EM/EY 225 FLUID MECHANICS
IES Abroad Madrid

DESCRIPTION:
This introductory course in Fluid Mechanics is designed for students of engineering who want to understand the behavior of fluids and the principles that govern their motion. The course starts with a qualitative description of fluid mechanics, introducing fundamental concepts like pressure, density, and viscosity, before moving on to more advanced topics like fluid flow, and boundary layers. Through analyzing simple everyday observation, the students will learn how to observe and analyze fluid behavior in real-world situations. Building on these observations, students will learn how to use scaling arguments to develop a quantitative understanding of fluid mechanics, which will lead to the development of a formal mathematical description. By the end of the course, students will have gained a deep understanding of fluid mechanics and the ability to apply this knowledge to practical engineering problems. They will be able to use mathematical models to predict fluid behavior, and analyze fluid-based systems, setting a solid foundation for their future studies in mechanical engineering, bioengineering…etc.

CREDITS: 4 credits

CONTACT HOURS: 60 hours

LANGUAGE OF INSTRUCTION: English

PREREQUISITES: Physics (Mechanics), Mathematics (Calculus I and II).

ADDITIONAL COST: None

METHOD OF PRESENTATION:
Lectures: 1 weekly session of 2 hours each (plus break times) where theory and practice will take place in each session. The instructor will present the theory and cover examples.

The different lessons will be delivered via whiteboard and using presentations to explain the theoretical concepts needed for each module. These will be supplemented with explanations of the numerical simulations used to obtain the results. After completing each module, several problems will be solved, and selected lab projects will be proposed to reinforce the concepts. Homework assignments and in-class quizzes will also be proposed, in which students will put into practice everything learnt in the course.
The Moodle platform will be mainly used to exchange course materials, delivering of Homework assignments, completion of quizzes, and doubt solving using the Forum.

REQUIRED WORK AND FORM OF ASSESSMENT:
- Final Exam - 25%
- Midterm Exam - 25%
- Homework Assignments - 30%
- In-class quizzes - 10%
- Participation - 10%

Course Element

Final Exam
The Final Exam will be comprehensive. It consists of a section to provide solution to exercises and multiple-choice questions.
Midterm Exam
The midterm exam covers the content of weeks 1-6. It consists of worked-out exercises and multiple-choice questions.
Homework Assignments
Referred to as problems in the syllabus. Different readings, problem solving and lab projects that will be proposed in the different sessions that will be assigned weekly. The completion of the assignment (reading and writing) should take 3-4 hours. No late

homework will be accepted. Each written assignment must include results and conclusions. Students are invited to work together on the assignments, but each student must complete and hand-on his/her own assignment.

In-class quizzes

Regular in-class quizzes will be proposed by the instructor to check the assimilation of the concepts and evaluate the progress of the students.

Participation

This includes the interaction of the student in the classroom, the ability to answer questions made by the instructor and the general interest shown in the course. Some of the in-class assignments will use tools such as Kahoot verifying understanding of concepts.

LEARNING OUTCOMES:

By the end of the course, students will be able to:

- Understand the fundamental concepts of fluid mechanics, including pressure, density, viscosity, and flow rate.
- Analyze fluid behavior under different conditions, including laminar and turbulent flow, boundary layers, and the effects of viscosity and turbulence.
- Use mathematical models to predict fluid behavior, including the Navier-Stokes equations and the Bernoulli equation.
- Analyze data to validate and improve fluid mechanics models.
- Understand the importance of fluid mechanics in practical engineering applications, including aerospace, civil, and mechanical engineering.
- Overall, the course aims to equip students with the knowledge and skills needed to apply fluid mechanics principles to solve real-world engineering problems.

ATTENDANCE POLICY:

As a member of our class community, you are expected to be present and on time every day. Attending class has an impact on your learning and academic success. For this reason, attendance is **mandatory for all IES Madrid classes**, including course-related excursions. Absences will only be excused in cases of documented medical or family emergencies. Any assessed work, including exams, tests, and presentations, will be rescheduled if the absence is justified; otherwise, it will be graded as 0. You are allowed a maximum of 1 unexcused absence for once-a-week courses and 2 unexcused absences for twice-a-week courses. Each additional absence will deduct 5 points from your final grade. **Accumulating 7 or more absences in twice-a-week courses, or 4 or more in once-a-week courses, may lead to a failing grade.** Students arriving more than 11 minutes after the scheduled start time will be marked as 'late.' Three 'late' arrivals will be counted as 1 absence. Any student arriving 30 minutes or more after the scheduled start time will be marked as 'absent.' For more information, please refer to the full Attendance and Punctuality Policy document.

CONTENT:

Week	Content	Assignments
Week 1	**Introduction to Fluid Mechanics.** • Introduction; Fundamental Concepts; Units, Definitions.	• Mitchell, J.W., Fox and McDonald's Introduction to Fluid Mechanics, 10th ed, Wiley Pages: 1-13; 15-17; A1-A3 • Fluid Mechanics" by Frank White. Chapter 1, Problems Ch1: 1,2,3,5,9,10,61,65,68

Week	Content	Assignments
Week 2	**Fluids statics** • Hydrostatic Pressure Variation; Barometry, Manometry • Hydrostatic Pressure Force and Center of Pressure for Planar Surfaces • Hydrostatic Pressure Force and Center of Pressure for Curved Surfaces • Buoyant Force and Center of Buoyancy	• Fox and McDonald's, Pages: 38-50, A4, 50-63 • White: Ch1-Ch2. Problems Ch1: 41,45,54 Problems Ch2: 28, 11,14,31, 62,63,64,121
Week 3	**Visualization** • Flow Visualization (Streamlines, Streaklines, and Pathlines)	• Fox and McDonald's Pages: 17-23 • White: Ch4, Ch6. P4.1, 4.2
Week 4	**Viscosity** • Dynamic and Kinematic Viscosity; Viscous Stresses	• Fox and McDonald's Pages: 23-29, 30-36, A5-A12
Week 5	**Integral control volumes** • Reynolds Transport Theorem; Conservation of Mass • Linear Momentum Equation for an Inertial FOR • Bernoulli's Equation • Linear Momentum Equation for a Non-inertial FOR	• Fox and McDonald's Pages: 70-105, 169-177 • White: Read chapters 3 and practical exercises Problems: 10-162
Week 6	**Differential Control Volumes (NS equations)** • Navier-Stokes Equations. • Euler Equations • Differential Control Volumes (Couette Flow) • Differential Control Volumes (Poiseuille Flow)	• Fox and McDonald's Pages: 230-245 • White: Read chapters 4 and practical exercises of Problems: 1,2,8,9,17,19
Week 7	**In-class review** • Homework revision • Interactive Q&A • In-class quizzes	• Review lessons 1-6
Week 8	**MIDTERM EXAM**	• Review lessons 1-6

Week	Content	Assignments
Week 9	**Dimensional analysis** • Buckingham-Pi Theorem; Method of Repeating Variables • Significant Dimensionless Numbers • Similarity and Scaling	• Fox and McDonald's Pages: 202-225. • White: Read chapters 5 and practical exercises Analyze and discuss the Ex: 5.3, 5.5, 5.10 Problems: 10, 12, 14, 16, 17, 44, 45, 50, 51
Week 10	**Boundary layers:** • Boundary layer equations. Blasius. • Boundary Layer Thickness Measures • Laminar Boundary Layers; Skin Friction Drag • Momentum Integral Equation; Turbulent Boundary Layers, Separation.	• Fox and McDonald's Pages: 293-316 • White: Read chapters 7 and practical exercises P 7.23, P 7.24, P 7.32, P 7.69, P 7.89, P 7.94, P7.101, P 7.108, P 7.111
Week 11	**Forces on immmerse bodies** • Drag on Immersed Bodies • Lift on Immersed Bodies	• Fox and McDonald's Pages:316-329; 337-340 • White: Read chapters 7 and practical exercises P 7.23, P 7.24, P 7.32, P 7.69, P 7.89, P 7.94, P7.101, P 7.108, P 7.111
Week 12	**Pipe Flows** • Extended Bernoulli's Equation • Major Head Losses; Moody Plot • Minor Head Losses; Shaft Head • Single & Multiple Path Systems	• Fox and McDonald's Pages: 177-181; 227-229; 241-276 • White: Read chapters 6 and practical exercises Problems: 1, 5, 6, 8, 19, 26, 28, 99, 101, 102, 103, 109, 142, 144, 149, 151, 156
Week 13	**EASTER BRAKE**	
Week 14	**Fluid Machinery** • Pump Types; Head Curve; Best Efficiency Point • Specific Speed; Dimensionless Coefficients; Scaling • Operating Point, Net Positive Suction Head	• Fox and McDonald's Pages: 343-348; 352-358; 362-379 • White: Read chapters 11 and practical exercises P 11.15 - P 11.18, P 11.84 – P 11.88, P 11. 100 – P 11. 103
Week 15	**In-class review** • Homework revision • Interactive Q&A • In-class quizzes	• Review lessons 7-11
Week 16	**FINAL EXAM**	• Review lessons 7-11

COURSE-RELATED TRIPS:

- None

REQUIRED READINGS:

- Mitchell, J.W., Fox and McDonald's Introduction to Fluid Mechanics, 10th ed, Wiley.
- Fluid Mechanics – Franck White, 8th edition - Mc Graw Hill.

RECOMMENDED READINGS:

- Physical Hydrodynamics - Etiene Guyon et al. - Oxford Academics.
- Physics of Continuous Matter – B. Lautrup – CRC Press.