ME 45310: MACHINE DESIGN—Fall Semester 2019

Department of Mechanical and Energy Engineering
Indiana University-Purdue University Indianapolis

Co-requisites ME 37200

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Textbook

R.G. Budynas and J.K. Nisbett, Shigley's Mechanical Engineering Design, McGraw-Hill, 10th Ed., 2014,
ISBN 9780073398204 (hard cover—expensive).
ISBN 9789339221638 (paperback—much less expensive).

Description

- Application of basic mechanics (statics and dynamics), mechanics of materials, and probably and statistics to the analysis and design of machines and machine components.
- Study of stress/strain and force/deflection relations in machine components.
- Fundamental approaches to stress and fatigue analysis and failure prevention.
- Design methods for machine components such as shafts, bearings, springs, gears, clutches, breaks, chains, belts, and bolted and welded joints.
- Solve open-ended machine design problems involving structural analysis, life prediction, cost, and technical drawing.

Goals

- Prepare students to apply principles of basic mechanics, mechanics of materials, and probably and statistics to the design of machines and machine components.
- Provide students with engineering criteria and design methods for material and component selection.
- Instruct students on the use of computer-aided design tools (e.g., Pro/Mechanica, Pro/Engineer, Matlab, Excel) to solve design problems.
- Apply engineering principles to open-ended mechanical design problems.

Outcomes

After completion of this course, the students should be able to:

- Apply knowledge of probably and statistics to mechanical design problems
- Apply knowledge of mechanical engineering science, such as solid mechanics and material science to mechanical design problems
- Design a mechanical system to meet desired engineering requirements
- Formulate and solve mechanical design problems
- Communicate effectively the solution to a design problem making of technical drawings and proper technical reports
- Analyze potential impact of designed machines on environment and society, including safety
- Conduct literature review, including research papers and patents
- Use modern engineering tools (e.g., Pro/Mechanica, Pro/Engineer, Matlab, Excel) in the analysis and design of machines and machine components

Grading

The course outcomes will be assessed as follows:

Items	***Percentage***
In-class exercises	15%
Homework	20%
First exam	25%
Second exam	25%
Design project	15%
Total	**100%**

Grade	A+	A	A-	B+	B	B-	C+	C	C-	D+	D	D-
Minimum%	97	93	90	87	83	80	77	73	70	67	63	60

Course schedule

The schedule shows the topics to be covered in each class meeting. You are expected to come to class prepared by studying the assigned material before the lecture. This allows for a more effective use of the class time. Note that the assigned material helps you establish some useful/relevant background on the subject but this doesn't necessarily mean that the exact same material will be covered during the lecture.

In-class exercises

An in-class exercise (IC) will be assigned in every lecture. Most of the ICs will be solved in class but, in some occasions, students are expected complete it outside the classroom. Students will have around 24 hours to submit the IC through Canvas. The IC is also used to check attendance, so only students who attended the lecture are expected to submit the IC.

Homework and Tests
Homework will be collected at the beginning of each period. If you are unable to attend a class, you may attach a note to your homework and submit it in advance. Late homework will not be accepted under normal circumstances. If late homework submission is available, there may be a penalty in the grade of up to 50%.

Test problems will be of a difficulty level similar to that of homework problems. You are strongly advised to study the example solutions in the textbook/handouts and problems solved in class as well as work out additional problems from the textbook /handouts. All homework must represent your own work. Consultation with other members of the class is allowed, but all work must represent an individual effort. Academic dishonesty is subject to punishment according to the relevant regulations. Cheating is cause for severe punishment.

Problem solution format
Homework and test answers must be on engineering paper or letter size white paper and in proper format. Homework solutions carried out using computer software may be submitted as a computer print-out. Neatness and a proper format are considered while grading.

Canvas usage
Canvas shall be used, but not as a comprehensive tool. Basic usage includes communicating with students, making course material (such as assignments, solutions, lecture notes, and handouts)

Cheating and plagiarism
Academic misconduct is subject to university punishment. Academic misconduct includes, but is not limited to, the following: 1) Cheating; 2) Fabrication; 3) Plagiarism; 4) Interference; 5) Violation of course rules; and 6) Facilitating Academic Dishonesty. Students needed to check IUPUI Student Misconduct policy section of the IUPUI Student Code of Conduct (http://life.iupui.edu/dos/code.htm), if they are not already familiar with it.

Additional policies
If you should arrive late, please be courteous to your fellow students by entering the room quietly, and quickly taking a seat. It is highly recommended that you attend all classes. In either case, you are responsible for turning in assignments on time and making up any work that you missed.

Additional help
During the semester, if you find that life stressors are interfering with your academic or personal success, consider contacting Counseling and Psychological Services (CAPS). All IUPUI students are eligible for counseling services at minimal fees. CAPS also performs evaluations for learning disorders and ADHD; fees are charged for testing. CAPS is located in UN418 and can be

contacted by phone (317-274-2548). For more information, see the CAPS web-site at: http://life.iupui.edu/caps/

Topics

1. Part I – Fundamentals of mechanical design (4 weeks)
    a. Stress-strain relations and deformation analysis
    b. Factor of safety
    c. Failure criteria
2. Part II – Failure prevention (4 weeks)
    a. Static failure analysis
    b. Fatigue failure analysis
    c. Surface failure analysis
3. Part III – Design of mechanical elements (7 weeks)
    a. Screws and fasteners
    b. Permanent joints (welding, brazing, and bonding)
    c. Mechanical springs: compression, extension, and torsion
    d. Bearing selection and mounts
    e. Gearing loads, stresses, strength, and safety factors
    f. Clutches, breaks, and flywheels
    g. Belts and chains
    h. Shaft and axles

Content

(subject to change)

Lecture	Date	Content	Reading
1	Aug 26	Course presentation. The design phases. Introduction to stress condition.	Ch. 1 Ch. 3
2	Aug 28	Equilibrium; Stress; Cartesian stress components. Shear force and bending moments in beams; Normal stress for beams in bending	3-1, 3-4, 3-5 3-2, 3-9, 3-10
3	Sep 4	Shear Stresses for beams in bending; Torsion; Combined stress.	3-10, 3-11, 3-12 Ch. 4
4	Sep 9	Singularity functions; General three-dimensional stress; Stress concentration; Elastic strain; Mohr's circle	3-6, 3-7, 3-8
5	Sep 11	Mohr's circle 3D; Deflection under tension, compression, torsion.	4-2 to 4-6
6	Sep 16	Deflection under bending. Critical load in long columns.	4-6, 4-11, 4-12, 4-13
7	Sep 18	Bending in 3D	4-6
8	Sep 23	Failure under static load in ductile materials	5-3 to 5-13
9	Sep 25	Failure under static load in brittle materials Fatigue failure: the stress-life method, endurance limit	6-1, -2, -3, -4, -7, -8, -9
10	Sep 30	Fatigue failure: Endurance limit modifying factors, characterizing fluctuating stress.	6-10, -11, -12
11	Oct 2	Fatigue failure: Stress concentration and notch sensitivity. Fatigue failure criteria. Fatigue safety.	6-12, -13, -14
12	Oct 7	Fatigue failure: Combination of loads, cumulative fatigue damage.	6-13, -14
13	Oct 9	Design of shafts and shaft components.	7-1, -2, -3, -4,
14	Oct 14	Miscellaneous shaft components: setscrews and keys	7-7
	Oct 16	Exam 1	Ch. 3 to 7
15	Oct 23	Limits and fits. Press and shrink fits.	7-8, 3-16
16	Oct 28	Rolling-contact bearings, Bearing life	11-1 to 11-4
17	Oct 30	Invited speaker: Greg Day, President, Jarret Engineering	
18	Nov 4	Bearing reliability and combined radial and thrust loading	11-5 to 11-7
19	Nov 6	Power screws. Threaded fasteners: fastener stiffness	8-1 to 8-6
20	Nov 11	Member stiffness. Tension load: bolt torque, safety factor.	8-7 to 8-9
21	Nov 18	Fatigue load and shear load	8-11, -12
22	Nov 20	Stresses in a bolt group under eccentric load	8-12
23	Nov 25	Welding symbols. Stresses in weld joints in torsion	9-1 to 9-3

Lecture	Date	Content	Reading
24	Dec 2	Stresses in weld joints in torsion and bending	9-4 to 9-7
25	Dec 4	Helical compression springs	10-1 to 10-6
26	Dec 9	Helical extension springs	10-11 to 10-12
27	Dec 11	Review	Ch. 7 to 11
	Dec 16	Exam 2	Ch. 7 to 11
28	Dec 18	Project review/GD&T and presentation of prototypes	Ch. 20

Additional/self-study topics

Gears
Flexible mechanical elements
GD&T

Important dates

Labor Day: Sep 2 (no class)
Fall Break: Oct 21-22 (no class)
Thanksgiving recess: Nov 27-Dec 1 (no class)
Last day of classes (Exam 2): Dec 16
Final exams (Final project): Dec 18
Faculty deadline for grade submission: Dec 24 (by 8 PM)