UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Engineering, Built Environment and Information Technology

Fakulteit Ingenieurswese, Bou-omgewing en Inligtingtegnologie

School of Engineering
Skool vir Ingenieurswese

Department of Mechanical and Aeronautical Engineering
Departement Meganiese en Lugvaartkundige Ingenieurswese

Structural design: MOW 227
Struktuurontwerp: MOW 227

Lecturer: Prof Schalk Kok
Last Revision: 10 August 2021

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Departmental Study Guide

This study guide is a crucial part of the general study guide of the Department. In the study guide of the Department , information is given on the mission and vision of the department, general administration and regulations (professionalism and integrity, course related information and formal communication, workshop use and safety, plagiarism, class representative duties, sick test and sick exam guidelines, vacation work, appeal process and adjustment of marks, university regulations, frequently asked questions), ECSA outcomes and ECSA graduate attributes, ECSA knowledge areas, CDIO, new curriculum and assessment of cognitive levels. It is expected that you are familiar with the content of the Departmental Study Guide. It is available in English on the Department's website at the following link:

https://www.up.ac.za/media/shared/120/Noticeboard/2021/departmental-studyguide-eng-2021_version27may2021.zp204392.pdf

Take note of the specific instructions in the above study guide on:

a. **Safety**
b. **Plagiarism**
c. **What to do if you were sick? (very important)**
d. **Appeal process on the adjustment of marks**

1. GENERAL PREMISE AND EDUCATIONAL APPROACH

The general objective of this module is to emphasise **understanding** rather than memorising, to stimulate **creative thinking** and the development of **innovative skills** amongst students in the field of Machine Design. A problem-driven approach to learning is followed. Student-centred and co-operative learning teaching methods are applied during lectures. Tutorial classes and practical sessions (online in 2020) are used to develop the above skills, and to enhance the development of communication skills, interpersonal skills and teamwork.

Students are expected to participate in discussions during (online) lectures and tutorials. Students are dependent on the inputs of other students in the (virtual) classroom environment, participation is therefore crucial.

The effective use of Machine Design is an essential tool to the solution of engineering problems. In this module, the learner is taught the capability to visualize an engineering solution to a problem, conceptualize the solution, do the mathematical calculations and communicate the design by making use of free hand sketches.

2. LECTURER, VIRTUAL VENUES AND CONSULTATION

	Name	**Telephone No.**	**Email Address**
Lecturer	Prof. S. Kok	082 419 0576	schalk.kok@up.ac.za

Are lectures are online, on the Blackboard Collaborate platform.
Monday lecture 11:30-12:20
Wednesday lecture 08:30-09:20
Thursday lecture 09:30-10:20
Friday tutorial 13:30-16:20

All lectures and the weekly tutorial session will be recorded. The recordings are available on Blackboard Collaborate.

Consultation: Arrange a virtual (Google Meet) appointment via e-mail.

3. STUDY MATERIALS AND PURCHASES

The study material required for this course consists of one prescribed textbook (9th, 10th SI or 11th Editions are adequate). The units in all the editions are inconsistent: even the US version sometimes use SI units, and the SI version of the textbook sometimes use US units. A softcopy of this textbook is adequate for 2021 since all assignments, tests and exam will be open book. But it is still recommended to purchase a hard copy of this textbook since it is so useful for general mechanical engineering design. Some additional notes may be uploaded to ClickUP during the semester.

Prescribed Textbook:

- 2019 prescribed book: Shigley's Mechanical Engineering Design, R. G. Budynas, J. K. Nisbett, 10th SI Edition, McGraw Hill, ISBN 978-981-4595-28-5.
- 2020 & 2021 prescribed book: Shigley's Mechanical Engineering Design, R. G. Budynas, J. K. Nisbett, 11th Edition, McGraw Hill, ISBN 978-126-0569-99-5.

There are probably lots of places where you can buy this book. One of the more convenient options is the online shop of Wize Books, and they deliver door-to-door throughout South Africa. The link to the textbook is https://www.wizebooks.co.za/Get/9781260569995-shigleys-mechanical-engineering-design

4. LEARNING ACTIVITIES

4.1 Online contact time and learning hours

Number of lectures per week: 3
Number of tutorials per week: 1

This module carries a weighting of 16 credits, indicating that on average a student should spend some 160 hours to master the required skills (including time for preparation of tests and examinations). The average contact time is approximately 5 hours per week, meaning that another 8 hours per week of own study time should be devoted to the module.

4.2 Online lectures

Online lectures cover the following: (a) material directly from the textbook, (b) using Excel to solve engineering problems and (c) showing you how to solve representative problems. Note that no electronic slides are available for this module. The lectures that cover the work in the textbook makes direct use of an electronic (pdf) version of the textbook. The main focus of the lectures is to show you how to use the textbook (using the various tables, figures and appendices) and Excel (using Solver and some provided macros) to solve some representative problems. **Students are advised to participate actively in online discussions and to take down additional notes**.

4.3 Tutorials and assignments

The timetable provides for one, 4-hour long tutorial session each week. This online tutorial session will be spent to practise the theory done during that week's lectures, by solving representative problems. **To make the most of these online tutorial sessions, students must be prepared: every homework problem must have been attempted before the tutorial session starts.** At the end of each tutorial session a formal assessment will take place (due on the following Monday) that covers the previous week's content.

5. ASSESSMENT

Also see the examination regulations in the Year Books of the Faculty of Engineering, Built Environment and Information Technology (Part 1: Engineering or Part 2: Built Environment and Information Technology).

Pass requirements: In order to pass the module a student must obtain a final mark of at least 50% and must achieve a subminimum of 40% on the exam. Only students with a semester mark of 40% or better quality to write the exam.

Calculation of the final mark: The final mark is weighted 50:50 between the exam and the semester mark.

Exam (3 hours) : 50.0%
Semester mark : 50.0%
The semester mark is calculated from semester tests, practicals and weekly class tests (based on the tutorial sessions)

Semester mark calculation:

Semester test 1	: 30.0%
Semester test 2	: 30.0%
Practical 1 (Beam strength and stiffness)	: 5.0%
Practical 2 (Shaft strength and stiffness)	: 5.0%
Practical 3 (Spring stiffness and strength)	: 5.0%
Class tests (best 6 of 8)	: 25.0%

Absence from practicals
Ample time is available to submit the practicals. Therefore, if you do not submit a practical on time, you get 0% for that particular practical.

Absence from class tests
Your best 6 of 8 class tests count in the calculation of the semester mark, so you can miss 2 class test before losing any marks. If you do not write any class test, for whatever reason, you simply get zero for that class test. No medical certificates will be processed for missing a class test, you simply get zero.

Absence from semester tests and exam
Refer to the study guide of the Department.

6. GENERAL

Although students are encouraged to ask questions during the online tutorial sessions, each student must practice doing his/her own work. You will not master the required skills to solve engineering design problems by simple watching how an experienced engineer does it. This aspect applies especially to the computer work using Excel solver.

7. MODULE STRUCTURE

	Study theme	**Mode of instruction**	**Notional hours**	**Contact sessions**
1	Introduction to Design	Lectures and self-study	9	2
2	Materials	Lectures and self-study	9	2
3	Load and Stress Analysis	Lectures and self-study	36	8
4	Deflection and Stiffness	Lecture and self-study	18	4
5	Failures Resulting from Static Loading	Lectures and self-study	13	3
6	Failures Resulting from Variable Loading	Lectures and self-study	18	4
7	Shafts and Shaft Component Design	Lectures and self-study	13	3
8	Mechanical Spring Design	Lectures and self-study	18	4
9	Screw, Fastener and Joint design	Lectures and self-study	13	3
10	Weld design	Lectures and self-study	13	3
	Total		160	36

Note: Notional hours include contact time, as well as the estimated time for practicals, self-study, preparation for tutorials and preparation for tests and the examination.

8 STUDY THEMES

8.1 Study theme 1: Introduction to Design

Study material: *Shigley textbook, Chapter 1*

8.1.1 Learning outcomes

At the completion of this study theme the student will be able to:

- Outline the mechanical engineering design process
- Define and use safety factors and load factors
- Use “Solver” in Excel to solve optimization problems

8.1.2 Study units

- Learn and understand the content of the textbook in addition to revising the content from first year Statics.
- Practice using the “Solver” add-in for Excel to solve optimization problems

8.1.3 Self-study activities

Revise the content from the first year Statics module. The important content from SWK122 is: Equilibrium in two and three dimensions. Trusses and space frames. Centroids and second moments of area. Beams: distributed forces, shear force, bending moment, method of sections, relationship between load, shear force and bending moment.

8.1.4 Tasks for assessment

To be announced on ClickUP.

8.2 Study theme 2: Materials

Study material: *Shigley textbook, Chapter 2*

8.2.1 Learning outcomes

After completion of this section, the student should be able to:

- Have an appreciation of what role material selection plays during the design process
- Have an understanding of the various materials a designer can choose from
- Understand the difference between strength and stiffness of materials

8.2.2 Study units

Learn and understand the content of the textbook.

8.2.3 Self-study activities

None.

8.2.4 Tasks for assessment

To be announced on ClickUP.

8.3 Study theme 3: Load and Stress Analysis

Study material: *Shigley textbook, Chapter 3*

8.3.1 Learning outcomes

After completion of this section, the student should be able to:

- Construct 2D free body diagrams and in the case of statically determinate problems, solve the reactions.
- Construct shear force and bending moment diagrams for beams, and compute the maximum shear forces and bending moments, and the locations
- Explain normal stress and strain
- Explain shear stress and strain
- Demonstrate a basic understanding of elasticity and plasticity
- Explain Hooke's law and Poisson's ratio
- Use Mohr's circle to rotate stress components to any axis system
- Compute uniform normal stresses due to axial loading
- Compute linearly varying bending stresses in beams due to moments
- Compute shear stresses in beams due to shear forces
- Compute linearly varying shear stresses in circular shafts due to torsion
- Design beam supports to minimize the maximum bending moments

8.3.2 Study units

Learn and understand the content of the textbook.

8.3.3 Self-study activities

Chapter 3 from the Shigley textbook.

8.3.4 Tasks for assessment

To be announced on ClickUP.

8.4 Study theme 4: Deflection and Stiffness

Study material: *Shigley textbook, Chapter 4*

8.4.1 Learning outcomes

At the completion of this study theme the student will be able to:

- Compute the deflection of bars loaded axially
- Compute the rotations of circular members loaded in torsion
- Compute the lateral deflections of beams
- Solve the reaction forces of statically indeterminate problems by making use of the method of superposition

8.4.2 Study units

Learn and understand the contents of the textbook.

8.4.3 Self-study activities

Chapter 4 from the Shigley textbook.

8.4.4 Tasks for assessment

To be announced on ClickUP.

8.5 Study theme 5: Failure due to static loading

Study material: *Shigley's textbook, Chapter 5*

8.5.1 Learning outcomes

At the completion of this study theme the student will be able to:

- Explain and use the maximum shear stress theory for ductile materials to assess if a component is safe against static failure
- Explain and use the distorsion energy theory for ductile materials to assess if a component is safe against static failure
- Explain and use the Coulomb-Mohr theory for ductile materials to assess if a component is safe against static failure

- Explain and use the modified Mohr theory for brittle materials to assess if a component is safe against static failure

8.5.2 Study units

Section 5.1 to 5.11

8.5.3 Self-study activities

Textbook examples

8.5.4 Tasks for assessment

To be announced on ClickUP.

8.6 Study theme 6: Failure due to variable loading

Study material: *Shigley's textbook, Chapter 6*

8.6.1 Learning outcome

At the completion of this study theme the student will be able to:

- Explain what fatigue in metals is
- Explain the stress-life approach to design for variable loading
- Define and compute the endurance limit
- Define and compute fatigue strength
- Define and compute the Marin factors (endurance limit modifying factors)
- Explain and use various stress life methods such as Goodman, Soderberg, ASME ellipse and Gerber to assess the safety of a structure subject to fluctuating stresses.
- Explain why methods such as rainflow counting are necessary to design for varying fluctuating stresses
- Use rainflow counting and Miner's rule to assess the safety of a component subject to varying fluctuating stresses

8.6.2 Study units

Sections 6.1 to 6.15

8.6.3 Self-study activities

Textbook examples

8.6.4 Tasks for assessment

To be announced on ClickUP.

8.7 Study theme 7: Shafts and shaft component design

Study material: *Shigley's textbook, Chapter 7*

8.7.1 Learning outcomes

At the completion of this study theme the student will be able to:

- Construct a free body diagram of a shaft and solve the reactions
- Compute the shear force and bending moment diagrams for a shaft
- Locate potential critical locations along the shaft
- Compute the minimum required shaft diameter at potential critical locations for variable loading using one of the established stress life methods

8.7.2 Study units

Section 7.1 to 7.4

8.7.3 Self-study activities

Textbook examples

8.7.4 Assignments for assessment

To be announced on ClickUP.

8.8 Study theme 8: Mechanical Spring Design

Study material: Shigley's textbook, Chapter 10

8.8.1 Learning outcomes

At the completion of this study theme the student will be able to:

- Compute shear stresses in a helical spring
- Compensate for the curvature effect using the Bergstrasser factor
- Compute the deflection of a helical spring
- Design a compressive helical spring for static or fatigue loading
- Design a helical tension spring for static or fatigue loading

8.8.2 Study units

Section 10.1 to 10.12

8.8.3 Self-study activities

Textbook examples

8.8.4 Assignments for assessment

To be announced on ClickUP

8.9 Study theme 9: Screw, Fastener and Joint design

Study material: *Shigley's textbook, Chapter 8*

8.9.1 Learning outcomes

At the completion of this study theme the student will be able to:

- Define thread standards
- Understand the mechanics of power screws
- Select an appropriate bolt for a particular application
- Compute the appropriate bolt torque to provide the required bolt tension
- Compute the shear stresses in a bolt group loaded in shear
- Design a bolted connection

8.9.2 Study units

Sections 8.1 to 8.12

8.9.3 Self study activities

Textbook examples

8.9.4 Assignments for assessment

To be announced on ClickUP.

8.10 Study theme 10: Weld design

Study material: Shigley's textbook, Chapter 9

8.10.1 Learning outcomes

At the completion of this study theme the student will be able to:

- Define the meaning of weld symbols

- Define the difference between butt welds and fillet welds
- Compute stresses in welded joints loaded in torsion and bending, for static and fatigue loading

8.10.2 Study units

Sections 9.1 to 9.9

8.10.3 Self-study activities

Textbook examples

8.10.4 Assignments for assessment

To be announced on ClickUP.