ABS 341 / ABS 541 — Structures I

School of Architecture — University of Nevada, Las Vegas

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Fall 2019 Syllabus

"The separation of technology and art is both unnecessary and incorrect; one is not an enemy of the other. Instead it is essential to understand that technology is often a necessary component of art and that art helps technology to serve man better. Nowhere is this more true than in architecture and structure, a marriage in which science and beauty combine to fulfill some of the most basic physical and spiritual needs of humanity."

Mario Salvadori

Prerequisites: MATH 127 or 128 and PHYS 151

Class Meetings: When: Tuesdays & Thursdays, 12:00–1:30
Where: ARC 152

Faculty: _
Office: _
Email: _
Office Hours: _

Teaching Assistant: _
Desk Hours: _
Location: _

Catalog Description: Fundamental principles of structures: Types of framing systems and their patterning in architecture, loads and force flow, vector mechanics and linear equilibrium, moments and rotational equilibrium, funicular structural systems, properties and behavior of materials under axial tension stress. An emphasis is placed on graphic static analysis of triangulated assemblies.

Course Objectives and Learning Outcomes: After completing this course, the student:

1. Will understand the fundamental principles of structure, including:
    - Forces (sources of loads, force actions & reactions)
    - Linear & rotational equilibrium
    - Structural framing systems
    - Structural analysis via graphic statics
2. Will be able to apply the fundamental principles in:
    - Funicular structures (cables & arches)
    - Trusses & triangulated structures
    - Basic framed structural systems
3. Will be able to synthesize the application of fundamental principles in design
    - Design project of the student's own creation

Further Information: Structure is an intrinsic part of a building and therefore of primary concern to architecture. A clear understanding of the basic principles of structure, including the nature of loads and forces on a building and their resolution through a sensible and economical support structural is a fundamental responsibility of the architect. The designer needs to be aware of the wide variety of available structural systems, and have the ability to evaluate their applicability for a given project in terms of appropriateness, safety and economy. Furthermore, effective communication with engineering professionals who perform the actual computations for a structural system is an essential aspect in the design of any building project, and so learning the "language" of structural engineering is a further objective of this class.

This course will focus at the foundational principles of structural design. Students will learn about basic structural systems, materials, patterns, and "rules of thumb" proportioning of members. Fundamental concepts of structural design will be introduced, including loads and force flow, statics and engineering mechanics, truss analysis. Graphic analysis procedures will form a core learning experience.

Course Format: The course will be composed of weekly lectures (some of which may be posted online to be viewed outside of class) accompanied with periodic lab classes and work sessions. Lab sessions will illustrate and reinforce the concepts discussed in the lectures and work sessions will allow time for in-class problem sets. Weekly homework problems will be issued, along with project assignments and examinations during the semester.

NAAB Criteria: **This course satisfies NAAB Student Performance Criteria B5, Structural Systems:** Ability to demonstrate the basic principles of structural systems and their ability to withstand gravitational, seismic, and lateral forces, as well as the selection and application of the appropriate structural system. More information regarding the 2014 NAAB Conditions of Accreditation and the Student Performance Criteria may be gathered by going to the NAAB website at www.naab.org

Completion Requirements: To allow the greatest flexibility in student learning, opportunities for hands-on experiences and adjustments to the course as the semester progresses, this class is based on a cumulative-point scale. The total number of points for final grades will be approximately 500, the exact total depending on the number of assignments, projects, labs, etc. during the semester. The various components of the class are equally weighted, thus helping to ensure students of all learning preferences can succeed equally well. There may also be opportunities to earn bonus points.

You can judge your performance in the class periodically by comparing your earned points as a percentage of the total possible at that point in the semester. The best approach for success is to attend all classes and labs, and put in effort to understand the information when it is presented and when you study and review. See page six of the syllabus for additional tips.

Components: The various activities of the class will be distributed approximately as follow:

Exams (2):	Approx. 80 points each
Quizzes (2):	Approx. 20 points each
Homework, Lab & Projects:	Approx. 300 points in total
Total Points for Semester:	**Approx. 500**

Grading: Homework assignments are graded on a 10 point scale, with up to three bonus points for exceptional effort. Not all homework assignments will be evaluated, however all assignments and projects must be completed to the instructor's satisfaction to pass the course. The specific grade point cut-offs are a percentage of the total semester points as follow:

A-, A, A+	90%, 93%, 97%
B-, B, B+	80%, 83%, 85%
C-, C, C+	70%, 73%, 77%
D-, D, D+	60%, 63%, 67%
F	59% or less

The University defines "A" as denoting excellent mastery of the subject and outstanding scholarship, "B" denotes good mastery of the subject and good scholarship, and "C" denotes average or acceptable mastery of the subject and the usual expected achievement. Excellent mastery and outstanding scholarship means world-class. You should not assume that simply working hard will guarantees you receive an A. However, if you do not work diligently you can expect to not receive an A grade.

Assignments:

Student assignments are to be completed on green engineering graph paper in pencil. ***Illegible or sloppy work is not acceptable and will be returned for revision.*** This policy will be strictly enforced.

Unless otherwise noted, homework is assigned on a Tuesday or Thursday class and due at the start of class the subsequent week. Plan on making a scan or photo-copy so that you have a record of what was submitted while the work is being re-viewed. The course TA will conduct the review of weekly assignments.

Weekly review sessions will be conducted by the course TA to review homework assignments after they are turned in.

"Daily Detail"

Periodically, the first five minutes of class will consist of a brief sketch exercise focus-ing on an architecturally relevant structural assembly or detail. **The sketches will be submitted for credit immediately after the exercise period**, with each drawing worth up to two points. Drawing quality itself per-se is not being evaluated, alt-hough repetitive hasty and sloppy work will not receive full credit. **Be sure to bring your sketchbook to every class!**

Structures Sketchbook

An exercise continuous throughout the semester will be a "structures sketchbook" where you will record sketch observations of structures and begin to understand diagramming of forces in them. Details will be provided on WebCampus.

Required Supplies:

Basic scientific calculator with trig functions (cell phone calculators not permissible – See "Academic Misconduct" below), green engineering calc paper, protractor, engineering scale, and either a rolling ruler or a pair of small drafting triangles to accurately transfer parallel lines; Moleskin Cahir Journal for "Daily Detail" sketch. Small stapler and three-hole punch recommended.

Laptop Computers and Other Electronic Devices:

Personal laptop computers, tablets, smartphones, etc. *are not permitted in this class* unless expressly given permission by the professor. The only exceptions are for spe-cific announced class activities. **WEB BROWSING, EMAIL, INSTANT MESSAGING, WORK ON STUDIO PROJECTS, OR ANY OTHER ACTIVITIES NOT RELATED TO THE CLASS IS EXPRESSLY PROHIBITED ON ANY LAPTOP, TABLET, SMARTPHONE OR OTHER INTERNET-CONNECTED DEVICE.** The first infraction will result in a 5-point penalty, and subse-quent infractions will be 10 points.

The detrimental effects of multitasking on learning have been clearly demon-strated, and this provision is to help instill productive habits. See "Multitasking" on page seven of this syllabus.

Attendance:

In accordance with School of Architecture policy, as stated in the SoA Student Handbook, if you accumulate three or more unexcused absences, you may auto-matically receive a grade of F for the course.

If you must miss class because of illness or injury requiring a visit to a doctor, a death in the immediate family, military or legal obligations, or other equally serious reasons, you will be given an excused absence when you provide acceptable written documentation of the reason. This should be done, if at all possible, in ad-vance of the class(es) you will miss; in any case, for an absence to be excused this documentation must be provided by no later than the third class meeting after the missed class(es) or the absence will be considered unexcused. Documenta-tion for excused absences should be given to your instructor.

NOTE: As a general rule, a student missing a class or laboratory assignment be-cause of observance of a religious holiday shall have the opportunity to make up missed work. Students must notify instructor of anticipated absences by the last day of late registration to be assured of this opportunity. Faculty may give stu-dents an additional week, but are encouraged to set a clear deadline.

NOTE: Students who represent UNLV at any official extracurricular activity shall have the opportunity to make up assignments, but the student must provide official written notification to the instructor no less than one week prior to the missed class(es). HOWEVER: NO make-up exams or quizzes will be given. If you have a documented valid excuse for missing an exam or a quiz (see Attendance Policy for valid reasons), it will be dropped before your final course grade is calculated. When disagreements regarding this policy do arise, they can be appealed to the department chair/unit director, college/school dean, and/or the Faculty Senate Academic Standards Committee.

For purposes of definition, extracurricular activities may include, but are not limited to; band, drama, intercollegiate athletics, recruitment, and any other activity sanctioned by a college/school dean, and/or the Executive Vice President and Provost.

Work Load: It should be clearly understood that the architecture faculty expects a time commitment on the part of each student enrolled of not less than two hours outside of class for every hour in class. You are therefore expected to spend anywhere from six to eight hours per week outside of class in addition to your time in class. If your life circumstances do not allow this type of time commitment, it will be difficult for you to do well in this class.

Ownership of Work: Any design project, drawing or model that is submitted for academic credit is recognized by the University of Nevada and the School of Architecture to be the equivalent to a formal examination. **Therefore, upon submission, in addition to all examinations, all projects, drawings and/or models become the property of the School of Architecture.** However, in practice, projects submitted to the School of Architecture are usually returned to the individual student for inclusion in their academic portfolio. The School of Architecture does reserve the right to retain certain projects or exams for use in publicity, display, or other official uses. In addition, projects or exams may be retained for archival reasons or in cases of grade disputes. In all cases, projects and exams will be made available to the authors for photocopying or photo reproduction.

Classroom Etiquette: Please make every effort to be on time for class. If you are unavoidably late, please take anything you will need during the class out of your bag or backpack before entering the classroom so as to minimize the disturbance for your classmates. No cell phone use or headphones in class.

Drinks only in closed containers. **No food is allowed in the classroom.**

UNLV Policies: Please refer to https://tinyurl.com/qsj7qpb for general UNLV Academic Policies applicable to all classes.

Other Notes

Tips for Academic Success:

- Attend ALL lectures and labs
- **Take Copious Notes! For heaven's sake, TAKE NOTES!**
- Arriving on time, being prepared, and taking good notes are essential to doing well. You are responsible for taking notes in class; the lecture overheads and PowerPoint cannot substitute for notes that you take. PowerPoint slides will be available on the course WebCampus site, so don't feel you must swiftly scrawl all information available during class. Research shows that we process information most deeply and recall it most easily when we write by hand. All students are responsible for bringing a paper notebook to class and taking notes with a pencil or pen.
- Try to concentrate during lecture not on copying down what is on the lecture hall screen word for word, but on tracking and understanding fundamental concepts and principles. Seek clarification for new ideas presented.
- Ideally, review your notes within 24 hours of the lecture. Make a list of the things that you do not understand or are unsure of. Write yourself several questions on the lecture material that might be on a test or quiz. Come to my office hours with questions about things you don't understand. Before a test concentrate your efforts on your notes, and think about the big picture as well as the details.
- **DON'T MULTITASK!** (See Below)
- Form a study group. The best way to learn something is to have to teach it. In order to teach you have to understand the material. Study groups work, can be fun, and are a good way to meet new people. Find one or form one. In a study group you will find that each person may find some components easy but have difficulty with others.

  The diversity of the group means that there will be one or more people who understand the concept and can explain. If no one can, it is time to ask for help, either electronically or in person. Study groups should meet at least once or twice a week and everyone should come prepared with questions for the study group. Studying for exams will be easier if you work on the material several times a week.
- One more imperative regarding studying: **DO NOT LEAVE IT UNTIL THE NIGHT BEFORE AN EXAMINATION. THERE IS TOO MUCH MATERIAL FOR A SINGLE NIGHT.**

Study Help:

I am ready to assist you in any way possible. Although, other obligations often preclude unannounced drop-in visits by students, you can meet with me during regular office hours or by scheduling an appointment outside of normal office hours. The time and place of any other informal meetings will be announced in lecture. I am always happy to chat with students immediately after lecture once I have packed up my things and left the room ready for the next class. To make the most of any discussions, please come prepared with specific questions. Study groups are encouraged to visit during office hours if you have questions. The course TA will similarly maintain a weekly desk schedule and conduct periodic review sessions.

On Multitasking ...

- Studies have shown ***unequivocally*** that multitasking seriously impairs learning, even among those who profess to be the best multitaskers out there. Here are a few quotes from an interview with a Stanford University researcher, Richard Nass, who has written extensively on the matter:

  > One of the biggest delusions we hear from students is, "I do five things at once because I don't have time to do them one at a time." And that turns out to be false. That is to say, they would actually be quicker if they

did one thing, then the next thing, then the next. It may not be as fun, but they'd be more efficient.

You're confident of that?

Yes. There's lots and lots of evidence. And that's just not our work. The demonstration that when you ask people to do two things at once they're less efficient has been demonstrated over and over and over. No one talks about it -- I don't know why -- but in fact there's no contradictory evidence to this for about the last 15, 20 years. Everything [as] simple as the little feed at the bottom of a news show, the little text, studies have shown that that distracts people. They remember both less. Studies on asking people to read something and at the same time listen to something show those effects. So there's really, in some sense, no surprise there. There's denial, but there's no surprise.

The surprise here is that what happens when you chronically multitask, you're multitasking all the time, and then you don't multitask, what we're finding is people are not turning off the multitasking switch in their [brain] -- we think there's a switch in the brain; we don't know for sure -- that says: "Stop using the things I do with multitasking. Focus. Be organized. Don't switch. Don't waste energy switching." And that doesn't seem to be turned off in people who multitask all the time.

Textbook References

Required Texts:

Salvadori, Mario, Heller, Robert, and Oakley, Deborah	*Structure in Architecture*, 4th ed., Pearson, 2017
Ching, Francis D.K., Onouye, Barry S., and Zuberbuhler, Douglas	*Building Structures Illustrated: Patterns, Systems and Design, 2nd Edition*; John Wiley & Sons, Inc., 2013
_	Course pack for Structures I, Fall 2019 Edition

Recommended Texts:

Allen, Edward, and Zalewski, Waclaw	*Form and Forces: Designing Efficient, Expressive Structures*; John Wiley & Sons, Inc., 2009
Allen, Edward	*Fundamentals of Building Construction: Materials and Methods*, Fifth Edition; John Wiley & Sons, Inc., 2008
Allen, Edward and Iano, Joseph	*The Architect's Studio Companion: Rules of Thumb for Preliminary Design*; Sixth Edition, John Wiley & Sons, Inc., 2013
Ching, Francis D.K.	*Building Construction Illustrated*, Fourth Edition; Van Nostrand Reinhold, 2009

Reference Texts:

Ambrose, James	*Building Structures,* Second Edition, John Wiley and Sons, 1998
Charleson, Andrew	*Structure as Architecture*, Second Edition. Routledge. 2015.
International Code Council	*International Building Code, 2015*
Lin, T.Y. and Stotesbury, S.D.	*Structural Concepts and Systems for Architects and Engineers*, 2nd Edition, Van Nostrand Reinhold, 1988
Millais, Malcom	*Building Structures: From Concepts to Design*, 2nd Ed., E& FN Spon, 2005
Moore, Fuller	Understanding Structures; WPB McGraw-Hill, 1999
Ramsey, C. G. and Sleeper, H. R.	*Architectural Graphic Standards,* Eleventh Edition, John Wiley & Sons, Inc, 2007
Sandaker, Bjørn N., Eggen, Arne P., and Cruvellier, Mark R.	*The Structural Basis of Architecture*, Second Edition. Routledge. 2011.
Schodek, Daniel and Bechthold, Martin	*Structures*; Seventh Edition, Pearson Education, 2014
Shaeffer, Ronald E.	*Elementary Structures for Architects and Builders*; Fifth Edition, Prentice-Hall, Inc., 2007.
Schueller, Wolfgang	*The Design of Building Structures*, Prentice Hall, Inc., 1995
Underwood, Rod and Chiuini, Michele	*Structural Design: A practical Guide for Architects*; Second Edition, John Wiley and Sons, Inc., 2007
Zalewski, Waclaw and Allen, Edward	*Shaping Structures: Statics;* John Wiley & Sons, Inc., 1997

Some Notable Architects and Designers of "Structural" Architecture

Gunnar Birkerts	A principal designer with famous firm, Skidmore, Owings & Merrill
Gordon Bunschaft	Another principal designer with famous firm, Skidmore, Owings & Merrill
Santiago Calatrava	Spanish architect, structural engineer & sculptor
Eladio Dieste	Uruguayan architect, designer of brick masonry shell structures
Lord Normal Foster	British "high tech" architect.
Buckminster Fuller	American inventor of the geodesic dome and all-around genius.
Antoni Gaudi	Spanish architect who studied funicular masonry structures in early 20th century.
Sir Nicholas Grimshaw	British "high tech" architect.
Chuck Hoberman	American designer of deployable structures.
Sir Michael Hopkins	British designer of lightweight fabric membrane structures
Louis Kahn	American architect noted for "structural honesty" in work.
Renzo Piano	Italian architect famed for exceptional detail. Early work with Richard Rogers.
Sir Richard Rogers	British "high tech" architect. Early work with Renzo Piano.
Kenneth Snelson	Structural artist who studied with Buckminster Fuller. True inventor of tensegrity.
Eugène Viollet-le-Duc	18th century French, famous for use of iron in stone masonry structures.

Some Notable Structural Engineers

Ove Arup	Founder of major British engineering firm, Arup
William Baker	Skidmore, Owings and Merill design of Burj Kalifa and SFO Int'l. Airport
Horst Berger	Designer of lightweight fabric membrane structures
Santiago Calatrava	Spanish architect, structural engineer & sculptor
Felix Candela	Spanish/Mexican designer of concrete shell structures
Eladio Dieste	Uruguayan designer of amazing brick shell structures
Gustav Eifel	Of the Tower fame. Pioneering 19th century French bridge engineer.
Eugène Freyssinet	French designer of early concrete shell structures
Ted Happold	British engineer, founding partner of Buro Happold
Fazular Kahn	Inventor of new structural forms for super high-rise buildings
August Kommandant	Engineer for many of Louis Kahn's most famous buildings
Heinz Isler	Swiss designer of funicular shell structures
Rober Maillart	Swiss bridge engineer, pioneer of elegant structural form
William LeMessurier	Designer of innovative structure for NYC Citicorp Tower
Pier Luigi Nervi	Italian engineer, developer of many revolutionary concrete systems
Frei Otto	Pioneering designer of form active structures
Peter Rice	Arup - British engineer of Sydney Opera House and Pompedieu Centre
John Roebling	Designer of the Brooklyn Bridge
Jörg Schlaich	German engineer of tensile structures
Eduardo Torroja	Spanish designer of early concrete shell structures

Some Other Notable Firms of Tectonically Expressive Architecture:

Bing Thom Architects	Kieren Timberlake	Pickard Chilton
Bohnlin, Cywinski, Jackson	Lake Flato	Rafael Viñoly Architects
Cutler Anderson	Miller-Hull	Skidmore, Owings and Merril
Gensler	Olson Kundig Architets	Studio Gang
Gwathmey Siegel & Assoc.	Patkau Architects	Von Gerken Marg & Partners

Structures I - Fall 2019 Course Calendar

Week/Date	Readings*	Topics
1 8-27 & 8-29	SinA Ch. 1 & 2 BSI Ch. 1	Overview of class . An Introduction to Architectural Structures. Structural systems and types, structural loads.
2 9-3 & 9-5	SinA Ch. 3 & 5.1, 5.2	Structural Materials and an Introduction to Stress. Structure and form. Structural design process. Free Body Diagrams
3 9-10 & 9-12	SinA Ch. 4	Structural Requirements & Introduction to Equilibrium
4 9-17 & 9-19	SinA Ch. 4	Focus on Moments and Rotational Equilibrium Introduction to rotational equilibrium
5 9-24 & 9-26	SinA Ch. 4	Principle of Moments, continued. Reactions, support types, section cuts. **Quiz 1**
6 10-1 & 10-3	BSI Ch. 2 BSI Ch. 3	Understanding Structural Framing. Structural grid patterns. Framing hierarchy. Rules of thumb for proportioning members.
7 10-8 & 10-10	WebCampus Readings	Simple Tension Structures – Introducing Graphic Statics
8 10-15 & 10-17	WebCampus Readings SinA Ch. 6	**Tue. 10-17 — Midterm Exam** Lessons from a Bridge – The Suspended Cable Graphic statics of cable structures
9 10-22 & 10-24	WebCampus Readings SinA Ch. 6	Lessons from a Bridge — The Arch. Graphic statics of arches. **Design project assigned**
10 10-29 & 10-31	WebCampus Readings	Introducing Trusses Selection of compression members
11 11-5 & 11-7	WebCampus Readings	Multi-Panel and Complex Trusses Fan and cable-stayed structures **Quiz 2**
12 11-12 &11-14	Course pack notes	Cable-Stayed Structures ***Design Project Intermediate Submittal Due***
13 11-19 & 10-21	Course pack notes	Optimal Truss Forms **Design projects individual team meetings w/ Prof. Oakley**
14 11-26	SinA Ch 11 & 12	Introducing Surface Structures – Membranes and Shells ***[11-21 & 11-22: Thanksgiving Recess]***
15 12-5	SinA Ch. 14	Wrap-up and review ***Completed design project due Friday 12-13 @ 5:00 pm***

* Note: See WebCampus weekly notes for specific pages of readings.
Final Exam: Tuesday, December 10,10:10 AM – 12:10 PM (Set by registrar's office)
Textbooks: SinA = *Structure in Architecture*; BSI = *Building Structures Illustrated*