



Faculty of
Environmental Sciences

Final State Examinations for Bachelor Programmes – Thematic Areas

2024

**Geographic Information Systems and Remote Sensing in
Environmental Sciences**

Geographical information systems

1. **What is GIS and what is it for:** Definition of GIS, structural and functional components. Geoinformation system as a model of the real world, spatial data. Object and phenomenon view of the real world. Examples of the use of GIS in environmental disciplines.
2. **Methods of spatial data acquisition:** Principle of geodetic and other mapping methods, i.e. tacheometry, surface levelling, GNSS, photogrammetry, laser scanning.
3. **Coordinate systems and map projections:** Planar and spatial coordinate systems, map projections by distortion and by projection surface, ellipse of distortion, projections used in the Czech Republic.
4. **Basics of GNSS:** Principles of positioning using GNSS, components of the GNSS architecture, formats and communication protocols of GNSS, existing systems, factors influencing the accuracy of GNSS positioning.
5. **Vector data model in GIS:** Geometry and topology, attributes, vector data formats. Principles of vectorization.
6. **Analyzes of vector data:** Spatial queries, topological overlay, buffer. Examples of use.
7. **Raster model of GIS data:** Geometry and topology, attributes, raster data formats, resolution, pyramids, thematic (discrete) and continuous rasters. Georeferencing (principle and transformation methods, RMSE as a measure of transformation accuracy). Raster resampling (when to use, what are the methods).
8. **Map algebra:** Local, focal, zonal functions. Principles, tools, examples of use.
9. **Spatial interpolation:** Overview of methods, principles of individual methods, comparison of methods based on their application. Examples of use. The concept of spatial autocorrelation.
10. **Digital terrain models:** Acquisition methods, available local and global models of terrain and surface, basic characteristics of individual products.
11. **Digital terrain analysis:** Basic terrain characteristics (definition and calculation in GIS), visibility analyses, hydrological terrain analyses (basic principles and tasks).
12. **Basics of relational databases:** Entities, relations, E-R diagram, primary and foreign key, cardinality and partiality of relation, decomposition of relation, referential integrity. How to proceed with database design.
13. **Basics of SQL:** Commands for creating and editing database tables. Construction of database queries.
14. **Spatial databases:** What they are and what they are used for. ArcGIS file geodatabase. Simple Features; OpenGIS; WKT; WKB; PostGIS; MBR in ST_x; basic functions for working with spatial relationships and spatial queries.
15. **Maps in the Czech Republic:** Historical maps - military maps, stable cadastre; state map series – topographic map, base map, state map, cadastral map, thematic maps; ZABAGED.
16. **Spatial data (not only) in the environmental sciences:** Data in nature and landscape protection (ISOP, VMB, NDOP ...), in agriculture and soil protection (LPIS, BPEJ ...), in forestry (ÚHÚL data ...), terrain and surface data (DMR xG, DMP xG, SRTM...), in planning and public administration (RÚIAN, digital data of the real estate cadastre, spatial analytical data...). National Geoinformation Strategy, INSPIRE.
17. **Open data and open software:** Definition of open data, examples of open data and institutions providing such data in the Czech Republic and in the world. Examples of open software and open formats (especially formats used for spatial data).
18. **Visualization of geographic data:** Qualitative and quantitative attributes of spatial data, map symbols and their parameters, design of color scales, classification. Terrain relief presentation (spot heights, contours, skeletal lines, hypsometric tints, shading, hachures).
19. **Thematic mapping:** Methods and their use in relation to the data types: choropleth maps, diagram maps, dot maps, isolines, cartograms.

20. **Technology for online publication of spatial data:** frontend; back end; local vs. remote (database) server; geodatabase GeoNames; (reverse) geocoding. Map services, OGC standards (WMS, WFS...).

Literature:

- Textbooks for subjects Geographical information systems I and II, Cartography and Mapping I and II, Geodatabases, Global Navigation Satellite Systems, Open Data and GIS (available at <https://moodle.czu.cz>).
- Portal DataCamp (www.datacamp.com)
- Portals of ČÚZK (www.cuzk.cz), ArcData Praha (arcdata.cz), AOPK ČR (www.ochranaprirody.cz), LPIS (eagri.cz), SZIF (www.szif.cz), ÚHÚL (www.uhul.cz) and other institutions.

Remote Sensing

1. **History and present of remote sensing (RS):** aerial imagery, military satellites (Corona, Hexagon); natural resource satellites (Landsat, SPOT, Sentinel); unmanned aerial vehicles; very high-resolution satellites (WorldView, Planet).
2. **Basic principles of RS:** definition and principle of RS; physical nature of RS; platforms and their advantages.
3. **Electromagnetic radiation:** wavelength; frequency; amplitude; SI units; types of radiation used in RS and their applications (UV, VIS, NIR, SWIR, TIR, Microwave).
4. **Radiation sources in RS:** radiation laws (Stefan-Boltzmann law, Wien's shift law, photon energy-frequency relationship); energy sources; day and night sensing; atmospheric effects.
5. **Colour perception:** additive and subtractive colour composition, colour models; colour synthesis and its applications.
6. **Types of RS platforms, sensors, sensing techniques:** platforms; active and passive sensing.
7. **RS data:** image origin; spatial, spectral, radiometric and temporal resolution; RGB, multispectral, hyperspectral RS data and their applications.
8. **Geometric correction of RS data:** types of possible data distortion; distortion correction; data pre-processing level.
9. **Radiometric correction of DPZ data:** radiometric calibration; influence of atmosphere - transmittance, absorption, and scattering; types of atmospheric corrections.
10. **Visualisation and highlighting of image data:** histogram (histogram expansion methods); single-band data and their highlighting (thresholding); multispectral data and their highlighting (colour synthesis).
11. **Basic image processing methods:** principle of separability of different surfaces; spatial filtering (low pass vs. high pass); principle of pan-sharpening; spectral band ratios.
12. **Spectral indices:** principle and purpose of spectral indices; ratio indices (NDVI, NDWI, GNDVI, SR, etc.); biophysical RS parameters (leaf area index, proportion of photosynthetically active radiation absorbed by vegetation, soil moisture, evapotranspiration).
13. **Image transformation:** principle of decorrelation; principal component analysis (PCA); Tasseled Cap transformation.
14. **Classification of DPZ image data:** principle and purpose of classification; thresholding, unsupervised, supervised and object-based approaches; validation of classification (error matrix, Kappa coefficient, user and processing accuracy).
15. **Radar basics and principles:** physical nature; real and synthetic apparatus; radar image and its properties and specifics (e.g. radar shadow); practical applications in environmental monitoring.

16. **Basics and principles of LiDAR:** physical nature; types of reflections; point cloud (principle, filtering, classification); practical application in environmental monitoring.
17. **Basics and principles of thermal data:** physical nature; temperature measurement (kinetic vs. radiative temperature); emissivity of basic surface types; practical application in environmental monitoring.

Literature:

- Kropáček, J., Moravec, D., Komárek, J. 2020: Remote Sensing - I, ČZU, Praha, 122 s.
- Klaus Tempfli, Norman Kerle, Gerrit C. Huurneman and Lucas L. F. Janssen 2009: Principles of Remote Sensing - An introductory textbook, ITC, Enschede.
- *Textbooks for individual subjects available at <https://moodle.czu.cz>.*

Ecology and nature conservation

1. **Populations and population dynamics:** definition, abundance and density, natality and mortality, sex ratio, age structure, biotic potential, carrying capacity of the environment, Allee effect, population cycles and outbreaks.
2. **Species distribution:** range, migration, dispersion, expansion, biological invasion, endemic species.
3. **Life strategies:** r and K strategies, consequences of stress and disturbance, territoriality, ecological niche.
4. **Interspecific interaction:** interference, exploitation, predation, types of predators, specialist, generalist, commensalism, proto cooperation, mutualism, allelopathy, competition, parasitism.
5. **Communities and succession:** definition, species diversity, ecotones, allogenic, autogenic, primary, secondary and degradation succession, edaphic and climatic climaxes.
6. **Ecosystem:** definition, functional components, energy flow, food chains and pyramids.
7. **Forest and non-forest ecosystems:** structure of natural and human-modified forest stands, primary and secondary non-forest vegetation in Central Europe, disturbance, the role of deadwood in forest ecosystems, vertical vegetation zonation.
8. **Introduction to nature conservation** (definitions; goals, basic instruments & approaches; brief history including development of paradigms; the current state of the art; nature conservation mainstreaming and integrating into other sectors; evidence-based nature conservation).
9. **Biological diversity** (definition; three main biodiversity levels + cultural diversity; advantages and disadvantages of the concept; global species richness; biological diversity assessment including monitoring and indicators; conservation planning).
10. **Key drivers of biodiversity loss** (natural and semi-natural habitat fragmentation – the main causes, major impacts and effective measurements for maintaining landscape and population connectivity; degradation, destruction and loss; overexploitation; invasive alien species; eutrophication; pollution and contamination; climate change; diseases; natural disasters; synergistic effect).
11. **Species conservation** – (definition, aims and tools; selection species to be protected or sustainably managed; Red Lists/Red Data Books; PVA; in situ species conservation: legislation, species recovery programmes/actions plans and establishing new populations: translocations, repatriations, restocking, introductions; ex situ conservation strategies – the possibilities and roles of gene banks, zoos, aquariums, botanical gardens, arboretums).
12. **Territorial protection** (protected areas – definition; IUCN management categories; the current state of the art at the global, pan-European and EU level; PAs effectiveness and

paper parks; SLOSS dilemma; PAs zonation; PA management plans; participatory approach; connectivity conservations; ecological networks; OECMs).

13. **Ecosystem management** (ecosystem – definition v. delineation; ecocomplex; “new” non-equilibrium paradigm of nature v. balance of nature in classical ecology; disturbance ecology; ecosystem resistance, resilience and carrying capacity; ecosystem integrity; ecosystem approach; adaptive management).
14. **Nature conservation/environmental management at the global scale** (global environmental patterns and issues; current state of and changes and trends in global biological diversity; sustainable development; international nature conservation policy: (i) multilateral biodiversity-related treaties; (ii) international intergovernmental and non-governmental organizations incl. private ones; (iii) international programmes, projects and initiatives; and (iv) bilateral and transboundary cooperation).
15. **Nature conservation in Europe and the European Union** (nature and landscape characteristics in the pan-European region and the EU; pan-European and EU nature conservation legislation: a common background v. differences; CAP and CFP debate; EU global footprint).
16. **Conservation genetics and genetic resources** (genetic diversity; genomics; small population genepool; inbreeding and outbreeding, bottleneck effect, founder effect; 100/1,000 rule; effective population size; vortex; genetic drift; biopiracy, bioprospecting, CBD’s Nagoya Protocol; new biotechnological methods/techniques: genetic engineering, synthetic biology, gene/genome editing, gene drive).
17. **Current nature conservation issues & emerging topics** (nature-based solutions; eDNA & DNA barcoding taxonomy; de-extinction; ecosystem services and natural capital, payments for ecosystem services; bioinformatics).

Literature:

Odum, E.P. 1959. Fundamentals of Ecology. W.B. Saunders Company. Philadelphia and London. (and later editions)

Begon, M., Harper, J.L., Townsend, C.R. 1990. Ecology: individuals, populations and communities. Blackwell Scientific Publications. Oxford.

Primack, R.B. 2006. Essentials of Conservation Biology. Sinauer Associates. Massachusetts.

Hydrology and water resources management

1. Hydrological cycle, hydrological system, dynamics of hydrological system, scale in hydrology.
2. Budyko curve, Regional hydrological balance, hydrological production, watershed, geomorphological characteristics of watershed, selected algorithms for processing DEM.
3. Hydrological data, hydrological process, hydrological variable, hydrological series, aggregation and disaggregation of hydrological series, autocorrelation function of hydrological series, introduction into the decomposition of hydrological time series.
4. The basic processing of hydrological time series, statistical properties of hydrological dataset, quantile estimation, hydrological extremes, return period, introduction into the linear model and its application in hydrology.
5. Precipitation, rainfall depth, rainfall intensity, meteorology of precipitation, convective and stratiform rainfall events, precipitation monitoring, estimation of missing rainfall data, interpolation methods of rainfall point measurement, mean areal precipitation.
6. Processing precipitation data for hydrological design purposes, probable maximum precipitation, IDF curves, DDF - depth duration frequency curves - maximum, design hyetographs.

7. Runoff, river discharge, hydrograph, flood hydrograph, N-year discharge, FDC curves, classification runoff processes, Hortonian runoff, runoff from variable source area, subsurface runoff, transformation of flood hydrograph by the river reach, transformation of flood hydrograph by the reservoir, runoff monitoring, stage-discharge relationship.
8. Evaporation, evapotranspiration, potential and actual evapotranspiration, interception, introduction into the snow hydrology, snow measurement, characteristics of snow cover, space-time dynamics of snow cover, melting, snowmelt model, day degree model.
9. Unsaturated zone, dynamics of unsaturated zone, soil water content, retention curve, Darcy Buckingham law.
10. Groundwater, Darcy law, groundwater regimes, aquifer, isolator, master recession curve.
11. Physical and chemical characteristics of water, water quality variables, monitoring of water quality, freshwater withdrawals – shares by sectors.
12. Modelling of water quality, the procedure of assessing the impacts of climate change, the climate parameters influencing water quality.
13. Urbanized Catchment, the principle of rainwater management, urban runoff pollution.
14. Groundwater, its quality, and vulnerability, the importance of groundwater.
15. Surface water, impacts influencing its quality, point and non-point sources of pollution.
16. Climate change impacts, intensification of hydrological cycle, hydrological extremes.

Literature

Dingman, S.L. (2002) Physical Hydrology. 2nd Edition, Prentice Hall, Upper Saddle River, 646 p.
Viessman, Warren, and Gary L. Lewis. Introduction to Hydrology. Upper Saddle River, NJ: Prentice Hall, 2003 (or another edition)