COURSE SYLLABUS - IGF PAN

1. Course title: **Introduction to river morphodynamics**

2. Course lecturer: dr hab. Michael Nones

3. Discipline, field, year of studies: Hydrology, Geophysics, all years

4. Course character: first part (60’) monographic lecture on theory, second part (30’) practical class on examples

5. Teaching method: hybrid

6. Language: English

7. Course type and number of hours: 1 h lecture 0.5 h seminar

8. Estimated amount of student’s independent work: 3 h

9. Total workload and number of ECTS points: 1 ECTS

10. Short description and main focus of the course:
    - the sediment journey: mass, linear and surface movements
    - sediment transport in rivers: basic definitions and modes of transport
    - river patterns and bedforms

11. References, literature, online resources:
    - Geomorphological Fluid Mechanics, eds. N.J. Balmforth & A. Provenzale, Springer-Verlag Berlin Heidelberg
    - Introduction to Morphodynamics of Sedimentary Patterns. E-book edited by the University of Genova, Italy. Available at http://gup.unige.it/node/198 by clicking on “per accedere all’e book”.
    - Numerical modelling and hydraulics. E-book written by Prof. Nils Olsen of the NTNU Trondheim, Norway. Available at http://folk.ntnu.no/nilsol/tvm4155/flures6.pdf

12. Educational outcomes including PQF level 8 codes:
    Students will have a few more information on how sediments are generated and transported along rivers, what are the main patterns generally observed in nature, and what are the major factors influencing river morphology; P8U_W, P8U_U, P8S_WG,

13. Evaluation of the educational outcomes:
    Exam: a single question, multiple (4) options, one correct answer

14. Criteria to complete the course:
    100% attendance and at least 3 on the exam

COURSE SYLLABUS - IGF PAN

1. Course title: **Computer programming in geoscience applications**

2. Course lecturer: dr hab. Mariusz Majdański

3. Discipline, field, year of studies: Geophysics, IT, all years

4. Course character: monographic lecture + practical course

5. Teaching method: hybrid

6. Language: English

7. Course type and number of hours: lecture (10h), seminar (20h)

8. Estimated amount of student's independent work: 20h

9. Total workload and number of ECTS points: 3 ECTS

10. Short description and main focus of the course:
    Description: This subject is aimed at student with basic programming experience. It aims to provide students with an understanding of the role computation can play in solving problems in geoscience, especially in seismic applications. The Course format will be strongly shifted toward practical classes, and individual work with codes.

    Summary of course content:
    - Introduction to programming languages and coding in linux environment (scripts, awk)
    - Python language syntax. Python interpreter and scripts. Arithmetic operations, if statements, loops, functions
    - Algorithms: e.g. monte carlo, numerical derivation and integration
    - Introduction to inversion theory, objective functions
    - Seismic signal processing: filters, aliasing, correlation, convolution
    - Data visualization
    - Selected geophysical problems: diffusion, wave equation, ray-tracing (optical geometry), fast marching, etc.

    The course are subject to change depending on number of student, their programming skills and individual interest. The class will use the Python programming language and personal laptops.

Course requirements: basic MSC. level course of physics and mathematics

11. References, literature, online resources:
- Machtelt Garrels, Introduction to Linux, A Hands on Guide
- Internet materials: www.python.org, www.numpy.org, www.scipy.org, matplotlib.org

12. Educational outcomes including PQF level 8 codes:
Course effects:
1. Reading and writing Python and Linux scripts
2. Creation of simple algorithms
3. Data analysis including data input, analysis with algorithms, visualization of results
4. Using external modules: numpy, matplotlib, scipy
P8U_W, P8U_U, P8U_K, P8S_WG, P8S_UW

13. Evaluation of the educational outcomes:
Two tests will be organized during the classes with simple coding tasks (90% of the score).
Activity during classes (10% of the score).

14. Criteria to complete the course:
100% attendance and at least 3 on the exam (see 14 above)

COURSE SYLLABUS - IGF PAN

1. Course title: **Simple Introduction to Complex Systems**

2. Course lecturer: dr hab. Mariusz Białecki

3. Discipline, field, year of studies: geophysics, physics, all years

4. Course character: general/monographic/interdisciplinary/optional

5. Teaching method: hybrid

6. Language: English

7. Course type and number of hours: lecture (30h)

8. Estimated amount of student's independent work: 20 h

9. Total workload and number of ECTS points: 3 ECTS

10. Short description and main focus of the course:
    The lecture course introduces on elementary level fundamental concepts of complex systems, that proved to be indispensable for proper understanding numerous natural phenomena of modern interest. The world is complex, thus strategies based on simple assumptions –like linear, Gaussian, small-scale –are just not sufficient nowadays. Unfortunately, students in classical education are very rarely introduced to knowledge of nonlinear, non-Gaussian, large coupled spatial systems. This lecture course is aiming at filling the gap by providing a complex system toolbox for modern research. The following mathematical topics will be introduced and discussed: fundamentals of dynamical systems (including: randomness, correlations, stationarity), linear systems (including: modes, system coupling, control), nonlinear dynamics (including: bifurcations, hysteresis, catastrophes), spatial systems (including: discretization, agent models, cellularautomata), power laws and complex systems (including: phase transitions, criticality, emergence).The way of presentation focuses on conceptual description of phenomena, rather than on technical or detailed calculations in order to enable grasping a big picture of interesting issues.

11. References, literature, online resources:

12. Educational outcomes including PQF level 8 codes:
    P8U_W, P8U_U, P8U_K, P8S_WG, P8S_UW

13. Evaluation of the educational outcomes:
    Attendance and a short written study/presentationon a selected topic in line with the student's specialization

14. Criteria to complete the course:
    100% attendance and at least 3 at the exam

COURSE SYLLABUS - IGF PAN

1. Course title: **Understanding probability**

2. Course lecturer: dr hab Mariusz Białecki

3. Discipline, field, year of studies: geophysics, physics, math, all years

4. Course character: general/monographic/interdisciplinary/optional

5. Teaching method: hybrid

6. Language: English

7. Course type and number of hours: lecture (30h)

8. Estimated amount of student’s independent work: 20h

9. Total workload and number of ECTS points: 3 ECTS

10. Short description and main focus of the course:
    The aim of the lecture course is to provide to a student a systematic presentation of the subject, with special focus on those aspect of probability, that often are not well represented in standard courses, but become more important in modern research practice. The range, pace and level of the lecture will be adjusted according to the audience’s advancementand interests. The core part of the lecture include: sources of unpredictability, frequency as probability, probability as degree of belief, binning of continuous distribution, conditional and marginal distributions, the algebra of expectations, transformation of probability distributions, macrostates and microstates, partitioning and systems with extra constraints, counting statistics, physical and mathematical origin of the Gaussian distribution, convolutions, error distributions, random walks, waiting time distributions, power law tails, moments of power law distributions, fitting of power law distribution, information, uncertainty, codes, Shannon entropy, time series, stationarity and non-stationarity, probabilistic models for discrete time series, Markov chains, complexity. The way of presentation focuses on precise explanation and range of applicability of mathematical concepts, thus require a rigour in analytical description.In order to keep the contents approachable for students from various disciplines, all non-standard mathematical concepts will be clearly introducedand discussed.

11. References, literature, online resources:

12. Educational outcomes including PQF level 8 codes:
P8U_W, P8U_U, P8U_K, P8S_WG, P8S_UW

13. Evaluation of the educational outcomes:
Attendance and a shortwritten study/presentationon a selected topicin line with the student's specialization

14. Criteria to complete the course:
100% attendance and at least 3 on the exam

COURSE SYLLABUS - IGF PAN

1. Course title: **Data Science and Machine Learning for Geoscientists and Engineers**

2. Course lecturer: dr Qamar Yasin

3. Discipline, field, year of studies: geophysics, all years, This course is intended for individuals of all levels.

4. Course character: general/monographic/interdisciplinary/optional,

5. Teaching method: hybrid

6. Language: English

7. Course type and number of hours: lecture (30h)

8. Estimated amount of student's independent work: 20h

9. Total workload and number of ECTS points: 3 ECTS

10. Short description and main focus of the course:
    Machine learning (ML) is a rapidly emerging technology that has the potential to solve long-standing research problems across all fields of scientific study. An important aspect of machine learning is its ability to recognize complex patterns in large datasets without the need for feature extraction or engineering. It isunsurprising that geoscientists and engineers, like domain experts in other scientific disciplines, are learning to see the significance of machine learning techniques. Recent advancements in the field of scientific machine learning highlight its mostly unexplored potential for long-standing challenges in the field of computational geosciences and engineering. In this lecture course, I will discuss my research on the application of data science and machine learning with hands-on codingfor handling complex problems quickly and efficiently in geoscientific prediction.I will explain the following major aspects in this course: (1) the role of machine learningin geosciences and engineering,(2) python for data science and machine learning, (3) machine learning use cases in geology,geophysics,andengineering, (4) future of machine learning in geoscientific prediction.This course will cover datasets from multiple domains and how to apply MLalgorithms on the available data, how to get value out of MLalgorithms, and how to present the output of those algorithms.

11. References, literature, online resources:

The course does not require any prerequisites, but a basic knowledge of Python is advantageous.

12. Educational outcomes including PQF level 8 codes:
By the end of this course, you will have enough knowledge and hands-on codingin Python to use and apply them in the real world around you.
P8U_W, P8U_U, P8U_K

13. Evaluation of the educational outcomes:
AttendanceandFinal Project onselected topic in line with the student's specialization

14. Criteria to complete the course:
Attendance 100% and 3 on the project.

COURSE SYLLABUS - IGF PAN

1. Course title: **Seismological Data – seismic networks, available formats and catalog description**

2. Course lecturer: dr hab. Łukasz Rudziński

3. Discipline, field, year of studies: geophysics, seismology all years

4. Course character: monographic lecture + practical tutorials

5. Teaching method: hybrid

6. Language: English

7. Course type and number of hours: lecture (8h), seminar (7h)

8. Estimated amount of student's independent work: 10 h

9. Total workload and number of ECTS points: 2 ECTS

10. Short description and main focus of the course:
    The courses will provide to the students the advanced information concerning data which are typical for seismological studies. After the courses, the students will be familiar with seismic networks and type of instruments which are used in seismological monitoring. We will introduce different seismic formats and provide practical exercises with data conversion. Basic seismogram analysis and how they are related to seismological investigations will be explained. Finally, students will know what is a seismic catalog. We will discuss, which kind of information are included in catalog and how a catalog can be used in different seismological problems. The subjects that are going to be addressed during the courses are:
    1. Seismic networks and seismic instruments,
    2. Signal formats in seismology and practical conversion among them,
    3. Basic seismograms analysis with practice,
    4. Catalog in seismology and how it is related to different seismological problems.

11. References, literature, online resources:
    Elementary knowledge of mathematics, Linux, Python and Seismology is desirable
    eg., relevant books, journal papers, links to on-line resources

12. Educational outcomes including PQF level 8 codes:
    P8U_W, P8U_U, P8U_K

13. Evaluation of the educational outcomes: test

14. Criteria to complete the course:
    100% attendance and at least 3 on the exam

COURSE SYLLABUS - IGF PAN

1. Course title: **Anthropogenic seismicity**

2. Course lecturer: Prof. Beata Orlecka-Sikora

3. Discipline, field, year of studies: geophysics, all years

4. Course character: monographic lecture, practical tutorials

5. Teaching method: hybrid

6. Language: English

7. Course type and number of hours: lecture (7 h), tutorials (1 h)

8. Estimated amount of student's independent work: 5 h

9. Total workload and number of ECTS points: 1 ECTS

10. Short description and main focus of the course:
    This course will introduce students to the problem of seismicity associated with the exploitation of geo-resources. We will discuss different geo-resource exploitation technologies that may induce seismicity and the mechanisms of interaction between technological activity and the rock mass. We will determine the necessary conditions to identify earthquake as an induced, triggered, or natural. Students will learn about the vital properties of anthropogenic seismicity. They will also learn what kind of scientific tools may be applied to assess the hazard they pose. Finally, they will learn about the international collaborative undertakings for research into anthropogenic seismicity.

11. References, literature, online resources:
    Elementary knowledge of physics, geophysics and seismology are desirable

12. Educational outcomes including PQF level 8 codes:
    P8U_W, P8U_U, P8U_K

13. Evaluation of the educational outcomes: test

14. Criteria to complete the course: 100% attendance and at least 3 on the exam

COURSE SYLLABUS - IGF PAN

1. Course title: **Introduction to Machine Learning with Python**

2. Course lecturer: dr Piotr Klejment

3. Discipline, field, year of studies: IT Tools (facultative) all years

4. Course character: general interdisciplinary lecture

5. Teaching method: hybrid

6. Language: English

7. Course type and number of hours: seminar (20 h)

8. Estimated amount of student's independent work: 10h

9. Total workload and number of ECTS points: 1 ECTS

10. Short description and main focus of the course:
    GENERAL DESCRIPTION: Machine learning offers great opportunities for data analysis and dependency search. In this branch of artificial intelligence, algorithms are trained to learn patterns from massive amounts of data in order to make decisions and predictions on new data sets. Today, examples of machine learning are all around us, and machine learning methods are also widely used in science and engineering problems. The same is happening in the Earth Sciences, from geophysics to oceanography. This course aims to develop practical skills in using machine learning algorithms, primarily working with Python packages.
    COURSE OUTLINE
    Python: basic syntax and Python packages - NumPy, Matplotlib, SciPy, Pandas, and Scikit-learn.
    Supervised learning: workflow for creating machine learning models, data preparation for the model - training, validation, and test data sets. Regression and classification problem: basic metrics, model selection - cross validation, underfitting and overfitting problem, working with various algorithms (Multiple Linear Regression, Decision Tree, Random Forest, Support Vector Machine, K-nearest, Naive Bayes and others...).
    Unsupervised learning: clustering, cluster analysis, Minkowski's metric, K-means algorithm, hierarchical clustering algorithm, dimensionality reduction methods, association rules.

Elements of Deep Lerning: TensorFlow and Keras, principles of artificial neural networks, example of image processing with Convolution Neural Network, predictions with Artificial Recurrent Neural Network, outline of Reinforcement Learning.

11. References, literature, online resources:

    The course is from scratch, but basic programming knowledge would be an asset.

12. Educational outcomes including PQF level 8 codes:

    P8U_W, P8U_U

13. Evaluation of the educational outcomes:

    test

14. Criteria to complete the course:

    100% attendance and 3 on the test

COURSE SYLLABUS - IGF PAN

1. Course title: **Introduction to seismology**

2. Course lecturer: dr hab. Grzegorz Lizurek

3. Discipline, field, year of studies: geophysics, all years

4. Course character: monographic lecture

5. Teaching method: hybrid

6. Language: English

7. Course type and number of hours: lecture (12h)

8. Estimated amount of student's independent work: 10h

9. Total workload and number of ECTS points: 1 ECTS

10. Short description and main focus of the course:
    Description of the topic: Introduction to seismology will cover the basic principles of the earthquake generation, seismic wave propagation and the ways how we can interpret data. Course will be divided on three parts: seismic waves and earthquake parameters, how the earthquakes are initiated and anthropocentric seismicity. Source physics, principals of focal mechanism and physical properties of the seismic source determination will be included within the scope of this lecture. Human influence on the earthquake occurrence and the basics of the hazard assessment as well as the early warning systems will be presented. Some exercises with use of the EPISODES platform (https://tcs.ah-epos.eu/) are prepared for better understanding the modern seismic analysis workflows and presentation of the data access and sharing tools.

11. References, literature, online resources:

12. Educational outcomes including PQF level 8 codes:

    P8U_W, P8U_U

13. Evaluation of the educational outcomes: Exam at the end of the course

14. Criteria to complete the course: 100 % Attendance, at least 3 at the exam