Geographic Information Systems  
Fall Semester 2017

Prerequisite:  
90-728, Introduction to Database Management Systems , equivalent course, or permission of instructor.

Kristen Kurland , Carnegie Mellon University, Fall 2017, 94-802A (12 units)  
Margaret Morrison 415 and Hamburg Hall 2101C, Office Hours by appointment <kurland@cmu.edu>

TAs: (Office hours to be posted on Canvas, 94-802)  
- Linda Kuster <lkuster@andrew.cmu.edu >  
- Ben Simmons <bsimmons@andrew.cmu.edu>

Course Description:  
A geographic information system (GIS) provides storage, retrieval, and visualization of geographically referenced data as well as design and analysis of spatial information. GIS provides unique analytical tools to investigate spatial relationships, patterns, and processes of cultural, biological, demographic, economic, social, environmental, health care, criminal, and other phenomena.

The course includes lectures, computer labs, and a project using the leading desktop GIS software, ArcGIS Desktop, from Esri, Inc. Subject areas include:

- Geographic concepts (world coordinate systems, map scale/projections, sea level/elevation),
- Government-provided map infrastructure (TIGER maps, census data, satellite and aerial photo images, local government cadastral maps),
- Map design (cartographics, interactive maps, map animations, and Web-based GIS),
- Geodatabases (importing spatial and attribute data, geocodes, table joins, data aggregation, and map queries),
- Creation of new spatial data (digitizing, geocoding, and dissolving vector features),
- Spatial data processing (clipping, merging, appending, joining, dissolving),
- Spatial analysis (proximity analysis, risk surface, site suitability, spatial data mining),
- Macros (form-based tools, flowchart-based design, user interface),
- 3D GIS (3D surface modeling, draping/extruding features, fly throughs, line-of-sight analysis),
- Raster GIS (hill shade, kernel density estimation, risk index modeling, raster queries),
- Data mining and cluster analysis (grouping analysis using centroid models and k-means algorithm), and
- Network analysis (traveling salesman problem, multi-vehicle routing problem, Huff gravity model location of facilities).
Learning Objectives:
1. Develop an understanding of the world’s quickly-growing spatial data infrastructure and of how to put it to work for producing location-based information.
2. Identify the relevant spatial characteristics of diverse application areas enabling professionals to integrate spatial thinking and GIS analysis into their careers.
3. Have an ability to use geospatial technologies to gain a significant advantage in the information technology field.

Course Materials:
- Power Point Slides: used in lectures for note taking (available from Canvas)
- ArcGIS Pro software: available from Heinz Computing Services or via Heinz VMWare
- GIS data copied from Canvas or CMU Box
- Videos and readings provided on Canvas

Grades:
Homework assignments (10@ 5% each) 50%
Quizzes (2@ 15% each) 30%
Final project 20%

*NOTE: I will curve grades and follow Heinz School guidelines that elective courses should have a mean grade of 3.5*

Class attendance
Students are expected to attend weekly lectures and lab sessions. Formal attendance will not be taken but you should alert me if you will miss due to interviews or other relevant excuse.

Communication
Clarification and discussion of GIS concepts and procedural knowledge are not limited just to lectures and lab sessions. Also provided are the instructor’s office and lab meetings, TA office hours, and a Canvas Discussion Board. Neither instructor nor the TAs will answer questions through email that would have benefit for the class, but instead will monitor the Canvas Discussion Board daily and respond to questions. Canvas Discussion Board questions are answered 9am-5pm Monday-Friday and occasionally on weekends.

Late Homework Policy:
- GIS assignments build upon each other, so it is important to be up to date on your assignments.
- **No assignment will be accepted after the due date** unless previously arranged with me due to extraordinary circumstances (e.g. illness, out of town).

Grading questions:
Gradesheets contain solutions as well as feedback and scores for your assignments. If you believe that there was an error in grading an assignment, please contact the TA who graded it to resolve the issue. If you cannot resolve the issue to your satisfaction with the TA, then please send an email message to
me with the issue. Please ask for any re-grading of an assignment within one week after it was returned, otherwise we will not re-grade the assignment.

If you believe that there was an error in grading your quizzes, please contact me immediately.

**Policy on Collaboration and Cheating:**
I will follow Heinz College policies on ethics and discipline as stated in student handbooks. A specific policy of this course is as follows:

*Homework*—Do not copy or modify homework solutions for your homework solutions. Homework must be individual work unless otherwise stated. You may consult each other on clarification, technical and conceptual issues, but you must do individual problem solving and derive your own solutions, including your own computer work. You are not permitted to be in possession of *any* assignments from another student or other source either from the current semester or from past semesters whether they are electronic or paper. Possession of or sharing such files constitutes an infraction of the academic integrity policies of this course.

*Quizzes*—One page of notes (handwritten or typed, front and/or back) is permitted for each quiz. Notes must be unique for each student and returned to the instructor with your name on the sheet at the end of each quiz. No other material (for example books, photocopied lectures, nor additional online materials) is allowed.

**University’s policy on accommodations**
Accommodations, academic adjustments, and auxiliary aids and services (collectively “accommodations”) are provided to students with disabilities, as required by the Americans with Disabilities Act (ADA), the Rehabilitation Act of 1973, and other applicable federal, state and local laws. Please refer to CMU’s website for information.

**Health and wellness**
Carnegie Mellon University and I believe in hard work but a balanced lifestyle. Do your best to maintain a healthy lifestyle this semester by eating well, exercising, avoiding drugs and alcohol, getting enough sleep and taking some time to relax. This will help you achieve your goals and cope with stress.

All of us benefit from support during times of struggle. You are not alone. There are many helpful resources available on campus and an important part of the college experience is learning how to ask for help. Asking for support sooner rather than later is often helpful.

If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support.

Counseling and Psychological Services (CaPS) is here to help: call 412-268-2922 and visit their website at http://www.cmu.edu/counseling/. Consider reaching out to a friend, faculty or family member you trust for help getting connected to the support that can help.
Class Schedule

Part 1: Using, making, and sharing maps

Week 1, Introduction to the ArcGIS Platform
8/29 and 8/31

Week 1 assignment, due 11:59 a.m. (12 noon), 9/7/2017
Note that all assignments are posted on Canvas
  o Course overview and policies
  o GIS Overview and examples
  o Databases and map layers
  o Log onto an Esri account

Video lectures (view on your own before 9/5)
  o GIS example: environmental study
  o History of GIS
  o GIS futures
  o ArcGIS Pro Overview

GIS Tutorial for ArcGIS Pro: A Platform Workbook, Chapter 1
  o Get an introduction to the ArcGIS platform.
  o Get an introduction to the ArcGIS Pro user interface.
  o Learn to navigate maps.
  o Work with tables of attribute data.
  o Get an introduction to symbolizing and labeling maps.
  o Work with side-by-side 2D and 3D maps.
  o Publish a map in ArcGIS Online.
  o Configure maps in ArcGIS Online.
  o Use Explorer for ArcGIS on a mobile device.

Week 2, Map design
9/5 and 9/7

Week 2 assignment due 11:59 a.m. (12 noon), 9/14/2017

Video lectures (view on your own, view before 9/5)
  o Cartography overview
  o Map Types
  o Symbolizing Maps
  o Colors
  o Numeric scales
  o Feature labels
  o Additional guidelines

GIS Tutorial for ArcGIS Pro: A Platform Workbook, Chapter 2
  o Symbolize maps using qualitative attributes and labels.
  o Use definition queries to create a subset of map features.
  o Symbolize maps using quantitative attributes.
- Learn about 3D maps.
- Symbolize maps using graduated and proportional point symbols.
- Create normalized maps with custom scales.
- Create density maps.
- Create group layers and layer packages.

**Week 3, Map outputs for GIS projects**  
9/12 and 9/14  
**Week 3 assignment due 11:59 a.m. (12 noon), 9/21/2017**
- Map layouts and story maps
- Visibility ranges

**GIS Tutorial for ArcGIS Pro: A Platform Workbook, Chapter 3**
- Learn about alternatives for sharing maps and information from GIS projects.
- Build map layouts.
- Add visibility ranges for interactive map use.
- Build story maps.
- Make professional-quality tables and charts in Microsoft Excel (optional).

**Part 2: Working with spatial data**

**Week 4, Geodatabases**  
9/19 and 9/21  
**Week 4 assignment due 11:59 a.m. (12 noon), 9/28/2017**
- File geodatabases
- Modifying tables and attributes
- Table calculations
- Joining tables
- Attribute queries
- Data aggregation with a spatial join

**GIS Tutorial for ArcGIS Pro: A Platform Workbook, Chapter 4**
- Import data into file geodatabases.
- Modify attribute tables and fields.
- Use Python expressions to calculate fields.
- Join tables.
- Get an introduction to SQL query criteria.
- Carry out attribute queries.
- Aggregate point data to polygon summary data.

**Week 5, Spatial Data**  
9/19 and 9/21  
**Week 5 assignment due 11:59 a.m. (12 noon), 10/5/2017**
- Map projections (small and large scale, conformal versus equivalent projections, spatial reference data)
- Projected coordinate systems (geographic/spherical versus rectangular, spheroids)
- Basemap data sources (physical surface, environmental, political, populations, biology/ecology)
o US Census map layers and tabular data

GIS Tutorial for ArcGIS Pro: A Platform Workbook, Chapter 5
o Work with world map projections.
o Work with US map projections.
o Work with projected coordinate systems (PCS).
o Learn about vector data formats.
o Download US Census map layers and tabular data.
o Explore, download, and process data from Living Atlas of the World.
o Explore sources of spatial data from government websites.
o Explore maps from a university’s web services.

Week 6, Geoprocessing
10/3 and 10/5
Week 6 assignment, due 11:59 p.m.(midnight), 10/12/2017
o Tabulate intersection
Video lectures (view on your own before 10/3)
o Attribute proximity selections
o Geoprocessing overview
o Append and merge
o Union and Intersect

GIS Tutorial for ArcGIS Pro: A Platform Workbook, Chapter 6
o Dissolve block group polygons to create neighborhoods and fire battalions and divisions.
o Extract a neighborhood using attributes to form a study area.
o Extract features from other map layers using the study area.
o Merge water features to create a single water map.
o Append separate fire and police station layers to one layer.
o Intersect streets and fire companies to assign street segments to fire companies.
o Union neighborhood and land-use boundaries to create detailed polygons on neighborhood
o land-use characteristics.
o Apportion data between two polygon map layers whose boundaries do not align.

Week 7, Quiz and Final Project Data Exploration
10/10 and 10/12
o Quiz 1 (Tuesday, October 10)
o Explore data sources for final projects
Week 8, Geocoding
10/17 and 10/19

Week 8 assignment, due 11:59 p.m. (12 midnight), 10/26/2017
Video lectures on your own (view before 10/10)
- Geocoding overview
- Address matching
- Linear address matching
- Polygon address matching
- Address matching problems solutions
- Geocoding Sources

GIS Tutorial for ArcGIS Pro: A Platform Workbook, Chapter 8
- Get an overview of the geocoding process.
- Geocode using ZIP Codes.
- Geocode addresses using streets.
- Use alias tables for place-name geocoding.

Part 3: Applying advanced GIS technologies

Week 9, Spatial Analysis
10/24 and 10/26

Week 9 assignment, due 11:59 a.m. (12 noon), 11/2/2017
- Buffers for proximity analysis
- Multiples-ring buffers
- Network Analyst
- Facility location
- Data clustering

GIS Tutorial for ArcGIS Pro: A Platform Workbook, Chapter 9
- Use buffers for proximity analysis.
- Use multiple-ring buffers to estimate a gravity model of demand versus distance from nearest facility.
- Estimate service areas of facilities using ArcGIS® Network Analyst.
- Optimal facilities using Network Analyst.
- Carry out cluster analysis to explore multidimensional data.

Week 10, Raster GIS
10/31 and 11/2

Week 10 assignment, due 11:59 a.m. (12 noon), 11/9/2017
- Extract and symbolize raster maps
- Create hillshade maps
- Smooth point spatial data with kernel density smoothing
- Build a raster-based risk index

GIS Tutorial for ArcGIS Pro: A Platform Workbook, Chapter 10
- Extract and symbolize raster maps.
Create hillshade maps.
Smooth point data with kernel density smoothing.
Build a raster-based risk index.
Build a model for automatically creating risk indices.

**Week 11, 3D GIS**
11/7 and 11/9
Week 11 assignment due 11:59 a.m. (12 noon), 11/16/2017
- LiDAR overview
- Procedural rules and multipatch features
- 3D Application for City Planning
- GIS, Augmented Reality, Virtual Reality

**GIS Tutorial for ArcGIS Pro: A Platform Workbook, Chapter 11**
- Explore global scenes.
- Learn how to navigate scenes.
- Create local scenes and TIN surfaces.
- Create Z-enabled features.
- Create 3D buildings and bridges from lidar data.
- Work with 3D features.
- Use procedural rules and multipatch models.
- Create an animation.

**Part 4: Managing operational systems with GIS**

**Week 12, Operations Management**
11/14 and 11/16

**Final Project Descriptions Due 11:59 a.m., 11/13/2017**

**Quiz 2 (Tuesday, November 14)**

**GIS Tutorial for ArcGIS Pro: A Platform Workbook, Chapter 12: Graffiti Mapping System**
- Get an introduction to operations management systems.
- Create tasks to prepare data for an operations management system.
- Build a ModelBuilder model to be used in a task.
- Create an ArcGIS Online map for use in an Operations Dashboard operation view.
- Create and use an Operations Dashboard operation view.

**GIS Tutorial for ArcGIS Pro: A Platform Workbook, Chapter 13: Graffiti Removal System**
- Build ModelBuilder models to automate an operations management system.
- Use Network Analyst to optimize routes for carrying out service deliveries.
- Use Python expressions to calculate fields.
- Prepare data for use in the Collector for ArcGIS® app.
- Prepare a map in ArcGIS Online for use in Collector.
- Use the Collector app to update data using a mobile device.

**Weeks 13-15, Work on final projects**

*12/5 GIS Projects due 11:59 p.m. (midnight), December 5, 2017*

*12/7 Story Maps due 11:59 p.m. (midnight), December 7, 2017*