3- Course Specification of Advanced Mechanics of Solid and Materials Course Code (ME511)

• General Information About the Course:

1.	**Course Title:**	**Advanced Mechanics of Solid and Materials**			
2.	**Course Code and Number:**	ME511			
3.	**Credit Hours:**	**Credit Hours**			**Total**
		Lecture	Practical	Seminar/Tutorial	
		3	--	--	**3**
4.	**Study Level and Semester:**	1st Level / 1st Semester			
5.	**Pre-requisites (if any):**	ME 234			
6.	**Co-requisites (if any):**	ME 501 & ME 502			
7.	**Program (s) in which the course is offered:**	MSc. In Mechanical Engineering Program			
8.	**Language of teaching the course:**	English			
9.	**Study System:**	Courses & Thesis			
10.	**Prepared By:**	Dr. Khalil Al-Hatab			
11.	**Reviewed by:**	Dr. ……			
12.	**Date of Approval:**				

• Course Description:

This course provides graduates the theoretical knowledge of stress and strain and advanced concepts of mechanics of materials to solve mechanical design problems and enable any component to be designed such that it will not fail within its service life. The course covers: 3-D analysis of stress and strain, equilibrium and compatibility equations, 3-D Hooke's law, 2-D problems in elasticity, failure criteria, numerical methods, energy methods, fatigue and fracture mechanics and plastic behavior of materials. Students will be able to apply gained knowledge and techniques to the stress analysis of curved beams, beams on elastic foundations, asymmetric beams, torsion of prismatic elements, thick-walled cylinders and rotating disks.

• Course Intended Learning Outcomes (CILOs):

Upon successful completion of **Advanced Solid Mechanics and Engineering Materials Course**, the graduates will be able to:

a1. Transformation of a physical problem into a mathematical problem to enable estimations of stress and deformation as well as safety assessment concerning the response of materials and structural elements to various applied loads.

a2. Acquire an in-depth understanding of advanced concepts, principles and solution techniques of elasticity and plasticity to analyze stress and strain of loaded members throughout the design of various machine elements and systems.

a3. Provide an in-depth understanding of failure modes and criteria, analysis methods and numerical approaches to analyze and design of a safe structure.

b1. Apply elasticity, plasticity, and numerical analysis principles and methods to a variety of common mechanical system components so as to perform safely their intended functions.

b2. Creatively thinking and apply proper stress and strain analysis techniques to obtain exact solutions for a variety of complex problems in structural mechanics and design of machine elements.

b3. Combining strength of material analysis together with failure theory in order to design a safe structure.

b4. Conduct failure analysis to determine the safety of a structure in the mechanical engineering contexts.

c1. Use numerical methods and modern computational tools to construct a suitable finite element model for a given solid mechanics problem.

d1. Effectively communicate, present and prepare documentations on stress and strain analysis activities to different audiences in contexts.

d2. Undertake lifelong learning of the developments in the field of advanced solid mechanics and engineering materials.

• Alignment of Course Intended Learning Outcomes (CILOs) to Program Intended Learning Outcomes (PILOs)

CILOs		PILOs
• **Knowledge and Understanding:** Upon successful completion of **Advanced Solid Mechanics and Engineering Materials Course**, the graduates will be able to:		• **Knowledge and Understanding:** Upon successful completion of the **MSc. In Mechanical Engineering Program**, the graduates will be able to:
a1.	Transformation of a physical problem into a mathematical problem to enable estimations of stress and deformation as well as safety assessment concerning the response of materials and structural elements to various applied loads.	**A1.** Acquire advanced concepts and knowledge of mathematics, scientific, mechanical engineering and associated technologies as well as across the boundaries of interdisciplinary disciplines.
a2.	Acquire an in-depth understanding of advanced concepts, principles and solution techniques of elasticity and plasticity to analyze stress and strain of loaded members throughout the design of various machine elements and systems.	**A2.** Identify and critically evaluate contemporary engineering technologies, current developments and emerging trends within the mechanical engineering contexts.
a3.	Provide an in-depth understanding of failure modes and criteria, analysis methods and numerical approaches to analyze and design of a safe structure.	**A3.** Provide a holistic description of principles, concepts, approaches, techniques and analysis tools to design and development of existing and novel mechanical systems, while taking a sustainable and environmentally-friendly approach.
• **Cognitive/ Intellectual Skills:** Upon successful completion of the **Advanced Solid Mechanics and Engineering Materials Course,** the graduates will be able to:		• **Cognitive/ Intellectual Skills:** Upon successful completion of the **MSc. In Mechanical Engineering Program,** the graduates will be able to:
b1.	Apply elasticity, plasticity, and numerical analysis principles and methods to a variety of common mechanical system components so as to perform safely their intended functions.	**B1.** Identify and apply specialized knowledge and skills to solve problems that are critical to future growth of industry and business.
b2.	Creatively thinking and apply proper stress and strain analysis techniques to obtain exact solutions for a variety of complex problems in structural mechanics and design of machine elements.	**B2.** Creatively thinking and apply analysis tools to formulate and solve complex engineering problems in the mechanical engineering context using modern techniques and tools.
b3.	Combining strength of material analysis together with failure theory in order to design a safe structure.	**B3.** Design and optimize mechanical components, systems and process to meet desired needs within realistic constraints.
b4.	Conduct failure analysis to determine the safety of a structure in the mechanical engineering contexts.	**B4.** Analyze and assess risks of the professional practice in the mechanical engineering contexts.

• **Professional and Practical Skills:** Upon successful completion of the **Advanced Solid Mechanics and Engineering Materials Course,** the graduates will be able to:		• **Professional and Practical Skills:** Upon successful completion of the **MSc. In Mechanical Engineering Program,** the graduates will be able to:
c1.	Use numerical methods and modern computational tools to construct a suitable finite element model for a given solid mechanics problem.	**C1.** Use modern manufacturing processes and materials, experimental tests, appropriate software packages and other modern tools for the design analysis and manufacture of mechanical components and systems.
c2.		**C2.** Conduct research and studies to solve mechanical engineering problems professionally, ethically and responsibly within realistic constraints.
c3.		**C3.** Demonstrate an in-depth understanding of the mechanical engineering business environment, including environmental aspects, and apply quality issues, modern operations and business management techniques and good practices in a range of contexts.
c4.		
• **Transferable Skills:** Upon successful completion of the **Advanced Solid Mechanics and Engineering Materials Course,** the graduates will be able to:		• **Transferable Skills:** Upon successful completion of the **MSc. In Mechanical Engineering Program,** the graduates will be able to:
		D1. Adopt effectively IT capabilities and other different resources of information to develop a scientific research in mechanical engineering fields.
d1.	Effectively communicate, present and prepare documentations on stress and strain analysis activities to different audiences in contexts.	**D2.** Communicate, present, challenge and defend research ideas, results and conclusions in both orally and writing forms to different audiences in contexts.
d2.	Undertake lifelong learning of the developments in the field of advanced solid mechanics and engineering materials.	**D3.** Identify a need for the latest relevant knowledge and technologies and undertake life-long learning.
		D4. Collaborate effectively within multidisciplinary teams and lead them in different professional contexts

• Alignment of CILOs to Teaching and Assessment Strategies

• Alignment of Knowledge and Understanding CILOs:

Knowledge and Understanding CILOs		Teaching Strategies	Assessment Strategies
a1.	Transformation of a physical problem into a mathematical problem to enable estimations of stress and deformation as well as safety assessment concerning the response of materials and structural elements to various applied loads.	▪ Lectures, ▪ Self-Learning ▪ Problems/Studies, ▪ Case study, ▪ Individual/Group	▪ Oral & Writing Exams ▪ Individual Projects and Studies Reports, ▪ Assignments

		Projects and Studies, ▪ Active learning, ▪ Computer hands-on sessions.	
a2.	Acquire an in-depth understanding of advanced concepts, principles and solution techniques of elasticity and plasticity to analyze stress and strain of loaded members throughout the design of various machine elements and systems.	▪ Lectures, ▪ Self-Learning Problems/Studies, ▪ Case study, ▪ Individual/Group Projects and Studies, ▪ Active learning, ▪ Computer hands-on sessions.	▪ Oral & Writing Exams ▪ Individual Projects and Studies Reports, ▪ Assignments
a3.	Provide an in-depth understanding of failure modes and criteria, analysis methods and numerical approaches to analyze and design of a safe structure.	▪ Lectures, ▪ Self-Learning Problems/Studies, ▪ Case study, ▪ Individual/Group Projects and Studies, ▪ Active learning, ▪ Computer hands-on sessions.	▪ Oral & Writing Exams ▪ Individual Projects and Studies Reports, ▪ Assignments

- **Alignment of Intellectual Skills CILOs:**

Intellectual Skills CILOs		Teaching Strategies	Assessment Strategies
b1.	Apply elasticity, plasticity, and numerical analysis principles and methods to a variety of common mechanical system components so as to perform safely their intended functions.	▪ Lectures, ▪ Self-Learning ▪ Problems/Studies, ▪ Case study, ▪ Individual/Group Projects and Studies, ▪ Active learning, ▪ Computer hands-on sessions.	▪ Oral & Writing Exams ▪ Individual Projects and Studies Reports, ▪ Assignments
b2.	Creatively thinking and apply proper stress and strain analysis techniques to obtain exact solutions for a variety of complex problems in structural mechanics and design of machine elements.	▪ Lectures, ▪ Self-Learning ▪ Problems/Studies, ▪ Case study, ▪ Individual/Group Projects and Studies, ▪ Active learning, ▪ Computer hands-on sessions.	▪ Oral & Writing Exams ▪ Individual Projects and Studies Reports, ▪ Assignments
b3.	Combining strength of material analysis together with failure theory in order to design a safe structure.	▪ Lectures, ▪ Self-Learning ▪ Problems/Studies, ▪ Case study, ▪ Individual/Group Projects and Studies, ▪ Active learning,	▪ Oral & Writing Exams ▪ Individual Projects and Studies Reports, ▪ Assignments

		▪ Computer hands-on sessions.	
b4.	Conduct failure analysis to determine the safety of a structure in the mechanical engineering contexts.	▪ Lectures, ▪ Self-Learning ▪ Problems/Studies, ▪ Case study, ▪ Individual/Group Projects and Studies, ▪ Active learning, ▪ Computer hands-on sessions.	▪ Oral & Writing Exams ▪ Individual Projects and Studies Reports, ▪ Assignments

- **Alignment of Professional and Practical Skills CILOs:**

Professional and Practical Skills CILOs		Teaching Strategies	Assessment Strategies
c1.	Use numerical methods and modern computational tools to construct a suitable finite element model for a given solid mechanics problem.	▪ Lectures, ▪ Self-Learning ▪ Problems/Studies, ▪ Case study, ▪ Individual/Group Projects and Studies, ▪ Active learning, ▪ Computer hands-on sessions.	▪ Oral & Writing Exams ▪ Individual Projects and Studies Reports, ▪ Assignments

- **Alignment of Transferable (General) Skills CILOs:**

Transferable (General) Skills CILOs		Teaching Strategies	Assessment Strategies
d1.	Effectively communicate, present and prepare documentations on stress and strain analysis activities to different audiences in contexts.	▪ Independent Study, ▪ Individual/Group Projects and Studies, ▪ Presentation,	▪ Presentation, ▪ Written Report
d2.	Undertake lifelong learning of the developments in the field of advanced solid mechanics and engineering materials.	▪ Independent Study, ▪ Individual/Group Projects and Studies,	▪ Presentation, ▪ Written Report.

• Course Content

- **Theoretical Aspect**

Order	Topic List / Units	Sub -Topics List	Number of Weeks	Contact Hours	Course ILOs
1	**Chapter 1: Analysis of Stress**	▪ Introduction ▪ Scope of Treatment ▪ Analysis and Design ▪ Conditions of Equilibrium ▪ Definition and Components of Stress ▪ Internal Force-Resultant and Stress Relations ▪ Stresses on Inclined Sections ▪ Variation of Stress within a Body	**2**	**6**	**a1, a2, a3, b1, b2, b3, b4**
		▪ Plane-Stress Transformation ▪ Principal Stresses and Maximum In-Plane Shear Stress ▪ Mohr's Circle for Two-Dimensional Stress ▪ Three-Dimensional Stress Transformation			

		▪ Principal Stresses in Three Dimensions ▪ Normal and Shear Stresses on an Oblique Plane ▪ Mohr's Circles in Three Dimensions			
2	**Chapter 2: Strain and Material Properties**	▪ Introduction (HW 1) ▪ Deformation & Strain Defined ▪ Equations of Compatibility ▪ State of Strain at a Point ▪ Engineering Materials ▪ Stress-Strain Diagrams ▪ Elastic versus Plastic Behavior ▪ Hooke's Law and Poisson's Ratio ▪ Generalized Hooke's Law ▪ Hooke's Law for Orthotropic Materials ▪ Measurement of Strain: Strain Rosettes ▪ Strain Energy ▪ Strain Energy in Common Structural Members ▪ Components of Strain Energy ▪ Saint-Venart's Principle	**2**	**6**	**a1, a2, a3, b1, b2, b3, b4**
3	**Chapter 3: Problems in Elasticity**	▪ Introduction (HW 2, Quiz 1) ▪ Fundamental Principles of Analysis ▪ Formulations and Methods of Solutions ▪ Plain Strain Problems ▪ Plain Stress Problems ▪ Comparison of Two-Dimensional Isotropic Problems ▪ Aery's Stress Function ▪ Solution of Elasticity Problems ▪ Thermal Stresses ▪ Basic Relations in Polar Coordinates ▪ Stresses Due to Concentrated Loads ▪ Stress Distribution Near Concentrated Loads ▪ Stress Concentration Factors	**1**	**3**	**a1, a2, a3, b1, b2, b3, b4**
4	**Chapter 4: Statics Failure Criteria**	▪ Introduction (HW 3) ▪ Failure defined & Modes ▪ Failure by Yielding ▪ Failure by Fracture ▪ Yield Criteria ▪ Maximum Shearing Stress Theory ▪ Maximum Distortion Energy Theory ▪ Octahedral Shearing Stress Theory ▪ Comparison of Yielding Theories ▪ Fracture Criteria ▪ Maximum Principal Stress Theory ▪ Mohr's Theory ▪ Coulomb-Mohr Theory ▪ Review for Midterm Exam	**1**	**3**	**a1, a2, a3, b1, b2, b3, b4**
5	**Chapter 5: Bending of Beams**	**Mid-Term Theoretical Exam** ▪ Introduction (HW 4) **Part A — Exact Solutions** ▪ Pure Bending of Beams of Symmetrical Cross Section ▪ Pure Bending of Beams of Asymmetrical Cross Section ▪ Bending of a Cantilever of Narrow Section ▪ Bending of Simply Supported Narrow Beam **Part B – Approximate Solutions** ▪ Elementary Theory of Bending ▪ Normal and Shear Stresses ▪ Composite Beams ▪ Shear Center ▪ Statically Indeterminate Systems	**2**	**6**	**a1, a2, a3, b1, b2, b3, b4**

		▪ Energy Methods for Deflections **Part C – Curved Beams** ▪ Elasticity Theory ▪ Curved Beam Formula ▪ Comparison of the Results of Various Theories ▪ Combined Tangential and Normal Stresses			
6	**Chapter 6: Torsion of Prismatic Bars**	▪ Introduction (HW 5) ▪ Elementary Theory of Torsion of ▪ Stresses on Inclined Planes ▪ General Solution of the Torsion Problem ▪ Prandtl's Stress Function ▪ Prandtl's Membrane Analogy ▪ Torsion of Narrow Rectangular Cross Section ▪ Torsion of Multiply Connected Thin Walled Sections ▪ Fluid Flow Analogy and Stress Concentration ▪ Torsion of Restrained Thin-Walled Members of Open Cross Section	**1**	**3**	**a1, a2, a3, b1, b2, b3, b4**
7	**Chapter 7: Numerical Methods**	▪ Introduction (HW6, Quiz 2) **Part A – Finite Difference Method** ▪ Finite Differences ▪ Finite Difference Equations ▪ Curved Boundaries ▪ Boundary Conditions **Part B – Finite Element Method** ▪ Fundamentals ▪ The Bar Element ▪ Arbitrarily Oriented Bar Element ▪ Axial Force Equation ▪ Force Displacement Relations for a truss ▪ Beam Element ▪ Properties of Two-Dimensional Elements ▪ General Formulation of the Finite Element Method ▪ Triangular Finite Element ▪ Computational Tools ▪ Case Studies in Plane Stress	**1**	**3**	**a1, a2, a3, b1, b2, b3, b4, c1**
8	**Chapter 8: Thick-Walled Cylinders and Rotating Disks**	▪ Introduction (HW 7) ▪ Thick Walled Cylinders Under Pressure ▪ Maximum Tangential Stress ▪ Application of Failure Theories ▪ Compound Cylinders: Press or Shrink Fits ▪ Rotating Disks of Constant Thickness. ▪ Disk Flywheels ▪ Finite Element Solution	**1**	**3**	**a1, a2, a3, b1, b2, b3, b4, c1**
9	**Chapter 9: Applications of Energy Methods**	▪ Introduction (HW 8) ▪ Work Done in Deformation ▪ Reciprocity Theorem Part A — Displacements by Energy Principles ▪ Castigliano's Theorem ▪ Unit- or Dummy-Load Method ▪ Crotti-Engesser Theorem ▪ Statically Indeterminate Systems Part B — Variational Principles ▪ Principle of Virtual Work ▪ Principle of Minimum Potential Energy ▪ Deflections by Trigonometric Series ▪ Rayleigh-Ritz Method	**1**	**3**	**a1, a2, a3, b1, b2, b3, b4, c1**

10	**Chapter 10: Introduction to Fatigue & Fracture Mechanics**	▪ Introduction (HW 9, Quiz 3) ▪ Nomenclature ▪ Cyclic Stress-Strain Behavior of Metals ▪ Cyclic Stress-Strain Curve ▪ S − N Diagram and Stress Life Relation ▪ Fatigue Strength Diagram (Haigh diagram) ▪ Endurance Limit Modifying Factor ▪ Failure Criteria for Metal Fatigue ▪ Impact or Dynamic Loads ▪ Dynamic and Thermal Effects ▪ Fracture Mechanics ▪ Fracture Toughness & Fracture Modes ▪ Stress and Displacement Field at the Crack Tip ▪ Stress Intensity Factor (SIF or K) ▪ Superposition of SIF ▪ Fracture Toughness (Critical SIF ▪ Strain Energy Release Rate and Its Equivalent to SIF ▪ Plastic Zone Size	**2**	**6**	**a1, a2, a3, b1, b2, b3, b4, c1**
11	**Chapter 11: Plastic Behavior of Materials**	▪ Introduction (HW 10) ▪ Plastic Deformation ▪ Idealized Stress-Strain Diagrams ▪ Instability in Simple Tension ▪ Plastic Axial Deformation and Residual Stress ▪ Plastic Deflection of Beams ▪ Analysis of Perfectly Plastic Beams ▪ Collapse Load of Structures: Limit Design ▪ Elastic-Plastic Torsion of Circular Shafts ▪ Plastic Torsion: Membrane Analogy ▪ Elastic-Plastic Stresses in Rotating Disks ▪ Plastic Stress-Strain Relations ▪ Plastic Stress-Strain Increment Relations ▪ Stresses in Perfectly Plastic Thick-Walled Cylinders	**1**	**3**	**a1, a2, a3, b1, b2, b3, b4, c1**
12	**Final Theoretical Exam**	**All Previous Topics**	**1**	**3**	**a1, a2, a3, b1, b2, b3, b4, c1**
Number of Weeks /and Contact Hours Per Semester			**16**	**48**	

- **Practical Aspect**

Order	Practical / Tutorials topics	Number of Weeks	Contact Hours	Course ILOs
1	▪ None			
Number of Weeks /and Contact Hours Per Semester				

- **Tutorial Aspect:**

No.	Tutorial	Number of Weeks	Contact Hours	Learning Outcomes (CILOs)
1	• None			
Number of Weeks /and Units Per Semester				

• Teaching Strategies:

- Lectures,
- Self-Learning Problems/Studies,
- Case study,
- Individual Projects and Studies,
- Active learning,
- Computer hands-on sessions.
- Independent Study, and
- Presentation

• Assessment Methods of the Course:

- Oral & Writing Exams
- Individual/Group Projects and Studies Reports,
- Presentation,
- Assignments

• Tasks and Assignments:

No	Assignments/ Tasks	Individual/ Group	Mark	Week Due	CILOs (symbols)
1	**Homework (10 sets)**	**Individual**	**10**	**W2, W4. W6, W8 & W9 - W15**	**a1, a2, a3, b1, b2, b3, b4, c1**
2	**Mini/Major Project**	**Group**	**15**	**W9 - W15**	**a1, a2, a3, b1, b2, b3, b4, c1, d1, d2**
3	**Case studies**	**Group**	**5**	**W3, W6, W10**	**b1, b2, b3, b4, c1, d1, d2**
	Total Score		**30**	==	===

• Learning Assessment:

No.	Assessment Tasks	Week due	Mark	Proportion of Final Assessment	CILOs
1	**Tasks and Assignments**	**Weekly**	**30**	**20%**	**a1, a2, a3, b1, b2, b3, b4, c1, d1, d2**
2	**Quizzes**	**W5, W10 & W13**	**10**	**6.7%**	**a1, a2, a3, b1, b2, b3, b4, c1**
3	**Midterm Exam (Theoretical)**	**W8**	**30**	**20%**	**a1, a2, a3, b1, b2, b3, b4, c1**
4	**Final Exam (Theoretical)**	**W16**	**80**	**53.3%**	**a1, a2, a3, b1, b2, b3, b4, c1**
Total			**150**	**100%**	**===**

• Learning Resources :

1. **Required Textbook(s) :**

1. Ugural, A. C. and S. K. Fenster, 2014, **Advanced Mechanics of Materials and Applied Elasticity**, 6th Edition, USA, Prentice Hall.

2. **Essential References:**

1. Arthur P. Boresi,Richard J. Schmidt, 2003, **Advanced Mechanics of Materials**, 6th Edition, USA, John Wiley and Sons.
2. L S Srinath, 2009, **Advanced mechanics of solids,** 3rd Edition, New Delhi, Tata McGraw-Hill.
3. Richard G. Budynas, 1999, **Advanced Strength and Applied Stress Analysis**, 2nd Edition, USA, McGraw Hill.
4. H. Jane Helena, **2017, Theory of Elasticity and Plasticity,** New Delhi, PHI.
5. Craig, R.R, 2011, **Mechanics of Materials**, 3rd Edition, John Wiley & Sons.
6. Logan, D.L., 2011, **A First Course in the Finite Element Methods**, 5th Edition, CL Engineering.

3. **Electronic Materials and Web Sites *etc.***

1. https://www.youtube.com/watch?v=HM7ZMPpbeDA
2. http://freevideolectures.com/Course/89/Fluid-Mechanics
3. https://www.youtube.com/watch?v=QEyUNvtZkH0
4. https://www.youtube.com/watch?v=QKCK4lJLQHU
5. https://www.av8n.com/how/htm/airfoils.html
6. http://faculty.dwc.edu/sadraey/Chapter%205.%20Wing%20Design.pdf

• الضوابط والسياسات المتبعة في المقرر Course Policies

بعد الرجوع للوائح الجامعة يتم كتابة السياسة العامة للمقرر فيما يتعلق بالآتي:

1	**سياسة حضور الفعاليات التعليمية Class Attendance:** **- يلتزم الطالب بحضور 75% من المحاضرات ويحرم في حال عدم الوفاء بذلك.** **- يقدم أستاذ المقرر تقريرا بحضور وغياب الطلاب للقسم ويحرم الطالب من دخول الامتحان في حال تجاوز الغياب 25% ويتم اقرار الحرمان من مجلس القسم.**
2	**الحضور المتأخر Tardy:** **- يسمح للطالب حضور المحاضرة إذا تأخر لمدة ربع ساعة لثلاث مرات في الفصل الدراسي، وإذا تأخر زيادة عن ثلاث مرات يحذر**

	شفويا من أستاذ المقرر، وعند عدم الالتزام يمنع من دخول المحاضرة.
3	**ضوابط الامتحان Exam Attendance/Punctuality:** - لا يسمح للطالب دخول الامتحان النهائي إذا تأخر مقدار (20) دقيقة من بدء الامتحان - إذا تغيب الطالب عن الامتحان النهائي تطبق اللوائح الخاصة بنظام الامتحان في الكلية.
4	**التعيينات والمشاريع Assignments & Projects:** - يحدد أستاذ المقرر نوع التعيينات في بداية الفصل ويحدد مواعيد تسليمها وضوابط تنفيذ التكليفات وتسليمها. - إذا تأخر الطالب في تسليم التكليفات عن الموعد المحدد يحرم من درجة التكليف الذي تأخر في تسليمه.
5	**الغش Cheating:** - في حال ثبوت قيام الطالب بالغش في الامتحان النصفي أو النهائي تطبق عليه لائحة شؤون الطلاب. - في حال ثبوت قيام الطالب بالغش او النقل في التكليفات والمشاريع يحرم من الدرجة المخصصة للتكليف.
6	**الانتحال Plagiarism:** – في حالة وجود شخص ينتحل شخصية طالب لأداء الامتحان نيابة عنه تطبق اللائحة الخاصة بذلك
7	**سياسات أخرى Other policies:** - أي سياسات أخرى مثل استخدام الموبايل أو مواعيد تسليم التكليفات ..... الخ

Academic Year: ……....

Course Plan (Syllabus) Advanced Mechanics of Solid and Materials
Course Code (ME511)

• Information about Faculty Member Responsible for the Course:

Name		**Office Hours**					
Location &Telephone No.		**SAT**	**SUN**	**MON**	**TUE**	**WED**	**THU**
E-mail							

• General information about the course:

	Course Title	**Advanced Mechanics of Solid and Materials**			
2.	**Course Code and Number**	ME511			
3.	**Credit Hours**	**Credit Hours**			**Total**
		Lecture	**Practical**	**Seminar/Tutorial**	
		3	--	--	**3**
4.	**Study Level and Semester**	1st Level / 1st Semester			
5.	**Pre-requisites**	ME 234			
6.	**Co –requisite**	ME 501 & ME 502			
7.	**Program (s) in which the course is offered**	MSc. In Mechanical Engineering Program			
8.	**Language of teaching the course**	English			
9.	**Location of teaching the course**	Faculty Buildings			

• Course Description:

This course provides graduates the theoretical knowledge of stress and strain and advanced concepts of mechanics of materials to solve mechanical design problems and enable any component to be designed such that it will not fail within its service life. The course covers: 3-D analysis of stress and strain, equilibrium and compatibility equations, 3-D Hooke's law, 2-D problems in elasticity, failure criteria, numerical methods, energy methods, fatigue and fracture mechanics and plastic behavior of materials. Students will be able to apply gained knowledge and techniques to the stress analysis of curved beams, beams on elastic foundations, asymmetric beams, torsion of prismatic elements, thick-walled cylinders and rotating disks.

• Course Intended Learning Outcomes (CILOs):

Upon successful completion of **Advanced Solid Mechanics and Engineering Materials Course**, the graduates will be able to:

a1. Transformation of a physical problem into a mathematical problem to enable estimations of stress and deformation as well as safety assessment concerning the response of materials and structural elements to various applied loads.

a2. Acquire an in-depth understanding of advanced concepts, principles and solution techniques of elasticity and plasticity to analyze stress and strain of loaded members throughout the design of

various machine elements and systems.

a3. Provide an in-depth understanding of failure modes and criteria, analysis methods and numerical approaches while concerning the design of a safe structure.

b1. Apply elasticity, plasticity, and numerical analysis principles and methods to a variety of common mechanical system components so as to perform safely their intended functions.

b2. Creatively thinking and apply proper stress and strain analysis techniques to obtain exact solutions for a variety of complex problems in structural mechanics and design of machine elements.

b3. Combining strength of material analysis together with failure theory in order to design a safe structure.

b4. Conduct failure analysis to determine the safety of a structure in the mechanical engineering contexts.

c1. Use numerical methods and modern computational tools to construct a suitable finite element model for a given solid mechanics problem.

d1. Effectively communicate, present and prepare documentations on stress and strain analysis activities to different audiences in contexts.

d2. Undertake lifelong learning of the developments in the field of advanced solid mechanics and engineering materials.

- **Course Content:**
  - **Theoretical Aspect:**

Order	Units	Sub Topics	Week Due	Contact Hours
1	**Chapter 1: Analysis of Stress**	▪ Introduction ▪ Scope of Treatment ▪ Analysis and Design ▪ Conditions of Equilibrium ▪ Definition and Components of Stress ▪ Internal Force-Resultant and Stress Relations ▪ Stresses on Inclined Sections ▪ Variation of Stress within a Body	**W1**	**3**
		▪ Plane-Stress Transformation ▪ Principal Stresses and Maximum In-Plane Shear Stress ▪ Mohr's Circle for Two-Dimensional Stress ▪ Three-Dimensional Stress Transformation ▪ Principal Stresses in Three Dimensions ▪ Normal and Shear Stresses on an Oblique Plane ▪ Mohr's Circles in Three Dimensions	**W2**	**3**
2	**Chapter 2: Strain and Material Properties**	▪ Introduction (HW 1) ▪ Deformation & Strain Defined ▪ Equations of Compatibility ▪ State of Strain at a Point ▪ Engineering Materials ▪ Stress-Strain Diagrams ▪ Elastic versus Plastic Behavior ▪ Hooke's Law and Poisson's Ratio ▪ Generalized Hooke's Law	**W3**	**3**
		▪ Hooke's Law for Orthotropic Materials ▪ Measurement of Strain: Strain Rosettes ▪ Strain Energy ▪ Strain Energy in Common Structural Members ▪ Components of Strain Energy ▪ Saint-Venart's Principle	**W4**	**3**
3	**Chapter 3: Problems in Elasticity**	▪ Introduction (HW 2, Quiz 1) ▪ Fundamental Principles of Analysis Part A – Formulations and Methods of Solutions ▪ Plain Strain Problems ▪ Plain Stress Problems ▪ Comparison of Two-Dimensional Isotropic Problems ▪ Aery's Stress Function ▪ Solution of Elasticity Problems ▪ Thermal Stresses ▪ Basic Relations in Polar Coordinates ▪ Stresses Due to Concentrated Loads ▪ Stress Distribution Near Concentrated Loads ▪ Stress Concentration Factors	**W5**	**3**
4	**Chapter 4: Statics Failure Criteria**	▪ Introduction (HW 3) ▪ Failure defined & Modes ▪ Failure by Yielding ▪ Failure by Fracture ▪ Yield Criteria ▪ Maximum Shearing Stress Theory ▪ Maximum Distortion Energy Theory ▪ Octahedral Shearing Stress Theory ▪ Comparison of Yielding Theories ▪ Fracture Criteria ▪ Maximum Principal Stress Theory	**W6**	**3**

		▪ Mohr's Theory ▪ Coulomb-Mohr Theory ▪ Review for Midterm Exam		
		Mid-Term Theoretical Exam	**W7**	**2**
5	**Chapter 5: Bending of Beams**	▪ Introduction (HW 4) Part A — Exact Solutions ▪ Pure Bending of Beams of Symmetrical Cross Section ▪ Pure Bending of Beams of Asymmetrical Cross Section ▪ Bending of a Cantilever of Narrow Section ▪ Bending of Simply Supported Narrow Beam Part B – Approximate Solutions ▪ Elementary Theory of Bending ▪ Normal and Shear Stresses ▪ Composite Beams ▪ Shear Center ▪ Statically Indeterminate Systems ▪ Energy Methods for Deflections Part C – Curved Beams ▪ Elasticity Theory ▪ Curved Beam Formula ▪ Comparison of the Results of Various Theories ▪ Combined Tangential and Normal Stresses	**W8**	**4**
6	**Chapter 6: Torsion of Prismatic Bars**	▪ Introduction (HW 5) ▪ Elementary Theory of Torsion of ▪ Stresses on Inclined Planes ▪ General Solution of the Torsion Problem ▪ Prandtl's Stress Function ▪ Prandtl's Membrane Analogy ▪ Torsion of Narrow Rectangular Cross Section ▪ Torsion of Multiply Connected Thin Walled Sections ▪ Fluid Flow Analogy and Stress Concentration ▪ Torsion of Restrained Thin-Walled Members of Open Cross Section	**W9**	**3**
7	**Chapter 7: Numerical Methods**	▪ Introduction (HW6, Quiz 2) Part A – Finite Difference Method ▪ Finite Differences ▪ Finite Difference Equations ▪ Curved Boundaries ▪ Boundary Conditions Part B – Finite Element Method ▪ Fundamentals ▪ The Bar Element ▪ Arbitrarily Oriented Bar Element ▪ Axial Force Equation ▪ Force Displacement Relations for a truss ▪ Beam Element ▪ Properties of Two-Dimensional Elements ▪ General Formulation of the Finite Element Method ▪ Triangular Finite Element ▪ Case Studies in Plane Stress ▪ Computational Tools	**W10**	**3**
8	**Chapter 8: Thick-Walled Cylinders and Rotating Disks**	▪ Introduction (HW 7) ▪ Thick Walled Cylinders Under Pressure ▪ Maximum Tangential Stress ▪ Application of Failure Theories ▪ Compound Cylinders: Press or Shrink Fits ▪ Rotating Disks of Constant Thickness. ▪ Disk Flywheels ▪ Finite Element Solution	**W11**	**3**

9	**Chapter 9: Applications of Energy Methods**	▪ Introduction (HW 8) ▪ Work Done in Deformation ▪ Reciprocity Theorem Part A — Displacements by Energy Principles ▪ Castigliano's Theorem ▪ Unit- or Dummy-Load Method ▪ Crotti-Engesser Theorem ▪ Statically Indeterminate Systems Part B — Variational Principles ▪ Principle of Virtual Work ▪ Principle of Minimum Potential Energy ▪ Deflections by Trigonometric Series ▪ Rayleigh-Ritz Method	**W12**	**3**
10	**Chapter 10: Introduction to Fatigue & Fracture Mechanics**	▪ Introduction (HW 9, Quiz 3) ▪ Nomenclature ▪ Cyclic Stress-Strain Behavior of Metals ▪ Cyclic Stress-Strain Curve ▪ S − N Diagram and Stress Life Relation ▪ Fatigue Strength Diagram (Haigh diagram) ▪ Endurance Limit Modifying Factor ▪ Failure Criteria for Metal Fatigue ▪ Impact or Dynamic Loads ▪ Dynamic and Thermal Effects	**W13**	**3**
		▪ Fracture Mechanics ▪ Fracture Toughness & Fracture Modes ▪ Stress and Displacement Field at the Crack Tip ▪ Stress Intensity Factor (SIF or K) ▪ Superposition of SIF ▪ Fracture Toughness (Critical SIF ▪ Strain Energy Release Rate and Its Equivalent to SIF ▪ Plastic Zone Size	**W14**	**3**
11	**Chapter 11: Plastic Behavior of Materials**	▪ Introduction (HW 10) ▪ Plastic Deformation ▪ Idealized Stress-Strain Diagrams ▪ Instability in Simple Tension ▪ Plastic Axial Deformation and Residual Stress ▪ Plastic Deflection of Beams ▪ Analysis of Perfectly Plastic Beams ▪ Collapse Load of Structures: Limit Design ▪ Elastic-Plastic Torsion of Circular Shafts ▪ Plastic Torsion: Membrane Analogy ▪ Elastic-Plastic Stresses in Rotating Disks ▪ Plastic Stress-Strain Relations ▪ Plastic Stress-Strain Increment Relations ▪ Stresses in Perfectly Plastic Thick-Walled Cylinders	**W15**	**3**
12	**Final Theoretical Exam**	**All Previous Topics**	**W16**	**3**
Number of Weeks /and Contact Hours Per Semester			**16**	**48**

- **Practical Aspect**

Order	Practical / Tutorials topics	Number of Weeks	Contact Hours	Course ILOs
1	▪ **None**			
Number of Weeks /and Contact Hours Per Semester				

• Training/ Tutorials/ Exercises Aspects:

Order	Tutorials/ Exercises	Week Due	Contact Hours
1	▪ None		
Number of Weeks /and Contact Hours Per Semester			

• Teaching Strategies:

- Lectures,
- Self-Learning Problems/Studies,
- Case study,
- Individual Projects and Studies,
- Active learning,
- Computer hands-on sessions.
- Independent Study, and
- Presentation

• Assessment Methods of the Course:

- Oral & Writing Exams
- Individual/Group Projects and Studies Reports,
- Presentation,
- Assignments

• Tasks and Assignments:

No	Assignments	Individual /Groups	Mark	Week Due
1	Homework (10 sets)	Individual	10	W2, W4. W6, W8 & W9 - W15
2	Mini/Major Project	Group	15	W9 - W15
3	Case studies	Group	5	W3, W6, W10
	Total Score		30	

• Learning Assessment:

No	Assessment Method	Week Due	Mark	Proportion of Final Assessment %
1	Tasks and Assignments	Weekly	30	20%
2	Quizzes	W5, W10 & W13	10	6.7%
3	Midterm Exam (Theoretical)	W8	30	20%
4	Final Exam (Theoretical)	W16	80	53.3%
	Total		150	100%

• Learning Resources:

1. **Required Textbook(s) :**
2. Ugural, A. C. and S. K. Fenster, 2014, **Advanced Mechanics of Materials and Applied Elasticity**, 6th Edition, USA, Prentice Hall.
2. **Essential References:**
5. Arthur P. Boresi, Richard J. Schmidt, 2003, **Advanced Mechanics of Materials**, 6th Edition, USA, John Wiley and Sons. **6.** L S Srinath, 2009, **Advanced mechanics of solids,** 3rd Edition, New Delhi, Tata McGraw-Hill. **7.** Richard G. Budynas, 1999, **Advanced Strength and Applied Stress Analysis**, 2nd Edition, USA, McGraw Hill. **8.** H. Jane Helena, **Theory of Elasticity and Plasticity,** New Delhi, PHI. **9.** Craig, R.R, 2011, **Mechanics of Materials**, 3rd Edition, John Wiley & Sons. **10.** Logan, D.L., 2011, **A First Course in the Finite Element Methods**, 5th Edition, CL Engineering.
3. **Electronic Materials and Web Sites etc.**
1. https://www.youtube.com/watch?v=HM7ZMPpbeDA **2.** http://freevideolectures.com/Course/89/Fluid-Mechanics **3.** https://www.youtube.com/watch?v=QEyUNvtZkH0 **4.** https://www.youtube.com/watch?v=QKCK4lJLQHU **5.** https://www.av8n.com/how/htm/airfoils.html **6.** http://faculty.dwc.edu/sadraey/Chapter%205.%20Wing%20Design.pdf

• **الضوابط والسياسات المتبعة في المقرر Course Policies**	
بعد الرجوع للوائح الجامعة يتم كتابة السياسة العامة للمقرر فيما يتعلق بالآتي:	
1	**سياسة حضور الفعاليات التعليمية Class Attendance:** **- يلتزم الطالب بحضور 75% من المحاضرات ويحرم في حال عدم الوفاء بذلك.** **- يقدم أستاذ المقرر تقريرا بحضور وغياب الطلاب للقسم ويحرم الطالب من دخول الامتحان في حال تجاوز الغياب 25% ويتم اقرار الحرمان من مجلس القسم.**
2	**الحضور المتأخر Tardy:** **- يسمح للطالب حضور المحاضرة إذا تأخر لمدة ربع ساعة لثلاث مرات في الفصل الدراسي، وإذا تأخر زيادة عن ثلاث مرات يحذر شفويا من أستاذ المقرر، وعند عدم الالتزام يمنع من دخول المحاضرة.**
3	**ضوابط الامتحان Exam Attendance/Punctuality:** **- لا يسمح للطالب دخول الامتحان النهائي إذا تأخر مقدار (20) دقيقة من بدء الامتحان** **- إذا تغيب الطالب عن الامتحان النهائي تطبق اللوائح الخاصة بنظام الامتحان في الكلية.**
4	**التعيينات والمشاريع Assignments & Projects:** **- يحدد أستاذ المقرر نوع التعيينات في بداية الفصل ويحدد مواعيد تسليمها وضوابط تنفيذ التكليفات وتسليمها.** **- إذا تأخر الطالب في تسليم التكليفات عن الموعد المحدد يحرم من درجة التكليف الذي تأخر في تسليمه.**
5	**الغش Cheating:** **- في حال ثبوت قيام الطالب بالغش في الامتحان النصفي أو النهائي تطبق عليه لائحة شؤون الطلاب.** **- في حال ثبوت قيام الطالب بالغش او النقل في التكليفات والمشاريع يحرم من الدرجة المخصصة للتكليف.**
6	**الانتحال Plagiarism:** **– في حالة وجود شخص ينتحل شخصية طالب لأداء الامتحان نيابة عنه تطبق اللائحة الخاصة بذلك**
7	**سياسات أخرى Other policies:** **- أي سياسات أخرى مثل استخدام الموبايل أو مواعيد تسليم التكليفات ..... الخ**