Unit 224 Advanced mathematical techniques for engineering applications

Unit summary
This unit is about the advanced mathematical techniques and their applications as required by professional engineers.

Aims
The unit aims to equip the candidate with the mathematical expertise required to function as a professional engineer.

Prerequisites
It is expected that the candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examinations.

Learning outcomes
There are **three** outcomes to this unit. The candidate will be able to:

- Solve engineering problems using mathematical methods
- Solve engineering problems using numerical methods
- Solve engineering problems using statistical methods

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
This unit contributes towards the Key Skills in the following areas:

N4.1
Develop a strategy for using application of number skills over an extended period of time.

N4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- deductive and inferential reasoning;
- algebraic manipulation.

N4.3
Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.3.2 Evaluate the results of research
4.1.1 Determine the operational requirements of engineering products or processes
4.2.2 Solve operational problems with engineering solutions
6.2.1 Assure the quality of engineering products or processes
6.2.3 Implement improvements to the quality of engineering products or processes
7.1.1 Develop objectives for projects
7.2.3 Evaluate projects
8.1.1 Maintain and develop own engineering expertise

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Outcome 1 Solve engineering problems using mathematical methods

Knowledge requirements
The candidate knows how to:

1 express functions of 2 or 3 variables in terms of other variables

2 find Taylor series expansions

3 determine both constrained and unconstrained maxima and minima

4 solve problems involving vector calculus

- a Green's theorem
- b Stokes' theorem
- c Gauss' theorem
- d employ vector calculus to simple applications

5 apply simple applications from field theory

6 solve problems involving complex variable theory

- a analytic functions
- b Cauchy-Riemann equations
- c poles, zeros and residues
- d conformal transformations

7 apply Laplace transform methods to the solution of differential equations

- a transfer functions
- b convolution theorem

8 apply Z-transform methods to the solution of difference equations and discrete systems

9 solve second order partial differential equations by separation of variables including the use of Fourier series

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Outcome 2 Solve engineering problems using numerical methods

Knowledge requirements
The candidate knows how to:

1 solve sets of linear equations
   a Gauss – Seidel and Jacobi methods
   b matrix factorization methods
2 solve numerical optimization problems
   a direct search method
   b simple gradient methods
3 determine matrix eigenvalues and eigenvectors
   a direct and inverse iteration
   b shift of origin
4 solve simple systems of ordinary differential equations using eigenvalue analysis
5 apply the above to vibration problems
6 solve initial value problems for ordinary differential equations numerically
   a Taylor series
   b Runge-Kutta method
   c Simple linear multi-step methods
   d convergence and stability
   e coupled ordinary differential equations
7 solve boundary value problems for ordinary differential equations numerically
   a shooting and finite difference methods
   b simple eigenvalue problems
8 use simple finite difference methods to solve partial differential equations
9 solve initial value problems for partial differential equations numerically
   a explicit and implicit procedures
   b simple ideas on errors and stability
10 solve boundary value problems for partial differential equations numerically
   a direct solution of finite difference equations
   b iterative solution of finite difference equations

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Outcome 3 Solve engineering problems using statistical methods

Knowledge requirements
The candidate knows how to:

1 solve problems using Binomial, Poisson and Normal distributions to include
   a probability of defects in production
   b errors in observation
2 test samples to make statistical decisions
   a χ^2
   b t-tests
   c regression
3 use Markov chains
4 apply the above to queuing theory

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Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Advanced Engineering Mathematics	Stroud	Palgrave	1403903123
Advanced Modern Engineering Mathematics	Glyn James	Addison-Wesley	0130454257
Applied Numerical Analysis Specialist book; this subject now features more strongly in the syllabus	Gerald, Wheatley	Addison Wesley	0201592908
Applied Statistics and Probability for Engineers Specialist book; this subject now features more strongly in the syllabus	Montgomery, Runger	John Wiley	0471426822
Modern Engineering and Mathematics	Glyn James	Addison-Wesley	0130183199
Other useful texts			
Advanced Engineering Mathematics Broad coverage, but quite advanced and may be too difficult for some students	Kreyszig	John Wiley	0471488852
Numerical Methods for Engineers Specialist book; this subject now features more strongly in the syllabus	Chapra, Canale	McGraw Hill	0071231404