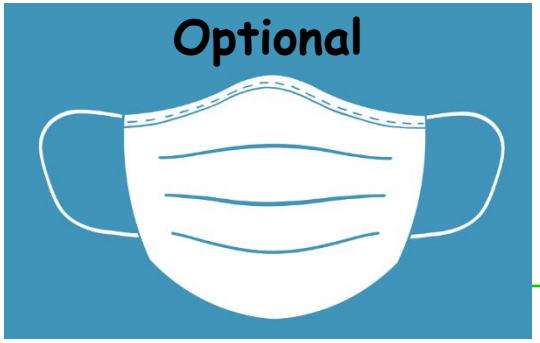
WORCESTER POLYTECHNIC INSTITUTE

MECHANICAL & MATERIALS ENGINEERING DEPARTMENT

DESIGN OF MACHINE ELEMENTS
ME-3320, B'2025

Lecture 01: Introduction

20 October 2025



General information

Instructor: Cosme Furlong
HL-152
(508) 831-5126
cfurlong@wpi.edu
http://www.wpi.edu/~cfurlong/me3320.html

Graduate Assistant: Mahendran K.
HL-149
mk1@wpi.edu

Office hours

- **INSTRUCTOR:** C. Furlong

Office: HL-152
Email: cfurlong @ wpi.edu

OFFICE HOURS:
M, Tu, Th, at 10:00 – 11:00 AM or by appointment – Via Zoom or in-person

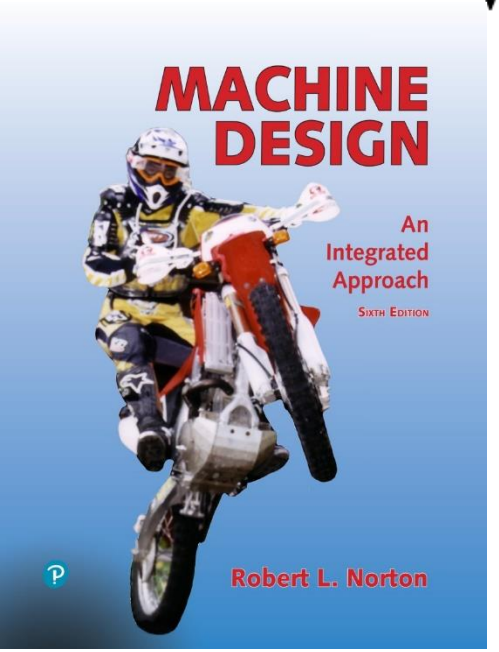
- **TA:** Mahendran K.

Office: HL-149
Email: mk1@wpi.edu

OFFICE HOURS: **TBD**

Please complete and return survey - handout

Course description



WORCESTER POLYTECHNIC INSTITUTE
MECHANICAL ENGINEERING DEPARTMENT

ME-3320
DESIGN OF MACHINE ELEMENTS
http://users.wpi.edu/~cfurlong/me3320.html

Category I

Term B'25

LECTURES: M, Tu, Th @ 9:00 am, *HL-202*

SECTION MEETINGS: F @ 10:00 – 11:50 AM, *HL-031*

Instructor: Cosme Furlong
Office: HL–152
Tel.: (508) 831–5126
Email: cfurlong@wpi.edu

Graduate Assistant: Mahendran K.
Email: mk1@wpi.edu

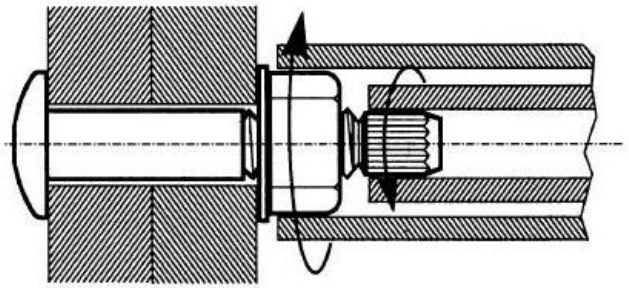
COURSE DESCRIPTION

This is an introductory course in mechanical design analysis, and it examines stress and fatigue in many machine elements. Common machine elements are studied, and methods of selection and design are related to the associated hardware. Topics covered include: combined stresses, fatigue analysis, design of shafts, springs, gears, bearings, and miscellaneous machine elements.

Recommended background: mechanics (ES-2501, ES-2502, ES-2503), materials (ME-1800, ME-2820), computer programming (CS 1001).

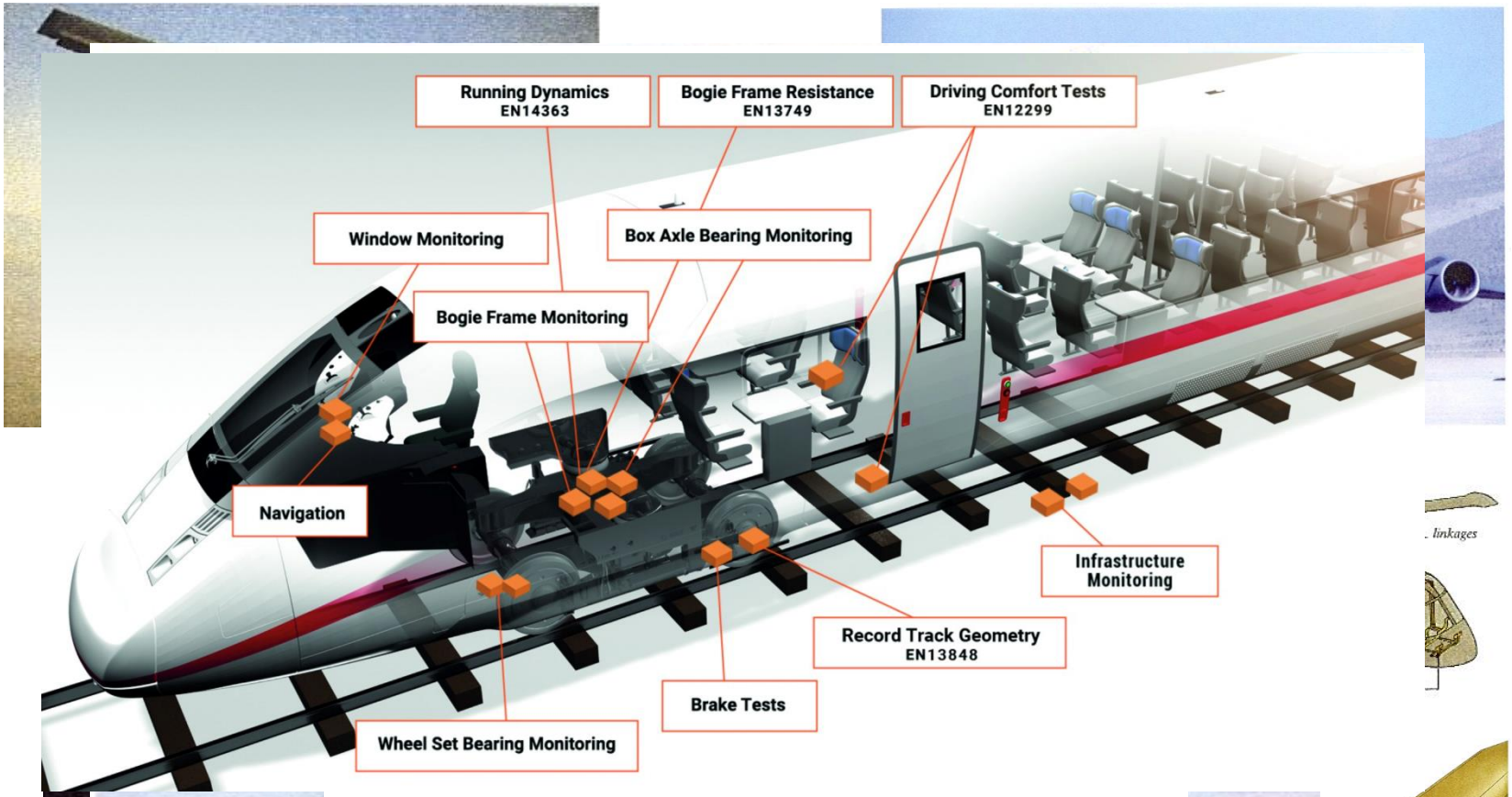
Representative components to be "designed" in this course

Determine: materials, geometry, dimensions,…



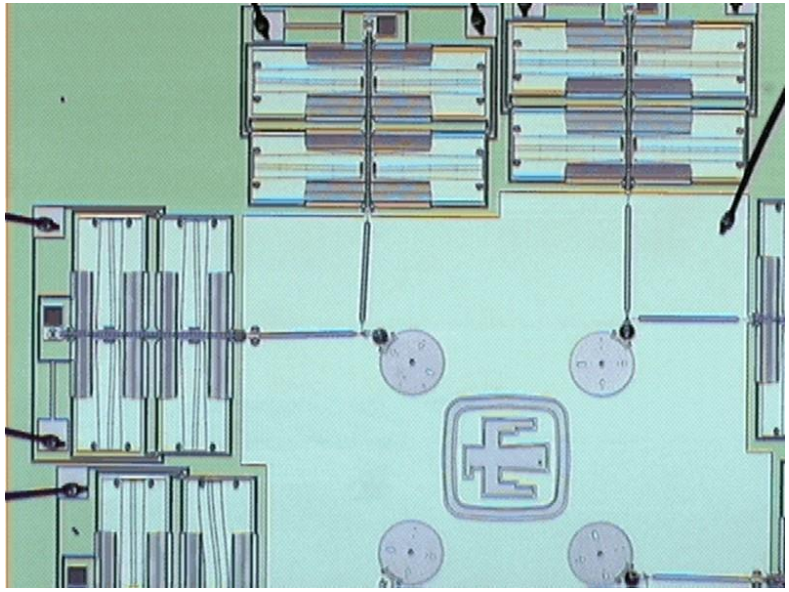
Subjected to: loads, boundary conditions, cost, efficiency, expected life,…

Large assemblies: millions of individual components



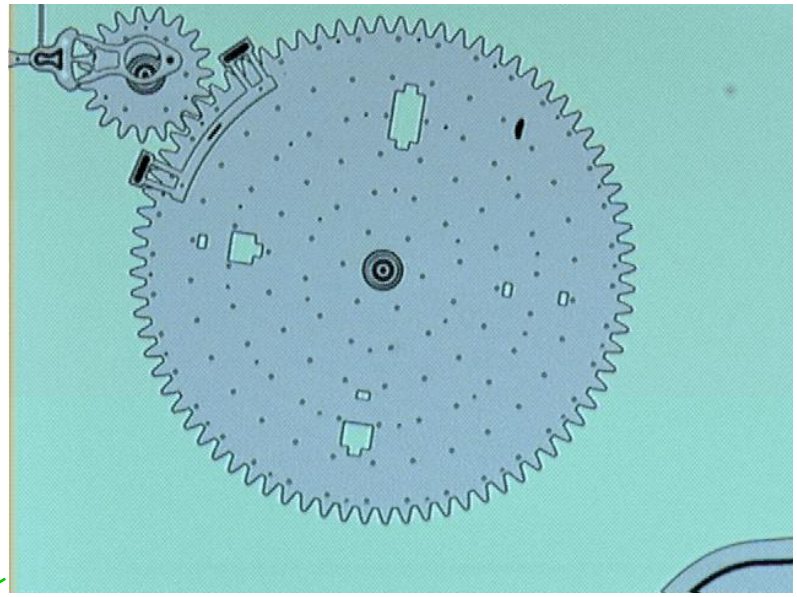
- Shape and Function
- Materials
- Tolerances and Manufacturing
- Multidisciplinary

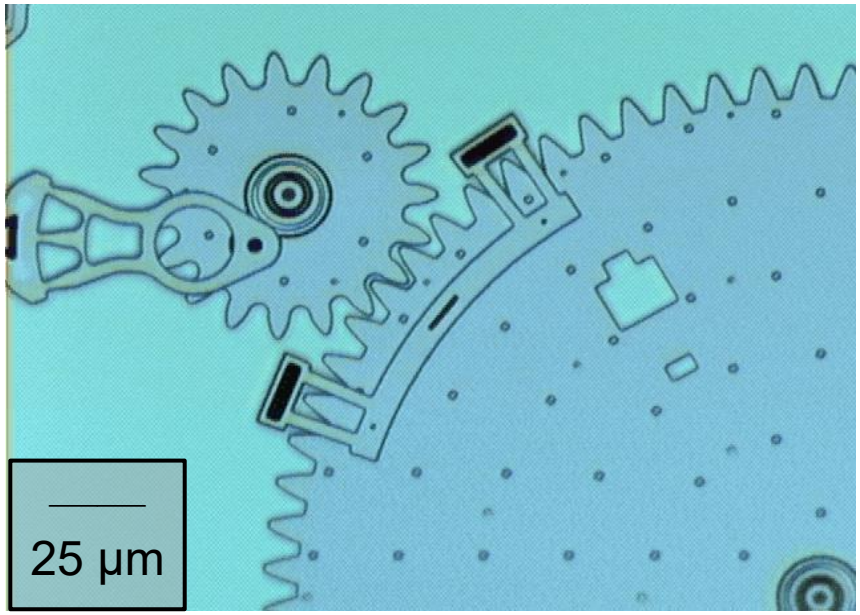
Sandia National Labs' 1,000,000 rpm microengine



Electrostatically
driven μ-engines

SNL – Sandia National Laboratories,
Albuquerque, NM

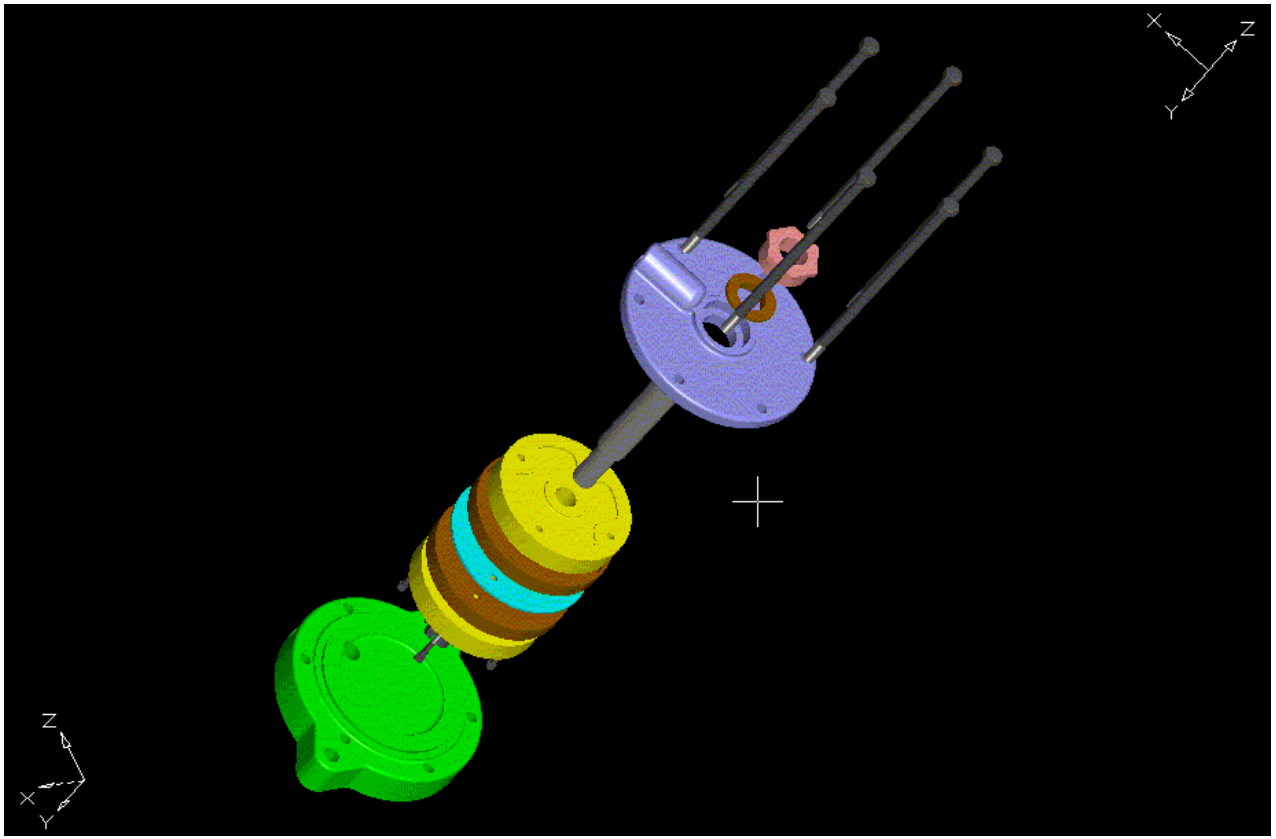




Close-up of the gears of a μ-engine

Multiple components (assemblies) - air cylinder

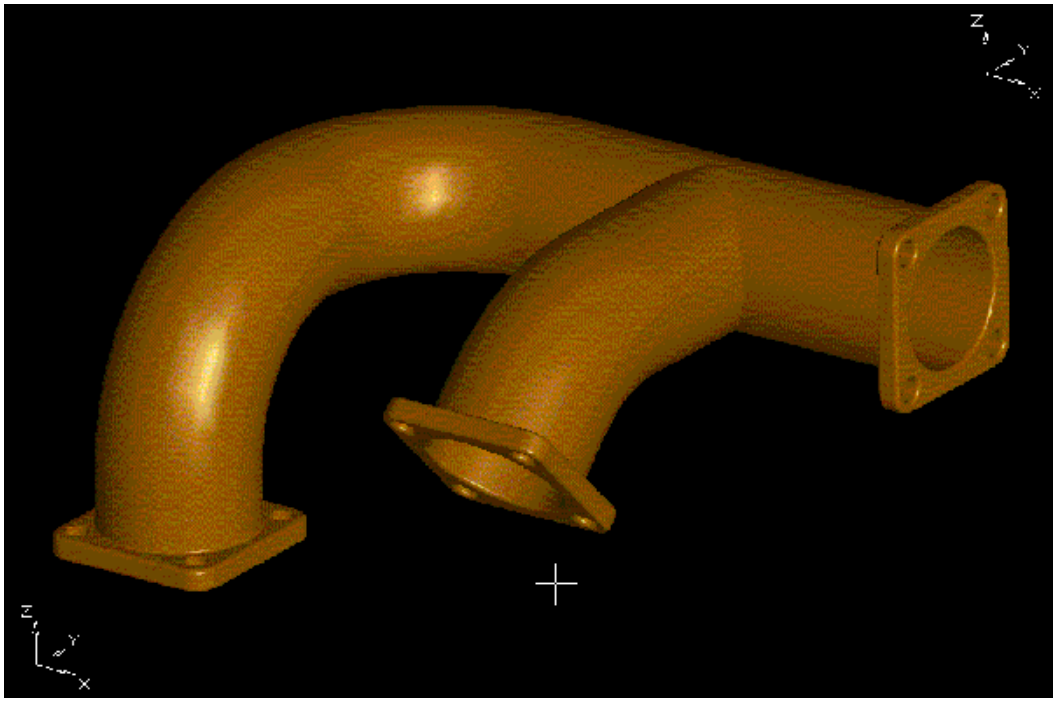
"Compatibility" of all components



Some design considerations:

- Dimensions
- Materials
- Tolerances
- Manufacturing
- Metrology
- Larger assemblies

Single component - manifold



Some design considerations:

- Dimensions
- Materials
- Tolerances
- Manufacturing
- Metrology

Topics covered in this course

Preliminary course outline:
see our ME3320's website & Canvas

Visit: ME3320's Canvas site

Visit: ME3320's website

http://www.wpi.edu/~cfurlong/me3320.html

Let's review these sites →

Homework

PLACE AND ORGANIZE ALL OF THE ASSIGNED **AUTHOR'S EXAMPLES** AND **SOLVED PROBLEMS** INTO A THREE-RING NOTEBOOK **and in** ELECTRONIC FORMAT

Instructor will ask you to submit several of those problems (randomly chosen) for grading at each exam

Good faith collaboration on the homework assignments is encouraged. *In good faith collaboration, students should first make serious attempts to solve the problems on their own, and only then discuss the problems with one another to clarify difficulties they may have had. If the collaboration is done properly then, even though students have worked together, the details of their solutions should still be quite different.*

Exams & Homework

THERE WILL BE SIX (6) EXAMS, which may involve the use of a computer program solver (e.g., Matlab, MathCad, ANSYS). *To ensure fairness in your evaluation, the lowest exam score will be dropped.*

Exams will be given on Fridays during our section meeting times or during other designated times – except during the first week of the term with no exam. *Exams are open books and open notes.* **Each exam will include all (everything) of the materials covered until Tuesday (inclusive) the week of the exam.**

Notes:

- MathCad software will be used. *Main help session is this Friday*
- Exams are solved individually without collaboration during portion of our conference times. If needed, additional time will be allowed for preparation and submission of solutions.
- First exam is on Friday, October 31.

Exams: representative example of an exam

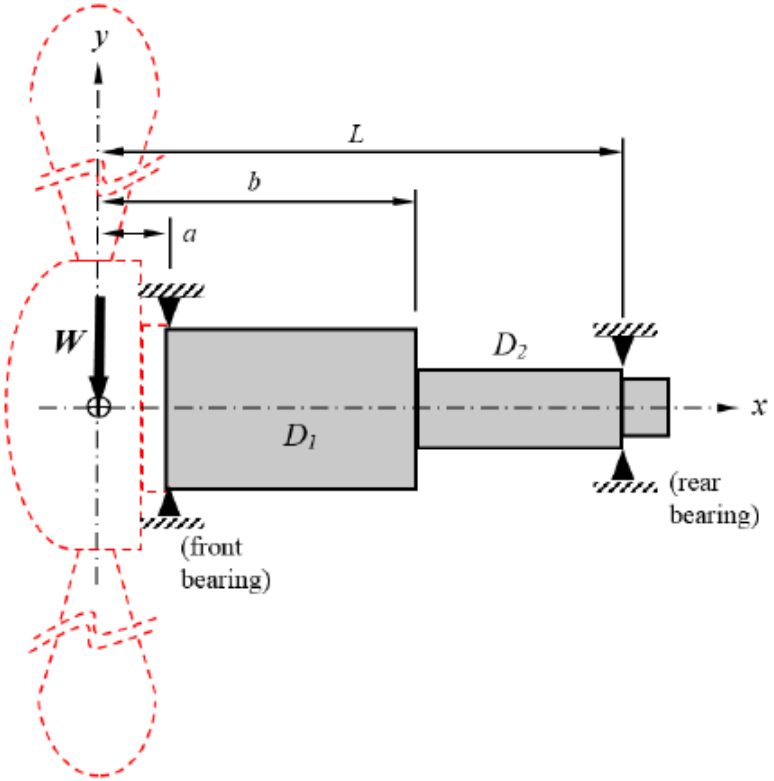
PROBLEM E2.1. Pass in author's problems:
(20 Points) 1) 3-4B,
2) 3-5B.

PROBLEM E2.2. Pass in solved problems:
(20 points) 1) 2-4,
2) 3-23(h).

PROBLEM E2.3. The main shaft of a wind turbine is being redesigned. As part of the efforts, *designers realized that it is necessary to calculate the deformations of the shaft that are produced by its own weight and by the weight of the flange-hub-blades assembly W.* Therefore, the *complete* load, shear, and moment functions are first necessary. Determine these functions, using singularity functions, for the solid shaft supported by two bearings as shown. Main shaft diameters are D_1 and D_2 and the weight density (weight per unit of volume) of the material used is γ. ***ONLY determine complete functions (including integration constants and reactions) – DO NOT plot functions at this time.***

(60 points)

← both (E2.1 and E2.2) randomly chosen from the assigned homework



Grading

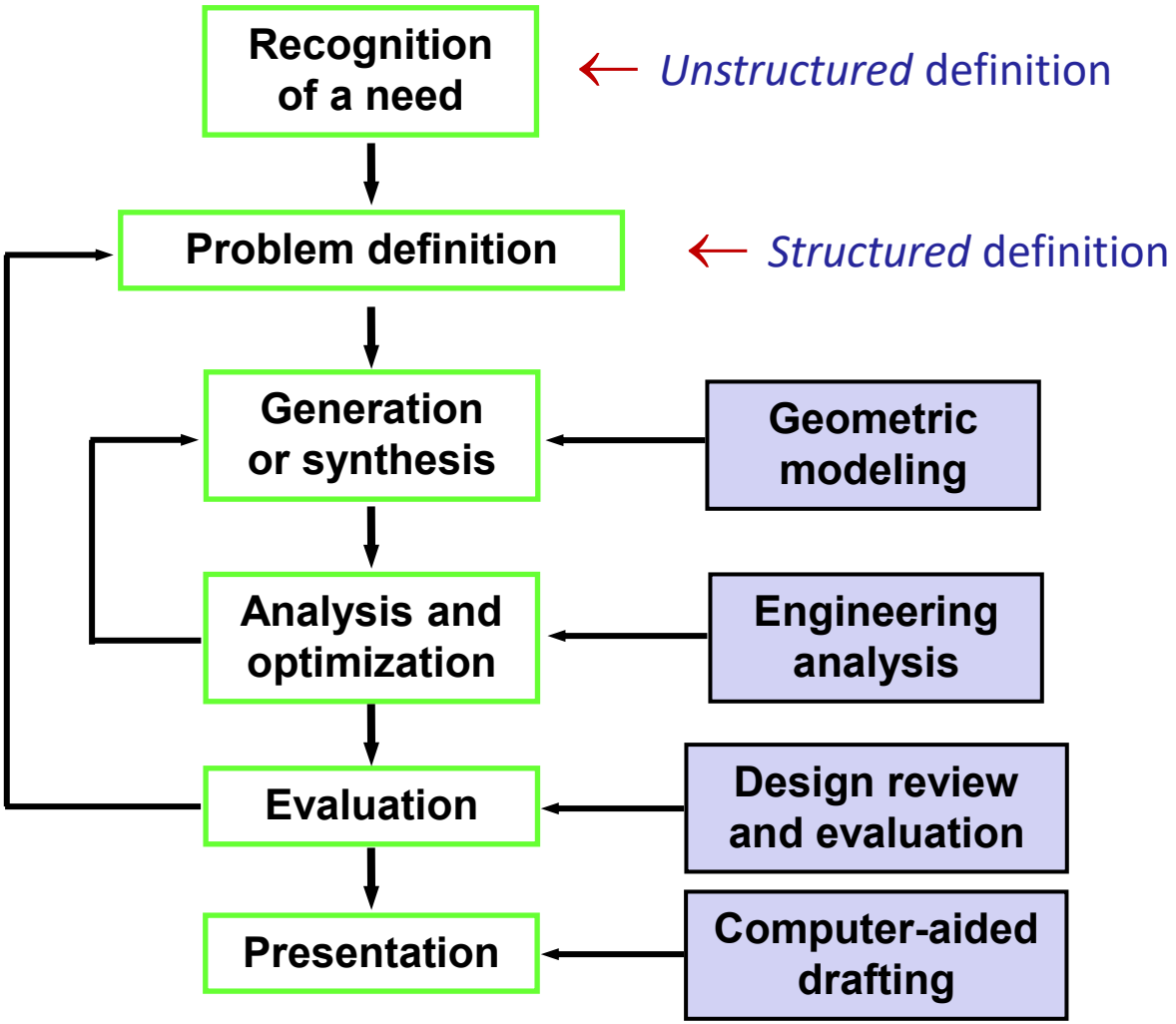
THE GRADE FOR THE COURSE WILL BE BASED **60% ON THE EXAMS** and **40% ON THE DESIGN PROJECT**. *Participation in course discussions will be taken into consideration.*

Design projects are developed in teams of 3-4 students.

Each team will be evaluated based on individual member efforts and on overall team outcomes and collaboration.

- Hand-in/email each team *name* and *roster* by Monday, October 27, 2024 – or earlier

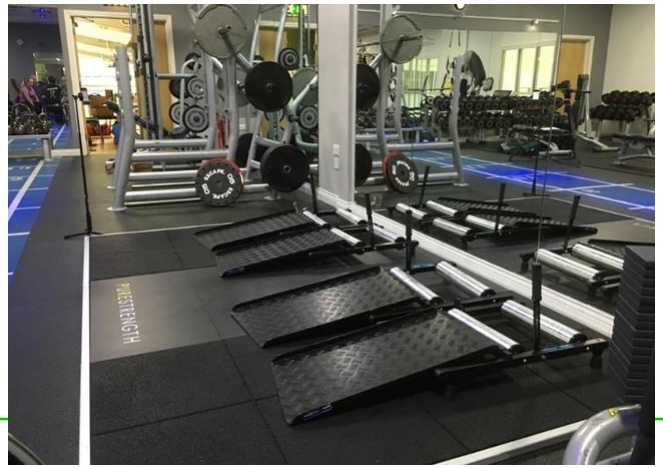
Engineering design methodology



Design project for this course

Indoor exercise machine for a wheelchair racer

Norton's Problem 9-17



Wheelchair exercise equipment is important for people to maintain their health and well-being. *Related exercise equipment comes in many varieties that can be tailored to user's needs*

Typical configuration

Reference:
https://howirollsports.com

Design project for this course

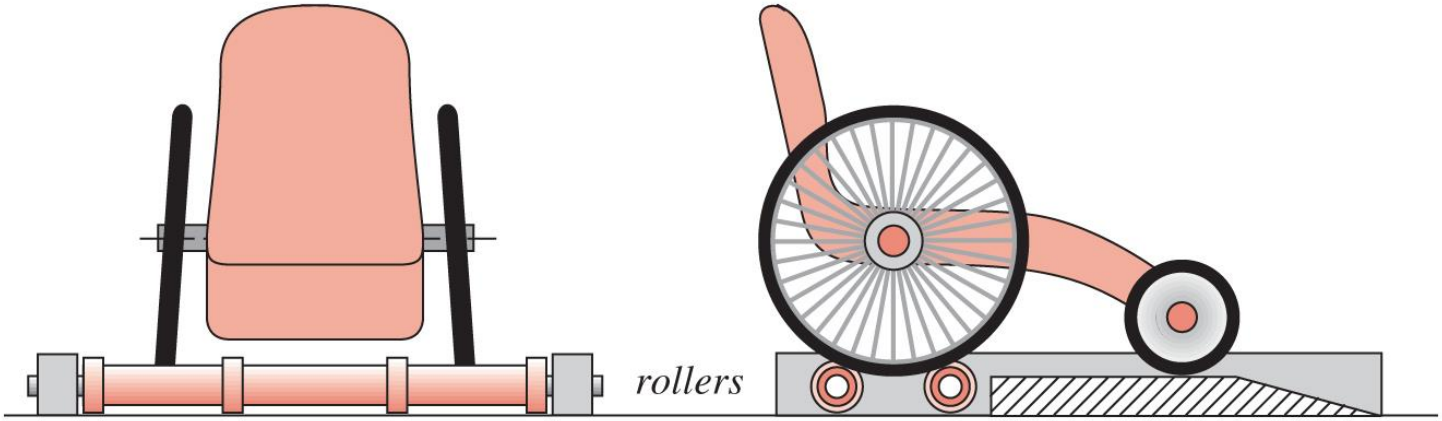
Indoor exercise machine for a wheelchair racer

Norton's Problem 9-17

Need: design an indoor bicycle exerciser with a *general configuration as shown*. The concept is to provide twin rollers to support the rear wheels and a single roller for the front wheel of a specific wheelchair.

Some **performance specifications**:

- The rear rollers to be attached in some kinematic fashion (to be designed) to a DC generator whose output is shunted through an electrical load that can be varied by the rider to provide a dynamometric resistance.
- All needed necessary components to have suitable geometries and materials to survive for infinite life and maintain safety.



Design of machine elements: a very general procedure

- Fully define: **objectives, constraints, performance specifications**
- Analysis:
  - Application of equilibrium conditions: **static and dynamic**
  - Identify critical sections: **stress and strain analyses**
  - Identify and consider: **effects of stress concentrations, residual stresses, material characteristics, etc…**
  - Apply design criteria: **safety factors, failure theories, fatigue life, vibrations, deformations, etc…**
- Select component geometry/dimensions/materials that satisfy objectives and constrains: **design iterations**
- Design review and presentation

Important notes

In all your work,

- State explicitly every assumption and/or approximation made
- Explain every procedure and justify their use
- Dimensional analyses are absolutely necessary, and therefore, all results must be expressed in appropriate units
- Your work MUST be neat, easy to follow, and professional in appearance for full credit
- PLEASE, ALWAYS SHOW ALL WORK

Reading assignment

- **Chapters:** 1 and 2 of textbook.
  Master Chapter 1 of textbook: fundamentals

- **Review notes and text:**
  ES2001, ES2501, ES2502, ES2503

Homework assignment: see Website of our course

- **Author's:** 1-1
- **Solve:** Solve: 1-3, 1-7 (Use of Mathcad is recommended)
  - MathCad software will be used. *Main help session is this Friday, October 24th*