GEO 345/445: Programming in Python for GIS
Spring 2016 (3/28/16-6/12/16)  |  Department of Geography | DePaul University

The class meets on Tuesday and Thursday at 4:20-5:50 pm in SAC 224 (GIS Lab)
Instructor: Sungsoon (Julie) Hwang (shwang9@depaul.edu, 773-325-8668, 990 W Fullerton #4513)
Instructor’s office hours: Tue/Thur 2-3:30 pm in her office and by appointment
Teaching Assistant: Cezar Papa (CEZARP@live.com; Lab hours: TBA in GIS lab)

1. Course Description: Knowledge of a scripting language is a valuable skill for GIS analysts. Students will learn the basics of Python (a programming language), including script writing and implementation. By completing this course, students should be able to manipulate GIS data, automate GIS workflows, and develop customized GIS tools by writing script in Python with ArcGIS. The class is largely conducted through hands-on activities in a GIS laboratory. Formerly GEO 342.
Prerequisites: GEO 242 for GEO 345; GEO 440 or GEO 441 for GEO 445.

2. Course Topics: Python is in high demand in GIS industry and beyond. Through GEO 345/445, you will learn Python as a scripting language and ArcGIS site package ArcPy. With Python you can manipulate various data and control workflow, and can call and execute geoprocessing functions (e.g. buffering, query) in ArcPy. US Department of Labor’s Geospatial Technology Competency Model identifies design and development of geospatial applications (tools) as one of three industry-sector technical competencies along with data acquisition and analysis. In this course you will be introduced to logics of programming language. Through the course you will learn to write a Python script to (a) automate routine tasks; (b) customize data processing; and (c) create a simple tool with GIS applications in mind. More specifically, you will

- Build a model using the ModelBuilder, and convert the model to a Python script
- Learn syntax, data types and operations in Python
- Learn conditional statement and loop structure in Python
- Get an overview of ArcPy, and access properties of datasets
- Retrieve and update rows in geospatial data using ArcPy Cursors along with SQL
- Read and write a text file using a file object with a Python script
- Access map document elements and create a map series using ArcPy mapping module
- Create a custom tool that takes a user input

3. Learning Outcomes – with the completion of this course you should be able to

- Write Python scripts for a given problem using various data types and operations
- Write Python scripts for a given problem using conditional statement and loop structure
- Perform geoprocessing tasks using ArcPy geoprocessing tools and classes
- Explore and manipulate geospatial data using ArcPy Cursors
- Create a custom tool for a geographic problem using an ArcPy and Python operations

4. Required Text: Python Scripting for ArcGIS (2013) by Paul A. Zandbergen, ESRI Press (ISBN: 9781589482821). In case you run into the 2014 edition, the 2014 edition is same as the 2013 edition content-wise. Although the text is written for ArcGIS 10.1, it works as well with ArcGIS 10.3 and Python 2.7.8 that are currently installed in selected labs at DePaul University.
## 5. Outlines of Topics and Tentative Schedules

<table>
<thead>
<tr>
<th>Wk.</th>
<th>Date</th>
<th>Topic</th>
<th>Reading</th>
<th>In-class lab activities</th>
<th>Assignments</th>
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<tbody>
<tr>
<td>1 T</td>
<td>3/29</td>
<td>Course overview</td>
<td>Ch1</td>
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<tr>
<td>R</td>
<td>3/31</td>
<td>1. Python script editor &amp; ModelBuilder</td>
<td>Ch2,3</td>
<td>1. IDLE and a Python script from ModelBuilder</td>
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<tr>
<td>2 T</td>
<td>4/5</td>
<td>2. Python fundamentals I: data types and operations</td>
<td>Ch4 p. 81</td>
<td>2A. Work with data types and operations in Python</td>
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<tr>
<td>R</td>
<td>4/7</td>
<td>Label features using Python string operations in ArcGIS</td>
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<td>2B. Use Python in the ArcGIS Label Expression dialog box</td>
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<tr>
<td>3 T</td>
<td>4/12</td>
<td>Help for Lab2A, Lab2B, HW1 &amp; ILGISA</td>
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<tr>
<td>R</td>
<td>4/14</td>
<td>3. Python fundamentals II: conditional statement and loop structure</td>
<td>Ch4 p. 81</td>
<td>3A. Control workflow using if, while, and for in Python</td>
<td>HW1 due 4/15 F</td>
</tr>
<tr>
<td>4 T</td>
<td>4/19</td>
<td>Calculate field using conditional statement in ArcGIS</td>
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<td>3B. Use if statement in the ArcGIS Field Calculator</td>
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<tr>
<td>R</td>
<td>4/21</td>
<td>Help for Lab3A, Lab3B, HW2 &amp; ILGISA</td>
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<td>ILGISA 4/22</td>
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<tr>
<td>5 T</td>
<td>4/26</td>
<td>4. Introduction to ArcPy</td>
<td>Ch5,6</td>
<td>4A. Use environmental settings and describe data</td>
<td>HW2 due 4/27 W</td>
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<tr>
<td>R</td>
<td>4/28</td>
<td>Batch geoprocessing using List objects in ArcGIS</td>
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<td>4B. Perform query and field calculation in batch</td>
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<td>6 T</td>
<td>5/3</td>
<td>Help for Lab4A, Lab4B &amp; HW3</td>
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<tr>
<td>R</td>
<td>5/5</td>
<td>5. Manipulate geospatial data with Cursors</td>
<td>Ch7 p. 149</td>
<td>5A. Use Cursors to read and write rows in the table</td>
<td>HW3 due 5/6 F</td>
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<td>7 T</td>
<td>5/10</td>
<td>Write a text file by looping through a table</td>
<td>Ch7 p. 149</td>
<td>5B. Write a report that summarizes text files</td>
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<tr>
<td>R</td>
<td>5/12</td>
<td>Help for Lab5A, Lab5B, HW4 &amp; proposal</td>
<td></td>
<td>HW4 due 5/13 F</td>
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<tr>
<td>8 T</td>
<td>5/17</td>
<td>6. Map scripting (ArcPy mapping module) if time allows</td>
<td>Ch10</td>
<td>6A. Access map document elements</td>
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<tr>
<td>R</td>
<td>5/19</td>
<td>Create a PDF map book consisting of multiple maps if time allows</td>
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<td>6B. Make a map series by looping through features</td>
<td>Proposal due 5/20 F</td>
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<td>9 T</td>
<td>5/24</td>
<td>Work on project</td>
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<tr>
<td>R</td>
<td>5/26</td>
<td>Work on project</td>
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<tr>
<td>10 T</td>
<td>5/31</td>
<td>Presentation</td>
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<td>R</td>
<td>6/2</td>
<td>Presentation</td>
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<td>11 R</td>
<td>6/9</td>
<td>Final product due 6/9 on D2L</td>
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## 6. Grading Components

<table>
<thead>
<tr>
<th>Components</th>
<th>Points</th>
<th>Notes</th>
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<tbody>
<tr>
<td>Participation</td>
<td>10</td>
<td>See below for rubric</td>
</tr>
<tr>
<td>11 labs</td>
<td>33</td>
<td>Each exercise accounts for 3 points</td>
</tr>
<tr>
<td>4 homework</td>
<td>36</td>
<td>Each homework accounts for 9 points</td>
</tr>
<tr>
<td>Project</td>
<td>21</td>
<td>• Proposal: 3 points</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Presentation: 3 points</td>
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<tr>
<td></td>
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<td>• Final Product (Python script, data, and documentation): 15 points</td>
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Extra credit up to 6
Present your GIS work at ILGISA Student Poster Symposium on 4/22 OR
Submit your GIS work to the DePaul Map of the Month (MOM)

6.1 Participation: score is assigned according to the criteria below.
- A (9-10) = Student is present in all or nearly class meetings, and prepared, at all times, to respond to questions. Student is an active participant in and out of class, and stays on task in class-time activities.
- B (8-9) = Student participates as above, 75% of the time.
- C (6.5-8) = Student does not volunteer comments; responses demonstrate vague familiarity with course readings. Student is a passive participant in and out of class, and/or does not stay on task during class-time activities.
- D (5-6.5) = Student never volunteers, cannot respond to direct questions, keeps silent during class discussions and is unable to summarize readings if asked.
- F (0-5) = Student misses many class sessions and/or sits silently in classes when present, or is disruptive and non-participatory in the classroom.

6.2 Labs: complete labs after lectures in the class when instructors are present. If you can’t complete the lab in time, make arrangement with a TA. Labs are due 11:59 pm one week after handouts are distributed in the class unless noted otherwise. See the table above for contents of each lab.

6.3 Homework: submit a Python script that does the following.
- HW1: export a model to a Python script; calculate distance between two points using functions and methods for numeric data; custom-label features using string methods in the Label expression dialog box
- HW2: calculate descriptive statistics using list methods; custom-label features & calculate fields using conditional statements in the Label expression dialog box; calculate fields using conditional statements
- HW3: visualize data distribution using list methods; retrieve properties of geospatial data with ArcPy functions and classes; perform batch processing with ArcPy
- HW4: check data quality by looping through the geodatabase table with ArcPy Cursor and SQL; generate a summary statistics by looping through multiple text files

6.4 Project: propose and complete a final project that uses Python to perform a geoprocessing task in the area of field that you’re familiar with (so that you know where to get data and what questions or tasks are worthwhile asking or performing). You should submit a tool written in Python as a final product along with the documentation of the tool you created. The proposed project should meet the following minimum requirements:

<table>
<thead>
<tr>
<th>The minimum requirements of a proposed project</th>
<th>GEO345</th>
<th>GEO445</th>
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</thead>
<tbody>
<tr>
<td># Python data types (strings, numbers, lists, tuples, dictionary, date &amp; time)</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td># Python operations, such as operators, and built-in functions and methods</td>
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<tr>
<td>• Generic operators (eg. ==,!=, =, +=, and, or, not, in, not in)</td>
<td>3</td>
<td>6</td>
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<tr>
<td>• Strings (eg. +, [], in, len(), upper(), find(), strip(), split(), replace())</td>
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<td></td>
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<tr>
<td>• Numbers (eg. +, -, /, *, **, int(), float(), abs())</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Lists (eg. len(), max(), min(), append(), count(), insert(), remove())</td>
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<tr>
<td># Python conditional statement and loop structure (if, while, for)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td># ArcPy geoprocessing tools, functions and classes</td>
<td>3</td>
<td>6</td>
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</table>
- Tools/functions (eg. Buffer, SelectLayerByAttribute, CalculateField, GetCount, SearchCursor, UpdateCursor, GeocodeAddresses)
- Classes (eg. SpatialReference, Extent, Cursor, Field)
- Functions (eg. Describe, Exists, ListFeatureClasses, ListFields)

<table>
<thead>
<tr>
<th>Others—for example,</th>
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<tbody>
<tr>
<td>Text file reading &amp; writing</td>
<td>1</td>
</tr>
<tr>
<td>User keyboard input (eg. raw_input(), ArcPy GetParameter())</td>
<td>1</td>
</tr>
<tr>
<td>ArcPy modules (eg. Data Access, Mapping, Spatial Analyst)</td>
<td>1</td>
</tr>
<tr>
<td>ArcGIS Python script tools (eg. Python toolboxes, Python add-ins)</td>
<td>1</td>
</tr>
<tr>
<td>Python modules &amp; functions (eg. math, random, datetime, csv)</td>
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</table>

A tool defined by the project proposal will usually perform tasks that cannot be accomplished effectively through manual processes. A well-conceived tool will make a good use of Python fundamentals like conditionals, iterations, and taking a user input, and ArcPy geoprocessing tools. For example, a tool you propose to create can accomplish a task such as the following:

**Python as a calculator**
- Calculate descriptive statistics from data (e.g., calculate average from the list of numbers)
- Calculate the distance or heading between POIs using Pythagorean theorem
- Count the number of place names in historical records

**Python as a data processing tool**
- Process existing data to create new variables (e.g., convert lat/long in DMS to decimal degree)
- Geocode POIs stored in a csv file in batch
- Check whether data values are missing or unusual, and correct the data value if needed

**Python as a data analysis tool**
- Summarize characteristics of population near facilities in many metropolitan areas
- Monitor changes in precipitation by watersheds over time in the US
- Identify activity patterns from GPS trace data or detect outliers (or noises) from data

**Python as an application development tool**
- Identify suitable sites based on a user input (eg. what is the best city to live?)
- Build a tool that is designed to increase situation awareness given a POI
- Create a series of thematic maps by different neighborhoods in a city

### 6.5 Extra credit: you can do one of the following that counts toward extra credit.

**A. ILGISA Student Poster Symposium** (up to 6 points): present any of your previous GIS work in the [2016 Student Poster Symposium](http://example.com). The symposium is sponsored by Illinois GIS Association (ILGISA), Geographic Society of Chicago (GSC) and HERE. The Student Symposium is a poster competition immediately following the [ILGISA Regional Meeting](http://example.com) held at DePaul Center (1 E Jackson Blvd) on 4/22. This is a great opportunity to meet GIS students and GIS professionals from IL and beyond.

The poster format is best when your material can be most effectively communicated in visual form, so it would be good to limit text to brief statement. Poster should be clearly legible from a distance of four feet. Poster will be displayed on a 4’ by 8’ (landscape-oriented only) poster board supplied by the host. Posters will be graded based on organization, visual presentation clarity, content, and significance. There will be cash prizes for four best posters (2 for undergraduate students and 2 for graduate students) in the symposium.
To be considered for extra credit, you should do the following:

- **By April 8 (Week 2 Fri) 11:50 pm**, register yourself online for the student symposium [here](#). Registration is free. In the form, you will be asked to enter your name, contact, and short description of poster. Also submit the short description of poster on D2L dropbox ExtraCredit
- **By April 15 (Week 3 Fri) 11:59 pm**, submit a draft poster file in ppt file on D2L. Feedback will be provided if submitted in time.
- **On April 22 (Week 4 Fri)**, present your work in the poster competition held at 3:30-5:00 pm in DePaul Center 8th Floor Conference Center (1 E Jackson Blvd Chicago IL 60604). Posters should be set up starting at 3:00 pm. Also submit the revised poster file on D2L.

If you want to attend the full day ILGISA event, Department of Geography can pay your conference fee. Please contact Sheila Sullivan ssulli24@depaul.edu by 4/7 with your name, contact phone, contact email and DePaul ID number and let her know you would like to attend the full ILGISA meeting.

**B. DePaul Map of the Month** (up to 4 points): submit a map and abstract from any of your previous GIS work to be considered for the DePaul Map of the Month (MOM) [http://via.library.depaul.edu/mom/](http://via.library.depaul.edu/mom/). A good map for the MOM is the one that tells a story, and can engage the public in the topic depicted in the map. Obviously, a well-designed map will go a long way. As of February 2016, the most popular maps in the MOM website are Hannah Eboh’s map that shows evacuation routes for hospitals at the event of volcanic eruption; Jack Floyd’s map depicting change in hate crimes, and Alex Williams’ map that shows hot spots of shooting incidences to demonstrate needs for level I trauma center in Chicago. This is a great opportunity to turn your GIS work to media.

You need to submit two files: (A) professional-quality map in a high-resolution image (300 dpi or high) of TIFF or JPG format; (b) an abstract in 150-250 words where you introduce a topic of the map, describe how the map is created, and discuss findings from the map. The submission will be graded based on quality of map (contents, map design, visual clarity), and quality of abstract. Click [here](#) for the checklist before you submit the MOM.

To be considered for extra credit, you should do the following:

- **By April 8**, submit a MOM proposal on D2L dropbox ExtraCredit
- **By April 15**, submit two files mentioned above in draft form. Feedback will be provided if submitted in time.
- **By April 22**, submit the revised MOM

**Grading scale:**
- A = 93-100%; A- = 90-92.99%; B+ = 87-89.99%; B = 83-86.99%; B- = 80-82.99%; C+ = 77-79.99%; C = 73-76.99%; C- = 70-72.99%; D+ = 60-69.99%; D = 50-59.99%; F = 0-49.99%

**Late Work Policy:** Late work will be accepted with 20% of the total grade deducted for each day being late. Extensions can be requested if needed, but will be only granted if excused. This policy applies to exercises only. Although I will accommodate to ongoing progress in the class, if group exercises are not completed in class, it is expected that your group will complete exercises in time through collaboration outside of the class.

**Makeup Exam/Incomplete Grade Policy:** A makeup exam or an incomplete grade can be arranged or granted only when credible dire and documented medical or family situations arise and these circumstances are communicated in a timely fashion.
7. Learning Objectives by Modules

Module 1: Script Editors and Model Builders
- Get familiar with script editors
- Build a model using ArcGIS ModelBuilder
- Create scripts from ArcGIS tools

Module 2A: Python fundamental I – data types and operations
- Get familiar with Python’s standard (or built-in) data types: numbers, strings, and lists
- Describe how an index positioning system works in strings and lists
- Distinguish functions, methods, and modules

Module 2B: use Python parser for labeling in ArcGIS
- Use methods for manipulating strings
- Define your own function
- Custom-label features using a Python parser in ArcGIS

Module 3A: Python fundamental II – workflow control
- Write conditional statements
- Use while loop structure
- Use for loop structure

Module 3B: use conditional statements for labeling and field calculator in ArcGIS
- Get familiar with list methods
- Use conditional statements for labeling in ArcGIS
- Use conditional statements for field calculator in ArcGIS

Module 4A: Introduction to ArcPy
- Understand how ArcPy is organized
- Differentiate ArcPy functions, classes, and modules
- Use environment settings
- Describe the data

Module 4B: Batch processing with ArcPy
- Get familiar with List Object functions
- Perform batch geoprocessing
- Perform multiple geoprocessing tasks

Module 5A: manipulate geospatial data using Cursors
- Work with SearchCursor
- Work with UpdateCursor

Module 5B: work with text files
- Read a text file
- Write a text file

Module 6A: access map document elements (if time allows)
- Reference map document
- Work with data frames and map layers
- Work with page layout elements

Module 6B: create a map series (if time allows)
- Add and update a map layer using a layer file
- Create a map series using Cursor
8. Miscellaneous

**Attendance/Absentee Policy:** Consistent with university’s policy, all students are expected to attend class meetings. Unless absence is explained on medical or compassionate grounds (documentation is required), absence from any classes is grounds for a grade adjustment.

**Academic Honesty and Plagiarism:** Academic honesty and integrity are expected at all times. Academic dishonesty, such as cheating or copying during exams, will be punished severely. Plagiarism – using someone else’s work without acknowledgment and, therefore, presenting their ideas or quotations as your own work – is strictly forbidden. DePaul University officials will be informed of any instance of academic dishonesty and notification will be placed in your file. Please read the DePaul Academic Integrity Resources page ([http://academicintegrity.depaul.edu/Resources/index.html](http://academicintegrity.depaul.edu/Resources/index.html)) for definitions and explanations of plagiarism and the University’s Academic Integrity expectations for students. Cutting and pasting text taken directly from a web-site without appropriate referencing and quotation marks is plagiarism and is forbidden. Submitting work that has any part cut and pasted directly from the internet is grounds for an automatic grade of zero.

**Accommodations:** Any student who requires assistance is asked to contact the University’s Center for Students with Disabilities (CSD) (Phone 773/325-1677, TTY 773/325-7296, Fax 773/325-7396, [http://studentaffairs.depaul.edu/studentswithdisabilities](http://studentaffairs.depaul.edu/studentswithdisabilities)). They will be able to assist both student and faculty. If you have a condition that requires accommodation from the Productive Learning Strategies program (PLuS Program) please contact them at the Student Center room 370 (Phone 773/3251677 or online: [http://studentaffairs.depaul.edu/plus/](http://studentaffairs.depaul.edu/plus/)).

**University Center for Writing-Based Learning:** Collaborates with writers from all disciplines, backgrounds, levels of expertise, and roles within the University community. Their goal is to help develop better writers along with better writing and reflection through continual revision. If you need assistance with writing assignments, they can be contacted at: 773.325.4272 (LPC) or [wcenter@depaul.edu](mailto:wcenter@depaul.edu)

**GIS lab open hours:** check out [http://qrc.depaul.edu/hours.htm](http://qrc.depaul.edu/hours.htm) or the GIS lab door.

**Labs with ArcGIS:** GIS lab, SAC 268, Richardson Library, Loop Library, and Daley 1327.

**To install ArcGIS in your computer:** ArcGIS for Desktop 10.2.2 free trial that is good for 60 days can be downloaded from [http://www.esri.com/software/arcgis/arcgis-for-desktop/free-trial](http://www.esri.com/software/arcgis/arcgis-for-desktop/free-trial). You can purchase a 1 year ArcGIS for Desktop Advanced for $100 with free ArcGIS online subscription at [http://www.esri.com/software/arcgis/arcgis-for-home](http://www.esri.com/software/arcgis/arcgis-for-home).

**Department of Geography Learning Goals**—GEO 345/445 addresses 1), 5), 6), and 7).

Courses in the Department of Geography teach students:

1) Understand spatial patterns and processes of modification of the Earth’s physical and cultural landscapes
   a. As social constructions.
   b. As systems that link the Earth with human society in interdependent, dialectical relationships, and
   c. Through mapping and visualization.
2) Understand the concept of scale as a spatial phenomenon that ties the local, the regional, the national, the transnational, and the global in a system of interaction.

3) Understand the phenomenology of the discipline of Geography—most importantly, “space”, “place”, “landscape,” “region,” and “location”.

4) Distinguish that spaces, places, and so on, may have both objective and subjective/symbolic dimensions.

5) Develop research and writing competences that would allow you to:
   a. Formulate a cogent research question about the spatial character of a physical, socio-cultural, or environment-societal phenomenon,
   b. Write about it in ways that reflect analytical and critical thinking, and
   c. Ethical concern over social and environmental justice, consistent with the University’s social mission.

6) Engage competently in qualitative and quantitative spatial analysis, and with exercises that are concerned with explaining spatial regularities (for example, the spatial calculus behind the location of retail commerce in Chicago, or transnational flows of capital).

7) Learn the basic utility and use competently one or more of the information technologies that are now redefining the logistical limits of spatial analysis: geographic information systems (GIS) and remote sensing.

8) Achieve greater general knowledge of the world, its regions, its physical systems, its cultures, and political-territorial divisions.