TKU211203

Differential Equations

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BASIC INFORMATION

Course Credit	3 / 150 minutes per Week
Course Type	Required
Course Classification	Basic Science
Prerequisites	Single-Variable Calculus; Multi-Variable Calculus; and Complex Variable Analysis

STUDENT AND LEARNING OUTCOMES

Covered Student Outcomes

Fundamental and Engineering Knowledge (KP.1)

Engineering Design (KP.3)

Development of Engineering Solution (KP.2)

Learning Outcomes

LO1 Students are able to undertand first order ODE, find the solutions using Analytical, Graphical,Numerical Methods, integrating factors, variation of parameters, and Undetermined Coefficients.

LO2 Students are able to solve a constant coefficient second order linear initial value problem with driving terms.

LO3 Students are able to compute Fourier coefficients, and find periodic solutions of linear ODEs by means of Fourier series.

LO4 Students are able to utilize Delta functions to model abrupt phenomena, compute the unit impulse response, and express the system response to a general signal by means of the convolution integral.

LO5 Students are able to find the weight function or unit impulse response and solve constant coefficient linear initial value problems using the Laplace transform.

LO6 Students are able to calculate eigenvalues, eigenvectors, and matrix exponentials, and use them to solve first order linear systems. Relate first order systems with higher-order ODEs.

LO7 Students are able to determine the qualitative behavior of an autonomous nonlinear two-dimensional system by means of an analysis of behavior near critical points.

COURSE DESCRIPTION

Differential equations plays an important role in science and engineering problem as many practical problems can be mathematically The main objective of this course is to help students gain understanding, constructing solution, and inteprenting differetial equations.

TOPICS

1. First-order differential equations

1.1 Natural growth, separable equations

1.2 Direction fields, existence and uniqueness of solutions

1.3 Numerical methods

1.4 Linear equations, models

1.5 Solution of linear equations, integrating factors

1.6 Complex numbers, roots of unity

1.7 Complex exponentials; sinusoidal functions

1.8 Linear system response to exponential and sinusoidal input; gain, phase lag

1.9 Autonomous equations; the phase line, stability

1.10 Linear vs. nonlinear

2. Second-order linear equations

2.1 Modes and the characteristic polynomial

2.2 Good vibrations, damping conditions

2.3 Exponential response formula, spring drive

2.4 Complex gain, dashpot drive

2.5 Operators, undetermined coefficients, resonance

2.6 Frequency response

2.7 LTI systems, superposition, RLC circuits.

2.8 Engineering applications

3. Fourier series

3.1 Fourier series

3.2 Operations on Fourier series

3.3 Periodic solutions; resonance

3.4 Step function and delta function

3.5 Step response, impulse response

3.6 Convolution

3.7 Laplace transform: basic properties

3.8 Application to ODEs

3.9 Second order equations; completing the squares

3.10 The pole diagram

3.11 The Transfer function and frequency response

4. First order systems

4.1 Linear systems and matrices

4.2 Eigenvalues, eigenvectors

4.3 Complex or repeated eigenvalues

4.4 Qualitative behaviour of linear systems; phase plane

4.5 Normal modes and the matrix exponential

4.6 Nonlinear systems

4.7 Linearization near equilibria; the nonlinear pendulum

4.8 Limitations of the linear: limit cycles and chaos

REFERENCES

[1] Edwards, C., and D. Penney. Elementary Differential Equations with Boundary Value Problems. 6th ed. Upper Saddle River, NJ: Prentice Hall, 2003. ISBN: 9780136006138.

[2] MIT., Differential Equations., https://ocw.mit.edu/courses/mathematics/18-03-differential-equations-spring-2010/index.htm