ME 153

# A First Course in Machine Design

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2nd Semester of A.Y. 2016–2017.
*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 | R1: ES 11 and ES 13 notes |
| | Introduction to engineering design | |
| 2 | Combined loading I: prismatic beams | R2: *H* 8.2 |
| 3 | Combined loading II: compound beams | A1; R3: *H* 6.6–6.7, 7.3 |
| 4 | Combined loading III: curved beams | R4: *H* 6.8, *B&N* 3.18 |
| 5 | Combined loading IV: machine structures | A2; R5: *B&N* 3.1, *J&M* 2.1–2.6 |
| **Introduction to energy methods** | | |
| 6 | Energy methods I: fundamentals | R6: *H* 14.1-14.3 |
| 7 | Energy methods II: Castigliano's beauty | A3; R7: *H* 14.8–14.10 |
| 8 | Energy methods III: application to machines | Start P1; R8: *B&N* 4.8–4.9, *J&M* 5.8 |
| | The engineering design process | |
| 9 | Energy methods IV: indeterminacy | A4; R9: *B&N* 4.10, *J&M* 5.9 |
| **Buckling and elastic instability** | | |
| 10 | Compression members I: fundamentals | P1-PR1; R10: *B&N* 4.11–4.13 |
| 11 | Compression members II: eccentric loading | A5; R11: *B&N* 4.14–4.16 |
| **Miscellaneous structural elements, static failure theories, and stresses in mechanisms** | | |
| 12 | Other elements I: pressure vessels | P1-PR2; R12: *J&M* 4.11, *B&N* 3.14 |
| 13 | Stresses at geometric discontinuities | A7; R13: *B&N* 3.13, 5.1–5.7 |
| | Static failure theories I: ductile materials | |
| 14 | Review meeting 1 | A6; R14: ME 153 notes |
| 15 | Review meeting 2 | P1-PR3; R15: ME 153 notes |
| | *End of midterm exam coverage* | |
| 16 | Other elements II: press and shrink fits | P1-PR4; R16: *B&N* 3.16 |
| 17 | Other elements III: rotating rings | A8; R17: *B&N* 3.15 |
| 18 | Mechanism stresses | P1; R18: ME 142 notes |
| 19 | Static failure theories II: brittle materials | A9; R19: *B&N* 5.8–5.11 |
| **Fatigue loading and failure theories** | | |
| 20 | Fatigue failure I: fundamental concepts | Start P2; R20: *B&N* 6.1–6.5, 6.7–6.8 |
| 21 | Fatigue failure II: stress and strength characterization | A10; R21: *B&N* 6.9–6.11, 6.13 |
| 22 | Fatigue failure III: failure theories | P2-PR1; R22: *B&N* 6.12 |
| 23 | Fatigue failure IV: combined loading and damage | A11; R23: *B&N* 6.14–6.15 |
| 24 | Fatigue failure V: review and muddy points | P2-PR2; R24: *B&N* 6.18 |
| **Analysis and Design of Shafts and Shaft Components** | | |
| 25 | Shaft design I: design guidelines | A12; R25: *B&N* 7.1–7.5 |
| 26 | Shaft design II: instability and fits | P2-PR3; R26: *B&N* 7.6, 7.8 |
| 27 | Shaft design III: shaft components | A13; R27 *B&N* 7.7 |
| 28 | Review meeting 3 | P2-PR4; R28: ME 153 notes |
| 29 | Review meeting 4 | A14; R29: ME 153 notes |
| | *End of final exam coverage* | |
| **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.