Course Specifications

Course Title:	**Fluid Mechanics**
Course Code:	**30114703-4**
Program:	**BSc. Mathematics 301100**
Department:	**Mathematics**
College:	**Al Leith University College**
Institution:	**Umm Al Qura University**

Table of Contents

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: Level Eight / Fourth Year								
4. Pre-requisites for this course (if any)**:** Continuum Mechanics 30113701-4								
5. Co-requisites for this course (if any): None								

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	**Traditional classroom**	4 hours \ 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**	60 hours
2	**Laboratory/Studio**	0
3	**Tutorial**	0
4	**Others** (Exam)	10 hours
	Total	70 hours
Other Learning Hours*		
1	**Study**	85 hours
2	**Assignments**	15 hours
3	**Library**	0
4	**Projects/Research Essays/Theses**	15 hours
5	**Others** (specify)	0
	Total	115 hours

* 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

This course covers important topics in fluid mechanics. Starting by introduction: Basic concepts of fluid mechanics. Fundamental terms. Physical values. Fluids and their properties. Forces inside fluid. Then **Fluid Statistics**: Pascal's law. Euler's equation of fluid statics. Measurement of pressure. Relative statics of fluid – constant acceleration, rotation. Forces of hydrostatic pressure. Buoyancy. Flotation. Stability. Next **Fluid Kinematics**: Euler and Lagrangian specification of fluid flow. Streamlines. Path lines. Stream surface. Stream tube. Mass/volume flow. Continuity equation, Control volume. In addition **Fluid Dynamics**: Basic laws of fluid dynamics – conservation of mass, conservation of linear momentum, conservation of energy. Ideal fluid flow. Application of Bernoulli's equation. Real fluid flow. Viscosity. Determination of losses. Reynolds experiment. Laminar and turbulent flow. Boundary layer. Velocity profile. Losses in pipes. Frictional losses. Navier-stokes equations of motion. Local losses. Coefficients of resistance.

2. Course Main Objective

The main objective of the course is to introduce concepts and quantitative techniques for the study of Fluid Mechanics and to introduce different types of flow, understanding basic laws, principles and phenomena in the area of fluid mechanics.

3. Course Learning Outcomes

	CLOs	Aligned PLOs
1	**Knowledge:**	
1.1	Identify viscosity as a fluid property	K3
1.2	Recall the different types of fluids and the phenomena of surface tension	K2
1.3	Recognize Lagrangian and Eulerian frames of reference	K1
1.4	Record pressure distributions normal to, and parallel to, streamlines in flowing fluids	K5
2	**Skills :**	
2.1	Compute shear stress involving Newtonian fluids	S7
2.2	Estimate the local, convective, and total acceleration in flowing fluids	S4
2.3	Locate the usefulness in presenting experimental data using dimensional analysis	S1
2.4	Apply Euler and Lagrangian specification of fluid flow	S5
3	**Competence:**	
3.1	Investigate the principles of fluid dynamics to analyze and to solve real world flow phenomena.	C5
3.2	Develop an engineering problem statement based on real-world applications of fluid mechanics	C2
3.3	Explore the possible solution space for fluids problems	C5

C. Course Content

No	List of Topics	Contact Hours
1	**Introduction** - What is a fluid and what distinguishes it from a solid? - What do we mean by density and viscosity? - Define fluid velocity and introduce the concepts of streamlines,	4

	streak lines and path lines and give some simple examples.	
2	**Conservation laws** - The material derivative and the law of conservation of mass. - Establish the transport theorem. - Discuss the notion of an incompressible fluid. - Introduce notions of force and the stress tensor. - Derive the equation for the balance of linear momentum. - Derive the equation for the balance of angular momentum and deduce that the stress tensor is symmetric.	10
3	**Ideal Fluid** - Define what is meant by an ideal fluid. - Show that kinetic energy is conserved for ideal fluids in motions with in a fixed volume if the body force is conservative. - Derive Bernoulli's Theorem for conservative body force. - Define vorticity and derive the vorticity equation for an ideal fluid. - Consider the special case of 2D flow for which vorticity is characterized by a scalar function. Give examples. - Define irrotational flow and particularize Bernoulli's theorem to irrotational flow. - Define circulation and establish its properties, for example, conditions under which the circulation is zero.	10
4	**Introduction to viscous flow** - Introduce the Newtonian Fluid and its stress tensor. - Derive the Navier-Stokes equation assuming incompressibility. - Verity that the presence of viscosity causes dissipation by considering the evolution of total kinetic energy in the motion of a viscous fluid. - Construct exact solutions for Poiseuille and Couette flow. Calculate shearing forces of boundaries. - Non-dimensionalise the Navier-Stokes equations with respect to characteristic lengths and velocities to obtain the Reynolds number. - Discuss the case Re >> 1 - low viscosity, flow is approximately that of an ideal fluid away from boundaries. Discuss also the case Re <<1 - low dominated by viscosity and inertia terms now ignorable. - Explain the reasoning driving the non-dimensionalisation procedure. Check that Reynolds number is indeed a non-dimensional number.	8
5	**Vorticity and Boundary layers** - Derive the vorticity equation for a viscous fluid and particularize to 2D flow. - Solve problem for an impulsively moved plane boundary for viscous fluid in a half-space. Observe the importance of the similarity variable - Use the exact solution to elucidate the idea of a boundary layer in the respect to that of inviscid solution. - Reconsider the Navier-Stokes equation and argue with general thickness of a boundary layer.	10
6	**Potential flow** - Consider only 2D incompressible inviscid flow and introduce the concept	8

	of the velocity potential and stream function. - Introduce the complex velocity potential via the CR equations. Illustrate complex VPs for some simple 2D flows, e.g. source, sink, line vortex, streaming flow at speed U etc.. - Establish the expression for the force on an obstacle in a 2D flow of an Inviscid fluid, that is, the integral expression for $Fx - iFy$ (Blausius's Theorem). - Establish the Milne-Thomson circle theorem for 2D flow around a circular cylinder. - Do some examples calculating forces for simple flows. - Analyze the general Joukowski airfoil in which z = 0 is interior to the airfoil so that the VP has a Laurent expansion about z = 0. - Introduce the Method of Images regions for semi-infinite.	
7	**Surface and Interfacial waves** - Introduce the concepts of amplitude, frequency (Hz and angular), wavelength and phase velocity. - Introduce the concept of dispersive waves leading to the notion of group velocity. Provide some examples of dispersion and calculation their group velocities. - Introduce the concept of surface tension and its mathematics formulation. - Establish expressions for the speed of surface waves on an incompressible inviscid fluid of depth h, ignoring surface tension and in the presence of surface tension. - Extend analysis to interfacial waves and do a few examples.	10
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	Identify viscosity as a fluid property	Lecture Tutorials	Exams (Quizzes, Midterm and Final). Written and possibly oral exam at the end of the course. In addition, compulsory work may be given during the course
1.2	Recall the different types of fluids and the phenomena of surface tension		
1.3	Recognize Lagrangian and Eulerian frames of reference		
1.4	Record pressure distributions normal to, and parallel to, streamlines in flowing fluids		
2.0	**Skills**		
2.1	Compute shear stress involving Newtonian fluids	Lecture Individual or group work	Exams (Quizzes, Midterm and Final). Homework
2.2	Estimate the local, convective, and total acceleration in flowing fluids		
2.3	Locate the usefulness in presenting experimental data using dimensional analysis		

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
2.4	Apply Euler and Lagrangian specification of fluid flow		
3.0	**Competence**		
3.1	Investigate the principles of fluid dynamics to analyze and to solve real world flow phenomena.	Lecture Individual or group work	Exams (Quizzes, Midterm and Final). Research Essays
3.2	Develop an engineering problem statement based on real-world applications of fluid mechanics		
3.3	Explore the possible solution space for fluids problems		

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Midterm Test (1)	6th week	20%
2	Midterm Test (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 :

The faculty will arrange teaching staff for individual student consultations and academic advice which includes amount of time teaching staff to be available each week.

Each group of students is assigned to a particular faculty where he or she will provide academic Counselling during specific academic hours. Each staff will provide at least one session/week. The instructor of the course is aware of the weaknesses of the student in the subject and try to resolve it.

F. Learning Resources and Facilities

1.Learning Resources

Required Textbooks	Batchelor, An Introduction to Fluid Dynamics, Cambridge University Press (1967). Acheson, Elementary Fluid Dynamics, Oxford University Press (1990). Drazin and Reid, Hydrodynamic Stability, Cambridge University Press (2004).
Essential References Materials	Lecture notes.
Electronic Materials	(a) Lectures presentations should be available for students. (b) Audio visual materials should also be available.

Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	Lecture theatre which can accommodate 30 students for lectures and tutorials and Computer laboratory.
Technology Resources (AV, data show, Smart Board, software, etc.)	Data Show (projector)
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**	**The mathematical sciences (college of applied sciences) and the mathematics (Al-Leith University College) department s first meeting of the coordinative committee**
Reference No.	**4101050782**	**First meeting**
Date	**Sunday, 17 November 2019**	**Thursday, 17 October 2019**

Department Head

Dr. Ali Hassani