課程綱要與教學進度

108 (2019) 學年度第 2 學期

課程名稱:(中文)偏微分方程與多重物理耦合模擬					開課單	單位	光電戶	ŕ	
(英文) PDE	英文) PDEs and Multihysics Coupling Simulations					果號			
· 必要要在· 生力· 生 June V Hugen (http://www.inhugen.idu.tw)									
投課教師・寅平垚 Jung Y. Huang (<u>http://www.jynuang.idv.tw</u>)									
學分數 3		必/選修 選修		開課年級		研究所	ŕ		
先修科目或先備能力:應用數學或工程數學									
課程概述與目標: Equiping with wide-spreading cloud computing resources and ever-increasing computing power, scientists and engineers are getting used to take a computational approach to solve their facing problems. Unfortunately, this approach to a new subject often faces a dilemma, where the governing equations and constitutive relations involved are esoteric and difficult to unravel. It is especially true for a problem involving multiple physics processes. This course (Partial Differential Equations and Multihysics Coupling Simulations 偏微分方程與多重物理耦合模擬) comes to provide a training by introducing the core knowledge and some hand-on experiences to students and preparing them with an ability to face this dilemma. After completion of the course, the students will be able to grasp the appropriate governing equations for a problem, can discover relevant constitutive relations for the simulation, and perform successful simulations on classic examples of multiple physics coupling systems. 教科書 NA but will be announced in the near future. Lecture notes will be timely posted on http://www.jyhuang.idv.tw/PDEs&MultiPhySim.html . Workshop examples will be demonstrated on either Malab FEATool_Multiphysics_APP or COMSOL_Multiphysics . Install an appropriate FEM package on your									
	recommende	d.							
課程大綱					分配日	借註			
單元主題		內容綱要		講授	示範	習作	其他 ¹	177	
1. Intro. to Partial Differential Equations (PDEs)	1.1 Conservations equations of n 1.2 Typical ph 1.3 Classificat 1.4 Initial con conditions (BC	ion laws for g nultiphysics s nysics-related ion of PDEs ditions (ICs) Cs)	governing imulations PDEs and boundary	4 hrs					
2. Methodology to Discover Approximate Solution of PDEs	 2.1 Solve PDF 2.2 Finite elem 2.3 Weak form 2.4 Basic step Discretization Selection of the Galerkin form equations for the algebraic of Solve the system efficiently. Workshop 1: and Helmholtz 	Es approxima nent method n of PDEs s to solve PD of the contin ne shape func ulation of the one element; equations for em of algebra Solving Pois z equation in	tely (FEM) Es with FEM: a) uum; b) tions; c) e algebraic d) Assembling all elements; e) aic equations eson equation FEATool.	4 hrs	2 hrs				

3. Governing Equations of Mechanical Deformation and Heat Transfer in Solids	 3.1 Concept of representative volume element (RVE) 3.2 Generic conserved quantity in unit mass and the associated flux 3.3 Governing equation, auxiliary relation and boundary conditions for heat transfer process 3.4 Displacement changes, strain, and stress in a solid under loading 3.5 Navier equation and constitutive relationship of solid deformation Workshop 2: Heat transfer in a ceramic strip 		2 hrs		
4. Fluid Mechanics	 4.1 Flow-induced spatial variations of fluidic properties 4.2 Flow types: a) compressible and incompressible fluids, b) inviscid, Newtonian, and Non-Newtonian fluids, c) Laminar and turbulent flow 4.3 Governing equations of fluid mechanics based on mass and momentum balance in a moving medium 4.4 Governing equations for some specialized flows a) viscous flow of Newtonian fluid, b) Stokes flow, and c) inviscid flow Workshop 3: Simulation of incompressible 2D 	4 hrs	2 hrs		
	Laminar now with Navier-Stokes equations				
5. Electrostatics and Magnetostatics	 5.1 Governing equation and boundary conditions of electrostatic phenomena using electric potential as dependent field variable 5.2 Constitutive relationship of a material in an electric field 5.3 Governing equation of magnetostatics 5.4 Constitutive relationship for a material in a magnetic field 	4 hrs	2 hrs		
	permanent U-shaped magnet		2 111 5		
6. Special Topics on Mutiphysics Coupling: Chemical Reaction Flow System	 6.1 Concept of chemical field and its relation with concentrations of chemical species 6.2 The mass balance principle of chemical species in a chemical reaction system 6.3 Energy/mass transport equations with source terms resulting from chemical reactions Workshop 5: A microreactor device design by coupling Laminar flow of reactants through a 	3 hrs	2 hrs		
	catalyst bed				
7. Special Topics on Mutiphysics Coupling: Electro-Thermo Effect	 7.1 Mechanisms of Joule heating and dielectric heating 7.2 Governing equation of electro-thermal effect for a dielectric in electromagnetic fields. 7.3 Boundary conditions 	3 hrs	2 hrs		
	actuator		- 110		

8. Special Topics on Mutiphysics Coupling: Fluid-Solid Structure Interaction	 8.1 Governing equation for the fluid subsystem 8.2 Governing equation for the deformable solid 8.3 Velocity/Displacement matching and momentum matching at the interface of fluid and solid subsystems Workshop 7: Fluid-structure interaction for a Laminar flow across a soft structure 	3 hrs	2 hrs		
9. Special Topics on Mutiphysics Coupling: Strain- Electrostatic Effect	 9.1 Mechanisms of piezoelectric/piezoresistive effects 9.2 Constitutive relationships of a solid in an electrostatic field 9.3 Governing equation of a solid with strainelectrostatic coupling 9.4 Boundary conditions Workshop 8: Simulation on a piezoelectric energy harvester 	4 hrs	2 hrs		
10. Special Topics on Mutiphysics Coupling: Electromagneti c Wave Propagation in Medium	 10.1 Mechanism of material responses to electromagnetic waves 10.2 Constitutive relationship of material responses 10.3 Governing equations of wave propagation in a medium 10.4 Initial conditions and boundary conditions for electromagnetic wave propagation in medium Workshop 9: To be announced 	3 hrs	2 hrs		

教學要點概述									
1 學期作業: 3 homeworks, and 1 project to study one out of several topics in the application									
of the course content.									
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2.考試狀況		C* 1							
No quizzes or final exam.									
3.評量方法	3.評量方法								
3 homewor	ks (6	50%), and	d 1 project (40%).						
4.教學方法	- 及孝	文學相關	配合事項(如網站	、助教、「	圖書講義及資料。	庫等)			
Lecture not	es w	ill be tin	nely posted on http:	//www.jył	huang.idv.tw/PDF	Es&MultiPhySim.html.			
師生晤談		排定時	問	tett.	聖上				
(Office		17F / C P 1	10]		μ. Mu				
Hours)		3:00-6:	:00 pm Every			ivhuang@faculty.nctu.edu.			
		Friday	00 pm 2			<u>t</u> w			
教學進度表	Ę	<u> </u>							
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週次	上書	果日期	課程進度、內容	、主題					
1,2			Introduction to Partial Differential Equations (PDEs)						
3,4			Methodology for Finding Approximate Solution of PDEs						
4,5			Governing Equations of Mechanical Deformation and Heat Transfer in						
		I	Solids						
5,6			Fluid Mechanics						
7,8			Electrostatics and Magnetostatics						
9			Chemical Reaction Phenomena						
10,11			Special Topics on Mutiphysics Coupling: Electro-Thermo Effect						
12,13			Special Topics on Mutiphysics Coupling: Fluid-Structure Interaction						
14			Special Topics on Mutiphysics Coupling: Strain- Electrostatic Effect						
15	15 Special Topics on Mutiphysics Coupling: Flow-Electrochemical Coupled								
Processes									
16			Student Project Presentation Session 1						
17	7 Student Project Presentation Session 2								

備註:

1.其他欄包含參訪、專題演講等活動。2. 請同學遵守智慧財產權觀念及勿使 用非法影印教科書。