Course Specifications

Course Title:	**Fluid Mechanics**
Course Code:	**4044703-4**
Program:	**Bachelor of Science (B.Sc.) Mathematics**
Department:	**Mathematical Science**
College:	**Applied Science**
Institution:	**Umm Al-Qura, University**

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A. Course Identification

1. Credit hours: 4	
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 (4043701-4)
5. Co-requisites for this course (if any):	N.A.

6. Mode of Instruction (mark all that apply)

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

7. Actual Learning Hours (based on academic semester)

No	Activity	Learning Hours
Contact Hours		
1	**Lecture**	60
2	**Laboratory/Studio**	
3	**Tutorial**	
4	**Others** (specify)	
	Total	60
Other Learning Hours*		
1	**Study**	85
2	**Assignments**	20
3	**Library**	
4	**Projects/Research Essays/Theses**	20
5	**Others** (specify)	
	Total	125

* 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
Introduction: Basic concepts of fluid mechanics. Fundamental terms. Physical values. Fluids and their properties. Forces inside fluid. **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. **Fluid Kinematics**: Euler and Lagrangian specification of fluid flow. Streamlines. Path lines. Stream surface. Stream tube. Mass/volume flow. Continuity equation, Control volume. **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 role 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	Understand viscosity as a fluid property and be able to compute shear stress involving Newtonian fluids. Understand the different types of fluids and the phenomena of surface tension.	
1.2	Understand field variables and be able to evaluate the local, convective, and total acceleration in flowing fluids. Recognize Lagrangian and Eulerian frames of reference	
1.3	Understand pressure distributions normal to, and parallel to, streamlines in flowing fluids	
1.4	Understand the usefulness in presenting experimental data using dimensional analysis.	
2	**Skills :**	
2.1	Be able to appropriately apply Bernoulli's principle to fluid dynamic situations and recognize the limitations of this principle	
2.2	Be able to apply mechanical energy equation it to laminar and turbulent flow with minor and major losses through pipe networks	
3	**Competence:**	
3.1	To utilize the principles of fluid dynamics to analyze and solve real world flow phenomena	
3.2	To use structured techniques to develop an engineering problem statement based on real-world applications of fluid mechanics and apply structured problem solving techniques	
3.3	To methodically explore the possible solution space for fluids problems.	

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 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 $F_x - iF_y$ (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	8

	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	Recognize basic knowledge of fluid flow and its properties and characteristics and its use in various fields.	Lectures, tutorials and e-learning	Mid-term exams and final exams
1.2	Get the knowledge of various physical terms such as shear, stress, pressure, vorticity etc.	Lectures, tutorials and power point presentation	Mid-term exams and final exams
2.0	**Skills**		
2.1	How to use the physical laws and principles in understanding the subject?	Tutorials	Home Assignments
2.2	How to simplify problems and analyze phenomena?	Tutorials and brain storming session	Solving problem
2.3	Ability to explain the idea with the students own words.	Tutorials and discussions	Assigning projects
3.0	**Competence**		
3.1	Plan practical activities using techniques and procedures appropriate to Fluid Mechanics.	Lectures	Homework and exams
3.2	Execute a piece of independent research using mathematics techniques of Fluid Mechanics.	Lectures	Homework and exams

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Midterm Test (1)	7th week	20%
2	Homework + Reports + Quizzes		5%
3	Midterm Test (2)	12th week	20%
4	Homework + Reports + Quizzes		5%

#	Assessment task*	Week Due	Percentage of Total Assessment Score
5	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 :

1. 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.
2. 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.
3. 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	

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)	

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Strategies for Obtaining Student Feedback on Effectiveness of Teaching	Program Instructor and Head of the Department.	student questionnaire feedback form
Strategies for Evaluation of Teaching	Students and Head of the Department.	staff questionnaire feedback form
Processes for Improvement of Teaching	Program Instructor and the committee responsible for quality check.	Submission of a course report after final result declared. New teaching strategies should be submitted after evaluation.
Processes for Verifying Standards of Student Achievement.	Program Instructor and the committee responsible for quality check	Compare the standards of students achievements' with standards archived elsewhere (inside KSA or students from outside the kingdom) by checking the marking of a sample of some student work : tests, course work
Describe the planning arrangements for periodically reviewing course effectiveness and planning for improvement	Staff members of UQU and other staff members of the university.	Reviewing feedback on the quality of course report from staff members, other university' staffs.

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	
Reference No.	
Date	