Course Specifications

Course Title:	**Continuum Mechanics**
Course Code:	**30113701-4**
Program:	**BSc. Mathematics 301100**
Department:	Mathematical Science
College:	Applied Sciences
Institution:	**Umm Al-Qura University**

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A. Course Identification

1. Credit hours: 4 hours	
2. Course type	
a. University ☐ College ☐ Department ☒ Others ☐	
b. Required ☒ Elective ☐	
3. Level/year at which this course is offered: Fifth Level/ Third Year	
4. Pre-requisites for this course (if any): Ordinary Differential Equations (30112502-4)	
5. Co-requisites for this course (if any): None. Does not exist.	

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	**Traditional classroom**	4 hours per week	100%
2	**Blended**	0	0%
3	**E-learning**	0	0%
4	**Correspondence**	0	0%
5	**Other**	0	0%

7. Actual Learning Hours (based on academic semester)

No	Activity	Learning Hours
Contact Hours		
1	**Lecture**	(3 hours) x (15 weeks)
2	**Laboratory/Studio**	
3	**Tutorial**	(1 hours) x (15 weeks)
4	**Others** (specify)	0
	Total	60
Other Learning Hours*		
1	**Study**	(1 hours) x (15 weeks)
2	**Assignments**	(1 hours) x (15 weeks)
3	**Library**	(1 hours) x (15 weeks)
4	**Projects/Research Essays/Theses**	(1 hours) x (15 weeks)
5	**Others** (specify)	0
	Total	60

* The length of time that a learner takes to complete learning activities that lead to achievement of course learning outcomes, such as study time, homework assignments, projects, preparing presentations, library times

B. Course Objectives and Learning Outcomes

1. Course Description

Continuum mechanics is a branch of mechanics that deals with the mechanical behavior of materials modeled as a continuous mass rather than as discrete particles. Key topics of the course include Tensors, Kinematics and deformation, Conservation laws, Constitutive laws, Nonlinear Elasticity and Linear elasticity.

2. Course Main Objective
The aim of this course is to provide students with the main concepts of Continuum Mechanics and the quantitative techniques for the resolution of mechanics problems.

3. Course Learning Outcomes

	CLOs	Aligned PLOs
1	**Knowledge:**	
1.1	Define the concept of tensor and their properties.	
1.2	Describe the kinematics and the deformation of a rigid body using the concept of tensors.	
1.3	Recognize Conservation laws.	
1.4	List the different Constitutive laws which used in continuum mechanics.	
2	**Skills:**	
2.1	Explain the connection between stress and strain using tensors.	
2.2	Derive the laws of conservation of mass, linear and angular momentum.	
2.3	Apply constitutive laws in solving fluids motion problems.	
2.4	Find out the exact solution of the pure shear and pure inflation in nonlinear elastic systems.	
2.5	Discuss wave propagation in a linear elastic system.	
3	**Competence:**	
3.1	Communicate effectively in both written and oral form.	
3.2	Use mathematical methods in solving physical problems	
3.3	Formulate important results and theorems covered by the course	

C. Course Content

No	List of Topics	Contact Hours
1	**Introduction to Cartesian Tensors** - Introduction to summation convention. Definitions of scalar product, cross product and matrix product in terms of the summation convention. - Definition of the Kronecker delta and the alternating tensor. Specialist properties of the alternating tensor in three dimensions. - Definition of a determinant and definition of the cofactors of a square matrix. Establish connection between a matrix and its adjugate matrix. - Define vector operations of gradient, divergence and curl using summation convention. - Use of the summation convention to establish a selection of vector identities and identities from vector Calculus. - Introduce symmetric tensors, skew-symmetric tensors, isotropic tensors of orders 2, 3 and 4. Eigenvalues and eigenvectors of rank 2 tensors.	12
2	**Kinematics and deformation**	10

	- Introduce the concept of a body, reference coordinates (Lagrangian coordinates) and material coordinated (Eulerian coordinates). Define what is meant by a deformation. - Define a rigid body motion and demonstrate why it is a rigid body motion. - Introduce the notion of a material or convected derivative. Define material velocity and material acceleration. - Define the deformation gradient tensor. - Define the velocity gradient tensor and deduce the deformation rules for elemental areas and volumes. - Establish the Transport Theorem. - Establish rules for the material differentiation of line and surface integrals. - Derive representation theorems for positive definite tensors. - Introduce the polar decomposition theorem. - Describe common deformations such as simple elongation, pure dilatation, pure shear, simple shear.	
3	**Conservation laws** - Derive the Law of Conservation of Mass. - Derive the Law of Conservation of Linear and Angular Momentum. - Use the tetrahedron argument to deduce the connection between the stress vector and the stress tensor. - Derive the Law of Conservation of Energy. - Introduce the Clausius Duhen Entropy Inequality and the Helmhottz Free Energy function. - Deduce expressions for pressure, the stress tensor and specific entropy in terms of the Helmholtz Free Energy.	10
4	**Constitutive laws** - Introduce the concept of a constitutive or phenomenological equation. - Introduce the constitutive function for a classical Thermo-Elastic Material. - Introduce the concept of Superimposed Rigid Body Motions and the concept of Objectivity. Apply this idea to refine the constitutive form of the equations of Thermo-Elasticity. - Introduce the constitutive function for a classical fluid and in this case refine the constitutive form of the equations for a fluid. - Introduce the concept of an isotropic solid and an isotropic fluid. - Introduce the principle stretches - 1, - 2 and - 3. Express the stress tensor in terms of the principle stretches. - Introduce the Perfect Fluid and investigate its thermodynamic properties, for example, specific heats at constant volume and constant pressure, adiabatic expansions etc. - Discuss the generic form for the linear stress tensor for a viscous fluid.	10

	- Introduce the Riener-Rivlin fluid.	
5	**Exact solutions in Nonlinear Elasticity** - Exact solution of the pure shear of a cube in nonlinear Elasticity. Particularisation to an incompressible elastic solid. - Exact solution of the pure inflation of a tube in nonlinear Elasticity. Particularisation to an incompressible elastic solid.	6
6	**Linear elasticity** - Develop the general equations for the infinitesimal deformations from the reference configuration. - Particularise the problem to an isotropic elastic solid. - Use the entropy inequality to deduce constraints of the material properties of the linearized isotropic stress tensor. Introduce Poisson's ratio. - Investigate various classes of pure homogeneous deformation for the linear theory of elasticity, for example, normal stress, uniaxial tension, pure shear etc. - Discuss wave propagation in a linearly elastic half space. Discuss S-waves and P-waves.	12
Total		60

D. Teaching and Assessment

1. Alignment of Course Learning Outcomes with Teaching Strategies and Assessment Methods

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
1.0	**Knowledge**		
1.1	Define the concept of tensor and their properties.	Lecture Individual or group work	Exams Homework.
1.2	Describe the kinematics and deformation of a rigid body using the concept of tensors.	Lecture Individual or group work	
1.3	Recognize Conservation laws.	Lecture Individual or group work	
1.4	List the different Constitutive laws used in continuum mechanics.	Lecture Individual or group work	
2.0	**Skills**		
2.1	Explain the connection between stress and strain using tensors.	Lecture Individual or group work	Exams Homework.
2.2	Derive the laws of conservation of mass, linear and angular momentum.	Lecture Individual or group work	

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
2.3	Apply constitutive laws to solve fluids motion problems.	Lecture Individual or group work	
2.4	Find the exact solution of the pure shear and pure inflation in nonlinear elastic systems.	Lecture Individual or group work	
2.5	Discuss wave propagation in a linear elastic system.	Lecture Individual or group work	
3.0	**Competence**		
3.1	Communicate effectively in both written and oral form.	Lecture Individual or group work	Exams Homework.
3.2	Use mathematical methods to solve physical problems	Lecture Individual or group work	
3.3	Formulate important results and theorems covered by the course	Lecture Individual or group work	

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Midterm 1	6th week	20%
2	Midterm 2	12th week	20%
3	Homework +Reports + Quizzes	During the semester	10%
4	Final Examination	End of semester	50%

***Assessment task** (i.e., written test, oral test, oral presentation, group project, essay, etc.)

E. Student Academic Counseling and Support

Arrangements for availability of faculty and teaching staff for individual student consultations and academic advice:

Each group of students is assigned to a faculty member where he or she will provide academic advising. All faculty members are required to be in their offices outside teaching hours. Each faculty member allocates at least 4 hours per week to give academic advice and to answer to the questions of students about concepts studied during the lectures

F. Learning Resources and Facilities

1.Learning Resources

Required Textbooks	Continuum Mechanics, A.J.M. Spencer, Dover publications (2004).
Essential References Materials	Illustrated Cartesian tensors with Applications in Mechanics, Fluid Dynamics and Elasticity, A.M. Goodbody, Ellis Horwood (1982).

Electronic Materials	None.
Other Learning Materials	None.

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	Large classrooms that can accommodate more than 50 students.
Technology Resources (AV, data show, Smart Board, software, etc.)	Data Show.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching and assessment.	Students	Direct
Quality of learning resources.	Students	Direct
Extent of achievement of course learning outcomes.	Faculty member	Direct

Evaluation areas (e.g., Effectiveness of teaching and assessment, Extent of achievement of course learning outcomes, Quality of learning resources, etc.)
Evaluators (Students, Faculty, Program Leaders, Peer Reviewer, Others (specify)
Assessment Methods (Direct, Indirect)

H. Specification Approval Data

Council / Committee	Council of the Mathematics Department
Reference No.	
Date	