



Advanced Python and Spatial Modeling Implementation

Monday 18:15 – 19:45

Prof. Motti Zohar

תיאור הקורס

הקורס פיתוח למתקדמים מיועד לסטודנטים שלמדו את הקורס פייתון למתחילים (או קורס אחר שווה ערך) ומעוניינים להעמיק את האופן שבו ניתן להשתמש בפייתון לבחינה ולניתוח מרחבי-עיתי של נתונים גיאוגרפיים. במסגרת הקורס נלמד כיצד לעבוד עם מבני נתונים טיפוסיים, נכיר חבילות מסחריות ומבוססות קוד פתוח לעבודה עם מידע מרחבי ונשלב נושאים מתקדמים דוגמת ניתוח סטטיסטי, מודלים של למידת מכונה, שילוב AI בפיתוח הקוד, עיצוב ותכנון פרויקטי מבוססי פיתוח וויזואליזציה.

Course description

The Advanced Python Course is designed for students who have completed the Python for Beginners course (or equivalent) and wish to deepen their understanding of Python for spatial-temporal analysis of geographic data. Throughout the course, participants will learn to work with typical data structures, explore commercial and open-source packages for spatial data manipulation, and delve into advanced topics such as statistical analysis, machine learning models, AI in code development, software design and visualization.

סטודנטים יקרים וסטודנטיות יקרות,

- אם יש לכם לקות למידה או מוגבלות/בעיה רפואית שעשויה להשפיע על לימודיכם, ושביגה אתם זקוקים להתאמות, אנא פנו לדיקנט הסטודנטים, למדור נגישות ולקויות למידה: דוא"ל LDA@univ.haifa.ac.il טל: 04-8249265
- לאבחון והתאמות בגין לקות למידה ו/או הפרעת קשב יש לפנות ליה"ל: דוא"ל mhait@univ.haifa.ac.il טל: 04-8249022
- אם יש ברשותכם מכתב התאמות מהאוניברסיטה ואתם זקוקים להנגשה בקורס אנא פנו אליי (למרצה) בשעות הקבלה או במייל, בסמוך לתחילת הקורס.

Dear students,

- If you have a disability that may affect your studies and for which you may require accommodation, please contact the Accessibility and Learning Disabilities Department at the Dean of Students office. E-mail: LDA@univ.haifa.ac.il Phone number: 04-98249265.
- If you receive an accommodation letter, and need academic adjustments, please contact me as soon as possible.



Goals of the course

- Master Python data structures and scripting techniques for efficient geographic data management and automation.
- Use NumPy, Pandas, Matplotlib, scikit-learn, and ArcPy to build and automate GIS workflows.
- Design and implement structured, modular, reusable GIS automation workflows for diverse datasets and operational needs.
- Gain practical experience applying linear and logistic regression within GIS-based analytical workflows.
- Automate spatial data processing and integrate modeling components into complete end-to-end GIS scripting solutions.

Requirements and duties

- There are 8 exercises. Students **MUST** submit at least eight (6) exercises and pass each with a grade of at least 61. The credit for 8 exercises is **8%** (1% each).
- At the conclusion of the semester, students will individually undertake a hybrid exam (Conceptual and practical components). The examination accounts for **92%** of the final course grade. A minimum score of 61 is required to successfully pass the course.

Pay attention!

In this course, a language model-based bot is used to support the assignment evaluation process. The bot receives predefined grading rubric and analyzes submissions accordingly. Its purpose is to assist in maintaining consistency in evaluation, identifying key components of the work, and generating preliminary feedback. However, full pedagogical and academic responsibility for the evaluation, interpretation, and final grade rests solely with the lecturer.

שימו לב!

בקורס זה נעשה שימוש בבוט מבוסס מודל שפה לצורך תמיכה בתהליך בדיקת המטלות. הבוט מקבל את מחוון ההערכה שהוגדר מראש ומנתח את המטלות לאורו. השימוש בו נועד לסייע בעקביות ההערכה, בזיהוי רכיבים מרכזיים בעבודה ובהפקת משוב ראשוני. עם זאת, האחריות הפדגוגית והאקדמית המלאה על ההערכה, הפרשנות והציון היא של המרצה בלבד



Syllabus

Lesson	Date	Themes
1	23.03.2026	Course goals, expectations, and grading; Introduction to Jupyter Notebook and ArcGIS Pro Notebook; Working with AI in the course; Writing and executing Python scripts; Markdown documentation; Visualizing outputs in Jupyter.
2	30.03.2026 (online)	Python fundamentals for GIS automation; Variables and data types; Lists and dictionaries; Control flow (if/else); Loops; Functions; Introduction to Object-Oriented Programming (OOP) for automation.
3	10.05.2026	Scientific Python for GIS workflows; NumPy arrays for raster processing; Pandas for attribute tables and joins; Matplotlib for visualization; Practical SciPy utilities.
4	11.05.2026	Foundations of supervised learning; Overview of supervised learning; Linear regression (applied focus); Model evaluation (R^2 , RMSE); Data preparation for modeling.
5	18.05.2026	Implementing linear regression using scikit-learn; Model training and testing; Applying spatial predictions; Automating modeling workflows; Introduction to GitHub and version control.
6	25.05.2026	Logistic regression for spatial classification; Binary classification workflows; Suitability and risk mapping; Model evaluation (accuracy, confusion matrix); Automating classification outputs.
7	01.06.2026 (online)	Working with AI for GIS automation; Using AI tools for code assistance; Prompt design for spatial scripting; Debugging with AI; Verifying generated code; Ethical and professional considerations.
8	08.06.2026	Project design and code architecture; Designing GIS automation workflows; Script modularization; Writing reusable functions; Logging and error handling; Folder organization and configuration management; Managing Python environments (conda); dependency management; reproducible environments.
9	15.06.2026	ArcGIS API for Python; Querying and analyzing hosted feature layers; Updating data programmatically; Automating web map creation; Publishing notebooks to the cloud.
10	22.06.2026	Spatial analysis using ArcPy (Part I); Batch processing; Parameterized scripts; Building custom script tools in ArcGIS Pro; Comparing Model Builder and Python scripting.



11	29.06.2026	Spatial analysis using ArcPy (Part II); arcpy.mp module; Automating buffer, clip, and intersect tools; Writing repeatable spatial workflows.
12	06.07.2026	Spatial analysis using ArcPy (Part II): geographic data arcpy.da module; Search, update, and insert cursors; Efficient attribute manipulation; Schema management; Performance considerations.
13	06.07.2026 (online)	Open-source GIS Python; GeoPandas; Shapely; Python in QGIS and GRASS; Comparing open-source and ArcGIS environments.

Bibliography

Books:

- Nelli. (2023). *Python Data Analytics with Pandas, NumPy, and Matplotlib* (3rd ed. 2023.). Imprint: Apress.
- Hetland, & Lie Hetland, M. (2024). *Beginning Python from Novice to Professional* (4th ed. 2014.). Imprint: Apress.
- Conley. (2022). *A geographer's guide to computing fundamentals: Python in ArcGIS Pro*. Springer.

Web sources:

1. <https://docs.python.org/3/>
The official Python documentation; a complete reference for Python syntax, standard libraries, and built-in functions.
2. <https://jupyter-notebook.readthedocs.io/>
Comprehensive guide to using Jupyter Notebooks, including features for code execution, markdown, and visualization.
3. <https://research.google.com/colaboratory/>
Introduction to Google Colab, a free cloud-based Jupyter environment that supports collaboration and GPU access.
4. <https://pro.arcgis.com/en/pro-app/latest/help/notebook/>
Esri's documentation for using Python notebooks directly in ArcGIS Pro, integrated with map and layer objects.



5. <https://realpython.com/>
A rich repository of Python tutorials, with hands-on examples covering core programming, data science, and OOP.
6. <https://numpy.org/doc/>
Documentation for NumPy, the fundamental package for array-based numerical computing in Python.
7. <https://pandas.pydata.org/docs/>
User guide and API reference for Pandas, essential for data manipulation and analysis, especially with tabular GIS data.
8. <https://matplotlib.org/stable/users/index.html>
Documentation for Matplotlib, the standard Python library for creating visualizations, plots, and graphs.
9. <https://scikit-learn.org/stable/>
Official documentation for Scikit-learn, a widely used Python library for implementing machine learning algorithms.
10. <https://developers.arcgis.com/python/>
Guide for the ArcGIS Python API, enabling access to Web GIS features such as querying, mapping, and analysis.
11. <https://geopandas.org/>
Combines the power of Pandas with spatial operations from shapely and fiona to work with geospatial vector data.
12. <https://hub.arcgis.com/>
Esri's Open Data Hub, offering access to thousands of open geospatial datasets from governments and organizations.

Usfull forums:

1. <https://gis.stackexchange.com/>
A Q&A forum focused on GIS software, spatial data, and geospatial programming-including ArcGIS, QGIS, and Python spatial libraries. Excellent for solving technical challenges in spatial analysis.
2. <https://stackoverflow.com/>



The largest programming Q&A site, covering all aspects of Python, data science, machine learning, and coding problems. Great for troubleshooting syntax errors, understanding libraries, and finding code snippets.