Subject Description Form

Subject Code	ME46003
Subject Title	Numerical Fluid Mechanics and Heat Transfer
Credit Value	3
Level	4
Pre-requisite/ Co-requisite/ Exclusion	Pre-requisite: ME34003 Thermofluid Mechanics
Objectives	To equip students with numerical methods and computational techniques in analyzing fluid dynamics and heat transfer problems which are usually encountered in the design of thermofluid systems.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Understand and apply numerical differentiation method, and analyze the stability and errors involved. b. Apply knowledge of thermofluid science/engineering to formulate numerical equations for solving steady-state/transient fluid mechanics or heat transfer problems, and apply appropriate mathematics methods for their evaluation. c. Apply knowledge of mathematics and thermofluid science/engineering via computational approaches to analyze and predict the performance of thermofluid systems/products.
Subject Synopsis/ Indicative Syllabus	***Introduction to Numerical Methods for Product Analysis*** – Mathematical modeling for fluid mechanics and heat transfer systems. Numerical approximations of scientific equations. Direct and iterative methods for solving simultaneous equations. Stability and major errors involved in numerical methods. ***Numerical Differentiation*** – Finite-differences for the first derivative and the second derivative. Finite-differences for partial differentiation. High-accuracy differentiation formulas. ***Finite-Difference Methods in Solving Heat Transfer Problems*** – Governing equations for heat transfer. Boundary conditions in heat conduction and heat convection. Steady-state and transient heat transfer problems. Dimensionless differential equations. Discretization. Explicit scheme finite-difference. Implicit scheme finite-difference. Direct and iterative mathematics methods. Analysis on solution stability and estimation of errors.

Finite-Difference Methods in Solving Fluid Dynamics Problems – Classification of partial differential equations for fluid dynamics. Navier-Stokes equations. Grid types. Explicit and implicit scheme finite-difference formulations. Introduction to turbulence and its modeling.

Introduction to computational approach – Introduction to commercial CFD software and their applications to solve fluid mechanics problems.

Teaching/Learning Methodology

1. The lectures are aimed at providing students with necessary background knowledge in related mathematical principles and computational approaches for analysis of thermofluid problems. (Outcomes a to c)

2. The tutorials and in-class exercises are aimed at enhancing the students' skills in effectively using numerical and computational approaches to solve thermofluid problems. Thus, some tutorial classes will be held in the Computational Laboratory. (Outcomes a to c)

3. The homework assignments are to get students engaged with learning activities continuously and to provide them with self-assessment opportunities on their progress of learning. (Outcomes a to c)

Teaching/Learning Methodology	Outcomes		
	a	b	c
Lecture	√	√	√
Tutorials/In-class exercises	√	√	√
Homework assignments	√	√	√

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed		
		a	b	c
1. Homework assignments/ In-class exercises	30%	√	√	√
2. Test	20%	√	√	√
3. End-of-semester Examination	50%	√	√	√
Total	100%	√	√	√

Assessment Methods in Alignment with Intended Learning Outcomes	Explanation of the appropriateness of the assessment methods in assessing the intended learning outcomes: Overall Assessment: 0.5 × Continuous Assessment + 0.5 × Examination. 1. Homework assignments and in-class exercises are aimed at evaluating students' progress in study, and assisting them in fulfilling the respective subject learning outcomes. Homework assignments and in-class exercises should include analyses of thermofluid systems, case-study of problems encountered in thermofluid design, and applications of computational technique (including CFD software) to solve thermofluid problems. 2. Test and end-of-semester examination will be used to assess the degree of achieving the subject learning outcomes by individual student. Their understanding of numerical methods and ability to apply them to critically analyze thermofluid problems will be evaluated.	
Student Study Effort Expected	Class contact:	**Time**
	▪ Lectures	26 Hrs.
	▪ Tutorials/In-class Exercises	13 Hrs.
	Other student study effort:	**Time**
	▪ Performing assignments including computational work	50 Hrs.
	▪ Self-study	31 Hrs.
	Total student study effort	120 Hrs.
Reading List and References	1. S.C. Chapra and R.R. Canale, Numerical Methods for Engineers, McGraw-Hill, latest edition 2. S.S. Rao, applied Numerical Methods for Engineers and Scientists, Prentice-Hall, latest edition 3. A. Cengel Yunus, and J. Ghajar Afshin, Heat and Mass Transfer-Fundamentals and Applications, 4th edition in SI units, McGraw-Hill, 2011. 4. H. K. Versteeg and W. Malalasekera, An Introduction to Computational Fluid Dynamics, 2nd edition, Pearson Prentice Hall 2007.	

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