“Mathematical modelling in mechanics – selected topics”

Lecturer: Jacek Pozorski (IMP PAN)

Description

The aim of the lecture series is to present selected methods and mathematical models of contemporary use in mechanics, with some emphasis on fluid dynamics. There is obviously a vast collection of math tools applicable for various problems, so a choice has been made towards some useful methods that are usually not presented during a first course in solid or fluid mechanics. They include the multiscale modelling ideas applied to problems involving a range of characteristic scales, in particular length (for physical/mechanical systems) and/or time (for phenomena/processes). Techniques of averaging (homogenisation) will be introduced, the deterministic and stochastic descriptions will be presented. The application examples include flow turbulence, microfluidics, porous and granular media, continua with microstructure. Also, a handful of simple, yet powerful mathematical methods of wider interest will be shown, including non-dimensionalisation, asymptotic expansions and perturbation methods. Several examples will be worked out during the lectures, and some more left as exercises to illustrate particular methods and techniques.

Target audience, prerequisites

The course will be of interest for PhD candidates who wish to get a better understanding and, whenever possible, a unifying view of mathematical models that are applied to problems of theoretical and applied mechanics. The selection of topics is meant, in particular, for those students (graduating in mechanical, civil, chemical and process engineering, applied physics) whose doctoral projects include a computational component.

The prerequisites for a successful follow-up of the lecture material are: a good understanding of fundamental mechanical phenomena (at least first courses in solid and fluid mechanics), a working knowledge of mathematical analysis and calculus, basic notions about differential equations and essential numerical methods, all taught at the Master of Engineering level.

Projekt „Centrum Studiów Zaawansowanych - rozwój interdyscyplinarnych studiów doktoranckich na Politechnice Gdańskiej w obszarach kluczowych w kontekście celów Strategii Europa 2020” jest współfinansowany przez Unię Europejską w ramach Europejskiego Funduszu Społecznego

Topics to be covered

Review of mathematical preliminaries: series expansions, tensor calculus, ordinary differential equations *(3 h)*

Generally useful tools: non-dimensionalisation, asymptotics, perturbation methods *(3 h)*

Multiscale problems - examples from physics and engineering: dynamical systems, flow and heat transfer in porous/granular media, continua with microstructure, composite materials, multiphase flows, microfluidics *(3 h)*

Multiscale methods: levels of description, averaging and homogenization techniques, issues in stochastic systems (fast variable elimination, maximum entropy principle) *(3 h)*

Fluid mechanics: self-similarity concept (boundary layers and free shear flows), hybrid continuum-particle models, deterministic and stochastic approaches for flow turbulence *(3 h)*

Selected literature

Derosa P., Cagin T. (2010) *Multiscale modeling: from atoms to devices*. CRC Press.

Fowler A.C. (1997) *Mathematical models in the applied sciences*. Cambridge Univ. Press.

Gardiner C.W. (2004) *Handbook of stochastic methods for physics, chemistry and natural sciences*. Springer.

Howison P. (2005) *Practical applied mathematics: modelling, analysis, approximation*. Cambridge Univ. Press.

Pavliotis G.A., Stuart A.M. (2008) *Multiscale methods: averaging and homogenization*. Springer.

Pope S.B. (2000) *Turbulent flows*. Cambridge Univ. Press.

Tabeling P. (2009) *Introduction to microfluidics*. Oxford Univ. Press.

TERMIN WYKŁADU			
Data	**Dzień tygodnia**	**Godzina**	**Sala**
2015-03-16	Pn	12.15-15.00	GG 300
2015-03-23	Pn	12.15-15.00	Mech 303
2015-03-25	Śr	12.15-15.00	Mech 303
2015-03-30	Pn	12.15-15.00	Mech 303
2015-03-31	Wt	12.15-15.00	Mech 303

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