EMT2101 Engineering Mathematics III

Period per Week			Contact Hour per Semester	Weighted Total Mark	Weighted Exam Mark	Weighted Continuous Assessment Mark	Credit Units
LH	PH	TH	CH	WTM	WEM	WCM	CU
45	00	30	60	100	40	100	4

Rationale

Drawing from the concepts covered in Engineering Mathematics I and II, this course is designed to consolidate and advance analytical techniques for solution of ordinary differential equations; and introduces concepts fundamental to the study of other courses in Computer Engineering. The major themes covered include integral transforms, series solutions to ordinary differential equations and special functions.

Objectives

- Introduce the student to Integral Transforms and their application to the solution of Ordinary Differential Equations
- Introduce the Power Series solution technique to Ordinary Differential Equations
- Expose the student to some special functions fundamental to engineering specifically Gamma, Beta, Bessel and Legendre

Course Content

1. ***Fourier Integrals and Transformations***
   - Motivation for the Fourier Integral
   - Definition of Fourier Integral as a limit to the Fourier Series with period tending to infinity
   - Conditions for existence of a Fourier Integral representation (Dirichlet's conditions, Existence of the absolute integral for the entire real axis)
   - Complex exponential Fourier Integral representation, Standard Fourier Integral representation, Fourier Cosine and Sine Integral representations
   - Definition of the Fourier Transform and its Inverse
   - Frequency spectrum of periodic and continuous functions
   - Distinction between the Fourier Transform and Integral
   - Properties of the Fourier Transform Transform: Linearity, First Shift Theorem, Second Shift Theorem, t-ω duality, Time differentiation, Frequency Differentiation, Convolution, Correlation
   - Fourier Transform of special functions: Delta function (Sifting property), Heaviside Step function,
   - Applications: Parseval's theorem, RCL circuits, Frequency shifting in Communication theory (carrier signals and Antenna design)
   - Solution of Ordinary Differential Equations with constant coefficients
2. ***Laplace Transformations***
   - Motivation for the Laplace transform
   - Definition of the Laplace transform
   - Comparison of the Laplace and Fourier Transforms
   - Conditions for existence of the Laplace transform (Dirichlet's conditions, Piecewise continuity of thee function)

- Properties of Laplace Transforms: Linearity, First Shift Theorem, Second Shift Theorem, Time differentiation, s-domain Differentiation, s-domain Integration
- Laplace Transforms of special functions: Delta function and Heaviside function
- Solutions of Ordinary Differential Equations by Laplace Transform Techniques
- Solutions of Simultaneous Linear Ordinary Differential Equations with constant coefficients
- Applications in RLC Circuit Analysis

3. Power Series Solutions to Ordinary Differential Equations

- Motivation of the Power Series solution method
- Concept of the Power Series method (Ordinary points, Singular points)
- Series solutions about Ordinary points
- Series solutions about Regular Singular points (Method of Frobenius)

4. Gamma and Beta Functions

- Integral Definition of Gamma and Beta Functions
- Properties of Gamma and Beta Functions
- Generalisation of the factorial by Means of the Gamma function
- Relations Between Gamma and Beta Functions
- Definition of Gamma Function for Negative Values of Argument

5. Bessel Functions

- Bessel's Equation and its Solutions.
- Familiarisation with Characteristics and Graphs of Bessel Functions
- Properties of Bessel Functions of the First Kind: Differentiation, Recurrence relationships, Generating functions
- Ordinary Differential Equations solvable using the notion of Bessel's equations
- Integral Representations of Bessel Functions
- Integrals Involving Bessel Functions
- Laplace Transforms of Bessel functions

6. Legendre Functions

- Legendre's Equation and its Solutions
- Legendre's Polynomials; the Generating Function for Legendre's Polynomials; Orthogonality of Legendre's Polynomials
- Rodriguez's formula
- Orthogonality Relations for the Associated Legendre Functions,
- Familiarisation with Characteristics and Graphs of Legendre's Polynomials and Associated Legendre Functions
- Integrals involving Legendre Polynomials

Learning Outcomes

On completion of this course the student should be able to:

- Demonstrate a firm understanding of the solution techniques for Linear Ordinary Differential Equations, Properties of Integral Transforms and Special functions
- Use the Integral Transforms in Circuit Analysis

References

[1] C. Ray Wylie and Louis C. Barrett, Advanced *Engineering Mathematics*, 6th ed., McGraw Hill, New York, 1995.

[2] Erwin Kreyszig, Advanced *Engineering Mathematics,* 8th ed., John Wiley and Sons.

[3] Murray R. Spiegel, 1981. *Applied Differential Equations*. 3rd Edition. Prentice-Hall, Inc., Englewood Cliffs, N.J. 07632

[4] Mary L. Boas, 1983. *Mathematical Methods in the Physical Sciences*. 2nd Edition. John Wiley & Sons, INC. New York

[5] Thomas M. Creese and Robert M. Haralick, 1978. *Differential Equations for Engineers*. McGraw-Hill, N. Y. US

[6] L. R. Mustoe, 1988. *Worked Examples in Advanced Engineering Mathematics*. John Wiley & Sons Ltd. Great Britain