ME 1014 – DYNAMIC SYSTEMS

2024-2025 Spring

(Modifications to this syllabus may be required during the semester. Any changes to the syllabus will be posted on the course website and announced in class)

Catalog Description:
This course is designed to introduce students to the modeling and analysis of dynamic systems. Topics covered include Laplace transformation; modeling and analysis of physical systems; time and frequency domain analysis; transient and steady state system responses to various excitations; transfer function formulation; and state space model representations. MATLAB and Simulink will be used in this course (3 credit hours).

Prerequisites:
- MATH 0280 Matrices & Linear Algebra or equivalent
- MATH 290 Differential Equation or equivalent
- ENGR 0012 Engineering Computing or equivalent
- MEMS 0031 Electrical Circuits or equivalent
- MEMS 1015 Rigid-Body Dynamics or equivalent

Lecture time/location: Monday 13:50 - 16:25 / room N209.

Textbook & References:
- Ramin S. Esfandiari and Bei Lu: Modeling and Analysis of Dynamic Systems, 3rd Edition, CRC Press, 2018.
- Additional references and supplementary materials will be posted on Blackboard.

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Office: Room N505
Office Hours: Tuesday 13:00 – 16:30 and Wednesday 09:00 – 11:30
For consultation outside office hours, please send an email to make an appointment. Note: please include the course name/number, your name and student number in the message. In the subject field of your email indicate the issue (and use your university email account).

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Course Objectives:
- Introduce students to the modeling of dynamic systems.
- Acquaint students with the analysis of dynamic systems in the time and frequency domains.
- Develop the students' skills in the utilization of computer tools to investigate the behaviors of dynamic systems.

Course Learning Outcomes:
After the successful completion of this course students should be able to:

- Formulate equations of motions for linear mechanical, electrical, fluid, & thermal systems,
- Represent the system model in different forms,
- Solve the system model to get the responses for different inputs,
- Analyze the system response characteristics in the time and frequency domains,
- Utilize computer tools to analyze system responses.

This course contributes to the following ABET Criterion 3 outcomes:
(1) Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
(2) Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
(3) Communicate effectively with a range of audiences.
(7) Acquire and apply new knowledge as needed, using appropriate learning strategies.

Assessment Policy:

ACTIVITIES	PERCENTAGES
Quizzes, studios	10%
Labs, Projects	20%
Midterms	40%
Final	30%

Grading Scale:

Letter	A	A-	B+	B	B-	C+	C	C-	D+	D	F
Percentage (%)	100~90	89~85	84~80	79~76	75~73	72~70	69~66	65~63	62~61	60	<60

Class Policies:

- Sichuan University attendance policy will be enforced. Attendance will be taken at the start and checked at the end of the class. Students who come to class more than 15 minutes late (without valid reasons) will be considered as absent. Students who leave class early (without valid reasons) will be considered absent. Students who sign the attendance for another student will be considered as absent and will be reported to the University as a misconduct. Students performing activities not associated with the course while in class (e.g., sleeping, watching video, playing games, doing other course assignments or personal work) will be considered absent.

- Students with 3 unexcused absences (including lateness or leaving class early) will receive zero for all quizzes, studios, laboratory exercises, and projects (i.e., only the midterm and final exams' marks will be considered towards their final grades).
- Students who missed more than a third of the classes (these absences included classes missed with and without approval and valid reasons) will lose the right to be assessed and will receive zero for the course. These students will NOT be allowed to take the makeup exam.
- All quizzes, studios, laboratory exercises, projects and exams have clearly stated submission requirements. No marks will be given if the submission requirements are not met. Late submissions will not be accepted. No makeup for quizzes, studios, laboratory exercises, and projects will be allowed.
- If a student cannot attend the midterm examinations, the student must contact the instructor immediately with a valid reason. If the reason stated is consistent with University Policy, arrangements can be made for alternate assessments. Otherwise, the student will get zero for the midterm examinations.
- If a student has a valid reason and cannot attend the final exam, the student must apply to the administration for a deferred examination.
- Challenge to the grading must be made within 7 days after the returned of the graded assessment item. No challenges to the grading will be entertained after the 7-day period.

Academic misconduct and non-academic misconduct will not be tolerated. All misconduct will be reported and dealt with by SCUPI.

Academic Misconduct:

All students in attendance at the Sichuan University are expected to be honorable and to observe standards of conduct appropriate to a community of scholars. The University expects from its students a higher standard of conduct than the minimum required to avoid discipline. Academic misconduct includes all acts of dishonesty in any academically related matter and any knowing or intentional help or attempt to help, or conspiracy to help, another student. The Academic Misconduct Disciplinary Policy will be followed in the event of academic misconduct.

Non-academic Misconduct:

All cell phones, and mobile phones are to be turned off and put out of sight during lectures (mobile phones and computers can be turned on during studios). All newspapers and other materials not related to the class are to be put away once class begins. Operating these devices and reading unrelated materials while in class is disrespectful to your instructor and fellow classmates. If you fail to abide by this rule, the instructor has the right to confiscate the device or materials and mark you as absent. If you have an emergency and need to have your phone turned on during class, ask your instructor for permission.

Tentative Course Schedule (changes will be announced):

Week	Topic	Description
1	Course introduction and Linear algebra revision • Ch. 1 & 3	Course objectives, prerequisites, learning outcomes, schedule, and learning resources. Class policies including assessment, and grading. Definition of dynamic systems with course overview. Matrix addition, subtraction, multiplication & transpose. Special matrices. Reduced-row-echelon form. Rank & Determinant. Inverse of a matrix and solving systems of equations. Cramer's rule. Eigenvalue problem and similarity transformation.
2	Linear Ordinary Differential Equations – revision • Ch. 2	Complex numbers. Differential equations & Laplace transformation. Impulse, step and ramp inputs. Laplace transform of derivative. Algebraic equation in Laplace domain. Final value and initial value theorems. Solving algebraic equation in Laplace domain. Partial fraction expansions for distinct real roots, repeated real roots, and pair of complex roots. Convolution.
3	Linear systems & State-space equations • Ch. 4	Principle of superposition. Linear systems. Generalized coordinates. System model representations. Configuration form. Second-order matrix form. State variables & state variable equations. State space format with state equation and output equation. Decoupling state equation. Symbolic programming & Numerical analysis in MATLAB.
4	Input-output equations & Transfer function • Ch. 4	Input-output equation. Input-output equations from ordinary differential equations. Transfer function and transfer function matrix. Obtaining transfer matrix from State space equations. Input-output equations to State-space equations: Lower and Upper companion forms.
5	Block diagram • Ch. 4	Represent an ordinary differential equation as a block diagram. Block diagram elements. Block diagram reduction. Block diagram and signal flow graphs. Manson's rule 1 and rule 2. Block diagram for Multiple input-multiple output systems. Block diagram from Ordinary Differential equations. Overview of different Model representations. Nonlinearities: operating point and linearization.
6	Electrical systems • Ch. 6	Electrical elements and their voltage-current relationships. Modelling of electrical systems using Kirchoff's voltage and current laws with applications. Modelling of electrical systems using Impedance method with applications.
7	Midterm 1	Covers Ch. 1, 2, 3 & 4.
8	Mechanical systems • Ch. 5	Mechanical elements: inertia, spring, & damper. Modelling of Translational mechanical systems using Free-body-diagrams & Newton's laws. Planar rotation about a fixed axis. Parallel axis theorem. Modelling of Rotational systems using Free-body-diagrams & Newton's laws. Rolling motion. Gears. Gears with parallel rotating axes. Gear train systems.

Tentative Course Schedule (continue):

Week	Topic	Description
9	Mixed mechanical systems • Ch. 5	Translation or rotational systems. Levers and Pulleys. Modelling of mixed mechanical systems using Free-body-diagrams & Newton's laws. Energy method. Modelling of mixed mechanical systems using Lagrange's equation.
9	Electromechanical systems • Ch. 5 & 6 (makeup for 5 May in week 11)	Operational amplifiers. Modelling of op-amp using impedance method. Magnetic field. DC motors: armature-controlled and field-controlled DC motors. Modelling of electromechanical systems.
10	Fluid and thermal systems • Ch. 7	Pneumatic systems: Pneumatic resistance and capacitance. Conservation of mass with modelling of pneumatic systems. Hydraulic systems: Hydraulic resistance and capacitance. Modelling of hydraulic systems. Thermal systems: Thermal resistance and capacitance. Modelling of thermal systems.
11	Holiday (makeup on 27 April in week 9)	
12	Midterm 2	Covers Ch. 5 & 6.
13	First order system responses • Ch. 8	Principle of superposition. First-order systems: time constant, stability, particular and complimentary solutions. General free response, impulse response, step response, & ramp response of 1^{st} order systems. Complex function and sinusoidal input. Frequency response and frequency response function of 1^{st} order systems. Steady-state time response of 1^{st} order systems to sinusoidal inputs.
14	Second order system time responses • Ch. 8	Second-order systems: natural frequency and damping ratio. Principle of superposition. General free response, impulse response, & step response for undamped, underdamped, critically damped & overdamped 2^{nd} order systems.
15	Holiday	
16	Frequency responses • Ch. 8	Frequency response and frequency response function of 1^{st} order systems. Steady-state time response of 2^{nd} order systems to sinusoidal inputs. Bode diagrams. Bode diagram characteristics and approximation for 1^{st} order systems. Bode diagrams characteristics and approximation for 2^{nd} order systems.
17	Final exam	Covers Ch. 1, 2, 3, 4, 5, 6, 7 & 8