MEMS 1028 – MECHANICAL DESIGN I

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 provides an overview of strength of materials analysis techniques as related to the design of mechanical elements. The basic topics of uniaxial tension/compression, torsion, bending and combined loading will be reviewed in the context of failure analysis. Failure theories and criterion for both static and fatigue conditions will be presented and applied to mechanical design (3 credit hours).

Prerequisites:
- ENGR0145 Statics & Mechanics of Materials II or equivalent

Lecture time/location: Tuesday 08:15 - 11:00 / zone 4 – room N209.

Textbook & References:
- Shigley's Mechanical Engineering Design, 11ed, Budynas & Nesbett, McGraw Hill, ISBN 9780073398211
- 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).

Teaching Assistant: Ms. Zhu Wenhui
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Course Objectives:
- Introduce students to the design of mechanical elements based on strength of materials analysis.
- Acquaint students with the application of standards and codes in engineering design using appropriate learning strategies.
- Develop the students’ skills in the communication of design analysis and synthesis.

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

- Analyze and report mechanical designs based on stress and strain.
- Apply static failure theories in the design of mechanical elements.
- Apply fatigue failure theories in the design of mechanical elements.
- Apply established standards and codes in engineering design.
- Consider uncertainties along with other social and economic factors in engineering design.

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 and studios	10%
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, 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, 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, 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	Introduction • Chap. 1 & 3	Course objectives, prerequisites, learning outcomes, schedule, and learning resources. Class policies including assessment, and grading. Definition of mechanical engineering design, including design analysis vs. synthesis with course overview. Engineering standards and design codes. Revision of free-body diagrams to determine design support reactions, internal loadings, and stresses inside the material. Material characteristics between stresses and material strength. Uncertainty & Factor of safety.
2	Load & Stress analysis • Chap. 3	Location of critical stresses. Relationship between shear force & bending moment. Shear force & bending moment diagrams. Singularity functions. Two-plane bending and stresses. Critical stress element & general 3-D stresses. Plane stress, transformation, & Mohr’s circle. Generalized Hooke’s law. Contact stress and thermal stress. Overview of design process.
3	Design with Beams • Chap. 3	Examples of beams and sign convention for bending analysis. Normal and shear stresses in beam bending. Synthesis of non-standard prismatic beams. Selection of standard prismatic beams. Curved beams in bending. Design codes & standards for hooks.
4	Design with (circular) Shafts • Chap. 3	Design of circular shafts based on different loading combinations. Torque diagrams. Attachment of elements to shaft. Analysis of stresses in non-circular shafts and closed thin-walled tubes. NBASA reference for the design of power transmitting shafts.
5	Design of Pressure vessels • Chap. 3	Cylindrical shells subjected to external and internal pressures. Analysis of thick-walled and thin-walled pressure vessels. ASME boiler & pressure vessel codes with applications. Stresses in rotating rings. Press and shrink fits. Consideration of stress concentrations in design.
6	Midterm 1	Covers Ch. 1 & 3.
7	Stiffness driven designs • Chap. 4	Review of beam deflection due to bending. Beam deflections by singularity functions. Principle of superposition. Beram deflections by superposition. Deflections of non-uniform beams. Spring elements in mechanical design. Spring rates and analysis.
8	Advanced deformation analysis • Chap. 4	Strain energy. Castigliano’s theorem with applications. Deflections of curved beams. Simplified analysis of thin curved beams.

Tentative Course Schedule (continue):

Week	Topic	Description
9	Columns • Chap. 4	Statically indeterminate problems. Columns. Critical buckling load for columns with central loading. Applications of Euler equation and parabolic equation. Columns with eccentric loading. Short compression members. Shock and impact loading.
10	Static Failure Theories • Chap. 5	Mechanical design failure examples & theories. Ductile vs. brittle materials and selection of failure criteria. Maximum normal stress theory. Maximum shear stress theory. Distortion energy theory. Estimation of shear strengths. Mohr theory. Coulomb-Mohr theory. Modified Mohr theory.
11	Midterm 2	Covers Ch. 4.
12	Fracture mechanics and Fatigue failures • Chap. 5 & 6	Introduction to fracture mechanics and mode 1 crack model. Introduction to fatigue and dynamic loading. Fatigue failure by crack nucleation and propagation. Fatigue stress concentration and notch sensitivity. Fatigue life methods: linear elastic fracture mechanics method and the strain-life method.
13	Fatigue Failure with Reversible simple load • Chap. 6	The stress-life method and S-N diagram. Estimating the endurance limit and endurance limit modifying factors. Idealized S-N curve and prediction of finite life (or fatigue strength) with examples.
14	Fatigue Failure with Fluctuating simple load • Chap. 6	Limitation of S-N diagram. Characterizing fluctuating stresses. The fluctuating stress diagram. First cycle yielding and Langer criterion. Fatigue failure criteria: Goodman criterion, Soderberg criterion, Morrow criterion, and Gerber criterion. Constant-life curves and the prediction of finite life. Application to shear stress.
15	Fatigue Failure with Combination of loading modes • Chap. 6	Introduction to combination of loading modes. Varying fluctuating stress. Cumulative fatigue damage and Miner’s rule. Examples of design codes covering fatigue design or analysis such as ASME BTH-1-2017 (design of below-the-hook lifting devices), NASA Reference Publication 1123 (design of power transmitting shafts), and ASME Boiler & Pressure vessel codes.
16	Design Ethics & Revision • Chap. 1	Review of design process. Economics consideration. Design & Manufacturability. Life cycle engineering. Product life cycle support and challenges. Design considerations. Engineer’s responsibility. Professional codes & ethics. Personal and Engineering ethics. Engineering professional ethics. The National Society of Professional Engineers Code of Ethics & Ethics decision matrix.
17	Final exam	Covers Ch. 1, 3, 4, 5, & 6.