Advanced mathematics and scientific programming with MATLAB for Marine sciences – 4 credits

Course Number: 224.4092

Lecturer: Dr. Regina Katsman

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Course Type: Lecture/Computational Lab

Course Level: MSc/ PhD

Prerequisites: No

Course Description:

The course is composed of two parts: mathematics & fundamentals of programming with MATLAB.

The main objective of the **mathematical part** is to gain a basic mathematical knowledge enabling the students to use it in their research projects, and to study the advanced courses of "Physical oceanography", "Time series analysis", "Numerical methods", and "Geophysical methods in the marine environment research", ", "Processing and imaging of seismic data". The following main subjects in Mathematics will be covered: 1) basics of trigonometry, analytical geometry, vector analysis; 2) fundamentals of theory of complex numbers (elementary algebraic operations, powers, roots, complex plane, function of complex variables, differentiation and integration); 3) ordinary differential equations (first and second order), partial differential equations with constant coefficients (method of separation of variables).

The main objective of the **scientific programming part** is to gain initial programming skills and a necessary modelling basics for the above listed courses and for their MSc & PhD research projects. The course includes a practical training.

Topics:

Mathematics
1. Basics of trigonometry: coordinate system, trigonometric functions of angles, periodicity, inverse trigonometric ratios.
2. Analytical geometry: equations of straight line, parabola, hyperbola.
3. Analytical geometry: equations of circle and ellipse.
4. Vector algebra and calculus.
5. Complex numbers: general and polar forms, conjugates, complex plane.
6. Complex numbers: elementary algebraic operations, powers, roots.
7. Complex numbers: exponent, Euler formula, logarithm, de Moivre's theorem.
8. Functions of complex variable, derivative of complex functions.
9. Integral of complex function, anti-derivative, definite integral.

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10. Ordinary differential equations, differential equations of the 1st order: linear constant coefficient equations, initial value problem.
11. Ordinary differential equations, differential equations of the 1st order: linear variable coefficient equations, integrating factor method, total derivative, initial value problem.
12. Differential equations of the 2nd order with constant coefficients.
13. Partial differential equations, separation of variables.

Scientific programming with MATLAB
1. Matlab Interface, scripts, workspace, help. Introduction to matrices: elementary operations, indexing.
2. Elementary mathematical operations (arithmetic, trigonometric, exponential, logarithmic, etc.).
3. Graphics.
4. Programming fundamentals (control flow: conditional statements, loops, branching).
5. Data import and analysis, file management.
6. Interpolation, curve fitting, differentiation and roots of polynomials.
7. Elementary matrix operations (functions for specific matrix generation, concatenation, deletion, size determination).
8. Advanced matrix operations: inverse, transpose, determinants, array functions, functions for solution of systems of linear equations.
9. Structure of advances Matlab scripts, external Matlab functions, code editing.
10. Signal filtering.
11. Geological and geophysical applications.
12. Oceanographic data analysis.

Learning Outcomes:

At the end of the course, students will be able to apply the basic mathematical and programming skills in the advanced courses and their research projects in the field of Marine Sciences.

Requirements: Attendance, Exam, Homework assignments.

Grading:

Pass grade >65%, composed of 40% final exam on math and final project on MATLAB, 60% weekly homeworks in math & MATLAB. The exemption exam in math pass grade is 85.

Reading List:

Mathematics
1. Grossman, S.I. (1984), Calculus, Orlando: Academic Press.
2. Janusz, G. J. (1994), Calculus, Dubuque, Iowa: Wm. C. Brown.
MATLAB
1. Valentine, D. T., Hahn, B. D. (2007) Essential MATLAB for engineers and scientists, Amsterdam : Butterworth Heinemann.
2. Hunt, B. R., Lipsman, R. L. (2009) A guide to MATLAB: for beginners and experienced users, Cambridge, UK : Cambridge University Press.