A two-day course on

UNIFIED FORMULATION APPLIED TO COMPOSITE STRUCTURES AND FINITE ELEMENT METHOD: Plates, Shells and Beams, including Component-Wise Approach

21-22 June 2012
A postconference course presented during the
The first International Conference on Mechanics of Nano, Micro and Macro Composite Structures (http://paginas.fe.up.pt/ icnmmcs)
18-20 June 2012 Politecnico di Torino, Italy

by
Erasmo Carrera, Maria Cinefra and Marco Petrolo
Politecnico di Torino, Italy, (www.mul2.com)

Background

Over the last few decades, computational methods, in particular the Finite Element Method, have made the use of classical structural theories much more successful and attractive. The possibility of solving complex structures with very different boundary conditions (mechanical and geometrical) has made it possible to analyze many complex problems involving thousands of degrees of freedom (DOFs) with acceptable accuracy. However, the difficulty of obtaining a complete stress/strain field remains an open issue in several cases (e.g. sandwich structures, thin-walled structures and multifield interaction problems). In this cases refined and advanced theories must be used.
Professor Carrera has recently proposed the Unified Formulation (CUF) for plates, shells and beams. CUF can deal with a large number of structural theories with a variable number of displacement unknowns by means of a concise notation and by referring to a few fundamental nuclei. Higher-order plate/shell/beam theories can be easily implemented on the basis of CUF, the number of the unknown variables is a free parameter of the problem. A three-dimensional stress/strain field can be obtained by an appropriate choice of these variables for a wide class of structural problems, including composites, thin-walled structures and multifield problems.

Course Objectives

This course is aimed at providing researchers and engineers with the concepts and the theory of CUF. The Unified Formulation will be presented by means of its theoretical formulations and applications. Also, the very last extension of CUF - the so-called Component-Wise approach - will be presented. Particular attention will be given to the following topics:

1. Basics on classical theories for laminated composites. Refined theories, Zig-Zag models, Layer-Wise kinematics and mixed approaches.
2. The unified formulation for 1D models.
3. The unified formulation for plates.
4. The unified formulation for shells.
5. The finite element method and CUF.
6. Numerical examples via MUL2 softwares.

The participants of the course must have a background in mechanics of materials and structures as well as basics of the finite element method.

Course Outline
Day 1, June 21

1. Basics on classical and refined for laminated composites (2h).
2. The unified formulation for 1D models (2h).
3. The unified formulation for plates (2h).
4. The unified formulation for shells (2h).

Day 2, June 22

1. The finite element method and CUF (4h).
2. Numerical examples via MUL2 softwares (4h).

Course Material
Much of the material for the course will come from these books: *Beam Structures: Classical and Advanced Theories* by E. Carrera, G. Giunta and M. Petrolo (John Wiley & Sons Ltd., 2011); *Plates and Shells for Smart Structures: Classical and Advanced Theories for Modeling and Analysis* by E. Carrera, S. Brischetto and P. Nali (John Wiley & Sons Ltd., 2011). However, they will not be included as the course material. A copy of all overheads used in the course will be distributed to the participants.

About the Instructors
Erasmo Carrera is Professor of *Aerospace Structures* at the Politecnico di Torino. His main research topics are: composite materials, finite elements, beams, plates and shells, postbuckling and stability, smart structures, thermal stress, aeroelasticity, multibody dynamics, and the design and analysis of non-classical lifting systems. He is author of more than 350 articles and books on these topics, many of which have been published in international journals. He serves as referee for international journals and as a contributing editor for Mechanics of Advanced Materials and Structures, Composite Structures, Journal of Thermal Stress, Computer and Structures and International Journal of Aeronautical and Space Sciences.
Maria Cinefra is Research Assistant at the Politecnico di Torino. She earned a PhD in aerospace structures from a joint doctoral program between Politecnico di Torino and the University of Paris Ouest Nanterre. Her PhD thesis dealt with the thermo-mechanical design of multi-layered plates and shell embedding FGM layers. She is teaching assistant for the courses of *Non-linear analysis of structures* and *Structures for space vehicles*.
Marco Petrolo is Research Assistant at the Politecnico di Torino. He earned a PhD in fluid dynamics at Politecnico di Torino, his thesis dealt with refined structural models for aeroelastic problems. He is teaching assistant for the courses of *Aeroelasticity* and *Structural Mechanics*. Marco currently works on the development of refined models for composite structures and multiscale problems.