Differential Equations and Transform Methods

Module code: EE 206

Credits: 5

Semester: 1

Mathematical Physics

Lectures (36 hours):

Dr. Jiri Vala
Department of Theoretical Physics
Room 1.9, Science Building

Tuesday 14:05 - 15:55 **JHL5**
Thursday 12:05 - 12:55 **PCT**

Tutorials (12 hours):

Ms. Aoibhinn Gallagher

T1 Wednesday 11:05 - 11:55 **E2.07**
T2 Wednesday 12:05 - 12:55 **E2.07**

Syllabus Overview:

- Ordinary differential equations
- Laplace Transform
- Fourier Series
- Z-Transform

Indicative Syllabus

- Differential equations
  - Review of Basic Differentiation techniques and an introduction to modelling.
  - Second-order differential equations
  - Linear constant coefficient equations. Solution using method of variation of parameters and method of undetermined coefficients.
  - Application to RLC series circuit and spring-mass systems.
  - Higher order linear differential equations.
- State-space
  - An introduction to state-space
  - State-space representation
  - Solving systems of linear ordinary differential equations in state-space form
- Laplace Transform
  - Introduction to the Laplace transform. Idea of a linear operator. Rationale for solution method for differential equations.
  - Inverse Laplace Transform and its relation to the solution to a differential equation.
  - Laplace transforms of the elementary functions.
  - Shifting theorems: s-shifting and t-shifting.
  - Applying the Laplace transform to solving first and second-order differential equations with elementary forcing functions.
  - Introduction to the unit step function and its use in modelling switching functions.
  - Introduction to the Dirac delta function and its use in modelling impulsive functions.
  - Applying the Laplace transform to solving first and second-order differential equations with non-trivial forcing functions (switching, impulsive, periodic).
  - Laplace transform of periodic functions (square waves, triangular waves) and solving differential equations with forcing functions of this type.
  - Laplace transform of integrals.
  - Convolution theorem. Solving integral equations using the convolution theorem and their relation to time-delay systems.
- Fourier Series
  - Introduction to Fourier series and its importance in applications.
  - Derivation of the Fourier coefficients.
  - Calculation of Fourier series for several types of periodic function.
  - Development and motivation of the Fourier transform.
  - Calculation of the Fourier Transform for various and special functions
  - Relation of the Fourier transform to signal analysis.
- Z-Transform
  - Introduction to simple difference equations. Idea that solution is a sequence.
  - Motivational examples of how difference equations arise in practice.
  - Solution techniques for simple linear first and second order difference equations.
  - Introduction to discrete transforms and specifically the Z-transform.
  - Calculation of the Z-transform of certain special sequences. (Unit Step sequence, Unit Impulse sequence)
  - Using the Z-transform to solve difference equations and the analogy between this method and the use of the Laplace Transform.

Learning Outcomes:

Upon completion of this module the student should be able to:

- Find solutions to linear higher-order ODEs and apply solution techniques to simple physical models.

- Use the Laplace Transform to solve simple initial value problems for ODEs.

- Formulate differential equations for physical problems involving switching/impulsive/periodic forcing functions.

- Solve integral equations using Convolution theorem and the Laplace transform.

- Obtain Fourier series representations (trigonometric & complex exponential) of general periodic functions.

- Obtain Fourier transforms of arbitrary and special functions.

- Solve simple linear difference equations using elementary techniques and using the Z-transform approach.

- Use a range of problem-solving skills to investigate systems modelled by both differential, and difference equations

- Apply and select the appropriate mathematical techniques to solve a variety of associated engineering problems.

Teaching & Learning methods

36 lecture hours
12 tutorial hours
12 Assignment hours
20 independent study hours.

Total: 80 hours.

Assessment Criteria:
Total: 100 %

- 80% University scheduled written examination (120 min)

- 20% Continuous Assessment (homework assignments and quizzes)

Pass standard: 40%

Penalties: Late submission of the course work will not generally be accepted.

Repeat Options

The continuous assessment mark is carried forward to the Autumn examinations as there is no facility available for repeating the continuous assessment components of the course.

University scheduled written examination (Autumn): 120 minutes.

Pre-requisites:

EE106 Engineering Mathematics 1
EE112 Engineering Mathematics 2

Co-requisites:

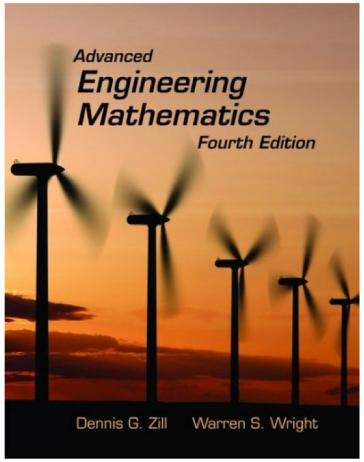
None

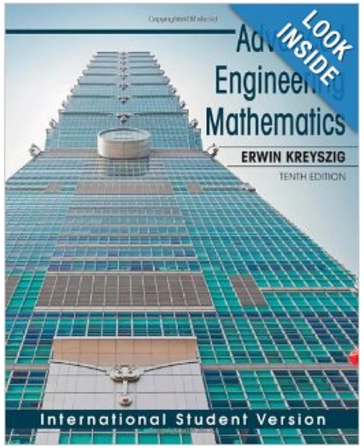
REFERENCES

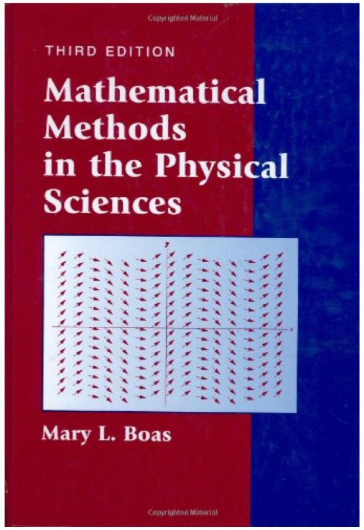
Dennis G. Zill, Warren S. Wright, Michael R. Cullen,
Advanced Engineering Mathematics,
4th Edition, Jones & Bartlett Publishers, 2009.

Edwin Kreyszig,
Advanced Engineering Mathematics,
10th Edition, John Wiley & Sons, 2011.

Mary L. Boas,
Mathematical Methods in the Physical Sciences,
3rd Edition, John Wiley & Sons, 2006.







LECTURE NOTES

http://www.thphys.nuim.ie/Notes/EE206/EE206.html