Course Specification

(Postgraduate Programs)

Course Title:	**Mathematical Fluid Mechanics**
Course Code:	**MAT 7266**
Program:	**Doctor of Philosophy in Mathematics**
Department:	**Mathematics and Statistics**
College:	**Science**
Institution:	**Imam Mohammad Ibn Saud Islamic University**
Version:	**2024 – V1**
Last Revision Date:	**None**

Table of Contents

A. General information about the course:

1. Course Identification:

1. Credit hours:					
4 (4 Lectures, 0 Lab, 0 Tutorial)					
2. Course type					
A.	☐ University	☐ College	☒ Program	☐ Track	☐ Others
B.	☐ Required		☒ Elective		
3. Level/year at which this course is offered: Level 3 / Year 2					
4. Course General Description:					
Without fluid motion on Earth, life could not exist. For example, blood moves through the vessels in our bodies and air flows into our lungs, we simply cannot live without air and water. Besides nowadays fluid mechanics is an essential part of the comprehensive design and manufacture of nearly all modern machinery, structures, and devices. This course is a graduate course on the mathematical modelling of fluid mechanics which is a central theme in modern applied mathematics. Specifically for incompressible fluids, we use the techniques from functional analysis, the analysis of partial differential equations and model the fluid flow.					
5. Pre-requirements for this course (if any):					
None					
6. Pre-requirements for this course (if any):					
None					
7. Course Main Objective(s):					
The objective of this course is to study mathematical theory for some essential advanced topics in fluid mechanics. In particular, the aim is to introduce tensors, elements of tensor algebra, derive governing momentum and energy equation for Newtonian fluid then introduce the Fourier transform and Galerkin Truncations for existence of the weak solution of Navier Stokes Equations (NSE).					

2. Teaching Mode: (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	60	100%
2	E-learning	0	0%
3	Hybrid • Traditional classroom • E-learning	0	0%
4	Distance learning	0	0%

3. Contact Hours: (based on the academic semester)

No	Activity	Contact Hours
1.	**Lectures**	**60**
2.	**Laboratory/Studio**	**0**
3.	**Field**	**0**
4.	**Tutorial**	**0**
5.	**Others (specify)……**	**0**
	Total	**60**

B. Course Learning Outcomes (CLOs), Teaching Strategies and Assessment Methods:

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
1.0	**Knowledge and understanding**			
1.1	To describe momentum and energy equation for viscous flow and Navier- Stokes equations.	K1, K2	●4 lecture hours\week ●Self-study	●Regular Exams ●Assignments ●Short Quizzes
1.2	To state Galerkin approximation and weak solution concept.	K1, K2		
2.0	**Skills**			
2.1	To develop techniques of proof in Tensor Calculus.	S1, S2	Deep problems	Short Quizzes
2.2	To develop oral communication and technical writing skills through evaluation of Energy Equations.	S3	Self-study	Participations
2.3	To use Internet in searching for some fluid model equations.	S4	Deep problems	Short Quizzes
2.4	To demonstrate proofs of convergence of Galerkin approximation.	S1, S2	Self-study	Participations
3.0	**Values, autonomy, and responsibility**			
3.1	To work independently.	V1, V3	Personal questions	Participation
3.2	To employ in team works.	V1, V2	Team work	Homework and Mini-projects

C. Course Content:

No	List of Topics	Contact Hours
1.	**Vectors, Tensors, and Operators;** Convective Derivatives and Conservation Equations; Boundary Conditions for Momentum Equation and Projection Formulation, Evaluation of Energy Equation and Vorticity.	**12**
2.	**Introduction to Viscous Fluids (Newtonian Fluid);** Navier-Stokes Equation; Boussinesq Approximation.	**10**
3.	**Boundary Conditions,** and Rayleigh-Benard Convection; Lorenz Equation.	**10**
4.	**Incompressible Navier-Stokes and Plane Coutte Flow**; Stability Plane Couette Flow; Computational Study for Stability of Plane Coutte Flow.	**12**
5.	**Navier-Stokes Equations** in Fourier Space and Galerkin Truncations.	**8**
6.	**Convergence** of Galerkin Approximations and Weak Solution of NSE (Navier Stokes Equations).	**8**
Total		**60**

D. Students Assessment Activities:

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	**HomeWorks, Quizzes, Mini projects**	**During the semester**	**30%**
2.	**Midterm**	**Week 9-10**	**30%**
3.	**Final Exam**	**Week 15-16**	**40%**

*Assessment Activities (i.e., Written test, oral test, oral presentation, group project, essay, etc.)

E. Learning Resources and Facilities:

1. References and Learning Resources:

Essential References	**C. Doering, and J.D. Gibbon,** *Applied Analysis of The Navier-Stokes Equations,* Cambridge University Press, 1995. **(Main Reference)**
Supportive References	• **A.J. Majda and A.L. Bertozzi,** *Vorticity and Incompressible Flow*, Cambridge University Press, 2002. • **Chorin, and J.E. Marsden**, *A Mathematical Introduction to Fluid Mechanics,* Springer, 3rd Edition, 1993. • **J. Robinson,** *Infinite-Dimensional Dynamical Systems*, Cambridge University Press, 2001. • **R. Temam,** *Navier-Stokes equations. Theory and numerical analysis.* Reprint of the 1984 edition. AMS Chelsea Publishing, Providence, RI, 2001.
Electronic Materials	**None**

Other Learning Materials	None

2. Educational and Research Facilities and Equipment Required:

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	▪ **Each classroom should be equipped with a whiteboard and a projector.** ▪ **Laboratories should be equipped with computers and an internet connection.**
Technology equipment (Projector, smart board, software)	**The rooms are equipped with data show and Smart Board.**
Other equipment (Depending on the nature of the specialty)	**None.**

F. Assessment of Course Quality:

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	Students	**Direct:** Questionnaire.
	Course Responsible	**Direct:** Course e-Portfolio. **Indirect:** Second examiner checklist-Course report.
	Peer Reviewer	**Direct:** Questionnaire. **Indirect:** External assessor report.
Effectiveness of students' assessment	**Instructor**	**At the end of each semester the course instructor should complete the course report, including a summary of student questionnaire responses appraising progress and identifying changes that need to be made if necessary.**
Quality of learning resources	Students	**Indirect:** Second examiner checklist-Course report.
	Faculty (Academic Advisory-GCC)	**Direct:** course Entrance/Exit. **Indirect:** Observations - Accreditation review.
	Program Leaders	**Direct:** Course e-Portfolio. **Indirect:** Course evaluation survey- Observations- Syllabus review- Accreditation review.
The extent to which CLOs have been achieved	**Instructor**	**At the end of each semester the course instructor should complete the course report, including a summary of student questionnaire responses appraising progress and identifying changes that need to be made if necessary.**

Assessment Areas/Issues	Assessor	Assessment Methods
Other	None	

Assessor (Students, Faculty, Program Leaders, Peer Reviewer, Others (specify)

Assessment Methods (Direct, Indirect)

G. Specification Approval Data:

COUNCIL /COMMITTEE	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
REFERENCE NO.	8/1446
DATE	05/04/1446 (08/10/2024)