TO: The Engineering Faculty

FROM: The School of Mechanical Engineering

RE: New Concentration in **Dynamical Systems Modeling & Analysis** for BSME

The Faculty of The School of Mechanical Engineering has approved the following new concentration for undergraduate students interested in advanced coursework on "how to model and analyze dynamical systems with different fidelities and for different reasons." This action is now submitted to the Engineering Faculty with a recommendation for approval.

Description:
This concentration in *Dynamical Systems Modeling & Analysis* provides a framework for the mathematical modeling and analysis of dynamical systems regardless of their physical origin, thereby enabling general problem-solving and critical thinking skills. The specialized training enables the rapid analysis and complex problem-solving of mechanical, electromechanical, and aerospace systems, and draws from the coursework in Dynamics and Vibrations, Signal Analysis and Control, and Numerical Analysis and Data Science.

Rationale:
Modeling and design are foundational skills enabling the design of engineering systems. The current automation and data science revolutions call for engineers capable of understanding the fundamentals of dynamic systems to efficiently employ computational and data-driven tools with confidence on the obtained results. The *Dynamical Systems Modeling & Analysis* concentration provides skills in complex systems problem-solving and data interpretation[1] currently in high demand, and applicable to both established industries, as well as rapidly growing ones including, robotics, autonomous systems, and advanced manufacturing.

See the appended documentation which provides the specifics of the concentration.

Jitesh Panchal
Associate Head for Undergraduate Studies
Professor of Mechanical Engineering

[1] 6 Business Skills Every Engineer Needs: https://online.hbs.edu/blog/post/business-skills-for-engineers, 12 Essential Engineering Skills for Your Resume: https://www.indeed.com/career-advice/resumes-cover-letters/essential-engineering-skills. Five transferable hard skills in high demand: https://www.asme.org/topics-resources/content/top-10-most-transferable-job-skills-for-engineers

Concentration in *Dynamical Systems Modeling & Analysis* for
Bachelor of Science in Mechanical Engineering (BSME)

Focus of the Concentration: Mathematical modeling and analysis of dynamical systems regardless of their physical origin through coursework in Dynamics and Vibrations, Signal Analysis and Control, and Numerical Analysis and Data Science.

Target Degree: BSME

Concentration Requirements: 10 credit hours comprising a required 1-credit hour course introducing dynamical systems modeling (ME 497), two 3-credit courses from List A, and a choice of one 3-credit hour course from List B provided below.

Requirements for the Concentration

1. **A 1-credit course**
   ME 497 Dynamical Systems (course overview is attached)

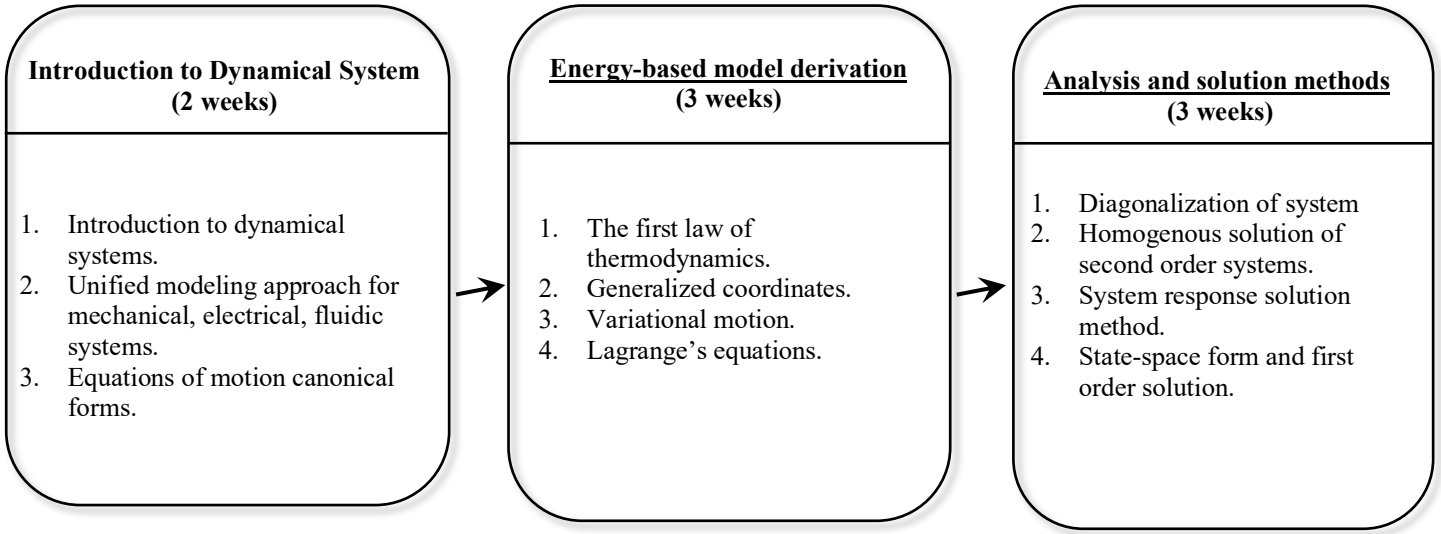
2. **Two courses from List A:**
   ME 562 Advanced Dynamics
   ME 563 Mechanical Vibrations or CE 573 Structural Dynamics
   ME 497/498 Research (3 credits) – to be approved by a faculty member in Dynamics and Vibrations Area

3. **One course from List B:**
   ME 47500 – Automatic Control Systems
   ME 53900 – Introduction to Scientific Machine Learning
   ME 57500 – Theory and Design of Control Systems
   ME 57900 – Fourier Methods in Digital Signal Processing
   ME 58400 – System Identification
   ME 58100 – Numerical Methods in Mechanical Engineering
   ME 58000 – Nonlinear Engineering Systems
   ME 59700 – Aeroelasticity (permanent course number request is in process)
   ME 59700 – Wave Propagation in Solids
   ECE 43800 – Digital Signal Processing with Applications

ME 49700: Dynamical Systems

Course Outcomes [1, 2, 3, 5, 7]

1. Familiarization with energy-based methods for equations of motion derivation.
2. Derivation and analysis of linear dynamical systems via canonical forms of equations of motion.
3. Familiarization with general solution approaches to linear dynamical systems.



COURSE NUMBER: ME 497 **COURSE TITLE:** Dynamical Systems

REQUIRED COURSE OR ELECTIVE COURSE: Elective, 1 credit hour course

TERMS OFFERED: Spring semester

TEXTBOOK/REQUIRED MATERIAL:
Analytical System Dynamics, Brian Fabien, 2009

PRE-REQUISITIES: MA 303 and ME 365 and ME 563

ATTRIBUTES: 1. Junior and Senior undergraduate students

COORDINATING FACULTY: Andres F. Arrieta

COURSE DESCRIPTION: This course introduces the modeling and analysis of dynamical systems providing the tools for problem-solving of complex mechanical, electromechanical, and aerospace systems. The course focuses on providing a unified approach to derive equations of motion of diverse linear systems the solution of which can be obtained in generic fashion. The course is designed to draw from differential equations, dynamics, and control systems courses, thereby unifying seemingly diverse concepts and tools under the dynamical systems umbrella.

COURSE OUTCOMES [1,3,5,7]:

1. Familiarization with energy-based methods for equations of motion derivation.
2. Derivation and analysis of linear dynamical systems via canonical forms of equations of motion.
3. Familiarization with general solution approaches to linear dynamical systems.

ASSESSMENTS TOOLS:

1. Homework
2. Project report*** & presentation
3. Exams

*** Projects will be focused on model derivation, solution, and analysis of different types of dynamical system.

RELATED ME PROGRAM OUTCOMES:

1. Ability to formulate and solve complex engineering problems applying basic principles from dynamical systems.
2. An ability to apply engineering analysis tools to design solutions addressing industrial and societal needs.
3. Ability to communicated to a diverse audience including ME students.
4. Ability to function effectively on teams to collaborate and create solutions that meet established goals, tasks and objectives.
5. Ability to develop and conduct appropriate experimentation, analysis and interpretation of data, and use of engineering judgement to draw conclusions. environment, establish goals, plan tasks, and meet objectives.
6. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

COMPUTER USAGE: Homework and project assignments will require the use of software packages to obtain problem solutions. Computer modeling will facilitate analysis of results.

COURSE STRUCTURE/SCHEDULE:

a. Classroom instruction – 2 days per week at 50 min each for 8 weeks

PREPARED BY: Andres F. Arrieta, James Gibert, Chuck Krousgrill **REVISION DATE:** August 14, 2024