FLUID MECHANICS 1, 034013

PREREQUISITES

- Thermodynamics 1, 034035
- Ordinary differential equations, 104131
- Partial differential equations, 104218 (may be taken in parallel with this course)

INSTRUCTURES

Name	email	Lecture time	Location	Reception	Office
Prof. Amir Gat (Lecturer)	amirgat @ technion.ac.il	Thursday 10:30-13:30	TBA	Via email	**ZOOM**
Mr. Ofek Peretz (TA)	ofekperetz@campus.technion.ac.il	Wednesday 15:30-17:30	TBA	Via email	**ZOOM**

MOODLE & EMAIL

- Please make sure you are registered to the course Moodle website.
- Please send emails to the course instructors with 034013 in the email subject line. For example: "Subject: [ME34013] Question about control volume in homework 5"

GRADES

- Final exam is 75% to 85% of the course grade Moed A – 14/2/2021.
- Homeworks 15% of the grade.
- Classroom/online Quizzes up to 10% magen, will be decided during the semester.
- Due to COVID19, the grade method may change due to state regulations.

HOMEWORKS

- Homeworks are 15% of the total grade.
- Homeworks will appear in the course website, mandatory and single submission in a readable PDF file.
- The final exam will have at lease one question from the homeworks (with minor changes).

PLANNED LECTURE SCHEDULE

1. INTRODUCTION - 22/OCT/2020

- Course regulations
- Why fluid is mechanics is important to mechanical engineers
- What is a fluid? What is a solid?

- Definition of viscosity, pressure, inertia, surface tension

2. INTEGRAL APPROACH - 29/OCT/2020

- The benefits of integral calculations
- Defining a control volume
- Integral quantities
- Conservation rules of integral quantities (Reynolds' Transport Theorem)
- Examples

3. THE NAVIER-STOKES EQUATIONS - 5/NOV/2020

- Substantive derivative
- Stream functions
- Cauchy's equation
- The Newtonian stress to strain rate relation
- The Navier-Stokes equations
- Scaling of the Navier-Stokes equations

4. THE KINEMATICS OF FLOW - 12/NOV/2020

- How can one see flows?
- Lagrangian description versus Eulerian description of flows
- Parametric description
- Stream lines, path lines and steak lines.

5. THE HYDROSTATIC LIMIT - 19/NOV/2020

- Fluids without flow?
- When is the hydrostatic limit assumption valid?
- The principle of communicating vessels
- Floatation
- Rotating systems

6. THE VISCOUS LIMIT I – THE FUNDMENTAL SOLUTIONS - 26/NOV/2020

- Derivation and scaling of the Stokes equations
- 2D Poiseuille flow
- Hagen-Poiseuille flow
- 2D Couette flows
- Bearing fluid dynamics

7. THE VISCOUS LIMIT II – MORE ADVANCED FLOWS - 3/DEC/2020

- Sphere in viscous fluid
- The Reynolds equation

8. THE INERTIAL LIMIT – EULER'S EQUATION - 10/DEC/2020

- Derivation of the Euler equation
- Derivation of the Bernoulli equation
- Combining the Bernoulli equation with integral considerations
- Example: Hydraulic jump
- Example: Venturi tube

9. THE INERTIAL LIMIT – POTENTIAL FLOW I - 24/DEC/2020

- Definition of potential flow, irritational flow
- Derivation of the Helmholtz equation
- The potential flow equations
- Examples

10. THE INERTIAL LIMIT – POTENTIAL FLOW II - 31/DEC/2020

- Reflection method
- Doublets
- Vortex
- Cylinder in potential flow
- Rotating cylinder – a very simplified wing
- The D'alembert paradox and how to solve it

11. BOUNDARY LAYERS I - 7/JAN/2021

- Example of a simple ODE with a boundary layer
- Derivation of the boundary layer equations for a flat plate
- Scheme for combining potential flow solution with boundary layer
- Approximated solutions

12. BOUNDARY LAYERS I - SIMILARITY - 14/JAN/2021

- What is similarity? When can we expect it? How can it be used?
- The first Stokes' problem – Suddenly moving plate
- The second Stokes' problem – an oscillating plate

13. SURFACE TENSION - 21/JAN/2021

- What is surface tension?
- Laplace pressure calculation
- Wetting angles

PLANNED TUTORIAL SCHEDULE

1. DIMENTIONAL ANALYSIS AND PI THEOREM - 21/OCT/2020

- Pi theorem – physical meaning and significance
- Examples of usage in Pi theorem and Dimensional analysis

2. VISCOSITY AND SHEAR STRESS IN FLUIDS - 28/OCT/2020

- Definition of shear stress in fluids
- Examples of force and moments analysis due to shear stress

3. INTEGRAL MASS CONSERVATION - 4/NOV/2020

- Steady state mass conservation
- Time dependent mass conservation

4. INTEGRAM MOMNETUM CONSERVATION - 11/NOV/2020

- Example for Drag calculation using mass and momentum conservation equations
- Solve a case of a time dependent mass conservation in accelerating system

5. KINEMATICS - 18/NOV/2020

- Examples for streamlines, sreaklines and pathlines
- Lagrangian and Eulerian specification of properties

6. HYDROSTATICS - 25/NOV/2020

- Force diagram on bodies submerged in a fluid
- Hydrostatic pressure, forces, and moments in rotating systems

7. VISCOUS FLOW – PART (A) - 2/DEC/2020

- Shear flow examples
- Flow field calculation in a cylindrical coordinate system

8. VISCOUS FLOW – PART (B) - 9/DEC/2020

- Stokes - drag on a sphere
- Viscous films

9. BERNOULLI EQUATION - 23/DEC/2020

- Different usages of Bernoulli equation in fluid mechanics

10. POTENTIAL FLOW – PART (A) - 30/DEC/2020

- Mirroring and superposition
- Streamfunctions

11. POTENTIAL FLOW – PART (B) - 6/JAN/2021

- Drag force and moments on bodies in potential flow
- Effects of flow separation

12. BOUNDARY LAYER - 13/JAN/2021

- Use Blasius solution to calculate forces acting or a flat plate.
- Laminar Jet example.

13. SIMILARITY - 20/JAN/2021

- Examples of similarities in fluid mechanics

BOOKS AND RELEVANT LINKS

BOOKS

- Fox and Mc Donald, Introduction to Fluid Mechanics, JohnWiley.
- Frank M. White, Fluid Mechanics, McGraw Hill.
- G.K. Batchelor, An Introduction to Fluid Dynamics, Cambridge Mathematical Library.
- L.D. Landau and E.M. Lifshitz, Fluid Mechanics, Pergamon Press.
- P.K. Kundu and I.M. Cohen, Fluid Mechanics, Academic Press.

RELATED VIDEOS

- Shapiro's collection of Fluid Mechanics movies, available on MIT's website: http://web.mit.edu/hml/ncfmf.html
- Galleries of fluid motion: http://pof.aip.org/gallery_of_fluid_motion, http://www.aps.org/units/dfd/gallery/index.cfm
- Milton van Dyke, An Album of Fluid Motion, Parabolic Press.

LECTURES

- Prof. Haber lectures: http://video.technion.ac.il/Courses/Zrima1.html
- Course notes from University of Kentucky: http://www.engr.uky.edu/~acfd/me330-lctrs.pdf
- Yale University: lecture on statics and Bernoulli's equation: http://www.youtube.com/watch?v=lfXDJKKPGfY

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