GEOPHYSICS

DYNAMIC METEOROLOGY I	0+0+0	4+2+0

COURSE CONTENT:

General knowledge on Earth and atmosphere. Air parcel. Types of equilibrium processes. Processes in dry atmosphere. Thermodynamics of the dry air, water substance and moist air. Measures of air humidity. Processes of humid and saturated air. Hydrostatic equilibrium. Boussinesq approximation. Vertical cells. Fundamental and pseudo-forces. Equation of motion in spherical coordinates. Scale analysis of atmospheric processes. Primitive equations in isobaric, isentropic, sigma and system with generalized vertical coordinate. Natural coordinate system, gradient, geostrophic, cyclostrophic and inertial motion. Trajectories and streamlines. Bjerknes circulation theorem. Barotropic and baroclinic atmosphere, solenoids, thermal wind. Vorticity equation. Conservation of absolute vorticity. Shallow fluid. Potential vorticity. Lee cyclogenesis. Equation of divergence. Helmholtz theorem. Balance equation. Rossby waves in geostrophic and quasigeostrophic atmosphere. Rossby's radius of deformation. Fundamentals of general circulation of atmosphere. Zonal index. Fultz's experiments.

PREREQUISITES FOR THE COURSE:

Attended: Introduction to Geophysical Fluid Dynamics

TERMS FOR RECEIVING THE SIGNATURE:

Attendance to the lectures at least 75%. Timely completed homeworks (at least 80%).

EXAMINATION METHODS:

Written and oral exam.

REQUIRED LITERATURE:

Holton, J. R., 2004: An introduction to dynamic meteorology. Elsevier Academic Press, Amsterdam, 535 pp.

Bluestein, H. B., 1992: Synoptic-dynamic meteorology in midlatitudes, Vol. I: Principles of kinematics and dynamics. Oxford University Press, New York, 431 pp.

Bluestein, H. B., 1993: Synoptic-dynamic meteorology in midlatitudes, Vol. II: Observations and theory of weather systems. Oxford University Press, New York, 594 pp.

Kundu, P. K., 1990: Fluid mechanics. Academic Press, San Diego, 638 pp.

DYNAMIC METEOROLOGY II	2+2+0	0+0+0

COURSE CONTENT:

Vertical structure of midlatitude large-scale perturbations. Quasi-geostrophic theory. Barotropic and baroclinic models of the atmosphere. Hydrodynamic instability of atmospheric large-scale processes. Baroclinic instability. Conservation of general circulation. Basics of energy conservation of midlatitude atmospheric circulation. Introduction of mesoscale processes. Internal gravity waves. Convection. Atmospheric boundary layer. Laminar and turbulent motions. Turbulent kinetic energy. Hypotheses of of Taylor and Kolmogorov. Turbulent fluxes. Similarity theory. Transport and diffusion in the atmosphere. Coastal and mountain circulations.

PREREQUISITES FOR THE COURSE:

Passed: General physics 1-4, Math. Analysis 1-2, Classical mechanics 1-2, Introduction to geophysical fluid dynamics.

TERMS FOR RECEIVING THE SIGNATURE:

Written course summary, 2-3 pages (main questions & assumptions, relations and conclusions).

EXAMINATION METHODS:
Written and oral examination (the former may be more or less passed via exercises and assignments).
REQUIRED LITERATURE:
Holton, J. R., 2004: An introduction to dynamic meteorology. Elsevier Academic Press, Amsterdam, 535 pp.
Šinik, N. i B. Grisogono: Dynamic Meteorology – Introduction to general circulation (in Croatian), Školska knjiga, Zagreb, 2008.
Grisogono, B. i D. Belušić: Introduction to mesoscale meteorology and atmospheric turbulence, Scripts 2009, http://www.gfz.hr/osobne_stranice/grisogono/DM4_SKRIPTA.htm.

DYNAMIC METEOROLOGY III	**0+0+0**	**3+2+0**

COURSE CONTENT:
Structures of midlatitude large-scale perturbations. Quasi-geostrophic prognosis, semi-geostrophic theory. Barotropic and baroclinic dynamical models of atmospheres. Atmospheric instabilities of large-, meso- and micro-scale processes: baroclinic, isentropic-inertial and buoyant instability. Fronts. Conservation of atmospheric circulations. Mountain waves. Deep convection. Atmospheric boundary layers and turbulence. Turbulent kinetic energy prediction. Monin-Obukhov length. Reynolds stress tensor prediction. Modeling transport and diffusion in the atmosphere. Local circulations. Modeling of the atmospheric dynamics, parameterizations for micro-scale processes. Prandtl model for inclined boundary layers.
PREREQUISITES FOR THE COURSE:
Attended: Dynamic meteorology II
TERMS FOR RECEIVING THE SIGNATURE:
Written course summary (two A4 pages).
EXAMINATION METHODS:
Written and oral exam.
REQUIRED LITERATURE:
Holton, J. R., 2004: An introduction to dynamic meteorology. Elsevier Academic Press, Amsterdam, 535 pp.
Šinik, N. i B. Grisogono: Dynamic Meteorology – Introduction to general circulation (in Croatian), Školska knjiga, Zagreb, 2008.
Grisogono, B. i D. Belušić: Introduction to mesoscale meteorology and atmospheric turbulence, Scripts 2009, http://www.gfz.hr/osobne_stranice/grisogono/DM4_SKRIPTA.htm.

SEMINAR IN DYINAMIC METEOROLOGY	**0+0+1**	**0+0+1**

COURSE CONTENT:
Structures of midlatitude large-scale perturbations. Mesoscale cyclones. Buoyancy waves. Atmospheric boundary layer. Turbulent kinetic energy prediction. Spectral description of turbulence. Transport and diffusion in the atmosphere.
PREREQUISITES FOR THE COURSE:
Passed: General Physics 1-4, Mathematical Analysis 1 and 2, Classical Mechanics 1 and 2, Introduction to Geophysical Fluid Dynamics, Dynamic meteorology I and II, Climatology I
TERMS FOR RECEIVING THE SIGNATURE:
Hold a seminar about the project assignment and write a report about the seminar (project assignment) on approximately two A4 pages.
EXAMINATION METHODS:

REQUIRED LITERATURE:

Holton, J. R., 2004: An introduction to dynamic meteorology. Elsevier Academic Press, Amsterdam, 535 pp.

Stull, R.B.: An Introduction to Boundary Layer Meteorology, Kluwer, Dordrecht, 1988

SEMINAR IN CLIMATOLOGY	0+0+1	0+0+1

COURSE CONTENT:

Student is required to study on his/her own a given topic from climatology. Topics are taken from scientific papers as well as from monographs. One problem per semester should be analyzed and presented, giving the motivation, results and conclusions. During discussions with teacher and other participants the knowledge acquired previously is deepened.

PREREQUISITES FOR THE COURSE:

Passed: Climatology I and II

TERMS FOR RECEIVING THE SIGNATURE:

Regular attendance to the lectures, as well as writing and oral presentation of two seminars.

EXAMINATION METHODS:

Writing and oral presentation of two seminars.

REQUIRED LITERATURE:

Relevant scientific journals, monographs and sources from Internet.

WEATHER ANALYSIS AND FORECASTING I	2+1+0	0+0+0

COURSE CONTENT:

Global Observing System – World Weather Watch. Weather data control. Analytic materials, stressing weather map projections (conic, cylindrical and polar-stereographic). Objective analysis of the weather fields: fitting methods (polynomial and spectral), optimal (statistical) interpolation, successive correction method and variational approach. Isoplet construction technique.

Atmospheric systems: air masses, atmospheric fronts (frontogenesis and frontolysis), jet stream including its genetic mechanism, baric circulation systems (cyclone, anticyclone, trough and ridge) including cyclogenesis (cyclolysis), anticyclogenesis (anticyclolysis) and tendencies of constant pressure surface heights. Differential characteristics of wind field, streamlines and trajectories. Vertical atmospheric motion diagnosis. Baric systems within global atmospheric circulation. Lee cyclogenesis, especially on the southern side of the Alps. Humidity field analysis and precipitation amount estimation. Atmospheric systems and weather. Orographic influences on weather. Coastal air circulation and weather.

PREREQUISITES FOR THE COURSE:

Passed: Meteorological Measurements, Dynamic meteorology I and II, Climatology I

TERMS FOR RECEIVING THE SIGNATURE:

Regular attendance (at least 70%) to the lectures and exercises Preparation of computer program from the exercises.

EXAMINATION METHODS:

Written and oral exam (preparation of a written concept or direct use of chalk and board).

REQUIRED LITERATURE:

Pandžić, K., 2002: Anlysis of weather fields and systems (in Croatian). HINUS, Zagreb. 314 pp.

Bluestein, H.B., 1992: Sinoptic-dynamic meteorology in midlatitudes, (Vol. I). Oxford University Press, New York. 431 pp.

Bluestein, H.B., 1993: Sinoptic-dynamic meteorology in midlatitudes, (Vol. II). Oxford University Press, New York. 431 pp.

WEATHER ANALYSIS AND FORECASTING II	0+0+0	2+1+0

COURSE CONTENT:

Subjective way of weather forecasting. Objective methods of weather forecasting: deterministic, stochastic and deterministic-stochastic approach.

The governing equations of the atmosphere in different co-ordinate systems (generalised, spherical, tangential and map projections). Review of numerical methods for solving the governing equations: method of final differences and function expansion into series (spectral and final elements). Non-linear numerical nonstability and filtering (low-pass and bandpass filters). Initialisation of numerical models: equilibrium equations, normal modes, 4-dimensional variational analysis. Boundary conditions. Barotropic limited area model in conic map projection. Six-layer hemispheric forecasting model with primitive equations. Global spectral model of the European Centre for Medium Range Weather Forecasts (ECMWF). Introducing with the regional models ALADIN (Aire Limitee Adaptation et Development International) and HIRLAM (High Resolution Limited Area Modelling). Stochastic (regression) approach to the weather forecasting. Analogy method. Deterministic-stochastic approach: atmospheric predictability, ensemble forecasts. Subjective interpretation of the prognostic model outputs. Regression way of interpretation (Method output Statistic, perfect Prognosis). Adaptive deterministic models (e.g. adaptation of air flow to the orography). Forecasts for special applications. Verification of the forecasts.

PREREQUISITES FOR THE COURSE:

Attended: Weather Analysis and Forecasting I

TERMS FOR RECEIVING THE SIGNATURE:

Regular attendance (at least 70%) to the lectures and exercises. Preparation of computer program from the exercises. Featuring a lecture as part of the Seminar in weather analysis and forecasting.

EXAMINATION METHODS:

Written and oral exam (preparation of a written concept or direct use of chalk and board).

REQUIRED LITERATURE:

Kalney, E., 2003: Atmospheric modeling, data assimilation and predictability. Cambridge University Press, Cambridge. 341 pp.

Haltiner, G.J. and R.T. Williams, 1980: Numerical weather prediction. John Wiley & Sons, New York. 477 pp.

Pielke R.A. and R.P. Pearce, 1994: Mesoscale modeling of the atmosphere. American Meteorological Society, Boston. 167 pp.

SEMINAR IN WEATHER ANALYSIS AND FORECASTING	0+0+1	0+0+1

COURSE CONTENT:

Teacher recommends to the students a topic for the seminar paper related to the weather analysis and provides appropriate literature. The topic should be related with operational meteorology as it is possible. The topics related with Croatian territory have some priorities (e.g. Mediterranean cyclones) or the topics devoted to special applications e.g. in aeronautical and marine meteorology.

PREREQUISITES FOR THE COURSE:

Passed: Meteorological Measurements, Dynamic meteorology I and II, Climatology I

TERMS FOR RECEIVING THE SIGNATURE:

Preparing in electronic form and presenting the seminar in oral form within wider issues of practice.

EXAMINATION METHODS:

Preparation and presentation of the wider issues of practice.

REQUIRED LITERATURE:

Pandžić, K., 2002: Anlysis of weather fields and systems (in Croatian). HINUS, Zagreb.

Bluestein, H.B., 1992: Sinoptic-dynamic meteorology in midlatitudes. Oxford University Press, New York.

Kalney, E., 2003: Atmospheric modelling, data assimilation and predictability. Cambridge University Press, Cambridge.

Pielke R.A. and R.P. Pearce, 1994: Mesoscale modeling of the atmosphere. American Meteorological Society, Boston.

PHYSICAL METEOROLOGY I	**2+1+0**	**0+0+0**

COURSE CONTENT:

1-4. Solar and terrestrial radiation processes. 5-9. Solar radiation extinction in the atmosphere. 10-11. Direct, diffuse and global Solar irradiation measurements and estimations. 12-13. Radiation modelling.

PREREQUISITES FOR THE COURSE:

Passed: General Physics 1-4, Mathematical Analysis 1 and 2, Climatology I, Dynamic meteorology I

TERMS FOR RECEIVING THE SIGNATURE:

Submit homeworks and hold a seminar.

EXAMINATION METHODS:

Written (written part of the exam may be exempt those who pass all preliminary exams) and oral exam.

REQUIRED LITERATURE:

Coulson, K.L.: Solar and Terrestrial Radiation, Academic Press, New York 1975.

Selby M.L.: Fundamentals in Atmospheric Physics. Academic Press 1996.

PHYSICAL METEOROLOGY II	**0+0+0**	**2+1+0**

COURSE CONTENT:

1-4. Optical and acoustical atmospheric phenomena. 5-8. Cloud and precipitation physics. 9. Artificial influences on weather. 10-11. Radars and the radar equation. 11-13. Numerical modelling of cloud and precipitation formation processes.

PREREQUISITES FOR THE COURSE:

Passed: Dynamic meteorology II

TERMS FOR RECEIVING THE SIGNATURE:

Submit homeworks and hold a seminar.

EXAMINATION METHODS:

Written (written part of the exam may be exempt those who pass all preliminary exams) and oral exam.

REQUIRED LITERATURE:

Rogers R.R. and Yau, M.K.: A Short Course in Cloud Physics, Pergamon Press, 1989 (3rd ed.)

Mason, B.J.: The Physics of Clouds. Clarendon Press, Oxford, 1971.

METEOROLOGICAL MEASUREMENTS	**0+0+0**	**2+1+0**

COURSE CONTENT:
1. Meteorological measurements and observations. 2. Visual observations of meteorological phenomena, clouds, cloudiness and wind strength. Meteorological symbols. Meteorological diaries. 3.-10. Terrestrial and aerological instrumental atmospheric measurements: precipitation, temperature, pressure, humidity, wind, short- and longwave Solar irradiation, visibility. 11. Automatic weather stations. 12. Remote measurements (satellites, radars, etc). 13. Exchange and types of meteorological informations (weather charts, internet).
PREREQUISITES FOR THE COURSE:
Passed: General Physics 1-4, Mathematical Analysis 1 and 2, Introductory Physical Praktikum 2
TERMS FOR RECEIVING THE SIGNATURE:
1. Measurements and observations of various atmospheric phenomena and states during a week and a brief review; 2. Successfully passed colloquium from cloud identification.
EXAMINATION METHODS:
Oral exam, which respects to the results of previous preliminary exams.
REQUIRED LITERATURE:
Ludlum D. M.: National Audubon Society: Field Guide to North American Weather, Chantideer Press Inc. N.Y. 1997.
Houhghton D. D. (ur.): Handbook of Applied Meteorology, Wiley, N.Y. 1985.

METEOROLOGICAL PRACTICUM	**0+0+0**	**1+2+0**

COURSE CONTENT:
Meteorological symbols, measurements and observations. Initial and boundary conditions for numerical prediction models; initialization. Some numerical model schemes and errors. Examples of geostrophic adjustment. Atmospheric predictability and prognostic models. Practical aspects of mountain, coastal and urban meteorology. The use of remote sensing. Elements of short- and medium-range forecasting.
PREREQUISITES FOR THE COURSE:
Passed: General physics 1-4, Calculus 1-2, Classical mechanics 1-2, Introduction to geophysical fluid dynamics, Dynamic Meteorology 1-2, Meteorological measurements, Climatology I.
TERMS FOR RECEIVING THE SIGNATURE:
Successful mini-reports, seminar (about measurements and/or model), practical weather analysis and forecasting.
EXAMINATION METHODS:
Accepted reports and seminar; practical weather analysis and forecasting.**REQUIRED LITERATURE:**
Mesinger, F.: Dynamic Meteorology (in Serbian). Građevinska knjiga, Beograd. 1976.

GEOPHYSICAL SEMINAR	**0+0+1**	**0+0+1**

COURSE CONTENT:
Course provides an opportunity for students to learn about recent research in geophysics both in Croatia and in the world.
PREREQUISITES FOR THE COURSE:

TERMS FOR RECEIVING THE SIGNATURE:
Regular attendance (at least 80%) to the lectures.
EXAMINATION METHODS:

REQUIRED LITERATURE:

THEORY OF ELASTICITY WITH APPLICATION IN GEOPHYSICS	2+1+0	2+1+0

COURSE CONTENT:
Analysis of stress and strain. Strain in the Earth's crust. Stress-strain relations. Constants and modules of elasticity. Lame's equations. Elastic motions and potentials. Kirchhoff's solution of wave equation. Application on different types of point sources.
PREREQUISITES FOR THE COURSE:
Attended: General Physics 1-4, Classical Mechanics 1 and 2
TERMS FOR RECEIVING THE SIGNATURE:
Attendance to the lectures (70%) and 70% of homeworks completed.
EXAMINATION METHODS:
Written and oral exam. Written exam may be passed through colloquiums during the year. Oral exam is mandatory.
REQUIRED LITERATURE:
Aki, K., P.G. Richards: Quantitative Seismology, 2nd Ed. Univ. Science Books, Sausalito, Calif. 2002.
Bath, M.: Mathemathical Aspects of Seismology, Elsevier, Amsterdam, 1968.
Mueller, G.: Theorie der elastischen Wellen, Univ. Frankfurt, Frankfurt 1986.

STATISTICAL MATHODS IN GEOPHYSICS	2+1+0	0+0+0

COURSE CONTENT:
Descriptive statistics. Discrete and continuous random variables and vectors. Empirical distributions. Theoretical distributions. Parameter fitting. Hypothesis testing. Nonparametric tests. Bivariate normal distribution. Simple and multiple linear regression with geometrical interpretation. Basics of time-series analysis. Tests for data homogeneity.
PREREQUISITES FOR THE COURSE:
Passed: Mathematical Analysis 1 and 2, Linear Algebra, Statistics and Basic Measurements
TERMS FOR RECEIVING THE SIGNATURE:
Regular attendance to the lectures. Successful and timely completed homework.
EXAMINATION METHODS:
Positively evaluated two preliminary exams with the possibility of correcting the grade on the oral exam. If a student has not taken preliminary exams than written and oral exams are mandatory.
REQUIRED LITERATURE:
Penzar B., B. Makjanić: Basic Statistical Data-Analysis in Climatology (in Croatian), Sveučilište u Zagrebu, 1978.
Wilks, D.S.: Statistical Methods in the Atmospheric Sciences, Academic Press, New York, 1995.

PHYSICAL OCEANOGRAPHY I	2+1+0	0+0+0

COURSE CONTENT:
Subject of the course and methodology. Measurement of salinity, temperature and pressure, determination of density, analysis of water masses. Measurement of currents (indirect methods, direct methods – according to Lagrange and to Euler), of high-

frequency (wave gauge) and of low-frequency (tide gauge) sea level variability. Equations of motion and continuity, equation of state and its approximations, equations of heat and salt exchange. Properties of the seas and oceans: salinity, temperature, pressure, density, water masses. Basic modeling of the spatial distribution of salinity and temperature and of the annual temperature cycle.
Exercises include analysis of vertical profiles of salinity and temperature and of horizontal distribution of these properties using subjective and objective methods. Vertical distribution of the pressure is considered as well, utilizing measured profiles of salinity and temperature.

PREREQUISITES FOR THE COURSE:
Passed: General Physics 1-4, Mathematical Analysis 1 and 2, Computer Science and Praktikum, Numerical Methods

TERMS FOR RECEIVING THE SIGNATURE:
Regular attendance to the lectures.

EXAMINATION METHODS:
Written and oral exam.

REQUIRED LITERATURE:

Knauss, J.A.: Introduction to Physical Oceanography, 2nd Edition, Prentice Hall, New Jersey 1996.

Open University Course Team: Seawater – Its Composition, Properties and Behaviour, 2nd Edition, Butterworth-Heinemann, Oxford 1995.

Open University Course Team: Ocean Circulation, 2nd Edition, Butterworth-Heinemann, Oxford 2001.

Pickard, G.L., W.J. Emery: Descriptive Physical Oceanography, 5th Edition, Butterworth-Heinemann, Oxford 1996.

Stewart, R.H.: Introduction to Physical Oceanography, Department of Oceanography Texas A&M University 2003 (http://oceanworld.tamu.edu/home/course_book.htm).

PHYSICAL OCEANOGRAPHY II	**0+0+0**	**2+1+0**

COURSE CONTENT:
Quasi-steady currents: geostrophic/hydrostatic model, currents in the seas and oceans, wind-driven currents (Ekman model), thermohaline currents (simple diffusion model). Free waves: model of waves in deep and shallow water and its use in the interpretation of swell and tsunami, gravity-inertia and Rossby waves. Forced waves: tides, response of the sea to the air pressure and wind forcing (storm surges), thermohaline forcing and its influence on annual variability of temperature, salinity and sea level.
Exercises include a basic analysis of current and sea level time series. Besides, the series are subjected to filtering and spectral analysis.

PREREQUISITES FOR THE COURSE:
Attended: Physical Oceanography I

TERMS FOR RECEIVING THE SIGNATURE:
Regular attendance to the lectures.

EXAMINATION METHODS:
Written and oral exam.

REQUIRED LITERATURE:

Bowden, K.F.: Physical Oceanography of Coastal Waters, Ellis Horwood, Chichester 1983.

Cushman-Roisin, B.: Introduction to Geophysical Fluid Dynamics, Prentice Hall, New Jersey 1994.

Knauss, J.A.: Introduction to Physical Oceanography, 2nd Edition, Prentice Hall, New Jersey 1996.
Open University Course Team: Ocean Circulation, 2nd Edition, Butterworth-Heinemann, Oxford 2001.
Open University Course Team: Waves, Tides and Shallow-Water Processes, 2nd Edition, Butterworth-Heinemann, Oxford 2002.
Pond, S., G.L. Pickard: Introductory Dynamical Oceanography, 3rd Edition, Butterworth-Heinemann, Oxford 1997.
Stewart, R.H.: Introduction to Physical Oceanography, Department of Oceanography Texas A&M University 2003 (http://oceanworld.tamu.edu/home/course_book.htm).

SEMINAR IN PHYSICAL OCEANOGRAPHY	0+0+1	0+0+1

COURSE CONTENT:
After an introductory lecture each student considers two physical oceanographic topics. The topics are selected from the papers recently published in scientific journals or from the monographs. Results of his/her study the student describes in writing and orally, paying attention to development of the problem, results of data analysis and/or mathematical modeling and main conclusions. Discussion with the teacher and other students enables the student to deepen the knowledge gained while attending the lectures and exercises during the previous years of study.
PREREQUISITES FOR THE COURSE:
Passed: Physical Oceanography I and II, Dynamics of Coastal Sea
TERMS FOR RECEIVING THE SIGNATURE:
Regular attendance to the lectures, as well as writing and oral presentation of two seminars.
EXAMINATION METHODS:
Writing and oral presentation of two seminars.
REQUIRED LITERATURE:
Papers recently published in scientific journals.
Monographs.

SEISMOLOGY I	2+2+0	0+0+0

COURSE CONTENT:
Origins, classification and distribution of the earthquakes, seismicity and structure of Earth, plate tectonics, macroseismology: macroseismical scale, interpretation of isoseismal maps. Body waves, travel time tables, Mohorovicic discontinuity, Wiechert-Herglotz method.
PREREQUISITES FOR THE COURSE:
Passed: General Physics 1-4, Mathematical Analysis 1 and 2, Linear Algebra
TERMS FOR RECEIVING THE SIGNATURE:
1. Regular attendance to the lectures, homeworks and neat notebook. 2. Attendance (at least 75%) to Geophysical Seminar (7014).
EXAMINATION METHODS:
Positively evaluated two preliminary exams with the possibility of correcting the grade on the oral exam. If a student has not taken preliminary exams than written and oral exams are mandatory.
REQUIRED LITERATURE:
Stein, S. and M. Wysession: An introduction to Seismology, Earthquakes and Earth structure, Blackwell Publ., 2003.
Udias, A.: Principles of Seismology, University Press, 1999, Cambridge.

Plummer, C.C. and D. McGrearry: Physical geology, WCB Publisher Dubuque, Iowa; Melbourne, Australia; Oxford, England, 1999.

SEISMOLOGY II	0+0+0	2+2+0

COURSE CONTENT:

1. Basic theory of elasticity (repetitorium), 2-3. Navier and wave equations and their solutions: Helmholtz theorem, elastic potentials, 4. Fourier principle of superposition. Snell's law, ray parameter. P, SV, SH-waves. 5-6. Reflection on the free surface: conversion of phases, coefficients of reflection and conversion. 7. Inhomogeneous waves. 8-9. Rayleigh waves in half-space, eigenfunctions. 10-12. Love waves in a layer over halfspace, period equation, dispersion, modes. 12-13. Phase and group velocity.

PREREQUISITES FOR THE COURSE:

Attended: Introduction to Spectral Analysis

TERMS FOR RECEIVING THE SIGNATURE:

1. Regular attendance to the lectures, completed exercise. 2. Attendance (at least 75%) to Geophysical Seminar (7014).

EXAMINATION METHODS:

Positively evaluated two preliminary exams with the possibility of correcting the grade on the oral exam. Otherwise, by the oral exam.

REQUIRED LITERATURE:

Aki, K., P. G. Richards: Quantitative Seismology, 2nd edition, University Science Books, Sausalito, California, 2002.

Stein, S. and M. Wysession: An introduction to Seismology, Earthquakes and Earth structure, Blackwell Publ., 2003.

Lay, T., T. C. Wallace: Modern Global Seismology, Academic Press, San Diego, 1995.

Udias, A.: Principles of Seismology, Cambridge University Press, United Kingdom, 1999.

Ben-Menahem, A., S. J. Singh: Seismic waves and sources, Springer Verlag, New York – Heidelberg – Berlin, 1981.

SEISMOLOGY III	2+1+0	0+0+0

COURSE CONTENT:

Seismic surface waves. Rayleigh equation. Propagation and dispersion of seismic surface waves in vertical heterogeneous medium (Thomson-Haskell method and generalisation matrix method). Periodic equation. Determination of eigenvalues and eigenfunctions of surface waves in layered media. Propagation of surface waves in laterally heterogeneous medium.

PREREQUISITES FOR THE COURSE:

Passed: Seismology I andi II, Theory of Elasticity with Application in Geophysics

TERMS FOR RECEIVING THE SIGNATURE:

Regular attendance to the lectures and solving two problems (homeworks).

EXAMINATION METHODS:

Oral exam.

REQUIRED LITERATURE:

Aki, K., P.G. Richards: Quantitative Seismology, 2nd Ed., University Science Books, Sansalito, California 2002.

Sato, H., M. C. Fehler: Seismic Wave Propagation and Scattering in the Heterogeneous Earth, Springer Verlag, Berlin 1997.

Stein, S. & Wysession: An introduction to Seismology, Earthquakes and Earth Structure, Blackwell Publ. 2003.

SEISMOLOGY IV	0+0+0	2+1+0

COURSE CONTENT:
Fundamentals of theory of scattering of elastic waves in inhomogeneous media. Coda waves of local earthquakes. Quality factor (Q) of coda waves, measurements and interpretation. Dependence Qc on frequency and elapsed time. Seismic anisotropy. Tensor of elasticity and fundamental properties of seismic plane waves in homogeneous anisotropic media. Equations of motion in 1-D and 2-D and in Earth as a uniform elastic sphere. Determination of eigen values and eigen functions of free oscillations. Spherical harmonics.
PREREQUISITES FOR THE COURSE:
Attended: Seismology III
TERMS FOR RECEIVING THE SIGNATURE:
Regular attendance to the lectures and solving two problems (homeworks).
EXAMINATION METHODS:
Oral exam.
REQUIRED LITERATURE:
Aki, K., P.G. Richards: Quantitative Seismology, 2nd Ed., University Science Books, Sansalito, California 2002.
Sato, H., M. C. Fehler: Seismic Wave Propagation and Scattering in the Heterogeneous Earth, Springer Verlag, Berlin 1997.
Stein, S. & Wysession: An introduction to Seismology, Earthquakes and Earth Structure, Blackwell Publ. 2003.

SEMINAR IN SEISMOLOGY	0+0+1	0+0+1

COURSE CONTENT:
Students learn how to read, write and understand scientific literature by reading and presenting selected papers. The seminar topic is selected by the student on his own, in agreement with the teacher.
PREREQUISITES FOR THE COURSE:
Passed: Seismology I-III
TERMS FOR RECEIVING THE SIGNATURE:
Hold two seminars.
EXAMINATION METHODS:

REQUIRED LITERATURE:
Recent seismological journals and books.
Internet pages.

PHYSICS OF THE INTERIOR OF THE EARTH	0+0+0	2+1+0

COURSE CONTENT:
Inverse problems (Lanczos's decomposition, Moore-Penrose matrix inverse, determination of seismic waves velocities using inverse method). Density, pressure and constants of elasticity in the Earth's interior (basics of density determination in the Earth's interior, Adams-Williamson equation for the variation of density in mantle). Physics of seismic sources (causes of earthquakes, elastic rebound theory, strain energy before an earthquake, Clapeyron's form of strain energy density, faulting sources, equivalent body forces, radiation pattern). Elastostatics (static displacement field due to a single force, a force couple and a double couple). Elastodynamics (near and far field displacements, far field radiation patterns, seismic moment tensor). Earthquake magnitude (energy of

earthquake waves, energy per unit area of wave front in an emerging wave, energy of body and surface waves, earthquake magnitude).

PREREQUISITES FOR THE COURSE:

Passed: Mathematical Methods in Physics 1 and 2, Theory of Elasticity with Application in Geophysics, Seismology I and II

TERMS FOR RECEIVING THE SIGNATURE:

Regular attendance to the lectures (at least 80%), homeworks.

EXAMINATION METHODS:

Oral exam.

REQUIRED LITERATURE:

Aki, K., P.G. Richards: Quantitative Seismology, Theory and Methods, Vol. I,II., W.H. Freeman and Co., San Francisco 1980.

Ben Menahem, A., B.A. Singh: Seismic Waves and Sources, Springer-Verlag, New York 1981.

Bullen, K.E., B.A. Bolt: An Introduction to the Theory of Seismology, Cambridge University Press, Cambridge 1985.

Tarantola, A.: Inverse Problem Theory, Methods for Data Fitting and Model Parameter Estimation, Elsevier Science Publishers, Amsterdam 1987.

Lay, T., T.C. Wallace: Modern Global Seismology, Academic Press, San Diego 1995.

GRAVITY AND FIGURE OF THE EARTH	**2+1+0**	**0+0+0**

COURSE CONTENT:

Foundations of the theory of the Earth's gravity field. The geoid. Normal gravity, Clairaut's theorem. Stokes' theorem. Isostasy. Gravity measurements and their reductions. Interpretation of gravity anomalies. The figure of the real Earth's surface.

PREREQUISITES FOR THE COURSE:

TERMS FOR RECEIVING THE SIGNATURE:

Students have to attend the lectures and to perform homeworks.

EXAMINATION METHODS:

Oral exam.

REQUIRED LITERATURE:

Lambeck, K.: Geophysical Geodesy, Clarendon Press, Oxford 1988.

Vaníček, P., E. Krakiwsky: Geodesy, The Concepts, Elsevier, Amsterdam 1986.

COMPUTING AND NUMERICAL MATHEMATICS	**2+1+0**	**0+0+0**

COURSE CONTENT:

Short review of GNU/LINUX operating system, Matlab and Fortran, errors in numerical computing (error types and floating point arithmetic), evaluation of polynomials and their derivatives, summation of series, recursions, nonlinear equations (methods of bracketing, secant and Newton), interpolation and polynomial approximation, least squares method, orthogonal bases, global and local smoothing, numerical differentiation, numerical integration (Newton-Cotes and Gauss formulae), basic numerical linear algebra (systems of linear equations, matrix condition number, basics of perturbation theory).

PREREQUISITES FOR THE COURSE:

Passed: Mathematical Analysis 1 and 2, Linear Algebra, Mathematical Methods in Physics 1 and 2, Numerical Methods

TERMS FOR RECEIVING THE SIGNATURE:

Regular attendance to the lectures. Successful and timely completed homework.

EXAMINATION METHODS:

Positively evaluated two preliminary exams with the possibility of correcting the grade on the oral exam. If a student has not taken preliminary exams than written and oral exams are mandatory.

REQUIRED LITERATURE:

Z. Drmač, M. Marušić, M. Rogina, S. Singer: Numerical Analysis, skripts on Internet (in Croatian), 2003/2004 (http://www.math.hr/~rogina).

J. H. Mathews, K. D. Fink: Numerical Methods using Matlab, Prentice Hall, New Jersey, 2004.

SELECTED CHAPTERS IN METEOROLOGY	2+1+0	0+0+0

COURSE CONTENT:

The course consists of several offered thematic modules. Each module contains the newest accomplishments in meteorology and links them to the existing knowledge of students. The modules topics deal with the following areas: dynamic and synoptic climatology (e.g. atmospheric oscillations at large scales such as North Atlantic Oscillation or Madden-Julian Oscillation), regional climatology (e.g. influence of the climate changes on local winds), climate change (e.g. scientific justifiability of the long-term climatic projections), interaction of the atmospheric processes at different scales (e.g. spectral energy cascade of the atmospheric processes), planetary and synoptic complex phenomena (e.g. potential vorticity (PV) thinking, structure and dynamics of warm and cold conveyor belts), atmospheric mesoscale phenomena (e.g. wind meandering, thermal local circulations such as sea/land breeze, slope winds, mesoscale convective systems), Adriatic meteorology (e.g. characteristics of the atmospheric phenomena along the Adriatic and their interaction with the sea, etesian, bora, sirocco), air quality (e.g. dispersion of pollutants under low wind speed conditions). The contents of modules are changeable following the newest achievements in the field. The students participate in 7 modules and each module lasts 2 weeks.

PREREQUISITES FOR THE COURSE:

Passed: Introduction to Geophysical Fluid Dynamics, Dynamic meteorology I

TERMS FOR RECEIVING THE SIGNATURE:

Seminars and projects. Attendance to the lectures 70%.

EXAMINATION METHODS:

Oral exam.

REQUIRED LITERATURE:

Marshall, J. i R. A. Plumb: Atmosphere, Ocean, and Climate Dynamics: An Introductory Text. Elsevier, Amsterdam, 2008.

Vallis, G. K.: Atmospheric and Oceanic Fluid Dynamics. Cambridge University Press, Cambridge, 2006.

Beniston, M.: From Turbulence to Climate. Springer, Berlin, 1998.

COMPUTATION OF ADJUSTMENTS	1+1+0	0+0+0

COURSE CONTENT:

Basic theory of random errors. Gauss's law on probability of errors. Estimation of precision of direct observations (measurements). Error equaitions and normal equations. Errors of adjusted measurements.

PREREQUISITES FOR THE COURSE:

Passed: Statistical Methods in Geophysics

TERMS FOR RECEIVING THE SIGNATURE:

Attending lectures and doing homeworks.

EXAMINATION METHODS:

With all homeworks done and active participation in the course optionaly oral exam. Otherwise, written and oral exam.

REQUIRED LITERATURE:

Feil, L.: Teorija pogrešaka i račun izjednačenja, Geodetski fakultet, Zagreb 1989.

SELECTED CHAPTERS OF SEISMOLOGY	2+1+0	0+0+0

COURSE CONTENT:

E.g.: Theoretical fundamentals – displacement caused by the force in an infinite medium, dipoles, pairs of forces. Models of the seismic source. Types of faults. Stereographic projections. practical determination of fault-plane solution.

PREREQUISITES FOR THE COURSE:

Passed: Seismology I and II

TERMS FOR RECEIVING THE SIGNATURE:

Attendance to the lectures. Completed homeworks.

EXAMINATION METHODS:

Oral exam.

REQUIRED LITERATURE:

Kasahara, K: Earthquake mechanics, Cambridge University Press, 1981.

Aki, K., P. G. Richards: Quantitative Seismology, 2nd edition, University Science Books, Sausalito, California, 2002.

Stein, S. and M. Wysession: An introduction to Seismology, Earthquakes and Earth structure, Blackwell Publ., 2003.

Lay, T., T. C. Wallace: Modern Global Seismology, Academic Press, San Diego, 1995.

Udias, A.: Principles of Seismology, Cambridge University Press, United Kingdom, 1999.

PHYSICS OF THE EARTH AND ATMOSPHERE	2+1+0	0+0+0

COURSE CONTENT:

Radiation on Earth. Hydrological cycle. Equation of state for air and seawater. Hydrostatic equlilibrium. Adiabatic processes and static stability. Motion of geophysical fluids. Governing equations. Geostrophic and gradient flow. General, secondary and local circulation of the atmosphere. Waves in the sea and tidal oscillations. Structure of the Earth. Seismic waves. Fundamentals of wave theory. Seismicity. Earthquake quantification (magnitude scales, magnitude, intensity, seismic moment, earthquake energy). Earthquakes and plate tectonics. Gravity and the figure of the Earth. Theory of isostasy. Geomagnetism. Geomagnetic elements.

PREREQUISITES FOR THE COURSE:

TERMS FOR RECEIVING THE SIGNATURE:

Regular attendance to the lectures.

EXAMINATION METHODS:

Written (written part of the exam may be exempt those who pass preliminary exam) and oral exam.

REQUIRED LITERATURE:

Shearer, P.M.: Introduction to Seismology, University Press, Cambridge, 1999

Garland, G.D.: Introduction to geophysics, W.B. Saunders Co., Toronto, 1979.

Moran, J. M., Morgan M. D.: Meteorology. McMillan Publ. Company, New York 1989.

Pond, S., Pickard G. L.: Introductory Dynamical Oceanography, Pergamon, Oxford, 1983.

Skoko, D., J. Mokrović: Mohorovičić (in Croatian), Školska knjiga, Zagreb, 1998.

Wells, N.: The Atmosphere and Ocean, Wiley, Chichester, 1997.

PLANETOLOGY	2+1+0	2+1+0

COURSE CONTENT:
Earth in the universe; astronomical data of planets, satelites and minor bodies. Distance determinations. Earth's internal structure, mechanical properties of the Earth-Moon system, tides, Chandlers wobble and variation of the length of the day, Milanković cycluses. Gravimetry, lunar structure and evolution. Overview of the internal structure of planets, and elemental abundance. Solid surfaces and geological processes. Thermal regime of the solar system and internal planetary heat. Interaction with the the solar radiations and common properties of the planetary atmospheres. Planetary ionospheres and magnetospheres. Planetary cosmogony and extrasolar planets.
PREREQUISITES FOR THE COURSE:

TERMS FOR RECEIVING THE SIGNATURE:
Attendance to the lectures 70%.
EXAMINATION METHODS:
Written (written part of the exam may be exempt those who pass all preliminary exams) and oral exam.
REQUIRED LITERATURE:
de Pater, I., Lissauer, J.J.: Planetary Sciences, Cambridge University Press, Cambridge 2001.
Chamberlain, J.W.: Theory of Planetary Atmospheres, Academic Press, London 1978.

GEOMAGNETISM I AERONOMY I	3+1+0	0+0+0

COURSE CONTENT:
Elements of geomagnetic field and global properties. Basic of spherical astronomy. Measuring instruments and methods of the geomagnetic field measurements. Electromagnetic induction, the electrical conductivity. Results of paleomagnetic investigations, secular variation and reversals. Operational kinetic theory of gases, atomic structure, atomic and molecular processes necessary for the explanation of the physical atmospheric properties. Atmospheric structure and investigation methods. Chemical composition. Physics and chemistry of the ozone layer. Global atmospheric electric field. Noctilucent clouds. Transfer of electromagnetic radiation through the atmosphere, line, band and continuous absorption and formation of different layers. Chapman layers. Measurements of the UV radiation.
PREREQUISITES FOR THE COURSE:
Passedi: Numerical methods in Physics, Planetology
TERMS FOR RECEIVING THE SIGNATURE:
Attendance to the lectures 70%.
EXAMINATION METHODS:
Written (written part of the exam may be exempt those who pass all preliminary exams) and oral exam.
REQUIRED LITERATURE:
Kasumović, M.: General and applied geophysics with spherical astronomy (in Croatian) III., PMF, Sveuč. u Zagrebu, 1971.
Campbell, W.H.: Introduction to Geomagnetic Fields, Cambridge Univ. Press, Cambridge 2003.
Banks, PM, Kocharts, G.: Aeronomy, Academic Press, London 1980.

GEOMAGNETISM I AERONOMY II	0+0+0	2+1+0

Physical properties of the gaseous plasmas. Motion of charged particles in the gravitational, electric and magnetic fields. Atmospheric electrodynamics. Thermodynamics of the atmosphere. Collisional processes in the thermosphere and radiowave propagation. Atomic and molecular processes in ionospheric layers; ionization and photodissociation. Atmospheric glow. Ionospheric sondage. Structure of the magnetosphere and processes. Solar activity and physical relations with the Earth; interplanetary magnetic field, space climate. Theory of magnetic field source, modelling the field elements. Planetary aeronomy and magnetic fields of the solar system bodies.

PREREQUISITES FOR THE COURSE:

Attended: Geomagnetism i aeronomy I

TERMS FOR RECEIVING THE SIGNATURE:

Attendance to the lectures 70%.

EXAMINATION METHODS:

Written (written part of the exam may be exempt those who pass all preliminary exams) and oral exam.

REQUIRED LITERATURE:

Vršnak, B.: Foundations of the plasma physics (in Croatian), Školska knjiga, Zagreb 1996.

Backus, G., Parker, R., Constable, C.: Foundations of Geomagnetism, Cambridge Univ. Press, Cambridge 2003.

Jacobs, J.A.: The Earth's Core, Academic Press, London 1987.

Chamberlain, J.W.: Theory of Planetary Atmospheres, Academic Press, London 1978.

GEOPHYSICAL PRAKTIKUM	**2+2+0**	**0+0+0**

COURSE CONTENT:

Basics of spherical astronomy. Determination of the horizontal component of the magnetic field and the declination. Lamont and Gauss's positions. Basics of inverse problems. Geiger's method for earthquake location. Graphical method for the fault-plane solution on Schmidt net.

PREREQUISITES FOR THE COURSE:

Passed: Seismology I-III

TERMS FOR RECEIVING THE SIGNATURE:

Regular attendance to the lectures.

EXAMINATION METHODS:

Written report and oral discussion.

REQUIRED LITERATURE:

Stein, S. and M. Wysession: An introduction to Seismology, Earthquakes and Earth structure, Blackwell Publ., 2003.

Lay, T., T. C. Wallace: Modern Global Seismology, Academic Press, San Diego, 1995.

Udias, A.: Principles of Seismology, Cambridge University Press, United Kingdom, 1999.

Kasumović, M., Opća i primjenjena geofizika s osnovama sferne astronomije I dio – opća geofizika, PMF Sveučilište u Zagrebu, 1971.

Kasumović, M., Opća i primijenjena geofizika s osnovama sferne astronomije III dio-opća geofizika, PMF Sveučilište u Zagrebu, 1971.

Fanselau, G., Geomagnetismus und Aeronomie – Band II, VEB Deutscher Verlag der Wissenschaften, Berlin 1960.

FUNDAMENTALS OF ATMOSPHERIC MODELLING	**0+0+0**	**2+1+0**

COURSE CONTENT:

Classification of atmospheric models. Numerical models. Numerical schemes, initial and boundary conditions. Model initialization. Nesting. Types of atmospheric numerical models: shallow-water models, global models, mesoscale models, microscale models, climate models. Parameterisations in atmospheric models: turbulence, surface layer, microphysics, convection, radiation, etc. Air quality models: Gaussian, Euler, Lagrange. Coupling of atmospheric and oceanographic models.

PREREQUISITES FOR THE COURSE:

Passed: Introduction to Geophysical Fluid Dynamics, Dynamic meteorology I

TERMS FOR RECEIVING THE SIGNATURE:

Homeworks, attendance to the lectures 70%.

EXAMINATION METHODS:

Written report and oral discussion.

REQUIRED LITERATURE:

Pielke, R. A.: Mesoscale Meteorological Modeling. Academic Press, San Diego, 2002.

Jacobson, M. Z.: Fundamentals of Atmospheric Modeling. Cambridge University Press, New York, 1999.

HYDROLOGY I	**2+1+0**	**0+0+0**

COURSE CONTENT:

Definition of hydrology and its connection with other sciences. Hydrological cycle. History, development, tasks and applicatin of hydrology. Estimated amounts of water on the Earth. Mean annual precipitaion on a basin. PDF and IDF curves and their application in hydrology. Evaporation from water surface and evapotranspiration. Infiltration and humidity in the ground. Hydraulics of open channels: application of Bernouly equation for ideal and real liquid, uniform flow, Chezy formula, Manning-Strickler formula, measuring equipment, spillways,ununiform flow. Filtration: Darcy's law, Dupuit's theory.

PREREQUISITES FOR THE COURSE:

TERMS FOR RECEIVING THE SIGNATURE:

Regular attendance to the lectures.

EXAMINATION METHODS:

Oral exam.

REQUIRED LITERATURE:

Žugaj, R.: HYDROLOGY, coursebook, Sveučilište u Zagrebu, Rudarsko-geološko-naftni fakultet, Zagreb, 2000.

HYDROLOGY II	**0+0+0**	**2+1+0**

COURSE CONTENT:

Properties of hydrological occurrences, hydrological data, basin, runoff factors. Hydrometry: measurements of water level, velocity, water and sediment discharge. Stage hydrograph, discharge curve, hydrograph and its component parts,frequency curves and water level and discharge curves, runoff coefficient and specific discharge from a basin. Probability and statistics in hydrology. Linear and nonlinear correlation, double mass amounts. High waters: distribution curves, unit hydrograph, triangle-shaped hydrograph, isochrone method. Rational formula and other empirical formulas. Low waters of various return periods, periods of low water and of hydrological drought. Sedimentation in watercourses. General equation of hydrological balance. Regional hydrological analysis.

PREREQUISITES FOR THE COURSE:

TERMS FOR RECEIVING THE SIGNATURE:

Regular attendance to the lectures.

EXAMINATION METHODS:

Oral exam.

REQUIRED LITERATURE:

Žugaj, R.: HYDROLOGY, coursebook, Sveučilište u Zagrebu, Rudarsko-geološko-naftni fakultet, Zagreb, 2000.

INTRODUCTION TO GEOPHYSICAL FLUID DYNAMICS	2+1+0	0+0+0

COURSE CONTENT:

Atmosphere-ocean system: Solar radiation. Temperature distribution. Greenhouse effect. Convection. Variability of radiative forcing and consequent horizontal gradients. Atmosphere-sea interaction. Characteristics of fluid in rest – Equation of state. Thermodinamic variables. Water vapor in atmosphere. Phase transitions. Fluid parcels in equilibrium (pressure gradient force, gravity), hidrostatic equation. Vertical structure of atmosphere and sea. Static stability, Brunt-Väisälä frequency, potential temperature, potencijalna density. Vertical profiles and their graphical presentation. Fluid in motion – Fluid parcel. Continuity equation. Equation of conservation of scalar quantity (humidity, salinity). Heat equation. Equation of motion, Coriolis force, viscosity effects (molecular, turbulent). Scales of motion. Boundary conditions (solid boudary, material boundary, internal boundary). Jednadžba gibanja, Coriolisova sila, viskozni efekti (molekularni, turbulentni).

PREREQUISITES FOR THE COURSE:

Passed: General Physics 1-4, Mathematical Analysis 1 and 2, Linear Algebra

TERMS FOR RECEIVING THE SIGNATURE:

Homeworks.

EXAMINATION METHODS:

Written and oral exam.

REQUIRED LITERATURE:

Gill, A., 1982: Atmosphere-Ocean Dynamics. Academic Press, Orlando. 662 pp.

Cushman-Roisin, B., 1994: Introduction to Geophysical Fluid Dynamics, Prentice Hall, London, 320 pp.

Kundu, P. K., 1990: Fluid mechanics. Academic Press, San Diego, 638 pp.

SEISMOMETRY	0+0+0	2+1+0

COURSE CONTENT:

Seismograph as a measuring system. Static characteristics of the system. Dynamic characteristics of the system. Transfer function and response functions. Poles and zeros. Mechanical seismographs. The indicator equation. Dynamic magnification (frequency response). Parts and construction. Electromagnetic seismographs. Frequency response. Parts and construction. Practical measuring and evaluating of frequency response. Broadband seismograph. Accelerograph. Time and GPS.

PREREQUISITES FOR THE COURSE:

Passed: General Physics 1-4, Introductory Physical Praktikum 1 i 2, Classical Mechanics 1 and 2, Mathematical Methods in Physics 1 and 2

Attended: Introduction to Spectral Analysis

TERMS FOR RECEIVING THE SIGNATURE:

Regular attendance to the lectures (70%) and exercises (100%) with positively evaluated report from exercises.

EXAMINATION METHODS:

Oral exam.

REQUIRED LITERATURE:

Scherbaum, F.: Of Poles and Zeros, Kluwer Academic Publishers, Dodrecht, Nederlands 1996,
Šantić, A. Electronical instrumentation (in Croatian), Školska knjiga, Zagreb 1988,
Skoko, D.: Basics of seismograph theory (in Croatian), Institut za zemljotresno inženerstvo i inženerska Seismology na Univerzitetot "Kiril i Metodij", Skopje 1981.

ENGINEERING SEISMOLOGY	0+0+0	2+1+0

COURSE CONTENT:

Earthquake catalogues. Gutenberg-Richter relation, estimation of the catalogue completeness. Functions of attenuation of intensity, PGA, PGV, PGD. Dinamic factor of amplification (DAF), amplification spectra for vertically incident SH-waves. Seismic hazard and risk.

PREREQUISITES FOR THE COURSE:

Passed: Seismology I and II
Attended: Seismology III

TERMS FOR RECEIVING THE SIGNATURE:

Regular attendance to the lectures.

EXAMINATION METHODS:

Oral exam.

REQUIRED LITERATURE:

Agarwal, P.N.: Engineering Seismology, Oxford & IBH Publishing, New Delhi 1991.
McGuire, R. K: Seismic Hazard and Risk Analysis, EERI, Oakland CA, 2004.
Reiter L.: Earthquake Hazard Analysis. Columbia University Press. New York 1991.

SEISMOTECTONICS	0+0+0	2+1+0

COURSE CONTENT:

Research methods. Regional tectonic movements. Classification of structures and faults. Types of structures (examples). Relation between stress and deformation of structures. Seismogene structures. Underthrusting, reverse, normal, transform and transcurrent displacement. Seismotectonic active faults. Structural relations in space, marker horizons. Earthquakes and zones of occurence. Tectonical causes of earthquakes. Energetic, spatial and temporal characteristics of earthquakes. Epicentral areas. Seismoc sources. Effects of seismic forces at the surface. Non-seismic evolvement.

PREREQUISITES FOR THE COURSE:

TERMS FOR RECEIVING THE SIGNATURE:

Attendance to the lectures 70%, and correctly completed and submitted programs.

EXAMINATION METHODS:

Oral exam.

REQUIRED LITERATURE:

Uyeda, S. (1979): The New View of the Earth. Freeman and Co. New York.
Moores, M. E. & Twiss, J. T. (1999): Tectonics. Freeman and Co., New York**.**
Balt, B. A. (1999): Earthquakes. Freeman and Co., New York.
Keller, E. & R Pinter, N. (2002): Active Tectonics, Earthquakes, Uplifts and Landscape. Prentiuc Will New York.
RGN fakultet i Geofizički odsjek PMF (1990): Seizmotektonska karta Hrvatske.

FUNDAMENTALS OF GEOPHYSICAL EXPLORATION I	2+2+0	0+0+0

COURSE CONTENT:
Gravity exploration – Physical bases. Gravimeter. Gravity effects of geometric forms. Equipment and instruments. Data acquisition and data reduction. Rock densities. Ambiguity in gravity interpretation. Gravity modelling. Isostasy. Applications of gravity exploration. Magnetic exploration – The Earth's magnetic field. Induced and remanent magnetization. Magnetic minerals and rocks. Proton magnetometer. Data acquisition. Data reduction. Interpretation. Applications of magnetic exploration. Geoelectrical exploration – Overview of geoelectrical methods. Electrical properties of rocks. Spontaneous potential method. Resistivity methods. Electrical sounding and profiling: instruments and equipment, measurements, data processing, interpretation. Induced polarization method. Applications of geoelectrical exploration.
PREREQUISITES FOR THE COURSE:

TERMS FOR RECEIVING THE SIGNATURE:
Attendance to the lectures 80%, passed one (of three) colloquiums, submitted all programs and completed field exercises.
EXAMINATION METHODS:
All three preliminary exams passed, or oral exam.
REQUIRED LITERATURE:
Parasnis, D.S.: Principles of Applied Geophysics, Chapman and Hall, New York 1986.
Šumanovac, F.: Geophysical Explorations – Geoelectrical and Seismic Methods (in Croatian), RGN, Zagreb 1998.

FUNDAMENTALS OF GEOPHYSICAL EXPLORATION II	**0+0+0**	**2+2+0**

COURSE CONTENT:
Seismic exploration – Generation and propagation of seismic waves. Time-distance graph for a layered medium. Instruments and equipment: seismic sources, detectors (geophones), seismographs. Refraction seismic exploration: data acquisition and processing, interpretation methods, complications in refraction interpretation (the blind and hidden layers), applications. Reflection seismic exploration: data acquisition, data processing (the static, the NMO and the residual corrections, the velocity analysis), seismic velocity measuring, interpretation of seismic reflection sections, migration, applications. Well logging – Overview of logging methods. Electrical properties of rocks and formation factor. Distribution of fluids and resistivities in a permeable layer. The spontaneous potential log. Resistivity logs: normal and lateral sounds, sounds with focused current (laterologs), microsounds, induction sound. Radioactive logging: the gamma-ray log, the density log, the neutron log. The sonic logging. Miscellaneous logging: the temperature log, the caliper log, the dipmeter log.
PREREQUISITES FOR THE COURSE:

TERMS FOR RECEIVING THE SIGNATURE:
Attendance to the lectures 80%, passed one (of three) colloquiums, submitted all programs and completed field exercises.
EXAMINATION METHODS:
All three preliminary exams passed, or oral exam.
REQUIRED LITERATURE:
Parasnis, D.S.: Principles of Applied Geophysics, Chapman and Hall, New York 1986.
Šumanovac, F.: Geophysical Explorations – Geoelectrical and Seismic Methods (in Croatian), RGN, Zagreb 1998.

CLIMATOLOGY I	**2+1+0**	**0+0+0**

COURSE CONTENT:
1. Definitions of climate. Historical development of climatology. 2. Climate system. Climate elements and factors. 3. Solar radiation. Atmospheric and terrestrial longwave radiation. 4. Radiation balance. Energy balance. 5. Air temperature distributions. 6. Oceanity and continentality measures. 7. General atmospheric circulation. Air movements on synoptic and local scales. 8. Hydrological cycle. 9. Precipitation amount distributions. 10. Basics of bioclimatology. 11. Climate classifications. 12. Climate changes. 13. Climate models.
PREREQUISITES FOR THE COURSE:
Passed: General Physics 1-4, Mathematical Analysis 1 and 2
TERMS FOR RECEIVING THE SIGNATURE:
Computer and regular exercises.
EXAMINATION METHODS:
Written (written part of the exam may be exempt those who pass all preliminary exams) and oral exam.
REQUIRED LITERATURE:
Hartman, D.L.: Global Physical Climatology. Academic Press, N.Y., 1994.
Hidore, J.J., J.E. Oliver: Climatology: An Atmospheric Science. Macmillan, 1993.
Penzar, B., B. Makjanić: Uvod u opću klimatologiju, Sveučilište u Zagrebu, Zagreb, 1978.

CLIMATOLOGY II	**0+0+0**	**2+1+0**

COURSE CONTENT:
1. Solar irradiation components. 2. Atmospheric and terrestrial longwave radiation. 3. Radiation balance. Energy balance. 4. Specific characteristics of global atmospheric circulation and air motions on different scales. 5. Microclimatology 6. Hydrological cycle. 7. Bioclimatology. 8. Natural and anthropogenic climate changes. 9-11. Parameterizations of physical processes in climate models. 12-13. Linking climate with other models. 14. Climate change.
PREREQUISITES FOR THE COURSE:
Passed: Introduction to Geophysical Fluid Dynamics, Dynamic meteorology I
TERMS FOR RECEIVING THE SIGNATURE:
Computer and regular exersises..
EXAMINATION METHODS:
Written (written part of the exam may be exempt those who pass all preliminary exams) and oral exam.
REQUIRED LITERATURE:
Hartman, D.L.: Global Physical Climatology. Academic Press, N.Y., 1994.
Hidore, J.J., J.E. Oliver: Climatology: An Atmospheric Science. Macmillan, 1993.
Penzar, B., B. Makjanić: Uvod u opću klimatologiju, Sveučilište u Zagrebu, Zagreb, 1978.

DYNAMICS OF COASTAL SEA	**0+0+0**	**2+1+0**

COURSE CONTENT:
Wind-driven currents in the seas: models developed by Weenink, Felzenbaum and Welander. Comparison with the wind-driven currents in the oceans: models proposed by Sverdrup, Stommel and Munk. Seiches: analytical modeling of generation and decay, development of a simple one-dimensional numerical model, comparison with the observations. Topographic Rossby waves: analytic models for the straight coast and circular basin. Exercises include analyses of analytic solutions for various sets of parameters and one-dimensional numerical modeling of seiches.
PREREQUISITES FOR THE COURSE:

TERMS FOR RECEIVING THE SIGNATURE:
Regular attendance to the lectures.
EXAMINATION METHODS:
Written and oral exam.
REQUIRED LITERATURE:
LeBlond, P.H., L.A. Mysak: Waves in the Ocean, Elsevier, Amsterdam 1978.
Schwind, J.J.: Geophys. Fluid Dynamics for Oceanographers, Prentice Hall, Englewood Cliffs 1980.
Simons, T.J.: Circulation Models of Lakes & Inland Seas, Dep.of Fisheries & Oceans, Ottawa 1980.
Stocker, T., K. Hutter: Topographic Waves in Channels and Lakes on the f-Plane, Springer Verl., New York 1987.
Wilson, B.W.: Seiches, Advances in Hydroscience, 8, 1972.

CLIMATOLOGY III	**2+2+0**	**0+0+0**

COURSE CONTENT:
Sources of climatological data. Climatological bulletins and atlases. Climatological data on Internet. Nature of climatological series: random and non-random part. Annual cycle, ways of computation and properties. Trend and long-term oscillations. Calculation of climatological normals for real data. Stationary stochastic processes, ergodicity, estimation of the autocorrelation function. White noise, general linear process, AR(1), AR(2) processes. Higher-order models, fitting the model to measured data. Simulations of climatological time series. Exercises comprise the processing and analysis of real-world time series. This includes writing programs (in Matlab) for analysis and simulation of time series, as well as interpretation of results.
PREREQUISITES FOR THE COURSE:
Passed: Statistical Methods in Geophysics, Climatology I and II
TERMS FOR RECEIVING THE SIGNATURE:
Regular attendance to the lectures. Successfully and timeley completed homework tasks.
EXAMINATION METHODS:
The exam consists of the practice (writing a computer programme and analysing specific data) and oral exam.
REQUIRED LITERATURE:
Wilks, D.S.: Statistical Methods in the Atmospheric Sciences, Academic Press, New Yorak, 1995.

INTRODUCTION TO SPECTRAL ANALYSIS	**2+1+0**	**0+0+0**

COURSE CONTENT:
1-2. Types of data. Fourier series and its complex form. 3. Fourier integral. Inverse Fourier trannsformation. 4. Power density spectrum, Autocorrelation function and its link to the power spectrum. 5. Properties of physical systems with respect to the frequency. 6. Dirac delta function, properties and applications. 7. Dirac's comb and its Fourier pair. 8-9. Digital filtering, convolution integral, ideal low-pass filter. 10. Filtering discrete data. Trend. 11. Sampling and aliasing. 12. Sampling theorem. Data samples of finite length.
PREREQUISITES FOR THE COURSE:
Attended: Mathematical Analysis 1 and 2, Mathematical Methods in Physics 1 and 2
TERMS FOR RECEIVING THE SIGNATURE:
Regular attendance to the lectures, completed exercise.
EXAMINATION METHODS:

Positively evaluated two preliminary exams with the possibility of correcting the grade on the oral exam. Otherwise, by the oral exam..

REQUIRED LITERATURE:

Bath, M. Spectral analysis in geophysics, Elsevier, Amsterdam, 1974.

Bracewell, R. N: The Fourier transform and its applications, McGraw-Hill, New York, 1983.

Papoulis, A: The Fourier integral and its applications, McGraw-Hill, New York, 1962.

INTRODUCTION TO METEOROLOGY	2+0+0	0+0+0

COURSE CONTENT:

1. Meteorological elements; 2. Weather, clima; 3. Radiation balance; 4. Air temperature; 5. Atmospheric processes (isobaric, adiabatic, isothermal); 6. Atmospheric processes (continued); 7. Conversion of water; 8. Clouds, precipitation; 9. Air masses, fronts; 10. Air pressure; 11. Atmospheric flows; 12. Basics of weather forcasting.

PREREQUISITES FOR THE COURSE:

TERMS FOR RECEIVING THE SIGNATURE:

Essays, project in the group.

EXAMINATION METHODS:

Colloquiums and oral exam.

REQUIRED LITERATURE:

Penzar, I., Penzar, B., 1985: Agroclimatology (in Croatian). Školska knjiga, Zagreb, 274 pp.

http://jadran.gfz.hr/

Penzar, B. i suradnici (1996): Meteorology for users (in Croatian), Školska knjiga, Zagreb, 274 pp.

ATMOSPHERE AND SEA DYNAMICS	0+0+0	2+2+0

COURSE CONTENT:

Atmosphere: Composition of air, division of the atmosphere, gas equation. Energy of solar and earth radiation. Heating and cooling of the land, sea and air. Changes in the water phase, physics of cloud and precipitation. Field pressure and motion of air. Winds, turbulent systems, general circulation of the atmosphere. Climatic classification. Basics of weather forecasting. Anthropogenic impacts on the atmosphere.

Sea: Features of the sea and motion in the sea - a review. Measuring instruments, "in-situ and Remote Sensing. Salinity: the exchange of moisture on the border between the atmosphere/sea, the salinity distribution. Temperature: heat exchange between the atmosphere and the sea, the distribution of temperature. Pressure, density, water masses, mixing; advection/convection. Circulation in seas and oceans; geostrophic currents, wind currents (Ekman spiral), thermohaline currents. Wind-driven waves, tsunami, seshee, inertial oscillations, Rossby's waves. Tides: causes of force, a description of the phenomenon, elementary dynamics. Slow down storm: the impact of air pressure and wind on the motion in the coastal area. Seasonal variability. *System of air-sea:* Climate fluctuations, El Nino, link between Atlantic and Europe. Climatic changes, astronomical cycles, anthropogenic effects.

PREREQUISITES FOR THE COURSE:

TERMS FOR RECEIVING THE SIGNATURE:

Regular attendance to the lectures.

EXAMINATION METHODS:

Written and oral exam.

REQUIRED LITERATURE:

Open University Course Team, 2001: Ocean Circulation, 2nd Edition. Butterworth-Heinemann, Oxford, 286 pp.

Open University Course Team, 1995: Seawater: Its Composition, Properties and Behaviour, 2nd Edition. Butterworth-Heinemann, Oxford, 166 pp.

Open University Course Team, 2002: Waves, Tides and Shallow-Water Processes, 2nd Edition. Butterworth-Heinemann, Oxford, 227 pp.

Penzar, I., Penzar, B., 1989: Agroclimatology - second edition (in Croatian). Školska knjiga, Zagreb, 274 pp.

GEOPHYSICS	**2+1+0**	**0+0+0**

COURSE CONTENT:

Introduction to the Earth (shape and size, mass and density, the Moon, the Earth's axis, the Earth's orbit, temperatures on Earth, atmosphere, origin of Earth, origin of water on Earth, Earth's interior – formerly and today). Coordinates on the Earth's surface (sphere coordinates – axis and major circle, latitude and longitude, Earth as spheroid, geoid and geoid undulations, altitude and depths). Gravity (Newton's law of gravitation and force of gravity, centripetal and centrifugal forces, gravitation, Clairaut's theorem, measurements of gravity accelerations, reduction of measured values of gravity accelerations – correction for altitude, Bouguer's correction, topographical correction, normal values of gravity accelerations, gravity field of the Earth, anomalies of gravity field, tides). Isostasy (concept of isostasy, Pratt's and Airy's theory of isostasy). Seismicity and the sources of earthquakes (concept of seismicity, spatial distribution and statistics of earthquakes, causes of earthquakes, sources and types of earthquakes, earthquake mechanism and Reid's elastic rebound theory, macroseismic method of earthquake investigation – earthquake intensity, macroseismic scales, isoseismal maps, microseismic method of earthquake investigation – earthquake magnitude, microseisms, tsunami). Seismic waves and Earth's internal structure (constants of elasticity, oscillation and waves, wave equation, reflection, refraction, concept of seismograph, earthquake waves – body and surface, hodochrones and microseismical method of epicenter determination, earthquake magnitude, investigations of Earth's interior, Moho discontinuity). Earth's magnetism (general terms, the Earth's magnetic field, geomagnetic elements, magnetosphere and main field, magnetic poles, polar light). Earth's internal heat (heat as energy transfer, heat flow, heat conduction, heat convection – adiabatic temperature gradient, measurement of the Earth's surface heat flow).

PREREQUISITES FOR THE COURSE:

TERMS FOR RECEIVING THE SIGNATURE:

Regular attendance to the lectures (at least 70%) and in each of two colloquiums collected at least 20% points.

EXAMINATION METHODS:

Written exam (those who on each of two colloquiums collect at least 50% points are exempt from written exam), and possibly oral exam - for a higher grade than received in written exam.

REQUIRED LITERATURE:

Bullen, K.E. and B.A. Bolt, 1985. Introduction to the Theory of Seismology, Cambridge

Kasumović M., 1971. General and Applied Geophysics with the Basics of Spherical Astronomy (I part - General Geophysics) - in Croatian, Sveučilište u Zagrebu, ZagrebLay, T. and T.C. Wallace, 1995. Modern Global Seismology, Academic Press, Toronto

Garland, G.D.,1979. Introduction to Geophysics, W.B. Saunders Co., Toronto

Turcotte D.L. and G. Schubert, 2002. Geodynamics, Cambridge University Press, Cambridge

FUNDAMENTALS OF GEOPHYSICS	2+1+0	0+0+0

COURSE CONTENT:
Introduction to the Earth. Coordinates on the Earth's surface. Gravity. Isostasy. Seismicity and the sources of earthquakes. Seismic waves and Earth's internal structure. Equation of a ray path. Condition that ray path has an extrem. Mohorovičić discontinuity. Earth's magnetism. Earth's internal heat.
PREREQUISITES FOR THE COURSE:

TERMS FOR RECEIVING THE SIGNATURE:
Regular attendance to the lectures (at least 70%) and in each of two colloquiums collected at least 20% points.
EXAMINATION METHODS:
Written exam (those who on each of two colloquiums collect at least 50% points are exempt from written exam), and possibly oral exam - for a higher grade than received in written exam.
REQUIRED LITERATURE:
Bullen, K.E. and B.A. Bolt, 1985. Introduction to the Theory of Seismology, Cambridge
Kasumović M., 1971. General and Applied Geophysics with the Basics of Spherical Astronomy (I part - General Geophysics) - in Croatian, Sveučilište u Zagrebu, ZagrebLay, T. and T.C. Wallace, 1995. Modern Global Seismology, Academic Press, Toronto
Garland, G.D.,1979. Introduction to Geophysics, W.B. Saunders Co., Toronto

FUNDAMENTALS OF GEOPHYSICS	2+1+0	0+0+0

COURSE CONTENT:
Introduction to the Earth (shape and size, mass and density, the Moon, the Earth's axis, the Earth's orbit, temperatures on Earth, atmosphere, origin of Earth, origin of water on Earth, Earth's interior – formerly and today). Coordinates on the Earth's surface (sphere coordinates – axis and major circle, latitude and longitude, Earth as spheroid, geoid and geoid undulations, altitude and depths). Gravity (Newton's law of gravitation and force of gravity, centripetal and centrifugal forces, gravitation, Clairaut's theorem, tides). Isostasy (concept of isostasy, Pratt's and Airy's theory of isostasy). Seismicity and the sources of earthquakes (concept of seismicity, spatial distribution and statistics of earthquakes, causes of earthquakes, sources and types of earthquakes, earthquake mechanism and Reid's elastic rebound theory, macroseismic method of earthquake investigation – earthquake intensity, macroseismic scales, isoseismal maps, microseismic method of earthquake investigation – earthquake magnitude, microseisms, tsunami). Seismic waves and Earth's internal structure (constants of elasticity, oscillation and waves, wave equation, reflection, refraction, concept of seismograph, earthquake waves – body and surface, hodochrones and microseismical method of epicenter determination, earthquake magnitude, investigations of Earth's interior, Moho discontinuity). Locating of an epicenter using macroseismic and microseismic methods. Earth's magnetism (general terms, the Earth's magnetic field, geomagnetic elements, magnetosphere and main field, magnetic poles, polar light). Earth's internal heat (heat as energy transfer, heat flow, heat conduction, heat convection – adiabatic temperature gradient, measurement of the Earth's surface heat flow).
PREREQUISITES FOR THE COURSE:

TERMS FOR RECEIVING THE SIGNATURE:
Regular attendance to the lectures (at least 70%) and in each of two colloquiums collected at least 20% points.
EXAMINATION METHODS:
Written exam (those who on each of two colloquiums collect at least 50% points are exempt from written exam), and possibly oral exam - for a higher grade than received in written exam.
REQUIRED LITERATURE:
Bullen, K.E. and B.A. Bolt, 1985. Introduction to the Theory of Seismology, Cambridge
Kasumović M., 1971. General and Applied Geophysics with the Basics of Spherical Astronomy (I part - General Geophysics) - in Croatian, Sveučilište u Zagrebu, Zagreb