Graduate Program in Historic Preservation
Stuart Weitzman School of Design, University of Pennsylvania

HSPV 552 *Building Diagnostics and Monitoring*
Michael C. Henry, PE, AIA, Adjunct Professor of Architecture

Course Syllabus

Class Meetings
Fridays, 1:45 PM to 4:45 PM (Eastern Daylight Time/Eastern Standard Time)
Class meetings for lectures will be synchronous via Zoom.
Class meetings for group exercises will be in-person, dependent on Covid-19 risk factors.

Communications
Each student is expected to meet with the instructor at least twice during the semester.
Office hours: Fridays, 10:00 AM to 1:00 PM (EDT/EST) *via Zoom on Lecture days*
Telephone: By appointment, Monday-Thursday, 9:00 AM to 5:00 PM (EDT/EST)
E-mail: henrmic@design.upenn.edu *Note: Subject heading of emails should state "HSPV 552".*
Note: I send emails from mhenry@watsonhenry.com *, please add this address to your "Safe Senders".*

Research/Graduate Assistant: Xiyue He, xiyuehe@design.upenn.edu

Course Description
Building diagnostics are the identification and analysis of a problem in a building's condition or performance. We diagnose a building through qualitative and quantitative observation and by investigation of its history, context, and use, yielding the identification of the possible causes of that condition/performance problem, concluding with a formal professional opinion as the probable cause(s).

Monitoring is the consistent observation and recordation of a selected condition or a performance attribute and the probable enabling factor(s) of either, taking qualitative and/or quantitative measures over a period of time. Monitoring results in useful data and information for analysis, development of a causal hypothesis. Ultimately, monitoring may be used to validate the hypothesis.

Building diagnostics and monitoring inform the development of appropriate interventions or corrective measures to address the cause(s) of the identified problem. In heritage buildings, the process informs the selection of interventions that satisfy the stewardship goals for the resource.

HSPV 552 *Building Diagnostics and Monitoring* examines the diagnostic process, including:
- Metacognition of our processes of collection and analysis of data, evidence, and information;
- Recognition of diagnostic bias;
- Application of systems thinking in framing problems of building condition and/or performance;
- The human vision system and qualitative observation of conditions or performance;
- Identification of potential mechanisms that may have resulted in the observed conditions and identification of necessary and sufficient enabling factors for those mechanisms;
- Analysis and development of multiple hypotheses as to the probable mechanism(s);
- Identification and validation of the strongest hypothesis.

Building Diagnostics and Monitoring presents the fundamentals of monitoring as a diagnostic tool, including:
- Basics of measurement theory and practice;
- Sampling and statistics;
- Diagnostic tools, such as instruments, imaging, dosimetry, and tests;
- Design of a diagnostic monitoring program, including selection of measurement and monitoring devices;
- Collection, analysis, and presentation of data.

Learning Objectives

Upon successful completion of *Building Diagnostics and Monitoring*, students should be able to:

- Apply the principles of critical thinking, systems thinking and creative problem solving;
- Develop a structured and logical diagnostic methodology for analysis of a building condition/performance;
- Research information in the professional literature concerning building pathology and diagnostics;
- Observe and describe conditions qualitatively and quantitatively;
- Organize and present data and information to facilitate analysis;
- Develop preliminary hypotheses correlating observed condition/performance problems to causal mechanism and the necessary and sufficient factors to enable those mechanisms;
- Develop a methodology to validate/invalidate the hypotheses through monitoring;
- Evaluate the available devices for monitoring;
- Present data and information to support conclusions; and,
- Prepare a professional-level technical proposal/report for diagnosis and monitoring for a particular building condition/performance problem.

Teaching and Learning

Building Diagnostics and Monitoring will be taught using the following platforms:
Canvas will be used to access lecture slides, readings, quizzes, and tests.
In-person class meetings will be used for exercises and group work applying the course material to real buildings in case studies and to the final assignment.
Zoom will be used live on-line class meetings for lectures.
Zoom and *telephone* will be used for meetings with individuals and teams.

On-Line class meeting time will be structured to maximize active learning and interaction among students and between students and the Instructor and as a consequence, class discussion of lecture content is expected. This approach will require thorough preparation before class, including review of the readings and lecture slides. Class meetings will not be recorded unless a student cannot attend due to exceptional circumstances, such as an acute health issue.

In-person class meetings will be used for exercises and group work applying the course material to real buildings in case studies and to the final assignment.

The final assignment will be introduced at the beginning of the semester. Drafts of the major sections of the final assignment will be submitted incrementally during the semester, so that feedback can be provided in time for more research and refinement of the final work product by the student teams.

After two and one-half semesters of on-line teaching, enough benefits and opportunities have emerged to retain the on-line approach for some class meetings, combined with in-person class experiences for collaborative problem-solving and exercises.

Feedback on the effectiveness of the methods used in this course will be welcome, so that we can make mutually agreeable adjustments and introduce improvements as *Building Diagnostics and Monitoring* proceeds through the semester. Your candid feedback on course content, readings, class exercises and teaching methods are encouraged so that the course may be continuously developed and improved. Course feedback may be delivered directly, or through the Teaching Assistant. Real time feedback, rather than feedback at the end of the course, is preferred.

Learning - Your Responsibilities as a Student

- **Attendance**

You are expected to attend all classes and attendance will be taken. Notify me by email before class if you will not be able to attend a class meeting. The Course Absence Report system will not be used for this course.

- **Preparation for Class**

The learning and teaching process is most effective when students and faculty thoroughly prepare for each class or individual meeting, whether on-line or in-person. At a minimum, you must absorb the assigned material, regardless of format. Preparatory materials for each week are listed in the syllabus.

- **On-line Conduct**

You should treat on-line class meetings as if you are in a live business meeting with other professionals. Eliminate distractions to you and your fellow students. Turn-off your phones, email, and texting apps/programs. Eat your lunch/dinner before or after, but not during, class.

- **Class Exercises and Problem-based Learning**

Class exercises and problem-based learning are an important part of the student-centered learning process and will apply information or methods addressed by the readings and lectures. Class exercises require reasoning, analysis, basic mathematical calculations, and sketching. Some exercises will be done individually; others will be collaborative. You will need a simple calculator, graph paper and writing/sketching instruments (or the digital equivalent) to complete the class exercises.

- **Quizzes**

Periodic quizzes demonstrate your progress with assimilation of the course material in the lectures and the readings. All quizzes will be "closed-book." You will need a simple calculator, graph paper and writing instruments to complete the quizzes.

- **Test of Knowledge**

The test of knowledge demonstrate that you have command of information that is essential to successful completion of the course. The test of knowledge requires your comprehension and retention of information contained in the readings and lectures. The test will be "closed-book." You will need a simple calculator, graph paper and writing instruments to complete the test.

- **Final Assignment Deadline**

The deadline for the final assignment is firm and there will be ample time for you to plan and execute the assignment. Short of hospitalization, no extensions will be granted. Late delivery of your assignment will be reflected in your grade.

- **Academic Integrity**

Honesty is fundamental to your future practice as a professional and academic honesty is fundamental to our community at the University of Pennsylvania. Honesty includes attributing and citing the sources used in your assignments.

The UPenn Code of Academic Integrity can be found at https://catalog.upenn.edu/pennbook/code-of-academic-integrity/ *A confirmed violation of that Code in this course will result in failure for the course.*

Prerequisites for this course

HSPV students must have successfully completed HSPV 551 *Building Pathology* prior to this course unless specifically waived by the Instructor due to equivalent education or professional experience.

MHPD and MEBD students must have a working knowledge of psychrometrics, climate factors, building envelopes and building environmental systems.

All students should complete the psychrometric tutorial http://www4.uwsp.edu/papersci/biasca/currentpages/ prior to the start of the course.

Metrics for Student Performance

Letter grades and their numerical equivalents will be based awarded upon successful completion of the course. The final grade will be based on the following allocation:

- Participation in class 25 %
- Test of Knowledge 35 %
- *Building Diagnosis & Monitoring Proposal* 40 %
- Total (maximum) 100 %

The final course grade will be adjusted to reflect unexcused absences and late assignments.

Participation in class will be based on:

- Preparation, including readings;
- Exercises - participation and outcomes;
- Engagement in discussions.

The *Building Diagnostic & Monitoring Proposal* will be graded on:

- Focused, substantive and concise content, founded on clear and logical analysis, substantiated by facts and independent research beyond the course materials;
- Clear and logical narrative exposition of the information, substantially free of grammatical, punctuation and spelling errors;
- Graphical presentation of key concepts illustrating the important or complex points of the narrative.
- Conformance with format requirements.

The full range of grades will be awarded in this course:

- A
  Exceptional work, equivalent to professional quality, thorough grasp, and synthesis of all information.
  Thorough preparation for class, demonstrated by engagement and participation.
  Writing: Logically organized, clear and concise with correct use of technical terminology.
  Research of the problem at hand: citation of professionally acceptable sources beyond course materials.
  Evaluation of proposed measurement/monitoring devices/method: thorough.
  Proposed graphics demonstrating causality: multi-variant, strong, clear, and compelling.
- B
  Very good work, near-professional quality, thorough grasp, and synthesis of nearly all information.
  Rare lapses in preparation for class, occasional lack of engagement and participation in class.
  Writing: rare lapses in clarity or application of technical terminology.
  Research of the problem at hand: limited citation of professionally acceptable sources beyond course materials.
  Evaluation of proposed measurement/monitoring devices/method: representative of range.
  Proposed graphics demonstrating causality: dual variant, clear and convincing.
- C
  Average work, sub-professional quality, understanding of basic information.
  Marginal class preparation, moderately engaged, occasional participation.
  Writing: Weak organization or structure, poor application of technical terminology.
  Research of the problem at hand: citation of professionally acceptable sources limited to course materials.
  Evaluation of proposed measurement/monitoring devices/method: limited options;
  Proposed graphics demonstrating causality: clear, but single variant.
- F
  Unacceptable work.

Overview of the Final Assignment
For the final assignment, you and your assigned teammate(s) will prepare a *Building Diagnosis & Monitoring Proposal*, consisting of a professional-level technical proposal for diagnosis and monitoring for a specific building material/performance problem.

In preparing the *Building Diagnosis & Monitoring Proposal*, you will apply and extend the critical concepts, fundamental principles, methods and information from the lectures and readings. You will also investigate and evaluate suitable methods/devices for measurement or monitoring as part of the *Building Diagnosis & Monitoring Proposal*. This effort will constitute the active learning component of the course and will provide student-centered, learning in the context of authentic, real-world building problems.

The Building Material/Performance Problem
The problem for the final assignment will be based on an actual building, but some information specific to definition of the problem will be fictionalized for simplicity. Some information will be released incrementally over the course, simulating the normal evolution and discovery process of a diagnostic problem in real practice. You are responsible for researching all other information necessary to address the problem and complete the assignment.

Submission
Students must submit the Final Assignment at the time specified in the *Syllabus*. Each team member must sign the cover sheet indicating that they have contributed equally to the assignment.

The Building Diagnosis & Monitoring Proposal
The *Building Diagnosis & Monitoring Proposal* is a professional-level technical proposal containing:
- Qualitative narrative and graphical description of the building material condition/ performance problem;
- Analysis of the problem and identification of at least two possible and differential hypotheses as to the probable cause and the necessary and sufficient enabling factors, substantiated by citations found outside of the course materials;
- Proposed diagnostic monitoring methodology to differentiate the two hypotheses and validate one of the hypotheses while invalidating the other. Identification of the expected outcomes, and possibility for unexpected results;
- Proposed methods for analyzing and presenting the information that will result from the proposed diagnostic monitoring methodology.

The narrative must be a clear and logical exposition of the facts.[1] Writing must be substantially free of grammatical and spelling errors. Graphics should illustrate the important or complex points of the narrative.[2] Conclusions and recommendations must be substantiated by facts and reflect a rational thought process.

The *Building Diagnosis & Monitoring Proposal* shall be organized as follows:
- **Cover sheet**
- **Title page**
  Property name and location/address;
  Course number, title, and program
  Date of report
  Each student's printed name and signature with statement "I have contributed equally with my team partner(s) in this assignment"
- **Table of contents**

[1] *Elements of Style Illustrated* by William Strunk, Jr. and E. B. White is a classic guide to writing. The current edition is delightfully illustrated by Maira Kalman.
[2] *The Visual Display of Quantitative Information, Second Edition* by Edward R. Tufte provides an excellent review of graphical presentation of information.

- **Executive Summary** (1-2 pages of text)
  Provide a brief introduction and overview of the condition and the important points of the *Building Diagnosis & Monitoring Proposal*.
- **Background and Overview of the Building** (2 pages of text, maximum, plus necessary graphics)
  Describe the spatial, environmental, and temporal contexts of the building and/or site, in order to orient the reader generally. Provide contextual details that are pertinent to the specific condition addressed by the *Building Diagnosis & Monitoring Proposal*.
- **Description of the Condition/Performance Problems** (3 pages of text, maximum, plus necessary graphics)
  Describe the selected building condition/performance problem qualitatively using professionally-recognized terminology.
- **Analysis of the Condition/Performance Problem and Two Hypotheses of Cause and Enabling Factors** (4 pages of text, maximum, plus necessary graphics)
  Analyze the condition/performance problem, the contextual information and identify two distinct possible mechanisms and the necessary and sufficient factor(s) that enable those mechanisms.
  Identify two hypotheses for the most probable mechanisms.
- **Proposed Validation Methodology** (4 pages of text, maximum, plus necessary graphics)
  Describe the proposed methodology for differentiating the two hypotheses, validating one and invalidating the other, including:
    Data/information required, including the necessary accuracy, resolution, and repeatability;
    Method and equipment necessary to collect the data/information, such as laboratory testing, sampling, in-situ monitoring;
    Evaluation of available data/information acquisition methods;
    Identification of recommended data/information acquisition methods.
- **Proposed Method for Analysis and Interpretation of Data** (3 pages of text, maximum, plus necessary graphics)
  Describe the proposed method/format for analysis and presentation of the results.
  Sample data graphics/plots showing causality and validation/invalidation of the hypotheses.
- **Appendices**
  Maps
  Floor plans or plan sketches
  Conditions maps (elevation drawings or photographs)
  Conditions glossary
  Manufacturers data sheets for devices/equipment
  Bibliography listing citations related to the problem and the development of the hypotheses

The **digital format** of the *Building Diagnosis & Monitoring Proposal* shall conform to the following:

- White paper, 8.5 by 11.0-inch, portrait orientation for text, single-sided;
- White paper, 11.0 by 17.0-inch, landscape orientation, single-sided printing, z-folded for large graphics;
- Calibri font, 11-point, black print, single spaced lines;
- Margins set at 1.25 inches (binding edge), 1.00 inches (other edges);
- Single-line footer with Project Name (left) and page number (right);
- Pages numbered sequentially:
  i, ii,… for contents; 1, 2, …for report body; A1, A2, … for appendix A, similar for B, et cetera;
- Endnotes for each section;
- Photographs, images, and charts/graphics:
  Landscape format (top edge to rings) or portrait format.
  Black and white or color, laser/bubble jet printed from digital images or scans.
  4 inches in the least dimension.
  Captioned with self-evident descriptive text, source name and date;
- Individually tab each report section and appendix and label tabs;
- Bind entire document as a single .pdf;
- Upload the entire document as a single digital file in .pdf format to a Canvas or Dropbox location to be designated later in the course.

Information Sources for the Course

In addition to the readings in the syllabus, the following books are also required for the course:

Meadows, Donella H. *Thinking in Systems, a primer.* White River Junction, VT: Chelsea Green Publishing, 2008.

Tufte, Edward R. *The Visual Display of Quantitative Information, Second Edition*. Chesire, CT, USA: Graphics Press LLC (www.edwardtufte.com), 2006.

Tufte, Edward R. *Visual and Statistical Thinking: Displays of Evidence for Making Decisions*. Chesire, CT, USA: Graphics Press LLC (www.edwardtufte.com), 1997. (N.B. this document is available as a pamphlet or as Chapter 2 of Tufte's book, *Visual Explanations*)

Watt, David S. *Building Pathology, Principles and Practice*, 2nd Edition. Oxford, UK: Blackwell Publishing Ltd., 2007. Chapter 5: *Survey and Assessment.*

Other Resources

American Concrete Institute. Home page. http://www.concrete.org/General/Home.asp?HP=h_home

American Society of Civil Engineers. Home page. http://www.asce.org/
ASCE 11-99 Guideline for Structural Condition Assessment of Existing Buildings. New York, NY, USA: ASCE, 1999.
ASCE 30-14 Guideline for Condition Assessment of the Building Envelope. New York, NY, USA: ASCE, 2000.

American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE). Home page. https://www.ashrae.org/

American Society for Testing and Materials. Home page. http://www.astm.org/

Association for Preservation Technology. Home page. http://www.apti.org/

Brick Industry Association. *Technical Notes*. http://www.gobrick.com/TechnicalNotes/tabid/7658/Default.aspx

Building and Environment. The International Journal of Building Science and its Applications. Elsevier. http://www.journals.elsevier.com/building-and-environment/

Building Science Corporation. *Building Science Digests* and *Building Science Insights* series http://www.buildingscience.com/index_html

Construction and Building Materials: An international journal dedicated to the investigation and innovative use of materials in construction and repair. Elsevier. http://www.journals.elsevier.com/construction-and-building-materials/

Engineering Weather Data: a compilation of National Climate Data Center Charts and Tables for worldwide locations as used in the course. Can be accessed for free at University of Indiana University, Bloomington website. http://webapp1.dlib.indiana.edu/cgi-bin/virtcdlib/index.cgi/4910250
at bottom of page select either "Download" for the entire file or "Browse" then open "EngineeringWeather.html" to find a location.

Forest Products Laboratory. Home page. http://www.fpl.fs.fed.us/

Masonry Institute of America. Technical Publications. http://www.masonryinstitute.org/products.php?catID=5

NDT & E International: an international journal for nondestructive testing and evaluation. Elsevier. http://www.journals.elsevier.com/ndt-and-e-international/

National Research Council of Canada. *Canadian Building Digests* series http://www.nrc-cnrc.gc.ca/eng/ibp/irc/cbd/digest-index.html

US Department of Agriculture, Natural Resources Conservation Service, *Web Soil Survey*. http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

Although not required, the learning experience can be enhanced by the following texts:

Fogler, H. Scott and Steven E. LeBlanc. *Strategies for Creative Problem Solving*, 2nd Edition. Upper Saddle River, NJ, USA: Pearson Education, Inc., 2008.

Course, Reading & Assignment Schedule			
Date	**Topic**	**Required reading before class**	**Preparation**
03 September Class 1 (In-Classroom) *Getting underway*	Course introduction: *Content, learning methodologies, quizzes, test of knowledge, final assignment, & student work product.* Diagnostics *Their importance* *Failures in problem identification & analysis* *Model for diagnostic reasoning*	Henry. HSPV 552 Course Syllabus Diagram: Watt. *Building Pathology.* Fig 5.13 Diagram: *ASCE Guideline for Condition Assessment of the Building Envelope*. SEI/ASCE 30-00 Diagram: ASHRAE-Guideline-0-The-Commissioning-Process Start reading Tufte, finish by class 5 Tufte. *The Visual Display of Quantitative Information, Second Edition*	Henry. Lecture Slides Class 1 Question: 1. Compare flowcharts by Watts, ASCE and ASHRAE. How might they apply to a diagnostic process for built cultural heritage?
10 September Class 2 (On-line) *Thinking in systems*	Thinking in Systems *Systems structures* *Stacks, flows & dynamic equilibrium* *Feedback loops, types & effects* *System response*	Keene, S. A systems view of museums. In *Managing Conservation in Museums*. 2nd ed., 2002, pp. 79-96. Meadows, Donella H. *Thinking in Systems, a primer.* (pp. 1-72)	Henry. Lecture Slides Class 2 Question: 1. How does "systems thinking" apply to a diagnostic process for built cultural heritage?
	Introduction to the Final Assignment	Review available documentation and the Final Assignment Brief. Croskerry. *A Universal Model of Diagnostic Reasoning.* Academic Medicine 2009/84:8/pp 1022-8 Watt. *Building Pathology.* pp 164-185	Question: 1. Provide examples of systems 1 and 2 thinking in the diagnosis of problems in built cultural heritage.
17 September Class 3 (In-Classroom)	Exercises & Problem Solving 1. Timelines 2. Systems diagrams	Read articles regarding Notre Dame Fire and Champlain Towers South Condominium collapse Notre Dame: https://www.nytimes.com/interactive/2019/07/16/world/europe/notre-dame.html?searchResultPosition=1 Champlain: https://www.nytimes.com/interactive/2021/09/01/us/miami-building-collapse.html https://www.wsj.com/articles/behind-the-florida-condo-collapse-rampant-corner-cutting-11629816205?page=1	Question: 1. List the subsystems that comprise the Notre Dame fire event. 2. List the subsystems that comprise the Champlain Towers South collapse event. 3. In each case, when you assemble all of the subsystems into a single system, what is the starting point in time for the event?

Course, Reading & Assignment Schedule			
Date	**Topic**	**Required reading before class/Required submissions before class**	**Preparation**
24 September Class 4 (On-line) *Seeing & Qualitative Assessment*	Seeing is knowing: *How we see, what we don't see & why* Qualitative Assessment: *Describing what we see, sharing what we've seen, terminology & visual glossaries, the repeatability problem*	Ashley-Smith, J. 1999. Definitions of damage. In *Risk Assessment for Object Conservation*. 1st ed., 1999, pp 99-119. Taylor, J. *An Integrated Approach to Risk Assessments and Condition Surveys*. Journal of the American Institute for Conservation 2005/44/pp 127-141 http://eprints.ucl.ac.uk/2286/ Castelhano, Mack, & Henderson. *Viewing task influences eye movement control during active scene perception.* Journal of Vision 2009 9(3):6, pp. 1-15. Williams & Castelhano. *The Changing Landscape – Influences on Eye Movement*. Vision 2019, 3, 33, pp 1-20.	Henry. Lecture Slides Class 4 Questions: 1. What are examples of your own failure to see something in plain sight? 2. How will you apply what you have learned to observation of a building. 3. How can you make qualitative observations precise?
Metacognition: Thinking about our thinking	The diagnostic process: *Diagnostic biases & traps* Critical thinking: *Evidence & information gathering, analysis & conclusions* Active listening	Croskerry, P. *The Cognitive Imperative: Thinking About How We Think.* Academic Emergency Medicine 2000/7:11/pp 1223-31 Croskerry, P. *The Theory and Practice of Clinical Decision-Making.* Canadian Journal of Anesthesiology 2005/52:6/pp R1-R8 Croskerry, P. *Context is everything or How could I have been that stupid?* Healthcare Quarterly 2009/v12 special/pp 171-7 Bondreau, Cassell, Fuks. *Preparing Medical Students to become Attentive Listeners.* Medical Teacher 31 (2009) Aper, et al. *The Dilemmas and Challenges that Medical Students Experience When Learning to Conduct Consultations.* Patient Education and Counseling 98 (2015) *Defining Critical Thinking/Our Concept of Critical Thinking/ Becoming a Critic of Your Thinking,* The Foundation for Critical Thinking	Henry. Lecture Slides Class 5 Question: 1. Are there parallels or similarities between active listening and careful observation?
01 October Class 5 (In-Classroom)	Exercises & Problem Solving 1. Critical review of technical information. 2. Review and discussion of Draft Assignment sections	**Submit Draft Assignment sections by 6:00 PM Thursday prior to class:** • **Background and Overview of the Building** • **Description of the Condition/Performance Problem**	Prepare Draft Assignment Section

Course, Reading & Assignment Schedule			
Date	**Topic**	**Required reading before class/Required submissions before class**	**Preparation**
08 October Class 6 (On-line) *Approaching a problem* *Transforming data into information*	Creative problem solving: *Open ended & closed ended problems, problem definition, creative problem solving* Aids to the diagnostic process: *Visualizing information, making connections.*	*Thoughts on Problem Solving* http://www.engin.umich.edu/~problemsolving/index.htm (you may ignore examples that deal with chemical engineering) Creative Problem-Solving model http://members.optusnet.com.au/~charles57/Creative/Brain/cps.htm Tufte. *Visual and Statistical Thinking: Displays of Evidence for Making Decisions* Tufte. Excerpt from *The Visual Display of Quantitative Information*	Henry. Lecture Slides Class 6 Question: 1. How do System 1 and System 2 thinking relate (or not relate) to Bloom's Taxonomy and CPS Model of divergent and convergent thinking phases?
	Visualizing Information: *Tufte's principles, sketching, spatial & temporal coordinates, graphs & trendlines, tables and matrices*	Tufte. *The Visual Display of Quantitative Information, Second Edition* (complete reading the entire book before this class). Koch & Denike, *Essential, Illustrative, or . . . Just Propaganda? Rethinking John Snow's Broad Street Map.* Cartographica 45 (1) 19 31 2010 Review the graphics of *The Orphan Tsunami of 1700* https://pubs.usgs.gov/pp/pp1707/pp1707.pdf	Henry. Lecture Slides Class 12 Questions: 1. What are Tufte's Principles? 2. How does visualization of information help in the diagnostic process?
15 October	Fall Break		
22 October Class 7 (In-Classroom)	Exercises & Problem Solving Presenting flows and data as information	**Submit Draft Assignment Section by 6:00 PM Thursday prior to class: Analysis of the Condition/Performance and a system diagram**	Prepare Draft Assignment Section
29 October Class 8 (On-line) *Measurement & Quantitative Assessment:* *1. The basics* *2. Moisture*	The measurement process: *Accuracy, precision & specification, device error & process error, recording, repeatability*	Henry, Michael C. *Technical Note: Monitoring, Interpretation and Use of Data.* Los Angeles, CA, USA: J. Paul Getty Trust, 2003. Device manufacturers' literature *HOBOWare Getting Started* plus *various device instructions*	Henry. Lecture Slides Class 8 Question: 1. Why is precision important in preservation measurements?
	Moisture in air and materials: *Principles and practicalities of measurement*	Harriman, Lewis G. *Practical Aspects of Locating and Measuring Moisture in Buildings.* http://c.ymcdn.com/sites/www.nibs.org/resource/resmgr/BEST/BEST1_002.pdf Onysko, Donald M, C. Schumacher & P. Garrahan. *Field Measurements of Moisture in Building Materials and Assemblies: Pitfalls and Error Assessment*. Journal of Building Envelope Design. 2008/pp 11-25 Sandrolini, Franco & Elisa Franzoni. *An operative protocol for reliable measurements of moisture in porous materials of ancient buildings.* Building and Environment 2006/41/pp 1372–1380 Lopez-Aparicio, Susana, T. Grøntoft & E. Dahlin. *Air Quality Assessment in Cultural Heritage Institutions Using EWO Dosimeters*. e-Preservation Science 2010/7/pp 96-101. Said. *Moisture Measurement Guide for Building Envelope Applications.*	Henry. Lecture Slides Class 9 Questions: 1. What is being measured when we measure moisture?

Course, Reading & Assignment Schedule			
Date	**Topic**	**Required reading before class/Required submissions before class**	**Preparation**
05 November Class 9 (In-Classroom)	Exercises & Problem Solving *1. Measuring loss* *2. What data & testing are needed?* *3. How much is enough?*		
12 November Class 10 (On-line) Visualizing Processes *Probing, sampling & testing*	Imaging: *Infrared thermography.* *Surface Penetrating Radar* *Moisture Surveys* Probes & sampling: *Statistical necessity* Material & assembly testing: *Non-destructive examination (NDE),* *non-destructive testing (NDT)*	Colantonio, Antonio. *Detection of Moisture and Water Intrusion Within Building Envelopes by Means of Infrared Thermographic Inspections.* Journal of Building Envelope Design. 2008/pp 47-54 *Exterior Building Envelope Inspections Using Thermal Infrared Imaging.* General Services Administration. 2006 Fairley, Wm. B. et al. *Establishing Quantity Estimates and Levels of Certainty in Predicting Structural Damage: A Masonry Case Study.* 1994 Friedman, Donald. *Ambiguity in Building Investigation A Study of Sampling and Decision-Making.* 2000 Binda, Luigia & Antonella Saisi. *Application of NDTs to the Diagnosis of Historic Structures.* NDTCE'09, Non-Destructive Testing in Civil Engineering. Nantes, France, June 30-July 3, 2009. *APTI PracticePoints 03, 09, 10* *ASCE 30 selections by Instructor* *ASCE 11 selections by Instructor*	Henry. Lecture Slides Class 10 Questions: 1. What are limitations of IRT imaging as a diagnostic tool? 2. What must be known if IRT images are to be meaningful? Henry. Lecture Slides Class 11 Questions: 1. What are the limitations of sampling/probes in diagnosis of built cultural heritage?
19 November Class 11 (In-Classroom)	Critical review of Draft Assignment Sections	**Submit Draft Assignment Sections by 6:00 PM Thursday prior to class:** • **Information required for Diagnosis** • **Proposed Method for Analysis and Interpretation of Data**	Prepare Draft Assignment Sections
24 November Class 12 (On-line) *Hypotheses*	Hypothesis development *Correlation versus Causality* Validating the hypothesis Modeling & simulations: *Past exposures* *Future scenarios*	Chamberlain. *Studies for Students: The Method of Multiple Working Hypotheses.* The Journal of Geology 5/8 (1897). Elliot and Brook. *Revisiting Chamberlain: Multiple Working Hypotheses for the 21st Century*. BioScience 57/7 (2007). WUFI Handbook for hygrothermal modelling Taylor, Joel, N. Blades, M. Cassar & I. Ridley. *Reviewing past environments in a historic house library using building simulation*. Article. http://discovery.ucl.ac.uk/2287/1/Microsoft_Word_-_ICOM_14.pdf Cassar, M and Taylor, J. *A cross-disciplinary approach to the use of archives as evidence of past indoor environments in historic buildings*. Journal of the Society of Archivists, 2004. 25 (2) 157 – 172	Henry. Lecture Slides Class 12 Questions: 1. From this week's readings, identify recommendations for hypothesis development at are relevant and irrelevant.

Course, Reading & Assignment Schedule			
Date	**Topic**	**Required reading before class/Required submissions before class**	**Preparation**
03 December Class 13 (In-Classroom)	Final Assignment Review and Feedback	**Submit Draft Final Assignment and present to Class.**	Prepare Draft Final Assignment
10 December Class 14 (On-Line)	Course Review		Request content review by Instructor
10 December Class 15 (In-Classroom)	Test of Knowledge Review test results		Prepare for test
17 December	**Submit Final Assignment *Building Diagnosis & Monitoring Proposal* and Final Exam no later than 12:00 noon EST online**		