

ME1029 Mechanical Design 2

Instructor: Ping C. Sui, Ph.D. Fall 2021

Class Schedules

	Time	Duration
Session 1	8:15 - 9:30	75 min
Session Break	9:30 - 9:45	15 min
Session 2	9:45 - 11:00	75 min



You May Wonder.....

- What is engineering design?
- Why mechanical design classes?
- Where does this knowledge apply to the job role as a Mechanical Engineer?



What is Engineering Design?

- Engineering design is a process of devising a system, component, or process to meet desired needs and specifications within constraints.
- It is decision-making (often iterative) process in which the basic sciences, mathematics, and engineering sciences are applied to convert resources to meet a staged objective.
- Among fundamental elements of a design process are the establishment of objectives and criteria, synthesis, analysis, and construction testing and evaluation.



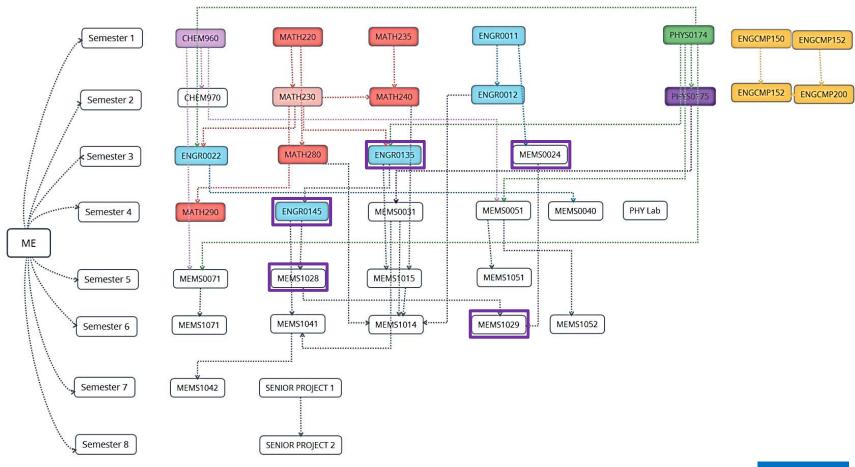
Why Mechanical Design Courses?

- We are engineers and we design/build things.
- We own the integrity responsibilities for the components, parts, and assemblies we design/build.
- To uphold the responsibilities, we have to possess the engineering knowledge and skills to properly design, build, and assess the structural risks.



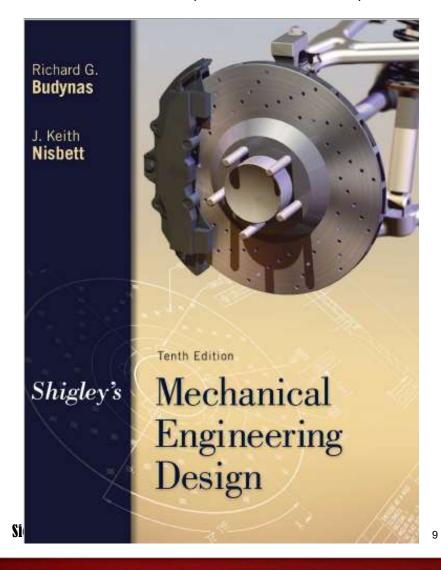
ME 1029 Mechanical Design 2

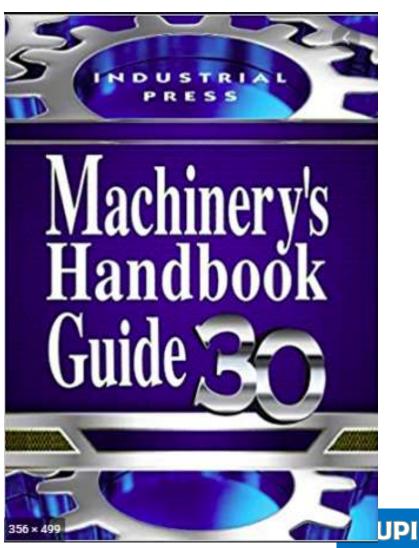
- Prerequisites
 - MEMS 1028 Mechanical Design 1
 - MEMS 0024 Intro to ME Design



Textbook

Shigley's Mechanical Engineering Design by Richard G. Budynas and J. Keith Nisbett, **10th edition**, McGraw-Hill Education, 2015.





Focus of Mechanical Design 1 & 2

Mechanical Design 1 (ME1028)

- Enhance knowledge of
 - material properties,
 - multi-axial and system-level stress analysis, and
 - stiffness/deflection analysis,
 which are the principles necessary for the remainder of the book.
- Introduce Failure Theories: Why machine parts fail and how they can be designed to prevent failure are difficult questions.

Mechanical Design 2 (ME1029)

- Design of mechanical elements
- Apply the concepts from Mechanical Design 1 to the analysis, selection, and design of specific mechanical elements.



Course Overview: Mechanical Design 2

- Advanced study with focus to introduce <u>elements frequently used</u> in mechanical designs.
- As class evolves, students will progressively develop the logical design discipline for understanding of
 - Functionality: understanding of components in static and dynamic mechanical applications,
 - Thought Process: in the decision of selecting components for the targeted applications, and
 - Failure Assessment: analysis and synthesis methodologies for evaluation of structural risks of the selected components.



Focus of Mechanical Design 1 & 2

Mechanical Design 1

Part 1	Basics 2
1	Introduction to Mechanical Engineering Design 3
2	Materials 41
3	Load and Stress Analysis 85
4	Deflection and Stiffness 161
Part 2	Failure Prevention 226
5	Failures Resulting from Static Loading 227
6	Fatigue Failure Resulting from Variable Loading 273

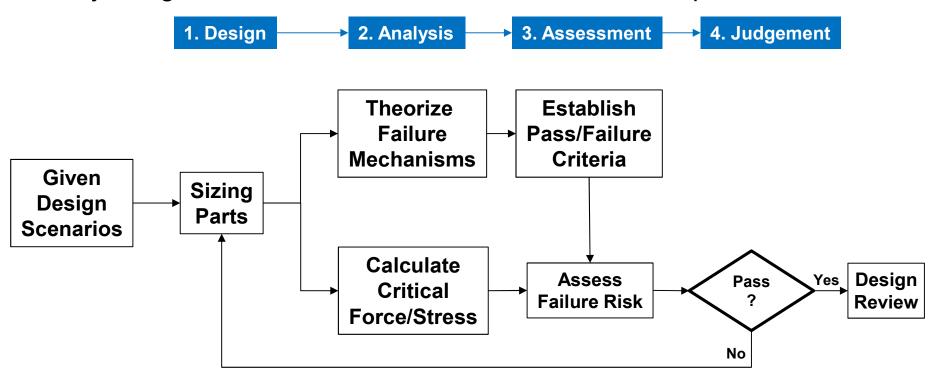
Mechanical Design 2

Part 3	Design of Mechanical Elements 350
7	Shafts and Shaft Components 351
8	Screws, Fasteners, and the Design of Nonpermanent Joints 401
9	Welding, Bonding, and the Design of Permanent Joints 467
10	Mechanical Springs 509
11	Rolling-Contact Bearings 561
12	Lubrication and Journal Bearings 609
13	Gears—General 665
14	Spur and Helical Gears 725
15	Bevel and Worm Gears 777
16	Clutches, Brakes, Couplings, and Flywheels
17	Flexible Mechanical Elements 871
18	Power Transmission Case Study 925



Design Discipline

Every design we do in this class, we will follow this discipline.....





Typical Design Calculations Used for Feasibility Study

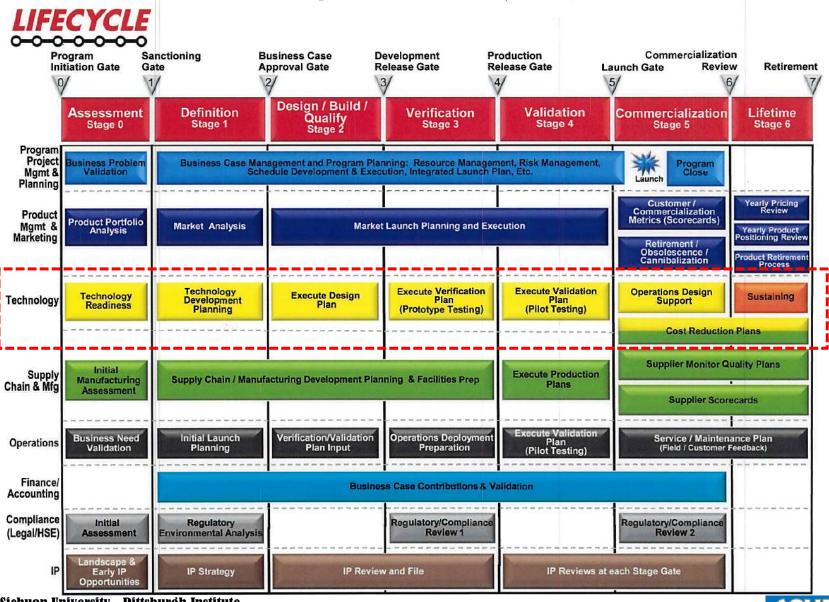
- Preserved first principles but calculation details are greatly simplified through assumptions and constraints for quick turnarounds
- Calculations to be performed using pencil-and-paper or spreadsheet-like tools
- Design per empirical data, correlation constants, or formulas-byexperience
- Referencing design to published design guidelines by technical societies and standard bureaus
- Range-bound per applications, most likely not universal



• Where does this learned knowledge apply to the job role as a Mechanical Engineer?



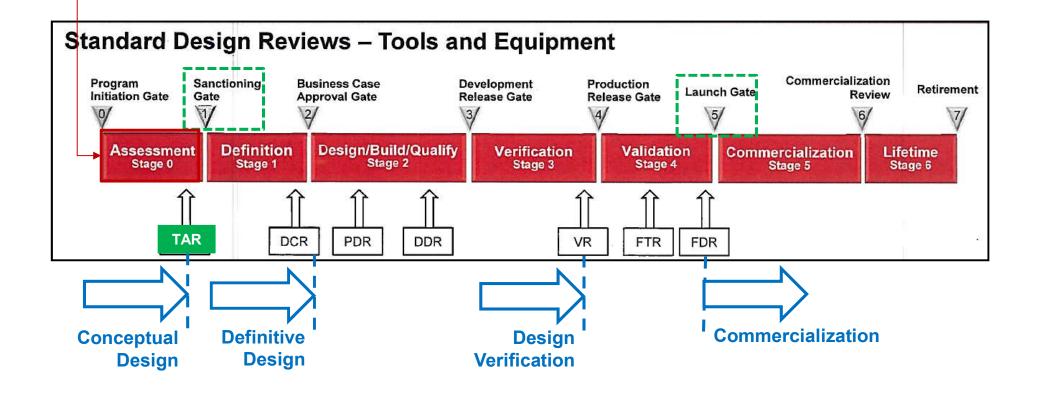
From Product Conceptualization to Commercialization



Technology Role in Development Cycle

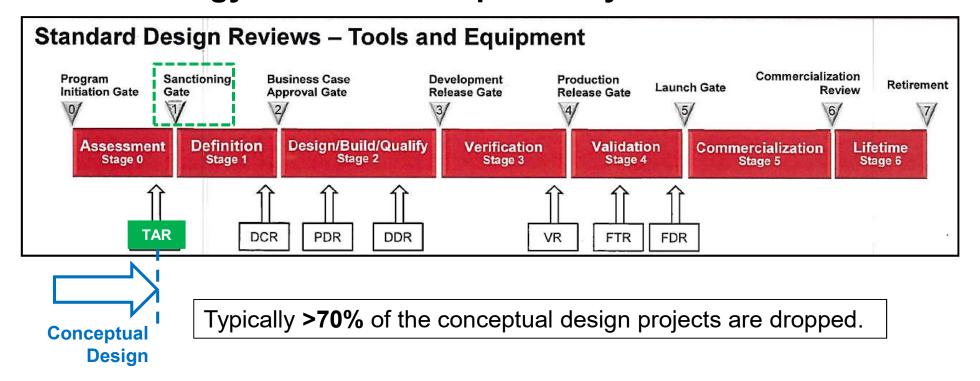
Operation: Performance Targets

Supply Chain: Product Manufacturing and Cost





Technology Role in Development Cycle



Feasibility Study: Assessment of the practicality of a proposed plan or method.

- Task Objective: deliver the conceptual design of prototype system
- Primary Efforts: dedicated to size the system
- **Execution Style**: fast-track, moderately conservative, short time span, ballpark estimation



Course Outline of Mechanical Design 2

Session	Class Date	Chapter	Topics		Homework	
1	Sep 01	Ch.3.16, 7.8	LN00 Course Overview	HW01		
			LN01 Press Fit Design			
2	Sep 08	Ch.3.16, 7.8	LN01 Press Fit Design	HW02		
		5.3 – 5.5, 5.7	LN02 Static Failure			
3	Sep 15	Ch.06	LN03 Review: High-Cycle Fatigue Des	HW03		
				Design Exercise 01		
4	Sep 22	Ch.06	LN03 Review: High-Cycle Fatigue Des	HW04		
		Ch.07	LN04 Shafts and Shaft Components			
5	Sep 29	Ch.07	LN04 Shafts and Shaft Components (F	HW05		
			Shaft Design for Stress)			
6	Oct 06		Section Exam 01			
7	Oct 13	Ch.11	LN07 Rolling Contact Bearings	HW06		
				Design Exercise 02		
8	Oct 20	Ch.11	LN07B Tapered Roller Bearings; Direct	HW07		
9	Oct 27	Ch.12	LN06A Lubrication & Journal Bearings	HW08		
10	Nov 03	Ch.12	LN06B Lubrication & Journal Bearings	HW09		
11	Nov 10		Section Exam 02			
12	Nov 17	Ch.08	LN05A Nonpermanent Joints	∣ Key Takea\	ways:	
13	Nov 24	Ch.08	LN05B Nonpermanent Joints	-	n Éxams	
14	Dec 01	Ch.08	LN05C Nonpermanent Joints			
		Ch.11	LN08A Gear Fundamentals	undamentals • 3 Design		
15	Dec 08		Section Exam 03			
16	Dec 15	Ch.11	LN08A Gear Fundamentals	HW12		
					Design Exercise 03	
17	Dec 22		LN08B Spur Gear Design Analysis			
18 Sienijan linis	Dec 29	ran incililla	LN08B Spur Gear Design Analysis			

Class Policies

In-Class Exercises (ICE)

- Hands-on calculations assigned during classes
- Duration: ~10 minutes

Homework (HW)

- HW's will be distributed each week after the class...
- HW Due Day: 8:00 AM on the day of the next class
- Late HW will not be accepted.
- Unforeseeable emergencies will be dealt with on a case-by-case basis.

Class Attendance

- Students are expected to attend every class period.
- Be punctual and arrive no later than the class starting time.
- Best Practice: Early is on time, on time is late



Class Policies: Section Exams

- Three section exams
- Each section exam will focus on individual section subject.
- Section exams will be <u>fast-paced and computation-intensive</u>.
 Purpose is to test your proficiency and familiarity with the section contents.
- The exams in this course will be open-book and open-note.
- No make-up will be given for the missing exam. Exams missed due to unpredictable events will be dealt with on a case-by-case basis.
- No programmable calculator of any kind is permitted in ME exams. Students can use their calculator of choice for other assignments.



Class Policies: Design Exercises

Purposes

- apply the learned knowledge to size their designs,
- deliberate the pros and cons of their designs,
- identify the failure mechanisms and define pass/fail criteria, and
- systematically draw conclusions per analytical opinions.

Duration: ~1-2 Weeks

Why Design Exercise?

- Homework/test questions have right and wrong answers.
- In terms of designs, there is absolutely no "right" design versus "wrong" design.
- There are designs that work and designs that don't work, and fifty shades of grey in between them.
- Engineers are not in business of seeking "Truth", but rather a compromised solution under a prescribed scenario bounded by resource constraints such as budget, schedule, and manpower, etc.
- Properly frame your mindset for design scenarios and solution boundaries



Design Thought Process.....

Typical Textbook Examples:

EXAMPLE 7-1

At a machined shaft shoulder the small diameter d is 1.100 in, the large diameter D is 1.65 in, and the fillet radius is 0.11 in. The bending moment is 1260 lbf \cdot in and the steady torsion moment is 1100 lbf \cdot in. The heat-treated steel shaft has an ultimate strength of $S_{ut} = 105$ kpsi and a yield strength of $S_y = 82$ kpsi. The reliability goal for the endurance limit is 0.99.

- (a) Determine the fatigue factor of safety of the design using each of the fatigue failure criteria described in this section.
- (b) Determine the yielding factor of safety.



Grading

In-Class Exercises: 10%

Homework: 25%

Section Exams: 35%

Design Exercises: 30%

附件: 等级成绩和百分成绩、绩点对照表

字母等级	A	A -	В+	В	В-	C+	C	C-	D+	D	F
中文等级	级 优秀		良好		中	中等		合格			不合格
百分制	100~90	89~85	84~80	79~76	75~73	72~70	69~66	65~63	62~61	60	<60
绩点	4	3.7	3.3	3	2.7	2.3	2	1.7	1.3	1	0

Heads-Up Reminder.....

四川大学匹兹堡学院推免研究生综合测评办法

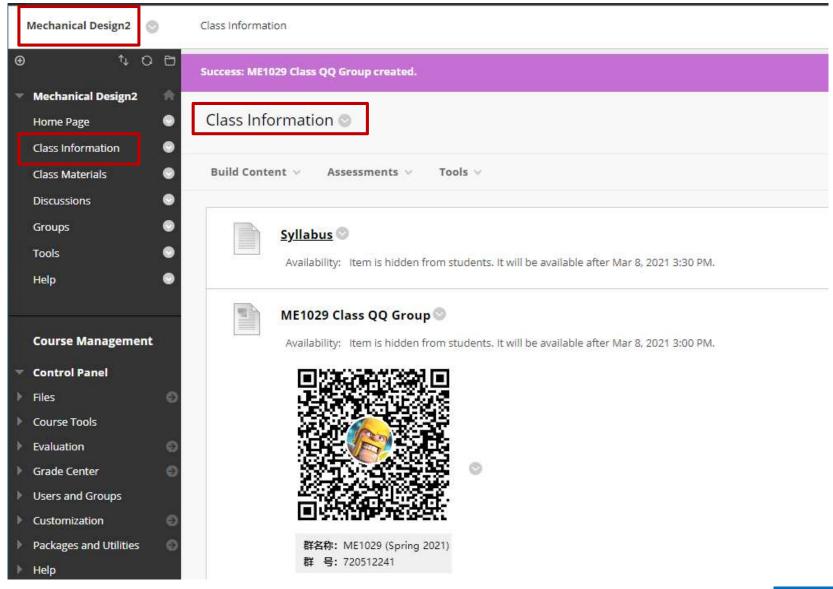
(2020年修订稿)

第二十五条 获得免试资格者如有下列情况之一的, 将取消其推免资格:

- 1. 在申请过程中弄虚作假;
- 2. 研究生入学前未取得学士学位;
- 3. 取得免试资格后有违法违纪、考试舞弊、学术不端行为或受到处分:
- 4. 在毕业学年中所修必修课程(包括毕业实习、毕业设计及毕业论文)考核成 绩低于满分的80%(或B+);

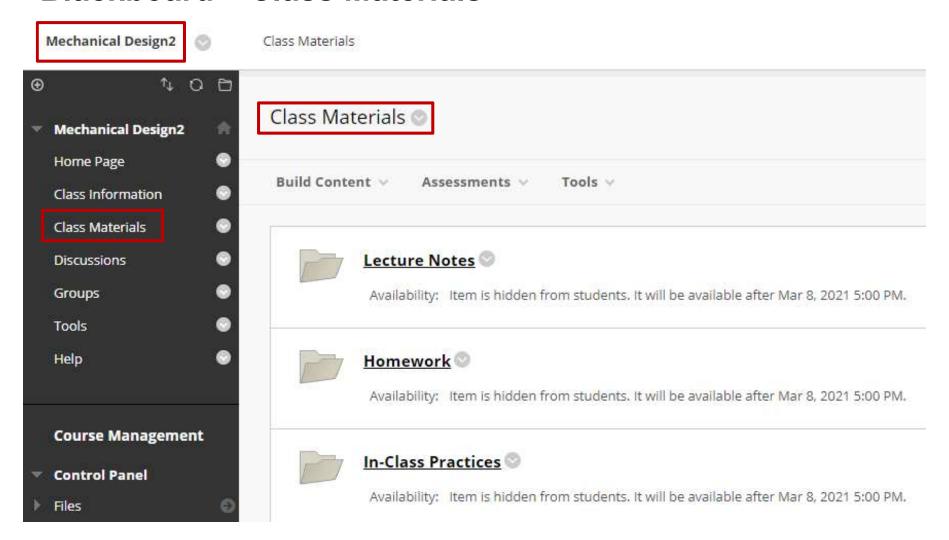


Blackboard – Class General Information



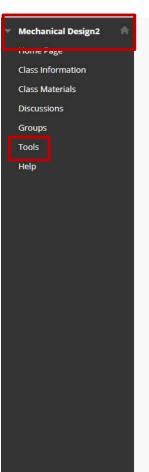


Blackboard – Class Materials





Blackboard – Your Grades



Tools

