# EME 150A   Spring 2014

# Mechanical Design

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**office hours**: Tuesdays 2:00–4:00 pm

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**office hours**: time & place TBA

lectures: MW 12:10–1:30 pm, 168 Hoagland

discussion: MW 1:40–2:00 pm, 168 Hoagland

**Synopsis**: In this course we investigate basic principles governing the design of mechanical components and systems to support given static and dynamic loads. We will learn how to analyze various types of loading conditions, and the deflections they induce in elastic members. We will also study the three–dimensional stress states resulting from these loads, and develop criteria to predict when these stresses incur static failure of parts. For dynamic loads, we develop models of fatigue failure allowing parts to be designed for a specified (possibly infinite) service life. These design principles are applied to specific mechanical components (springs, gears, bearings, etc.) in EME 150B.

# 1 prerequisites

As preparation for this course, you should have taken the following:

- ENG 35 Statics
- ENG 45 Properties of Materials
- ENG 104 Mechanics of Materials
- EME 50 Manufacturing Processes (can be concurrent)

Please note that the ABET accreditation procedure now requires the diligent observance of prerequisites — they are *not* at the instructor's discretion.

# 2 textbook

The required text for this course is Shigley's *Mechanical Engineering Design*, 9th edition, McGraw–Hill. EME 150A covers Parts I & II of this book, while EME 150B covers Part III (machine components). Homework problems will be assigned from the 9th edition. If you have a different version, consult the library copy or a colleague's copy of the 9th edition for the homeworks.

# 3 syllabus

The following is (a superset of) the list of topics that we shall cover:

**introduction to design** — 1 week

design creativity & methodology
teamwork & design projects
failure modes & safety factors

**brief review of statics** — 1.5 weeks

free-body diagrams
equilibrium of beams
bending moment & shear force diagrams
use of singularity functions
vibrational & impact loading

**properties of materials** 0.5 week

tensile test & stress-strain curve
ductile & brittle materials
Young's modulus & elastic limit
yield strength & ultimate strength
strength in compression
modulus of rigiditiy & shear strength
impact & fracture toughness
Brinell, Rockwell hardness
heat treatment & cold working

**stress in mechanical components** 2 weeks

direct & shear stresses
stress tensor: principal stresses
plane stress: Mohr circle diagram
3D stress: Mohr 3-circle diagram
tension, bending, torsional stresses
superposition: combined stresses
deflection analysis of beams
statically indeterminate beams
deflections by Castigliano's method
stress concentration effects
columns & elastic instability

**design for static loading** 1.5 weeks

safety factors
maximum normal stress theory
maximum shear stress theory
distortion energy theory
failure of ductile & brittle materials
fracture mechanics

**design for fatigue loading** 2.5 weeks

historical context & anecdotes
phenomenology of fatigue failure
R. R. Moore rotating beam test
SN diagram & endurance limit

endurance limit: modification factors
characterization of cyclic loads
Goodman diagram, load lines, safety factors
stress concentration factors in fatigue
fatigue under multiaxial stresses
cumulative fatigue damage
fracture mechanics approach to fatigue

**surface failure** 1 week

surface roughness characterization
coefficients of friction
adhesive, abrasive, corrosive wear
Hertzian contact stresses
surface fatigue: spalling & pitting

# 4 exams

There will be two exams — an in–class midterm, and a comprehensive final.

No make–up exams will be given — if you have a legitimate reason (medical condition, etc.), *corroborated by written documentation*, arrangements may be made in **exceptional circumstances** for you to take the exam somewhat earlier or for a missed exam to not count towards your grade.

# 5 design projects

There will be two mini–projects that illustrate various aspects of the design and analysis of mechanical components and systems. In these projects you will be working in teams, to be set up in class. Teamwork is a key aspect of real–world engineering, and each member is expected to participate diligently. At the conclusion of the project, you will have the opportunity to evaulate your team–mates contributions, and these peer evaluations will be taken into consideration in deciding individual grades. These projects may involve class presentations and written reports (due dates will be announced in class).

# 6 homeworks

Homeworks will be assigned on Thursdays, and are due *at the beginning of class* on the following Thursday. No late homeworks are accepted — however, the homework with the lowest score will not count toward your final grade. Solution sets for the homeworks will be posted after the due date.

Homeworks are to be completed on your own. You may consult with classmates about conceptual aspects of a problem, but all written work (whether in scrap or final form) must be your own.

# 7 discussions

The discussion sections will cover problem–solving, clarification of material covered in the lectures, homeworks, and exams, and planning for the course projects. Since the projects are an integral part of the course, attendance at the discussion sections is **required**.

# 8 grading policy

Penalties may be imposed on homeworks, project reports, and exams for lack of neatness, legibility, or clear organization of your work.

**The UC Davis Code of Academic Conduct is in effect with regard to homeworks, exams, and projects. Your mature and responsible adherence is expected — violations will be taken very seriously.**

# 9 course grade

Exams, projects, and homeworks contribute to your overall grade as follows:

| | |
|---|---|
| mid–term exam | 20% |
| final exam | 30% |
| design projects | 40% |
| homeworks | 10% |
| total | 100% |

## 10 additional reading

There are many other texts with the same scope as Shigley and Mischke — you may wish to consult one or more of them:

- A. D. Deutschman, W. J. Michels, and C. E. Wilson,
  *Machine Design: Theory and Practice*,
  Macmillan (1975).
- K. S. Edwards and R. B McKee,
  *Fundamentals of Mechanical Component Design*,
  McGraw–Hill (1991).
- R. C. Juvinall and K. M. Marshek,
  *Fundamentals of Machine Component Design*,
  Wiley (1991).
- R. L. Norton,
  *Machine Design: An Integrated Approach*,
  Prentice–Hall (1998).
- R. M. Phelan,
  *Fundamentals of Mechanical Design* (3rd ed.),
  McGraw–Hill (1970).
- M. F. Spotts,
  *Design of Machine Elements* (6th ed.),
  Prentice–Hall (1985).

Finally, for both fun and enlightenment, I recommend:

- M. J. French, *Invention and Evolution: Design in Nature and Engineering*, Cambridge University Press (1988).
- H. Petroski, *Design Paradigms: Case Histories of Error and Judgement in Engineering*, Cambridge University Press (1994).
- H. Petroski, *To Engineer is Human: The Role of Failure in Successful Design*, St. Martin's Press (1985).