PURDUE UNIVERSITY | College of Engineering

Engineering Faculty Document
No.: EDF 51-24
November 30, 2023

TO: The Engineering Faculty

FROM: The Faculty of the Department of Agricultural and Biological Engineering

RE: Title, Description, Requisite Change, and Learning Outcomes to ABE 45000

The Faculty of the Department of Agricultural and Biological Engineering approved the following requisite changes to an undergraduate course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

Title, Description and Requisite Change to ABE 45000

FROM:

COURE TITLE: Finite Element Method in Design and Optimization

COURSE DESCRIPTION: Fundamentals of the finite element method as it is used in modeling, analysis, and design of thermal/fluid and mechanical systems; one- and two-dimensional elements; boundary value problems, heat transfer and fluid flow problems; structural and solid mechanics problems involving beam, truss, plate and shell elements; computer-aided design and optimization of machine components, structural elements and thermal/fluid system.

REQUSITIES: (MA266 or MA366 or MA303 or MA304 or MA262) and (BME204 or NUCL273 or AAE204)

LEARNING OUTCOMES: N/A

TO:

COURE TITLE: Computational Modeling and Data Analysis in Agricultural Engineering

COURSE DESCRIPTION: The course is divided into three sections. Students will (1) learn about first and second order dynamic systems, block diagram, modeling of mechanical and electrical systems, and control theory, while using Matlab and Simulink for modeling; (2) Learn about numerical methods for modeling of continuum mechanics and transport phenomena including finite element method and finite difference method. Applications in heat transfer, fluid flow, and solid mechanics will be studied in the computer lab; (3) Learn about data analysis topics including statistical models, probability theory, regression analysis, classification techniques, and machine learning.

REQUSITIES: (MA262 or (MA265 and MA266)) and (ABE301 or AAE204 or BME204 or ME274 or NUCL273)

LEARNING OUTCOMES:

Course Learning Objectives

1. Understand the fundamentals of dynamic systems modeling.
2. Create block diagram models for mechanical and electrical systems.
3. Understand control theory concepts and use it to design controllers.
4. Understand the fundamentals of finite element method and finite difference method including 1-D and 2-D formulations, boundary conditions, and postprocessing.
5. Effectively use a major FEA software tool.
6. Evaluate the accuracy of the results.
7. Understand probability theory and regression analysis.
8. Explore classification techniques and machine learning concepts.
9. Apply data analysis skills to real-world datasets.

RATIONALE

The course has been focused on the theory of the Finite Element Method, however, students need less of a focus on the theory for one method and more hands-on experience solving problems with multiple numerical methods and an understanding of when one method might be better suited for a specific application. The proposed updates will introduce students to both finite element and finite difference methods for solving problems in heat transfer and fluid flow. There will also be more hands-on experiences provided with modeling software and data analysis methods. Title, course description, and learning objectives updates are based on the revised course focus. It should also be noted that the previous entry did not include course objectives. The pre-requisites were updated to better reflect the pre-requisite knowledge needed to be successful in the course and incorporate equivalent courses.

Head/Director of the Department of Agricultural and Biological Engineering

Link to Curriculog entry:

https://purdue.curriculog.com/proposal:26582/form

Supporting Document

ABE 450 – Fall 2024
Computer Modeling and Data Analysis
Class meets: M 8:30-9:20am in ABE B061, WF 8:30-9:20am in ABE computer labs 2096
Course credit hours: 3
Prerequisites: (MA262 or (MA265 and MA266)) and (ABE301 or AAE204 or BME204 or ME274 or NUCL273)

Instructor: Prof. Sadegh Dabiri, 765-496-2044, dabiri@purdue.edu
Office hours by request in ABE 2041K or online at https://purdue-edu.zoom.us/my/dabiri

BrighSpace: We will use Brightspace https://purdue.brightspace.com/ for posting lecture notes, homework, etc. The homework assignments must be submitted electronically (pdf file) on gradescope https://www.gradescope.com

Resources: · Lecture notes
- Dynamic Modeling and Control of Engineering Systems 3rd Edition, B.T. Kulakowski, J.F. Gardner, J.L. Shearer
- A First Course in Finite Element Method, 6th Edition, Daryl Logan.

Course Description
The course is divided into three sections. Students will (1) learn about first and second order dynamic systems, block diagram, modeling of mechanical and electrical systems, and control theory, while using Matlab and Simulink for modeling; (2) Learn about numerical methods for modeling of continuum mechanics and transport phenomena including finite element method and finite difference method. Applications in heat transfer, fluid flow, and solid mechanics will be studied in the computer lab; (3) Learn about data analysis topics including statistical models, probability theory, regression analysis, classification techniques, and machine learning.

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1. Understand the fundamentals of dynamic systems modeling.
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Grading	Weight
Homework and in lab reports	20%
Two Midterm Exams	40%
Final project presentation and report	40%
Total	100%

Grading

Grades will be awarded based on the grading table with only slight deviations as appropriate.

Grade	GPA value	Numerical Range
A+	4.0	97-100
A	4.0	93-96.9
A-	3.7	90.0-92.9
B+	3.3	87.0-89.9
B	3.0	83.0-86.9
B-	2.7	80.0-82.9
C+	2.3	77.0-79.9
C	2.0	73.0-76.9
C-	1.7	70.0-72.9
D+	1.3	67.0-69.9
D	1.0	63.0-66.9
D-	0.7	60.0-62.9
F	0.0	<60.0

Academic Integrity:

The policy of Purdue University is as follows:

> "The commitment of the acts of cheating, lying, stealing, and deceit in any of their diverse forms (such as the use of ghostwritten papers, the use of substitutes for taking examinations, the use of illegal cribs, plagiarism, and copying during examinations) is dishonest and must not be tolerated… Moreover, knowingly aiding and abetting, directly or indirectly, other parties in committing dishonest acts is in itself dishonest."

Zero tolerance policy toward cheating:

Integrity is an important attribute in the success of Purdue graduates. Thus, cheating on homework, exams, and projects will result in failure of the course. This does not mean that students are precluded from studying together for exams or from discussing or assisting each other to a "limited degree" on homework problems. In fact, this is encouraged. The bottom line is that we expect and will require you to do your own work.

Use of AI/ChatGPT

Artificial intelligence (AI) language models, such as ChatGPT, may be used for assignments in this course. In any cases where students use AI, it is critical that they cite their work; students are also required to submit: 1) any prompts they used and 2) the output generated by AI. Students are responsible for fact

checking information provided by AI language models and are expected to use AI ethically and responsibly.
Students who do not disclose the use of AI in an assignment will be in violation of the academic integrity expectations for this course. Violations can include a failing grade on the assignment in question, a failing grade for the course, restrictions from further class attendance. All suspected incidents of academic dishonesty will also be referred to the Office of Student Rights and Responsibilities for further review of the student's status with the University.

Policies

- Brightspace and email are the primary means of communication.
- Please have "ABE450" in the subject line of any email to the instructor or TA.
- Late assignments will be accepted up to five days after the due date. However, 10% may be deducted for each day that the assignment is late.
- Once exams are graded, you have one week to request a regrade.
- Make-up exams will be given only in extenuating circumstances and must be taken as soon as possible.
- Tests will contain both theoretical and computational problems. You will need to understand the lectures and homework problems.

ABE 450 Lecture Schedule

Section 1: Dynamic Modeling

Week 1: Introduction to Dynamic Modeling

Overview of dynamic systems in engineering.
Introduction to Matlab and Simulink.

Week 2: Mathematical Tools for Dynamic Modeling

Ordinary differential equations (ODEs) and their solutions.
Laplace transforms and transfer functions.
Block diagram representation of dynamic systems.

Week 3: Mechanical System Modeling

Modeling mechanical systems using Newton's laws.
Second-order systems and damping ratios.
Vibrations and resonance in mechanical systems.

Week 4: Electrical and Control System Modeling

Modeling electrical circuits using Kirchhoff's laws.
Transfer functions of electrical systems.
Stability analysis.

Week 5: Advanced Topics

Introduction to linear control theory.
Controllable and observable systems.
P, PI, and PID controllers.

Section 2: Modeling Continuum Mechanics and Transport Phenomena

Week 6: Introduction to Finite Difference Method

- Basics of numerical methods and discretization.
- Taylor series expansion, approximation of derivatives.
- Implicit, explicit, and Crank–Nicolson methods.

Week 7: Application in Agricultural Engineering

- Flow and transport equation.
- Application in watershed hydrology.
- Convergence, accuracy, and stability.

Week 8: Introduction to Finite Elements Method

- Strong form and weak form of the governing equations.
- Galerkin formulation and element matrices.
- Element types (e.g., 1D, 2D, 3D) and their selection.

Week 9: Applications in Agricultural Engineering

- Boundary conditions and constraints.
- Structural analysis of agricultural machinery.
- Heat transfer and transient analysis.

Week 10: Validation and Error Analysis

- Interelement condition and error estimation.
- Types of mesh refinement.
- Adaptive mesh refinement.

<u>Section 3: Data Analysis</u>

Week 11: Introduction to Data Analysis

- Introduction to Data Analysis and its applications.
- Descriptive statistics and data visualization.
- Basic understanding of statistical models.

Week 12: Statistical Models and Probability

- Probability theory and its role in data analysis
- Probability distributions and their applications
- Frequentist statistics.

Week 13: Regression Analysis

- Linear and nonlinear regression models.
- Techniques for model fitting and parameter estimation
- Interpretation of regression results.

Week 14: Classification, kNN, and Model Evaluation

- k-nearest neighbors algorithm.
- Cross-validation techniques for model evaluation.
- Support-vector machines (SVM).

Week 15: Machine Learning

- Decision Trees and Random Forests.
- Machine Learning.

<u>Week 16: Final Project Presentation</u>