Massachusetts Institute of Technology - Department of Urban Studies and Planning

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<td>Spatial Database Management and Advanced Geographic Information Systems</td>
<td>1st half, before Spring Break</td>
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<td>11.523</td>
<td>Fundamentals of Spatial Database Management</td>
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Syllabus - Spring 2016

Subject Website: [http://mit.edu/11.521](http://mit.edu/11.521)

Lectures & Labs

Tuesday, **Lab:** 4-7 PM (**4-5:00** is the most important part) in **Room W31-301**
Thursday, **Lecture:** 5-6:30 PM in 9-251

Room W31-301, in the third floor of the Armory across the street from DUSP.
Room 9-251 is the SA+P School computing lab in building 9

NOTE #1: The 4-5:00 PM portion of the Tuesday lab is the most important part when the lab introduction and lab tips are presented. Students with conflicts after 5 can finish the lab exercises on their own at other times.

NOTE #2: After Spring Break, the 11.523 portion of the class ends and the 11.524 portion begins. The 11.524 portion is run as a workshop with almost all Tuesday and Thursday times devoted to class project work.

Instruction Staff

**Prof. Joseph Ferreira**  Room 9-532  x3-7410  jf@mit.edu
**Admin: Sue Delaney**  Room 9-530  x3-0779  sld@mit.edu

Office Hours

<table>
<thead>
<tr>
<th>Instructor</th>
<th>Room</th>
<th>Time</th>
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<tbody>
<tr>
<td>Joseph Ferreira</td>
<td>Room 9-532</td>
<td>Tues. 2:00-3:00, Thursday 10:30-noon</td>
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<tr>
<td>Mike Foster</td>
<td>Room 9-528</td>
<td>As the Department's GIS specialist, Mike has posted office hours in the Building 9 first floor lab and will provide assistance with web mapping and geoprocessing services during the second half of the semester.</td>
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Description

This semester long subject (11.521) is divided into two halves. The first half focuses on learning spatial database management techniques and methods for urban analytics and the second half focuses on using these
skills to address a "real world," client-oriented planning problem. The first half of the semester may be taken separately using the class number 11.523 and the second half may be taken separately as 11.524.

GIS and urban sensing have greatly expanded the volume and availability of spatially detailed data about urban activities, land use patterns, and mobility. Taking advantage of these new 'big data' requires a basic understanding of the tools and technology for designing, querying, analyzing, and sharing complex, constantly-changing spatial databases and maps that are distributed among data repositories and local machines. The requisite knowledge representation methods, client-server technologies and access control issues are quite different from what are needed to model and visualize standalone datasets on a personal computer.

The 11.523 portion of the semester addresses these issues while retaining a focus on planning (rather than on computer science). This is an intensive, hands-on class that stresses learning by doing. Exercises and examples involving real-world data, maps, and images are used to develop skills with database query languages and the design, development, and use of structured databases. Class work utilizes web tools, GIS, and database software with lab exercises. To provide 'real world' context, we focus on parcel-level data about residential properties and real estate transactions in Boston and examine some of the social and physical characteristics of neighborhoods that might explain the observed spatial variation in land and building values.

Technically, we will work with database servers (Oracle 11g and PostgreSQL) using SQL (structured query language) and we will use ArcGIS (including ArcScene, and Model Builder) for spatial analysis and modeling. We will also use MS-Access, Excel, Google Maps and Google Earth for desktop data manipulation and map mashups. Each week there is one ninety-minute lecture plus another 90 to 180 minute hands-on lab in the electronic classroom. Class lectures will focus on concepts and case discussion, the scheduled lab time focuses on computer mechanics and skill building. Specific topics during the 11.523 half of the semester include:

- finding, understanding and structuring digital spatial data that are available on the Internet using various browsing, visualization, and data management tools
- considerable work with relational database technologies and the Structured Query Language (SQL) to design, construct, query, and update urban planning databases
- some experience with so-called 'client/server' and 'enterprise geoprocessing' technologies for facilitating distributed access to complex spatial data and urban planning applications
- an introduction to 'big data' urban analytics
- advanced GIS topics such as 3D visualizations and geospatial web services.

The 11.524 portion of the semester will begin after Spring Break. This project portion of the semester focuses on spatial analyses and urban analytics of land use and transportation patterns and planning options related to sustainability and mobility in two metro areas, Boston and Singapore. We will explore ways of developing indicators and visualizations that can facilitate regional/local planning dialog through the use of State and Local government GIS data layers together with metropolitan planning models. For Boston, we will work with the Metropolitan Area Planning Council (MAPC) and the State GIS Office (MassGIS). For Singapore, we will work with the "future urban mobility" program within the Singapore/MIT Alliance for Research and Technology. In both cases, we will use block and building-scale data about land use, demographics, building characteristics, real estate prices, and transportation accessibility to build urban performance indicators and model spatial interactions. The 11.524 portion of the class will be organized as a workshop and the lab exercises and lecture/lab schedule for that part will be adjusted weekly to match the
project work schedule. 11.524 will also offer optional labs and exercises for those who want to utilize web mapping and geoprocessing services (using CartoDB and PostGIS) in their project work (in addition to the ArcGIS and Oracle tools and methods learned during the 11.523 portion of the semester.

Choosing 11.521 versus 11.523 or 11.524

- 11.521 = 11.523 + 11.524 and you can register for 11.521 or (11.523 plus 11.524) or either one of the half semester modules.
- 11.521 is a full-semester class that earns 12 units (3-3-6) of graduate credit
- 11.523 includes classes 1-13 of 11.521 (plus labs) and earns 6 units (2-2-2) of graduate credit. This subject covers the spatial database management portion of 11.521
- 11.524 includes classes 14-26 of 11.521 (plus labs) and earns units to be arranged (generally 1-1-4). This subject covers the advanced GIS project portion of 11.521.
- 11.521 cannot be taken for credit together with 11.523 or 11.524 in the same semester.
- 11.524 can be taken more than once for credit. This option allows advanced students to obtain additional credit for additional advanced project work in subsequent semesters.
- Students undecided between 11.521 (full semester) and 11.523 (first half-semester only) can sign up for both and then drop one before the drop date.

Prerequisites

The prerequisites for 11.521 (or 11.523) are (a) sufficient understanding of analytic methods, and (b) some background in GIS and database management. For MCP students the analytic methods are covered in 11.220: Quantitative Reasoning and Statistical Analysis I (which may be taken concurrently in the same Spring semester). For most undergraduates the general Institute requirements are sufficient. The introductory GIS and database management are covered in 11.520: A Workshop on Geographic Information Systems, or 11.188 Urban Planning and Social Science Lab (the undergraduate version of 11.520). However, we have designed 11.521 (and 11.523) to be accessible to students with only the half-semester Fall introduction to GIS: in 11.205 - Introduction to Spatial Analysis (see http://stellar.mit.edu/11.205). Students eager to learn more GIS whose only GIS and database management experience is 11.205 can take 11.523 (or the full-semester 11.521) if they have a little extra time to do a few additional online GIS and database lab exercises during the first few weeks of the semester.

Requirements

Exercises, class discussions, and projects use real databases and problems taken from current Urban Information Systems work in MIT's Urban Studies and Planning Department and involving local and regional planning agencies. These data include parcel-level maps, digital orthophotos, and spatially detailed real estate and transportation transactions, along with land use, wetland, and other environmental and demographic datasets from state and local sources.

The full course includes two homework exercises and six lab exercises (11.523 students complete the first five labs, and 11.524 students do the last one). Each lab includes an assignment to be turned in. To facilitate a quick turnaround on grading, the lab assignments will be evaluated on a three-mark scale: check-minus, check, check-plus. Students in 11.521 and 11.523 will complete two homework sets and have one in-lab test before Spring Break. Students in 11.521 and 11.524 will complete a half-semester group project during the second half of the term that provides an opportunity to apply GIS and database concepts in a 'real world' context. The project concludes with an oral presentation to the clients and a written report. In addition to preparing paper maps, the group will have the option to use a wiki for project collaboration and to build a
web site to showcase their work.

Grading

11.521: Grade is the average of 11.523 and 11.524 grades

| 11.523 | • 5 Lab Exercises (collectively) (25%)  
| 11.523 | • 2 Problem Sets (collectively) (35%)  
| 11.523 | • Examination (35%)  
| 11.523 | • Class Participation (5%)  

| 11.524 | • Lab 7 (10%) 
| 11.524 | • Project Proposal and lab work (35%) 
| 11.524 | • Final Project Presentation (35%) 
| 11.524 | • Final Project Writeup (20%) 

Lateness Policy

Turning in assignments promptly is important both for keeping current with the subject matter, which is cumulative, and to keep all students on a level playing field. Lab exercises are typically due one week after the lab is scheduled. A late lab exercise will be accepted up until one week after the original due date for a loss of one grade (e.g., a "check" becomes a "check-minus"). After that, late assignments will receive no credit and will not be accepted. Late problem sets will have two points deducted for each weekday or weekend after the due date. Final project writeups are due on the last day of classes. However, students always ask for extra time to turn in these writeups. They will be accepted without penalty until the following Monday. Writeups turned in later will lose 5 points per day. No project writeups will be accepted for grading purposes beyond one week after the last class.

Disabilities

If you have a documented disability, or any other problem you think may affect your ability to perform in class, please see me early in the semester so that arrangements may be made to accommodate you.

Academic Misconduct

Plagiarism and cheating are both academic crimes. Never (1) turn in an assignment that you did not write yourself, (2) turn in an assignment for this class that you previously turned in for another class, or (3) cheat on an exam. If you do so, it may result in a failing grade for the class, and possibly even suspension from college. Please see me if you have any questions about what constitutes plagiarism. Anyone caught cheating on an exam will be reported to the provost in line with recognized university procedures.

Texts

There are no required texts and most readings will be available online. Recommended papers and books will be on reserve at Rotch Library.

• Oracle 11g Documentation
Available online at http://www.oracle.com/technology/documentation/index.html
The documentation is generally available both in HTML format (good for viewing online in a browser) and PDF format (better for printing). You will be prompted to set up a (free) account before you can access these documents on the Oracle site. This semester, we will be using Oracle 11g (specifically, release 11.2.0.2.0). Some particularly useful references are:

- Oracle 10g SQL Reference. This is the authoritative reference for Oracle's flavor of SQL.
- SQL*Plus Quick Reference. A concise guide to SQL*Plus commands.
- Oracle 8i Designing and Tuning for Performance. Suggests ways to tune queries and database designs to improve performance. Offers insights into how Oracle operates.
- Oracle 8i Error Messages. Provides extra information about Oracle's sometimes cryptic error messages.

However, the Oracle documentation site is so cluttered that I find it quite hard to locate Oracle reference documents for these basic SQL queries. Accordingly, we have placed copies of the Oracle SQL Reference and SQL*PLUS Reference in the class locker:

  
  *Note: The book is a good introduction to what's under the covers of GIS software. A slightly updated edition was published in 1999 with the same ISBN.*

- Loney, Kevin. *Oracle 11g: The Complete Reference*. Berkeley: Osborne ORACLE Press Series, 2004. **ISBN-10:** 0071598758 and **ISBN-13:** 978-0071598750 This is a 1300+ page hardcover that is bulky but a very handy reference. (It is available at Amazon for about $50.) Rotch Library has an older version (Oracle 8i I believe). The older 8i version is still very useful since the basic SQL query language is essentially unchanged.


- We will also provide links to recent UIS-research related theses and papers that utilize the data and methods covered in the class.

**Schedule**

**Part I: Spatial Information and Database Management**

**Tuesday, 2 February**

*Introduction the Course +*
Lab 1: Lab Introduction using ArcGIS, Oracle, MS-Access and Excel

Topics:

- Check that everyone has an Athena account and can log into WinAthena PCs.
- Run lab exercise using 'toy' parcel database with MS-Access, Excel, and Oracle
- Run introductory ArcMap exercises from 11.188/11.205
- Brief description of the course

Thursday, 4 February

Class 2: Relational database management, geospatial data (jf)

Readings:

- Worboys, pp. 45-67.
- SQLnotes (first 3 parts on setup, SQL help, and the parcel database)

Topics

- Data models; Structured and unstructured data:
- Planning vs. IT professional views of DBMS
- Beyond text: Multidimensional data, geospatial data, metadata, web services
- Mapping Massachusetts' population density – when the map is too good to make it easy
- Spatial reference systems, coordinates, and projections

Tuesday, 9 February

Class 3: Land Use and Land Value Patterns in East Boston: Getting Comfortable with Relational Queries and Map-Database-Spreadsheet Interaction (Handling One-to-Many Relations - Grouping & Aggregation)

Lab 2: Intermediate Oracle and SQL queries to study land use and land value patterns in East Boston

Out: Lab Exercise 2
Due: Lab Exercise 1

Reading: Trimble and Chappell, Chapters 1-5, 7, and 8.

Topics:

- Joins: multiple table queries
- Creating/Dropping a table: CREATE TABLE, DROP TABLE
- Aggregation: GROUP BY, group functions
- Adding/Changing/Deleting rows: INSERT, UPDATE, DELETE
- Boston datasets: Parcels, Assessing, Zoning variances

Thursday, 11 February

Class 4: Advanced SQL - Subqueries and Complex joins (jf)

Reading: Trimble and Chappell, Chapter 6.
Topics:

- More SELECTs with GROUP BY and HAVING clauses
- Outer Joins, Self joins, Subqueries
- Boston parcel data examples

**Tuesday, 16 February NO CLASS (use Monday Schedule this day)**

**Thursday, 18 February**

*Class 5: The Zoning Variance Database & Advanced Query Construction (jf)*

**Due: Lab Exercise 2**

**Out: Problem Set A (in lieu of Lab 3):** More SQL -- The Zoning Variance Database & Categorization via Lookup Tables

**Readings:**

- Zoning variance database help pages

**Topics:**

- Top-down and bottom-up strategies for ‘cleaning’ official administrative databases
- Using lookup tables to interpret read-only city data
- Strategies for encoding, accumulating, and utilizing local knowledge

**Tuesday, 23 February**

*Class 6: Linking ArcGIS with Oracle and MS-Access databases*

*Lab 4: Mapping Boston Parcels and Zoning Variances*

**Out: Lab Exercise 4**

**Thursday, 25 February:**

*Class 7: Advanced SQL, Referential Integrity and Relational Database Design (jf)*

**Reading:** Worboys, pp. 68-84 (Optional: pp. 84-95).

**Topics:**

- Review of relational database design
- Enforcing referential integrity in the database

**Part II: Integrating Mapping and DBMS**

**Tuesday, 1 March**
Class 8: Distributed Databases and Map mashups (jf)

Due: Lab Exercise 4

Lab 5: Raster Modeling with ArcGIS's Spatial Analyst and Model Builder - Developing a Land Value Surface for Boston suing Spatial Analyst and Model Builder

Topics:

- Exercise of client/server concepts
- Using a graphical tools to query/map Oracle data
- Map mashups and distributed databases

Thursday, 3 March

Class 9: Review of SQL, Homework and GIS-RDBMS Integration

Due: Problem Set A (Part I)

Readings:

- Craig, "Why we couldn't get the data we wanted," Journal of the Urban and Regional Information Systems Association (URISA), Vol. 4 No. 2. 1992.

Tuesday, 18 March

Class 10: Metro Boston Modeling using TINs, Model Builder and Community Viz

Due: Lab Exercise 5

Lab 6: Community Viz and Boston's MetroFuture planning model

Thursday, 10 March

Due: Problem Set A (Part II)

Class 11: Database Design, Distributed GIS, and Urban Modeling; Integrating Mapping with RDBMS Tools II (jf)

Tuesday, 15 March

Class 12: In-Lab Examination

Thursday, 17 March

Class 13: Modeling VMT and built environment interactions; 3D visualization and Geospatial Services; Project introduction (jf)

Due: Lab Exercise 5

Out: Problem Set B (Referential Integrity and Relational Database Design)
11.523 Ends

Tuesday, 22 March: NO CLASS (Spring Break)
Thursday, 24 March: NO CLASS (Spring Break)

11.524 Begins - GIS Project

Tuesday, 29 March

Class 14: Intro to web mapping and Geoprocessing Services

Due: Lab Exercise 6 (for 11.521 and 11.523 but not 11.524)

Thursday, 31 March - Class 15: Web mapping exercises

Tuesday, 5 April - Class 16: Introduction to Project (jf)

Due: Problem Set B (Referential Integrity and Relational Database Design)

Thursday, 7 April - Class 17: Project planning with Clients

Tuesday, 12 April: Class 18: Project work

Thursday, 14 April - Class 19: Project work

Tuesday, 19 April: NO CLASS Patriots Day--Vacation

Thursday, 21 April - Class 20: Project Work

Tuesday, 26 April - Class 21: Project Work

Thursday, 28 April - Class 22: Project Work

Tuesday, 3 May - Class 23: Project Work

Thursday, 5 May - Class 24: Internal Project Presentation

Tuesday, 10 May - Class 25: Project Writeup and Class Wrapup

Thursday, 12 May - Class 26: Project Presentation

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Last modified: 31 January 2016 [jf]