacturing sector problems by relating sinusoidal wave and vector functions to their respective applications

LO4 Examine how differential and integral calculus can be used to solve engineering and manufacturing sector problems.

Essential Content

LO1 **Apply a variety of mathematical methods to a range of engineering and manufacturing sector problems**

Mathematical concepts:

Dimensional analysis

Arithmetic and geometric progressions

Complex Numbers.

Matrices

Functions:

Exponential, logarithmic, trigonometric, and hyperbolic functions.

Engineering and manufacturing sector examples:

Case studies with vocational scenarios, occupation/sector specific applications, modern industrial trends, needs and goals (e.g., sustainability, digitalisation).

LO2 **Investigate applications of statistical and probability techniques to interpret, organise, and present data**

Summary of data:

Data collection methods

Presentation of data − histograms; bar charts; line diagrams; cumulative frequency diagrams; scatter plots

Grouped and ungrouped data

Mean, mode, median, and standard deviation of data

Pearson's and Spearman's correlation coefficient

Linear regression, Classification methods, linear correlation coefficient and product moment correlation

Coordinate systems and reference frames

Effective data communication and representation methods/formats for stakeholder groups; accessible, inclusive, and diversity considerations and implications.

Hypothesis Testing:

Null hypothesis

Alternate hypothesis

Probability theory:

Conditional and unconditional probability

Binomial, Poisson, and normal distribution

Confidence intervals

Estimation of reliability and quality of engineering components and systems.

LO3 **Use analytical and computational methods for solving engineering and manufacturing sector problems by relating sinusoidal wave and vector functions to their respective applications**

Sinusoidal waves:

Sine waves and their applications

Trigonometric and hyperbolic identities.

Vector functions:

Vector notation and properties

Representing engineering quantities in vector form

Vectors in three dimensions.

Mathematical software for engineering and manufacturing sector:

Use of mathematical software packages (e.g. Mathcad, Microsoft Excel)

Confirmation of analytical results.

LO4 **Examine how differential and integral calculus can be used to solve engineering and manufacturing sector problems**

Differential calculus:

Definitions and concepts

Definition of a function and a derivative, graphical representation of a function, notation of derivatives, limits and continuity, derivatives; rates of change, increasing and decreasing functions and turning points

Differentiation of functions

Differentiation of functions including:

- standard functions/results
- using the chain, product, and quotient rules
- second order and higher derivatives

Types of function: polynomial, logarithmic, exponential, and trigonometric (sine, cosine, and tangent), inverse trigonometric and hyperbolic functions.

Integral calculus:

Definite and indefinite integration

Integrating to determine the area

Integration of functions including:

- common/standard functions
- using substitution
- by parts

Exponential growth and decay

Types of function: algebraic including partial fractions and trigonometric (sine, cosine, and tangent) functions

Engineering and manufacturing sector problems involving calculus:

Including: stress and strain, torsion, tolerancing, torque settings, motion, dynamic systems, oscillating systems, force systems, heat energy and thermodynamic systems, fluid flow, AC theory, electrical signals, information systems, transmission systems, electrical machines, electronics

Efficient problem-solving competencies in the chosen occupation/sector and effective written/verbal communication of solutions.

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Apply a variety of mathematical methods to a range of engineering and manufacturing sector problems</td><td rowspan="5">LO1 and LO2

D1 Present data as meaningful information using appropriate methods that can be understood by a non-technical audience.</td></tr>
<tr><td>P1 Apply dimensional analysis techniques to solve complex engineering/manufacturing problems.

P2 Generate answers from engineering arithmetic and geometric progressions.

P3 Determine solutions of engineering equations using exponential, logarithmic, trigonometric, and hyperbolic functions.</td><td>M1 Use three mathematical concepts to solve engineering/ manufacturing problems, justifying your chosen methods.</td></tr>
<tr><td colspan="2">LO2 Investigate applications of statistical and probability techniques to interpret, organise, and present data</td></tr>
<tr><td>P4 Investigate engineering data by calculating mean, mode, median, and standard deviation.

P5 Calculate probabilities within Poisson, binomially and normally distributed engineering random variables.</td><td>M2 Conduct an engineering hypothesis test and interpret the results.</td></tr>
</table>

Pass	Merit	Distinction
LO3 Use analytical and computational methods for solving engineering and manufacturing sector problems by relating sinusoidal wave and vector functions to their respective applications		
P6 Solve engineering/ manufacturing problems relating to sinusoidal functions. **P7** Use appropriate methodology to determine engineering parameters of data represented in vector form.	**M3** Use compound angle identities to combine individual sine waves into a single wave, and illustrate graphically.	**D2** Apply engineering mathematical software to confirm the analytical solutions for at least three engineering/ manufacturing problems involving sinusoidal and vector functions.
LO4 Examine how differential and integral calculus can be used to solve engineering and manufacturing sector problems		
P8 Examine rates of change for a range of mathematical functions. **P9** Use integral calculus to determine a range of mathematical functions.	**M4** Solve a range of complex engineering/ manufacturing problems using both differential and integral calculus.	**D3** Evaluate a range of engineering/ manufacturing problems that involve second-order derivatives and the concept of maxima and minima.

Recommended Resources

Note: See HN Global for guidance on additional resources.

Print Resources

Bird J. (2021) *Higher Engineering Mathematics*. 9th Ed. Routledge.

Bird J. (2019) *Science and Mathematics for Engineering*. 6th Ed. Routledge.

Glyn J. and Dyke P. (2020) *Modern Engineering Mathematics.* 6th edition. Pearson.

Made Easy Editorial Board (2022) *Engineering Mathematics for GATE 2023 and ESE 2023 (Prelims) – Theory and Previous Year Solved Papers*. India: Made Easy Publications Pvt Ltd.

Rattan K.S., Klingbeil N.W., and Baudendistel C.M. (2021) *Introductory Mathematics for Engineering Applications*. 2nd Ed. Wiley.

Ram M. (2021) *Recent Advances in Mathematics for Engineering.* CRC Press.

Teodorescu P., Stanescu N., and Pandrea N. (2013) *Numerical Analysis with Applications in Mechanics and Engineering.* Wiley-IEEE Press.

Ram M. (2020) *Mathematics in Engineering Sciences: Novel Theories, Technologies, and Applications.* 1st Edition. CRC Press.

Sobot, R. (2022) *Engineering Mathematics by Example*. 1st Ed. Springer.

Stroud, K.A. and Booth, D.J. (2020) *Engineering Mathematics*. 8th Ed. Bloomsbury Publishing

Urbano M. (2019) *Introductory Electrical Engineering with Math Explained in Accessible Language*. Wiley.

Vick B. (2020) *Applied Engineering Mathematics.* CRC Press.

Journals

Note: Example journals listed below provide a broad range of articles related to unit content and those relevant for the qualification. Staff and students are encouraged to explore these journals and any other suitable journals to support the development of academic study skills, and subject specific knowledge and skills as part of unit level delivery.

Annals of Mathematics

Computational Geometry

Communications on Pure and Applied Mathematics

International Journal of Engineering Mathematics

Journal of Computational and Engineering Mathematics

Journal of Engineering Mathematics

Journal of Geometry and Physics

Journal of Mathematical Physics

Links

This unit links to the following related units:

Unit 5006: Further Engineering Mathematics