Subject Guide – Fluid Mechanics for Simulation and Design

Shortened Name	FMSD	**Semester**	1-2023
Class Time (weekly)	Mon, 9-12	**Lecture hours**	3h x 15w
Subject Code	090125103	**Assignment and self-study**	5h x 15w
ECTS credits	6	**Preparation for exam**	30
KMUTNB Credits	3(3-0-6)	**Total working hours/semester**	150

1 Revision date of this document, reasons for revision

- 07.08.2023, start of semester

2 Course description

Fluid kinematics; Continuity equation; Bernoulli equation; Energy equation; Momentum analysis of flow systems; Dimensional analysis and modeling; Internal flow; Differential analysis of fluid flow; Approximate solution of the Navier-Stokes equation; External flow; Compressible flow; Turbomachinery; Interaction between fluid flow, heat transfer and thermodynamics. Students will also take part in a research seminar.

3 Lecturer

- Assoc. Prof. Dr. Ekachai Juntasaro

4 Expected learning outcomes (in accordance with the MAE program ELOs)

Primary LOs (primary content of class, knowledge is explicitly evaluated (for example, by exams), larger share of overall grade)

- Ability to define a technical task or problem, to analyze/structure it and formulate a strategy to solve it (GELO 1)
- Knowledge and understanding of scientific fundamentals relevant for the understanding of the behavior of fluids in engineering applications (SELO 2)

Secondary LOs (not primary content of class, but implicitly taught and evaluated by application (for example, by project work or assignments), lower share of overall grade)

- Ability to independently conduct a literature study on a given topic, identify and acquire relevant sources, extract and sum up the essence in writing (GELO 5)
- Ability to present a project in front of a professional audience (GELO 6)

Note: These ELOs correspond to the Program ELOs (referenced in parentheses).

5 Assessment

Each student will be individually assessed based on the performance on written exams and seminar, with the overall grade resulting from the shares in the table below:

Evaluated items	**shares**
Midterm exam, 180 minutes, in content of "**Chapters 4, 5, 6, 7, 8**" of the class	40%
Final exam, 180 minutes, in content of "**Chapters 9, 10, 11, 12, 14**" of the class	40%
Seminar: 30-minute presentation of current research interest	20%
Total	**100%**

- Both exams are closed-book and paper-based
- Each student has to propose one journal paper (to be presented in seminar) for approval by week 9.

6 Teaching materials

- Power-point presentation of each lecture is handed over (after the class) as reference
- E-books are provided by email before the first day of the class
- The links of relevant VDOs from youtube are also given

7 Books and references

1) *Fluid Mechanics: Fundamentals and Applications* by Yunus A. Cengel and John M. Cimbala (Latest Edition), McGraw-Hill. **(MAIN TEXTBOOK)**
2) *Fundamentals of Fluid Mechanics* by Bruce R. Munson, Donald F. Young, and Theodore H. Okiishi (Latest Edition), John Wiley & Sons.
3) *Fluid Mechanics* by Frank M. White (Latest Edition), McGraw-Hill.

The books of items 2 & 3 are not required to take part in the course but recommended as background reading.

8 Course schedule

Week	Date/Month	Activity, Class Title (Book Chapter)	Evalu-ation %	Class Hours
1	07/08	Course Introduction; Fluid Kinematics (Ch 4)		3
2	21/08	Fluid Kinematics (Ch 4); Mass, Bernoulli and Energy Equations (Ch 5)		3
3	28/08	Mass, Bernoulli and Energy Equations (Ch 5); Momentum Analysis of Flow Systems (Ch 6)		3
4	**Wed** 30/08	Momentum Analysis of Flow Systems (Ch 6); Dimensional Analysis and Modeling (Ch 7)		3
5	18/09	Dimensional Analysis and Modeling (Ch 7); Internal Flow (Ch 8)		3
6	**Wed** 20/09	Internal Flow (Ch 8); Introduction to Turbulence Modelling		3
7	25/09	Differential Analysis of Fluid Flow (Ch 9)		3
8	02/10	**** Midterm Examination (Ch 4, 5, 6, 7, 8) **** 9.00-12.00 hrs, Room 1104	40%	3
9	09/10	Differential Analysis of Fluid Flow (Ch 9); Approximate Solutions of the Navier-Stokes Eq. (Ch 10)		3
10	16/10	Approximate Solutions of the Navier-Stokes Eq. (Ch 10); External Flow: Drag and Lift (Ch 11)		3
11	30/10	External Flow: Drag and Lift (Ch 11); Compressible Flow (Ch 12)		3
12	06/11	Compressible Flow (Ch 12)		3
13	13/11	Compressible Flow (Ch 12); Turbomachinery (Ch 14)		3
14	20/11	Turbomachinery (Ch 14)		3
15	27/11	Turbomachinery (Ch 14)		3
16	04/12	**** Final Examination (Ch 9, 10, 11, 12, 14) **** 9.00-12.00 hrs, Room 1104	40%	3
17	**Wed** 06/12	**** Seminar **** 9.00-12.00 hrs, Room 1104	20%	3
		Sum	100%	45

9 Content details

Chapter	Title	Lesson (L) Contents
4	Fluid Kinematics (Ch 4)	• Lagrangian and Eulerian descriptions • Other kinematic descriptions • Vorticity and rotationality • Reynolds transport theorem
5	Mass, Bernoulli and Energy Equations (Ch 5)	• Conservation law of mass • Bernoulli equation • Energy equation
6	Momentum Analysis of Flow Systems (Ch 6)	• Newton's laws • Choosing a control volume • Forces acting on a control volume • Linear momentum equation • Angular momentum equation
7	Dimensional Analysis and Modeling (Ch 7)	• Dimensions and units • Dimensional analysis and similarity • Method of repeating variables • Buckingham pi theorem
8	Internal Flow (Ch 8)	• Laminar and turbulent flows • Entrance region • Laminar flow in pipes • Turbulent flow in pipes
9	Differential Analysis of Fluid Flow (Ch 9)	• Continuity equation (conservation of mass) • Stream function • Cauchy equation (differential eq. of linear momentum) • Navier-Stokes equation • Differential analysis of fluid flow problems
10	Approximate Solutions of the Navier-Stokes Equation (Ch 10)	• Non-dimensionalized equation of motion • Creeping flow approximation • Approximation for inviscid regions of flow • Irrotational flow approximation • Boundary layer approximation
11	External Flow: Drag and Lift (Ch 11)	• Drag and lift • Friction and pressure drag • Parallel flow over flat plates • Flow over cylinders and spheres • Lift
12	Compressible Flow (Ch 12)	• Stagnation properties • One-dimensional isentropic flow • Isentropic flow through nozzles • Shock waves and expansion waves
14	Turbomachinery (Ch 14)	• Pumps • Pump scaling laws • Turbines • Turbine scaling laws

10 Details on Evaluation of Expected Learning Outcomes

		Midterm Exam	Final Exam	Seminar			
				Quality of Paper	Quality of Slides	Presen-tation	
		40%	40%	5%	10%	5%	
GELO1	Ability to define a design task or problem, to analyze/structure it and formulate a strategy to solve it	20.0%	20.0%				**40%**
SELO2	Knowledge and understanding of scientific fundamentals relevant for the understanding of the behavior of fluids in engineering applications	20.0%	20.0%				**40%**
GELO5	Ability to independently conduct a literature study on a given topic, identify and acquire relevant sources, extract and sum up the essence in writing			5.0%	10.0%		**15%**
GELO6	Ability to present a project in front of a professional audience					5.0%	**5%**