Course title:	Computational methods
Institute/Division:	Institute of Physics, Faculty of Materials Engineering and Physics
Number of contact hours:	45 hours
Course duration:	1 semester
ECTS credits:	3

Course description:
This course is designed to give an overview of basic computational techniques that may be of interest to a physicist involved in computational research (simulation of physical and engineering processes governed by equations that cannot be solved using analytical methods). Discussed are also techniques of performing lengthy symbolic computations important not only in theoretical physics but also in the phase of defining and reducing any problem to be solved. The methods and concepts are presented step-by-step and illustrated with concrete examples (such as propagation of light in inhomogeneous media or in arbitrarily curved optical fibers, etc). The presented computational routines are written mainly in Mathematica – a modern computing environment used in many branches of science and technology, however, the built in ready to use numerical procedures offered by this system are intentionally not used at all. Instead, rather than to blindly utilizing black boxes, the student is encouraged to develop a better understanding of computational algorithms and the theory behind, by preparing less complicated working computer routines anew and applying them to solving example computational tasks. Topics covered include:

- symbolic computations – tensor calculus and differential geometry
- proper choice of coordinates and transformation of equations
- computational methods originating from variational calculus
- basic numerical algorithms for ordinary and partial differential equations
- avoiding singularities in numerical computations
- shooting to a fitting point and other basic methods for singular equations
- solving nonlinear problems with solution-dependent constraints
- solving n-body problems

Literature:

- Samuel SM Wong, *Computational Methods in Physics and Engineering*, London, 1977, World Scientific
- S.E. Koonin, D.C. Meredith, *Computational Physics*, 1990, Westview Press
- W.H. Press, S.A Teukolsky, W.T. Vetterling, B.P. Flannery, *Numerical Recipes 3rd Edition. The Art of Scientific Computing*, New York, 2007, Cambridge University Press
- L.D. Landau, F.M. Lifshitz Fluid Mechanics, Oxford, 1987, Pergamon Pres

Course type:	lectures (15 hours), computer labs (30 hours)
Assessment method:	report on solved computational tasks, oral presentation (LaTeX Beamer)
Prerequisites:	elementary knowledge of algebra with geometry, mathematical analysis and mathematical methods in physics, some background in programming
Primary target group:	Computer Modelling
Lecturer:	dr hab. Łukasz Bratek, prof. PK
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