1.013: Senior Civil and Environmental Engineering Design:
Sensor Networks and the Smart Campus

Spring 2014

TuTh 1-4pm, Beaver Works, 300 Technology Square

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Office hours: By appointment
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OBJECTIVES

The objective of this class is to synthesize prior educational concepts from the Civil and Environmental Engineering program into a semester-long design experience. This will be achieved through the concurrent exploration of three major projects: first, the deployment and analysis of a specific on-campus sensor network to measure air quality; second, the design of a campus "smart city"; and third, the design, construction, and analysis of a tower structure. As part of this class students will participate in all levels of design: research, system design, prototyping, and analysis. Complementary lectures and reading will introduce students to relevant concepts in smart cities, sensor network design, and engineering practice and ethics. Instruction and practice in oral and written communication are an integral part of this course.

REQUIRED TEXT

"Engineering Communication: From Principles to Practice", Robert Irish and Peter Weiss, Oxford University Press, Second Edition, 2013

COURSE OVERVIEW

The class involves three distinct but closely-related projects, all of which relate to the concept of the "smart city" and sensor networks. In these projects, your role is that of civil/environmental engineering consultants, hired by us, your instructors (in the role of MIT/the client). The three projects are as follows:

I. The implementation of a single sensor network on campus. The second project involves the construction and use of a targeted sensor network (similar to those designed in Project I) on campus, in order to meet a defined objective. For the 2013-14 academic year, your specific task is to **assess the exposure of the MIT population to airborne pollution**. Poor air quality is one of the largest causes of premature death worldwide, and, because of rapid increases in global urban populations (especially in developing countries), is likely to become an increasingly central problem in civil and environmental engineering over the next several decades. The development of an air quality sensor network for MIT's campus will allow us to understand the health risks our own community faces, and ideally will address specific air quality concerns associated with a campus research university. Moreover, the network will serve as a generic testbed/prototype for future air quality networks, for deployment across a diverse array of urban and rural environments in both the developed and developing world. **Finally, through this implementation project you will tackle deployment, communication (e.g. web interface), and analysis challenges common to all sensor networks.** In this class you will take an existing prototype design (from the fall semester class, 1.S992) and make it into to a full-scale, campus-wide sensor network. Various tasks associated with implementation will be carried out in 4-5 person teams. You will use this network to assess MIT's air quality (which you will describe in a formal report) as well as to provide a means for the MIT community to have access to the data (which you will describe in a public presentation).

II. The design of a "smart campus". Your smart campus design will consist of several networks for sensing and/or control of various aspects of current or future campus/urban life. You will break up into teams of 2-3 and each team will define a focus area and design an individual network. Sample topics include energy efficiency, transportation, structural integrity, and environmental health, but the focus of your group's network is entirely based on your own interests. The ultimate goal is scalability, such that a larger version of the same design could be implemented for a entire urban area (Cambridge, Boston, etc). The product of this project will be a written proposal for an on-campus sensor network, articulating the motivation and needs for the measurements, the context, the approach, and the implementation design and estimated costs.

III. The design, model construction, and evaluation of a tower structure. In this third project, teams of three will apply structural principles to the design of a tower that supports a sensor package like those used in the second project and resists wind loading. The design goals include meeting strength and stiffness requirements while minimizing the amount of structural material used. You will develop the designs using hand calculations, finite element analysis software, and structural optimization software. You will then construct models of your towers using digital fabrication tools in the Beaverworks facility. The structural performance of the designs will be evaluated through static load testing, and observed deflections and other behavior will be compared to those predicted by finite element analysis. The design, fabrication, and testing phases of this project will be documented in a technical lab report carried out in teams.

GRADING

I. Concept Network Presentations (teams of 2-3)	5%
I. Written Network Proposals and Poster (teams of 2-3)	15%
II. Status Report Presentations and Gantt Chart	5%
II. AQ Network Implementation and Analysis Report (all)	15%
II. Public Presentation on AQ Network & Web Portal (all)	20%
III. Lab Report on Tower Structure (teams of 3)	20%
I/II/III. Participation (individual): *based on instructor/peer evaluations*	20%

The schedule for individual assignments/presentations is given on the next page. Details for each will be provided later in the semester.

CLASS SCHEDULE:

<table>
<tr><th colspan="3" rowspan="2">DATE</th><th rowspan="2">LECTURE</th><th colspan="3">COURSE ROADMAP, DUE DATES</th></tr>
<tr><th>I: AQ network</th><th>II: network design</th><th>III: tower design, test</th></tr>
<tr><td rowspan="8">February</td><td>4</td><td>T</td><td>Class introduction; 1.S992 team report</td><td rowspan="8">Node construction; calibration; planning</td><td rowspan="2"></td><td rowspan="8"></td></tr>
<tr><td>6</td><td>Th</td><td>WAC: Team communication</td></tr>
<tr><td>11</td><td>T</td><td>Markus Buehler</td><td rowspan="5">Teams; problem statement</td></tr>
<tr><td>13</td><td>Th</td><td>Andrew Whittle
2pm: Anne Graham</td></tr>
<tr><td>18</td><td>T</td><td>No class</td></tr>
<tr><td>20</td><td>Th</td><td>WAC: communication, genres</td></tr>
<tr><td>25</td><td>T</td><td>Marta Gonzalez</td></tr>
<tr><td>27</td><td>Th</td><td></td><td>Concept network presentations</td></tr>
<tr><td rowspan="8">March</td><td>4</td><td>T</td><td rowspan="6">Mueller/Ochsendorf</td><td rowspan="6">Node testing</td><td rowspan="11">Research, planning</td><td rowspan="6">Construction/ evaluation activities (in class)</td></tr>
<tr><td>6</td><td>Th</td></tr>
<tr><td>11</td><td>T</td></tr>
<tr><td>13</td><td>Th</td></tr>
<tr><td>18</td><td>T</td></tr>
<tr><td>20</td><td>Th</td></tr>
<tr><td>25</td><td>T</td><td rowspan="2">No class (Spring Break)</td><td rowspan="7">Implementation. Data collection</td><td rowspan="2"></td></tr>
<tr><td>27</td><td>Th</td></tr>
<tr><td rowspan="9">April</td><td>1</td><td>T</td><td>Saurabh Amin</td><td>Lab report due</td></tr>
<tr><td>3</td><td>Th</td><td>WAC: Proposal Writing</td><td rowspan="13"></td></tr>
<tr><td>8</td><td>T</td><td>Oral Buyukozturk</td></tr>
<tr><td>10</td><td>Th</td><td>Pete Shanahan: Professional Ethics</td><td>Draft network proposals</td></tr>
<tr><td>15</td><td>T</td><td>Pete Shanahan: Professional Practice</td><td rowspan="3"></td></tr>
<tr><td>17</td><td>Th</td><td></td><td rowspan="5">Data collection, Analysis</td></tr>
<tr><td>22</td><td>T</td><td>No class</td></tr>
<tr><td>24</td><td>Th</td><td></td><td>Final network proposals, posters</td></tr>
<tr><td>29</td><td>T</td><td>Paul Breimyer (LL)</td><td rowspan="6"></td></tr>
<tr><td rowspan="5">May</td><td>1</td><td>Th</td><td></td></tr>
<tr><td>6</td><td>T</td><td></td><td>4-6: Public presentation</td></tr>
<tr><td>8</td><td>Th</td><td></td><td rowspan="2"></td></tr>
<tr><td>13</td><td>T</td><td></td></tr>
<tr><td>15</td><td>Th</td><td></td><td>Network Analysis/ Implementation Report</td></tr>
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