AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Module name: Nonlinear Dynamics

Academic year: 2016/2017 Code: JFI-3-404-s ECTS credits: 4

Faculty of: Physics and Applied Computer Science

Field of study: Physics Specialty: —

Study level: Third-cycle studies Form and type of study: Full-time studies

Lecture language: English Profile of education: Academic (A) Semester: 4

Course homepage: http://www.ftj.agh.edu.pl/~kulakowski/

Responsible teacher: prof. dr hab. Kułakowski Krzysztof (kulakowski@fis.agh.edu.pl)

Academic teachers:

Module summary

The lecture is intended to familiarize students with qualitative methods of analysis of nonlinear dynamics. Most of these issues concern ordinary differential equations.

Description of learning outcomes for module

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Connections with FLO	Method of learning outcomes verification (form of completion)
Skills			
M_U001	students knows numerical methods to detect chaotic effects	FI3A_U03	Execution of a project
M_U002	students knows qualitative methods of handling of nonlinear differential equations	FI3A_U01, FI3A_U02	Execution of exercises
Knowledge			
M_W001	student understands limitations of classical mechanics due to the deterministic chaos	FI3A_W01, FI3A_W02	Examination
M_W002	Student understand questions and problems formulated in terms on NL	FI3A_W01, FI3A_W02	Examination, Participation in a discussion

FLO matrix in relation to forms of classes

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Form of classes										
		Lectures	Auditorium classes	Laboratory classes	Project classes	Conversation seminar	Seminar classes	Practical classes	Fieldwork classes	Workshops	Others	E-learning
Skills												
M_U001	students knows numerical methods to detect chaotic effects	-	-	-	-	-	-	-	-	-	-	-
M_U002	students knows qualitative methods of handling of nonlinear differential equations	-	-	-	-	-	-	-	-	-	-	-
Knowledge												
M_W001	student understands limitations of classical mechanics due to the deterministic chaos	+	-	-	-	-	-	-	-	-	-	-
M_W002	Student understand questions and problems formulated in terms on NL	+	-	-	-	-	-	-	-	-	-	-

Module content

Lectures

Properties of dynamical systems described with differential or difference equations. Qualitative methods.

1. Elementary methods of analysis of 2-dimensional problems: • Stability of fixed points • Linearization, Jordan forms • Constant of motion, isoclines, phase portrait • Approximated calculation of trajectories near a fixed point
2. Selected qualitative methods: • Lyapunov function and her applications. Bounding function • Diagram Determinant-Trace • Invariant manifold • Types of fixed points • Poincare indices and their properties • Divergence test. Dulac criterion • Poincare-Bendixon theorem • Landau symbols • Resonances • Poincare theorem on linearization
3. Approximated analytical methods: • Perturbation calculus • Method of two time scales
4. Bifurcations in differential equations: • Saddle-node bifurcation • Transcritical bifurcation • Pitchfork bifurcation • Hopf bifurcation
5. Bifurcations in difference equations: • Stability of fixed points in difference equations • Bifurcations in difference equations • Period-doubling bifurcation • Logistic equation
6. Elements of symbolic dynamics: • Sharkovskii ordering • Superstable cycles • Word Lifting technique • Structural universality • Arnold tongues • Farey tree and devil staircases
7. Data analysis: • Fractal dimension • Lyapunov indices. Li-Yorke conjecture • Experiment Fermi-Pasta-Ulam • Invariant measure. Frobenius-Perron equation •

Correlation function • Bernoulli shift • Mixing • Deterministic diffusion • R/S analysis. Hurst law • Multifractals

Method of calculating the final grade
final exam (at least satisfactory, 3.0)

Prerequisites and additional requirements
Prerequisites and additional requirements not specified

Recommended literature and teaching resources
Basic literature: P. Glendinning, Stability, instability and chaos, Cambridge UP 1994

Scientific publications of module course instructors related to the topic of the module
Additional scientific publications not specified

Additional information
None

Student workload (ECTS credits balance)

Student activity form	Student workload
Preparation for classes	42 h
Participation in lectures	28 h
Realization of independently performed tasks	28 h
Summary student workload	98 h
Module ECTS credits	4 ECTS