

ME 153

A First Course in Machine Design

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WFR: ME 4 WF 08:30–10:00.

COURSE OBJECTIVES

This course reinforces and extends concepts learned from engineering mechanics courses (i.e. ES 11 to 13), and applies them to the identification, analysis, and design of structural elements for both static and dynamic applications. Computational tools are employed when warranted, e.g. in parametric analyses. This is a first course in machine design; as such, a systematic approach to engineering design is introduced and practical design considerations of structural elements are interwoven throughout the course material. This course aims to:

- Provide students with the ability to identify, analyze, and design structural elements and machine structures.
- Introduce students to the engineering design process.
- Provide students with a range of experiences, group or individual, of engineering design.
- Let students apply their solid modeling and drafting skills on producing engineering drawings of structural elements and structures.
- Enhance students' analytical, problem-solving, and communication skills via a reasonable number of guided and unguided problem-solving exercises, brief reports, and formal design projects.
- Ensure students have the confidence and ability to participate in the design of functional, safe, and sufficiently long-lasting engineering products.

LEARNING OUTCOMES

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

- Identify, analyze, and design structural elements and machine structures for static and dynamic service.
- Explain and use yield and fatigue failure theories in analysis and design.
- Explain and quantify the effects of geometric discontinuities in static and dynamic applications.
- Identify and explain the design considerations of different structural elements, functionalities, safety requirements, and service and environmental conditions.
- Systematically design engineering products for functionality, safety, and longevity.
- Communicate engineering information in the context of mechanical design effectively.

REFERENCES

- Budynas, R. G., & Nisbett, J. K. (2011). *Shigley's Mechanical Engineering Design* (9th ed.). New York, NY: McGraw-Hill. *B&N
- Hibbeler, R. C. (2014). *Mechanics of Materials* (9th ed.). Upper Saddle River, NJ: Pearson. *H
- Juvinall, R. C., & Marshek, K. M. (2012). *Fundamentals of Machine Component Design* (5th ed.). Hoboken, NJ: Wiley. *J&M
- Ullman, D. G. (2010). *The Mechanical Design Process* (4th ed.). New York, NY: McGraw-Hill.
- Vinogradov, O. (2000). *Fundamentals of Kinematics and Dynamics of Machines and Mechanisms*. Boca Raton, FL: CRC Press.

CALENDAR

Lecture	Topics	Activities
0	Course introduction	
Combined loading in structural elements		
1	Review of engineering mechanics Introduction to engineering design	R1: ES 11 and ES 13 notes
2	Combined loading I: prismatic beams	R2: <i>H</i> 8.2
3	Combined loading II: compound beams	A1; R3: <i>H</i> 6.6–6.7, 7.3
4	Combined loading III: curved beams	R4: <i>H</i> 6.8, <i>B&N</i> 3.18
5	Combined loading IV: machine structures	A2; R5: <i>B&N</i> 3.1, <i>J&M</i> 2.1–2.6
Introduction to energy methods		
6	Energy methods I: fundamentals	R6: <i>H</i> 14.1–14.3
7	Energy methods II: Castigliano's beauty	A3; R7: <i>H</i> 14.8–14.10
8	Energy methods III: application to machines The engineering design process	Start P1; R8: <i>B&N</i> 4.8–4.9, <i>J&M</i> 5.8
9	Energy methods IV: indeterminacy	A4; R9: <i>B&N</i> 4.10, <i>J&M</i> 5.9
Buckling and elastic instability		
10	Compression members I: fundamentals	P1-PR1; R10: <i>B&N</i> 4.11–4.13
11	Compression members II: eccentric loading	A5; R11: <i>B&N</i> 4.14–4.16
Miscellaneous structural elements, static failure theories, and stresses in mechanisms		
12	Other elements I: pressure vessels	P1-PR2; R12: <i>J&M</i> 4.11, <i>B&N</i> 3.14
13	Stresses at geometric discontinuities Static failure theories I: ductile materials	A7; R13: <i>B&N</i> 3.13, 5.1–5.7
14	Review meeting 1	A6; R14: ME 153 notes
15	Review meeting 2	P1-PR3; R15: ME 153 notes
<i>End of midterm exam coverage</i>		
16	Other elements II: press and shrink fits	P1-PR4; R16: <i>B&N</i> 3.16
17	Other elements III: rotating rings	A8; R17: <i>B&N</i> 3.15
18	Mechanism stresses	P1; R18: ME 142 notes
19	Static failure theories II: brittle materials	A9; R19: <i>B&N</i> 5.8–5.11
Fatigue loading and failure theories		
20	Fatigue failure I: fundamental concepts	Start P2; R20: <i>B&N</i> 6.1–6.5, 6.7–6.8
21	Fatigue failure II: stress and strength characterization	A10; R21: <i>B&N</i> 6.9–6.11, 6.13
22	Fatigue failure III: failure theories	P2-PR1; R22: <i>B&N</i> 6.12
23	Fatigue failure IV: combined loading and damage	A11; R23: <i>B&N</i> 6.14–6.15
24	Fatigue failure V: review and muddy points	P2-PR2; R24: <i>B&N</i> 6.18
Analysis and Design of Shafts and Shaft Components		
25	Shaft design I: design guidelines	A12; R25: <i>B&N</i> 7.1–7.5
26	Shaft design II: instability and fits	P2-PR3; R26: <i>B&N</i> 7.6, 7.8
27	Shaft design III: shaft components	A13; R27 <i>B&N</i> 7.7
28	Review meeting 3	P2-PR4; R28: ME 153 notes
29	Review meeting 4	A14; R29: ME 153 notes
<i>End of final exam coverage</i>		
Machine Design and Beyond		
30	Denouement: introduction to machine elements	P2

REQUIREMENTS

- *Readings.* 29 instances at 0% each. Students should read assigned readings before corresponding lectures.
- *Assignments.* 14 instances at 1% each. Collaboration is highly encouraged and allowed but copying is not. All should be submitted in due time; failure to do so will result to a grade of 5.0.
- *Exams.* The midterm exam is 20% and the final exam is 26%. Scores are out of 100 and should not go below 30.
- *Projects.* 2 instances at 20% each. Each project has 4 progress reports and 1 final report. All reports should be submitted in due time; failure to do so will result to a grade of 5.0.