ME-475: Machine Design I Fall 2014

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Goals: To introduce students methods of machine design and factors they must consider either to prevent a component failure or to estimate its service life where life estimates are possible.

Textbook: Richard G. Budynas and J. Keith Nisbett, 2011, Shigley's Mechanical Engineering Design, 10th edition, McGraw Hill, New York, NY.

Your must purchase access to Connect because you will do homework assignments using Connect. You can buy access to Connect along with the book. This will be cheaper. However, you can buy access to connect separately.

References :	B. J. Hamrock, S. R. Schmid and B. Jacobson, Fundamentals of Machine								
Elements, McGrawHill, New York, NY.									

- M. F. Spotts, T. E. Shoup and L. E. Hornberger, Design of Machine Elements, Prentice Hall.
- R. L. Norton, Machine Design: An Integrated Approach, Prentice Hall.

Topics:

- 1. Introduction to Mechanical Engineering Design and Materials (Chapters 1 & 2) Note: These topics will be discussed only briefly.
- 2. Review of Stress-Strain Relationships:

Type of stresses, Principal stresses, Mohr's circle, Shear and Moment Diagrams, Torsion, Curve members in Flexure

- Deflection and Stiffness: Tension, Compression, Torsion and Flexure, Strain Energy – Castigliano's Theorem, Deflection of Curved Members
- Failure Resulting from Static Loading Static Strength, Stress Concentration, Failure Theories for Ductile Materials (Maximum-Shear-Stress, Distortion-Energy, Columb-Mohr), Failure Theories for Brittle Materials (Maximum-Normal-Stress, Modified Mohr Theory)
- 5. Fatigue Failure Resulting from Variable Loadings
 - The Endurance Limit and Fatigue Strength, Fatigue Failure Theories
- 6. Shafts and Shaft Components Shaft Design for Stress, Shaft Design for Deflection
- Rolling Contact and Journal Bearings and Lubrication Bearing Types, Bearing Life and Reliability Types of Lubrication, Viscosity, Journal bearings, Heat Balance, Boundary-Lubricated Bearings

Note: We may cover these topics in different order. We may borrow materials from other books.

Lecture: Hours: MWF 8-8:50 AM, Room: ENGR A 111

Help sessions/recitation hours: ?

Prerequisites: Statics, (Dynamics?) Mechanics of Materials, Calculus, Matlab Programming **Reading Assignments**: You are advised to read the topics to be covered in the class from the textbook before you come to the class. This will help you understand the subject better.

Distribution of points for grading: Total points = 100, Homework = 20%,

Three tests = 46% (16% each), Final = 32%.

50 % of the Final will be comprehensive.

Final Exam Schedule: Wednesday, May 8, 2013, 12:50-2:50 PM. **Grading Scale**: 90-100 = A, 80-89 = B, 70-79 = C, 60-69 = D, and 0-59 = F.

Depending on the class effort, (homework performance, class attendance, class participation, visiting me during the office hours, and attending help sessions) I may curve the grade.

Incomplete: You will be given an incomplete grade only if you will face an extreme circumstance such as a serious accident or a serious illness.

Being absent from class: If you are planning to be away, then you must inform me in advance. However, it will be your responsibility to find out what was done in class and during the help sessions while you were away. If you do not inform me that you will be away, and I give a test or a quiz during that period, then I will not give you a makeup test or quiz.

Homework Assignments done on papers:

There may be sometime, when you will have to do the work on paper, and submit it in class. In that case, you must follow the following format:

- 1. All computations must be done using Matlab. However, you should not submit the program or the entire output, but you should submit only the final answers.
- 2. Homework assignment that you will submit in class should follow the following format:
 - a. Your name, the assignment no., and the date,
 - b. Problem #, given data, the requested variables,
 - c. Equations, substitute the values in the equation, the answer from Matlab
 - d. If you take a value from a table, graph, chart, figure, etc. then state so.
 - e. If you make engineering judgments then state so, and give reasons for doing so.
 - f. Your computation must follow a sequential order. Do not write the calculations all over the paper/sheet.
- 3. Your handwriting should be clear. If we have trouble in reading your handwriting then you may lose points.
- 4. If you have more than one sheet, then staple them. Loose sheets (or sheets with folded corners) will not be accepted.

Homework assignment due dates:

For connect assignments, the due dates will be posted on Connect. Typically, homework assignments will be due after 2 days. This means, a homework assigned on Monday will be due just before midnight on Wednesday. Thus you essentially have more than 2 and a half day to

complete the assignments. You will be allowed to submit assignments late. However, in that case, you will lose 20% credit every day you are late in completing the assignments. For paper copy homework, you will receive 2 extra days. However, in that case, the homework will be due in class. However, for paper copy assignments, the penalty for a late assignment would be 20% for one day late, 60 % for two day late, and 100 % for three and more days late.

Emergency Procedures

Southern Illinois University Carbondale is committed to providing a safe and healthy environment for study and work. Because some health and safety circumstances are beyond our control, we ask that you become familiar with the SIUC Building Emergency Response Team (BERT) program. Emergency response information is available on posters in buildings on campus, available on BERT's website at <u>www.bert.siu.edu</u>, Department of Public Safety's website <u>www.dps.siu.edu</u> (disaster drop down) and in Emergency Response Guideline pamphlet. Know how to respond to each type of emergency.

Instructors will provide guidance and direction to students in the classroom in the event of an emergency. It is important that you follow these instructions and stay with your instructor during an evacuation or sheltering emergency. The Building Emergency Response Team will provide assistance to your instructor in evacuating the building or sheltering within the facility.

Homework #1

Note: Submit the program and the answer (output). Problems 1-5 should not be more than one page, and problems 6-9 should not take than one page.

- 1. Write a Matlab program to find c where c=a+b. Take a=5 and b=7.
 - (a) In the first case, define the values of a and b in the program.
 - (b) In the second case, read the values of a and b from the terminal.
- 2. Write a Matlab program to find the sum of two matrices A and B. (a) In the first case, take $A = \begin{bmatrix} 3 & 7 & -1 \end{bmatrix}$ and $B = \begin{bmatrix} 2 & -3 & 4 \end{bmatrix}$.

	[2	1	-3]		[3	7	2]	
(b) In the second case, take $A =$	1	4	5	and $B =$	4	-1	1	1
	L3	-4	2		L5	2	6	

- 3. Find the values of x, y and z, where x, y, and z satisfy the following equations: 3x - 6y + 7z = 3 9x - 5z = 3or $\begin{bmatrix} 3 & -6 & 7 \\ 9 & 0 & -5 \\ 5 & -8 & 6 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 3 \\ 3 \\ -4 \end{bmatrix}$
- 4. A circular shaft of diameter 1 in is subjected to a bending moment of 10 kip-in. Find the bending stress. (Hint: $I = \pi d^4/64$ and $\sigma = Mc/I$, c = d/2)
- 5. The state of stress at a point is: $\sigma_x = 12$ kpsi, $\sigma_y = 6$ kpsi, and $\tau_{xy} = 4$ kpsi ccw. Find the normal and the tangential stresses on a plane that makes an angle of 30 degree from the x-plane. (Hint: Use Eqs. 3-8 and 3-9 of the book.)
- 6. At a point in a machine element, the stress is only in the x-y plane, i.e. this point is in the state of plane stress. Write the expressions for normal and tangential stresses on a plane that makes an angle of θ from the x-axis. What is a principal stress? Write the expressions for principal stresses and the maximum shear stress (both magnitudes and the directions) for the plane stress element.

- 7. Write the expressions, the equation numbers from the book of the expressions, and the page numbers of the pages on which these expressions appear: Explain each term.
 - (a) Second moment of area of a uniform shaft about a neutral passing through the origin.
 - (b) Second moment of area of a uniform shaft about the axial axis of the shaft (the axis that passes through the center of a circular cross-section and is parallel to the length of the shaft.
 - (c) Bending stress in a straight beam.
 - (d) Torsional stress in a straight bar.
- 8. Find the following properties. Write the numbers of the tables which list these properties. Write the numbers of the pages on which these tables appear.
 - (a) Young modulus of steel, cast iron, aluminum
 - (b) Ultimate tensile and yield strengths of 1020 AISI cold-drawn steel
 - (c) Ultimate tensile and compressive strengths of ASTM No. 30 cast iron.
- 9. Write the expression for deflection of a simply supported beam subjected a point load at an arbitrary location between the two supports. Explain all terms. Write the paper number on which you found the expression.

Homework #2

- 1. At a point in a machine element, the stress is only in the x-y plane, i.e. this point is in the state of plane stress. Derive the expressions for normal and tangential stresses on a plane that makes an angle of θ from the x-axis. What is a principal stress? Derive the expressions for a principal stresses and the maximum shear stress (both magnitudes and the directions) for the plane stress element.
- 2. Problems: 3.2, 3-4, 3-5, 3-8, 3-9, 3-12.

Hints for problem 1.

- 1. See the element on the right. If the area of ac is A, what is the area of ab? What is the area of bc?
- 2. If the normal stress on plane ab is σ_x and the stress on plane ac is σ , then find σ in terms of σ_x . (Hint: Equate the forces in the x-direction.) Find the normal and the tangential components of σ .



- 3. If the normal stress on plane bc is σ_y and the stress on plane ac is σ , then find σ in terms of σ_y . (Hint: Equate the forces in the y-direction.) Find the normal and the tangential components of σ .
- 4. Consider shear stresses on planes ab and bc. Find the normal and the tangential stresses on plane ac due to the shear stress.
- 5. Combined the expressions obtained in steps 2, 3 and 4 to find the normal and the tangential stresses on plane ac.

Cheating and consequences:

Consulting a friend about a homework problem or a computer assignment:

What is allowed? Discussing homework problems and how to solve them and discussing computer algorithms and how to fix a syntax error with a friend are allowed and encouraged. Your friend can explain the solution procedure and computer algorithms to you and help you in finding a syntax error. It is recommended that you talk to your friends if s/he is willing to help you in the above manner.

What is not allowed? You should not take your friends' homework, copy it, and submit it as your homework. You should not take your friends' computer files, and use it to solve your own homework problems. Copying your friends file and modifying it so that it looks different is also not allowed.

What is the penalty for doing this?

First offence: Both you and your friend will get a lower grade at the end of the semester. Second offence: You will get "F" grade, and your friend will get the second lower grade.

Consulting a solution manual:

What is allowed? If you have a copy of the solution manual, then you can use it to learn the subject and cross-check your understanding of the procedure with the procedure given in the solution manual. Once you know the steps, you should close the solution manual and solve the problem by yourself. You can periodically consult the manual if you forget the steps.

What is not allowed? You should not copy the solution manual and submit it as your homework solution. In some cases, students change the variable names, or order of the computations, or add some comments to make it look different from the solution given in the solution manual. This is also not allowed.

What is the penalty for doing this?

First offence: You will get a lower grade at the end of the semester.

Second offence: You will get the second lower grade at the end of the semester.

Question/remark: One of my classmates has the solution manual. Thus, s/he is in a position of advantage, and it seems unfair that you are allowing him/her to see the solution manual.

Answer/response: You can consult the TA, your other friends, and me if you have difficulty in solving a problem. You can ask your friend to share the solution manual with you. In any case, if your friend is using the solution manual without understanding the procedure, then the chances are that s/he will do poorly in the tests/final.

Note: I am open to other suggestions on this issue.