ELENCO DEI CORSI DELLA SCUOLA DI DOTTORATO DEL POLITECNICO DI BARI EROGATI PER IL XXXVIII CICLO BANDO n. 2 (A. A. 2022-2023)

Il Consiglio della Scuola all'unanimità ha deliberato in data 14/07/2022 di ribandire per l'A. A. 2022-2023 **diciassette corsi non assegnati** nel precedente bando (corsi n. 4, 7, 8, 14, 17, 20, 31, 33, 34, 35, 36, 37, 45, 47, 52, 53, 54) e i **cinque corsi addizionali** qui elencati con il corrispondente syllabus, per un **totale di ventidue corsi**:

4) Numerical Methods for Ordinary Differential Equations. MAT/08, 2 CFU.

The course shall address the numerical solution of ordinary differential equations concerning theoretical description of numerical methods and their implementation.

Syllabus:

Finite difference approximation of derivatives.

One-step methods.

Linear multistep methods.

Stability and convergence issues of linear multistep methods.

Runge-Kutta methods.

Stiff equations and A-stability.

Collocation methods.

Boundary value problems.

17) Multidisciplinary Research Applications of Extrusion Based 3D Printing. ING-IND/16, 2 CFU.

The course shall address the various research applications of Fused Filament 3D Printing with non-conventional materials, also through a theoretical study of the process.

Syllabus:

1) 3D Printing processes and materials according to ISO/ASTM 52900
2) Fused Filament Fabrication analytical models
3) Latest research applications of filament extrusion and polymerization processes

a. 3D printed microfluidics
b. 3D printed sensors
c. 3D printed actuators

33) Residual stress evaluation by X-ray diffractometry. ING-IND/14, 2 CFU.

Rationale

Almost every manufacturing process creates residual stresses notably by casting, welding and forming. However, despite their widespread occurrence, the fact that residual stresses occur without any external loads makes them easy to overlook and ignore.

Modern residual stress measurement practice is largely based on the early historical roots. However, the modern techniques have attained a very high degree of sophistication due to greatly increased conceptual understanding, practical experience and much more advanced measurement/computation capabilities.

The X-ray diffraction method provide the possibility for non-destructive procedures to measure residual stresses. "Non-destructive" implies that the component may be returned to service after the residual stresses are measured and the stress fields evaluated. Furthermore, the measure is rather cheap and fast. Due to these advantages, this method became the most widespread in the evaluation of the residual stresses in mechanical and aeronautical field.

The course aims to provide the students with the foundations of measure of RS by x-ray diffraction. To acquire basic skills on x-ray diffraction. To learn the main problems and possible causes of error. At the end of the course, the student must be able to implement the measure of RS by x-ray diffraction, critically evaluate the results obtained and know how to expose them through the proper drafting of a technical report.
Program
1. Introduction 2. Principles 3. Measurement of Lattice Strain 4. Analysis of Regular $d_{\varphi\psi}$ vs. $\sin^2\psi$ 5. Calculation of the stress 6. Effect of the Sample microstructure 7. Apparatus 8. XRD Depth Profiling Using Successive Material Removal 9. Measurement Procedure 10. Examples and practical consideration 11. Laboratory.

35) Dynamical systems theory and applications to fluid machinery and energy production. ING-IND/08, 2 CFU.

1. Introduction
General examples and classification of systems. Phase space and trajectories.
2. First order systems
2.1 THEORY
Fixed points and linear stability analysis. Potentials. Bifurcations: saddle-node, transcritical, pitchfork, supercritical/subcritical, imperfect bifurcation and catastrophes. Bifurcation diagrams.
2.2 APPLICATIONS (with matlab)
One-mass models of wind turbines. Simple models for room heating and hydraulic reservoirs and pumps.
3. Second order systems
3.1 THEORY
3.1.1 Linear systems
Phase portraits. Lyapunov stability (global and asymptotical stability). Classification of linear systems: stable nodes, unstable nodes, saddles, centers, stable and unstable spirals, non isolated fixed points.
3.1.2 Nonlinear systems
Equilibrium points and linearization. Phase portraits: fixed points, periodic orbits, homoclinic and heteroclinic orbits. Conservative systems, reversible systems. Stable and unstable limit cycles. Lyapunov functions. Bifurcations: supercritical/subcritical Hopf bifurcation, saddle-node bifurcation of limit cycle, infinite period bifurcation, homoclinic bifurcation. Hysteresis. Poincaré maps.
3.2 APPLICATIONS (with matlab)
The surge in turbomachinery. The Van-der-Pol oscillator model. Controlling the Van-der-Pol limit cycle. Inertial and non-inertial power control.
4. Third order systems
4.1 THEORY
Lorenz equations and properties. Lorenz map. Strange attractors. Chaos and metastable chaos. Lyapunov exponents. Universality: qualitative and quantitative. Fractals. Rossler systems.
4.2 APPLICATIONS (with matlab)
The Doubly-fed wind turbine model: the wind turbine mechanical system, pitch control, yaw control, active power control.
5. Order n and infinite dimensions systems
5.1 : THEORY
Fixed points and limit cycles in an infinite dimensions system. Example of bifurcations.
Bifurcations in fluid dynamics. Concept of edge of chaos. Dual systems and adjoints.
5.2 : APPLICATIONS (with matlab):
Thermoacoustic instability in combustors and their control: limit cycles and their bifurcation towards turbulence, sensitivity of the system, triggering, direct-adjoint optimization and control.

Instability and transition to turbulence in flows in pipes and implications for energy saving and production.

A.1 AN INTRODUCTION TO FINITE ELASTICITY, ICAR/08, 2 CFU

Tensor algebra & analysis.

Kinematics.

Non Linear Elastic Deformations. Polar Decomposition of the Deformation Gradient

Internal constraints. Fiber Reinfoced Bodies.

Balance Laws, Stress.

Cauchy & Piola Kirchhoff stress tensor.

Elasticity.

Simple Materials. Cauchy Elastic Material. Green Elastic Material.

Change in Observer. Invariance of Material Response.

Symmety transformation and symmetry group. Anisotropic Elastic Solids, Transversely Isotropic & Isotropic Elastic Solid.

Internal constraints. Residual Stress.

Boundary Value Problems.

Constitutive Inequalities. Ellipticity conditions.

Hyperelastic bodies.

Incremental Elastic Deformations.

A.3 ZERO-ENERGY BUILDINGS MULTI ENERGY SYSTEMS INCLUDING HYDRO, WIND, SOLAR, AND HYDROGEN, ING-IND/10, 2 CFU

Course Summary

Zero energy buildings combine energy efficiency measures and renewable energy generation to consume only as much energy as can be produced onsite through renewable resources over a specified time period. This course aims to discuss how to address the energy issues in net-zero energy buildings (ZEB), using multicarrier energy systems with hydro-wind-solar-hydrogen-methane-carbon dioxide-thermal energies. The course aims to present approaches and solutions to make possible the evolution of the building sector away from a carbon-based (and GHG-intensive) approach. Multiple solutions will be investigated from traditional renewable hydro-wind-solar energy sources to new technologies such as fully-electrical systems or hydrogen-based systems. The course aims to present solutions for minimizing the released CO_2 to the atmosphere due to buildings and in doing this, it will teach approaches to increase the energy resilience within the built environment.

Course objectives and intended learning outcomes

At the end of this course, students will be able to:

1. Assess the energy demand of buildings and to discuss strategies to achieve net-zero targets
2. Carry out the design of multiple building renewable energy systems, including photovoltaics and solar thermal systems.
3. Design multi-source smart renewable energy resources for buildings
4. Calculate the carbon and energy balance of building HVAC systems and compare them within a life cycle approach
5. Design and size fuel cells and electrolyzers to explore opportunities and challenges of hydrogen-ready buildings
6. Calculate the emission factors of different energy systems and their respective trade offs