جامعة الملك عبدالله
للعلوم والتقنية
King Abdullah University of
Science and Technology

Course Syllabus: Fluid Mechanics - ME 200A

Division	Physical Science and Engineering Division
Course Number	ME 200A
Course Title	Fluid Mechanics
Academic Semester	Fall
Academic Year	2019/2020
Semester Start Date	08/25/2019
Semester End Date	12/10/2019
Class Schedule (Days & Time)	04:00 PM - 05:30 PM | Sun Wed

Instructor(s)

Name	Email	Phone	Office Location	Office Hours
Gaetano Magnotti	GAETANO.MAGNOTTI@KAUST.EDU.SA	+966128082874	4335, 5, Al-Kindi (bldg. 5)	To be determined with students.

Teaching Assistant(s)

Name	Email
None	N/A

Course Information

Comprehensive Course Description	This course is an introductory graduate level course in Fluid Dynamics. It starts by introducing the continuum hypothesis. Streamlines and other flow-lines are then described and equation derived to describe them. We then introduce the concept of convective acceleration and the difference between Eulerian and Lagrangian description of the flow. The conservations laws of mass, momentum and energy will be derived using the Reynolds Transport Theorem. In this way we will derive the continuity equation as well as the Navier-Stokes equations. Following this we derive specialized forms, like the Bernoulli equation, the inviscid Euler equations, before finding exact solutions of the Navier-Stokes equations, when the flow is unidirectional. This includes the flow down an inclined plane, the First and Second Stokes problems of a solid plate suddenly moving tangentially. We introduce dimensional analysis using the Buckingham Pi-theorem and show various self-similar phenomena. Other exact solutions are the flow in convergent or divergent channel. We then introduce the velocity potential and the streamfunction. This includes the complex potential and Cauchy-Riemann conditions. Then we give the basic potential flow solutions of source, sink, point vortex, doublet, flow in a sector and the flow around a circular cylinder. Then we calculate the lift on a rotating cylinder and introduce the d'Alemberts paradox and the Blasius drag laws. We mention conformal mappings and the Schwarz-Christoffel transformation. Then we derive the vorticity equations, explain the Kelvin's circulation theorem and the Biot-Savart law and apply these to the motion of a vortex ring. Explain the importance of stretching and tilting terms in the vorticity dynamics. We also introduce flow in rapidly rotating systems, like Taylor columns and Eckman layers.
Course Description from Program Guide	Fundamentals of fluid mechanics. Microscopic and macroscopic properties of liquids and gases; the continuum hypothesis; review of thermodynamics; general equations of motion; kinematics; stresses; constitutive relations; vorticity, circulation; Bernoullis equation; potential flow; thin-airfoil theory; surface gravity waves; buoyancy- driven flows; rotating flows; viscous creeping flow; viscous boundary layers; introduction to stability and turbulence; quasi one-dimensional compressible flow; shock waves; unsteady compressible flow; acoustics.

Goals and Objectives	The objective of the course is to provide the students with 1:) a foundation in fluid mechanics; 2) experience in the analytical formulations of basic fluid mechanics problems; 3) understanding of dimensional analysis and similitude, and knowledge of the fundamental non-dimensional groups in fluid-mechanics; 4) ability to distinguish between flow regimes based on non-dimensional groups; 5) ability to solve for simple internal and external flows.
Required Knowledge	Basic concepts of mechanics. Newton's laws of motion. Undergraduate fluidmechanics or equivalent. Differential calculus.
Reference Texts	Incompressible flows by R.L. Panton, Wiley Fluid Mechanics. by P.K. Kundu & I. M. Cohen. AP
Method of evaluation	**10.00**% - Attendance and Participation **30.00**% - Midterm exam **25.00**% - Homework /Assignments **35.00**% - Final exam
Nature of the assignments	Weekly homework assignments.
Course Policies	Lecture attendence is mandatory. Midterm and Final exams are closed book/ closed notes. Late homeworks are allowed only once, and the maximum delay is 6 days.
Additional Information	

Tentative Course Schedule

(Time, topic/emphasis & resources)

Week	Lectures	Topic
1	Sun 08/25/2019	Introduction to Fluid mechanics. The Continuum Hypothesis. Review of Thermodynamics
1	Wed 08/28/2019	Vector Calculus and Index Notation
2	Sun 09/01/2019	Second order tensors and vector calculus
2	Wed 09/04/2019	Kinematics. Lagrangian vs Eulerian viewpoint. Streamlines and pathlines. Material derivatives
3	Sun 09/08/2019	Kinematics. Decomposition of motion. Strain and rotation rates
3	Wed 09/11/2019	Governing equations: Conservation of mass, momentum and energy
4	Sun 09/15/2019	Integral form of the governing equations. Constitutive equations. Newtonian fluids.
4	Wed 09/18/2019	Navier Stokes equations.
5	Sun 09/22/2019	University holiday
5	Wed 09/25/2019	Review
6	Sun 09/29/2019	Governing equations in curvilinear coordinates
6	Wed 10/02/2019	Dynamic similarity. Pi theorem
7	Sun 10/06/2019	Incompressible flows. Flow down an inclined plate
7	Wed 10/09/2019	Plane Poiseuille flow. Plane Couette flow
8	Sun 10/13/2019	Midterm exam
8	Wed 10/16/2019	Unsteady unidirectional incompressible flow. Stokes first and second problems.
9	Sun 10/20/2019	Oscillatory Poiseulle flow between 2 flat plates. Decay of an ideal vortex
9	Wed 10/23/2019	Burger's vortex. Von Karman Viscous pump. Bodewadt Problem
10	Sun 10/27/2019	Streamfunctions and the velocity potential.
10	Wed 10/30/2019	Vorticity dynamics. Helmottz vortex theorems.
11	Sun 11/03/2019	Kelvin's circulation theorem. Vortex interaction.
11	Wed 11/06/2019	Geostrophic flows
12	Sun 11/10/2019	Review
12	Wed 11/13/2019	Planar ideal flow. Complex velocity potential.
13	Sun 11/17/2019	Source, sink, vortices and doublets.
13	Wed 11/20/2019	Cylinder in a stream. Joukowsky airfoil. Conformal mapping.
14	Sun 11/24/2019	Creeping flows. Stokes solution for flow past a sphere.
14	Wed 11/27/2019	Lubrication theory. Slipper pad and journal bearings.
15	Sun 12/01/2019	Review
15	Wed 12/04/2019	Review
16	Sun 12/08/2019	Exams

Note

The instructor reserves the right to make changes to this syllabus as necessary.