

**GEOG 4730/5730****Principles of Geographic Information Systems****Fall Semester 2019-20****Lecture:** M/W/F 10:45 am – 11:40 pm**Lab:** M 2:00 pm – 3:50 pm OR @ 4:10 pm – 6:00 pm

Name	Contact	Office Hours
Dr. Gaurav Sinha (Instructor)	Office: Clippinger, 105A Email: <a href="mailto:sinhag@ohio.edu">sinhag@ohio.edu</a> Phone: 740.593.0304 Web: <a href="http://ohio.edu/people/sinhag">http://ohio.edu/people/sinhag</a>	M/W/F @ 9:30 am – 10:30 am F @ 12:45 pm – 1:45 pm (and by appointment)
Rabeya Akhtar (Teaching Assistant)	Office: Clippinger, 102 Email: <a href="mailto:ra036018@ohio.edu">ra036018@ohio.edu</a>	T @ 2:00 pm – 4:00 pm (and by appointment)
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**Course overview**

Geographic Information Systems (GIS) technologies are a functional integration of several types of digital geographic technologies designed for surveying, mapping, database management systems, and spatial analysis. Broadly speaking, geographic information systems are a special class of information systems designed specifically for the storage, management and analysis of *geographically referenced data* (i.e., data linked to some location on Earth (or another planetary body)). The value of GIS, and more generally, geospatial technologies, is widely recognized in numerous disciplines within physical and social sciences, planning and engineering, and business analytics. GIS continues to be extended in ways pioneers never imagined.

Efficient use of GIS requires spatial thinking and spatial analysis skills. It also requires a strong understanding of software technology used to build mapping and spatial analysis tools. This understanding should not be tied to specific software platforms because GIS software vary in their strengths and weaknesses, but all full-fledged GIS support a core set of functions and tools. There are significant differences in how the graphical and command line user interfaces are designed, how databases are maintained, how much flexibility users have with handling and visualizing data, and the extent of support for exporting data to other GIS and data analysis software. There is also an abundance of niche GIS software that are available as stand-alone software or as extensions to popular GIS software. Similarly, there are several reasons – popularity, technical expertise, business model, financial resources, institutional legacy, lack of knowledge, etc. – why an organization or institution would choose one software package over another. Although you will be using the leading and industry standard ArcGIS software suite for all lab exercises, **the goal in this class will always be to differentiate between the software tools and the conceptual task that needs to be completed with those tools.** Thus, the appendix to this syllabus identifies the core competencies that anybody claiming to have GIS capabilities should be proficient with.

Keeping the above in mind, this level course is designed to introduce students to the **fundamental principles** governing the design and operation of geographic information systems. Both the lectures and the labs will focus on training students to establish a connection between the principles of mapping and spatial analysis and the corresponding tools provided in commonly used GIS software. Students will complete a suite of modular lab exercises, which will focus on specific GIS skills that will collectively prepare students to solve typical GIS problems encountered in most entry level jobs.

## Learning Objectives

**The lectures are designed to help student understand and demonstrate knowledge of**

- the ever-changing scope of geographic information systems and the services they can provide to the wide variety of consumers and creators of geographic information
- the strong relationship between mapping principles and the design and operation of both simple geobrowsers and advanced GIS software
- what geographic data models are and how they determine what can be done with GIS
- the diverse ways in which geographic data can be acquired for analysis and mapping
- the fundamentals of designing, managing, and querying GIS databases and how to recognize those principles while using tools and functions embedded in GIS software
- the principles of mapping and map-based analysis by applying concepts of scale, generalization, map design, geodetic datums, map projections, and map coordinate systems
- the fundamentals of spatial analysis and how to solve geographic problems using ArcGIS mapping and spatial analysis tools.

**The lab exercises are designed to provide students practical skills in using GIS software so that they learn how to:**

**(also see appendix for more details)**

- use online mapping tools for mapping and exploring geographic information
- create GIS based interactive desktop and/or online maps
- collect georeferenced data from field-mapping and online data sources
- assign and update coordinate systems associated with geospatial datasets
- create, manage and query geospatial databases
- design and implement feature and raster based spatial analysis workflows
- utilize GIS tools in combination with other analytical tools such as MS-Excel, MS-Access, and Google Earth to solve geographic problems
- develop an intuitive sense for recognizing how spatial analysis and mapping with GIS can help study and solve complex real-world problems.

## Course Prerequisites

Undergraduate: *GEOG 2680: Introduction to GIS & Mapping Sciences*

Graduate: *None*

## Suggested Text

All necessary reference material will be provided by the instructor. *Optional* text book:

*GIS Fundamentals: A First Text on Geographic Information Systems (choose latest edition)*

Paul Bolstad, Eider Press, [www.AtlasBooks.Com](http://www.AtlasBooks.Com), Ashland, OH, USA 44805.

## Modules

The class is organized into modules. Each module will include its own set of readings, lecture slides, lab exercise and an online quiz. The module topics are listed below but might change during the class if the instructor feels the need to adapt to students' collective needs and performance. A more detailed list of targeted GIS skills by the end of this class is provided in the appendix.

<b>Introduction to GIS</b>	Definition; Functions of GIS; Components of GIS; Using GIS; GIScience; Evolution of GIS and Mapping; Current and Future Trends; Online Mapping and Web-GIS
<b>Georeferencing Systems</b>	Datums, Map Projections, GIS Coordinate Systems, Geocoding
<b>Representing Geography for Computational Analysis</b>	Geographic Representation Basics; Geographic Data Modeling Fundamentals; Vector, Raster, Object and Network Data Models
<b>Database Fundamentals</b>	Overview of Database Types; SQL Queries; Spatial Queries; Managing ESRI Geodatabases
<b>Geographic Data Creation &amp; Collection</b>	Vector and Raster Data Creation and Editing; Metadata; File Systems; Ground Surveys, GPS, Aerial Photography, Satellite Imagery; Lidar; Typical Online GIS Data Sources
<b>Spatial Analysis</b>	Analysis of Features/Vector Data; Raster Analysis; GIS workflow models

## Grading (4 credits)

The lecture/reading assignments and lab exercises will define the scope of all quizzes and exams. Assignment deadlines must be met to earn the best possible grade. If any assignment is late by more than 3 days (an automatic grace period) without seeking prior approval for extra time from the instructor, the following rule may be imposed: “A late assignment will be graded but cannot earn the student more than 80% of the maximum score possible for that assignment”. The following is the grading strategy that will be used to determine the final grade for each student. Compared to undergraduate students, graduate students will be assigned extra work for labs, reading assignments and exams.

<b>Grading Criteria</b>	<b>Weight %</b>
Online Quizzes	10
Lab Exercises	55
Mid-Term Exam ( <i>Mon, Oct 28, 2:00 pm or 4:05 pm</i> )	15
Final Exam ( <i>Mon, Dec 9, 10:10 am</i> )	20

### *Final Grade Criteria*

Grade	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F
%	100-	93-	89-	86-	83-	79-	76-	73-	69-	66-	63-	≤59
Range	94	90	87	84	80	77	74	70	67	64	60	

**Class Technology Instructions**

The course will utilize Blackboard only partially for some postings. For all topics, review lecture slides and a set of readings will be made available. Please check your Ohio University email regularly as that will be the preferred system of communication. Also note that this course, especially the lab exercises, are quite time intensive. Please allocate sufficient time to work on labs beyond the officially allocated class hours. During lectures, computer monitors should be switched off unless being used for taking notes and authorized by the instructor. No phone calls or texting (except for responding to in-class quiz questions) is allowed during class. Students will be disciplined and penalized depending on the judgment of the instructor.

**Student Responsibility**

Students are ultimately responsible for their own learning. Instructors and teaching assistants can only facilitate learning. We will help you as much as we can, but learning the material is ultimately up to the student. This includes: attending class meetings without fail, getting assignments and notes from others for missed classes, asking questions, either in class or out of class, doing the assignments on time and participating in class; and contacting us to resolve personal and academic difficulties. Since the course relies heavily on in-class demonstrations and project work, punctuality and attendance is critical and required for every lecture and lab class. Any planned absence from lab or lecture must be communicated in writing to the TA and the instructor ahead of time. Emergency absences must be supported with documentation later on.

**Academic Integrity and Misconduct**

Please help maintain an academic environment of mutual respect and fair treatment. Academic misconduct will not be tolerated and will be dealt with procedurally in accordance with the Ohio University [Student Code of Conduct](#) policies. Students should read the code and be careful to abide by the code. Specifically, for this class, it should be noted that although collaborative learning and working on assignments is encouraged, students must write up their assignments individually. Plagiarism from your current or former students will not be tolerated and reported to proper authorities. Additionally, depending on the perceived severity of the violation, the instructor's response may range from imposing grade penalty to assigning an automatic failure grade. Students may appeal academic sanctions through the grade appeal process. Note that University Judiciaries may impose additional sanctions.

**Institutional Equality**

In compliance with the Americans with Disabilities Act (ADA), all students who have a document disability are entitled to "reasonable academic accommodations." Any student who suspects s/he may need an accommodation based on the impact of a disability should contact the class instructor privately to discuss the student's specific needs and provide written documentation from the Office of Student Accessibility Services. If the student is not yet registered as a student with a disability, s/he should contact the Office of Student Accessibility Services.

## **APPENDIX: GIS Competency Curriculum**

*(While not everything listed here can be covered in one class, this compilation includes all the tasks/functions you should be able to perform as an intermediate level GIS user. Use this list to address gaps in your knowledge and to prepare for jobs and interviews)*

- **Exploring Desktop and Web-Mapping/GIS Technologies:**
  - Desktop GIS: ArcGIS Pro; ArcGIS Desktop 10.x; QGIS.
  - Geo-Browsers/Digital Globes: Google Earth.
  - Web-Mapping/GIS Services: The National Map, Google Maps, Bing Maps, ArcGIS Online, OpenStreetMap, MangoMap, eSpatial, Tableau, MapBox, Leaflet, CartoDB, Tableau.
  
- **Exploring Desktop GIS Based Mapping:**
  - GIS map viewers: Defining features, layers, and data frames; Exploring map scale; Understanding the relationship between features and attributes; Identify tool; Measure tool; Select tool; Drawing tools.
  - Managing map layers: Zooming to layers; Bookmarks; Display windows; Scale ranges; Group layers; Selection layers; Online map service layers; Layer symbology files; Clipping layers to specific extents; Hyperlinks; Data frame versus layer properties.
  - Symbolizing categorical data: Choosing symbology styles; Types of symbols (marker, line, fill); Adding symbology styles; Displaying polygons as hollow boundaries.
  - Symbolizing quantitative data: Choosing variables; Symbology options (graduated colors, graduated symbols, proportional symbols, dot density, charts); Value normalization; Multiple variable symbology; Classification methods (Natural Breaks, Equal Interval, Quantile, Manual); Excluding data from a classification; Rendering raster data.
  - Labeling map features: Label placement for different feature types (points, lines, polygons); Label symbology; Controlling label display using scale range and SQL query; Label classes; Label expressions; Label ranks and weights; Geodatabase annotation; Map annotation.
  - Creating map layouts: Understanding data view and layout view; Using the Layout toolbar; Using map templates; Modifying map elements; Legend formatting; Dynamic vs. static graphic legends; Scale bar customization; Exporting and printing maps.
  - Sharing/Moving datasets and map projects: Relative vs. Absolute path names; Map folder management; ArcGIS Earth; Google Earth KML/KMZ layers; Online map services.
  - Publishing maps online: Connecting to a map server; Publishing a map as a service; Consuming the service in a web-map layer in ArcGIS.
  
- **Exploring GIS File Formats:**
  - Managing geospatial data: Managing geospatial data using geospatial data management systems; ArcCatalog vs. Windows view of datasets; Adding and displaying data in ArcMap; Geometric data storage, attribute data tables, and layers.
  - Vector data formats: KML; CAD; Shapefile; Coverage; Geodatabase; TIN, Lidar.
  - Raster data formats: ESRI Grid; ESRI ASCII; Imagine; (Geo)JPEG; GeoTIFF.
  - Attribute table formats: DBF; INFO; Geodatabase; MS-Excel; MS-Access.
  - GIS files: .lyr/lyrx files; xml files; rrd files;
  - Sharing data: ASCII; ZIP; KML/KMZ; Shapefile; Layer packages
  - Understanding metadata: Creating, viewing, and editing metadata; Updating metadata; Importing and exporting metadata; Data quality parameters.

- **Exploring Map Projections and Coordinate Systems:**
  - Measuring location: Reading and finding location coordinates on a map; Measuring distance and area on a map; GIS layer alignment needs.
  - Understanding georeferencing principles: Ellipsoids and Geoids; Datums; Coordinate systems; Map projections.
  - Spatial reference system: Layer spatial reference system; Data frame spatial reference system; Globe (unprojected) versus map (projected) coordinate systems; Creating new spatial reference systems; Geodatabase feature datasets and coordinate systems; Projection information storage strategies for different GIS data formats; Virtual globes spatial reference system.
  - Transforming coordinates: Geographic transformations; Working with an unknown coordinate system; Projecting feature data; Projecting raster data; Defining a projection;
  - Troubleshooting coordinate system problems: Layer alignment problems; On-the-fly projection in ArcMap; Data frame vs. layer spatial reference system; Define projection vs. Project tool; Using geodatabase feature datasets to enforce common spatial reference system; Designing custom spatial reference systems (only for experts).
  
- **Georeferencing:**
  - Georegistration: Hyperlinking files and multimedia; Georeferencing features; Georeferencing images; Georeferencing maps.
  - Geocoding: Adding <x, y> coordinate data to maps; Finding places and addresses; Finding routes and nearby places; Geocoding components (address table, address locator, reference data); Address matching overview; Online geocoding services.
  
- **Creating and Editing GIS Data:**
  - Creating features: Creating features in Google Maps, Google Earth, and ArcGIS Online; Exporting selected features from existing feature classes to shapefiles, geodatabases or coverages; Importing GPS data; Importing text format <x, y> and attribute data with coordinate system assigned; Tables with point coordinates (DBF, Excel, Access tables); Vectorizing raster data; Digitizing from base maps.
  - Creating raster data: Rasterization of vector data; Importing ESRI ASCII format; Satellite/aerial imagery and orthophotos; Georeferenced scanned maps; Resampling or projecting existing raster data; Reclassification of raster data.
  - Creating and managing geodatabases: Personal and file geodatabases; Geodatabase organization; Feature class import/creation and organization; Feature class properties and attributes; Feature datasets; Coded domains and ranges; Topology creation and management; Geometric networks; Raster data import and management; Storing map annotations.
  - Editing features and attributes: Preparing for editing; Common editing tools; Snapping to features while editing; Editing attributes; Calculating values for fields; Calculating values for geometric fields (new and updates); Editing shapefiles; Editing geodatabases; Editing topology.
  
- **Managing GIS Databases:**
  - Managing attribute tables: Table structure; Feature attribute tables; Raster attribute tables; Non-spatial tables; Getting information from tables; Field properties; Creating new fields; Exporting features; Exporting tables; Table appearance; Creating graphs and reports.
  - Querying attribute data: Performing attribute queries; Joining tables; Cardinality; SQL syntax; Selecting features/records; Definition queries; Label queries; Table summarize;
  - Spatial queries: Location based queries; Integrating spatial and attribute queries; Spatial join; Spatial-SQL.

- **Spatial analysis of features:**
  - Selection: Manual; Graphic; Attribute query; Location query.
  - Generalization: Table Summarize; Dissolve; Line simplification.
  - Reclassification: Cartographic reclassification; Permanent reclassification by creating new coded fields.
  - Proximity analysis: Measuring nearest neighbor; Simple/nested/variable buffer analysis; Thiessen/Voronoi polygons.
  - Overlay (combining overlapping features): Clip; Union; Intersect; Erase.
  - Combining (non-overlapping) features into one dataset: Append; Merge.
  
- **Spatial analysis of rasters:**
  - Generalization: Resampling; Aggregation.
  - Reclassification: Cartographic reclassification; Value/Class based reclassification.
  - Proximity analysis: Distance rasters; Allocation rasters; Reclassified distance rasters.
  - Overlay (combining overlapping rasters): Raster calculator; Boolean operators; Relational operators; Mathematical operators; Conditional operator.
  - Combining (non-overlapping) rasters: Mosaic; Merge.
  - Surface analysis: Slope; Aspect; Contour; Hillshade; Viewshed; Cut & Fill.
  
- **ArcGIS Workflow Management:**
  - Custom Toolboxes: Adding/Making a new ArcToolBox; Adding and naming a model; Storing a toolbox.
  - Customizing ArcGIS: Managing environment variables; Adding new toolbars, commands, and menus; Saving templates.
  - GIS Programming: Automating with ArcGIS Model Builder; Python scripting; Javascript for web-maps; GIS libraries and packages typically imported for scripting.