ABET
Self-Study Report

for the

Bachelor of Science in Architectural Engineering

at

University of Colorado Boulder

Boulder, CO

July 1, 2023

CONFIDENTIAL

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Program Self-Study Report
for
EAC of ABET Reaccreditation

BACKGROUND INFORMATION

A. Contact Information

Karl Linden
Professor and Chair
Civil, Environmental, & Architectural Engineering (CEAE)
1111 Engineering Drive ECOT 441 UCB 428
University of Colorado Boulder
Boulder, CO 80309-0428
E-mail: karl.linden@colorado.edu
primary pre-visit contact person for the program

Wil V. Srubar III
Associate Professor and Associate Chair of Undergraduate Education
1111 Engineering Drive ECOT 441 UCB 428
University of Colorado Boulder
Boulder, CO 80309-0428
E-mail: wsrubar@colorado.edu
primary author of this self-study

B. Program History

The Bachelor of Science in Architectural Engineering (AREN) degree at the University of Colorado Boulder (CU) is offered through the Department of Civil, Environmental, and Architectural Engineering (CEAE), which resides within the College of Engineering and Applied Science (CEAS). The Architectural Engineering program was established in 1925, awarded its first degree in 1929, and has been continuously accredited since 1936. In the 2017-2018 general review by the Engineering Accreditation Commission of ABET, our program received a Next General Review with accreditation through Sept. 30, 2024.

The AREN program at the University of Colorado Boulder is unique. The University of Colorado Boulder is a Tier I research institution. It is the top-ranked institution of higher education throughout the Rocky Mountain region. One of 25 ABET-accredited undergraduate AREN programs in the United States, the AREN program at the University of Colorado Boulder consistently ranks as a top choice for undergraduate AREN students. Unlike other programs that may offer two or three areas of specialization, ***our AREN program affords students the opportunity to study five major areas***, including construction engineering and management, lighting, electrical systems, structural systems, and mechanical systems for buildings. Our hands-on, project-based courses, including two architectural studio experiences, are attractive to students. Graduates from our program are in very high demand from employers, many of whom are University of Colorado Boulder alumni, along Colorado's front range and beyond.

After the last AREN ABET accreditation in 2018, a new curriculum was implemented for the 2018-2019 academic year. The 2015 AREN Joint Evaluation Committee (JEC), a committee of external industry professionals, students, and faculty, sanctioned the change. The current curriculum was officially implemented in Fall 2018. Below is a summary of the most important revisions.

1. **Ensuring Early Exposure to Architectural Engineering.** Following the recommendation of the 2015 AREN JEC to instill early and meaningful exposure to the five subdisciplines of Architectural Engineering: construction, lighting, electrical, structures, and mechanical engineering, the AREN and CVEN combined first-year introductory course became a standalone one-credit introductory course (AREN 1316) dedicated to Architectural Engineering. Today, AREN 1316 spends two weeks of class time on each of the five subdisciplines, with the remaining five weeks of the semester dedicated to other professionalism topics, such as sustainability, professional licensure, and engineering ethics.

2. **Encouraging Specialization While Maintaining Breadth.** Students majoring in Architectural Engineering that entered the program prior to Fall 2018 were required to choose (a) two **proficiencies** (*i.e.*, selecting a design-level courses in two of the five subdisciplines) and (b) a **concentration** (*i.e.*, selecting one area to take two additional design-level courses). This structure of the curriculum allowed for students to concentrate and achieve technical depth in a particular subdiscipline of architectural engineering.

   Faculty observed that, while students were able to perform well in their own tracks, they lacked *breadth* and knowledge of building systems integration. The AREN 2015 JEC report concurred, noting that “choosing two proficiency classes in semester 6 does not leave a complete impression on the student of how a building is designed.”

   To address this issue, the Fall 2018 curriculum removes the choice of concentrations, proficiency courses in all five engineering disciplines—structural engineering, mechanical engineering, electrical engineering, illumination engineering, or construction engineering and management. Each student must also select a discipline for specialization. Each specialization is a separate option within the program, defined by 6 credit hours of upper division technical elective courses. Students have the option of pursuing (a) an additional 6 credit hours of technical elective courses in a specialized discipline to acquire technical depth in that area or (b) selecting an additional 6 credit hours in another area (or areas) of specialization. Students also have the option to pursue postgraduate education through our concurrent bachelor’s and master’s program (BAM).

   As a result, graduating students now have breadth and depth in all the subdisciplines making them well equipped to work on interdisciplinary teams in the architecture, engineering, and construction (AEC) industry.

3. **Capstone Restructuring.** To support the notion that Architectural Engineering graduates have expertise in all subdisciplines, the senior capstone was restructured to emphasize an *integrated design process*. Prior to Fall 2018, the capstone consisted of a fall semester

architecture studio followed by a spring semester engineering capstone course. In that format, little to no integration occurred between the engineered systems and the architecture of the students' building designs.

To address this shortcoming, a **year-long integrated design project** is used for the capstone, aligned with the Architectural Engineering Institute (AEI) student design competition. The credits and courses were restructured to include a three-credit "junior" studio (AREN 3080) in the sophomore year that teaches the fundamentals of architectural design and a "senior" studio built into the new fall semester capstone course (AREN 4318). As a result, students are now able to apply their well-rounded knowledge of architectural engineering in the integrated design of a commercial building.

The current block diagram that reflects the changes above can be found in Criterion 5.

C. Options

Graduates of the AREN program are expected to acquire a broad education in architectural engineering by taking proficiency courses in all five engineering disciplines—structural engineering, mechanical engineering, electrical engineering, illumination engineering, or construction engineering and management. Each student must also select a discipline for specialization. Each specialization is a separate option within the program, defined by 6 credit hours of upper division technical elective courses. Students have the option of pursuing (a) an additional 6 credit hours of technical elective courses in a specialized discipline to acquire technical depth in that area or (b) selecting an additional 6 credit hours in another area (or areas) of specialization. Please see **Program Criteria** for more information.

D. Program Delivery Modes

The bulk of the required Architectural Engineering curriculum is provided to students via courses offered between 8 am – 5 pm on weekdays on the Boulder campus as traditional lecture/laboratory/recitation courses. Humanities and social science electives may be taken as web-based or distance education courses through CU Continuing Education, but that is not common. Some technical electives could also potentially be taken as web-based or distance education courses. The program offers the opportunity for students and encourages them to participate in internships and Cooperative Education ("co-op") program, but co-ops do not fulfill any of the curriculum requirements and few students participate.

E. Program Locations

The program is regularly offered at the University of Colorado Boulder main campus. Students may participate in Study Abroad programs offered by the University and transfer some of these credits into the major. Students also sometimes take summer courses from other institutions that can be transferred into the major, subject to the approval of the departmental transfer course evaluator.

F. Public Disclosure

The Program Educational Objectives (PEOs) and student outcomes (SOs) are published in the catalog of the University of Colorado Boulder. These are also published on the website of the CEAE Department (http://www.colorado.edu/ceae/current-students/undergraduate-studies/educational-objectives-outcomes). Annual student enrollment data (including demographic data), retention and graduation data, post-graduate career outcomes, and rankings are posted on the College of Engineering & Applied Science (CEAS) website (https://www.colorado.edu/engineering/facts-figures).

G. Deficiencies, Weaknesses or Concerns from Previous Evaluation(s) and the Actions Taken to Address Them

The previous ABET evaluation committee noted three program concerns. These concerns are directly quoted below, followed with statements related to the program progress in these areas over the past six years.

Program Concerns:

1. Criterion 1. Students. This criterion requires that students be advised regarding curriculum and career matters. The students are adequately advised regarding curriculum matters. Students have access to career advising through Engineering Career Services. Upper-class students are required to select a program track, after which they are assigned to a faculty advisor with whom they are supposed to have mandatory meetings each semester. However, during interviews, students indicated that they had little opportunity to interact with faculty prior to selecting a track and that career advising by faculty members was limited. While the criterion appears to be met, limited interactions regarding career matters could jeopardize future compliance with this criterion.

   Response: Starting in the 2018-2019 academic year, the CEAE Department transitioned to a new model for academic advising and mentoring. Prior to this, the advising model was as follows: freshman and sophomore students were required to meet every semester with the staff advisor for their major. Juniors selected a faculty advisor in the fall of their junior year and were required to meet with their faculty advisor every semester until graduation. Faculty advisors conducted 20-minute individual meetings with each student over a designated two-week period each semester.

   At our last ABET site visit in Fall 2017, students indicated that they wished they had more time to talk about careers with their faculty advisors, instead of just spending the time picking classes. In response to this feedback, the architectural engineering program piloted a new advising model in Spring 2019. Under this system, the staff advisor took over responsibility for advising all AREN students regarding their degree requirements and making sure they were enrolling in the correct classes every semester. Faculty advisors were renamed "faculty mentors" to align with other programs in the College and were asked to focus more on career-related discussions with students. This included career options, choice of technical electives, internships, graduate school, research opportunities, etc.

   The pilot program received only positive feedback from students or faculty and was expanded to the civil engineering program in Spring 2020. Once the entire CEAE Department was following the same advising model, it made additional changes. Faculty now have the option to conduct their mentoring meetings via individual appointments, drop-ins, or group sessions based on their preferences. Some faculty have reported that group sessions give the opportunity for more discussion among the students, and students have the option to request an individual meeting if they prefer.

2. Criterion 2. Program Educational Objectives. This criterion requires the program to have published Program Educational Objectives (PEOs) that are consistent with the mission of the institution, the needs of the program's various constituencies, and the engineering accreditation criteria. The criteria define program educational objectives as broad statements that describe what graduates are expected to attain within a few years of graduation. One of the PEOs represents an outcome for students upon graduation rather than a broad statement about an anticipated attainment within a few years of graduation. By not adhering to the definition, appropriate input may not be received from constituencies during periodic review. Thus, compliance with this criterion might be jeopardized in the future.

   Response: Since the 2017-18 ABET accreditation cycle, the faculty review and publish our Program Educational Objectives (PEOs). Every 24 months, the PEOs are presented to the faculty, discussed, and debated. The PEOs are also presented annually to our Joint Evaluation Committee (JEC). Proposed changes to the PEOs are voted on (and approved) by the faculty every other fall. The most current PEOs (approved Fall 2022) are published on our departmental website (Click here) and the University of Colorado Boulder course catalog website (Click here).

   The most current PEOs are as follows:

   Program Educational Objectives
   The educational objectives of the Architectural Engineering bachelor of science degree program are to produce graduates capable of reaching the following career goals within five years:

   1. Our alumni will build on the educational foundation gained through our program by establishing themselves in engineering, science, or other professional careers.
   2. Our alumni will begin advancing the state-of-the-art of their profession including one of five core disciplines of the building industry: electrical systems; lighting systems; heating, ventilating, and air conditioning (HVAC) systems; materials and structural systems; construction engineering and management.
   3. Our alumni will exercise leadership in their field.
   4. Our alumni will enhance the sustainability of the built environment.

3. Continuous Improvement. This criterion requires that the program regularly use appropriate, documented processes for assessing and evaluating the extent to which the student outcomes are being attained. The results of these evaluations must be systematically utilized as input for the continuous improvement of the program. Student outcome (a) was directly assessed through the results of the Fundamentals of Engineering (FE) exam and indirectly assessed by a survey of graduating seniors and discussion among faculty members who comprise the Joint Evaluation Committee. However,

specific administrations of the FE exam identify only topics rather than details of actual questions, and results from students' personal achievement and notes of Joint Evaluation Committee meetings reveal only general data. As a result, detailed information suitable for continuous improvement may be inconsistent or unavailable for outcome (a). If the resolution of the assessment method or consistency of results is not sufficient to inform program improvement, the potential exists that compliance with this criterion could be jeopardized in the future.

Response: During the last ABET cycle concerns were raised that there was not enough direct assessment under Criterion 4, continuous improvement that focused on specific examples of student work for ABET outcome a: Apply knowledge of math, science, and engineering fundamentals. In the current ABET cycle, outcome A has been mapped to the new outcome 1: an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics. To provide additional direct assessment for this new outcome, specific examples problems mapped to outcome 1 have been selected from three courses, AREN 3040, AREN 3540, and AREN 2110. Rubrics were developed for instructors to categorize student performance on the examples of student work into four categories: Poor, Needs Improvement, Adequate and Superior. It is expected that 80% of rated students will be rated as Adequate or above. Please see **Criterion 4 Continuous Improvement** for new direct assessment data related for this reaccreditation cycle.

GENERAL CRITERIA

CRITERION 1. STUDENTS

Undergraduate admissions are handled by the College and the Campus admissions office. Individual departments do not have any input into student admission decisions except to provide input on target enrollments for the College's enrollment management strategy.

A. Student Admissions

In the first-year freshmen admission process, the College seeks to admit applicants with a high probability of successfully completing their undergraduate engineering degree program at the University of Colorado, Boulder. The Office of Admissions and the College consider the following factors in making admission decisions:

- Evidence of scholastic ability and accomplishment as demonstrated by grade point averages, tests of scholastic aptitude and achievement (ACT or SAT), class rank, grades earned in courses directly applicable to an engineering academic program, and essays.

- Personal motivation and academic success as demonstrated by trends in the student's academic record, rigor, and challenge of coursework, success in the academic community, ability to balance academic and personal interests, and letters of recommendation.

Beginning for the fall 2020 class, CU Boulder adopted a "test score optional" admissions policy. Under this policy, students do not need to submit test scores to be considered for admission. The College implemented a rubric to quantify an applicant's level of academic rigor, leadership experience, and shown interest in their desired major. These scores, along with the holistic factors described above, are used to determine whether a student is admissible to their desired major within the College. For fall 2022, 66% of students submitted test scores. The College set a policy that a student's test scores can only help their admissibility, not harm it. If a student was not admissible using their test scores, they would be evaluated using the "test score optional" rubric and criteria.

If a student is not admissible to their desired major, they are reviewed for the Program of Exploratory Studies at the Campus level. The Program of Exploratory students allows students the opportunity to explore all majors on the CU Boulder campus and support to transfer into their desired College and major once meeting academic requirements.

The College is committed to increasing the quality of its programs, in part by increasing the holistic diversity of its students (ethnic, gender, geographical, cultural, socio-economic and first-generation students). This commitment is reflected in the admissions process and the special programs established to support these students.

The following mean average information is provided from prior first-year classes in the College of Engineering and Applied Sciences:

New Studs Entering in	High School Rank	HS GPA	ACT Math	ACS Engl.	SAT Math	SAT Crit. Read	# of New Studs
Fall 2022	86%	3.94	30.1	30.5	693	670	1083
Fall 2021	89%	3.92	30.6	30.7	703	672	1022
Fall 2020	88%	3.9	30.1	30.2	686	654	1197
Fall 2019	89%	3.91	30.5	30.8	699	665	946
Fall 2018	87%	3.91	30.7	31.0	701	668	923
Fall 2017	87%	3.93	30.3	30.1	696	664	850

For more information about first-year admissions, see http://www.colorado.edu/admissions

Due to large increases in the size of the incoming freshman classes, and heightened student interest in specific majors, the College has implemented several enrollment management policies over time. Currently, when students apply to the College of Engineering and Applied Science (CEAS) from high school, they may indicate to enter the College as “open option” (unsure of engineering major), or they may select a preliminary engineering major.

Sometime after completion of the first semester, and by the eighth week of the second semester, all students should finalize their choice of major in the College. Students wishing to make a major change within the College use the Change of Major Form to finalize their choice of major.

Students are encouraged to confirm their choice of major by the middle of their second semester (before they enroll in coursework for the third semester). If a change is desired, students follow the procedure outlined at https://www.colorado.edu/engineering-advising/majorchange.

B. Evaluating Student Performance

CU Boulder employs an online degree audit system which monitors student progress for all Civil Engineering B.S. requirements, including individual course requirements and cumulative credit hour totals in each category (Humanities & Social Sciences, Math and Basic Science, Free Electives, Technical Electives, and Civil Engineering). Each requirement is displayed as incomplete, in progress, or complete. The degree audit includes all transfer coursework, AP and IB credit, completed coursework, and coursework in progress. The undergraduate advising team reviews each student’s degree audit periodically and makes any necessary adjustments, such as when exceptions or substitutions are approved via petition.

Course pre-requisites, co-requisites, and other restrictions (class level, major, etc.) are automatically enforced by the course registration system - students cannot enroll in a course unless all pre- and co-requisites are either completed (with a grade of C- or higher) or in progress. Students currently enrolled in a pre- or co-requisite course are enrolled on a conditional basis. The curriculum coordinators in each department monitor student grades at the end of each semester, via Enrollment Requirement Rosters built into the registration system. Conditionally enrolled students who do not pass a pre-requisite course with a grade of C- or higher are administratively dropped from the subsequent course. Academic advisors also monitor grades for their assigned rosters and work with students to adjust their course schedules if a course must be repeated. Students may request to have a pre-requisite or co-requisite waived by the course instructor. The CEAE Department requires students to obtain such permission in writing.

Students are awarded grades on a course-by-course basis. For each course, students earn grades A (4 quality points) through F (0 quality points), augmented with plus (+) and minus (-) which add or subtract 0.3 quality points from the letter grade they accompany (except that no A+ is available). These grades are used to compute a grade point average (GPA) every semester and an overall cumulative GPA for courses taken at CU. Grading policies are detailed at http://www.colorado.edu/engineering-advising/get-your-degree/academic-expectations-policies and at https://catalog.colorado.edu/undergraduate/credits-grading/. Course dossiers contain information describing how individual courses are graded.

Students are subject to the University's Academic Standing policy (https://catalog.colorado.edu/undergraduate/academic-records/#academicstandingtext), which is managed by the University's Registrar's Office. Students need a minimum CU GPA of 2.000 to stay in good academic standing.

C. Transfer Students and Transfer Courses

External Transfers:

External transfer students are admitted to the College of Engineering and Applied Science through the CU Boulder Admissions Office, based on criteria set by the College. Like the first-year freshman admission process, the College seeks to admit external and internal transfer applicants with a high probability of successfully completing their undergraduate engineering degree program at the University of Colorado Boulder.

To qualify for admission as a new transfer student, the applicant must have completed a minimum of two semesters of college-level calculus and one-semester of science (college chemistry and/or calculus-based physics). If the applicant has less than 24 semester credit hours, a high school transcript and other holistic admission review factors typically used in the freshman admission process will be used, in conjunction with the college transcript.

CEAS Competitive Transfer Admission Criteria:

- 3.00 cumulative GPA. This includes all college-level coursework from any post-high school enrollment, though more recent coursework after a pause in academic enrollment can be used in lieu of older coursework.
- Completion of two semesters of college-level calculus AND one semester of calculus-based physics OR college-level chemistry
- Grades in math and science courses should be B or better

Additionally, The College of Engineering and Applied Science guarantees admission to any of its baccalaureate degree programs to students transferring from a Colorado Community College.

Guaranteed Admission Criteria:

1. At least two full-time semesters (or 24 credit hours) at a Colorado Community College must be satisfactorily completed immediately prior to the transfer.
2. Completion of **two** semesters of college-level Calculus
3. Complete **one** of the following science courses:
    - PHY 211 – Physics 1
    - PHY 212 – Physics 2
    - CHE 111 – General College Chemistry 1
        - *CHE 112 strongly recommended for Chemical, Chemical & Biological, and Environmental Engineering applicants*
    - Complete **one** engineering course from the following list:
        - EGG/EGT 140
        - EGG 145
        - CSC 160
        - EGG 106 AND EGG 151
        - EGG 211
4. **All** grades in math, science, engineering, and computer science courses of B or better.
5. Cumulative college GPA of 3.00

The College of Engineering and Applied Science and the Colorado Community College System have an articulation agreement for admission, as well as select Associate of Engineering Science (AES) degree pathways to specific engineering departments. Currently, Mechanical Engineering and Civil Engineering are articulated, with plans to include Architectural, Electrical, and a general engineering pathway.

There are also several direct equivalent engineering courses that allow community college students to transfer basic math, science and certain engineering courses to CU Boulder. The participating institutions agree to the agreement's policies governing the transfer of credit among Colorado public institutions for students pursuing baccalaureate majors in the College of Engineering and Applied Science. Further, the College of Engineering and Applied Science has special agreements with select Colorado Community Colleges where more advanced engineering and computer science courses are offered for enhanced degree applicability. Please see the following for these agreements:

- Colorado Community College Resources
- https://www.colorado.edu/engineering/CCCSTransfer
- Basic Math, Science, Engineering and Computer Science Courses by major:
- https://www.colorado.edu/engineering/courses-will-transfer

Accelerated Admission Pathway:
Some students decide to transfer externally to CU Boulder before completing all of the transfer admission requirements, but are interested in engineering. For students who have taken at least one Math course completed with B or better (Calculus 1 or higher) or in-progress, no other prerequisites listed in our admission criteria and all other math/science courses are B or better, we allow these students to be admitted to our Accelerated Admission Pathway.

We admit these students to the Program in Exploratory Studies (PES) where they complete the remaining prerequisites they needed as an external applicant in one semester to be directly admitted. If at the end of the semester they meet the external admission criteria, we allow them direct admission to the major of their choice and they do not need to follow the Intra-University Transfer (IUT) pathway. In the event they do not meet that criteria, they can still internally transfer via the IUT criteria.

Internal Transfers:

Internal transfer applicants (degree-seeking students from another college/school at the CU Boulder campus) are admitted by the College, via the Intra-University Transfer (IUT) process. The IUT process allows CU Boulder students to transfer into the College if they complete a set of requirements that demonstrate their ability to be successful in an engineering curriculum. As with external transfers, IUT students must complete a minimum of two semesters of calculus and two semesters of science. CU cumulative and technical GPAs of at least 2.7 are required. The full set of IUT requirements is posted at: https://www.colorado.edu/engineering-advising/intra-university-transfer-iut-college-engineering-applied-science-bachelors-degree-programs

D. Advising and Career Guidance

Staff Advising Program

The College of Engineering and Applied Science (CEAS) understands the importance of good advising in supporting student development and engagement. All baccalaureate students are advised by professional academic advising staff in the CEAS Student Support & Advising Services (SSAS) unit (https://www.colorado.edu/engineering-advising). The Civil, Environmental & Architectural Engineering Department has an embedded team of three advisors (two full-time academic advisors, and an Area Director who supervises advisors in multiple programs) that support both Civil Engineering and Architectural Engineering students. Each student has an assigned primary advisor, but may meet with other members of the advising team during drop-in hours or when their assigned advisor is out of the office.

The advising team creates a degree planning worksheet for each student based on the Architectural Engineering block diagram, which is used to help students with long-term planning and course selection for each semester. This degree planner is shared with the student via Google Drive, so the student can access it at any time. These degree planners are used in conjunction with the online degree audit to help students monitor their degree progress and stay on track for their intended graduation date.

Students are encouraged to meet with their professional staff advisor regularly to discuss the student's academic progress and their planned future courses in the major. The academic advisor also provides guidance and referrals regarding additional majors, minors, certificates, Bachelor's – Accelerated Master's (BAM) programs, study abroad planning, extracurricular activities, tutoring and academic support, academic standing, resources for personal support, etc.

The CEAS has a robust onboarding program for new advisors and supports ongoing professional development and growth for all advisors. This includes training on policies and procedures, advising expectations and best practices, and engagement in diversity, equity, and inclusion work to best serve our students. SSAS professionals meet regularly to share information, discuss pertinent issues, and identify ways to improve the student advising experience. A comprehensive student-facing advising website at www.colorado.edu/engineering-advising has details on policies, procedures, forms, etc.

Students are provided with several resources to help them understand degree requirements. The curriculum of record is described in the annual University Undergraduate Catalog (https://catalog.colorado.edu/undergraduate). This is supplemented by university and college web sites describing policies, along with the Architectural Engineering curriculum website (https://www.colorado.edu/ceae/current-students/undergraduate-studies/architectural-engineering) and CEAE Graduation Requirements & Advising Guide (https://www.colorado.edu/ceae/current-students/undergraduate-studies/graduation-requirements-advising-guide).

Student contacts with advisors may include pre-scheduled individual advising meetings, drop-in meetings, group advising sessions, and/or email correspondence. Students have options to meet with advisors in-person or virtually. Students early in their academic career at CU, reaching certain milestones in the curriculum, not in good academic standing, etc. are typically required to meet with their academic advisor. This is managed by having an "advising hold" placed on their student record (which prohibits course enrollment until the student connects with the advisor).

Records of student meetings are stored in the campus-wide Buff Portal Advising (https://www.colorado.edu/buffportaladvising/) system, which is used for offering advisor meeting availability to students, communicating with student advisees, and logging meeting notes.

The Registrar's Degree Audit system assists both students and advisors in monitoring fulfillment of degree requirements. Student petitions, Independent Study Agreements, and other student records involving department/program review, are maintained by academic advisors in digital format. More general records are maintained by the CEAS Dean's Office (foreign language exam results, change of major forms, etc.) or the Registrar's Office (e.g., course enrollments, approved grade changes, student transcripts and degrees, etc.).

Professional Mentorship and Advising Program

In academic year 2022-2023, the department kicked off a pilot professional mentorship program in partnership with the college and the CU Alumni Association. The program is hosted on the Forever Buffs Network (FBN) platform for CU alumni. While the program is therefore restricted to alumni mentors, it is an approach that allows any undergraduate student to sign up for a mentor if they choose to do so.

Mentor/mentee matches are made through a mixed manual and automated approach based on what is known about the goals of the students, mentors, and information included in their FBN profiles. Matches are made in the fall semester and then mentorship pairs fill out a contract together that allows them to define and agree upon meeting time, modes, and topics. Training is provided for the mentors and mentees via the FBN platform.

The department collaborated with the college to set up an engineering subgroup on the FBN platform. All CEAE mentorship pairs are part of this group. They receive information in addition to that provided by the CU Alumni Association such as engineering-specific mentorship questions, and links to professional accomplishments and project case studies.

In the 2022-2023 academic year, the campus-wide mentorship program had 158 active mentorship relationships. The College of Engineering and Applied Science has 70 relationships, 39 of which include civil, environmental, or architectural engineering students. The pilot program ends in May of 2023 at which time feedback about the program will be collected from mentees and mentors. Adjustments will be made as needed to improve program efficacy prior to the 2023-2024 academic year.

Faculty Advising

Starting in the 2018-2019 academic year, the CEAE Department transitioned to a new model for academic advising and mentoring. Prior to this, the advising model was as follows: freshman and sophomore students were required to meet every semester with the staff advisor for their major. Juniors selected a faculty advisor in the fall of their junior year and were required to meet with their faculty advisor every semester until graduation. Faculty advisors conducted 20-minute individual meetings with each student over a designated two-week period each semester.

At our last ABET site visit in Fall 2017, students indicated that they wished they had more time to talk about careers with their faculty advisors, instead of just spending the time picking classes. In response to this feedback, the architectural engineering program piloted a new advising model in Spring 2029. Under this system, the staff advisor took over responsibility for advising all AREN students regarding their degree requirements and making sure they were enrolling in the correct classes every semester. Faculty advisors were renamed "faculty mentors" to align with other programs in the College, and were asked to focus more on career-related discussions with students. This included career options, choice of technical electives, internships, graduate school, research opportunities, etc.

The pilot program received no negative feedback from students or faculty, and was expanded to the civil engineering program in Spring 2020. Once the entire CEAE Department was following the same advising model, it made additional changes possible. Faculty now have the option to conduct their mentoring meetings via individual appointments, drop-ins, or group sessions based on their preferences. Some faculty have reported that group sessions give the opportunity for more discussion among the students, and students have the option to request an individual meeting if they prefer.

Faculty mentors offer students support for technical questions, research opportunities, graduate school, independent study, career directions, course content, and guidance on electives depending upon the student's interests and future plans. The AREN Faculty Director serves as the default faculty advisor for freshmen and sophomores, but students may be referred elsewhere if they have questions relating to a particular faculty member's area of expertise. As juniors, students choose a faculty mentor who aligns with their career interests, and are required to meet with their mentor every semester thereafter. Faculty mentors have the option to schedule individual meetings, drop-in hours, or group meetings with their mentees, although students can always request an individual meeting if they prefer.

Academic coaches (https://www.colorado.edu/engineering-advising/academiccoaching) support students by meeting with them to delve into topics such as motivation, time management and prioritization, strategies for learning, studying, and test preparation, and establishing supportive study habits, etc.

Advising and tutoring are also offered by the Broadening Opportunity through Leadership and Diversity (BOLD) Center (www.colorado.edu/engineering/bold), which promotes scholarship, leadership, and community-building among students who are traditionally underrepresented in engineering. In addition, the Engineering Ambassadors (https://www.colorado.edu/engineering-advising/ambassadors) peer advising and mentoring program provides convenient student-to-student assistance and guidance.

The College of Engineering and Applied Science (CEAS) is committed to the career and professional development success of its students. Branded as ProReady, and led by the Sr. Director of Student Professional Development, the ProReady portfolio works to help students to become workforce ready by helping them chart their career path, gain relevant experience, and grow their professional network. Full information can be found here https://www.colorado.edu/engineering/proready

One component of ProReady is the Engineering Career Services team, comprised of career advisors specifically dedicated to CEAS students. In partnership with the campus Career

Services office, Engineering Career Services provides services including career advising appointments (with professional staff and peer mentors), career workshops, and a robust suite of web-based resources (www.colorado.edu/engineering/career). Typical topics covered by the Engineering Career Services team include career/major exploration, effective application materials (resumes, cover letters, etc.), job/internship search strategy, career fairs and interviewing skills, and salary negotiations.

Within the Engineering Career Services team is our employer relations staff, who work directly with employers to connect them with students. In partnership with campus Career Services office, the employer relations staff help employers register for career fairs, schedule company information sessions and tables, post positions on Handshake, and connect with targeted student populations.

The second component of the ProReady portfolio is Active Learning, which focuses primarily on undergraduate research. CEAS provides a comprehensive suite of undergraduate research offerings from introductory (Spring Break for Research), intermediate (Discovery Learning Apprenticeship), to advanced (Summer Program for Research). Full information can be found at https://www.colorado.edu/engineering/students/research

The third component of the ProReady portfolio is International Programs. CEAS provides a plethora of opportunities for all students to study abroad, ranging from global intensive experiences (2-4 weeks), summer experiences, to full academic year experiences. CEAS students can take their required university Humanities & Social Science courses anywhere in the world or take technical courses in their major with our partner global institutions. Full information can be found at https://www.colorado.edu/engineering-international/engineers-abroad

The ProReady team also supports and promotes additional valuable professional development activities across CEAS. These programs include department-based career development initiatives, graduate school preparation, student leadership development, entrepreneurship, on-campus employment, and alumni engagement.

E. Work in Lieu of Courses

AP/IB Credit: See the Undergraduate Catalog for a listing of AP and IB exam scores correlating to CU Boulder course equivalents

Advanced Placement (AP). For students who have taken an Advanced Placement (AP) course in high school and who make the required score in the College Board's AP examination, college credit is granted by CU Boulder. If a student elects to take the equivalent college course, the credit for that course will replace the AP credit.

International Baccalaureate (IB). For students who make the required score in the IB examination, college credit is granted by CU Boulder. If a student elects to take the equivalent college course, the credit for that course will replace the IB credit.

College-Level Examination Program (CLEP). College credit may be earned for appropriate scores on CLEP examinations. A list of subjects in which CLEP examinations are accepted for CU Boulder can be found in the Undergraduate Catalog. Individual degree programs advise students on if and how earned CLEP credit may apply toward specific degree requirements.

Credit for DANTES Subject Standardized Tests (DSST) in the humanities, mathematics, physical science and social sciences areas may be granted for a score of 400 or above. Credit award and course equivalency information listed in this table applies only to degree programs completed entirely at the Boulder Campus.

Military Service: https://www.colorado.edu/veterans/prospective-new-students/military-credit Credit for military schooling, both for courses and for occupations, is evaluated upon receipt of Form DD 214, Service Separation Certificate, a Joint Services Transcript (JST) or a transcript from the Community College of the Air Force (CCAF). For military courses and occupations that have been approved for GT Pathways credit by the Colorado Department of Higher Education students will be awarded GT Pathways credit, which will fill General Education requirements in most, but not all, programs at CU Boulder. For qualifying scores at the American Council on Education (ACE) recommended cut scores on Defense Language Proficiency tests students will be awarded GT Pathways World Language credit (GT-AH4), which will fill General Education requirements, usually as a Humanities course, in most, but not all, programs at CU Boulder.

F. Graduation Requirements

To graduate with a Bachelor of Science degree from the College of Engineering and Applied Science, a student must meet all of the following minimum requirements:

1. The satisfactory completion of the prescribed and elective work in any curriculum as determined by the college and the appropriate academic department/program. A student must complete a minimum of 128 semester hours, of which the last 45 must be Boulder coursework earned after admission to the university and the college.
2. A University of Colorado cumulative grade point average of at least 2.000 for all courses attempted.
3. A separately computed grade point average, Major GPA, of at least 2.000. The manner in which the Major GPA is computed is to take the most recently earned grade in all courses designated by the major department/program. For Architectural Engineering students, the Major GPA includes all AREN and CVEN courses.
4. The satisfactory completion of all Minimum Academic Preparation Standards (MAPS) deficiencies (https://www.colorado.edu/engineering-advising/get-your-degree/degree-requirements/maps-minimum-academic-preparation-standards).
5. Architectural Engineering requires the successful completion of the Fundamentals of Engineering (FE) examination as an outcome measurement prior to graduation.

Students meet with their academic advisor to discuss progress towards degree requirements, and then apply for graduation via the Registrar's Office online system (https://www.colorado.edu/registrar/students/graduation#apply_for_graduation-677) Academic advisors review these students' academic records after final grades post and certify whether or not the student has met all degree requirements.

G. Transcripts of Recent Graduates

The program will provide transcripts from some of the most recent graduates. **The team chair will specify which transcripts to provide.**

CRITERION 2. PROGRAM EDUCATIONAL OBJECTIVES

A. Mission Statement

University of Colorado Boulder Mission

The Mission of CU is: *To shape tomorrow's leaders, be the top University for innovation, and to positively impact humanity.* It is published on the University website: https://www.colorado.edu/academicaffairs/homepage/mission-vision-values

This mission is aligned with the Statutory Mission of the Boulder Campus described as:

CU Boulder's vision is grounded in its statutory mission as a national public research university. In Colorado statute, the university is defined as the "comprehensive graduate research university with selective admissions standards . . . offer(ing) a comprehensive array of undergraduate, master and doctoral degree programs" of what is now designated the University of Colorado System. This is published on the University website: https://www.colorado.edu/about/mission

The University of Colorado strives to be a leader in addressing the humanitarian, social, and technological challenges of the twenty-first century. CU Boulder's identity is defined by respect for diversity and inclusivity.

College of Engineering and Applied Science Mission

The college's mission is to generate new knowledge in engineering and related fields, and to equip students from diverse backgrounds to become leaders and citizens responsible for the betterment of individuals and society. Our vision is to be a recognized world leader for excellence and innovation in engineering research and education, with an emphasis on inclusive excellence, active learning and global society.
https://www.colorado.edu/engineering/mission-vision

Dean Keith Molenaar is leading Strategic Visioning and Planning throughout 2023-24. For more information about that process, visit https://www.colorado.edu/engineering-facultystaff/2022-23-strategic-planning.

The Department of Civil, Environmental, and Architectural Engineering's mission is to educate undergraduate and graduate students to become leaders in the professional practice of engineering, contributing to technological advances that benefit humankind while enhancing the earth's physical and biological resources.

B. Program Educational Objectives

The program educational objectives (PEOs) of Bachelor of Science degree in architectural engineering program are as follows:

1. Our alumni will build on the educational foundation gained through our program by establishing themselves in engineering, science, or other professional careers.
2. Our alumni will begin advancing the state-of-the-art of their profession including one of five core disciplines of the building industry: electrical systems; lighting systems; heating, ventilating, and air conditioning (HVAC) systems; materials and structural systems; construction engineering and management.
3. Our alumni will exercise leadership in their field.
4. Our alumni will enhance the sustainability of the built environment.

These objectives are published on the departmental website:
http://www.colorado.edu/ceae/current-students/undergraduate-studies/educational-objectives-outcomes

The objectives are also published in the University of Colorado catalog:
https://catalog.colorado.edu/undergraduate/colleges-schools/engineering-applied-science/programs-study/civil-environmental-architectural-engineering/architectural-engineering-bachelor-science-bsare/#letext

C. Consistency of the Program Educational Objectives with the Mission of the Institution

The overall themes in these mission statements include the education of professionals who exhibit technological knowledge, leadership, and responsible citizenship; these are reflected strongly in the Program Educational Objectives (PEOs) of the Architectural Engineering program. The University of Colorado Boulder mission is mapped to the Program Education Objectives in Table 2.1:

Table 2.1. Mapping of Program Educational Objectives (PEOs) to Institutional Mission

Program Educational Objectives	Mission Statement 1: Shaping Leaders	Mission Statement 2: Innovation	Mission Statement 3: Positively Impact Humanity
1. Establish Career	X		X
2. Advance State-of-the Art		X	X
3. Exercise Leadership	X		
4. Enhance Sustainability		X	X

D. Program Constituencies

The primary constituents of the AREN program are the students and alumni of the program, and the employers of our graduates. The departmental faculty members are also a constituency. The AREN students and alumni are served through the program objectives by having employable skills that will help them find and advance in rewarding careers, building from their foundational skills in architectural engineering. The alumni are invited to provide feedback to the program objectives formally via the online alumni survey distributed each summer. Alumni about five and/or eight years after earning their Bachelor’s degree are invited to participate in the alumni survey.

Employers of our graduates are served through the program objectives by having employees with competence and commitment to keeping their technical skills up-to-date. Alumni and employers of our graduate are invited to serve on advisory boards (i.e. the Joint Evaluation Committees, JECs) through which they can review and provide additional input to the educational objectives.

The departmental faculty members can use the program objectives to guide their teaching and mentoring activities of architectural engineering students moving through the program. The faculty can revise these objectives if they believe that they are no longer serving our students, alumni, and the engineering profession.

E. Process for Review of the Program Educational Objectives

There are two primary mechanisms that the department uses to review and revise the program educational objectives. First, the annual Joint Evaluation Committee (JEC) process affords faculty, students, and industry representatives the opportunity to review the educational objectives and give associated feedback on a yearly basis. The JEC meetings are held in May each year. Each JEC is comprised of program constituencies: practicing, professional engineers who are employers of our graduates and/or program alumni; one or more current students; and departmental faculty representatives.

All constituents also have informal but important input through ongoing contact with the program faculty. Potential changes to the program educational are discussed and approved by the architectural engineering faculty every two years with a vote in September at a regularly scheduled department meeting. The discussion process is often facilitated via the departmental ABET coordinator and curriculum committee, which has representatives from the major faculty groups in the department. The potential changes are also discussed by the faculty at large and must be approved by a majority vote.

CRITERION 3. STUDENT OUTCOMES

A. Student Outcomes

The outcomes that students are expected to have attained upon graduation with a bachelor of science degree in civil engineering are listed below.

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

3. an ability to communicate effectively with a range of audiences.

4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.

6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.

7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

These student outcomes are published on the departmental website:
http://www.colorado.edu/ceae/about/undergraduate-degrees/educational-objectives-outcomes?qt-quicktab_educational_outcomes=1#qt-quicktab_educational_outcomes

The student outcomes are also published in the University of Colorado catalog:
https://catalog.colorado.edu/undergraduate/colleges-schools/engineering-applied-science/programs-study/civil-environmental-architectural-engineering/architectural-engineering-bachelor-science-bsare/

B. Relationship of Student Outcomes to Program Educational Objectives

The architectural engineering program objectives map to the 7 student outcomes of our program, as shown below where an “x” indicates that the accomplishment of the related outcome is an important ingredient for accomplishing the objective. Table 3.1 illustrates that all four objectives are linked to two or more outcomes. Philosophically, consistency between the architectural engineering program educational objectives (PEOs) and the student outcomes (SOs) for engineering students is highly desirable for ensuring the professional success of our graduates.

Table 3.1. Mapping of Student Outcomes to the Program Objectives

	Student Outcomes						
Program Educational Objectives	1	2	3	4	5	6	7
Our alumni will build on the educational foundation gained through our program by establishing themselves in engineering, science, or other professional careers.	x	x	x	x	x	x	x
Our alumni will begin advancing the state-of-the-art of their profession including one of five core disciplines of the building industry: electrical systems; lighting systems; heating, ventilating, and air conditioning (HVAC) systems; materials and structural systems; construction engineering and management.	x	x				x	x
Our alumni will exercise leadership in their field.			x	x	x		
Our alumni will enhance the sustainability of the built environment.		x		x			

CRITERION 4. CONTINUOUS IMPROVEMENT

A. Student Outcomes

Outcomes Assessment Methods Summary

Table 4.1 provides a summary of the multiple direct and indirect methods that are used to assess achievement of each of the student outcomes. Not all methods are used for all outcomes. Each of the assessment methods is described in more detail in the paragraphs below. For some of the assessment results, data from the 2022-2023 academic year is still being compiled and analyzed. This data will be made available upon request. Assessment results are separated by major where possible.

The FE exam is the national NCEES Fundamentals of Engineering exam. It is a direct evaluation method that is used to assess 4 of the 7 student outcomes. All CU AREN students are required to take the exam before they graduate; they typically take the exam during one of their last two semesters. There is no exam specific to architectural engineering, so most of the AREN students take the “Other Disciplines” exam; a few students also take the Civil Engineering exam. Data are provided from the NCEES summarizing the performance of our students twice per year (returned to the university about three months after the students take the exam). The FE exam topics have been mapped to our student outcomes. Outcomes are flagged as a concern if CU AREN students have a ratio score relative to national AREN students at 0.92 or lower. Data highlights including the overall pass rate and any weaknesses identified are presented to the CEAE faculty at an at-large meeting once per semester. Any problems are also discussed by the CEAE curriculum committee and the JEC.

The capstone course offers an opportunity to evaluate the cumulative knowledge of students on many of the outcomes. Five faculty and/or PhD students representing each AREN discipline (CEM, lighting/electrical, mechanical, structures) rate their respective project deliverables on a rubric. All senior capstone faculty have adopted a similar rubric that clearly describes on a scale from 4 to 1 where: superior = 90% or more, adequate = 80%-90%, needs improvement = 70-80%, and poor = below 70%. The target is for 80% or more of our students to be rated adequate or above on each embedded indicator. In addition, faculty along with industry mentors assess two oral presentations (conceptual and schematic). Each team also receives specific feedback with suggestions for improvement. The rubric described above has been consistently employed to assess the quality of reports (written and drawing communication). Individual assignments related to professional issues are used as evidence of achievement of some student outcomes. A graduate student serving as teaching assistant (TA) rates the individual homework assignments.

Within specific courses, various assignments (or questions on assignments), projects, lab write-ups, or exams are used as embedded indicators to directly measure student learning of some outcomes. Frequently, the normal grades on a particular assignment or question on an assignment are converted by the instructor to a rubric with a four-point scale, where: superior = 90% or more, adequate = 80%-90%, needs improvement = 70-80%, and poor = below

70%. The target is for 80% or more of our students to be rated adequate or above on each embedded indicator. Examples of rubrics mentioned here will be presented below with the evidence of student outcomes.

Two indirect assessment methods are also used to evaluate each of the 7 student outcomes. First, at the end of each semester, CU students are asked to evaluate the extent to which each of the AREN and CVEN undergraduate courses contribute to their achievement of the 7 student learning outcomes. These are questions that have been added to the university-wide Faculty Course Questionnaires (FCQs) that are administered by the campus. We expect that student ratings (on a scale of 1-6 for the first three years of the cycle and 1-5 the last three years) should be 80% or higher for targeted courses. The data for relevant courses are summarized for the JECs. Data from selected courses targeted for each outcome are presented for each outcome in the following sections. Each academic year, the data from required courses are compiled in a spreadsheet to ensure that our targets are being met. In addition, the student evaluation data are compared to faculty ratings of how their courses contribute to the learning outcomes. For comparison purposes, assessment results are presented as a percent in the tables below.

The second indirect assessment method used to evaluate each of the 7 student outcomes is the senior survey. The senior survey is administered by the College of Engineering & Applied Science; students graduating in May, August and December are emailed invitations to participate in the survey, which is administered via Qualtrics. Response rates are typically very high (over 90%) for AREN students. In one section of the survey, students rate their achievement of the 7 student outcomes, using a scale of 1 to 5. Achievement should be rated at 3.5 (70%) or higher to be satisfactory. The college previously returned data twice per year; it now combines the data for an academic year into a single report. The senior survey data are presented to the JECs for evaluation. They are also examined and summarized in an annual report written by the Assessment Coordinator and reviewed by the Department Chair. A mapping of assessments to each outcome is presented in Table 4.1.

Table 4.1. Student Outcomes Assessment Methods Summary. N/A = Not Applicable

	Direct Assessment			Indirect Assessment	
CU AREN Student Outcomes ABET 1-7.	FE exam	Capstone Design course	Other Direct Assessment	Student FCQ ratings	Senior survey # Quest.
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	4 topics	N/A	AREN 3040, Circuits for Architectural Engineers; AREN 2110, Thermodynamics	1	1
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare as well as global, cultural, social, environmental, and economic factors	N/A	Team presentation, Final report	AREN 3010 Energy Efficient Buildings and 4570 Electrical Systems	2	2

3. an ability to communicate effectively with a range of audiences	N/A	Team presentation, Final report	N/A	2	2
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	Ethics & Professional Practice	N/A	AREN 1316, Intro to Architectural Engineering	1	1
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	N/A	CATME Peer evaluation, Course rubric	N/A	1	1
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	Statistics	N/A	CVEN 3161, Mechanics of Materials 1	2	2
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies	N/A	Reflective Essay	N/A	1	1

The data for each outcome will be presented in detail in the following sections.

Outcome 1 (a). an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

Outcome 1. FE exam

Direct assessment of this outcome is largely conducted by student performance on the NCEES Fundamentals of Engineering (FE) exam. We have decided to rely on 4 topics from the Other Disciplines exam to evaluate this outcome: math, chemistry, statics, and dynamics. Ratio scores are reported, representing the ratio of the average percentage of questions on a topic that CU AREN students answer correctly divided by the average percentage of questions on a topic that AREN students nationally answer correctly. The goal is to equal or exceed a ratio score of 0.92. We successfully met this goal for all topics individually. Overall, no deficiency is evident (Table 4.2).

Table 4.2. FE exam results for Outcome 1.

Academic Year/Term:	2018-2019	2019-2020	2020-2021	2021-2022
N	*18*	*28*	*21*	*7*
FE Exam Topic	**Ratio Scores of CU performance vs. National**			
Math	1.01	1.08	1.07	0.96
Chemistry	0.99	0.98	1.01	0.93
Statics	0.92	0.95	0.86	0.98
Dynamics	0.97	0.96	0.93	1.02

Outcome 1. Courses
This outcome was assessed directly by instructors in AREN 3040, AREN 2110 through a course problem set. A rubric was developed to assess homework assignments and can be viewed below in Figure 4.1. The target across the year is 80% of students will be adequate or above. Data was collected in 2019-2020 with 91% of students above the cutoff, 2020-21 with 85% of students above the cutoff, and 2021-2022 with 78% of students above the cutoff. Across courses targets were met except for 21-22.

Poor	Needs Improvement	Adequate	Superior
1	2	3	4
Poor identification of the given engineering problem, making unnecessary or overly simplified assumptions. Solution is severely flawed, does not address required tasks.	Some tasks are missing/flawed, have difficulties in resorting to the correct tools or use them properly to solve the problem.	Can identify correct approach to address problem. Solution represents a basic level of understanding for all tasks.	High level ability to identify problem. Design and approach are largely flawless. Solution represents a high-level of understanding.

Figure 4.1. Rubric for assessment of Outcome 1

Outcome 1. Student Ratings on Course FCQs
The FCQ for outcome 1 was mapped to AREN required courses. Ratings are presented as a percent in Table 4.3 below with a 75% cutoff. Ratings of Outcome 1 on the FCQ were well above the cutoff across all available data.

Table 4.3. FCQ ratings of Outcome 1.

Academic Year	Required Courses
2018-2019	79%
2019-2020	82%
2020-2021	85%
2021-2022	78%

Outcome 1. Senior Survey

On the survey distributed to all graduating senior students, students are asked to rate their personal achievement on the outcome "ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics." using a Likert-scale from 1 to 5. These achievement ratings all exceed the target of 70% (3.50/5) and indicate no weaknesses for this outcome (Table 4.4).

Table 4.4. Senior survey ratings of Outcome 1

Senior Survey	Year	2018-19	2019-20	2020-21	2021-22	2022-23
Rating Math, Science, and Engineering		*85%*	*87%*	*81%*	*81%*	*NA*

<u>Summary</u>: All direct and indirect assessment measures met our targets except for course ratings from 21-22 in each academic year. While this assessment should be monitored in 22-23, overall, this outcome has been sufficiently achieved.

Outcome 2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

Outcome 2. Capstone Design Rubric

For outcome 2, Capstone Design instructors rated students' abilities to apply engineering design and consider a variety of contextual factors in the design. Results for the application of design were rated from the team design presentation and considerations of the design context from the report. Table 4.5 below displays the results across years. It was expected that students would be rated at 80% on a 100% scale. Ratings are displayed below in Table 4.5.

Table 4.5. Capstone design rubric ratings of Outcome 2.

Academic Year	Design Application: Team Presentation	Considerations of Context: Final Report
2018-2019	92%	92%
2019-2020	92%	95%
2020-2021	92%	91%
2021-2022	88%	89%

The design data indicate sufficient fulfillment of this outcome, since >80% of students possessed an adequate ability to design a system or component and consider the context of the design.

Outcome 2: Course Rubrics, AREN 3010 and 4570
Course rubrics to measure skills with design applications and considerations of the design context were developed for AREN 3010 and 4570. It was expected that 75% of students would be rated above the cutoff. Results were slightly below expectations for design applications for 2020-2021, but overall expectations were met (Table 4.6).

Table 4.6. Capstone design rubric ratings of Outcome 2.

Academic Year	Design Application:	Considerations of Design Context:
2019-2020	86%	90%
2020-2021	74%	84%
2021-2022	93%	85%

Outcome 2. Student Ratings on Course FCQs
Students were asked two questions on the FCQs for Outcome 2. The first asked about their ability to apply engineering design to produce solutions and the second asked about their ability to design with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors. Ratings were made on a 6-point scale in 18-19 and a 5-point scale afterwards. Results are presented below in Table 4.7 as percentages to allow for comparisons and expected to be above 75%. Results are unavailable for 2020 due to the global pandemic.

Table 4.7. Capstone design rubric ratings of Outcome 2.

Academic Year	Design Application: FCQ	Considerations of Context: FCQ
2018-2019	91%	88%
2019-2020	N/A	N/A
2020-2021	98%	94%
2021-2022	76%	68%

Ratings on FCQs were above the cutoffs for senior design for outcome 2 for all years except for 21-22, second question, indicating that we are meeting targets. Results will be monitored for considerations of design context for 22-23.

Outcome 2. Senior Survey
The senior survey included two questions related to design ability; results are summarized in Table 4.8 below. The first question asked about their ability to apply engineering design to produce solutions and the second asked about their ability to design with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors. Ratings were made on a 5-point scale with a 3.50/5 or 70% target.

Table 4.8. Senior survey ratings of Outcome 2.

Academic Year	Design Application: Senior Survey	Considerations of Context: Senior Survey
2018-2019	84%	77%
2019-2020	85%	86%
2020-2021	77%	77%
2021-2022	82%	85%

Overall, ratings on the senior survey are meeting goals for outcome 2.

<u>Summary:</u> The direct assessment data from capstone design is supported by the indirect assessment data, and demonstrates that the students have adequate abilities to design when they graduate.

Outcome 3. an ability to communicate effectively with a range of audiences.

Outcome 3. Capstone Design Rubric
In the Capstone design course, the final team oral presentations and written reports were assessed using a rubric by instructor and industry advisors, with four elements to embody oral presentation and communication ability with clients. Each semester four raters assess each team using a scale of 1 to 4 with expectations that 80% of student would be rated above a 3, Adequate. Results are shown in Table 4.9. Over 80% of the teams were adequate or higher in all four categories, indicating adequate communication skills among the CVEN students.

Table 4.9. Capstone design rubric ratings of Outcome 3.

Academic Year	Oral Communication: Final presentation	Written Communication: Final Report
2018-2019	92%	92%
2019-2020	92%	93%
2020-2021	92%	90%
2021-2022	86%	80%

Outcome 3. Student Ratings on Course FCQs
The ability to communicate effectively via oral presentations and written reports with a range of audiences is most consistently included in the senior design course. Students were asked two questions on the FCQs for Outcome 3. The first asked about their ability with oral communication skills and the second asked about their ability with written communication skills. Ratings were made on a 6 point scale in 18-19 and a 5 point scale afterwards. Results are presented below in Table 4.10 as percentages to allow for comparisons and expected to be above 75%. Results are unavailable for 2020 due to the global pandemic.

Table 4.10. Capstone design FCQ ratings of Outcome 3

Academic Year	Oral Communication: FCQ	Written Communication: FCQ
2018-2019	95%	90%
2019-2020	N/A, pandemic	N/A, pandemic
2020-2021	98%	96%
2021-2022	84%	68%

Ratings on FCQs were above the cutoffs for senior design for outcome 3, except for written communication for 21-22. Overall, we are meeting targets with a need to monitor written communication moving forward.

Outcome 3. Senior Survey
The senior survey included two questions related to communication ability; results are summarized in Table 4.11 below. The first question asked about their oral communication ability and the second asked about their written communication ability. Ratings were made on a 5-point scale with a 3.50/5 or 70% target.

Table 4.11. Senior survey ratings of Outcome 3.

Academic Year	Oral Communication: Senior Survey	Written Communication: Senior Survey
2018-2019	77%	73%
2019-2020	77%	78%
2020-2021	75%	75%
2021-2022	79%	84%

Overall, ratings on the senior survey are meeting goals for outcome 3, with the exception of 18-19 for written communication.

Summary: The strongest measure that students have sufficient ability in communication skills is based on direct evaluation via the co-instructors and industry mentors of the senior design course. The students make a formal oral presentationand develop a written design report in the course and the data shows strong evidence of abilities by most students. The direct assessment measurement supports sufficient attainment of this outcome. Indirect assessment flagged written communication once for FCQs so written communication should be monitored in future assessments.

Outcome 4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

Outcome 4. FE Exam
There are questions on the FE exam that relate to professional and ethical responsibility. It is expected that students will be equal to or above .92 on this topic. In all evaluation cycles, except in spring 2019 and spring 2020, we met or exceeded our minimum goal (Figure 4.2). In the other six semester students were above the cutoff.

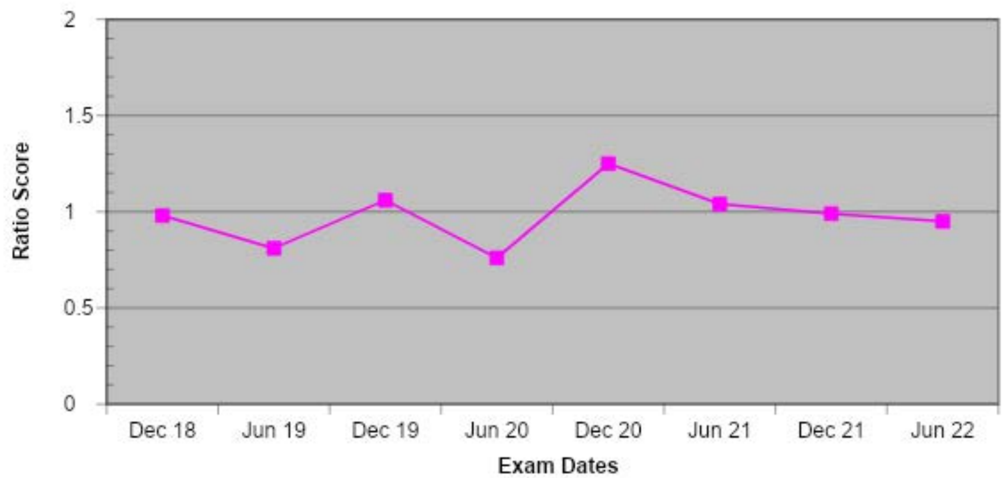


Figure 4.2. FE exam results for Outcome 4.

Outcome 4. Direct Assessment: Student Performance on Homework
AREN 1316 includes a homework assignment focused on sustainability. Homework assignments were rated by the course instructor on the rubric below (Figure 4.3).

Poor	Needs Improvement	Adequate	Superior
under 62	**62 to 79**	**80 to 88**	**88+**
The student is unable to understand the given situation. The student does not understand his/her responsibility as an engineer. The student makes a decision without consulting the ASCE code of ethics. The student cannot make proper decision on how to go about the issue. Student does not consider impact of context	The student is able to understand the given situation but not to the full extent. The student consults the ASCE code of ethics but cannot relate specific canons to the given situation. Lack of professionalism in conveying the decision to the manager. Consideration of context needs improvements.	The student demonstrates full understanding of the given situation. The student shows basic level of understanding of the ASCE code of ethics. Student's consideration of context is adequate.	The student demonstrates full understanding of the given context and the possible consequences of his/her decision. The student shows a high level of understanding of the ASCE code of ethics by quoting the relevant canons to support his/her decision. The student makes an informed decision and professionally conveys the decision to the manager.

Figure 4.3. Rubric for assessment of outcome 4

It was expected that 80% of student assignments would be rated at or above an adequate rating. Results are presented in Table 4.12 from 2019 when ABET 1-7 outcomes were adopted. Results were above the target for each year indicating the goals were met for this assessment.

Table 4.12. Capstone design rubric ratings of Outcome 4.

Academic Year	Outcome 4: Homework
2019-2020	82%
2020-2021	87%
2021-2022	87%

Outcome 4. Student Ratings on Course FCQs
The ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts is rated on the FCQs for Capstone Design. Ratings were made on a 6 point scale in 18-19 and a 5 point scale afterwards. Results are presented below in Table 4.13 as percentages to allow for comparisons and expected to be above 75%. Results are unavailable for 2020 due to the global pandemic.

Table 4.13. Capstone design FCQ ratings of Capstone Design for Outcome 4

Academic Year	Outcome 4: Ethics FCQ
2018-2019	84%
2019-2020	N/A, pandemic
2020-2021	93%
2021-2022	84%

Ratings on FCQs were above the cutoffs for senior design for outcome 4 indicating that we are meeting targets.

Outcome 4. Senior Survey
The senior survey included one question related to ethics ability; results are summarized in Table 4.14 below. The question asked about their ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts. Ratings were made on a 5-point scale with a 3.50/5 or 70% target.

Table 4.14. Senior survey ratings of Outcome 4.

Academic Year	Ethics: Senior Survey
2018-2019	77%
2019-2020	86%
2020-2021	81%
2021-2022	81%

Overall, ratings on the senior survey are meeting goals for outcome 4.

Summary: Both the direct and indirect data are supportive that architectural engineering students at CU have sufficient knowledge of ethical and professional issues.

Outcome 5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.

Outcome 5. Senior Design Rubric

AREN 4319 Architectural Engineering Design provides a true multidisciplinary experience in which teams of up to five students, each working in a different discipline of the AREN program, work together to develop a building design. Students in this course are fully exposed to the collaborative and integrated design environment in which they work to a common goal, but with discipline-specific and often competing objectives, requirements, and schedules. In addition, they must interact with a team of faculty and professionals throughout the project. To understand how well students work in their teams, they all must participate in a confidential assessment developed by CATME[1]. They rate themselves and their peers after the completion of each design phase. The sub-categories for teamwork varied somewhat each year. In general, these include: contribution to work, interaction with teammates, keeping team on track, and expecting quality.

CATME results are used in three ways:

1. The instructor of record provides guidance and mentoring to the student teams and intervenes as needed with teams that are dysfunctional.

[1] CATME is a web-based tool developed by Purdue University designed to, among other things, enhance "team learning by teaching students how to contribute effectively to teamwork and creating accountability for team-member contributions." More information can be found at https://info.catme.org/.

2. CATME generates an adjustment factor which "attempts to show the contribution of a given student relative to the other members of their team" (CATME.org). This factor is applied to students' final grades to better reflect the individual contribution of a given student within the team and throughout the semester. CATME caps the factor at 1.05 and values above 0.95 are rounded up to 1.00 as values in this range are considered noise. Adjustment factors used in this class include the students' self-ratings. The data shown below are averages of adjustment factors from the three design phases, where above 1.02 = superior, between 0.95 and 1.02 = adequate, and below 0.95 = below adequate.

3. CATME Results – Peer evaluation including self-ratings. The minimum level for sufficient achievement of this outcome is that the average of ratings for each year will be above .95 indicating adequate or above ratings. This goal was achieved in all years where the students achieved the minimum level of adequate or above (Table 4.15).

Table 4.15. CATME peer ratings of Outcome 5.

Academic Year	Outcome 5: Peer Ratings
2018-2019	.99
2019-2020	1.00
2020-2021	.97

In 2022, the Capstone design course moved away from CATME and began assessing Outcome 5 with a rubric applied to the team's final design report (see Figure 4.4).

Poor	Needs Improvement	Adequate	Superior
A lack of effort is given to the student's contribution to the essay. The section of the essay is brief and/or not on-topic.	Student's contribution to the essay complies with the expected content of the assignment. Student does not elaborate on ideas and does not provide original thought to the topic.	The essay is between "superior" and "needs improvement"	Student's contribution to the essay complies with the written assignment, obvious effort and consideration is applied by the student. Student displays clear understanding of ideas presented, and provides elaboration (with examples)

Figure 4.4. Rubric for assessment of Outcome 5 on the final design report, 2021-2022. Expected results were that 80% of students would be rated adequate or above on the rubric. Results revealed 100% of the students were rated above the cutoff and targets were met for this assessment.

Outcome 5. Student Ratings on Course FCQs
An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives is rated on the FCQs for Capstone Design. Ratings were made on a 6-point scale in 18-19 and a 5-point scale afterwards. Results are presented below in Table 4.16 as percentages to allow for comparisons and expected to be above 75%. Results are unavailable for 2020 due to the global pandemic.

Table 4.16. Capstone design FCQ ratings of Senior Design for Outcome 5.

Academic Year	Outcome 5: Teamwork FCQ
2018-2019	92%
2019-2020	N/A, pandemic
2020-2021	96%
2021-2022	68%

Ratings on FCQs were above the cutoffs for senior design for outcome 5, except for 2021-2022 indicating that we are overall meeting targets. FCQ teamwork results should be monitored for 22-23.

Outcome 5. Senior Survey
The senior survey included one question related to Outcome 5, teamwork ability; results are summarized in Table 4.17 below. The question asked about their ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives. Ratings were made on a 5-point scale with a 3.50/5 or 70% target.

Table 4.17. Senior survey ratings of Outcome 5.

Academic Year	Outcome 5: Senior Survey
2018-2019	86%
2019-2020	87%
2020-2021	83%
2021-2022	87%

Overall, ratings on the senior survey are meeting goals for Outcome 5.

Summary: The direct and indirect assessments provide sufficient evidence that our students reliably graduate with the ability to function on multidisciplinary teams.

Outcome 6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.

Outcome 6. FE exam.
Direct assessment of this outcome is largely conducted by student performance on the NCEES Fundamentals of Engineering (FE) exam. We have decided to rely on the Probability and Statistics assessment. Ratio scores are reported, representing the ratio of the average percentage of questions on a topic that CU AREN students answer correctly divided by the average percentage of questions on a topic that AREN students nationally answer correctly. The goal is to equal or exceed a ratio score of 0.92. We successfully met this topic for five of the eight semesters measured indicating some deficiency but a good recovery in the last three semesters (Figure 4.5).

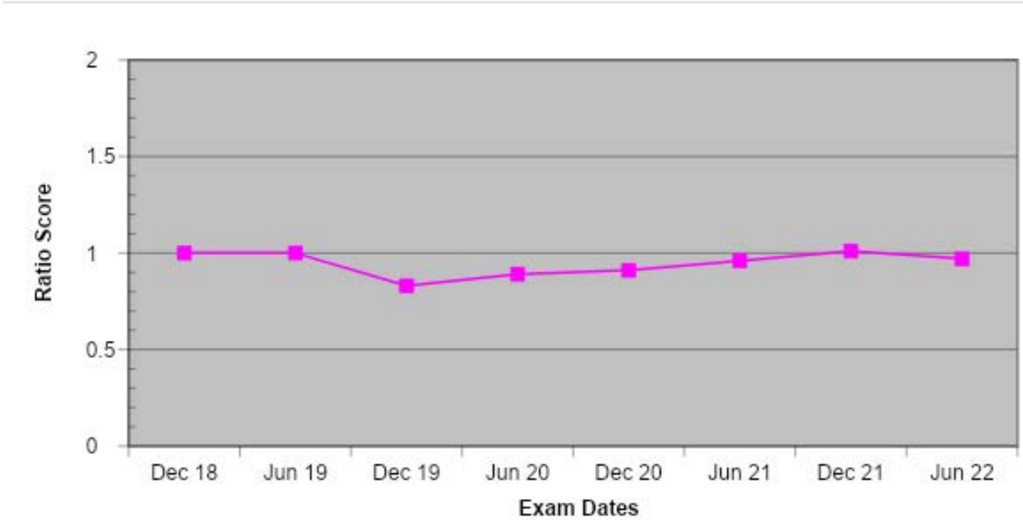


Figure 4.5. FE exam results for Probability and Statistics topic.

Outcome 6. Course rubric

CVEN 3161, Mechanics of Materials, includes a homework assignment with a written report focused on Outcome 6. AREN student reports were rated by the course instructor on the rubrics below. Rubrics were created for experimentation (Figure 4.6) and data analysis and judgement (Figure 4.7) below.

Ability to develop and conduct appropriate experimentation	Unable to follow the lab procedure and failed to acquire expected data from the experiments.	Can follow the lab procedure and finish the tasks. Poor data management and interpretation, leading to incorrect conclusions from the experiment.	Correctly follow the lab procedure, properly record and process the data, and deliver an adequate lab report. Can derive proper conclusions from the data.	Demonstrates strong experimentation skills in conducting the lab, checks the correctness of the data as the lab proceeds. Flawless post-processing of the data, leading to correct conclusions and can comment on potential source of errors

Figure 4.6. Rubric for assessment of homework assignment mapped to Outcome 6, Experimentation.

Ability to acquire and apply new knowledge as needed, to analyze and interpret data, and use engineering judgment to draw conclusions	Very incomplete or incorrect interpretation of trends and comparison of data indicating a lack of understanding of results. Conclusions missing or missing the important points.	Some of the results have been correctly interpreted and discussed; partial but incomplete understanding of results is still evident. Conclusions regarding major points are drawn, but many are misstated, indicating a lack of understanding.	Almost all of the results have been correctly interpreted and discussed, only minor improvements are needed. All important conclusions have been drawn, could be better stated.	All important trends and data comparisons have been interpreted correctly and discussed (with sources), understanding of results is conveyed. All important conclusions have been clearly made, student shows good understanding.

Figure 4.7. Rubric for assessment of homework assignment mapped to Outcome 6, Data Analysis and Judgement.

Expected results were that 80% of students would be rated adequate or above on the rubric. Results revealed students were rated above the cutoff and targets for each year and that targets were met for this assessment (Table 4.18).

Table 4.18. Course Rubrics assessment for CVEN 3161, Mechanics of Materials

Academic Year	Outcome 6: Experimentation Course Rubric	Outcome 6: Data Analysis/Judgement Course Rubric
2018-2019	90%	89%
2019-2020	94%	89%
2020-2021	84%	84%
2021-2022	97%	86%

Outcome 6. Student Course FCQs
An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions is rated on the FCQs for AREN 2120, Fluid Mechanics and Heat Transfer. Two questions were asked for this outcome 1) An ability to develop and conduct experimentation and 2) analyze and interpret data, and use engineering judgment to draw conclusions. Ratings were made on a 6 point scale in 18-19 and a 5 point scale afterwards. Results are presented below in Table 4.19 as percentages to allow for comparisons and expected to be above 75%. Results are unavailable for 2020 due to the global pandemic.

Table 4.19. Capstone design FCQ ratings of AREN 2120 for Outcome 6.

Academic Year	Outcome 6: Experimentation FCQ	Outcome 6: Data Analysis/Judgment FCQ
2018-2019	83%	83%
2019-2020	N/A, pandemic	N/A, pandemic
2020-2021	57%	81%
2021-2022	32%	60%

Ratings on FCQs were below cutoffs for AREN 2120, Fluid Mechanics and Heat Transfer for Outcome 6, except for 2018-2019. We did not meet targets for this assessment of Outcome 6.

Outcome 6a. Senior Survey
The senior survey included one question related to Outcome 6 ability; results are summarized in Table 4.20 below. The question asked about their ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions. Ratings were made on a 5-point scale with a 3.50/5 or 70% target.

Table 4.20. Senior survey ratings of Outcome 6.

Academic Year	Outcome 6: Experimentation Senior Survey	Outcome 6: Data Analysis/Judgment Senior Survey
2018-2019	66%	80%
2019-2020	70%	82%
2020-2021	79%	79%
2021-2022	73%	84%

Overall, ratings on the senior survey were below targets for outcome 6 in 18-19. Where we did not meet targets for this assessment with respect to experimentation.

Summary: Assessment found some deficiencies on the FE exam, FCQ and Senior survey while the course rubric met targets. Overall, results for Outcome 6 are not meeting targets and work is needed to improve results on this outcome.

Outcome 7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Outcome 7. FE Exam
We believe that students' overall performance on the FE exam is indicative of their motivation, ability, and willingness to acquire and apply new knowledge as needed, using appropriate learning strategies, given that this is a first step on the path to become a licensed PE, and PE licensure requires additional learning. CU AREN students primarily take the "other disciplines" exam. Pass rates for AREN students on this exam were compared with national averages with pass rates no more than 5% below the national average. Results are presented below in Table 4.21. Overall, CU AREN students performed above national peers in three academic years. Overall, we are meeting targets on this assessment.

Table 4.21. AREN student pass rates on FE exam.

Year	18-19	19-20	20-21	21-22
n CU students	*30*	*14*	*33*	*37*
CU student pass rate	76%	83%	69%	70%
Exam % difference from national average	*+3.6*	*-2.6*	*-1.2*	*+14*

Outcome 7. Direct Assessment: Course Assignments
Outcome 7 is measured by the Capstone design rubric rated by instructor and industry advisors with students completing an essay discussing the development of their skills on this Outcome. Results are expected to be rated above 80%. We were above targets each year indicating that the outcome targets are met on this assessment (Table 4.22).

Table 4.22. Capstone Design ratings of Outcome 7.

Academic Year	Outcome 7: Capstone Rubric
2018-2019	97%
2019-2020	95%
2020-2021	90%
2021-2022	94%

Outcome 7. Student Ratings on Course FCQs
The ability to acquire and apply new knowledge as needed, using appropriate learning strategies was mapped to AREN 3540, Illumination 1. Ratings were made on a 6-point scale in 18-19 and a 5-point scale afterwards. Results are presented below in Table 4.23 as percentages to allow for comparisons and expected to be above 75%. Results were above targets on assessment indicating we are meeting objectives for Outcome 7 on this assessment.

Table 4.23. FCQ ratings of Outcome 7.

Academic Year	Outcome 7: Illumination Rubric
2018-2019	84%
2019-2020	89%
2020-2021	89%
2021-2022	93%

Outcome 7. Senior Survey
The senior survey included one question related to Outcome 7 ability; results are summarized in Table 4.24 below. The question asked about their ability to acquire and apply new knowledge as needed, using appropriate learning strategies. Ratings were made on a 5-point scale with a 3.50/5 or a 70% target.

Table 4.24. Senior survey ratings of Outcome 7.

Academic Year	Outcome 7: Senior Survey
2018-2019	81%
2019-2020	79%
2020-2021	79%
2021-2022	84%

Overall, ratings on the senior survey were above targets for outcome 7. We met targets for this assessment.

Summary: Direct and indirect assessment of Outcome 7 indicated students have developed sufficient skills that are above targets on the assessments.

Overall Summary Across Outcomes Assessment

Across outcomes, assessments are above targets on 5 of the 7 outcomes. For outcome 3, assessments were below target on written communications skills and for outcome 6, assessments were below target on experimentation indicating partial success on these outcomes, but also offering areas for improvement.

B. Continuous Improvement

Assessment results are reported in department meetings and to the JEC. Results are discussed in meetings of the curriculum committee. A variety of continuous improvement initiatives were implemented during the ABET cycle and these are summarized below.

Improving Outcome 6, Experimental Design Skills

CVEN 3161, "Mechanics of Materials," is a required course for AREN students and is taught as a lecture with an associated laboratory section, providing ample opportunity for the students to develop and conduct appropriate experiments both during the laboratory section and in class.

In terms of the laboratory sessions, we focused on having students write about how they would redesign each experiment in the class knowing that the experimental results do not align with published data, which they had to research in developing their lab reports. This would encourage them to consider experimental design issues (in addition to issues related to material imperfections and equipment calibration).

We also changed the text of the third laboratory experiment, which is the concrete cylinder compression test. The data from the experiments typically showed a great deal of variability, so we reworded that assignment to include detailed statistical analysis. Students now quantify the scatter, calculate the mean and standard deviation of the compressive test results (grouped by compressive strength of each concrete cylinder), and then discuss how they might handle variability in measured values in the mechanics design process. This was not discussed in class on purpose to encourage them to draw on their knowledge of statistics and the equations from class when developing improvements in their experimental design. Additionally, we ask students to interpret their results and recommendations for two audiences: (1) for a more general audience with varying levels of familiarity with the scientific tests performed, and (2) for a scientific audience. The students were graded based on how they might "redesign the experiment to improve consistency in results", and how they might improve their experimental design otherwise.

We considered larger changes to the laboratory experiments, but were unable to enact these changes due to restrictions and other changes that occurred during the COVID-19 pandemic.

In addition to laboratory experiments, we conducted in-class experiments that allowed individual students to draw conclusions and share their analysis with the entire group. During one experiment, students simulated a torsion test by twisting (1) tootsie rolls and (2) chalk, drawing the failure surfaces, and discussing why chalk had a 45-degree failure plain (while the tootsie roll did not). Students recorded their observations, shared with pairs, shared in larger groups, and then reported results to the whole class. During another experiment, students put pieces of spaghetti under compression to demonstrate Euler Buckling. Before we learned deeply about Euler Buckling, students were asked to write down their observations related to the mode of failure, and what properties (material and geometric properties) they could change to prevent the spaghetti from failing in this mode. Again, they shared results in pairs, larger groups, and with the whole class. Students correctly identified that they could increase the cross-sectional area, decrease the length, or change the material properties - which helped them to identify similar design improvements once they were analyzing structural columns. Students were graded based on their observations from these in-class experiments on their final exam with a multiple-choice question.

Undergraduate Student Pathways Committee

The Undergraduate Student Pathways Committee (pathways committee) was started in Fall 2019 as a mechanism for staff, faculty, and department leadership to collaborate and co-develop programs and activities that help shape the out-of-class student experience in the department. The pathways committee has since convened bi-weekly during fall and spring academic semesters, and it has a set membership each year as determined by the department chair. The committee members include representation from the academic advisors, architectural engineering faculty, and civil engineering faculty. The committee reports to the department Executive Committee periodically for feedback on initiatives and committee scope. The current committee goal and objective are as stated below.

In support of the CU Boulder mission and vision to shape leaders who address the humanitarian, social, and technological challenges of the twenty-first century, this committee's purpose is to *support activities that inspire students to participate* in this vision and to *help students develop their personal aspirations for contributing* to the greater good.

This committee will *develop CEAS* activities and *support* other related university and CEAS activities to:

1. Recruit students to apply to the Civil, Architectural, and Environmental Engineering degree programs
2. Welcome undergraduate students into the department degree programs;
3. Provide opportunities for students to understand and get excited about the range of how CEAE engineers engage in and positively impact the world;
4. Provide opportunities for students to create CEAE community with peers, faculty, advisors, and mentors;
5. Actively support students in identifying pathways including:
   (a) Undergraduate academic;
   (b) Graduate academic;
   (c) Career;
6. Recognize excellence and celebrate students upon graduation.

Specific, current committee activities that support the objectives include:

1. Developing and implementing a recruiting strategy that includes outreach to high school and admitted college students and their families via social media and high school visits.
2. Planning and hosting of an annual student welcome fair.
3. Planning and hosting of an industry panel of recent graduates.
4. Piloting a professional mentorship program.
5. Planning and hosting of a fall and spring career fair.
6. Nominating students for college and department awards in the fall and spring semesters.

Professional Mentorship Program

In academic year 2022-2023, the department kicked off a pilot professional mentorship program in partnership with the college and the CU Alumni Association. The program is hosted on the Forever Buffs Network (FBN) platform for CU alumni. While the program is therefore restricted to alumni mentors, it is an approach that allows any undergraduate student to sign up for a mentor if they choose to do so.

Mentor/mentee matches are made through a mixed manual and automated approach based on what is known about the goals of the students, mentors, and information included in their FBN profiles. Matches are made in the fall semester and then mentorship pairs fill out a contract together that allows them to define and agree upon meeting time, modes, and topics. Training is provided for the mentors and mentees via the FBN platform.

The department collaborated with the college to set up an engineering subgroup on the FBN platform. All CEAE mentorship pairs are part of this group. They receive information in addition to that provided by the CU Alumni Association such as engineering-specific mentorship questions, and links to professional accomplishments and project case studies.

In the 2022-2023 academic year, the campus-wide mentorship program had 158 active mentorship relationships. The College of Engineering and Applied Science has 70 relationships, 39 of which include civil, environmental, or architectural engineering students. The pilot program ends in May of 2023 at which time feedback about the program will be collected from mentees and mentors. Adjustments will be made as needed to improve program efficacy prior to the 2023-2024 academic year.

Faculty Advising

Starting in the 2018-2019 academic year, the CEAE Department transitioned to a new model for academic advising and mentoring. Prior to this, the advising model was as follows: freshman and sophomore students were required to meet every semester with the staff advisor for their major. Juniors selected a faculty advisor in the fall of their junior year and were required to meet with their faculty advisor every semester until graduation. Faculty advisors conducted 20-minute individual meetings with each student over a designated two-week period each semester.

At our last ABET site visit in Fall 2017, students indicated that they wished they had more time to talk about careers with their faculty advisors, instead of just spending the time picking classes. In response to this feedback, the architectural engineering program piloted a new advising model in Spring 2019. Under this system, the staff advisor took over responsibility for advising all AREN students regarding their degree requirements and making sure they were enrolling in the correct classes every semester. Faculty advisors were renamed “faculty mentors” to align with other programs in the College, and were asked to focus more on career-related discussions with students. This included career options, choice of technical electives, internships, graduate school, research opportunities, etc.

The pilot program received no negative feedback from students or faculty and was expanded to the civil engineering program in Spring 2020. Once the entire CEAE Department was following the same advising model, it made additional changes possible. Faculty now have the option to conduct their mentoring meetings via individual appointments, drop-ins, or group sessions based on their preferences. Some faculty have reported that group sessions give the opportunity for more discussion among the students, and students have the option to request an individual meeting if they prefer.

Modifications to the Architectural Engineering (AREN) Curriculum

A year prior to the last AREN ABET accreditation review, the AREN faculty with impetus from the 2015 AREN Joint Evaluation Committee (JEC) began the process of revising the curriculum. The curriculum we currently operate under was officially implemented in Fall 2018. Below is a summary of the most important revisions.

Early exposure to Architecture Engineering

Following the recommendation of the 2015 AREN JEC to instill early and meaningful exposure to the five subdisciplines of Architectural Engineering: construction, lighting, electrical, structures, and mechanical engineering, the AREN and CVEN combined first year introductory course became two one-credit dedicated courses. Today, AREN 1316 spends two weeks of class time one each of the five subdisciplines, with the remaining five weeks of the semester dedicated to other professionalism topics such as sustainability, licensure, and engineering ethics.

Change to Required Specializations

Students majoring in architectural engineering who entered the program prior to Fall 2018 were required to choose (a) a proficiency: choosing two of the five subdisciplines. Design-level courses (AREN 4110, HVAC System Design; AREN 4570, Building Electrical Systems Design 1; CVEN 4545, Steel Design or CVEN 4555, Reinforced Concrete Design; and AREN 4550, Illumination 2) are taught in each of these subdisciplines and (b) a concentration: choosing one area to take two additional design-level courses. This structure of the curriculum allowed for students to concentrate in a particular subdiscipline of architectural engineering.

Faculty observed that while students were able to perform well in their own tracks, they lacked the overarching familiarity of building systems interaction. The AREN 2015 JEC report concurred saying that “choosing two proficiency classes in semester 6 does not leave a complete impression on the student of how a building is designed.” To address this, the Fall 2018 curriculum shifted to remove the choice of concentrations, and instead require all students to take proficiency courses in each of the five subdisciplines. Students are now encouraged to focus on a specific discipline through up to four technical electives courses or through postgraduate education, such as the concurrent bachelor’s and master’s program (BAM). As a result, graduating students now have breadth and depth in all the subdisciplines making them well equipped to work on interdisciplinary teams in the architecture, engineering, and construction (AEC) industry.

Capstone Restructuring

To support the notion of architectural engineering graduates with expertise in all subdisciplines, the senior capstone was restructured to foster an integrated design process. Prior to Fall 2018, the capstone consisted of a fall semester architecture studio followed by a spring semester engineering capstone. In this structure, little to no integration occurred between the engineered systems and the architecture.

To address this shortcoming, a year-long integrated design project is used for the capstone, aligned with the Architectural Engineering Institute (AEI) student design competition. The credits and courses were restructured to include a “junior” studio (AREN 3080) that teaches the fundamentals of architectural design, and then a “senior” studio (AREN 4080) that supports the engineering portion of the capstone (AREN 4318). As a result, students are now able to apply their well-rounded knowledge of architectural engineering in the integrated design of a commercial building.

AREN Joint Evaluation Committee (JEC) Meeting Format Improvement: A Case Study in Support of Criterion 2.0 Program Objectives and 4.0 Continuous Improvement

Context: Through AY 2018-2019, the Department of Civil, Environmental, and Architectural Engineering (CEAE) underwent a periodic evaluation by a committee comprised of students, faculty, and industry professionals known as the Joint Evaluation Committee (JEC). The evaluation occurred every three years. The format of the meeting included a day-long agenda, composed of presentations by faculty to the committee, a review of program objectives, a review of the curriculum, a review of student work, research presentations by the faculty, and an in-depth, conversation regarding suggested changes or additions to the curriculum in light of an evolving industry. The meeting was then summarized in a lengthy report written by the committee members. The report often took months to prepare and finalize, given the limited bandwidth of the industry representatives. The faculty then reviewed the report and offered comments and responses to the points raised in the report prior to initiating any curricular changes. Because curricular changes are also a lengthy process, the recommendations by the committee took years to be integrated into the curriculum.

Objective: The objective of the JEC meeting format improvement was to restructure the meeting so that it would yield outcome-oriented results (i.e., continuous improvement) on a more frequent basis.

JEC Meeting Format Improvement In AY 2019-2020, the Department of Civil, Environmental, and Architectural Engineering made significant changes to its JEC meeting format, including:

a. Changing the meeting frequency from triannual (meeting every three years) to occur annually. Reasoning: The program wished to receive more regular feedback to respond to changes occurring in the industry in a more timely manner;
b. Changing the meeting time from 8 hours to 2 hours. Reasoning: The program wished to focus the conversation and to lower the time commitment burden for industry professionals;
c. Sending a pre-read in advance that contained (a) the program objectives, (b) the previous year's JEC summary report, and (c) the current curriculum. Reasoning: The JEC representatives could review the necessary material on their own time rather than spending time in the actual meeting doing so;
d. Focusing the conversation to three major discussion points, namely (a) a review of program objectives, (b) an open discussion of required professional skills, and (c) an open discussion of required technical skills within the discipline. Reasoning: This focus kept the conversation structured to that the program received the most salient feedback with respect to the curriculum. Summarizing a two-page report within a week of the meeting, soliciting industry feedback within the next week, and

circulating to faculty over the summer and early fall to identify action items with respect to the program and curriculum. Reasoning: Curricular changes implemented in the fall semester take effect the following fall semester. The short summary and quick turnaround allow the faculty to implement important and timely changes on a much more frequent basis.

Impact: The new JEC format has been in effect for three (3) academic year cycles: AY 2019-20, AY 2020-21, and AY 2021-22. More frequent feedback from the JEC has enabled the faculty to make important and timely changes, such as (i) modifying the type and frequency of course offerings to reflect important skillsets needed in the industry (e.g., Embodied Carbon in Buildings, Design of Wood Structures), (ii) establishing our Student Pathways Committee that enhances our students' experience outside of the classroom, and (iii) establishing a mentorship program to connect our students with professionals in the industry, among many others. The program is thrilled with this new format, as it enables enhanced continuous improvement of our program to better serve our students and the fields in which they will enter.

Teaching Quality Framework Initiative

Introduction: Acknowledgment and value of teaching quality in reappointment, tenure, and promotion (RTP) systems remain a point of contention to those attempting to create more equitable, transparent, and formative evaluation methods for their work. To date, the Teaching Quality Framework Initiative (TQF), an ongoing initiative at the University of Colorado Boulder (CU-B), has been successful at helping departments transform their teaching evaluation practices. A common rubric that defines seven dimensions of quality teaching and draws from "three voices" of teaching evaluation - self, peer, and student is used as a guiding tool.

Purpose: Assessment of teaching practices were needed for the development of faculty in the CEAE department. A need for discipline-based, collegial, structured, and formative feedback was identified by the CEAE Teaching Quality Framework (TQF) Departmental Action Team (DAT).

Overview of Initiative: The Classroom Interview Process (CIP) in CEAE consists of three components: a pre-consultation between the participating faculty and CIP facilitator; the classroom observation and interview; and a post-consultation between the participating faculty and facilitator. The CIP was developed in the 2020-2021 academic year, piloted in spring 2021, and expanded starting in the fall of 2021.

Faculty Participation: To date, 11 CEAE faculty participated in the CIP in the fall semester of 2021, and 10 faculty participated in spring 2022. Courses observed span the 2000, 3000, and 4000 level across AREN, CVEN, and EVEN listings. Faculty participating in a CIP represented all six faculty groups. The faculty who facilitated a CIP during 2021-2022 represented a group that have received varied and prestigious teaching accolades, including college and department teaching awards and fellowships, engineering education authorship, and FTEP CLIP experience (e.g., ASCE ExCEEd New Faculty Excellence in Teaching Award, Boulder Faculty Assembly Excellence in Teaching Award). Faculty who facilitated a CIP included faculty at the Assistant, Associate, and Full Professor designations. Table 4.25 below provides a breakdown of those who participated in a CIP in the fall 2021 and spring 2022 semesters.

Table 4.25. Breakdown of CIP participation.

Faculty who have completed the classroom interview process to date			
# of faculty	Faculty groups represented (#)	Career level represented (#)	Peer letters provided
21	Building/Civil Systems (4) Construction (3) Environmental (5) Geotechnical (4) Structural (4) Water Resources (1)	Assist. Teaching Prof.(3) Assoc. Teaching Prof. (4) Assist. Prof.(11) Assoc. Prof.(1) Professor (2)	7+

Faculty Feedback on CIP: Based on post-consultation meetings with participating faculty, some senior faculty mentioned thinking the CIP was a helpful process for improving teaching. The pre-meetings with faculty were helpful in alleviating concerns and misconceptions about the process of the CIP and as a way for facilitators to emphasize the opportunity for the CIP to provide formative feedback.

Management of Initiative: Along with the formation / movement of a classroom interview committee, the following are tasks that help in managing the CIP as well as suggestions for delegation of these tasks:

- Requesting and compiling data for courses to be observed
    - Timing - This task takes approximately 2-4 hours to complete prior to the beginning of the semester that a CIP occurs
- Contacting identified and interested faculty
    - Timing - This task takes approximately 2-4 hours to complete prior to the beginning/first few weeks of the semester that a CIP occurs
- Scheduling of the CIP with faculty (3 meetings per CIP)
    - Timing - This task takes approximately 1-2 hours prior to the beginning/first few weeks of the semester that the CIP occurs
- Recruiting facilitators
    - Timing - This task takes a varied amount of time depending on the top-down messaging and any related incentives, ideally prior to the beginning of the CIP in a given semester
- Training facilitators

    - Timing - This task could take a varied amount of time depending on the top-down messaging and any related incentives, ideally prior to the beginning of the CIP in a given semester
- Preparing survey links, feedback spreadsheet, and bit.ly links for the CIP facilitator
    - Timing - This task takes approximately 2-4 hours prior to the beginning/first few weeks of the semester that the CIP occurs
- Sharing CIP survey links and feedback documents to facilitators
    - Timing - This task takes approximately 1-2 hours prior to the beginning/first few weeks of the semester that the CIP is occurs
- Answering questions from participating faculty
    - Timing - This task can occur as needed and as questions arise
- Soliciting feedback from participating faculty
    - Timing - This task can either be within a month of the participating faculty's CIP, or at the end of the semester of the CIP depending on the method of evaluation (e.g., focus group at the end of the semester vs survey sent within month of CIP)
- Presenting at select faculty meetings to address fears and goals of the CIP
    - Timing - Once per semester that the CIP will take place

Future Value: The TQF CEAE team believes that the CIP provides valuable formative feedback to faculty. There is also opportunity for participating faculty and the department to:

- Request and receive quality peer letters (if requested) for comprehensive review, reappointment, promotion, and tenure dossiers
- Receive credit for engaging in a CIP for facilitators and participating faculty for merit review purposes.
- Develop growth at the junior faculty and senior faculty levels, both for formative and remediation identification
- Use CIP for its fit within supplemental data collection options for the CEAS TQF model rubric for CRPT.

C. Additional Information

The FE exam serves as a direct assessment method for 4 of our 7 student outcomes. The 'other disciplines' engineering exam requirements from the NCEES, performance reports from the NCEES on the performance of CU architectural engineering students and the full FE summary spreadsheet will be available for examination at the time of the visit.

Student reports and presentations in the senior capstone design course are used as direct assessments for four student outcomes. The course dossier will include current and historical data from the course rubric.

Assignments in other courses that are used to assess student outcomes, including laboratory reports and homework assignments from the Introduction to Architectural Engineering course will be available for examination in files compiled for each relevant outcome, as well as the course dossiers.

CRITERION 5. CURRICULUM

A. Program Curriculum

The Architectural Engineering curriculum is commonly referred to by students, faculty, and other constituents as the so-called "Block Diagram". The block diagram lays out the expected and recommended order of courses to complete the requirements for the program in eight semesters (four academic years). The first semester is shown in the bottom row of the diagram, and subsequent semesters build to the final semester at the top. The block diagram indicates courses that are part of pre-requisite and co-requisite sequences in their proper order. Some courses are also offered only fall or spring semester, and those courses are shown in an appropriate location (and also denoted with a #). Students have opportunities to select courses, including four humanities/social science (HSS) electives, two AREN technical electives, two general technical electives, and one free elective. There are lists of acceptable courses for each of these choices. The technical elective list is quite extensive; it is periodically reviewed by the curriculum committee and published online for students (https://www.colorado.edu/ceae/sites/default/files/attached-files/ceae_tech_elective_list_oct_2020.pdf). HSS electives are vetted by the H&SS subcommittee of the CEAS and approved by the Undergraduate Education Council of the College. These HSS electives include courses offered by the Herbst Program for Engineering, Ethics & Society. It also includes courses approved as part of the College of Arts & Sciences General Education requirements in the topic areas of arts & humanities and social sciences. Additional courses have been approved (https://www.colorado.edu/engineering-advising/get-your-degree/degree-requirements/humanities-social-sciences-and-writing-requirements). Finally, the curriculum also includes one free (minimally restricted) elective.

We have included below the 2022 Block Diagram. The curriculum has also been shown in Table 5-1. Courses have been listed from first to eighth semester, in the same recommended order shown in the Block Diagram. The maximum section enrollments for all courses in the program for the last two terms the course was taught have been included.

AREN Block Diagram – Fall 2022

Sem.	CR						
8 SPR	14	**Technical Elective**-3cr From AREN specialization list on page 2	**Technical Elective**-3cr	**Free Elective**-3cr	**AREN 4319**-2cr AREN Design 2 (AREN 4318) #		**HSS Elective**-3cr Upper-division
7 FALL	17	**Technical Elective**-3cr From AREN specialization list on page 2	**AREN 4570**-3cr Electrical Systems for Buildings (AREN 3040) #	**Technical Elective**-3cr	**AREN 4318**-5cr AREN Design 1 (See notes****) #		**HSS Elective**-3cr
6 SPR	15		**AREN 3040**-3cr Electrical Circuits (APPM 2360, PHYS 1120) #	**AREN 4110**-3cr HVAC System Design (AREN 3010) #	**AREN 4506**-3cr Pre-Construction Estimating & Scheduling (CVEN 3246)	**Structural Design**-3cr CVEN 4545 or 4555** (CVEN 3525)	**ARCH 3214**-3cr History and Theory of Arch. 2 #
5 FALL	15		**AREN 4550**-3cr Illumination 2 (AREN 3540) #	**AREN 3010**-3cr Energy Efficient Buildings (AREN 2050, 2110, 2120) #	**CVEN 3246**-3cr Introduction to Construction (Junior standing)	**CVEN 3525**-3cr Structural Analysis (CVEN 3161)	**College-Approved Writing Course**-3cr***
4 SPR	17	**APPM 2360**-4cr Introduction to Linear Algebra & Diff. Equations (APPM 1360)	**AREN 3540**-3cr Illumination 1 (CSCI 1200, APPM 2350) #	**AREN 2120**-3cr Fluid Mech. & Heat Transfer (AREN 2110, co-reqs. APPM 2350, 2360) #	**AREN 3080**-3cr Arch. Design Studio 1 (AREN 1027) #	**CVEN 3161**-3cr Mechanics of Materials 1 (CVEN 2121, co-req. APPM 2360)	**CVEN 2017**-1cr Excel and Matlab Primer (CSCI 1200) #
3 FALL	17	**APPM 2350**-4cr Calculus 3 for Engineers (APPM 1360)	**PHYS 1120**-4cr Gen. Physics 2 (PHYS 1110, co-req. APPM 1360)	**AREN 2110**-3cr Thermodynamics (PHYS 1110, co-req. APPM 1360)	**AREN 2050**-3cr Bldg. Materials & Systems (Soph. standing) #	**CVEN 2121**-3cr Analytical Mechanics 1 (PHYS 1110, co-req. APPM 2350*)	
2 SPR	17	**APPM 1360**-4cr Calculus 2 for Engineers (APPM 1350)	**PHYS 1110**-4cr Gen. Physics 1 (co-req. APPM 1350)		**AREN 1027**-3cr Engineering Drawing	**GEEN 1400**-3cr Engrg. Projects OR **Basic Engineering Elective**	**HSS Elective**-3cr***
1 FALL	16	**APPM 1350**-4cr Calculus 1 for Engineers (APPM 1235 or placement)	**CHEN 1201**-4cr Gen. Chem. for Engineers 1 (1yr HS chem. or CHEM 1021, HS algebra)	**Science Lab**-1cr † CHEM 1114 or PHYS 1140	**AREN 1316**-1cr Introduction to Architectural Engineering #	**CSCI 1200**-3cr Intro to Computational Thinking #	**HSS Elective**-3cr***

Fall 2022/Updated July 2022

**Course is offered only once per year (FALL or SPRING as shown).**
( ) **Prerequisite and co-requisite requirements for course listed.**
***** **Co-requisite APPM 2350; OR co-requisite APPM 1360 and prerequisite GEEN 3830 Engineering Analysis & Problem Solving.**
****** **CVEN 4545 Steel Design offered SPRING only; CVEN 4555 Reinforced Concrete Design offered FALL only.**
******* **College-approved writing courses: ENES 1010 (first-year students only); or ENLP 3100, ENES 3100, WRTG 3030, WRTG 3035, or PHYS 3050 (jr. standing). Students who want to take ENES 1010 can switch the HSS elective in Term 1 or 2 with the writing course in Term 5.**
******** **Prerequisites for AREN 4318: AREN 3080, AREN 4110, AREN 4506, AREN 4550, and CVEN 4545 or 4555. Co-requisite: AREN 4570.**
† **Students can choose either the chemistry lab CHEM 1114 in Term 1 or physics lab PHYS 1140 in Term 3.**

AREN ELECTIVES AND OPPORTUNITIES FOR SPECIALIZATION

At least two technical electives must be selected from this list, from any emphasis area(s).
Some technical electives are offered intermittently, and are not guaranteed to be offered every year.
Graduate versions of combined courses (e.g. CVEN 5728 instead of CVEN 4728) are also accepted.

STRUCTURAL SYSTEMS

Strongly recommended:	**CVEN 4545 Steel Design*** (CVEN 3525) – spring
	CVEN 4555 Reinforced Concrete Design* (CVEN 3525) – fall
Recommended:	CVEN 4565 Design of Wood Structures (CVEN 3525) – spring every other year
	CVEN 4728 Foundation Engineering (CVEN 3718) – spring
Other options:	AREN 4315 Masonry Design (CVEN 3525) – spring every other year
	AREN 5660 Embodied Carbon in Buildings (instructor consent) – spring
	CVEN 4161 Mechanics of Materials II (CVEN 3161) – fall

Can only be taken as a technical elective if not used to fulfill the Structural Design requirement.

MECHANICAL SYSTEMS

AREN 4010 Energy System Modeling & Control (AREN 4110) – fall, intermittent
AREN 4080 Computer Simulation of Building Systems (AREN 3010) – spring, intermittent
AREN 4025 Building Energy Audits (AREN 3010) – spring, intermittent
AREN 4890 Sustainable Building Design (AREN 3010) – fall, intermittent
AREN 4990 Computational Fluid Dynamics (CFD) Analysis (AREN 2120, APPM 2360) - intermittent

LIGHTING/ELECTRICAL SYSTEMS

Strongly recommended:	**AREN 4130 Optical Design** (AREN 3540) – fall
	AREN 4580 Daylighting (AREN 4130, 4550) – spring
	AREN 4620 Adaptive Lighting Systems (AREN 4550) – fall
Recommended:	AREN 4530 Advanced Lighting Design (AREN 4550) – spring
	AREN 4560 Luminous Radiative Transfer (AREN 3540) – spring

CONSTRUCTION ENGINEERING & MANAGEMENT

Strongly recommended:	**AREN 4606 Construction Project Execution & Control** (AREN 4506) – spring
	CVEN 3256 Construction Equipment & Methods (CVEN 3246) – fall and spring
Other options:	AREN 4315 Masonry Design (CVEN 3525) – spring every other year
	CVEN 3708 Geotechnical Engineering 1 (CVEN 3161) – fall and spring
	CVEN 3718 Geotechnical Engineering 2 (CVEN 3708) – fall and spring
	CVEN 4565 Design of Wood Structures (CVEN 3525) – spring every other year

Note: Students are encouraged to consider CVEN 2012 Intro to Geomatics as a basic engineering or free elective.

ELECTIVE REQUIREMENTS

Basic Engineering Elective – any 3-credit technical course given in the engineering college with a designator ASEN, AREN, APPM, CHEN, COEN, CVEN, CSCI, ECEN, EMEN, EVEN, GEEN, or MCEN, or other course approved by the CEAE Curriculum Committee. Remedial courses (precalculus, etc.) or courses approved as HSS electives may not be used.

Free Elective – Any college-level course, except: cannot be remedial courses needed to fulfill deficiencies (precalculus, introductory chemistry, etc.) and cannot be similar to other courses used toward graduation requirements (algebra-based physics, etc.).

Humanities and Social Science (HSS) Elective – See the College requirements and list of approved courses at www.colorado.edu/engineering/academics/policies/HSS.

Technical Elective – Generally, an upper-division (3000+) science or engineering course with technical content. All upper-division AREN/CVEN courses are technical electives; up to 6 credits outside of AREN/CVEN may be selected from the approved course list posted at https://www.colorado.edu/ceae/node/111/attachment. Up to 3 credits of independent study are allowed for technical elective credit.

Table 5-1 Curriculum: Architectural Engineering

Course (Department, Number, Title) List all courses in the program by term starting with the first term of the first year and ending with the last term of the final year.	Indicate whether course is Required, Elective or a Selected Elective by an R, an E or an SE.[1]	*Subject Area (Credit Hours)* Math & Basic Science	Eng. Topics Check if Contains Significant Design (√)	Other	Offered: Year and, Semester, or Quarter	Maximum Section Enrollment for the Last Two Terms the Course was Offered[2]
[1] AREN 1316 Introduction to Architectural Engineering	R		1		Fall 2022, Fall 2021	48
[1] APPM 1350 Calculus 1 for Engineers	R	4			Spring 2023, Fall 2022	Sp 23-81 lec, 25 lab, Fall 22-152 lec, 26 lab
[1] CHEN 1201 General Chemistry for Engineers	R	4			Spring 2023, Fall 2022	Fall 2022-350, Spring 2023-153
[1] CHEM 1114 Engineering General Chemistry 1 Lab	R	1			Spring 2023, Fall 2022	20
[1] HSS Course	E			3		
[1] CSCI 1200 Intro to Computational Thinking	R		3		Fall 2021, Fall 2022	Fall 22-195 lec, 45 lab, Fall 21- 152 lec, 38 lab
[2] AREN 1027 Engineering Drawing	R		3		Spring 2023, Fall 2022	Fall 22-90 lec, 45 lab, Sp 23- 68 lec, 34 lab
[2] APPM 1360 Calculus 2 for Engineers	R	4			Spring 2023, Fall 2022	Sp 23-152 lec, 26 lab, Fall 22-103 lec, 25 lab
[2] PHYS 1110 General Physics 1	R	4			Spring 2023, Fall 2022	Fall 22-330 lec, 28 lab, Sp 23-333 lec, 29 lab
[2] GEEN 1400 Engineering Projects	R		3√		Spring 2023, Fall 2022	Fall 2022-32 lec, 31 lab, Spring 2023-30 lec, 30 lab
[2] HSS Course	E			3		
[3] APPM 2350 Calculus 3 for Engineers	R	4			Spring 2023, Fall 2022	Sp 23-80 lec, 24 lab, Fall 22-111 lec, 25 lab
[3] PHYS 1120 General Physics 2	R	4			Spring 2023, Fall 2022	Sp 23-300 lec, 29 lab, Fall 22-337 lec, 28 lab

[3] AREN 2050 Building Materials and Systems	R		3		Fall 2022, Fall 2021	Fall 22-55, Fall 21-58
[3] CVEN 2121 Analytical Mechanics 1	R		3		Spring 2023, Fall 2022	Spring 2023-77, Fall 2022-106
[3] AREN 2110 Thermodynamics	R	1	2		Spring 2023, Fall 2022	Fall 2022-106, Spring 2023-48
[4] CVEN 2017 Excel and Matlab Primer	R		1		Spring 2023, Spring 2022	24+online section
[4] APPM 2360 Intro. to Differential Equations with Linear Algebra	R	4			Spring 2023, Fall 2022	Sp 2023-130 lec, 26 lab Fa 2022-100 lec, 26 lab
[4] AREN 2120 Fluid Mechanics & Heat Transfer	R		3		Spring 2023, Spring 2022	48
[4] CVEN 3161 Mechanics of Materials 1	R		3		Spring 2023, Fall 2022	Fall 22-48 lec, 24 lab; Spring 23-84 lec, 48 lab
[4] AREN 3080 Architectural Design Studio 1	R		3√		Spring 2022, Spring 2023	Spring 2022-48 lec, 48 studio, Spring 2023-60 lec, 30 studio
[4] AREN 3540 Illumination 1	R	2	1		Spring 2022, Spring 2023	48
[5] CVEN 3246 Introduction to Construction	R		3√		Spring 2023, Fall 2022	Spring 2023-64, Fall 2022-90
[5] AREN 4550 Illumination 2	R		3√		Fall 2021, Fall 2022	Fall 21-49, Fall 22-43
[5] AREN 3010 Energy Efficient Buildings	R		3√		Fall 2022, Fall 2021	48
[5] CVEN 3525 Structural Analysis	R		3		Spring 2023, Fall 2022	Fall 2022-106, Spring 2023-48
[5] College-Approved Writing Course	SE			3		
[6] AREN 4110 HVAC System Design	R		3√		Spring 2022, Spring 2023	68
[6] AREN 3040 Electrical Circuits	R	1	2		Spring 2023, Spring 2022	48
[6] AREN 4506 Pre-Construction Estimating & Scheduling	R		3√		Fall 2022, Spring 2023	Fall 2022-56, Spring 2023-48
[6] CVEN 4545 or CVEN 4555, Structural	SE		3√		CVEN 4555-Fall	Fall 2022-64, Spring 2023-60

Design					2022, CVEN 4545-Spring23	
[6] ARCH 3214 History and Theory of Architecture 2	R			3	Spring 2023, Spring 2022	Spring 2023-150, Spring 2022-135
[7] AREN 4570 Building Electrical Systems Design 1	R		3√		Fall 2022, Fall 2021	Fall 22-45, Fall 21-48
[7] AREN 4318 Architectural Engineering Design 1	R		5√		Fall 2022, Fall 2021	48
[7] AREN Technical Elective	SE		3√			
[7] Technical Elective	SE		3			
[7] HSS Course	E			3		
[8] AREN Technical Elective	SE		3√			
[8] Technical Elective	SE		3			
[8] Free Elective	E			3		
[8] HSS Course	E			3		
[8] AREN 4319 Architectural Engineering Design 2	R		2√		Spring 2022, Spring 2023	48
TOTALS-ABET BASIC-LEVEL REQUIREMENTS		33	74	21		
OVERALL TOTAL CREDIT HOURS FOR COMPLETION OF THE PROGRAM	128					
Total must satisfy minimum credit hours	Minimum Semester Credit Hours	30 Hours	45 Hours			

1. **Required** courses are required of all students in the program, **elective** courses (often referred to as open or free electives) are optional for students, and **selected elective** courses are those for which students must take one or more courses from a specified group.
2. For courses that include multiple elements (lecture, laboratory, recitation, etc.), indicate the maximum enrollment in each element. For selected elective courses, indicate the maximum enrollment for each option.

Curriculum Alignment with Program Educational Objectives

The overall philosophy of the architectural engineering curriculum is to provide all students with a broad foundation in engineering, architecture, and architectural engineering, then to provide each student with the opportunity for in-depth study in a specific discipline within architectural engineering. As such, the program provides both breadth and depth; **breadth** in that each AREN student must take courses in all five specialty areas (structural engineering, lighting, electrical systems, mechanical systems, construction engineering and management), as well as general architecture, fundamental engineering, and architectural engineering courses; **depth** in that each student must select an area for specialization and complete a minimum of two additional courses in that area. Students have the option to specialize further by selecting two additional technical electives in the area of specialization ***or*** to choose courses in complementary areas to maintain breadth. Students may choose instead to take two technical electives courses outside of the department, too, from a list of approved options. All students pursuing the architectural engineering degree must take a common, 7-credit senior capstone design course throughout the senior year (fall and spring) that provides a culminating design experience.

The **Program Educational Objectives** are linked to desired outcomes. The outcomes are fulfilled by various required courses in the curriculum, as described below. The alignment of the curriculum with the program educational objectives is summarized in the table below. For example, all courses in the curriculum contribute to meeting **Objective 1,** Our alumni will build on the educational foundation gained through our program by establishing themselves in engineering, science, or other professional careers. The importance of pursuing professional licensure is particularly emphasized in three key courses in the curriculum: Introduction to Architectural Engineering, Introduction to Construction, and Senior Design (fall and spring senior year). AREN Senior Design also covers a review of fundamentals in preparation of the Fundamentals of Engineering (FE) exam, along with other professional issues in the architectural engineering profession (e.g., ethics, leadership, communication, teamwork). For **Objective 2**, Our alumni will begin advancing the state-of-the-art of their profession including one of five core disciplines of the building industry: electrical systems; lighting systems; heating, ventilating, and air conditioning (HVAC) systems; materials and structural systems; construction engineering and management, all AREN fundamental and survey-style courses contribute to its fulfillment, including AREN 1316 Introduction to AREN and the senior design capstone courses, AREN 4318 and AREN 4319. Our students take at least two (2) courses in all five core disciplines: electrical systems; lighting systems; heating, ventilating, and air conditioning (HVAC) systems; materials and structural systems; construction engineering and management. Our students have the opportunity to specialize in one of the areas by selecting two additional AREN technical electives from a prescribed list, as well as two additional electives in the same area or in other areas. For **Objective 3**, Our alumni will exercise leadership in their field, our students take an Introduction to Construction course taught by our construction engineering and management faculty. Our students also have access to elective courses in the areas of engineering management. In their senior year, students sharpen their leadership, communication, and teamwork skills in our AREN 4318 and AREN 4319, our senior design capstone. For **Objective 4**, Our alumni will enhance the sustainability of the built environment, students are introduced to core principles of sustainability in AREN 1316 Introduction to Architectural Engineering. They are further exposed to sustainability concepts, principles, and design strategies in Building Materials and Systems, the Junior Studio (i.e., Architectural Design Studio I), Energy Efficient Buildings, and AREN 4318 and AREN 4319, our senior design capstone.

Table 5.1. Alignment of PEOs with AREN Curriculum.

Program Educational Objective (PEO)	1st yr courses	2nd yr courses	3rd year courses	4th year courses
1. Our alumni will build on the educational foundation gained through our program by establishing themselves in engineering, science, or other professional careers.	All provide foundation	All provide foundation	All provide foundation	All provide foundation
Our alumni will begin advancing the state-of-the-art of their profession including one of five core disciplines of the building industry: electrical systems; lighting systems; heating, ventilating, and air conditioning (HVAC) systems; materials and structural systems; construction engineering and management.	Intro to AREN	Thermodynamics, Building Materials and Systems, Analytical Mechanics, Illumination I, Mechanics of Materials	Illumination 2, Energy Efficient Buildings, Intro to Construction, Structural Analysis, Electrical Circuits, HVAC System Design, Concrete *or* Steel Design, Pre-Construction Estimating and Scheduling	Electrical Systems for Buildings, AREN Technical Electives (2), AREN Senior Design Capstone
Our alumni will exercise leadership in their field.			Introduction to Construction	AREN Senior Design Capstone (Professional Issues Module)
Our alumni will enhance the sustainability of the built environment.	Intro to AREN	Building Materials and Systems; Junior Architectural Studio	Energy Efficient Buildings	AREN Senior design Capstone

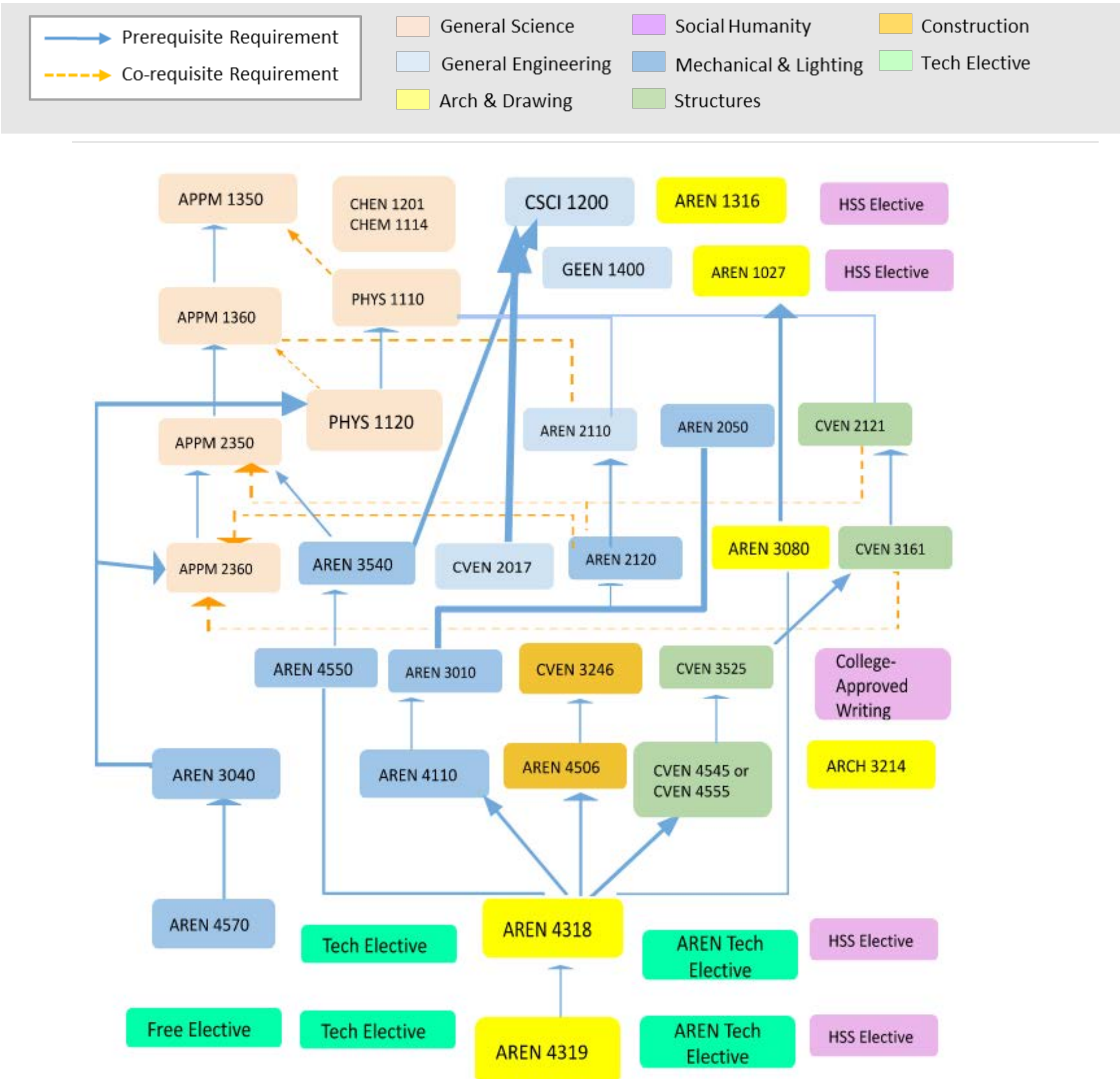
Curriculum Alignment with Student Outcomes

All engineering courses in the AREN curriculum have been mapped to the extent to which they contribute to each of the 7 student outcomes, based on faculty ratings: large contribution (red), medium (orange), small (yellow), none. Missing from the table are required courses in the curriculum outside of engineering.

Table 5.2. Alignment of Required engineering courses in the AREN degree with Outcomes [faculty ratings: red = large, orange = medium, yellow = small; average student ratings on a scale from 0 to 6 shown as the numbers in each cell]. N/A = data not available

	Student Outcomes									
Courses	**1**	**2a**	**2b**	**3a**	**3b**	**4**	**5**	**6a**	**6b**	**7**
AREN 1027-3 [1]										
AREN 1316-2 [1]										
AREN 2050-3 [3]										
AREN 2110-3 [3]										
CVEN 2121-3 [3]										
AREN 2120-3 [4]										
CVEN 3161-3 [4]										
AREN 3540-3 [4]										
CVEN 3246-3 [4]										
AREN 3080-3 [4]										
CVEN 2017-1 [4]										
CVEN 3246-3 [5]										
AREN 3010-3 [5]										
CVEN 3525-3 [5]										
AREN 4550-3 [5]										
AREN 3040-3 [6]										
AREN 4110-3 [6]										
AREN 4506-3 [6]										
CVEN 4545/4555										
AREN 4570-3 [7]										
AREN 4318-5 [7]										
AREN 4319-2 [8]										
Number Large	11	8	8	0	3	2	2	0	2	3
Number medium	2	5	4	4	6	9	3	3	3	10

Figure 5.1. We also prepared the following flowchart illustrating prerequisite structure of AREN required courses (based on 2022-2023 Block Diagram).



Curricular Areas and General and Program Criteria

The ABET basic-level general criteria require that a minimum of 30 credit hours must be in the curricular area of math and basic sciences and that a minimum of 45 credit hours must be in the curricular area of engineering topics. Table 5-1 shows that the AREN curriculum meets these requirements.

Math and basic sciences: Table 5-1 shows that the program contains sufficient coverage of the math and basic science requirements, with 33 credits of the curriculum. These are courses from applied math (APPM), chemistry, physics, and basic science courses such as Building Materials and Systems, Fluid Mechanics, and Electrical Circuits.

Engineering topics and design: Table 5-1 also shows that the program contains sufficient coverage to meet the engineering topics requirement, with 74 credit hours of the curriculum devoted to these topics. The table also shows which of these courses contain a large amount of design. See evidence in the colored mapping tables.

General education: The curriculum provides 18 credits of humanities and social sciences (HSS) coursework, including 6 credits that are upper-division and an upper-division writing course. The College provides a listing of approved courses for these electives (see https://www.colorado.edu/engineering-advising/get-your-degree/degree-requirements/humanities-social-sciences-and-writing-requirements) to ensure that the courses have sufficient quality and complement the technical portions of the curriculum; in general, courses that are "skills" oriented are not approved for these electives. Instead, the College's list focuses on courses with a broad view of history, literature and the humanities. The majority of these courses are approved as College of Arts & Sciences (A&S) general education courses, and as such undergo scrutiny from A&S to ensure quality. Courses beyond the A&S general education requirements that are approved for engineering students are reviewed and approved by the College's Undergraduate Education Council. Students are encouraged to pick a particular area of humanities or social science and devote their humanities electives to courses in that single area. Many also choose to take advantage of the College's Herbst Program for Engineering, Ethics, and Society, described in Appendix D.

Other: The Architectural Engineering curriculum includes three credits of free electives. These credits were classified as "other". They may be technical or non- technical courses. They provide students with a small amount of autonomy to customize their college experience. They may include study abroad courses, courses that contribute to a minor or certificate, etc.

Major Design Experience

The AREN curriculum has elements throughout the four years that are focused on preparing students for engineering practice. The program culminates in a major design experience in the required AREN 4318, AREN 4319, and AREN 4080 Architectural Engineering Design courses. These courses build directly on previous courses with architectural and engineering design content. Before taking AREN 4318, 4319, and 4080, students take five fundamental engineering analysis courses and five proficiency courses (design) all related to the five building disciplines.

Fundamental engineering analysis courses:

- CVEN 3525 Structural Analysis
- AREN 3010 Energy Efficient Buildings
- AREN 3040 Electrical Circuits
- AREN 3540 Illumination 1
- CVEN 3246 Intro to Building Construction

Proficiency courses:

- CVEN 4545 Steel Design or CVEN 4555 Reinforced Concrete Design
- AREN 4110 HVAC Design
- AREN 4570 Building Electrical System Design
- AREN 4550 Illumination 2
- CVEN 4506 Pre-Construction Estimating and Scheduling

In addition, students are required to take two specialization courses within any of the categories listed below discipline:

- Structural Systems:
  - CVEN 4545 Steel Design or CVEN 4555 Reinforced Concrete Design (whichever is not selected as proficiency) **(Strongly Recommended)**
  - CVEN 4565 Design of Wood Structures **(Recommended)**
  - CVEN 4728 Foundation Engineering **(Recommended)**
  - CVEN 4315 Masonry Design **(Optional)**
  - AREN 5660 Embodied Carbon in Buildings **(Optional)**
  - CVEN 4161 Mechanics of Materials II **(Optional)**
- Mechanical Systems:
  - AREN 4010 Energy System Modeling & Control **(Recommended)**
  - AREN 4080 Computer Simulation of Building Systems **(Recommended)**
  - AREN 4025 Building Energy Audits **(Recommended)**
  - AREN 4890 Sustainable Building Design **(Recommended)**
  - AREN 4990 Computational Fluid Dynamics (CFD) Analysis **(Recommended)**
- Lighting and Electrical Systems:
  - AREN 4130 Optical Design **(Strongly Recommended)**
  - AREN 4580 Daylighting **(Strongly Recommended)**
  - AREN 4620 Adaptive Lighting Systems **(Strongly Recommended)**
  - AREN 4530 Advanced Lighting Design **(Recommended)**
  - AREN 4560 Luminous Radiative Transfer **(Recommended)**
- Construction Engineering Management:
  - AREN 4606 Construction Project Execution & Control **(Strongly Recommended)**
  - CVEN 3256 Construction Equipment & Methods **(Strongly Recommended)**
  - CVEN 3708 Geotechnical Engineering 1 **(Optional)**
  - CVEN 3718 Geotechnical Engineering 2 **(Optional)**

In these discipline-specific design courses, students are introduced to methods of analysis and software tools widely used in the industry. They are also exposed to codes and standards that guide and constrain designs, including the International Building Code (IBC), the National Electric Code (NEC), ASCE/SEI 7 Minimum Design Loads for Buildings and Other Structures, ANSI/ASHRAE/IESNA Standard 90.1 Energy Efficiency for Buildings Except Low-Rise Residential Buildings, ANSI/ASHRAE Standard 62.1 Ventilation for Acceptable Indoor Air Quality, and the USGBC LEED Rating System.

The final-year design experience begins with AREN 4080 Architectural Design Studio 2 and AREN 4318 Architectural Engineering Design 1, both offered in the fall semester. AREN 4080 is a 2-credit studio-based course which engages students in the conceptual architectural design of a non-residential building. AREN 4318 accompanies AREN 4080 and consists of an engineering component which guides the architectural design. These two courses are complementary and result in students creating the conceptual design of a non-residential building. The project is then continued into AREN 4319 Architectural Engineering Design 2, where students complete a schematic-level and design-development level engineering design for their project. This year-long project is aligned to the Architectural Engineering Institute Student Design Competition, and uses the project brief from this competition. For example, in recent years, the projects were (a) a 140,000SF Community College Building and (b) an 85,000SF Children's Museum. These projects are developed under realistic constraints for a specific site with relevant life safety and local codes considered. The result of the project is a comprehensive program and a set of architectural plans for the building.

Students work in large teams (7-8 people) to create their integrated architectural and engineering solutions. The teams work to design all the engineering systems for the building: structural, mechanical, lighting and electrical, as well as develop construction costs and a schedule for project delivery. The student teams use an integrated design process, and each student is required to work on multiple disciplines of the project. The course is organized and managed by the faculty member in charge, but 15-20 professionals are also involved in providing mentorship to the student teams. Other program faculty in the five disciplines serve as the discipline-specific experts who provide review lectures, meet regularly with the individual student teams, and evaluate the work in their particular disciplines. Partnered with each faculty member are at least three industry mentors from the local engineering community, who present case studies of their work, meet with students to help guide the integrated design process, and participate in evaluating and providing feedback on project deliverables. There are also lectures by building professionals throughout the semester on topics such as sustainable design, professional ethics, teamwork, and building information modeling. Students must again face realistic constraints on their design ideas, as they seek to integrate the various systems in the project and address code-related issues.

Throughout the capstone design courses, students demonstrate their progress through a series of interim submittals and presentations, following the typical professional progression of programming, conceptual design, schematic design, and design development. The final deliverables for the course are complete sets of documents and drawings for the various engineering systems of the building. Successful completion of the AREN 4318, 4319, and 4080 courses represents the achievement of many of the program's outcomes.

The following represents a typical deliverable package (final report) required from each group:

a. Project abstract and introduction
b. Program (project parameters)
    i. Site
    ii. Building
    iii. Story

    iv. Architectural drawings
c. Written narratives describing process and design calculations per discipline:
    i. Construction
        1. Base cost estimate
        2. Risk and contingency analysis
        3. Schedule
        4. Cost monitoring and reporting
        5. Value engineering
        6. Codes
    ii. Structures
        1. Codes
        2. Applicable loads
        3. Structural system and material selection
        4. Framing and LLRS narrative
        5. Moment frame design
        6. Moment frame connection
    iii. Mechanical
        1. Benchmark and EUI targets
        2. Ventilation and thermal comfort requirements
        3. Zoning plan
        4. HVAC system research and selection
        5. Load calculations
        6. Equipment sizing
        7. Design methodology
    iv. Electrical
        1. Electrical load calculations
        2. Emergency systems
        3. Codes
    v. Lighting
        1. Design concept
        2. Lighting design criteria
        3. Luminaire selection
        4. Daylighting study
        5. Electric lighting compliance
        6. Code discussion and compliance
        7. Renderings
d. Drawings, calculations, and specifications set presented in appendix form
    i. Architecture
        1. Site plan
        2. Floor plans

3. Sections
4. Elevations
5. 3D models

ii. Construction
1. Site plan
2. Estimate table
3. Schedule
4. Risk analysis table
5. Industry quote table

iii. Structural
1. Calculations:
    a. Joist and deck
    b. Beams
    c. Columns
    d. Lateral loads
    e. Overturning moment
    f. Moment frame
    g. Moment frame connections (shear / flange)
    h. Shear wall
2. Drawings:
    a. Dead and live loads
    b. Snow loads
    c. Wind loads
    d. Floor loads
    e. Column layouts
    f. Governing beams/columns
    g. Lateral load distribution
    h. Stairway design
    i. Moment frame detail
    j. Shear wall detail

iv. Mechanical
1. Zoning plans
2. Duct layout
3. Single line
4. Mechanical equipment cut sheets

v. Electrical
1. One-line/riser diagram
2. Site and floor electrical plans
3. Site and floor lighting circuiting plan
4. Site and floor electrical HVAC plans

            5. Enlarged electrical rooms
                a. Main service entrance section
                b. Main distribution panel schedule
            6. Power panel schedules
            7. Lighting panel schedules
        vi. Lighting
            1. Lighting concept boards
            2. Site and floor lighting plans
            3. Lighting elevations and sections
            4. Interior and exterior luminaire schedules
            5. Luminaire cut sheets
    e. Various mini reports done by individual team members. Topics change from year to year. Examples of some topics are LEED compliance and clash detection.

The deliverables above are consistent with the specific objectives for the courses:

1. Integrate the technical sub-disciplines of structural, mechanical, lighting, and electrical, and construction engineering management to create a professional-level solution to a modest commercial building.
2. Gather relevant data; understand "client" needs (as defined by Architectural Engineering faculty and industry mentors); identify budgetary, environmental, and ethical constraints; and identify and use applicable regulations, codes, and standards.
3. Create feasible alternative designs, where appropriate, and carry out value engineering analysis.
4. Prepare increasingly detailed designs and construction planning that satisfies the project's constraints while also conforming to relevant codes, regulations and established sustainable practices.
5. Prepare design documentation including design rationale and intent, design details and integrated project planning, scheduling, and construction cost analysis to support each design stage.
6. Communicate effectively both through oral presentations and written reports and drawings the design intent, proposed solutions, and engineering details.
7. Work in multi-disciplinary teams and in interdisciplinary formats as appropriate during the various phases of the project.
8. Realize the importance of obtaining professional credentials and engaging in life-long learning throughout their careers as engineers.
9. Understand the professional and ethical responsibilities they must exercise as students and as future practicing engineers.
10. Integrate engineering and architectural design to create a professional-level solution to a modest commercial building.
11. Iterate design alternatives to evaluate their feasibility and ability to address an architectural design problem.

2022-23 Senior Design Prompt:

Architectural Engineering Institute (AEI) Student Design Competition (see **Appendix E**)

Cooperative Education

Cooperative education is not allowed to satisfy curricular requirements addressed by the general or program criteria.

Course Syllabi

In **Appendix A**, a syllabus is included for each course used to satisfy the mathematics, science, and discipline-specific requirements required by Criterion 5 and applicable program criteria.

CRITERION 6. FACULTY

A. Faculty Qualifications

There are 43 tenured/tenure-track (T/TT) faculty (23 Professors, 9 Associate Professors and 11 Assistant Professors) and 6 Assistant/Full Teaching Professors or Full-time Instructors in the CEAE department. These faculty members are distributed among six specialty groups (see table below). See Table 6-1 for the qualifications of these faculty members, presented alphabetically. Table 6-2 gives the approximate percentage each member of the faculty devotes to civil engineering. The building systems group contributes almost solely to the Architectural Engineering program. The construction and structures faculty contribute about equally to both the Civil and Architectural Engineering programs. The geotechnical faculty contribute almost solely to Civil Engineering. The water resources faculty contribute mostly to the Civil and Environmental Engineering programs. Many of the environmental engineering faculty contribute solely to the Environmental Engineering program, primarily teaching courses for the Environmental Engineering program. All CEAE faculty vote on objectives, outcomes, and curriculum matters, and as such have some contribution to the architectural engineering program.

CEAE faculty members are grouped according to their specialization, with groupings shown below:

Specialty	Approx. % to AREN Program	Full professors	Associate Professors	Assistant Professors	Asst. or Full / Teaching Professors or Full-Time Instructors
Building Systems	100	3	1	1	3
Construction	50	3	0	2	2
Structures	50	3	3	0	0
Geotechnical	10	4	1	3	0
Environmental	20	6	1*	5	1
Water Resources	5	4	3	0	0
Total		~8	~3	~3	~4

*Includes Prof. Evan Thomas, Director of the Mortensen Center in Global Development.

The faculty are highly diversity, with 14 T/TT (33%) and 3 teaching professors (50%) on the faculty that identify as women, at least three T/TT faculty who identify as LGBTQ+ (7%), and four T/TT and teaching professors from underrepresented minority populations (8%).

Eleven T/TT faculty members (~25%) have received the prestigious NSF CAREER award. Awardees include Professors Prof. John Crimaldi, Prof. Roseanna Neupauer, Prof. Mark Hernandez, Prof. Matthew Hallowell, Assoc. Prof. Wil Srubar, Assoc. Prof. Mija Hubler, Assoc Prof. Sherri Cook, Prof. Abbie Liel, Asst. Prof. Kyri Baker, Asst. Prof. Fatemeh Pourahmadian, and Assoc. Prof. Shideh Dashti.

Two faculty members, Prof. Diane McKnight and Prof. Bernard Amadei, are members of the National Academy of Engineering (NAE). Three faculty members, Prof. Fernando Rosario-Ortiz, Prof. Keith Molenaar, and Prof. Evan Thomas, in CEAE hold endowed chair positions. Four faculty members, Prof. Amy Javernick-Will, Prof. Karl Linden, Prof. Matthew Hallowell, and Prof. Mark Hernandez, hold endowed professor positions. Six faculty members, Prof. Sherri Cook, Prof. Abbie Liel, Prof. Wil Srubar, Prof. Joseph Kasprzyk, and Prof. Matthew Morris, and Prof. Sandra Vásconez, hold fellow positions.

Our faculty have been recognized for teaching excellence and educational research. Multiple faculty members, including Prof. Roseanna Neupauer, Prof. Wil Srubar, Prof. Azadeh Bolhari, and Prof. Amy Javernick-Will, have received the ExCEEd New Faculty Excellence in Teaching Award from the American Society of Civil Engineers (ASCE). Three faculty have been recognized as a University of Colorado Boulder President's Teaching Scholar, including Prof. Roseanna Neupauer, Prof. Angela Bielefeldt, and Prof. Matt Hallowell. Prof. Roseanna Neupauer, Prof. Matt Hallowell, and Prof. Kyri Baker received the University of Colorado Boulder College of Engineering and Applied Sciences John and Mercedes Peebles Innovation in Education Award in 2010, 2012, and 2022, respectively. Prof. Roseanna Neupauer, Prof. Matt Hallowell, Prof. Abbie Liel, and Prof. Matt Morris received the University of Colorado Boulder College of Engineering and Applied Sciences Charles A. Hutchinson Memorial Teaching Award in 2008, 2010, 2012, and 2022, respectively. Prof. Roseanna Neupauer received the 2011 Boulder Faculty Assembly Excellence in Teaching Award and the University of Colorado Boulder College of Engineering and Applied Sciences 2010 Sullivan-Carlson Innovation in Teaching Award. Prof. Keith Molenaar, Prof. Abbie Liel, and Prof. Amy Javernick-Will, Prof. Matt Hallowell, Prof. Sandra Vasconez, and Prof. Joe Ryan received the University of Colorado Boulder College of Engineering and Applied Sciences Outstanding Advisor Award, which recognizes one faculty and one staff advisor who demonstrate exceptional advising skills, in 2020, 2015, 2014, 2013, 2011, and 2010, respectively. Prof. Bielefeldt has won twelve (12) Best Paper awards for her pioneering engineering education research at the 2009 and 2015, 2016, 2017, 2018, and 2020 American Society of Engineering Education (ASEE) Annual Conferences.

B. Faculty Workload

Standard Teaching Load

The standard teaching expectation for research-active, tenured and tenure-track faculty is three courses or course equivalents per academic year, in addition to mentoring individual students in research. The department defines course equivalents to provide greater weighting for courses that have very large enrollments or more than three credits, or reduced weighting for courses with small enrollments, less than three credits, or team teaching. The standard teaching weight for evaluation purposes is 40% and includes individual mentoring in addition to courses.

Reductions in Teaching Load

Research-active faculty are allowed to "buy down" their teaching responsibilities to two courses per academic year. Buydown typically requires payment of 10% of the academic-year salary from research or service funds, though the amount may vary among the departments. Newly hired faculty are typically provided with two years of a reduced teaching load of two courses per year, without buydown, though some departments may extend this startup period and others may provide one semester off from classroom teaching. Faculty whose salaries are rostered in a research institute also typically have a reduced teaching load of two courses per year and an increased research expectation. Other reasons for reductions in teaching loads include the awarding of Dean's Faculty Fellowships and administrative appointments such as Department Chair and require approval by the Dean. The teaching weight for evaluation purposes may be reduced when there is a reduction in teaching, but it may not be less than 25% without approval of the Dean and it should account for both course instruction and individual mentoring.

Increases in Teaching Load

Faculty who are less research active are expected to contribute to their departments with additional teaching and/or service. The individual departments may select other criteria to determine when an increase in teaching load is warranted. A one-year "grace period" is recommended before increasing a faculty member's teaching load, to provide an opportunity to rebuild his or her research program. Also, with approval of the Department Chair or Program Director, a faculty member may have an increased teaching load in one academic year and then a reduced teaching load in a subsequent year, which is known as "course banking." The teaching weight for evaluation purposes may be increased when there is an increase in teaching, but it may not be more than 55% without approval of the Dean.

Guidelines on Teaching loads can also be found here: https://www.colorado.edu/engineering-facultystaff/guidelines-teaching-loads-tenured-tenure-track-faculty

C. Faculty Size

Faculty Size and Undergraduate Teaching

There is an adequate faculty size to teach and mentor architectural engineering students, as shown above. The table below shows the number of Full Time Equivalent (FTE) Faculty, student credit hours (SCH) taught by CEAE faculty, and total number of undergraduate students. CEAE has been below the CU CEAS average for number of student credit hours (SCH) per faculty since 2013; CEAE is currently near our lowest level in 10 years. SCH are a good metric since our faculty teach courses that serve civil engineering, architectural engineering, and the bulk of the environmental engineering degree.

Fall Semester:	2018	2019	2020	2021	2022
Tenure-Line Faculty	41	38	41	42	39
Tenure-Line Budgeted Elsewhere	3	4	4	4	4
Instructional Faculty*	4	5	12	13	13
SCH, all CEAE	13,708	13,789	13,548	14,268	12,607
CEAE SCH/Faculty	286	293	238	242	225
CU CEAS College SCH/Faculty	429.8	430.6	421.7	409.7	N/A
# architectural engineering undergraduate students	149	156	154	161	145

***This number <u>includes</u> adjunct, post-doctoral researchers, or Ph.D. student instructors that fill vacancies due to sabbatical or in-process hires**. The number of permanent instructional faculty is six (6).

In addition to full- and part-time faculty, some individuals are hired to teach specific courses. Occasionally, post-doctoral researchers or Ph.D. students who are building their teaching skills will teach courses under the mentoring supervision of their advisor. More often, highly qualified senior individuals have been hired to teach courses. The table below summarizes the individuals who have been hired to teach specific courses in recent years, their qualifications, courses that they have taught, which semester(s), and average student ratings on the FCQs. The FCQ ratings were on a scale of 1-6 [1 = lowest, 6 = highest] until 2020 when the scale was changed to 1-5 [1 = lowest, 5 = highest]. Results for two questions are reported below: course overall and instructor overall.

Name	Qualifications	Courses Taught (type), dates [FCQs on scale of 1-6 (pre-2020) or 1-5 (post 2020)]
Lance Cayko	- Master's Architecture 2008 from North Dakota State University - Licensed architect in CO 2015 - Project Manager with Studio H:T (1 yr) - Owner and co-founder of F9 Productions (2009-present) residential BIM projects	**AREN 1027** Engineering Drawing (required), Fall 2017-Fall 2021 [Course 4.1-5, Instructor 4.5-5.4]
Rebecca Atkins	- BS Civil Engineering, Colorado School of Mines - Armstrong Consultants, Inc. Engineering Project Coordinator - Project Manager, Colorado Department of Transportation - SERVICE TO PROFESSION. - Extensive experience in transportation systems, asphalt pavements, project management.	**CVEN 4899** Senior Project Design**,** Spring 2023 [Course: 4.5-5.4, Instructor: NA (first term teaching)]
Charles Beamer	- BS, MS, PhD Architectural Engineering, University of Colorado Boulder - Principal Illuminating Engineer, Acuity Brands, Boulder, Colorado - Senior Instructor, University of Colorado Boulder - Extensive experience in lighting and acoustics.	**AREN 3440** Architectural Daylighting Design**,** Fall 2021, rating on a scale 1-5 [Course: 3.75-4.38 Instructor: 2.75-4.29]
Alex Gore	- Masters of Architecture - Masters Degree in Construction Management, North Dakota State University - Founder and co-owner of F9 Productions (2009-present) serving as designer and project manager for multiple residential and commercial BIM projects.	**AREN 1027** Engineering Drawing (required), Fall 2017-Fall 2022 [Course 4.1-5.1, Instructor 4.4-5.6]

Name	Qualifications	Courses Taught (type), dates [FCQs on scale of 1-6 (pre-2020) or 1-5 (post 2020)]
Mark Jongewaard	- Master of Science, Civil Engineering, Illumination Emphasis, University of Colorado, May 1991. - President & Principal, LTI Optics, LLC - Adjunct Professor, University of Colorado - Board Member, Rocky Mountain Lighting Academy and Council for Optical Radiation Measurements. - Extensive experience in lighting software development, lighting and optical analysis, illumination optical design and training.	**AREN 4130** Optical Design**,** Fall 2018, Spring 2020, Fall 2021, [Course: 4.4-5.5, Instructor: 5.2-5,8]
Joann Silverstein, PE, PhD (Professor Emerita)	- PhD Civil Engineering, University of California Davis - Professor, University of Colorado Boulder - Extensive expertise in wastewater treatment, water treatment, nutrient management, statistical modeling of wastewater systems, nutrient emissions trading.	**CVEN 4147** Civil Engineering Systems**,** Fall 2017-Fall 2022 [Course: 3.6-4, Instructor: 3.8-5.9]
James Zarske, PE	- MS Architectural Engineering, University of Colorado Boulder - Noresco, Director of Sustainability Services - NExant, Sneior Engineering Manager - SERVICE TO PROFESSION. - Licensed PE, CEM, LEED AP and is currently a Director of Sustainability Services at NORESCO. He has over 20 years of engineering experience with a focus on building energy efficiency and sustainable design.	**AREN 5020** Building Energy Units**,** Spring 2023 [Course: 4.7-5.1, Instructor: NA]

Faculty-Student Interactions

CEAE faculty members are actively involved in advising and mentoring students in the civil, architectural, and environmental engineering programs. Normally each CEAE faculty member advises 6 to 20 undergraduate students, meeting individually with each advisee in each semester of their junior and senior year. Details of the student academic advising have been provided in **Criterion 1: Students (Section D: Advising and Career Guidance)**. Faculty help students prepare for engineering careers by finding internships, reviewing student's resumes and bringing professional colleagues to meetings of student societies, special seminars and to classes as guest speakers. Through supervision of undergraduate research opportunities and independent study projects, faculty encourage many undergraduate Architectural Engineering students to continue their studies at the Masters level in accordance to the expectations imposed by industry (e.g. the structures field expects students to have earned master's degree upon graduation), either at the University of Colorado or other universities.

Faculty members advise student chapters of professional societies such as Association of General Contractors (AGC), Illuminating Engineering Society of North America (IESNA), Architectural Engineering Institute (AEI), and Society of Women Engineers (SWE). One Civil Engineering faculty member founded Engineers Without Borders - USA (EWB-USA), with the first student chapter at the University of Colorado Boulder. EWB has engaged students to work with practitioners to help communities in developing countries with projects for sustainable infrastructure for water, sanitation, housing, and transportation. This concept of outreach education and service has captured the enthusiasm of many engineering students, and there are now EWB-USA student chapters at about half of all engineering programs throughout the US.

University Service Activities

Each faculty member serves on at least one standing Department Committee (e.g., Graduate, Curriculum, Operations, Computers, Facilities, Executive, Student Pathways Committee, Justice, Equity, Diversity, and Inclusion (JEDI)). In addition, faculty members serve on dozens of committees at the College and University level for developing curriculum, program evaluation, searches for new faculty and administrators, promotion, awards and fellowships, etc. Faculty resumes in **Appendix B** show the diversity of faculty service to the University community.

Professional Service and Interaction with Practitioners

Most CEAE faculty members are involved in 2 to 10 committees for national professional engineering societies, involving such diverse activities as evaluating revisions in building and material codes, peer review of proposed environmental and health regulations, and development of national research programs. Some examples are: American Society for Testing Materials (ASTM), American Society of Civil Engineers (ASCE), American Ceramic Society (ACerS), American Concrete Institute (ACI), and American National Standards Institute (ANSI) code-evaluation committees, and specialty committees within ASCE, the IESNA, ASHRAE, WEF, and AWWA. Faculty members chair sessions at national and international technical conferences and have themselves been conference directors. Many faculty members volunteer their professional expertise to community boards and public groups such as the Colorado municipalities and state agencies. All these activities regularly bring faculty in contact with their practicing colleagues in Civil and Architectural Engineering. Details of these activities are in the faculty resumes in **Appendix B**.

D. Professional Development

The department, college, and campus provide considerable resources to support faculty throughout their careers. New tenure-track faculty are provided with start-up packages that allow them to develop robust research programs and integrate themselves into the life of a department. In addition to the funding provided in their start-up packages, new tenure-track faculty are given reduced service and teaching responsibilities and are encouraged to take part in campus workshops to help them thrive in all aspects of their faculty roles. New instructional faculty are provided more modest start-up funds, typically used to cover computer equipment, a course development stipend (in the summer before starting their role), and conference registration. The University of Colorado places a priority on supporting faculty. Through the Leadership Education for Advancement and Promotion (LEAP) Program, pre-tenure faculty have an opportunity to participate in an Introductory Leadership Workshop with other junior tenure-track faculty. This is a two-and-a-half-day, skill-based workshop held on campus two to three times each year. The Center for Teaching and Learning provides professional development support to all educators—both regular and temporary (i.e., lecturers and adjuncts) —on the CU Boulder campus. And, starting with AY 2022, the College is supporting new faculty hired through the college-wide search process to participate in the National Center for Faculty Development & Diversity (NCFDD) Faculty Success Program (FSP). FSP is a twelve-week program intensive focused on supporting new tenure-track faculty learn as they learn strategies for greater success in and securing external funding for and publishing their research.

The college and the campus provide assistance in grant writing in the form of workshops and direct resources through the Research Support Office. Of particular importance are a series of intensive workshop activities centered around the submission of NSF CAREER Awards and providing insight into key differences between how NSF criteria of Intellectual Merit, Broader Impacts, and Broadening Participation are scored during reviews.

Senior, tenured faculty members also receive ongoing support. The University has moved toward formal professional planning and development of faculty via in-depth Post-Tenure Review of every faculty member every five years. In addition, every tenure-track faculty member maintains a Professional Plan (updated every 5 years), detailing the professional growth of the faculty member and concrete plans for achieving that growth. This periodic review provides a valuable venue for enhancing the professional development of all our faculty members. For instructional faculty, the reappointment and promotion process now includes a self-reflection statement on teaching philosophy and experiences that provides an opportunity for reviewers to gain greater insight into the work that the faculty members are doing and provides an opportunity for feedback. Below are examples of activities faculty have pursued for professional development:

Faculty member name	**Professional Development Example**
Jay Arehart	Learning Faculty Fellow (Fall 2021) Engineering Unleashed Faculty Fellow: Problem Solving Studio (Fall 2020)
Kyri Baker	I have been participating in a Faculty Fellows program through the Research and Innovation Office at the University of Colorado Boulder to improve my leadership skills. I have additionally taken media training and active learning training through the university to improve my communication and teaching skills. I have also given over 30 invited talks at various venues in the past 4 years to increase awareness about my research and improve my public speaking skills.
Amelia Celoza	one Training, Center for Inclusion and Social Change, University of Colorado er, October 2022

	pal Investigator Academy, Research & Innovation Office, University of Colorado er ng at CU, Office of Faculty Affairs, University of Colorado Boulder enter for Teaching and Learning Intensive, University of Colorado Boulder, t 2022 esk Construction School, August 2022 e Design and Academic Technology Overview for New Faculty, Center for ing and Learning, University of Colorado Boulder, July 2022 uction Faculty Teaching Excellence Program, July 2022 ced Teaching Preparation Certification, Faculty Innovation Center, University as at Austin, 2020
Alex Gore	Co-Host of Inside the Firm Podcast – Topics: Architecture/Construction
George Hearn	Faculty Diversity Search – Web training
Gregor Henze	Time Series Analysis with a Focus on Modeling and Forecasting in Energy Systems, Danish Technological University, Copenhagen, Denmark, August 15-19, 2022.
Amy Javernick-Will	Excellence in Leadership Program, *University of Colorado*, 2022-2023. Academic Leaders Institute Training, *University of Colorado Boulder*, 2020. In-depth Media Coaching, *University of Colorado Strategic Communication*, October 2019. National Science Foundation Coastlines & People Workshop, *San Diego, CA*, September 2018. National Science Foundation Research in Engineering Practice Workshop, October 2018. Crucial Accountability Course, *Boulder, CO,* June 2018. Crucial Conversations Course, *Boulder, CO*, June 2017. Philippines Shelter Cluster Meeting, *Tacloban, Philippines,* November 2016. United Nation's Habitat 3 Conference, *Quito, Ecuador,* October 2016. Penn State PACE, Innovation Research Roadmapping Workshop, *Pennsylvania,* June 2015. National Science Foundation IDEAS Lab, *Virginia,* March 2014. Presenting Data and Information, Edward Tufte in *Denver, CO* for Friday, July 2012 ASCE ExCEEd Teaching Workshop, University of Colorado at *Boulder, CO,* July 2010. National Science Foundation CAREER Workshop, University of Connecticut, April 2011. National Science Foundation Construction Engineering Conference, Virginia Tech, 2010.
Moncef Krarti	DOE Conference on Collaboration between Universities and DOE Research Laboratories, Washington DC, April 1-2, 2015. ASES Workshop, on Energy Efficient Residential Buildings, Phoenix, Aug. 5-6, 2014.
Yu-Hsuan Lee	Engineering Mechanics Institute Conference 2022

	Research of DEM simulations and constitutive analysis of hyper-velocity penetration
Matthew Morris	Organization of Construction Diversity Summit Discussion of Marshall Fire experience and rebuilding on the "Concrete Credentials" podcast
Jennifer Scheib	Community-Based Participatory Research semester course, 2022 Climate Across the Curriculum two-day pedagogy workshop, 2022 Learning by Design semester course on active student-centered learning, 2021 Supporting Student Resiliency workshop series, 2020 Course consultation and student interviews for AREN 3540 (ABET-tracked course), 2019
Jeong-Hoon Song	
Sandra Vasconez	Lightfair International, 2018 International Association of Lighting Designers, Enlighten Americas Conference, 2019
Yunping Xi	ICIC virtual webinar, Nov. 16-17, 2021 International Conf. on Plasticity, Damage & Fracture (ICPDF), Punta Cana, Dominican Rep., Jan. 3-9, 2023
John Zhai	Has been actively engaged in developing new curriculum in sustainable building development for both developed and developing countries, which led to the successful establishment of several international post-graduate programs (e.g., for Brazil, Mexico, Indonesia, and China). Has an established track record of collaboration with specialists in different engineering and non-engineering areas, such as, architecture, ecology, evolutionary biology, and public health etc. These collaborations have led to a specialization in interdisciplinary research topics. Has been actively involved in several professional societies (as the Fellow of ASHRAE, ISIAQ, IBPSA), promoting effective communications between academia and industry.

The College provides overarching guidelines for faculty mentoring. The college holds a new faculty orientation program at the start of the academic year for tenure-track and instructional-track faculty. The Dean delivers a mentoring workshop at orientation, and new faculty and their mentors are invited to attend. Assignments of faculty mentors for new faculty are tracked by the Dean. In addition, the Dean has written a document on mentoring for faculty, Tips for Faculty Mentoring (see http://www.colorado.edu/engineering-facultystaff/tips-faculty-mentoring).

College Supported Programs:

The College supports the professional development of faculty through the Faculty Excellence Program, which provides a number of financial support opportunities. (See http://www.colorado.edu/engineering-facultystaff/awards-incentives/college-awards/faculty-excellence-program). This program includes:

- **Dean's Faculty Fellowships -** Selected faculty members are given one semester off from teaching a course, to focus on a major initiative in research and scholarly work or development of substantial educational materials or initiatives

- **Dean's Seed Funds for Novel Ideas -** Discretionary funds up to $10,000 ($15,000 if multiple units involved) provide seed support for new ideas, and are matched 1:1 by the department or program
- **Dean's Performance Awards -** $5,000 awards are given for top performance in categories such as research, teaching, professional progress, and overall performance of junior faculty, based on the annual performance evaluations for the prior calendar year
- **Matching funds** for research grants, laboratory renovation funds, and travel to funding agencies
- **Sabbatical Supplement Program -** This program offers an additional 20% of the academic-year salary to faculty members taking full-year sabbaticals, on top of the normal 50% of the academic-year salary that they receive on sabbatical. The department then retains the remaining 30% of the academic-year salary, and the faculty member is responsible for raising (or forgoing) 30% of her or his salary. In addition, the Dean will provide $4,000 in discretionary funds for research, travel, etc. to each faculty member who successfully applies for this program.

All tenured faculty members are eligible for sabbatical after each six years of full-time service. The sabbaticals may either be one semester at full pay or two semesters at half pay. The College of Engineering and Applied Science created a sabbatical supplement program, in which faculty are provided an additional 20% of their salary (70% total) for full-year sabbaticals, with the department keeping the other 30% for teaching replacement. These faculty members also receive $4,000 in discretionary funds from the dean. It is expected that the faculty member will use the sabbatical assignment in a manner that will enhance his/her scholarly and/or teaching competence and potential for service to the University in addition to advancing departmental program goals. A sabbatical assignment is an important tool in developing academic scholarship and is a time for concentrated professional development. More information can be found at:
www.colorado.edu/facultyaffairs/career-milestones/leaves-and-sabbaticals/sabbaticals
Senior and Principal Instructors are now eligible to apply for differentiated workload semesters that provide full release from classroom teaching for one semester so that the faculty member can focus on a major teaching-related professional development project. As with tenure-track faculty, these opportunities require six years (twelve semesters) of continuous teaching service prior to application. Faculty receive full pay during the semester in which they have teaching relief.

The Center for Teaching & Learning supports CU's community of educators (including lecturers and adjuncts) through free consultations, teaching resources, programs, seminars, workshops, and other events. The CTL aims to cultivate attitudes toward teaching that are open, curious, and innovative. As a Center, they invite educators to an open, common space where all are welcome to explore teaching practices, pose questions, have brave conversations, take creative risks, and embrace intellectual humility.
https://www.colorado.edu/center/teaching-learning

Financial Support Opportunities:

- Sabbatical assignments (tenured faculty only)
- Provost's faculty achievement awards: research grants for assistant and associate professors.
- Faculty conference awards from the Office of the Vice Chancellor (VC) for Research
- Innovative seed grant program from the Office of the VC for Research
- Hazel Barnes prize for "enriching interrelationship between teaching and research" - $20,000
- Boulder Faculty Assembly (BFA) Award for Excellence in Teaching - $3,000
- BFA Awards for Excellence in Service - $3,000
- BFA Awards for Excellence in Research, Scholarly, and Creative Work - $3,000
- Boettcher Foundation, Webb-Waring Biomedical Research Awards

- Butcher Symposium in genomics and biotechnology

Recognition Awards:
- President's Teaching Scholars
- Distinguished Professor title (promotional opportunity for exceptional full professors)
- Alumni Association award

E. Authority and Responsibility of Faculty

*The following is copied from the College Rules (*Approved: November 1, 2022)
https://www.colorado.edu/engineering-facultystaff/rules-policies/college-rules

1. **The Faculty.** The members of the faculty shall consist of all Professors, Associate Professors, Assistant Professors, Principal Instructors, Senior Instructors, Instructors, Scholars in Residence, Research Professors, Research Associate Professors, and Research Assistant Professors in the College of Engineering and Applied Science on the Boulder campus. The Dean may also appoint members to one-year renewable terms from departments outside the College involved in degree-granting programs such as Engineering Physics and Applied Mathematics. These additional members may be recommended for membership at the start of each academic year by their respective department chairs. Other additional members from outside the College may be appointed by the Dean for one-year renewable terms.
    a. **Voting Members.** The voting membership of the faculty shall consist of all Professors, Associate Professors, Assistant Professors, Research Professors, Research Associate Professors, Research Assistant Professors, Scholars in Residence, Principal Instructors, Senior Instructors, and full-time Instructors in the College of Engineering and Applied Science, plus any additional members appointed by the Dean. Faculty with such titles as adjoint, adjunct, visiting, lecturer, research associate, etc., are not voting members of the College but may be voting members of a department (or program) based on the rules of that unit.
    b. **Powers.** The college faculty shall collaborate with the Dean in the governance of the College of Engineering and Applied Science in all matters that concern only the College (in accordance with the Laws of the Regents, Article 4.A). In particular, through shared governance with the administration, the faculty shall have principal responsibility for academic and scholastic policy and ethics, and the faculty shall act jointly with the administration in areas of faculty appointment and review, regulation of student conduct and activities, budgeting review and resource recommendations, selection of academic administrators, determination of candidates for degree, and other policies concerning the general academic welfare of the College (in accordance with the Laws of the Regents, Policy 5.A.1).
    c. **Faculty Meetings.** Faculty meetings shall be held at least once during each of the fall and spring semesters. Special meetings may be called by the Dean or shall be called by the Dean upon the written request of five members of the faculty. Twenty-four hours' notice of a special meeting will be given. The members present at any regular or special meeting shall constitute a quorum.
2. **Dean of the College of Engineering and Applied Science.** The Dean of the College shall be its administrative head. The Dean shall be responsible for the enforcement of admission requirements and for the general efficiency of the College and its departments and programs, and has overall responsibility for budgetary planning and allocation of funds, space and other resources, faculty assignments and workloads, recommendations on personnel actions, planning, accountability and reporting (in accordance with the Laws of the Regents). The Dean shall enforce rules and regulations of the College. The Dean shall confer with the Department Chairs about departmental needs. The Dean shall make regular reports to the Provost of the Boulder Campus, and to the faculty of the College.

The Dean of the College of Engineering and Applied Science reports to the Provost. The Provost leads the Division of Academic Affairs at the University of Colorado Boulder. The Division of Academic Affairs is responsible for administering the academic programs and policies of the Boulder campus, and for providing intellectual leadership for excellence in teaching, scholarship, and creative work. The division recruits faculty, deans, and other academic leaders, and allocates resources to ensure high-quality teaching, research and creative work, and service. The Provost reports to the Chancellor, who in turn reports to the President of the University of Colorado.

Table 6-1. Faculty Qualifications

Architectural Engineering

Faculty Name	Highest Degree Earned- Field and Year	Rank [1]	Type of Academic Appointment[2] T, TT, NTT	FT or PT [3]	Years of Experience			Professional Registration/ Certification	Level of Activity[4] H, M, or L		
					Govt./Ind. Practice	Teaching	This Institution		Professional Organizations	Professional Development	Consulting/summer work in industry
Bernard Amadei	Ph.D. 1982	P	T	FT	22	44	41	N/A	H	M	M
Jay Arehart	Ph.D. 2021	AST	NTT	FT	5	3	3	Engineer in Training	M	H	H
Kyri Baker	Ph.D. 2014	AST	TT	FT	3	6	6	N/A	L	L	H
Rajagopalan Balaji	Ph.D. 1995	P	T	FT	0	23	23	N/A	H	M	L
William Becker	Ph.D. 1995	O	NTT	PT	40	30	4	New York PE	M	H	H
Angela Bielefedt	Ph.D. 1996	P	T	FT	4	27	27	Professional Engineer	L	H	L
Azadeh Bolhari	Ph.D 2013	ASC	NTT	FT	1	10	3	PE	H	H	L
Amelia Celoza	Ph.D. 2022	AST	TT	FT	3	2	2	OSHA Engineer in Training	H	H	L
Sherri Cook	Ph.D 2014	ASC	T	FT	N/A	9	10	N/A	M	L	L
John Crimaldi	Ph.D, 1998	P	T	FT	4	25	24	N/A	M	L	L
Shideh Dashti	Ph.D. 2009	ASC	TT	FT	2	12	12	N/A	H	M	L
Michael Gooseff	Ph.D. 2001	P	T	FT	4	21	8	Engineer in Training	H	M	L
Matthew Hallowell	Ph.D 2008	P	T	FT	4	15	15	N/A	M	M	H
George Hearn	D.E.S. 1989	ASC	TT	FT	35	35	35	Professional Engineer	H	M	H
Gregor Henze	Ph.D. 1989	P	T	FT	15	34	15	Professional Engineer ASHRE-certified HBDP	H	M	H
Mark Hernandez	Ph.D 1994	P	T	FT	5	27	26	California Registered Professional Engineer	H	M	H

Mija Hubler	Ph.D. 2013	ASC	TT	FT	0	9	9	N/A	M	L	L
Amy Javernick-Will	Ph.D. 2009	P	T	FT	8	14	14	LEED AP	H	H	L
Joseph Kasprzyk	Ph.D. 2013	ASC	TT	FT	0	11	11	N/A	M	M	L
Rita Klees	Ph.D. 1989	O	NTT	PT	20	16	16	N/A	M	L	L
Julie Korak	Ph.D. 2014	AST	TT	FT	3	5	5	PE, Colorado	M	M	L
Moncef Krarti	Ph.D. 1989	P	T	FT	3	32	32	Professional Engineer LEED AP	H	M	L
Richard Kuchenrither	Ph.D. 1992	O	NTT	FT	40	17	17	PE Colorado, Nebraska, Nevada	H	L	H
Abbie Liel	Ph.D. 2008	P	T	FT	17	16	15	PE, California	H	L	H
Karl Linden	Ph.D. 1997	P	T	FT	2	25	17	EIT, BCEEM (Board Certified Environmental Engineering Member)	H	M	L
Benjamin Livneh	Ph.D. 2012	ASC	TT	FT	3	13	11	N/A	H	M	M
Shrikanth Madabhushi	Ph.D. 2018	AST	TT	FT	0	3	3	Aff. M. ASCE, Earth Retaining Structures and Earthquake Engineering and Soil Dynamics Technical Committee	H	M	L
Cresten Mansfeldt	Ph.D. 2013	AST	TT	FT	5	4	4	Engineer in Training	H	H	L
Sheldon Masters	Ph.D. 2015	AST	TT	FT	6	2	2	Future Professoriate Certificate	H	M	M
Diane McKnight	Ph.D. 1979	P	T	FT	17	27	26	N/A	H	M	L
Keith Molenaar	Ph.D. 1997	P	T	FT	7	26	26	Design-Build Certified Professional, Fellow	M	M	L
Matthew Morris	M.S. 2022	I	NTT	FT	13	11	11	Professional Engineer	L	M	H
Roseanna Neupauer	Ph.D. 2000	P	T	FT	22	21	18	Professional Engineer	H	M	H
Ronald Pak	Ph.D. 1984	P	T	FT	1	38	38	N/A	L	L	L
Tad Pfeffer	Ph.D. 1987	P	T	FT	0	35	35	N/A	H	M	L
Keith Porter	Ph.D. 2000	A	NTT	PT	16	16	16	Professional Engineer	H	H	H
Fatemeh Pourahmadian	Ph.D. 2016	AST	TT	FT	0	6	6	N/A	H	H	L
Richard Regueiro	Ph.D. 1998	P	T	FT	7	20	18	N/A	M	L	L
Fernando Rosario-Ortiz	Ph.D. 2006	P	T	FT	4	15	15	N/A	H	H	M

Joseph Ryan	Ph.D. 1992	P	T	FT	2	29	29	N/A	M	L	M
Carlo Salvinelli	Ph.D. 2016	I	NTT	FT	6	9	3	N/A	M	M	L
Victor Saouma	Ph.D. 1980	P	T	FT	2	40	40	N/A	M	L	M
Jennifer Scheib	M.S. 2004	AST	NTT	FT	13	6	6	LEED AP	H	H	L
Christopher Senseney	Ph.D. 2011	ASC	NTT	FT	12	9	3	Professional Engineer NCEES	H	H	M
Jeong-Hoon Song	Ph.D. 2008	ASC	T	FT	0	12	9	N/A	H	M	L
Wil Srubar	Ph.D. 2013	ASC	TT	FT	2	10	10	Engineer in Training, LEED AP	H	H	H
Anthony Straub	Ph.D. 2017	AST	TT	FT	0	4	4	N/A	L	L	L
Evan Thomas	Ph.D. 2009	P	T	FT	19	13	5	PE, State of Texas	M	H	H
Cristina Torres-Machi	Ph.D. 2015	AST	TT	FT	4	12	6	N/A	L	M	H
Sandra Vasconez	M.A. 2000	AST	NTT	FT	13	20	16	NCQLP Lighting Cert.	M	M	M
Bradley Wham	Ph.D. 2015	AST	NTT	FT	1	6	6	EIT	H	M	H
Yunping Xi	Ph.D. 1991	P	T	FT	4	30	26	N/A	H	M	L
Edith Zagona	Ph.D. 1992	P	NTT	FT	10	5	35	Registered PE (for 30 years but now lapsed)	M	H	H
John Zhai	Ph.D. 2003	P	T	FT	1	20	20	N/A	H	M	L
Yida Zhang	Ph.D. 2016	AST	TT	FT	0	7	7	N/A	H	H	L
Wangda Zuo	Ph.D. 2010	ASC	TT	FT	3	10	6	N/A	H	L	L

1. Code: P = Professor ASC = Associate Professor AST = Assistant Professor I = Instructor A = Adjunct O = Other
2. Code: T = Tenured TT = Tenure Track NTT = Non-Tenure Track
3. FT = Full-Time Faculty or PT = Part-Time Faculty
4. The level of activity (high, medium or low) should reflect an average over the three years prior to the visit.

Table 6-2. Faculty Workload Summary

Architectural Engineering

Faculty Member (name)	PT or FT[1]	Classes Taught (Course No./Credit Hrs.) Term and Year[2]	Program Activity Distribution[3]			% of Time Devoted to the Program[5]
			Teaching	Research or Scholarship	Other[4]	
Amadei, Bernard	FT	CVEN 4157, A Systems Approach to Global Engineering, 3 Credit, S 23 CVEN 5157, A Systems Approach to Global Engineering, 3 Credit, S 23	25	35	40	10
Arehart, Jay	FT	AREN 1316, Intro to Architectural Engineering, 1 Credit, F 22 AREN 4080, Architectural Design Studio 2, 2 Credits, F 22 AREN 4830, Special Topic: Sustainable Building Design, 3 Credits, F 22 AREN 3080, Architectural Design Studio 1, 3 Credit, S 23 AREN 4318, Senior Design 1, 5 credits, F 22 AREN 4319, Senior Design 2, 2 Credits, S 23 AREN 4890, Sustainable Building Design, 3 Credit, S 23 AREN 5890, Sustainable Building Design, 3 Credits, S 23	80	0	20	100
Baker, Kyri	FT	AREN 5001, Building Energy Systems 1, 3 Credits, F22 CVEN 5830, Special Topics: Grid Connected Systems, 3 Credits, F22 AREN 3040, Circuits for Architectural Engineers, 3 Credit, S 23 AREN 4319, Senior Design 2, 2 Credit, S 23	30	40	30	100
Balaji, Rajagopalan, Former Department Chair	FT	CVEN 6393, Hydrologic Sciences and Water Resources Engineering, 3 Credits, F 22 CVEN 5454, Statistical Methods for NAtural and Engineered Systems, 3 Credit, S 23 CVEN 6393, Hydrologic Sciences and Water Resources Engineering, 3 Credit, S 23	25	25	50	5
Becker, William	PT	CVEN 5594, Water Reuse and Reclamation, 3 Credit, F 22 CVEN 4434, Environmental Engineering Design, 3 Credit, S 23	60	10	30	20
Bhaskar, Aditi	FT	CVEN 4833, Special Topic: Analysis of Urban Water Systems, 3 Credit, S 23 CVEN 5833, Analysis of Urban Water Systems, 3 Credit, S 23	40	40	20	5
Bielefeldt, Angela	FT	CVEN 1317, Intro to Civil and Environmental Engineering, 1 Credit, F 22	30	40	30	20

Faculty Member (name)	PT or FT[1]	Classes Taught (Course No./Credit Hrs.) Term and Year[2]	Program Activity Distribution[3]			% of Time Devoted to the Program[5]
			Teaching	Research or Scholarship	Other[4]	
Bolhari, Azadeh	FT	CVEN 4404, Water Chemistry, 3 Credit, F 22 CVEN 4414, Water Chemistry Lab, 3 Credit, F 22 EVEN 4494, Contaminant Fate and Transport, 3 Credit, F 22 CVEN 4434, Environmental Engineering Design, 3 Credit, S 23	70	10	20	20
Celoza, Amelia	FT	AREN 2050, Building Materials and Systems, 3 Credits, F 22 CVEN 5836, Special Topic: Program and Project Management, 3 Credit, S 23	40	40	20	50
Cook, Sherri	FT	Maternity Leave, F 22 Course Buy-Out, S23	40	40	20	20
Crimaldi, John	FT	CVEN 5313, Environmental Fluid Mechanics 3 Credits, F 22 CVEN 5343, Transport and Dispersion in Surface Water, 3 Credit, S 23	10	80	10	5
Dashti, Shideh, Interim Associate Dean of Research, College of Engineering and Applied Sciences	FT	CVEN 3708, Geotechnical Engineering 1, 3 Credit, F 22 *Teaching Buy-Out Due to Deanship*	10	15	75	10
Gooseff, Michael	FT	CVEN 3313, Theoretical Fluid Mechanics, 3 Credit, S 23 CVEN 5833, Surface-Groundwater Exchanges, 3 Credit, S 23	25	80	15	5
Hallowell, Matthew	FT	Sabbatical, F 22 Sabbatical, S 23	15	65	20	50
Hearn, George	FT	CVEN 4555, Reinforced Concrete Design, 3 Credit, F 22 CVEN 5575, Advanced Topics in Steel Design, 3 Credits, F 22 CVEN 5333, Physical Hydrology, 3 Credits, F 22 CVEN 4545, Steel Design, 3 Credit, S 23 CVEN 5585, Advanced Topics in Reinforced Concrete Design, 3 Credit, S 23	53	27	20	50
Henze, Gregor	FT	AREN 2110, Thermodynamics, 3 Credits, F 22 AREN 4110, HVAC System Design, 3 Credit, S 23 AREN 5110, HVAC System Design, 3 Credits, S 23	25	60	15	100
Hernandez, Mark	FT	Sabbatical, F 22 Sabbatical, S 23	10	80	10	20
Hubler, Mija	FT	Sabbatical, F 22 Sabbatical, S 23	10	80	10	50

Faculty Member (name)	PT or FT[1]	Classes Taught (Course No./Credit Hrs.) Term and Year[2]	Program Activity Distribution[3]			% of Time Devoted to the Program[5]
			Teaching	Research or Scholarship	Other[4]	
Javernick-Will, Amy	FT	AREN 4506, Pre-Construction Estimating and Scheduling, 3 Credit, S 23 CVEN 5346, Managing Construction and Engineering Projects and Orgs, 3 Credit, S 23	30	50	20	50
Kuchenrither, Richard	PT	CVEN 5564, Water Profession: Communication and Utility Finance, 3 Credit, S 23	60	0	40	5
Kasprzyk, Joseph	FT	CVEN 5423, Water Resources Engineering Design, 3 Credits, F 22 CVEN 5393, Water Resources System Management, 3 Credit, S 23	25	60	15	5
Klees, Rita	FT	CVEN 5939, Global Development Practicum, 3 Credit, S 23	80	0	20	5
Korak, Julie	FT	CVEN 4464, Environmental Engineering Process, 3 Credit, F 22 EVEN 5444, Analytical Methods, Experimental Design, and Applied Data Analysis, 3 Credit, S 23 EVEN 5830, Special Topic, 3 Credit, S 23	40	40	20	20
Krarti, Moncef	FT	AREN 4570, Electrical Systems for Buildings, 3 Credits, F 22	25	60	15	100
Liel, Abbie	FT	Sabbatical, F 22 Sabbatical, S 23	25	60	15	50
Linden, Karl Department Chair	FT	Sabbatical, F 22	10	80	10	20
Livneh, Ben	FT	Sabbatical, F 22 Sabbatical, S 23	40	40	20	5
Madabhushi, Srikanth	FT	CVEN 3718, Geotechnical Engineering 2, 3 Credit, F 22 CVEN 4728, Foundation Engineering, 3 Credit, S 23 CVEN 5728, Foundation Engineering, 3 Credit, S 23	40	40	20	10
Mansfeldt, Cresten	FT	CVEN 4484, Intro to Environmental Microbiology, 3 Credit, S 23	40	40	20	20
Masters, Sheldon	FT	CVEN 3414, Fundamentals of Environmental Engineering, 3 Credit, F 22	40	40	20	20
McKnight, Diane	FT	CVEN 5323, Applied Stream Ecology, 3 Credits, F 22 CVEN 3434, Intro to Applied Ecology, 3 Credit, S 23	40	40	20	5
Molenaar, Keith	FT	*Teaching Buy-Out Due to Deanship*	10	15	75	50

Faculty Member (name)	PT or FT[1]	Classes Taught (Course No./Credit Hrs.) Term and Year[2]	Program Activity Distribution[3]			% of Time Devoted to the Program[5]
			Teaching	Research or Scholarship	Other[4]	
Dean of the College of Engineering and Applied Sciences						
Morris, Matthew	FT	CVEN 3246, Intro to Construction, 3 Credit, F 22, S 23 CVEN 5006, Construction Engineering and Management Fundamentals, 3 Credits, F 22 AREN 4606, Construction Project Execution and Control, 3 Credit, S 23 CVEN 4899, Senior Project, 3 Credit, S 23	70	0	30	50
Neupauer, Roseanna	FT	CVEN 3323, Hydraulic Engineering, 3 Credit, F 22 CVEN 4353, Groundwater Engineering, 3 Credit, F 22 CVEN 5353, Groundwater Hydrology, 3 Credits, F 22	35	40	25	5
Pak, Ronald	FT	CVEN 5798, Dynamics of Soil and Structure, 3 Credits, F22 CVEN 3708, Geotechnical Engineering 1, 3 Credit, S 23 CVEN 5131, Continuum Mechanics and Elasticity, 3 Credit, S 23	40	40	20	10
Pfeffer, William (Tad)	FT	CVEN 2012, Intro to Geomatics, 3 Credit, F 22	40	20	40	10
Pourahmadian, Fatemah	FT	CVEN 5111, Structural Dynamics, 3 Credits, F 22 CVEN 3111, Analytical Mechanics 2, 3 Credit, S 23 CVEN 5151, Wave Methods for Design and Characterization of Advanced Materials, 3 Credit, S 23	40	40	20	10
Regueiro, Richard	FT	CVEN 5537, Numerical Methods in Civil Engineering, 3 Credits, F 22 CVEN 7511, Computational Finite Inelasticity and Multiphase Mechanics, 3 Credits, F 22 CVEN 4899, Senior Project Design, 3 Credit, S 23	30	40	30	10
Rosario-Ortiz, Fernando Associate Dean of Faculty, College of Engineering and Applied Sciences	FT	*Teaching Buy-Out Due to Deanship*	10	15	75	20
Ryan, Joseph	FT	CVEN 4424, Environmental Organic Chemistry, 3 Credit, S 23	30	30	40	20

Faculty Member (name)	PT or FT[1]	Classes Taught (Course No./Credit Hrs.) Term and Year[2]	Program Activity Distribution[3]			% of Time Devoted to the Program[5]
			Teaching	Research or Scholarship	Other[4]	
Salvinelli, Carlo	FT	EVEN 4830, Special Topic: Applied Global Engineering, 3 Credit, F 22 EVEN 2004, Intro to Global Engineering, 3 Credit, F 22 CVEN 5830, Intro to Humanitarian Aid, Disaster Risk Reduction, 3 Credit, F 22 EVEN 5999, Refugees and Displacement, 3 Credit, F 22 CVEN 5837, Special Topic: Study Design and Impact Eval, Community Appraisal 3 Credit, S 23	65	25	10	20
Saouma, Victor	FT	CVEN 5525, Matrix Structural Analysis, 3 Credits, F 22 CVEN 4525, Matrix Structural Analysis, 3 Credit, F 22	40	40	20	50
Scheib, Jennifer	FT	AREN 4620, Adaptive Lighting Systems, 3 Credits, F 22 AREN 5001, Building Energy Systems: Thermal, Electrical, and Lighting Systems, 3 Credits, F 22 AREN 5620, Adaptive Lighting Systems, 3 Credits, F 22 AREN 5580, Daylighting, 3 Credits, S 23 AREN 3080, Architectural Design Studio 1, 3 Credit, S 23 AREN 3540, Illumination 1, 3 Credit, S 23 AREN 4580, Daylighting, 3 Credit, S 23	80	0	20	100
Senseney, Christopher	FT	CVEN 2012, Intro to Geomatics, 3 Credit, F 22, S 23 AREN 4318, Senior Design 1, 3 Credits, F 22 CVEN 3256, Construction Equipment and Methods, 3 Credit, F 22 AREN 4319, Senior Design 2, 2 Credit, S 23 GEEN 1400, Engineering Projects, 3 Credit, S 23	70	10	20	50
Song, Jeong-Hoon	FT	CVEN 2121, Analytical Mechanics 1, 3 Credit, S 23 CVEN 3525, Structural Analysis, 3 Credit, S 23	10	80	10	50
Srubar, Wil V.	FT	AREN 5830, Building Energy Systems 2, 3 Credits, F 22 CVEN 4565, Design of Wood Structures, 3 Credit, S 23 CVEN 5835, Special Topic: Design of Wood Structures, 3 Credit, S 23	25	60	15	100
Straub, Anthony	FT	CVEN 3414, Fundamentals of Environmental Engineering, 3 Credit, S 23	40	40	20	50
Thomas, Evan	FT	EVEN 4830, Special Topic: Applied Global Engineering, 3 Credit, F 22 EVEN 2004, Intro to Global Engineering, 3 Credit, F 22	15	40	45	20

Faculty Member (name)	PT or FT[1]	Classes Taught (Course No./Credit Hrs.) Term and Year[2]	Program Activity Distribution[3]			% of Time Devoted to the Program[5]
			Teaching	Research or Scholarship	Other[4]	
		CVEN 5838, Special Topic: Intro to Global Health for Engineers, 3 Credit, S 23				
Torres-Machi, Cristina	FT	CVEN 3602, Transportation Systems, 3 Credit, F 22 CVEN 5836, Special Topics: Infrastructure Asset Management, 3 Credits, F 22 CVEN 3227, Probability, Statistics, and Decision for CVEN, 3 Credit, S 23	40	40	20	50
Vasconez, Sandra	FT	AREN 4830, Special Topic: Architectural Lighting Design, 3 Credits, F 20 AREN 4530, Advanced Lighting Design, 3 Credits, F 22, S23 AREN 4550, Illumination 2, 3 Credits, F 22 AREN 5830, Special Topic: Advanced Lighting Design, 3 Credits, F 22, S 23 AREN 3430, Architectural (Interior) Lighting Design, 3 Credit, S 23 AREN 4319, Senior Design 2, 2 Credit, S 23 CVEN 4837, Outdoor Lighting, 3 Credit, S 23	70	0	30	100
Xi, Yunping	FT	CVEN 4161, Mechanics of Materials 2, 3 Credit, F 22 CVEN 5831, Special Topic: Advanced Construction Materials, 3 Credits, F 22 CVEN 5161, Advanced Mechanics of Materials, 3 Credits, F 22 CVEN 3161, Mechanics of Materials 1, 3 Credit, S 23	40	40	20	50
Zhai, Zhiqiang (John)	FT	AREN 3010, Energy Efficient Buildings, 3 Credits, F 22 AREN 5830, Building Energy Systems 2, 3 Credits, F 22 AREN 2120, Fluid Mechanics and Heat Transfer, 3 Credit, S 23 AREN 2121, Heat Transfer, 1 Credit, S 23	40	40	20	100
Zhang, Yida	FT	CVEN 5708, Soil Mechanics, 3 Credits, F 22 3 Credit, S 23 CVEN 7718, Engineering Properties of Soil, 3 Credit, S 23	40	40	20	10

1. FT = Full Time Faculty or PT = Part Time Faculty, at the institution
2. For the academic year for which the Self-Study Report is being prepared.
3. Program activity distribution should be in percent of effort in the program and should total 100%.
4. Indicate sabbatical leave, etc., under "Other."
5. Out of the total time employed at the institution. Most faculty are less than 100% to the Civil Engineering program due to time devoted to Architectural Engineering (AREN) or Environmental Engineering (EVEN) students via course instruction and/or advising.

CRITERION 7. FACILITIES

A. Offices, Classrooms and Laboratories

1. Offices (such as administrative, faculty, clerical, and teaching assistants) and any associated equipment that is typically available there. The administrative office for the Department of Civil, Environmental, and Architectural Engineering is located on the 4th floor of the Engineering Center. Four faculty groups (building systems, geotechnical engineering, structural engineering, construction engineering and management) have offices on the 2nd, 4th, and 5th floor of the Engineering Center. Two faculty groups (water resources, environmental engineering) have offices in the Sustainability, Energy, and Environment Complex (SEEC) on East Campus. The department has made four desks in offices on the 4th floor of the Engineering Center available for hoteling for faculty with offices on East Campus so that they can hold office hours on Main Campus. Teaching Assistants have offices on the 2nd, 1st, and Basement levels of the Engineering Center. All staff have offices on the 1st or 4th floor of the Engineering Center.

2. Classrooms and associated equipment that are typically available where the program courses are taught. The majority of courses are taught in the Engineering Center, 1111 Engineering Drive, ECOT 441 UCB 428, Boulder, Colorado 80309. Classrooms in the Engineering Center Civil Engineering (ECCE) wing, the Engineering Center Classroom (ECCR), and Engineering Center Computer Science (ECCS) wing are used by the department. A few courses are taught in the adjacent Koebel (KOBL) business school building, as well as the Fleming (FLEM) building and the new Center for Academic Success and Engagement (CASE) building.

3. Laboratory facilities used by AREN Students include the Center for Infrastructure, Energy, and Space Testing (CIEST) Laboratory, the Larson Building Systems Laboratory, and the Larson Building Systems Lighting Laboratory. The CIEST Laboratory includes the laboratory classrooms and equipment students use for structural engineering courses (e.g., CVEN 3161 Mechanics of Materials). The Larson Building Systems Laboratory and the Larson Building Systems Lighting Laboratory include a laboratory classroom and equipment used by students in the mechanical systems, electrical systems, and lighting courses. See **Accreditation Policies and Procedures Manual** for the comprehensive laboratory and safety manuals of these facilities.

Other Facilities Include:

Engineering Center

The Engineering Center comprises over 600,000 square feet of classrooms, computing facilities, faculty offices, and research laboratories. This includes facilities on central campus, the SEEC (Sustainability, Energy and Environmental Complex) building, the SEEL (Sustainable Energy and Environmental Laboratories) building, the Jennie Smoly Caruthers Biotechnology Building, and the Aerospace Building. These buildings also house centrally-scheduled classrooms, which are used heavily for engineering classes (but not exclusively) and open computer labs, available to all students. Working with the campus OIT organization, the College ensures that the open computer labs are configured with software tools needed by engineering students. The Lesser House, home to the Herbst Program for Engineering, Ethics and Society, is across the street from the Engineering Center and is very accessible to engineering students.

Idea Forge

The Idea Forge, which opened during the fall of 2014 is a flexible, cross-disciplinary collaborative space where students can imagine, design, create, and test products and solutions to meet a range of societal and customer needs. The space supports student teams working on invention and innovation as part of courses, as well as design and development driven by entrepreneurial-minded individuals and service-oriented groups. With all these students working side-by-side, the Idea Forge boosts student learning through collaborative, hands-on experience, while supporting industry interaction through scheduled workshops as well as spontaneous exchanges. The Idea Forge space resources that support the design curriculum include the following (pictures are available at http://www.colorado.edu/ideaforge/facilities):

- Idea Forge Commons: The Commons, the figurehead space within the Idea Forge, provides students with an open, spacious area for ideation and brainstorming as well as worktables for project work.
- Project-Based Learning Studio: a classroom completely dedicated to learning through hands-on experience. With its round tables, the room holds classes that focus on teamwork and small group discussion rather than lecture. There are many dry-erase boards on wheels to use for breakout sessions, general group work, or dividing the room into multiple sections.
- Drop-In Design Lab: The space holds a SolidWorks CAD computer lab and plenty of project work space. There are two study rooms available for students to reserve.
- Chevron Design Studio: The Chevron Design Studio is a large design and build space run by Design Center Colorado and dedicated to the Mechanical Engineering Senior Design class. This course allows students to work on industry sponsored projects while guided by a faculty advisor.
- Micro-Motion Thinking Lab: Break Space

Integrated Teaching and Learning Laboratory

The Integrated Teaching and Learning (ITL) Program at the University of Colorado Boulder is a nationally recognized award-winning engineering education leader. The ITL Program supports hands-on engineering learning through an innovated environment where students integrate engineering theory with practice and learn through doing.

The Integrated Teaching and Learning Laboratory (ITLL) is a state-of the-art facility that provides 34,400 square feet of space for students to engage in hands-on design activities, including a learning plaza that facilitates interdisciplinary, team-based projects, along with manufacturing, fabrication, and electronics centers where students can create projects for their engineering courses or extracurricular learning pursuits. The architecture of this facility was driven entirely by curricular reform initiatives focused on increasing student learning and engagement through the integration of design-based learning into the curriculum.

The ITLL hosts the First Year Engineering Projects course and 10-20 other Mechanical Engineering courses each academic year. These courses range from required sophomore and junior level courses such as Statics, Structures, Thermodynamics, and Fluids, to senior and graduate level electives such as Bioinspired Robotics and Flow Visualization.

Engineering students have access to five teaching spaces within the ITLL. Two design studios dedicated to the First-Year Engineering Projects course where they experience the engineering design process in a hands-on way, two large lab plazas where faculty can lecture while students have direct access to computers and test equipment, and one active learning classroom where faculty host lecture-based courses.

Engineering students in any engineering course have access to a full suite of fabrication resources as detailed below:

- The manufacturing center provides students with access to a wide range of computer guided and manual equipment used to fabricate project components out of wood, plastic, and metal. The available equipment includes hand tools, saws, drills, manual mills and lathes, CNC Lathes, a 3-axis CNC mill and a 5-axis CNC mill.
- The electronic center allows students to learn how to solder and protype basic electronic circuits.
- The electronics fabrication center allows students to design, fabricate and assemble custom printed circuit boards.
- The fabrication station includes a wide range of tools used for prototyping and fabrication including ten 3D printers, four laser cutters, and two sewing machines.

The ITLL has 115 computers dedicated to students with a myriad of software available for use. Commonly used software includes Ansys, Arduino IDE, Blender, Digilent Waveforms, EES, Labview, MATLAB, and SolidWorks (full list available at https://itll.colorado.edu/software/). The two lab plazas in the ITLL have 76 fixed lab stations equipped with computers with dual monitors, data acquisition systems, external power supplies, multimeters, wave form generators, and oscilloscopes. The lab plazas are used extensively by ME students enrolled in upper-division classes including Circuits & Electronics, Data Analysis & Experimental Methods, and System Dynamics.

The ITLL also manages an inventory of over 3000 commonly used items for students to check out. Examples include laptops for students to complete testing offsite, sensors and actuators for use in projects and course work, and electronics development kits so students can prototype electrics before needing to purchase items themselves.

Each workstation has the following:

2x Desktop Power Supplies
1x Function Generator
1x Desktop Multi Meter
1x Oscilloscope

Total workstations in the building:
1B10 – 39 workstations
2B10 – 37 workstations
ECCE 167 – 6 workstations
ECCE 168 – 6 workstations
Checkout equipment – 5 workstations

Total equipment:
186x Desktop Power Supplies
93x Function Generator
93x Desktop Multi Meter
93x Oscilloscope

Additional Classrooms and Learning Spaces

Students, faculty, and staff have access to a variety of technology enhanced learning spaces. OIT (Office of Information Technology) maintains over 500 technology-equipped classrooms campus wide, which includes most (but not all) College of Engineering and Applied Science's classrooms. Each technology-equipped classroom and lecture hall contains at minimum a video display (LCD or Data Projector), audio reinforcement, and wireless networking capability. This includes 44 classroom capture equipped classrooms and over 300 hybrid capable classrooms. Classroom sizes range from 12 to 375 seats. Most classrooms on campus have an audience response system, CU iClicker.
Room types and features:

- Media Equipped Classrooms (ME): Includes LCD TV monitor with cables to display laptop content, but no DVD Player.
- Smart Classrooms (SC): Contains a data projector or monitor, a projection screen, a sound system, and a DVD/CD Player (unless noted otherwise).
- Active Learning Rooms (ALR) : Features furniture allowing students to face each other, supporting small-group work. Tables are often paired with whiteboards and large LCD displays. Instructors can choose a table's work to share with the entire class.
- Large Lecture Halls (LLH): Same functionality as Smart Classrooms with larger capacity. Some have multiple projector setup, all have voice reinforcement and classroom capture. Supports Hybrid Instruction
- Remote-Capable Classroom (RCC): CU Boulder's new Remote-Capable Classroom (RCC) Service is a hybrid teaching solution which allows for synchronous (real-time) and asynchronous (on-demand) lecture and presentation delivery. The RCC Service provides instructors with a simple technology solution, a Crestron Mercury X system, that enables the simultaneous delivery of lectures to students that are physically in the classroom as well as students working remotely.
- Classroom Capture (CC): Capture audio and video from lectures or special events then make available online for on-demand viewing. Learn more about Classroom Capture. Supports Hybrid Instruction.

- Classroom Capture Pluc (CC+): Offers the same functionality of standard Classroom Capture spaces with the addition of audience microphones to record audience participation. Supports Hybrid instruction.
- CUClickers Receivers (CR): Classrooms with a capacity of over 40 have an iClicker receiver in the media cabinet.
- Wireless Microphones (WM): Some larger classrooms on campus have wireless microphones.
- Computing Labs (LAB): OIT managed student computing labs contain varied configurations of workstations.

Building	**Room**	**Features**	**Capacity**
ENGINEERING CENTER	ECCE 141 CAD	Windows LAB, SC, RCC, CR, WM	48
ENGINEERING CENTER	ECCE 1B41	SC, CC+, CR, WM - No DVD Player	49
ENGINEERING CENTER	ECCR 105	SC, CC+, CR, WM - No DVD Player	68
ENGINEERING CENTER	ECCR 108	SC, RCC, CR	28
ENGINEERING CENTER	ECCR 110	SC, RCC, CR	27
ENGINEERING CENTER	ECCR 116	SC, RCC, CR	27
ENGINEERING CENTER	ECCR 118	SC, RCC, CR	27
ENGINEERING CENTER	ECCR 131	SC, RCC, CR	28
ENGINEERING CENTER	ECCR 135	SC, RCC, CR	47

ENGINEERING CENTER	ECCR 139	SC, RCC, CR	29
ENGINEERING CENTER	ECCR 143	Windows LAB, SC, CR	26
ENGINEERING CENTER	ECCR 150	SC, CC+, CR, WM - No DVD Player	64
ENGINEERING CENTER	ECCR 151	SC, RCC, CR, WM	48
ENGINEERING CENTER	ECCR 155	SC, RCC, CR, WM	48
ENGINEERING CENTER	ECCR 1B08	SC, RCC, CR	20
ENGINEERING CENTER	ECCR 1B40	SC, RCC, CR, WM	138
ENGINEERING CENTER	ECCR 1B51	SC, CC+, CR, WM - No DVD Player	48
ENGINEERING CENTER	ECCR 1B55	SC, CC+, CR, WM - No DVD Player	48
ENGINEERING CENTER	ECCR 200	SC, CC, CR, WM	106
ENGINEERING CENTER	ECCR 245	SC, RCC, CR, WM	106
ENGINEERING CENTER	ECCR 265	SC, RCC, CR, WM	152
ENGINEERING CENTER	ECCS 1B12	SC, CC+, CR, WM - No DVD Player	94

ENGINEERING CENTER	ECCS 1B14	SC, CC+, CR, WM - No DVD Player	30
ENGINEERING CENTER	ECCS 1B28	SC, CC+, CR, WM - No DVD Player	78
ENGINEERING CENTER	ECCS 201	LLH, CC, CR, WM	191
ENGINEERING CENTER	ECST 1B21	SC, RCC, CR	20

Blow Things Up (BTU) Lab

The ATLAS BTU Lab is a hackerspace and maker community situated on the first floor of the Roser ATLAS Building (ATLS 113). The lab is operated by the ATLAS Institute and it is **open to all CU Boulder students**, regardless of department or field of study. The BTU will have separate access to two areas: the BTU Lab work area and classroom (ATLS Rm 113 and 113A), and the BTU Tool Room (ATLS 105). Members of the BTU Lab have access to a wide range of tools and fabrication equipment, including 3D printers, a laser cutter, woodworking tools, electronic equipment and more.

SEEC

The Environmental Engineering program recently joined numerous other sustainability programs, institutes and agencies in the Sustainability, Energy and Environment Complex (SEEC) on CU Boulder's East Campus. The building is a national hub for learning, research and innovation in environmental sustainability designed to spur collaboration on global energy and environmental challenges. All the classrooms, offices, labs, equipment, and facilities that are housed within university buildings conform to standard fire, safety, building, and health codes.

JSCBB

The Jennie Smoly Caruthers Biotechnology Building is a 330,000 square foot research and teaching facility. It houses faculty, staff and students from the Biofrontiers Institute, the department of Chemical and Biological Engineering, and the Division of Biochemistry

Aerospace Building

The Aerospace Engineering Sciences building opened in 2019. At nearly 180,000 square feet, the building features world-class learning spaces for the department’s signature hands-on experiential learning curriculum. It also features laboratories for testing autonomous aircraft and ground vehicles, studying aerodynamics, structures and materials, and houses a *Dream Chaser* spacecraft cockpit module provided by Sierra Nevada Corp. used for human factors and human-machine interaction studies as part of the department’s broader research into next generation human spaceflight systems. Students and faculty here also conduct groundbreaking Earth and space sciences research, learning about everything from the ocean to the solar wind and more.

Engineering Space Assessment by Unit- 2016 Data

Space Type	Admin	AES[1]	ChBE	CEAE[2]	CS	ECEE	ME	ATLAS	GEEN	ITL	IDEA FORGE	BOLD	HERBST	EMP	ITP	CSGC	CNL	NCF	Total (sq ft)
Office*	20,705	18,722	21,384	25,352	12,012	26,105	21,749	8,378	390	7,939	3,647	3,112	2,146	1,371	2,692	603	131	162	176,600
Instructional	680	9,341	4,495	10,962	2,770	11,130	6,977	13,101	0	15,664	8,495	0	291	0	2,213	2,840	0	0	88,959
Research	0	32,670	30,627	35,255	13,387	30,644	29,148	0	0	191	2,689	0	0	0	780	0	4,175	1,524	181,090
Totals	21,385	60,732	56,506	71,569	28,169	67,879	57,874	21,479	390	23,794	14,831	3,112	2,437	1,371	5,685	3,443	4,306	1,686	446,648

[1] Includes: Aerospace Engineering, Astrodynamics Research, Center for Aerospace Structures, Bioserve Space Technologies & RECUV

[2] Includes: Civil Engineering, Environmental Engineering & CADSWES

* Includes all central storage (except ECEE 2B75)

Space Type	CEAS	AES[1]	ChBE	CEAE[2]	CS	ECEE	ME	ATLAS	UGRAD Programs	GRAD Programs	Research Facilities		Total (sq ft)
Office*	23,817	18,722	21,384	25,352	12,012	26,105	21,749	8,378	14,725	4,063	293		176,600
Instructional	680	9,341	4,495	10,962	2,770	11,130	6,977	13,101	27,290	2,213	0		88,959
Research	0	32,670	30,627	35,255	13,387	30,644	29,148	0	2,880	780	5,699		181,090
Totals	24,497	60,732	56,506	71,569	28,169	67,879	57,874	21,479	44,895	7,056	5,992		446,648

B. Computing Resources

Campus-wide/Institutional Computing Resources

The majority of campus-wide computing resources are provided by the Office of Information Technology (OIT), which provides CU-Boulder with innovative, customer-focused IT support and core IT services. Under the leadership of the Office of the Senior Associate Vice Chancellor for IT and CIO, OIT partners and collaborates with academic, research, and administrative units in order to create a robust, best-in-class IT environment.

Computing resources are provided by OIT as well as colleges, departments, institutes, centers, etc. OIT provides coordinated, centralized IT support as well as core IT services in areas such as academic technologies, communication technologies, enterprise IT services, infrastructure, Research Computing and IT security.

Networking

The University of Colorado has a robust, enterprise-level network that serves both wired and wireless Internet access to nearly every corner of the campus, as well as providing VPN opportunities for off-campus connections.

1. Wired connectivity – 1 Gigabit/secs Ethernet, 13 distribution routers, 700 switches, servicing ~50,000 hardwire attached devices
2. Wireless connectivity – 802.11a/b/g/n/ac/ax, 100,000+ registered wireless devices, 8,800+ access points
3. VPN connectivity
4. Institutional network backbone – 100 Gigabit/sec Ethernet Distribution to Switch Edge. 90 Gigabit/sec aggregate Internet (2x40 Gbps; 1x10 Gbps) connectivity.
5. ScienceDMZ –800 GigaBit/sec core with no firewalls and 90 Gigabit/sec Internet connectivity managed jointly by Research Computing and OIT networking

Cloud Computing

CEAS Cloud Computing is an online lab environment administrated by the Integrated Teaching and Learning Program, providing students within the College of Engineering and Applied Science access to educational software anywhere in the world since August 2020. This environment includes software such as AutoCAD, ANSYS, EES, LabVIEW, MATLAB, Solidworks and dozens more (full list available at https://www.colorado.edu/engineering/cloudcomputing) that are fully pre-configured for quick and easy use. Different virtual hardware options allow students to select from desktops geared toward computational needs as well as those who need dedicated graphics hardware regardless of the hardware specifications of their personal computing device. Using the scalability afforded by cloud services, the capacity of this system can be increased or decreased, as needed, throughout the day to support our student population."

Computer Labs

There are thirty-six centrally-managed labs on campus. The University maintains a three- or four-year hardware replacement schedule for most workstations. Software on the machines is upgraded every semester with new or updated versions of important Engineering software packages. The hours of availability and access vary according to the policies of individual buildings and departments. However, most Engineering labs are open at all hours for students in the College of Engineering.

There are eight centrally-managed labs in the Engineering complex. These labs are configured with similar workstation hardware and software in all locations. Current configurations and software availability can be found on the OIT website: https://keyserver.colorado.edu/software (VPN access is required if off campus).

The following engineering-related software is installed on most computers:

- A variety of software compilers
- Abaqus
- Alteryx Designer
- ANSYS
- ArcGIS
- AspenONE Suite
- AutoCAD Suite
- COMSOL
- EES (Engineering Equation Solver)
- ENVI
- EQS
- IDL
- JMP PRO
- LabVIEW
- Mathcad Prime
- Mathematica
- MATLAB
- Maple
- Minitab
- MPlus
- MVPstats
- OriginPro
- Praat
- R/R Studio
- Revit
- SAS
- Schedule and Super Pro
- SPSS
- SolidWorks
- TeXworks

Academic Technologies

Besides ubiquitous Internet connectivity and laboratory space, students are provided with many other computing services and software to support their learning needs. Teaching and learning technologies provided and supported by the Office of Information Technology (OIT) at CU Boulder include learning management system Canvas, audience response system CUClickers, lecture capture tool Classroom Capture, in-video questions software PlayPosit, remote proctoring service Proctorio, and video conferencing tool Zoom. OIT strives to provide a unified digital experience for students and integrates all the standalone learning tools with the learning management system to achieve the unified experience and make transitions between tools seamless for the students. OIT also extends the learning management system integration service to learning tools not supported by the campus on a per-request basis and requires that the tools undergo CU Boulder security and accessibility compliance review initiated via the Digital Technology Compliance Review Request (Form A). Each campus-supported tool also undergoes accessibility review and some features are also tested by the Digital Accessibility Office. The Digital Accessibility Office also provides accessibility guidelines, training, universal design consultations, and captioning service to campus constituents.

C. Guidance

The Department provides students with guidance on the use of the computing tools, resources, and labs discussed in this section through a variety of means. In courses where students will be using laboratory facilities (e.g. Mechanics of Materials, Introduction to Geotechnical Engineering), the instructor and/or teaching assistants (TAs) describe the relevant equipment to students. Important health and safety requirements and precautions are described. Safe equipment use is monitored during the laboratory sessions by the TA and/or faculty. User guides and/or instructions for each laboratory and necessary equipment are provided to the students. The students work with the laboratory equipment during supervised laboratory times, with immediate access to teaching assistants and/or faculty to answer their questions.

The primary methods of guidance include leveraging University-wide OIT training resources, semester-length tooling courses, online and video documentation, extracurricular training sessions, and peer-tutoring. Each method is discussed in greater detail below. Many of the computer resources leveraged by the Department are provided by the University-wide Office of Information Technology (OIT). OIT provides training and guidance for such resources to students directly via their website, walk-in support desk, and phone and email support center. OIT provides a range of support service to AREN students, staff, and faculty including:

- Campus Single-Sign-On (SSO) and Directory (LDAP) Support
- OSX and Windows end-user software licensing, installation, and training
- Email, contacts, and calendaring support (Google Applications, OneDrive, and/or Microsoft Exchange)
- Classroom technology upkeep and training
- Backup services, hosted servers, etc.
- Wireless, wired, and VPN network access
- Phone (via Microsoft Teams) and related telecommunication services

Beyond the general IT support provided by OIT, the department also has a designated individual for desktop support.

D. Maintenance and Upgrading of Facilities

Larson Building Systems Laboratory

The Larson Building Systems laboratory has served the AREN program well for 40 years. To enhance the research and teaching capacity, attract students and faculty, and provide hands-on education, the laboratory underwent a >$500K renovation to update and modernize the two roof-top commercial HVAC systems and the two reconfigurable full-scale test chambers. In order to support the ongoing maintenance of the Larson Building Systems Laboratory, the CEAE Department provides $15,000 annually for facility maintenance.

CEAE Departmental Experimental Laboratories

The faculty who teach courses using the undergraduate teaching laboratories monitor the equipment used and generally perform basic maintenance. The department collects student fees, and the money is used to maintain, repair, and replace the laboratory equipment, when needed. The relevant course instructor simply informs the department chair of any needs, and makes the necessary purchases or contracts for needed service. Instructors can also request new equipment as they keep laboratory experiences up-to-date with current practice. Major equipment requirements are often cost-shared between the College (via a request for funding to the Engineering Excellence Fund) and the Department.

Integrated Teaching and Learning Laboratory (ITLL)

The Integrated Teaching and Learning Laboratory (ITLL) at the University of Colorado Boulder is a nationally recognized award-winning engineering education leader. The ITLL supports hands-on engineering learning through an innovated environment where students integrate engineering theory with practice and learn through doing. Program components include a first-year design course, sophomore- and junior-level experimental hands-on learning courses, senior design projects and design expos.

OIT Controlled Computing Facilities

The computer hardware in the centrally-managed computer labs are configured to meet the high-end demands of the software specific to Engineering disciplines. The labs are outfitted with workstation-class hardware that provides the necessary CPU, memory and GPU to support these applications. The hardware is purchased with a 3-year warranty, and the machines are refreshed at the end of the three years to ensure that the labs can stay current with the demands of new and updated software. All the hardware is managed centrally using management tools like Microsoft SCCM and AppSense. These tools allow us to deploy software, manage the user environment, and monitor the security and performance of the machines. Microsoft security updates are applied weekly after-hours to ensure they do not impact the availability of the machines during classes or while students are using the machines. In addition, because these machines are used in multi-user environments, we ensure that changes made by previous users are not maintained across logins. This ensures a consistent and familiar environment for the students and faculty that use them. The machines are all configured with antivirus software to protect the students and other machines from viruses, and logins and application usage data is tracked to help us make decisions about software licensing and machine availability.

E. Library Services

The Leonard Gemmill Engineering, Mathematics & Physics Library, opened in 1992, is an 18,000 square foot facility. In the fall 2021 semester approximately 27,315 user visits were recorded. The library is presently open 40 hours per week and receives 25,000-30,000 visits per semester. Gemmill Library provides a mix of study spaces for students, including open collaborative areas where students are encouraged to meet with groups and talk, open quiet study areas where students are encouraged to keep noise to a minimum, and seven group study rooms available for students to reserve. Gemmill Library provides 22 OIT-managed computers with the general engineering software loadset for students, faculty and staff, as well as several public computers with more limited software. Printers and scanners are available in Gemmill Library. Study space and computer and printing access is available to students in the four additional Libraries that constitute University Libraries, including more extended study hours at Norlin Library which is presently open 91 hours per week

University Libraries contain vast physical collections across five campus libraries and an offsite storage facility. The Gemmill Library contains a core print monograph collection, print periodicals, a materials collection, microform technical reports, and a popular science reading collection. Extensive electronic collections are available 24/7 and since 2019 collection development has focused on adding electronic monographs and periodicals in order to increase access. Access to online materials includes bibliographic indexes, such as Compendex and INSPEC on the Engineering Village platform and the Web of Science reference and citation database. The Libraries also subscribe to searchable full text providers, such as IEEE Electronic Library and ACM Digital Library. Additional subscriptions include technical ebook platforms like O'Reilly-Safari eBooks, AccessEngineering, Knovel Library, Springer E-Books which provide access to ebooks, reference sources, and video material. Access to standards is provided electronically from several publishers such as AIAA, ASCE, ASTM and IEEE. Standards from other publishers are purchased upon request. A comprehensive list of electronic tools and databases is available (https://libguides.colorado.edu/az.php?a=all). Additionally, students have access to regional and world-wide interlibrary loan services free of charge. The Libraries continually assess collection use, relevance, and needs and are highly responsive to monograph and subscription suggestions, within the constraints of the collections budget.

Research and library help is provided to students via multiple means. In Gemmill Library a team of student assistants and full time Libraries' employees, including a mix of paraprofessional and professional librarians, are available to help users with their questions about library services and finding information. In-depth research questions are referred to and answered by an engineering liaison librarian and a computer science and mathematics liaison librarian, with support from additional liaison librarians serving related disciplines (i.e. physics, chemistry, health sciences) across University Libraries. The liaison librarians answer questions via email and via one-on-one meetings, either in a library location or via Zoom. Additional research support is provided by a team of librarians who staff Ask a Librarian services in Norlin Library and on University Libraries' IM chat service.

Further, liaison librarians are available to provide in-class information literacy instruction, online tutorials, and workshops. We offer course-integrated instruction, designed around finding information resources for particular assignments or projects in a class. Workshops are also provided for co-curricular research programs. Additionally, liaison librarians create and maintain asynchronous learning materials to support learning and research for specific subjects, courses, student populations, and source formats. Instruction situates immediate student needs for skills development within a larger cognitive framework, aligned with ACRL's *Framework for Information Literacy* and the *Companion Document to the ACRL Framework for Information Literacy for Higher Education: Science, Technology, Engineering, and Mathematics.*

The Gemmill Library is committed to building an evidence-based, user-centered library. Various assessments have led to the Library reconfiguring its space to provide flexible study areas. We gather and respond to feedback from students but also attend to the larger institutional context. Liaison Librarians sit on the College's Undergraduate and Graduate Education Councils and use information gathered from those councils to help guide library decision-making. In short, this library is envisioned as one where students can access information and information professionals to support acquiring new knowledge.

F. Overall Comments on Facilities

All of the classrooms, offices, labs, equipment, and facilities that are housed within university buildings conform to standard fire, safety, building, and health codes.

The Environmental Health and Safety (EH&S) department at the University of Colorado at Boulder (http://www.colorado.edu/ehs) provides comprehensive environmental, health and safety services to minimize health and safety impacts to the campus and the greater Boulder community. EH&S accomplishes this through training, emergency planning, consultation and partnership with members of the campus community as well as with local, state and federal agencies. Environmental Health and Safety provides regular training programs for UCB faculty, staff and students. These classes are mandatory for those who handle, manage or come into contact with potentially hazardous materials. EH&S has a substance disposal service in which hazardous waste or expired chemicals are removed from laboratories and disposed of according to state and federal regulations, ensuring a safe laboratory environment.

Facilities Management at the University of Colorado at Boulder (http://www.colorado.edu/facilitiesmanagement/) further ensures a safe working environment. The Mission of Facilities Management is "To plan for and provide a physical and operational environment that supports the University of Colorado at Boulder's mission of education, research and outreach." One of the core values of Facilities Management is "A safe environment" and Facilities Management supports this value by providing waste removal, custodial services, pest management, recycling, the fire alarm and fire sprinkler systems, landscaping, snow removal, and safe steam and electricity generation. All of these support services contribute to the overall safety of students in the program.

The Engineering Center and the Discovery Learning Center (DLC) are generally open Monday-Friday from 7 a.m. to 7 p.m.; card access is required at all other times. The Integrated Teaching and Learning Lab (ITLL) is open Monday-Friday 8 a.m. to 6 p.m., and via after hours card access Monday-Thursday 7:30 a.m. to 11 p.m., Friday 7:30 a.m. to 7 p.m. and Sunday 2 p.m. to 11 p.m. Card access for the exterior doors of the Engineering Center is gained by requesting access from the Building Proctor in the Dean's Administrative area of the College of Engineering and Applied Science. Students must show their CU ID Card (BuffOne Card) and the last 7 digits of that card number is used to provide access via the C*Cure System; access to the Discovery Learning Center is provided in the same way. The Integrated Teaching and Learning Lab (ITLL) staff provides access for the doors to this building, (after completion of an ITLL in-person tour) as described on this website: https://itll.colorado.edu/information/access-and-tour-information/

Safety Training is required to use the Manufacturing Center (more information can be found at Safety Orientation and Saws & Drills).

CRITERION 8. INSTITUTIONAL SUPPORT

A. Leadership

The CEAE department is the sole home for the architectural engineering Bachelor's degree; it also is the sole home of the architectural engineering Bachelor's degree and supports the environmental engineering degree (which is a college-wide program with various affiliated faculty that is administratively supported by CEAE). Faculty members in the CEAE department are represented in six traditional civil/architectural engineering groups for administrative purposes:

- building systems (devoted to architectural engineering)
- construction engineering & management (with equal commitment to civil and architectural engineering),
- structural engineering & mechanics (with equal commitment to civil and architectural engineering),
- water resources (committed to civil engineering, and some support environmental engineering)
- environmental (with commitment to civil and environmental engineering)
- geotechnical (fully devoted to civil engineering)

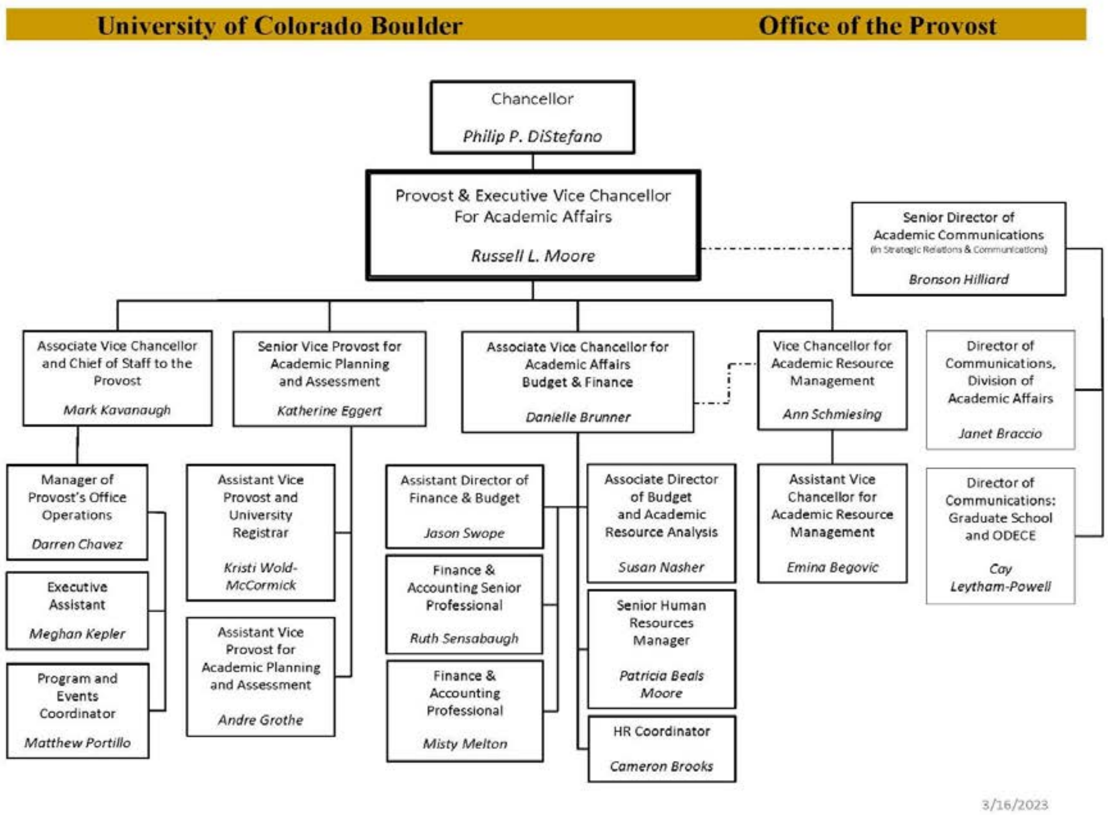
The CEAE department has a democratic governance structure with collaborative planning and decision-making. The Department chair is elected by the faculty, with final appointment by the Dean; until now the Dean has not gone against the wishes of the faculty. The department chair is the chief administrative officer.

The CEAE Department is led by the Chair and the Executive Committee. Professor Balaji Rajagopalan was elected in 2014 and served until June 2022. Professor Karl Linden was elected in 2022 and is serving one 4-year term until 2026. While Professor Linden was on sabbatical in Fall 2022, Professor Rich Regueiro served as Interim Chair.

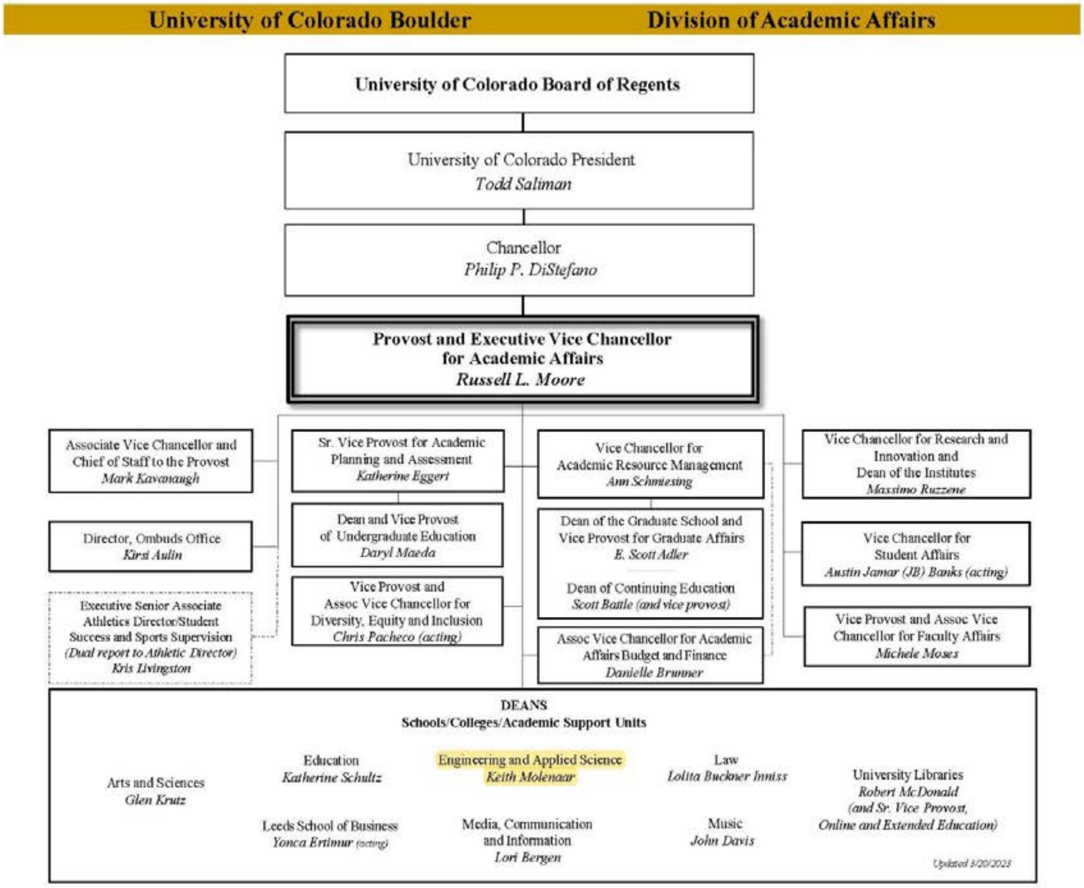
Faculty members in each sub-group nominates a member for the Executive Committee, who is then approved (or not) by a vote of the entire CEAE faculty for a three-year term. CEAE faculty are also assigned to standing committees which are considered sub-committees of the Executive Committee: Curriculum (chaired by the Associate Chair for Undergraduate Education), Graduate Recruiting & Admissions (chaired by the Associate Chair for Graduate Education), Graduate Programs & Students (P&S), Transfer, Study Abroad, and Enrichment, Undergraduate Student Pathways Committee, Facilities, Personnel (Promotion) and Operations. Ad hoc committees can be formed by the faculty to serve special purposes. Current ad hoc committees include the Justice, Equity, Diversity, and Inclusion (JEDI) Committee, Strategic Planning Committee, Mentoring Committee, Teaching Quality Framework (TQF), and Computing. Rostered instructors and research professors are voting members of the faculty and serve on the standing committees of the department, including the Executive Committee. The faculty governance structure is one of the strengths of the department. The representative structure of each sub-discipline area on the executive committee ensures that all faculty have a voice in the direction of the program. The leadership structure is adequate to ensure the direction, continuity, and quality of the architectural engineering program.

University of Colorado Boulder Leadership Organizational Charts:

Office of the Provost - https://www.colorado.edu/academicaffairs/sites/default/files/attached-files/provosts_office_org_chart_3.16.23.pdf



Academic Affairs - https://www.colorado.edu/academicaffairs/sites/default/files/attached-files/provost_division_aa_org_chart_032023.pdf



College of Engineering and Applied Science Organizational Chart:
https://www.colorado.edu/engineering-facultystaff/deans-office-organizational-chart

B. Program Budget and Financial Support

The expenditures by the College of Engineering and Applied Sciences distributes the general fund budget (monies from tuition and fees, state funds, and indirect costs from grants) to the departments and programs in specific categories (ex., faculty salaries, staff salaries, TA stipends, operating funds) using well-defined formulas, established by the dean with advice from and discussion with the department chairs. These formulas are based on input data, such as enrollments, student credit hours, and research expenditures.

The Department receives its budget from the College of Engineering and Applied Science through (1) allocation of faculty positions, (2) funds to cover staff and teaching assistant salaries and operating expenses, and (3) recovery of indirect costs from grants and contracts. A portion (approximately 15%, plus 8% embedded in staff salaries) of the indirect costs recovery (ICR) from faculty's sponsored research activities is returned to the Department to augment its operating budget.

College Budget for the Department of Civil, Environmental, and Architectural Engineering						
	FY18	FY19	FY20	FY21	FY22	% Change
Salaries	$6,005,585	$5,961,331	$6,062,386	$6,526,506	$6,316,788	5.2%
Fringe Benefits	N/A	N/A	N/A	$2,029,196	$1,867,328	N/A
Student Support	$980,989	$1,070,264	$1,070,264	$1,070,264	$1,134,107	15.6%
Capital Projects	$15,748	$15,748	$15,748	$15,748	$15,748	0.0%
Miscellaneous	$122,737	$122,737	$122,737	$122,737	$93,196	-24.1%
Program Fees	$139,584	$138,315	$136,624	$136,216	$135,808	-2.7%
Cont Budget Subtotal	**$7,264,643**	**$7,308,395**	**$7,407,759**	**$9,900,667**	**$9,562,975**	**36.3%**
Faculty Temp Budget	$102,500	$(91,238)	$83,250	$(1,893)	$(3,333)	N/A
ICR	$404,423	$377,838	$342,184	$275,982	$291,753	-27.9%
PMP Revenue	$117,465	$92,075	$54,993	$73,038	TBD	TBD
Total	**$7,889,031**	**$7,687,070**	**$7,888,186**	**$10,247,794**	**TBD**	**TBD**
Faculty FTE	44.00	42.00	43.10	46.60	46.85	6.5%
Staff FTE	10.00	12.00	9.34	9.84	9.84	-1.6%

Currently, the Department of Civil, Environmental, and Architectural Engineering has an annual operating budget of **~$12.5M**. In addition to the ~$10M in funds received from the College of Engineering and Applied Sciences each year, the department has several gift endowments that provide another ~$2.5M in continuing support each year for departmental programs and initiatives for students, staff, and faculty. The endowments alone produce an income stream of ~$100K that is used for purposes specified in the original donations, such as acquisition of instructional equipment, funding of student scholarships, and funding of named lecture series.

The staff, teaching assistant, and operating budgets are determined based primarily on student credit hour (SCH) generation, the number of undergraduate and graduate students in the Department's programs, and the number of faculty in the Department. Funds for additional teaching support are added when the SCH generation per faculty member exceeds the College average. The CEAE department chair and staff, with inputs from the Executive Committee, creates budget based upon teaching, research, and administrative needs. The budget is presented to the Executive Committee for approval each fall with updates throughout the year as necessary.

1. Describe the process used to establish the program's budget and provide evidence of continuity of institutional support for the program. Include the sources of financial support including both permanent (recurring) and temporary (one-time) funds.

The campus went through a phased budget model design, change, and implementation from 2020 – 2022. The old model allocated funding to colleges, schools, and campus support units using an incremental model. Budgets for colleges, schools and campus support units were based on what they had received the previous year, plus or minus a small amount depending on whether campus revenues increased or decreased. Only a small percentage of revenues might be available in a typical year for investment in mission-aligned projects or activities. Interviews with deans, vice-chancellors and business officers conducted in 2019 suggested that innovative teaching and research ideas and initiatives could be stifled by our previous budget model. Our previous model lacked transparency and the flexibility to respond to external factors. The prior funding model was still based on inputs such as enrollment, degrees, credit hours, grant expenditures and awards, current faculty lines, etc., but there was a recognized need to look wholistically at the allocation rather than just small incremental changes year over year. The goals for the new model are to:

- Provide greater flexibility for strategic investments and to respond to the rapidly changing higher education landscape, including opportunities and crises that may arise.
- Increase transparency, enabling the campus community to better understand and engage in budgetary discussions that further the university's mission and strategic objectives.
- Better reflect our values and priorities, instead of reflecting legacy decisions that may no longer be relevant.
- Provide enhanced incentives to support and reward growth in key areas, respond to declines, and ensure accountability for the use and allocation of funding.
- Focus on the whole allocation, and not just the incremental changes that might occur year-over-year.

The new model includes elements that enable the university to better support retention, graduation, and diversity, equity and inclusion goals. The new model is an incentive-based model, whereas the current model is an incremental model.

Under the new model, the budget for department or program is determined via a two-step process. Step one is the incentive budget model recently adopted which credits tuition revenues based upon the college of record of the student population and upon the college of instruction for the courses that said student population enrolls in. Once the home college of the department is credited with its share of the undergraduate and graduate tuition revenue, those funds are then put through a college level budget model. The funding that comes to the department via this two-step process includes continuing and temporary budget to pay for faculty, staff, graduate students, student hourly employees, fringe benefits, operations, and financial aid. Additional funding comes to the department via indirect cost recovery on the sponsored research activity of the department. As this is the first year of the new budget model, all department and program budgets are being "held harmless" relative to last fiscal year with additional funding provided for new faculty hires, merit increases, and increased indirect cost recovery from overhead on sponsored research. "Hold harmless" means that all colleges and campus support units will receive **at least as much** funding in fiscal year 2022-2023 as they did in the previous year while the new model is implemented. This approach creates **budget stability** while also allowing us to see how the model works and to adjust as needed. The College continues to grow in all facets of its operation and department and program budgets will receive additional funds for their portion of the growth.

More information about the campus budget model can be found here:
https://www.colorado.edu/bfp/budget-model

2. Describe how teaching is supported by the institution in terms of graders, teaching assistants, teaching workshops, etc.

Teaching support from the institution is provided via the campus budget model which then flows through the college budget model to the respective departments. The units then, based upon their design and needs, determine the number of graders, TAs, and other support needed to best meet the needs of their student population at the undergraduate and graduate levels. The University of Colorado also places a priority on supporting faculty. Through the Leadership Education for Advancement and Promotion (LEAP) Program, faculty have an opportunity to participate (within their first four years on campus) in an Introductory Leadership Workshop with other junior faculty. This is a two-and-a-half-day, skill-based workshop held on campus two to three times each year. Additionally, the Center for Teaching and Learning offers all faculty a variety of professional development workshops throughout the year in establishing strong learning environments and discipline-specific pedagogy.

3. To the extent not described above, describe how resources are provided to acquire, maintain, and upgrade the infrastructures, facilities, and equipment used in the program.

The success of our faculty and students is predicated on the quality and age of our infrastructure, facilities, labs, and equipment. The University and the College put a priority on ensuring these are the very best that can be provided at the time. Over the last decade over $200M have been invested in Engineering to either renovate existing spaces or to build new buildings that will accommodate not only the student growth of our College but also the depth and breadth of the research portfolio. The funding for this has come from campus and the College via funding from deferred maintenance, capital asset planning, debt issuance, startup funding, and calls for smaller renovation and beautification projects throughout the College.

4. Assess the adequacy of the resources described in this section with respect to the students in the program being able to attain the student outcomes.

The campus and the college continue to strategically place resources towards increasing the retention and graduation of its students and achieving our student outcomes. Financial support for students comes in the form of institutional financial aid, financial aid provided by the college, student hourly and work-study positions, and funding for assistantship positions. Ancillary support comes in the form of extensive undergraduate and graduate advising, health and wellness programs and counseling, support for student groups, a multitude of opportunities for undergraduate and graduate level research, and connections with industry for capstone projects as well as internships and post-graduation job opportunities. Through updating of student spaces, labs, classrooms, and the construction of new buildings, the infrastructure support has been extensive.

C. Staffing

All staff members complete specific training courses upon hiring. These include a general campus employee orientation, college orientation, harassment and discrimination awareness, fiscal code of ethics, and IT security. Training specific to individual positions is facilitated by the campus and college. For example, initial training of the undergraduate advisors is supported by the dean's office. The Program's office manager also holds regular staff meetings to review best practices and any procedural changes. As needed, the office manager and financial manager also recommend additional training courses for their supervisees, such as interpersonal conflict resolution or communication courses. Self-directed training is also available for the professional development of staff, which is often facilitated by the office manager and finance manager.

The college additionally supports training and professional development for staff with funding for exam fees, training sessions, workshops, conferences, certification programs or other activities that enhance professional skills. The request may be directly related to the individual's current job or may enhance general professional development and should be in alignment with CU Boulder's strategic emphasis on leadership, innovation and positive impact. Funding of up to $500 per staff member per fiscal year and per event is available on a first-come, first-served basis. A 1:1 or greater cost share is expected from the staff member's unit.

The department has an excellent staff to support the Architectural Engineering program:

- Human Resources and Operations Manager (Madison Lane)
- Office Operations Coordinator (Andraa von Boeselager)
- Student Services & Curriculum Coordinator (Rebecca Rico)
- Undergraduate Academic Advisor Area Director (Erin Jerick)
- Undergraduate Academic Advisors (Rebecca Dizon, Toni Gossett)
- Financial Services Manager (Kathy Stutzman)
- Senior Finance & Grant Specialist (Sharon Mackey)
- Senior Finance & Grant Specialist (Tracy Hertzfeld)
- Senior Communications Specialist (Susan Glairon)

Part-time student assistants are hired on an as-needed basis to assist with special activities demanding more staff time.

The Department has a contract with the University's Office of Information Technology (OIT) to provide desktop support to faculty and staff, and to its Bechtel Lab Computer Lab. This OIT contract is equivalent to approximately a half-time position. The Department supports the Laboratory positions through its operating budget. The OIT contract is supported through program fees.

The Department participates in the College's Staff Excellence Program. This program funds - (i) opportunities for staff training and professional development, (ii) performance-recognition awards, (iii) a peer-mentoring program, and (iv) engagement in social events and college activities. The Department financially supplements the College's program to assist in professional development for the staff. Professional development and training strengthens staff members' capabilities to take on additional responsibilities, (e.g. the latest upgrade of the Human Resources and Financial Systems, CU Marketplace, CU-SIS student information system, and the new graduate application system). Staff are also given the opportunity to enroll in job-related or career enhancing classes on campus, taking advantage of the tuition benefit of 9 credit hours per academic year. Staff arrange work time, if necessary, with their supervisor, to take these classes.

Staff Awards

The Staff Excellence Program was formed in 2009 based on recommendations made as part of strategic planning. These recommendations include staff growth, training, engagement, and recognition, as well as improving efficiency of administrative processes. Listed below are several opportunities for staff to help meet these recommendations.

- The Commitment to Excellence Award was established by the college to retain excellent staff by creating a supportive work environment for its employees. Recipients of this award shall have reached a five-year anniversary of continuous service as a professional exempt or classified staff member of the college with an appointment of at least 50% time.
- Staff Incentive Award recognizes classified and exempt professional staff employees' special accomplishments or contributions to the college, such as innovate ideas, creativity and exemplary performance while undertaking special projects or tasks. The form of the award is a cash award that would generally not exceed $100 in value, though occasionally awards up to $500 in value may be made for particularly substantial service. Funding is provided by the nominating unit. Nominations may be submitted at any time via a short email to the Dean and the CEAS Director of Human Resources.
- The Employee Recognition Award recognizes outstanding classified and professional exempt staff. The award is rotated between the various departments and programs of the College on a monthly basis so that each unit (or clusters of small units) has an opportunity to honor a staff member once each academic year. The award amount is $500 (funding provided by the nominating unit).
- College of Engineering Outstanding Staff Award recognizes a staff member who has made outstanding contributions that benefit the students, staff and faculty of a CEAS department, program, or the college itself. As many as three staff may be selected for this honor each year. The award is presented annually and the winner receives a stipend of $2,000.
- College of Engineering and Applied Science Staff Advisor Award recognizes staff advisors who demonstrate exceptional advising skills and who may serve as role models to other staff advisors in the College. This award is given annually and carries a $1,000 stipend. Recipients of the award are selected based on the scores and comments received on class and advising surveys conducted by the College.

In addition to the awards mentioned above, several departments and programs have established unit-specific staff awards to honor their employees.

D. Faculty Hiring and Retention

The dean, with advice and discussion with the department chairs, assigns growth and replacement (losses due to retirements, resignations, etc.) faculty lines to departments. Faculty recruiting is the responsibility of the department executive committee. Once the department in consultation with the Dean has determined it is allowed to recruit for the following academic year, the executive committee recommends the search area or search areas to the voting faculty for approval. An ad hoc search committee is then formed from all members of the executive committee supplemented by other faculty who agreed to be on the committee after being invited by the executive committee.

The ad hoc committee is responsible for advertising the position(s), evaluating candidates and recommending to the Chair and the faculty a slate of candidates to be interviewed. The slate must be approved by the Dean. The search committee will organize the campus visit by the finalists and provide the faculty with an evaluation and ranking of the candidates after all visits are complete. The voting faculty shall discuss the candidates and vote by secret written or electronic ballot on which candidate to recommend to the Dean.

In some cases, the search will be for an interdisciplinary faculty member. In those cases, the search committee will have members from several departments. Detailed information about the procedures for faculty hiring are found at http://www.colorado.edu/engineering-facultystaff/recruitment-process-tenure-track-faculty.

When the department has selected its preferred faculty hire, the Dean must then approve the individual. Note that if a faculty is being hired with tenure, the individual must be reviewed through the entire standard tenure process (review by primary unit, first level review, Dean, VCAC, and eventually approved by the Regents).

To retain current qualified faculty, the University benchmarks its salary and benefits against peer institutions. The College and University can also offer a retention package if a faculty member has a competing offer from another university. Retention packages vary, but typically include salary increases, student support, reduced teaching load, lab space or other benefits to entice the faculty member to stay.

E. Support of Faculty Professional Development

The College and the Department provide funds for professional training at workshops or national meetings. These opportunities are available to all faculty on a “funds available” basis. Examples include a College program that sends faculty to American Society for Engineering Education (ASEE) meetings and workshops, and a program to provide travel funds for faculty to visit funding agencies, with the Department providing funds to match what the College is providing.

The College supports professional development of faculty through the Faculty Excellence Program[colorado.edu/engineering-facultystaff/awards-incentives/college-awards/faculty-excellence-program](colorado.edu/engineering-facultystaff/awards-incentives/college-awards/faculty-excellence-program), which provides a number of financial support opportunities. This includes:

- **Dean's Faculty Fellowships -** Selected faculty members are given one semester off from teaching a course, to focus on a major initiative in research and scholarly work or development of substantial educational materials or initiatives
- **Dean's Seed Funds for Novel Ideas -** Discretionary funds up to $10,000 ($15,000 if multiple units involved) provide seed support for new ideas, and are matched 1:1 by the department or program
- **Dean's Performance Awards -** $5,000 awards are given for top performance in categories such as research, teaching, professional progress, and overall performance of junior faculty based on annual performance evaluations for the prior calendar year
- **Matching funds** for research grants, laboratory renovation funds, and travel to funding agencies
- **Sabbatical Supplement Program -** This program offers an additional 20% of the academic-year salary to faculty members taking full-year sabbaticals, on top of the normal 50% of the academic-year salary that they receive on sabbatical. The department then retains the remaining 30% of the academic-year salary, and the faculty member is responsible for raising (or forgoing) 30% of her or his salary. In addition, the Dean will provide $4,000 in discretionary funds for research, travel, etc. to each faculty member who successfully applies for this program.

PROGRAM CRITERIA

The program criteria for architectural engineering programs include requirements for both curriculum and faculty. Each of these requirements and how the CU Architectural Engineering program fulfills the requirement are explained below.

1.1 The curriculum must demonstrate that graduates can apply mathematics through differential equations, calculus-based physics, and chemistry.

All Architectural Engineering students in the BS program take 33 credits of math and basic sciences, including three semesters (12 credits) of calculus, one semester of differential equations and linear algebra (4 credits), two semesters of calculus-based physics (8 credits), and one semester of basic chemistry with a laboratory (5 credits). [These courses are shown on the block diagram in section 5.A and associated Table 5-1.]

Performance in subsequent engineering courses both depends on and reinforces students' basic knowledge in mathematics, physics, and chemistry. Calculus and differential equations (APPM 1350, 1360, 2350, 2360) and Physics 1 (PHYS 1110) are prerequisites for the fundamental engineering science courses (thermodynamics, analytical mechanics 1, fluid mechanics & heat transfer). These courses are in turn pre-requisites for the various AREN fundamentals courses, which in turn are pre-requisites for proficiency courses and AREN/CVEN technical elective courses.

Measures of students' attainment of proficiency in math and basic science depends on internal measures, such as student work in architectural engineering courses requiring application of these fundamentals, and on external measures such as the Fundamentals of Engineering (FE) Examination. As described above in section 4B for student outcome 1, ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics, our direct and indirect evidence indicates adequate student fulfillment of this outcome.

1.2 The five basic architectural engineering curriculum areas are structural engineering, building mechanical systems, building electrical systems, construction engineering and management, and lighting. Graduates are expected to reach the synthesis (Design) level in one of these areas.

Graduates of the AREN program are expected to acquire a broad education in architectural engineering by taking comprehension- (see Section 1.4) and application-level (see Section 1.3) courses in all five engineering disciplines—structural engineering, mechanical engineering, electrical engineering, illumination engineering, or construction engineering and management. Each student must also select a discipline for specialization. Each specialization is a separate option within the program, defined by 6 credit hours of upper division technical elective courses. Students have the option of pursuing (a) an additional 6 credit hours of technical elective courses in a specialized discipline to acquire technical depth in that area or (b) selecting an additional 6 credit hours in another area (or areas) of specialization.

1.3 …the application level in a second area…

The current curriculum requires all AREN students to take application-level courses in *all* five areas of AREN, as shown below:

Area	Fundamental Courses (application)
Structural Engineering	CVEN 4545 (Reinforced Concrete Design) or CVEN 4555 (Steel Design)
Building Mechanical Systems	AREN 4110 (HVAC Design)
Building Electrical Systems	AREN 4570 (Electrical Systems)
Construction/construction management	AREN 4506 (Pre-Construction Estimating & Scheduling)
Lighting	AREN 4550 (Illumination 2)

1.4 …and the comprehension level in the remaining two areas.

There are five fundamental/comprehension-level courses that all AREN students are required to take that cover all five areas of AREN as shown below:

Area	Fundamental Courses (comprehension)
Structural Engineering	CVEN 3525 Structural Analysis
Building Mechanical Systems	AREN 3010 Energy Efficient Buildings
Building Electrical Systems	AREN 3040 Electrical Circuits
Construction/construction management	CVEN 3246 (Introduction to Construction)
Lighting	AREN 3540 Illumination 1

1.5 The engineering topics required by the general criteria shall support the engineering fundamentals of each of these five areas at the specified level.

The five fundamental courses are supported by the following required general engineering topics:

Engineering Fundamentals	Pre-Requisite General Engineering Courses
CVEN 3525 Structural Analysis	CVEN 3161-3 Mechanics of Materials I
AREN 3010 Energy Efficient Buildings	AREN 2110-3 Thermodynamics, AREN 2120-3 Fluid Mechanics & Heat Transfer

AREN 3040 Electrical Circuits	APPM 2360-3 Intro Differential Equations PHYS 1120-4 General Physics 2
AREN 3540 Illumination 1	APPM 2350-3 Calculus III for Engineers, CSCI 1200-3 Intro to Engineering Computing
CVEN 3246-3 Introduction to Construction	Restricted to students with 57-180 credits (Junior or Senior)

1.6 Graduates are expected to discuss the basic concepts of architecture in a context of architectural design and history.

All AREN students are required to take 1 course (3 credits) of the history and theory of architecture (ARCH 3214). In addition, they must take AREN 3080, a junior architectural studio in the sophomore year. In addition, all students take AREN 4318 Architectural Engineering Design 1, a 5-credit course that includes two credits of architectural design and 3 credits of systems design that precedes and feeds into the AREN 4319 capstone design course. Syllabi for these courses are found in Appendix E.

2. The design level must be in a context that:

a. Considers the systems or processes from other architectural engineering curricular areas

The AREN 4318/4319 senior capstone is a project-based course aimed at having students synthesize and apply the knowledge acquired in previous courses. Only students in their fourth year may take this course and they must have taken the fundamentals of architectural engineering as pre-requisites:

- AREN 3080: Architectural Design Studio 1
- AREN 4110: HVAC System Design
- AREN 4506: Pre-Construction Estimating and Scheduling
- AREN 4550: Illumination 2
- CVEN 4545 Steel Design or CVEN 4555 Reinforced Concrete Design

Students must petition entrance to the course if they don't meet a requirement.

In addition, since students are divided in teams whereby each discipline is represented. Students hoping to lead their own discipline should meet their respective specialization course, that is:

- CVEN 3256 Construction Equipment & Methods
- AREN 4550 Illumination 2
- AREN 4570 Electrical Systems
- AREN 4110 HVAC Design
- CVEN 4545 Steel Design or 4555 Reinforced Concrete

Students may need to be paired in a group with another person of the same discipline if deficiencies are encountered. Students may also volunteer to do a different discipline. An example of this is with the HVAC discipline. In the last few years, there have not been enough HVAC students in the class and in order to form a complete group (with all five disciplines) students choose to work on HVAC.

b. Works within the overall architectural design,

The AREN curriculum is designed so that all students take a 7-credit design experience in their senior year. Two of those credits are spent in a studio design experience in which students learn architectural principles and design. Students also design a building (typically 15,000 to 30,000 ft. sq. commercial building) which they will bring to the engineering design class. It is to these buildings that students apply architectural engineering processes and systems.

c. Includes communication and collaboration with other design or construction team members

Students work in teams for the duration of the course. The teams are multidisciplinary as all five architectural engineering tracks are represented. Collaboration within the teams is not only encouraged but necessary in particular during the schematic and design development phases as students need to coordinate with each other to ensure a cohesive design and one that meets specific constraints like LEED, codes, budgets, and equipment placement. Lectures, workshops, and assignments related to LEED, value engineering and clash detection help ensure communication and collaboration between team members.

d. Includes computer-based technology and considers applicable codes and standards

Starting with the programming phase, students begin their re-acquaintance with the codes and standards that govern their buildings. Students use early-stage computer programs, like SketchUp, Rhino, and Grasshopper, to inform preliminary designs. Specific discipline lectures by industry professionals kick off this process. In the conceptual phase, students explore and synthesize in their reports the codes and standards that apply to their respective disciplines. In the schematic students are asked to provide some kind of corroboration that they are meeting the most relevant codes and standards. By the design developing phase, students use software to perform calculations to demonstrate compliance.

e. Considers fundamental attributes of building performance and sustainability

Students receive specific assignments per discipline that helps them develop, from the ground up, systems that will be functional and sustainable. Students are required to show, not only that their buildings meet codes and standards, but that these also comply with minimum standards of care, function, and comfort. Lectures on these topics are provided by industry professionals. In addition, students are assigned professional mentors who review their work, provide feedback and share with them current techniques and practices related to building performance and sustainability.

2.1 Faculty Qualifications to Teach Design

"The program shall demonstrate that those faculty members teaching courses that are primarily design in content are qualified to teach the subject matter by virtue of education and experience or professional licensure." (ABET, EAC, 2017-2018… p. 9-10)

For the capstone design course in AREN, a team of 5 faculty routinely teach the course. For the past two years (Fall 2021-Spring 2023), the course has been coordinated and led by Jay Arehart, an EIT who has industry design experience. Prof. Arehart worked as a structural designer at KL&A for two years designing custom residential and mixed-use projects along the Front Range of Colorado and Wyoming. He is a co-chair of the Structural Engineering Institute (SEI) Sustainability Committee, responsible for directing the development of a standard. Consultant to architecture firms and software companies conducting preliminary structural designs and performing life cycle assessments. For the previous four years (Fall 2017-Spring 2021), it was led by Sandra Vásconez, who is a Senior Instructor in the Department. While she is not a licensed Professional Engineer or Registered Architect, she has extensive experience with lighting design since 1998. As manager of program development at the Lighting Research Center at Rensselaer Polytechnic Institute, she was heavily involved in research, testing, and design projects with the lighting industry. She was the manager of the DELTA (Demonstration and Evaluation of Lighting Technologies and Applications) Program. As such, she published 8 lighting studies demonstrating best-practices and lessons learned in lighting design. From 2004-2007, she worked on design and installation of museum exhibits at a lighting design firm in Boulder, CO. She continued to freelance in this area until 2010. Other instructors vary somewhat each term. Each term the course includes a minimum of 1 instructor who is a licensed PE. Instructors are summarized below:

AREN 4318/4319 Instructors

Term	Instructor Team
Spring 2020 AREN 4317	Zuo, Stershic, Bastias, Krarti (electrical PE) Vásconez (lighting), Xi (structures)
Fall 2021 AREN 4318	Senseney (CEM PE), Arehart (HVAC), Vásconez (lighting), Taylor (structures)
Spring 2021 AREN 4317	Senseney (CEM PE), Arehart (HVAC), Krarti (electrical PE) Vásconez (lighting), Zhai (structures)
Fall 2022 AREN 4318	Senseney (CEM PE), Arehart (HVAC), Krarti (electrical) Vásconez (lighting), Taylor (structures)
Spring 2022 AREN 4319	Senseney (CEM PE), Arehart (HVAC), Krarti (electrical PE) Vásconez (lighting), Taylor (structures)

Fall 2022 AREN 4318	Senseney (CEM PE), Arehart (HVAC), Krarti (electrical PE) Vásconez (lighting), Taylor (structures)
Spring 2023 AREN 4319	Senseney (CEM PE), Arehart (HVAC), Taylor (structures), Baker (electrical) Vásconez (lighting)

For the instructors who are not PEs (as noted in the table above), design experience is summarized below with more detail provided in the individual resumes in Appendix B (full-time faculty). CVs for Ph.D students are provided in the supplemental materials available during the site visit.

Jay Arehart, Ph.D.
Worked as a structural designer at KL&A for two years designing custom residential and mixed-use projects along the Front Range of Colorado and Wyoming. Co-Chair of the Structural Engineering Institute (SEI) Sustainability Committee, responsible for directing the development of a standard. Consultant to architecture firms and software companies conducting preliminary structural designs and performing life cycle assessments.

Kyri Baker, Ph.D.
Dr. Baker has worked in both residential buildings and power systems engineering. She designed operational algorithms to control physical devices within a home that was later deployed in a mountain community in Colorado to improve community resilience and lower cost for residents. During her time at the National Renewable Energy Laboratory, she designed a technique to operate smart inverters for voltage stability and was lead inventor on a patent on this topic.

Sandra Vásconez
Co-created, co-manage, and co-teach in CU's graduate Architectural Lighting certificate and the short intensive summer course offered by the Rocky Mountain Lighting Academy. Both these offerings by the lighting program within Architectural Engineering are focused on industry professionals, which require current and applicable lighting knowledge to meet the needs of a lighting field practitioners.

Wangda Zuo, Ph.D. (Now at Penn State)
Worked as Research Scientist at DOE national lab to develop open source software for building energy and control system. Conducted research on various building energy and control software development and performed multiple demonstration projects in real-world systems, including chilled water plants, data centers, district cooling systems.

Yunping Xi, Ph.D.
Worked as structural engineer at Beijing Central Research Inst. of Building and Construction and Beijing Design Institute of Building and Construction. In these institutions participated in many projects designing high-rise apartment buildings, a middle school, a movie theater, and rehabilitation projects for steel mills. Conducts research and evaluation projects related

to highway bridges, DIA radar control building, and containment structures of nuclear power plants.

John Zhai, Ph.D.
Combined degree in Mechanical Engineering and Architecture with both research and practice interest and experience in sustainable building design. Leads the evaluation and development of a few building systems and associated code developments sponsored by ASHRAE (such as for active chilled beam system, hospital and data center ventilation systems etc.). Serves as full-time senior fellow and project manager for RMI, participating/leading over 10 design and retrofit projects in 2011. Recently, has served as green building consultant for several major projects in China, such as the 452m tall Suzhou International Finance Square project, designed by KPF.

The instructors for other proficiency and concentration courses in the curriculum with large design elements are shown below.

Proficiency:

Course	AREN 4110 HVAC Design	AREN 4550 Illumination II	AREN 4570 Electrical Systems for Buildings	CVEN 3256 Constr Equip & Methods	CVEN 4545 Steel Design	CVEN 4555 Reinforced Concrete Design
Instructor	Henze (PE) Zhai	Vasconez	Krarti (PE)	Senseney (PE)	Hearn (PE)	Hearn (PE)

Concentration:

Course	AREN 4550 Illumination II	AREN 4570 Electrical Systems for Buildings	AREN 4560 Luminous Radiative Transfer	AREN 4080 Computer Simulation of Building System	AREN 4890 Sustainable Building Design	CVEN 4545 Steel Design	CVEN 4555 Reinforced Concrete Design
Instructor	Vasconez	Krarti (PE)	Scheib	Krarti (PE)	Henze (PE)	Hearn (PE)	Hearn (PE)

A brief summary of the design experience for individuals without a PE license who have not been described already above is provided here.

Jennifer Scheib
Worked as a daylighting design consultant at Architectural Energy Corporation and as a research engineer at the National Renewable Energy Laboratory. In both roles, worked on daylight and electric light modeling software development projects that required an understanding and use of light modeling approaches including stochastic ray tracing and luminous radiative transfer.

2.2 It must demonstrate that the majority of the faculty members teaching architectural design courses are qualified to teach the subject matter by virtue of professional licensure, or by education and design experience.

AREN 3080 and AREN 4318 architectural design courses and components are taught by Jay Arehart and Jennifer Scheib.

Jennifer Scheib
Worked as a daylighting design consultant at Architectural Energy Corporation and as a research engineer at the National Renewable Energy Laboratory. In both roles, worked on daylight and electric light modeling software development projects that required an understanding and use of light modeling approaches including stochastic ray tracing and luminous radiative transfer.

Jay Arehart, Ph.D.
Worked as a structural designer at KL&A for two years designing custom residential and mixed-use projects along the Front Range of Colorado and Wyoming. Co-Chair of the Structural Engineering Institute (SEI) Sustainability Committee, responsible for directing the development of a standard. Consultant to architecture firms and software companies conducting preliminary structural designs and performing life cycle assessments.

ACCREDITATION POLICIES AND PROCEDURES MANUAL

A. Accreditation Status

The Architectural Engineering Bachelor of Science degree is accredited by the Engineering Accreditation Commission of ABET, https://www.abet.org, under the General Criteria and the Architectural Engineering Program Criteria.

B. Publicization

Accreditation Status

https://www.colorado.edu/ceae/accreditation

Program Educational Objectives (PEOs) & Student Outcomes (SOs)

https://www.colorado.edu/ceae/about/undergraduate-degrees/architectural-engineering-educational-objectives

Enrollment and Graduation/Degree Data

https://www.colorado.edu/engineering/accreditation

C. Safety Manuals

Center for Infrastructure, Energy, and Space Testing (CIEST)

Operations and Safety Protocol

Prepared by

Thomas Bowen & Victor Saouma

Revisions by

Victor Saouma, Petros Sideris & Yunping Xi

October 2014

&

Brad Wham

October 2017

Department of Civil, Environmental, and Architectural Engineering
University of Colorado Boulder

Contents

For your safety and for the safety of those around you, please adhere to the safety guidelines of CIEST. Below is a summary of the most important safety requirements for use of the labs. Please be sure to review them prior to using the laboratories, and always check with CIEST staff if you have any questions.

1 Getting Started

The Center for Infrastructure, Energy, and Space Testing (CIEST) is currently managed by the CIEST Manager, Dr. Brad Wham, and Co-directors Prof. Mija Hubler and Prof. Shideh Dashti.

CIEST places the safety of individuals in the lab above all else. As such, all individuals wishing to access the lab must comply with the following policies:

- Review this Safety Manual and prepare for a safety test with a designated CIEST personnel
- Fill out and submit the *Release from Responsibility, Assumption of Risk and Waiver*, available at the end of this document
- Fill out and submit the *User Agreement and Acknowledgement of Safety Orientation*, available at the end of this document
- If you are starting a new project, fill out and submit a CIEST Research Information Sheet to the CIEST staff

Hours of Operation for the CIEST facilities are Monday to Friday from 8:30am to 5:00pm. All doors to CIEST are locked at the end of the day. After hours and weekend operations must be approved by the CIEST Management.

All tasks taking place in the CIEST lab or making use of CIEST equipment, tools and machinery must be approved by the CIEST staff.

Due to the risk posed by the testing and machining environments within CIEST, CIEST is **not** a walk-through lab. Access to CIEST must be approved by lab personnel.

Any questions should be directed to Brad Wham (Brad.Wham@colorado.edu), Mija Hubler (Mija.Hubler@colorado.edu) and Shideh Dashti (Shideh.Dashti@colorado.edu).

2 IN CASE OF INJURY

2.1 EMPLOYEE ON-THE-JOB (OTJ) INJURY PROTOCOL

If you are injured while OTJ please follow the following procedure. Please note that CU Risk Management pays for all OTJ injuries (including ambulance rides) and requires injured employees to follow certain protocols to receive care. For medical emergencies, or if you are unsure of what to do, CALL 911. First responders can provide additional first aid and tell you if you need the ambulance or not, and you are never charged for an ambulance showing up or for taking one to the hospital if you are injured OTJ.

1. Before administering care, assess the scene and person for safety hazards. Identify the cause of the injury. Do not approach the person unless the scene is safe.
2. If the person is awake and responsive and there is no life-threatening or severe bleeding, put on appropriate PPE (such as disposable gloves for any bleeding) and get the First Aid Kit. Inspect the person for all injuries and administer first aid as required. If the person requires treatment beyond first aid for their injury, they are required to seek treatment at one of CU's Designated Medical Providers, a list of which is available at the CU's Risk Management Website.
3. If there is severe bleeding, head injury, any injury severe enough to be questionable, or if the person cannot transport themselves to get care, CALL 911.
4. If the person appears to be unresponsive, shout to get their attention, tap their shoulder, and look for normal breathing. Check for responsiveness for no more than 5 seconds. If the person is unresponsive, CALL 911. If the person is not breathing, ensure that they are face-up. Begin CPR or use an AED if one is available. If the person is breathing and does not appear to have obvious signs of injury, roll them onto their side and obtain information about what happened while you wait for first responders to arrive.
5. After treatment, you have 4 days to complete the Employee Injury Report Form on Risk Management's Website. Failure to do so may reduce your Worker's Compensation. Report your injury to Brad Wham, Shideh Dashti, Mija Hubler, and Brice Lucero as soon as you are able.

2.2 NON-EMPLOYEE INJURY PROTOCOL

For medical emergencies, or if you are unsure of what to do, **CALL 911**. First responders can provide additional first aid and tell the student or non-employee whether they need the ambulance or not. No one can be charged for the ambulance unless they choose to ride it to the hospital or if the first responders determine that the injured person needs emergency medical attention. Note that students and all non-employee users of the lab are required to sign a liability waiver provided to CIEST by the University.

The injury procedure for non-employees is outlined in steps 1-4 above.

3 Personal Protection Equipment (PPE)

Personal Protection Equipment (PPE) is required to both enter CIEST and use its equipment, and the level of PPE must be adequate for the activity being performed. The lab provides the following PPE for use by all individuals in the lab:

- Hard Hats
- Gloves
- Safety Glasses
- Up to APF 10/N95 Respiratory Protection

Individuals in the lab are responsible for utilizing the correct PPE to protect themselves and others from injury. If you are unsure of what PPE you need to complete a task, you are responsible for asking CIEST personnel. Please note that it is the responsibility of the Principal Investigator to provide PPE, other than what is provided by CIEST, for their researchers or employees working in the lab. This may include, and is not limited to, long pants, steel-toed boots, high-grade respiratory protection, hearing protection, and/or hazardous materials storage and disposal devices.

3.1 Hazardous Materials

All persons working in any fashion at CIEST MUST receive Hazardous Materials safety training from the Environmental Health & Safety Program on Campus. This is mandated by University policy. All such personnel will be given 60 days receive the training and failure to do so will result in a revocation of lab access until policy compliance is satisfied.

Prior to procurement or production of any Hazardous Materials researchers MUST review all storage and disposal guidelines outlined on the University's Environmental, Health and Safety website (https://ehs.colorado.edu/). Regarding the Hazardous Materials Used or Produced section on the "Research Information Sheet" included at the end of this document, please list all materials to be used as they may be considered harmful by themselves (the status of which may change in different states) or with combinations with other materials used within the laboratory.

Hazardous materials should be handled only within their designated areas and must be stored and disposed of properly. It is the responsibility of the lab user to know how to safely store and dispose of all materials they use in the lab. A project in the lab is not considered complete until all materials have been stored or disposed of properly. Failure to properly store and dispose of materials, hazardous or not, will result in a disposal fee from the lab and a warning. Continued failure to comply with the storage and disposal policy will result in revocation of lab access. If you are not sure of designated areas and/or appropriate disposal methods and storage locations, please contact the CIEST staff. We are here to assist you with your research.

3.2 Materials, Machinery, Equipment and Tools

Before you use any materials, machinery, tools and equipment, you need to receive permission and training by CIEST staff. Lab users may only use tools, machinery, and materials that they have received explicit permission and training to use by CIEST staff and may only use them for their intended purpose. When finished, please return all materials, machinery, equipment, and tools to their designated location in safe and clean condition. **If damage occurs to any machinery, equipment, or tools during operation, please report to CIEST personnel immediately**.

Most of CIEST's electrical equipment and tools are contained in a limited access storage area. You may sign-out these items Monday-Friday from 9:00am - 4:30pm with a CIEST personnel. Please remember to return them by the end of each day, so that we can make them available for other lab users.

CIEST personnel are available to assist you. Please ask for their help rather than risking personal injury or damage to any equipment. **Operation of the forklift and overhead crane is restricted to trained CIEST personnel only**. The CIEST Manager or a designated employee may make exceptions on a case specific basis.

3.3 Basic Rules

1. Wear a hard hat and safety glasses at all times you are on the strong floor. Use all PPE as directed.
2. Long-hair must be tied back to keep it from catching in equipment or machinery.
3. Keep doors closed at all times, and locked after 5:00pm, Monday - Friday and all weekends.
4. Observe safety rules for hoisting
5. Keep areas clean and uncluttered. Work areas must be cleaned after use.
6. Clean and return tools after use
7. DO NOT modify machinery, equipment, or tools for your own use
8. Immediately notify CIEST staff of damaged machinery, equipment, or tools
9. All materials, hazardous or not, must be stored and disposed of properly. No pouring chemicals of any kind down the drains.

4 SAFETY INTRODUCTION AND ORIENTATION TO CIEST AND LIABILITY WAIVER

At the back of this safety packet you will find two pages that must be filled out and returned to CIEST staff prior to beginning any work in CIEST. Those documents are the: (i) User Agreement and Acknowledgement of Safety Orientation, and (ii) Waiver of Liability Form.

4.1 AWARENESS

CIEST is covered with machinery and equipment that can cause life-threatening injury if interacted with improperly. All CIEST users are responsible for being aware of their surroundings, which both protects themselves and the other users of the lab. Being aware of your surroundings entails, but is not limited to, ensuring machinery is being used safely; ensuring materials are not positioned in an unsafe manner; watching for any hoisting activity; ensuring long hair is tied back; etc. CIEST staff reserve the right to revoke access to the lab if they have reason to believe someone's lack of awareness is compromising lab safety.

4.2 POWER TOOLS

4.2.1 General

When working with any of the power tools kept in the lab, proper PPE must be worn. This may include, but is not limited to:

- Steel-toed boots
- Safety goggles
- Gloves
- No loose clothing or hair
- Long pants

Plan how you intend to use all tools, equipment, and machinery and prep your work area before use. Be familiar with the power tool you are planning to use. <u>If you are not familiar with the equipment, ask for assistance from CIEST staff.</u>

4.2.2 Equipment

Always seek tool specific training from CIEST personnel before use. Always inspect the equipment for damage before use. Clean and return the tools when you are done with them.

4.2.3 Power Saws

1. Only use the saw as it is intended.
2. Ensure hands, hair, body parts, and loose clothing are secured and out of the way before use.

3. When applicable, use clamps or guards (i.e. clamp on steel chop saw)
4. If you change a blade, first unplug the saw. Ensure it is the right blade (size, arbor size and style, rpm rating) and that it is in the correct orientation, as well as tightly secured.
5. Be sure to ask for assistance if the object you are cutting is too large or cumbersome for one person to handle.

4.2.4 Power Drills

1. Ensure hands, hair, body parts, and loose clothing are secured and out of the way before use.
2. Ensure you are using the proper drill bit for what you are doing (end mills are not drill bits).
3. If using the mill or drill press, do not to drill into the support platform. Set up a depth stop or place a piece of scrap wood under the object you are drilling through.
4. All objects must be properly secured when being drilled through. This means utilizing clamps, vices, or other supports to immobilize the object.
5. Use the proper cutting lubricants when drilling. Failure to do so can cause unnecessary wear to the drill bits and damage the item being drilled through.
6. Use a safety chain to support the magnetic-based drill if used in any orientation other than vertical

4.2.5 Nail Gun/Stapler

1. Be sure the pressure on the compressor is set to the correct setting for the specific tool. Do Not use excessive pressure.
2. Only use with wood.
3. Ensure the safety of the environment around you. Do not point the nail gun where a nail could hit another person in the lab or damage other equipment.

4.2.6 Remington Powder Nail Gun

1. Wear additional PPE including ear protection and a hard hat. It is loud and the force of the nail can cause the concrete to shatter.
2. Notify people that you are using this tool and ensure that the environment around you is safe. Do not point the nail gun where a nail could hit another person in the lab or damage other equipment.
3. Only use charges and nails that are approved.

4.2.7 Grinders

1. Clean and inspect area around you before starting. Make sure there are no flammable materials nearby.
2. When grinding, pay attention to where the sparks are flying. Do not grind in such a fashion as to throw sparks onto other personnel in the lab or sensitive equipment.
3. Do not grind aluminum on bench grinders.
4. Use appropriate grinding wheels (size, arbor, material, rpm) and make sure they are in the correct orientation.
5. When using cut-off wheels on the handheld grinders, be sure to position yourself out of danger. The wheels may bind with the material and shoot the grinder back.
6. Make sure the grinding wheels are in good shape. Worn out grinding wheels will fragment during use and send pieces of the grinding wheel flying across the room.

7. Make sure the specimen being cut is correctly supported so it doesn't fall on you or others when the cut is complete.

4.2.8 Arc Welding, MIG Welding, and Plasma Cutting

For electric welders, there is a substantial risk of shock or electrocution if performed incorrectly. Failure to demonstrate adequate safety knowledge of the welding machine and process will result in an immediate revocation of access to the machine.

1. A Hot-Work Permit should be completed before electric arc welding is performed.
2. Inspect all equipment before welding. Look for frayed cables, poor connections, and proper grounding and shielding. Ensure the electrode holder and welding cable are well insulated and in good condition. Ensure all output terminals are insulated, which includes wearing rubber-soled footwear. Are the cables the right size for your job? Are they spread out properly to prevent overheating? Is the gas cylinder connected properly? Is the cylinder secured safely in an upright position? Is your workstation stable, secure, and easy to reach from where you're standing? Is there adequate ventilation in your workspace?
3. Welding currents create substantial Electro-Magnetic Fields (EMF) which can interfere with nearby equipment and medical implants such as pacemakers. Anyone with a pacemaker wishing to weld must contact their physician prior to performing any welding. All personnel welding should implement the following EMF procedures to minimize exposure to EMF from the welding circuits:
   a. Route the electrode and work cables together and secure them with tape whenever possible.
   b. <u>Never</u> coil the electrode lead around your body.
   c. <u>Never</u> place your body between the electrode and work cables. If the electrode cable is on your right side, the work cable should be on your right side as well.
   d. Connect the work cable as close to the area being welded as possible.
   e. Do not work directly next to the welding power source.
4. Keep all flammable materials out of the workspace. This includes grease or oil of any kind.
5. Wear all proper PPE for welding. This includes the appropriate welding jacket, gloves, helmet, and respirator. Long pants and closed shoes must be worn. Other protective wear for heavy work or especially hazardous situations includes flame-resistant suits, aprons, leggings, leather sleeves/shoulder capes, and caps worn under your helmet. Hearing protection must also be worn to both protect the users hearing and to ensure flying sparks or metal stay out of your ears. **Arc welds release significant amounts of UV radiation. Failure to cover all exposed skin will result in UV burns.**
6. Ensure that proper ventilation is in place before beginning the weld, which includes ensuring that you are wearing proper respiratory protection. There are multiple severe risks that arise when welding without proper ventilation and respiratory protection, including exposure to toxic fumes or mass displacement of local oxygen supplies which can cause dizziness, unconsciousness, and death. **The fume plume from welding contains solid particles from the consumables, base metal, and base metal coating. This plume can contain, but is not limited to, Barium, Cadmium, Chromium, Lead, Cobalt, Copper, Manganese, Nickel, Silica, and Zinc. Exposure to these fumes without proper respiratory protection or ventilation <u>can be fatal or cause lifelong respiratory problems and/or cancer.</u> Be aware of what you are welding: was the metal treated with a degreasing agent which will react and outgas when exposed to heat? Is the metal coated in a hazardous substance? If you**

do not know what it is, DO NOT WELD IT. There is one easy way to reduce the risk of fume exposure: keep your head out of the fume plume at all times! If you ever feel lightheaded, dizzy, or a burning sensation in your eyes, nose, or throat, cease welding and get fresh air immediately. Failure to comply with proper ventilation and respiratory protection guidelines can result in the death of you and other people working in the lab.

7. Ensure the work area is dry. Failure to do so exponentially increases the likelihood and severity of electrocution. This includes making sure that your own perspiration is not comprising the safety of the work area.
8. Ensure the settings on the machine are correct for the job you are about to perform.
9. Use the appropriate equipment to handle materials after placing a weld. The materials will be extremely hot and will cause serious burns if you attempt to pick it up without proper equipment and PPE.
10. Protect all other lab users by properly shielding the light from the weld or plasma arc. Looking at an arc without eye protection can cause permanent eye damage, even if only briefly or from a large distance.
11. Never strike an arc on compressed gas cylinders.
12. Place used electrode stubs in a metal container.
13. Always wear a helmet when overhead welding and when other overhead hazards exist.
14. Do not attempt to modify any of the welding machine equipment. Note that power inside the welding machine does not go away when the machine is "turned off." Notify CIEST staff with any concerns you have about the state of the machine.
15. There must be a fire extinguisher in an easily and rapidly accessible location from the welding area.

4.2.9 Oxyacetylene Welding

Gas welding machines should be treated with the same level of precaution as live explosives. Oxyacetylene welding setups have tanks of pure oxygen and pure acetylene. The oxygen and acetylene are not to be used, under any circumstances, for anything except for welding as the setup was designed for. Pure oxygen is not the same thing as air. Never use pure oxygen to blow out any piping or lines or for any such activity. Failure to do handle pure oxygen safely can result in an explosion. Pure acetylene is an unstable gas and has an auto-ignition temperature of 763-824 degrees Fahrenheit. This means that if acetylene is heated sufficiently or reaches 30 psi in a free state, it will violently decompose and explode. The acetylene should **never** be pressurized above 15 psig. Oxygen and Acetylene combusted together creates one of the hottest known flames with a burn temperature up to **6300 degrees Fahrenheit**.

6. A Hot Work Permit should be completed before oxyacetylene welding is performed.
7. Use only certified welding components.
8. Inspect all equipment before welding. Check gas cylinders, flashback arrestors, backflow/ pressure protectors, regulators, hoses, torches and shielding.
9. Check for leaks in the hoses, regulators and connections whenever you change tanks or suspect a leak.

10. Check equipment with soapy water, never a flame. If you detect or suspect a leak in the equipment, stop and effect repairs promptly.
11. Do not use oil on the torch, blow pipe, valves, regulators or any other portion of the equipment as oxygen and oil can start a fire.
12. Do not use pliers on apparatus. Use the proper wrench. Keep wrench on acetylene cylinder valve while in use so it can be shut off quickly if necessary.
13. In the event of a fire emergency, tanks should be shut off and removed from the area. If this is not possible, responding emergency personnel must be notified of the hazard before entry.
14. Do not exceed 15 psi for acetylene or an explosion may occur.
15. Make sure connections are tight when you change tips or other apparatus. Do not over tighten.
16. Do not use oxygen or any other compressed gas to blow dirt off your clothes.
17. Do not permit equipment to run over the hoses; protect them from sharp objects, kinks, and heat sources.
18. Use flint spark lighter; never matches or cigarette lighters
19. Follow the proper sequence for torch ignition.
20. Use special care when cutting, so hot pieces do not fall onto you or equipment hoses
21. Lighted torches should never be laid down, hung up or left unattended.
22. Never "crack" a cylinder in the vicinity of an open flame or fire source.
23. Keep cylinders upright and secured. Keep valve caps on cylinder when not in use.

4.2.10 Slug Cutter

1. Make sure you have had hands on training.
2. Be sure you have enough cutting fluid.
3. Cut at a steady pace as the material will heat-harden and burn up our bit if you start and stop or jam bit into material with varying force.
4. Follow correct usage procedure from training or manual.

4.2.11 Ladders

At CU, there are approximately 20 ladder accidents each year. Consider the following: a Consumer Product Safety Commission report on ladder safety revealed that ladders are one of the most dangerous items in the work environment:

- Nearly 100,000 people are sent to the Emergency Department each year for ladder-related injuries.
- Elevated falls account for 700 occupational deaths every year, which amounts to **15% of annual occupational deaths.**
- Approximately 50% of all ladder-related injuries were due to individuals carrying items as they climbed

There are four main causes of ladder accidents:

1. **Selecting an Improper Ladder for the Job:** When selecting a ladder, ensure that you will not be exceeding the weight capacity or loading height limit for the ladder (you should never step onto the top two rungs of a ladder, and the ladder should extend at least 3 feet above where it is being supported at the top).

2. **Using Worn or Damaged Ladders:** Ladders, like all materials, fatigue with repeated loading over time. Ladders should be periodically inspected for signs of fatigue, such as cracking. If any signs of fatigue are found, the ladder should be discarded immediately.
3. **Improper Use of the Ladder:** Using a ladder improperly by using too few points of contact (you should always have 3 points of contact with the ladder), reaching for things from the top of the ladder, not facing the ladder when climbing, etc. can cause the ladder to tip over or otherwise fail to safely support you. When climbing a single or non-self-supporting (i.e. step ladder) ladder, always have someone to support the base of the ladder.
4. **Incorrect Placement of the Ladder:** Ladders should never be placed against a fragile or mobile surface such as windows or doors and should never be placed next to high-traffic areas or moving objects that are not locked, blocked, or guarded.

The following is a list of safety guidelines that must be followed for use of ladders in the lab:

1. Periodic safety inspections of all ladders is a requirement. Before using a ladder, you should inspect it thoroughly. Check for cracks in the steps and rails, loose or damaged hinges, steps, or braces, and that the ladder is clean and dry. On extension ladders, check that the safety feet are in place and that ropes are not frayed or worn. Metal ladders should be checked for dents and/or bends.
2. **Check if anything is on top of the ladder before moving it**. People are known to leave tools such as wrenches or scissors on top of ladders which can fall and cause life threatening injury.
3. Read and follow all marking and labels on the ladder. Never paint a ladder as this may hide markings and labels as well as cracks and defects.
4. Avoid electrical hazards when using a ladder. Observe overhead for powerlines or exposed electrical equipment. Only non-conductive (non-metal) ladders may be used near electrical equipment.
5. Always maintain 3-point (two hands and a foot, two feet and a hand) contact on the ladder when climbing. Keep your body centered over the middle of the step/rung and <u>always</u> face the ladder when climbing.
6. Ladders must be free of any slippery material on the rungs, steps, or feet.
7. Do not use a self-supporting ladder (e.g. a folding step ladder) and a single ladder (e.g. a non-folding extension ladder) or in a partially closed position.
8. Never use the top rung of a ladder as a step unless it has been designed for that purpose.
9. Only use ladders on a stable and level surface, unless it has been properly secured (top and bottom) to prevent displacement.
10. Do not place ladders on boxes, barrels, or other unstable bases to obtain additional height.
11. Never shift or attempt to move a ladder while a person or equipment is on it.
12. An extension ladder or straight ladder used to access an elevated surface <u>must extend at least 3 feet above the point of support</u>. Never stand on the top 3 rungs of a straight, single, or extension ladder.
13. The proper angle for setting up a ladder is to place its base a quarter of the working length of the ladder from the wall or object serving as the point of support for the top of the ladder. For example, if a 20 ft. ladder makes contact with the top of a wall at 16 ft. of its length, the base of the ladder should be 4 ft. away from the wall.
14. A ladder placed in a location where it can be displaced by other work activities must be secured to prevent displacement or a barricade must be erected to keep traffic away from the ladder.
15. Be sure that all locks of an extension or self-supporting ladder have engaged before climbing.
16. Never exceed the maximum load rating of a ladder. Be sure to incorporate the weight of any equipment you are carrying.

4.2.12 Scaffolding

Scaffolds are used when above-ground jobs require more workers and/or equipment than a ladder can safely handle. Scaffolds should be designed maintained and used in compliance with safety standards and specifications. Use only manufacturer's parts when replacing damaged or worn components. A scaffold should be made of strong metal, stress grade lumber, or approved fiberglass. When in use, the scaffold should be secured to the building or wall (mobile scaffolds and ladder stands shall have wheel "locks" to prevent movement). When working on or around a scaffold, a hard hat and safety shoes with nonskid soles should be worn. A safety harness and/or tie offs may be required. The first line of protection in scaffold safety is to inspect a scaffold carefully before each use to look for:

- Footings that are sound, rigid, and capable of holding the intended weight (boxes, barrels, etc., do not qualify)
- Guard rails that are 2" X 4" wide and 3 to 3 1/2 feet high
- Guard rail supports every 10 feet on all open sides
- Toeboards that are 4" high on all sides
- Screens between the guard rails and toeboards if people will pass underneath
- Ladders or other safe methods to get on and off the scaffold
- Poles, legs, or other uprights that are plumb and secured
- Planks that extend 6 to 18 inches over the end supports on wooden scaffolds
- Cross braces on metal scaffolds
- Pedestrian traffic should be routed away from overhead work

Scaffolding can only be used if more than one person is present. Do not use scaffolding by yourself.

4.3 Lifting Safety

Heavy lifting is one of the leading causes of injury in the workplace. In 2001, the Bureau of Labor Statistics published a report detailing that 36% of missed workdays were the result of injuries to the shoulders and back.

When lifting objects to head height or above, regardless of the method, a hard hat is required. Safety glasses should be worn at all times.

4.3.1 Awareness

Take stock of your environment prior to engaging in lifting activities. Do you have enough space to lift? Is your path clear from obstructions and/or slipping or tripping hazards?

1. Be aware of people and equipment around you so nobody gets hit with what you are lifting.

2. Make sure you use the correct pick points when lifting equipment.
3. Think about the next person who will be lifting what you are moving
4. Make sure they will be able to get under it to pick it up (put it on blocks!)

4.3.2 Crane Safety

Cranes are one of the leading causes of workplace fatality. In 2008, the CPWR reported an annual average of 42 deaths in the construction industry directly related to crane incidents. The most common crane accidents are crane-related electrocution (25% of fatalities), crane-load strikes (21% of fatalities), crane strikes (20% of fatalities), and crane collapse (21% of fatalities). Observe the following guidelines:

1. Make sure all straps are in good shape and are rated high enough for what you are lifting. Make sure that the object you are lifting is balanced. There are three ways to use lifting straps:
    - Choker: Least strength
    - Vertical: Medium strength
    - Basket: Strongest
2. Inspect clevises for wear/fatigue and ensure that the clevis you are using has the appropriate rating for the weight you are hoisting. Tighten clevis completely, then back it off ½ of a turn before lifting.
3. Always attach a tag line to the object you are hoisting to keep it balanced and in control while in the air.
4. Ensure sufficient clearance before lifting, which includes inspecting the path that the hoisted object will take to its destination.
5. Always attach a tag line to what you are lifting to keep it balanced and in control while in the air.
6. Make sure you have clearance along any walls you are lifting by, crane can rip stuff off the wall (i.e. pipes, wires, conduit). Make sure you have vertical clearance if moving something over another object (can't go over South Stack).
7. When moving to the loading dock, make sure the wedge is in place before moving crane out the door.

4.3.3 Forklift Safety

Forklift operators and employees around the forklift are susceptible to collisions, falls, tip-overs, and struck-by collisions.

1. Only trained and certified individuals over the age of 18 may operate the forklift.
2. Always operate the vehicle in accordance with the manufacturer's instructions.
3. Always wear a seatbelt when the forklift has one.
4. Never exceed the rated load of the forklift, which is 3500 lbs for the current forklift in the lab.
5. Never raise or lower the load while the forklift is in motion.
6. Always keep the forklift away from platform and ramp edges, or other surfaces which would cause the forklift to fall or tip over.
7. Inspect the pathway of the forklift and ensure you have enough clearance for raising or lowering the load.
8. Always use the horn at cross aisles, blind corners, or other obstructed areas.
9. Do not give rides or use the forklift to lift people.

10. Inspect the forklift regularly and remove it from service if it is found to be in unsafe operating condition.
11. Ensure that the forks are free of excess oil and grease.
12. Set the parking brake when done with the fork lift. Also set the parking brake when lifting someone in the bucket.
13. The forklift has a capacity of 3500 Lbs. This capacity is never to be exceeded.
14. When using straps to lift with the fork lift, you must use clamps to prevent straps from slipping off.
15. When done with the fork lift, put forks on the ground or hidden under something so no one trips over them.

4.3.4 Manual Lifting Safety

A person's ability to lift things manually in a safe manner varies from person to person. For some stronger people, they may be able to carry 50-100 lbs safely; for others, attempting to lift this weight poses a danger to their physical health and safety as well as the health and safety of others. In general, be aware of your personal safe weight lifting capacity. You should never have to strain to pick something up. As a rule of thumb, if you cannot carry something comfortably, get another person to help you move it. If the item is too heavy for two people to lift, perform the lift using the assistance of a machine, such as the crane, the forklift, or a pallet jack.

If you must pick something up, pick up the item from a squat or deadlift position and lift with a straight spine – do not lift and twist your back. If you are uncomfortable lifting or unfamiliar with proper lifting form, ask for assistance from CIEST staff. Someone else can help you lift the item or you can use a machine to do it.

4.4 Hydraulic Safety Protocol

4.4.1 Hydraulic Components in CIEST

On a day to day basis, CIEST may use any of the three hydraulic pumps associated with the lab. This may include working with any of the three MTS machines, any of the actuators, and any other component of the hydraulic systems. CIEST may work on hydraulics during periods of routine maintenance as well. The forklift also utilizes hydraulics for lifting.

Hydraulic equipment uses confined liquid pressure to exert a mechanical force, generally through a piston-like actuator. As such, hydraulic operators are subject to hazards from high-pressure liquids and large mechanical forces, both of which have the potential to cause fatal injury. All safety devices should be in place and in good condition before the equipment is put into operation. All personal **must** be trained on how to use the equipment before operating it. Safety glasses and a hard hat are required to use any hydraulic equipment.

4.4.2 Introduction to Hydraulics

1. Hydraulic systems must store fluid under high pressure using accumulation.
2. Safe hydraulic system performance requires regular general maintenance.
3. Proper coupling of high and low pressure hydraulic components and pressure relief valves are important safety measures.

4.4.3 Hazards of Hydraulics

1. Burns from the hot, high pressure spray of fluid
2. Bruises, cuts or abrasions from flailing hydraulic lines
3. Injection of hydraulic fluid into the skin
4. Fire and explosion from Conveyed Fluids, or Static-Electric Discharge
5. Electric shock- hydraulic hoses are conductive and may carry charge

4.4.4 Pinhole Leak Injuries

Pinhole leaks in hydraulic lines are difficult to locate. A person may notice a damp, oily, dirty place near a hydraulic line. Not seeing the leak, the person runs a hand or finger along the line to find it. When the pinhole is reached, the hydraulic fluid can be injected into the skin as if from a hypodermic syringe. Immediately after the injection, the person experiences only a slight stinging sensation and may not think much about it. Several hours later, however, the wound begins to throb and severe pain begins. By the time a doctor is seen, it is often too late, and the person may lose a finger or their entire arm.

To reduce the chances of this type of injury, **never** check for a hydraulic leak using your hand, even if your are wearing a glove. Alternatively, run a piece of wood or cardboard (or other such material) along the hose to detect the leak.

4.4.5 Improper Coupling

Another hazard is improper coupling of low- and high-pressure hydraulic components. Do not connect a high-pressure pump to a low-pressure system. Do not incorporate a low-pressure component, hose or fitting into a high-pressure system. Component, hose or fitting ruptures are likely to occur.

Make sure to use appropriate hoses for the system. Never use a hose rated lower than the intended pressure for the system. Be aware of the minimum bend radius of hoses, and use elbows and adapters when necessary. Design hoses for change in length due to machine motion and tolerances.

4.4.6 Fire and Explosion Risks

Fires and explosions can occur even with fire-resistant hydraulic fluids under certain conditions. Escaping fluids may form a mist or fine spray, which can explode upon contact with an ignition source. Fluids passing through the hose may generate static electricity, which can ignite fluids under static-electric discharge conditions.

4.4.7 Accumulators

Accumulators can become lethal projectiles if disassembled when pressurized. To ensure safety during disassembly, relieve the nitrogen pressure using the accumulator charging kit. Ensure that hydraulic pressure is at zero before routine maintenance operations. Make sure to use the right type of gas, because mixing gasses can produce unpredictable results. Avoid rapid and extreme pressure changes, which can damage valve seals. Transferring gasses from high to low pressures creates freezing temperatures, this occurs when venting pressurized gas.

4.4.8 Maintenance

An improperly maintained hydraulic system can lead to component failures. Safe hydraulic system performance requires general maintenance.

1. Weekly checks for oil leaks and worn hoses.
2. Keep contaminants from hydraulic oil and replace filters periodically.
3. Check accumulation monthly, more frequently in special cases.
4. Be aware during routine operations of any changes in the behavior of hydraulic systems

4.4.9 Tips for Safe Operation

1. Never service the hydraulic system while the machine engine is running unless absolutely necessary (bleeding the system).
2. Do not remove cylinders until the working units are resting on the ground or securely on safety stands or blocks; shut off the engine.
3. When transporting the machine, lock the cylinder stops to hold the working units solidly in place.
4. Before disconnecting oil lines, relieve all hydraulic pressure and discharge accumulators to avoid lethal projectiles
5. Be sure all line connections are tight and lines are not damaged; escaping oil under pressure is a fire hazard and can cause personal injury.
6. Always use hoses appropriate for the system with correct specifications
7. When washing parts, use a nonvolatile cleaning solvent.
8. To ensure control of the unit, keep the hydraulics in proper adjustment.

4.5 Hot Work

4.5.1 Building Systems

1. Fire sprinklers kept operational
2. Building ventilation protected from smoke and fumes
3. Fire alarm system kept operational; detectors removed only if necessary in the vicinity if they would likely be activated by the work; Facilities Management Fire Alarm Group requires at least 72 hour notice to perform these functions.
4. Cutting and welding equipment in good operating condition

4.5.2 Personnel / Occupant Protection

1. Workers protected from smoke, fumes, toxic materials by use of exhaust ventilation or other approved safety measures
2. Vision screens / barriers in place
3. Confined space entry permit / procedures in place
4. Energized equipment locked / tagged out of service
5. Workers properly trained in use of equipment

4.5.3 Within 35 Feet of Work

1. Floors swept clean of combustibles
2. Combustible floors swept down & covered with damp sand, metal or other spark / heat shields
3. Combustible and flammable materials removed
4. Fixed combustibles and flammables covered with covers, guards, and/or shields
5. Wall and floor openings covered with non-combustible covers
6. Covers suspended beneath work to collect sparks

4.5.4 Work On Walls or Ceilings

1. Construction must be non-combustible and without combustible covering.
2. Combustibles moved away from opposite side of wall and second fire watch provided

4.5.5 Work on Enclosed Equipment (tanks, ducts, plenums, etc.)

1. Confined space entry permit / procedures
2. Compressed gases out of confined space
3. Equipment empty, cleaned of residues, pressure released, purged of vapors, gases shut off

4.5.6 Fire Watch (at work site)

1. Fire watcher shall be present during and for 30 minutes after operation. Fire watcher shall search for any smoldering or flaming ignition and extinguish any such sources.
2. Fire watcher shall be supplied with hose and fire extinguishers of proper size and type and be properly trained in use of same.
3. Fire watcher shall be trained in emergency procedures and activating fire alarm.

4. The permit applicant or their representative shall protect all combustibles from hot work ignition sources. This includes sealing of floor and wall penetrations.
5. Fire watcher shall stop hot work if any of the safety precautions cannot be met.

4.5.7 Intent of Fire Alarm System

The intent of National Fire Protection Association (NFPA) 72 for a protected premise connected to a central monitoring station, requires the fire alarm system to: notify occupants to evacuate when there is a fire in the building, notify the central monitoring station (Facilities Management Service Desk) to initiate emergency personnel response, and activate fire protection systems, e.g., release door holders and shut down fans.

4.5.8 When Building Fire Watch Is Required

1. When, in the opinion of the Authority Having Jurisdiction (FM FPG), it is essential for public safety, one or more qualified persons are to be on fire watch duty (Uniform Fire Code, sec.25.117).
2. In the event of temporary failure of the alarm system or an excessive number of accidental alarm activations, the Jurisdiction's authorized representative may require the building owner or occupant to provide stand-by personnel until the system is restored (UFC, sec.14.110).
3. When work necessitates disabling any fire detection, suppression or alarm system component which would conflict with the intent of NFPA 72.
4. Whenever welding or torch cutting is performed in locations where other than a minor fire might develop, or any of the conditions required by NFPA 51B exist, as indicated on the Hot Work Permit.

4.5.9 How Building Fire Watch is Accomplished

1. Fire watch personnel are to keep diligent watch for fires and are not to perform any other simultaneous duties.
2. Fire watchers are to be familiar with facilities and procedures for sounding an alarm in the event of a fire. The fire watch is to have planned a response method meeting the intent of NFPA 72 (see A. above).
3. Fire watchers are to have fire extinguishing equipment readily available and be trained in its use, including practice on test fires.
4. Fire watchers are to look for signs of fires in all exposed areas, and try to extinguish fires if it can be done safely and within the capacity of the equipment available, and after sounding the building fire alarm to summon emergency response personnel.
5. Fire watch is to be maintained for at least one half hour after completion of hot work operations.

5 Safety Waiver Forms

See pages that follow

University of Colorado
Boulder | Colorado Springs | Denver | Anschutz Medical Campus
UNIVERSITY RISK MANAGEMENT

Revised 2017 October 15

Notice to Participants of Risk and Waiver of Responsibility

Activity____

NOTE: IT IS IMPORTANT THAT THIS DESCRIPTION BE CLEAR AND UNIQUE.

Date: Starting____Ending______________________________________

Participant Name____

Parent/Guardian Name (if minor participant) ____

Emergency Contact Phone Numbers____

The University of Colorado welcomes you as a participant in this activity, including the use of University of Colorado facilities and equipment. Please read through the following important information.

I exercise my own free and voluntary choice to participate in the designated activity, including use of facilities and equipment provided by the University of Colorado. **I understand and assume all associated risks of the designated activity. These risks include, but are not limited to** (add risks specific to event here):

I agree to assume all risk of personal injury or loss, bodily injury (including death), damage to or loss of, or destruction of any personal property resulting from or arising out of participation in the designated activity. I also release, waive, indemnify, hold harmless, and discharge the University of Colorado from all claims, damages, and injuries arising out of my activities, including my use of equipment and facilities provided by the University of Colorado.

The University of Colorado does not provide health insurance for individuals participating in activities made available or sponsored by the University of Colorado. As such, you or your personal health insurance will be responsible for payment of medical services and care for any injuries sustained during the designated activity.

I hereby certify that I have read and understand the provisions above. For participants under 18 years of age, the parent or guardian accepts the above terms and grants permissions for the student's participation on behalf of said minor, as **permitted by *C.R.S. § 13-22-107*.**

____ __________________________
Activity Participant Date

____ __________________________
Parent/Guardian for Minor Date

University of Colorado
Center for Infrastructure, Energy, and Space Testing (CIEST)

User Agreement and Acknowledgement of Safety Orientation

I, ____________________________, hereby agree to abide by the rules and policies of the Center for Infrastructure, Energy, and Space Testing at the University of Colorado while using this facility. I have received and reviewed a copy of these rules and policies as part of the laboratory safety orientation given to me by laboratory personnel.

________________________________ ________________________
Signature Date

____
Print Name and Affiliation

Always remember:

1. This is **NOT a walk-through lab**. You must be working/have a valid reason to be here!
2. Please notify CIEST personnel of your presence. Anonymous use of the lab is not allowed.
3. **Ask CIEST personnel to borrow tools or use equipment**. DO NOT rummage through the office for tools, or use anything in the lab without permission!
4. Follow the **dress code** (steel-toe boots, hard hat and safety glasses).
5. **Clean up** after yourself.

University of Colorado
Center for Infrastructure, Energy, and Space Testing (CIEST)

Research Information Sheet

Nature of Experiment, Equipment Used:		Location in Lab (Room #):	
Start Date:		Expected End Date:	
Research Assistant (RA) Name, Phone, Email		Principle Investigator (PI):	

Hazardous Materials Used or Produced:

Date of Most Recent CU-Sponsored Hazardous Materials Safety Training:

Safety Manual

Lighting Laboratory

Engineering Center ECST 313

University of Colorado Boulder

Laboratory Managers

Sandra Vásconez, sandra.vasconez@colorado.edu

Jennifer Scheib, jennifer.scheib@colorado.edu

Contact Information

Emergencies: 9-1-1

For general inquiries, contact the laboratory managers.

Table of Contents

Introduction

The Lighting Laboratory is primarily a teaching and learning laboratory used to support Architectural Engineering coursework taken by students focusing on the subdiscipline of lighting. In this context, the space is used for design projects, laboratory experiments, and other active learning exercises both during and outside of class time. The space is also used to host events for the student chapter of the Illuminating Engineering Society, to house experimental setups for graduate student research, and to support hands-on learning related to our professional education programs.

The space consists of four rooms (Figure 1): an entry corridor (CR310), the main “lighting lab” room (ECST313), a storage room (ECST 311), and a supplementary “daylighting and controls lab” room (ECST320).

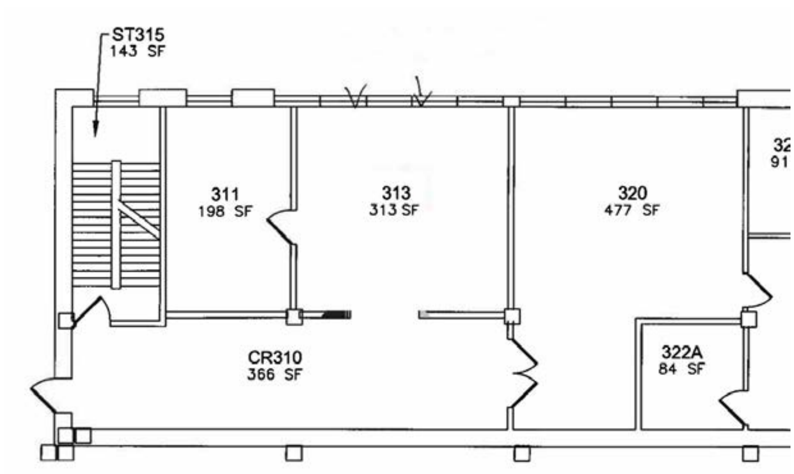


Figure 1: Lighting lab floor plan

Entry Corridor

The entry corridor is wide enough to house lighting demonstrations including adjustable panels for explorations of washing, grazing, and accenting various surfaces and materials, and wall-mounted boxes that allow for visualization of correlated color temperature and color rendering across different lamp types as seen in Figure 2.

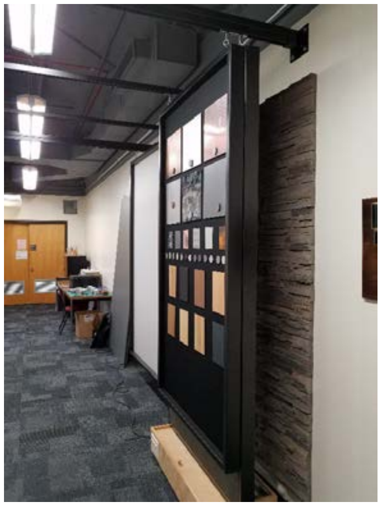


Figure 2: Lighting demonstrations in main corridor (CR310)

Lighting Lab

The lighting lab has various luminaire types installed in an adjustable ceiling, blackout shades, and a system for hanging curtains across the lab to further divide, hang mockup objects, or darken the space. The space houses a wall-mounted goniophotometer that bends the path of light toward an illuminance meter using a large mirror that moves and locks in position using a counterweight and pin connector system.

Figure 3: Wall-mounted goniophotometer (left); blackout shades and curtain-hanging system (right)

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Workshop and Storage Room

The storage room is directly adjacent to the lighting lab, and it houses lamps, luminaires, meters, tripods for mounting lamps, and myriad tools and materials used for demonstrations, model-making, and other course activities. This space also houses a working bench for student use. See Figure 4.

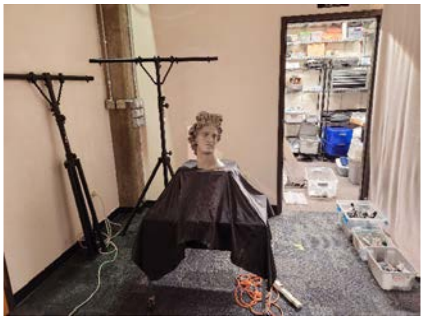

Figure 4: Workshop area in the storage room (left); view to the storage room from the lighting lab (right)

Daylighting and Controls Lab

The daylighting and controls lab has an automated, dual-shade system on the windows, and suspended direct-indirect luminaires connected to an architectural lighting control system. The lab also has four moveable wall panels that are set up to enclose a mock office space lighted by twelve RGBW LED luminaires (Figure 5). Cabinetry is mounted on two walls of the lab for storage of daylighting and controls equipment including microcontrollers, sensors, connectors, and power supplies.

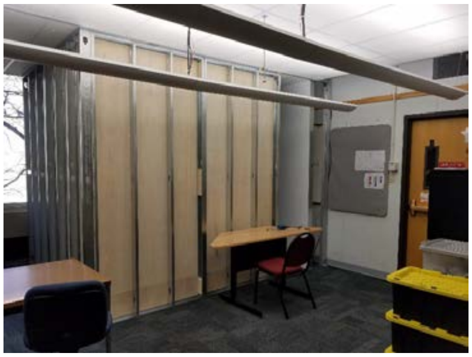

Figure 5: Moveable walls to enclose a mock office space.

Additional Lighting Equipment

Three pieces of equipment are mounted on wheels and moved between spaces to accommodate teaching and learning activities. One is a cart with a mounted illuminance sensor meant to be aimed at the goniophotometer at different distances. The second is an integrating sphere for testing lumen output of sources. The last one is a frame to hold accent fixtures around a bust to test three-point lighting.

Figure 6: Cart with illuminance meter along with integrating sphere (left); frame with accent luminaires (right)

Laboratory Safety

The **primary entrance/exit** for the laboratory is located at the top of the stair tower, ST CHI-28. The door to the laboratory should be closed and always locked except when a laboratory manager or student TA/grader is present and running a class session or event. An additional entrance/exit is in the daylighting and controls lab. This door is to remain locked and alarmed but can be used as an exit in case of an emergency. The door leads to a different laboratory space, which has stairs to other floors of the Engineering Center. There is also an elevator, but it is not available for public use.

A **campus phon**e is in the storage room, which is accessed through the main lighting lab room. The phone is located between the two large black cabinets on the interior wall.

A **first-aid kit** is also located in the storage room, which is accessed through the main lighting lab room.

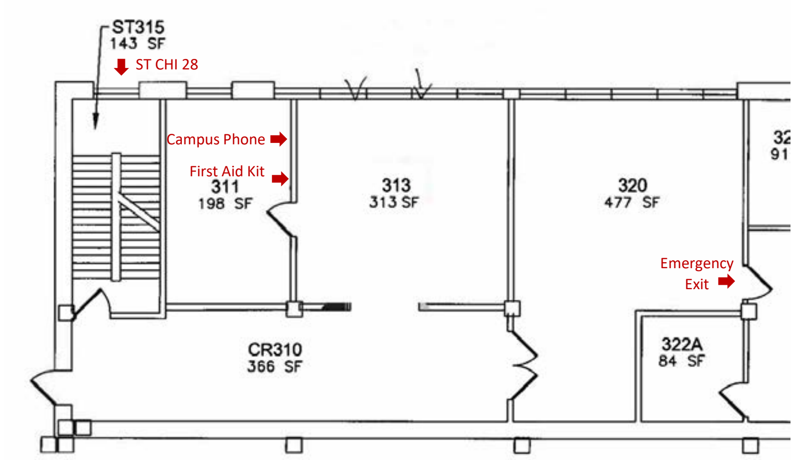

Figure 7: Location of entrance/exit doors, campus phone, first aid kit

Laboratory Procedures and Behavioral Expectations

The following are the procedures and behavioral expectations for all people using the lab:

- Obtain a key from a lab manager to access the lab. Do not share your key with anyone. Keys must be returned at the end of the semester or school year.
- Read and familiarize yourself with the Emergency and Incident Procedures section before using the laboratory.
- Do not work in the laboratory alone. Work in pairs, at a minimum, and let others know you will be using the space through a class sign-up sheet or email to lab managers.

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- Do not block the corridor with objects such as backpacks, bikes, furniture, and the like. When working on demonstrations in the corridor ensure there is a clear path to the primary entrance/exit.
- Do not attempt to retrieve objects on shelves if the use of a ladder is required. The lab managers will have all materials needed for class activities and exercises ready.
- Do not bring the moveable ceiling up or down unless the lab manager is present. The ceiling must remain fully retracted and in the horizontal position unless used for an experiment or mockup.
- Do not leave hazardous materials such as spray paint and other compressed air containers in the lab.
- Do not paint or other materials that release fumes in the lab.
- Do not cut, solder, or use power tools anywhere other than in the workshop area.
- Do not take tools or equipment from the lab without consent from the lab manager.
- Be mindful of your noise level. The adjacent campus laboratory (through the alarmed door) is not acoustically isolated from the lighting laboratory.
- Leave the laboratory tidier than you found it to mitigate incidents such as cuts or tripping, and to support a culture of caution and care.
- Notify laboratory managers immediately with any questions about use or storage of equipment, or with concerns about the behavior of others using the space.

Emergency and Incident Procedures

If an emergency occurs in one of the lab spaces:

- If it is safe to do so, use the fire extinguisher mounted in the corridor near the entry door to put out fire.
- If it is safe to do so and the emergency includes equipment, deenergize the equipment by turning off switches or unplugging power supplies.
- **Use a cell phone or the phone in the storage room (accessed through the lighting lab) and dial 9-1-1.**
- Tell operators you are in:
  - The CU Boulder Engineering Center at 1111 Engineering Dr, Boulder, CO, 80309
  - Room ECST 313 at the top of stair tower, ST CHI-28

If a non-emergency incident occurs in one of the lab spaces:

- If it is safe to do so and the incident includes equipment, deenergize the equipment by turning off switches or unplugging power supplies.

- Use the first aid kit mounted on the interior wall of the storage room (accessed through the lighting lab) to treat minor cuts, burns, or bruises.
- Report the incident immediately to the laboratory managers.

Equipment Use Procedures

When participating in design activities using lamps, tripods, and moveable panels:

- Use the laboratory manager/instructor prepared setup.
- Use gloves to add, adjust, and remove lamps. These are in the workshop area in the storage room.

When participating in laboratory experiments:

- Use the laboratory manager/instructor prepared setup.
- Participate in training on use of goniophotometer prior to completing the class exercises.

When participating in controls demonstrations:

- Use the laboratory manager/instructor prepared setup.
- Do not touch line voltage equipment including lighting and blind control panels, ceiling-mounted luminaires, or demonstration setups and power supplies.
- Adjust sensors and power supplies for low voltage demonstrations (i.e., those using microcontrollers) only as described by the laboratory manager/instructor prior to class exercises.

Safety Manual

Larson Laboratory

Engineering Center ECCE210, 215, 220

University of Colorado Boulder

Laboratory Manager

Nicholas Clements, PhD., nicholas.clements@colorado.edu, 303-532-6546

Contact Information

Emergencies: 9-1-1

For general inquiries, contact the laboratory manager.

Table of Contents

Introduction

The Larson Laboratory is a research and teaching facility used to support the Architectural Engineering Department. Graduate and undergraduate students may leverage the laboratory in conducting research related to heating, ventilation, and air conditioning (HVAC) systems, hydronic systems, managing interior/exterior heat loads, indoor air quality, and energy efficiency. Research uses include the use of two test chambers equipped with independent air handling units (AHUs), or researchers may use the laboratory space to house stand-alone experimental setups. Laboratory equipment and chambers are also used for educational purposes, for example providing a space to train students on blower door testing and energy audit instrumentation use.

As shown in Figure 1, the first floor of the laboratory consists of an entry corridor, workspace, conference area, equipment storage areas (ECCE215), and two test chambers (east and west zones, ECCE220). The second floor of the laboratory consists of an office space (ECCE210) and a mechanical equipment area where the test chamber AHUs are located.

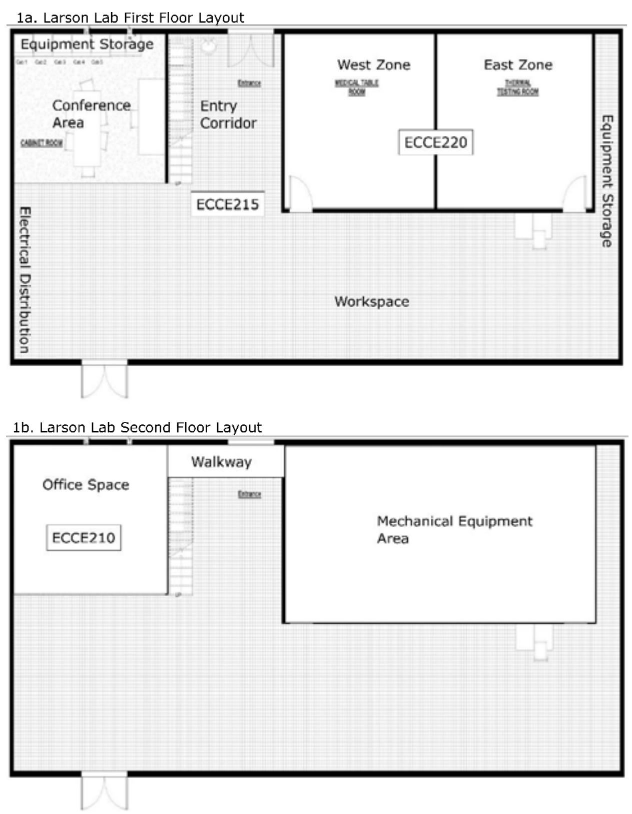

Figure 1. Larson Lab Floor Plan, (a) First Floor and (b) Second Floor.

1

Entry Corridor

The entry corridor consists of a kitchen and sink area and cabinets for historical equipment storage and document storage (Figure 2). The kitchen area includes a refrigerator, microwave, cabinets, coffee makers, electric kettle, and sink. Cleaning equipment is also stored in this area.

Figure 2. Picture of the kitchen and storage area of the entry corridor (ECCE215).

Workspace

The Larson Laboratory workspace, shown in Figure 3, is an area where stand-alone research setups are located. Limited capabilities exist for building experimental setups in this space, though tools and other equipment are available for simple building needs. This space has access to various water systems to allow testing with hydronic heating and cooling coils, for example. Any changes to plumbing systems are coordinated with the university's facilities management team. Currently this space is also housing multiple architectural engineering-related demonstration projects. Laboratory manager approval is required for use of the workspace for projects.

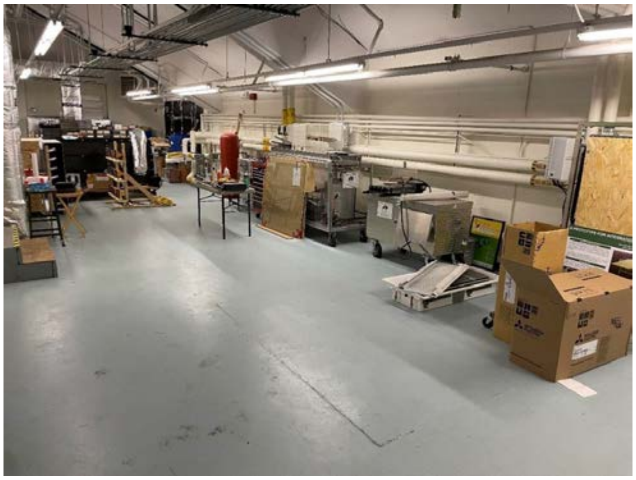

Figure 3. Picture of the workspace area (ECCE215).

Test Chambers

Two test chambers are located in the Larson Laboratory, designed to allow research and educational projects to leverage carefully controlled AHUs in projects. AHU-1 (up to 2000 CFM) serves the West Zone, currently setup to simulate an operating room. AHU-2 (up to 1000 CFM) serves the East Zone, currently setup for testing heat loads (Figure 4). The AHUs are controlled with a building automation system (BAS). Test chambers may be remodeled to fit the needs of specific projects, including changing ventilation design, heat loads, simulating various built environments, and installation of various instrumentation and other equipment. Use of the test chambers must be approved by the laboratory manager.

Figure 4. Pictures of the test chambers (ECCE220), West Zone (left) and east zone (right).

Mechanical Equipment Area

The mechanical equipment area, located on the second floor above the two test chambers, is where the AHUs and related systems are located (Figure 5). Access to this area must be approved by the laboratory manager. In this area, researchers can access supply, return, and exhaust ducting, ventilation fans, filters, heating/cooling coils, humidification systems, sensors, dampers, and other AHU-related components. As shown in Figure 6, outside air is brought into the AHUs from the east wall of the lab, and air is exhausted through a different penetration in the same wall. AHU-1 serves the West Zone and can supply up to 2000 CFM. AHU-2 serves the East Zone and can supply up to 1000 CFM. Dampers control the amount of return air that is mixed with outside air or exhausted to the outside. Each AHU is equipped with a cooling and heating coil, as well as a filter housing.

Figure 5. Pictures of the mechanical equipment area (left) and access door (right).

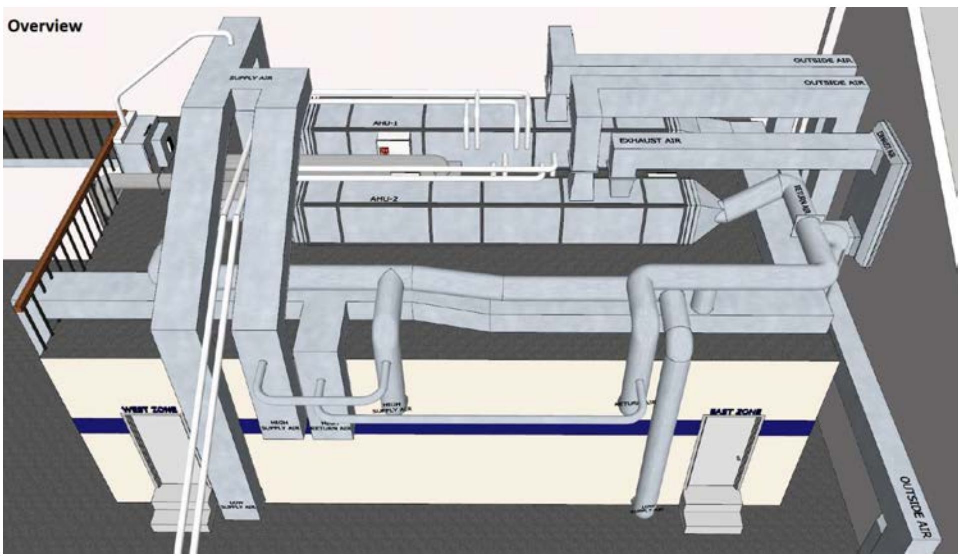

Figure 6. Drawing of the mechanical equipment area.

Equipment Storage

Two areas in the laboratory are designated as equipment storage areas, shown in Figure 7. Cabinets in the conference area house instrumentation including blower doors, thermal imagers, temperature/humidity data loggers, electricity monitors, air flow monitors, and air quality monitors. On the east wall of the laboratory, various equipment and building supplies are stored. An inventory is maintained by the laboratory manager noting the location and status of all instrumentation and equipment. Students must check equipment out from the laboratory manager for equipment use for classes. Graduate students can coordinate long-term equipment use with the laboratory manager.

Figure 7. Pictures of the equipment storage areas (ECCE215), in the conference area (left) and on the far edge of the lab (right).

Conference/Office Area

The conference area in Figure 8 includes two tables and a television used for meetings and holding office hours for courses. This area can serve as part of the workspace when tables are needed.

Figure 8. Picture of the conference area (ECCE215).

The office area in Figure 9 includes up to 9 workstations and conference table for students and serves as the office of the laboratory manager. The campus phone is in this room.

Figure 9. Picture of the office area (ECCE210).

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Laboratory Safety

The **primary entrance/exit** for the Larson Laboratory is located along the north wall and connects to the Architectural Engineering department offices, as shown in Figure 10. This door remains closed but always unlocked, though the door to the Architectural Engineering department offices is locked at nights and on weekends. An additional entrance/exit is located along the south wall, which leads to the building roof and remains locked, requiring key card access. Similarly, on the second floor along the north wall there is a second roof access door requiring key card access. Two **fire extinguishers** are located on the first floor, and one is located on the second floor. A **first aid kit** is in the entry corridor, and a **campus phone** is in the office area.

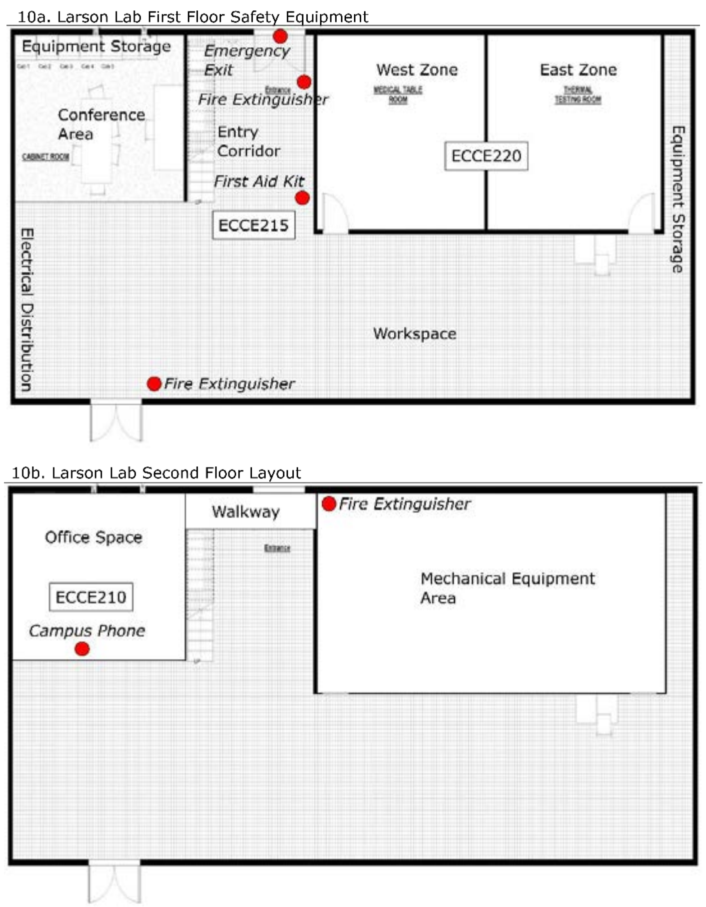

Figure 10. Location of entrance/exit doors, campus phone, fire extinguishers, and first aid kit.

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Laboratory Procedures and Behavioral Expectations

The following are procedures and behavioral expectations for all people using the lab:

1. Obtain permission to use the workspace and test chambers from the laboratory manager.
2. Obtain a key to the Architectural Engineering department offices for off-hours laboratory access. Do not share this key with anyone, and keys must be returned when students leave the university.
3. Read and familiarize yourself with the Emergency and Incident Procedures section before using the laboratory.
4. Do not work in the laboratory alone. Work in pairs, at a minimum, and let others know you will be using the space by notifying the laboratory manager via email.
5. Where close-toes shoes when doing any work related to using tools or other building equipment.
6. Coordinate with the laboratory manager and university facility managers when connecting to plumbing and electrical systems, as well as when using or modifying the AHUs.
7. Safely store all supplies and other equipment in designated areas and keep from introducing tripping/fall hazards.
8. Do not block the corridor, stairs to the second floor, or doors to the test chambers.
9. Do not attempt to retrieve objects on shelves if the use of a ladder is required. Contact the laboratory manager to access such equipment.
10. Do not modify the test chambers without coordinating with the laboratory manager.
11. Do not leave hazardous materials, such as spray paint or other compressed air containers, in the laboratory. A flammable materials cabinet is available for use in the workspace to house volatile and flammable materials.
12. Do not paint or use other materials that release hazardous fumes in the laboratory.
13. Keep the use of power tools in the laboratory to a minimum and always clean up your workspace after their use.
14. Do not take materials, tools, equipment, or instrumentation from the laboratory without approval from the laboratory manager.
15. Be mindful of your noise level, as the lab office area and department offices are adjacent.
16. Notify the laboratory manager immediately with questions related to laboratory use, equipment storage, behavioral concerns, and any other inquiries.

Emergency and Incident Procedures

If an emergency occurs in the Larson Laboratory:

1. If it is safe to do so, use the fire extinguisher mounted closest to the incident to put out a fire. Fire alarms are located throughout the laboratory in the case of a fire that cannot be put out with a fire extinguisher.
2. If it is safe to do so, in the event of an electrical issue unplug or trip power supplies to deenergize equipment.
3. Use a cell phone or campus phone and dial 9-1-1 in the event of a serious emergency or health incident. Tell operators you are in the CU Engineering Center 1111 Engineering Dr., Boulder, CO 80309, Room ECCE215 (or 210/220) in the Architectural Engineering Department.

If a non-emergency incident occurs in the laboratory:

1. Deenergize equipment, if safe to do so.
2. Use the first aid kit mounted in the entry corridor to treat minor cuts, burns, or bruises.
3. Report the incident immediately to laboratory managers and to your supervisor.

APPENDIX A – COURSE SYLLABI

APPM 1350 Course Syllabus

1. **Course Number and Name:** APPM 1350 Calculus 1 for Engineers

2. **Credits, contact hours, and categorization of credits in Table 5-1**: 4 credit hours; 3x50 minute lectures weekly and 1x50 minute recitation weekly; Basic Math and Science

3. **Course Coordinator:** Anne Dougherty (anne.dougherty@colorado.edu)

4. **Textbook:** Chapters 1-5 of Essential Calculus, Second Edition by James Stewart, March 2006

5. **Specific course Information:**
   A. **Brief description of the content of the course (catalog description)**: Topics in analytical geometry and calculus including limits, rates of change of functions, derivatives and integrals of algebraic and transcendental functions, applications of differentiations and integration. Students who have already earned college credit for calculus 1 are eligible to enroll in this course if they want to solidify their knowledge base in calculus 1.
   B. **Prerequisites or co-requisites**: Requires prerequisite course of APPM 1235 or MATH 1021 or MATH 1150 or MATH 1160 or MATH 1300 (minimum grade C-) or an ALEKS math exam taken in 2016 or earlier, or placement into calculus based on your admissions data and/or CU Boulder coursework.
   C. **Indicate whether a required, elective, or selected elective**: Required

6. **Specific goals for the course:**
   A. **Specific outcomes of instruction**: (1) Understand the concepts, techniques and applications of differential and integral calculus, and (2) improve problem solving and critical thinking. This class will form the basis for many of the standard skills required in all of Engineering, the Sciences, and Mathematics.
   B. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course**.

7. **Brief list of topics covered:** Trigonometry, limits, derivatives, and integrals

APPM 1360 Course Syllabus

1. **Course Number and Name:** APPM 1360 Calculus 2 for Engineers

2. **Credits, contact hours, and categorization of credits in Table 5-1**: 4 credit hours, 3x50 minute lecture and 1x50 minute recitation weekly; Math and Basic Science

3. **Course Coordinator:** Anne Dougherty (anne.dougherty@colorado.edu)

4. **Textbook:** Chapters 6-9 of Essential Calculus, Second Edition by James Stewart, March 2006

5. **Specific course Information:**
   A. **Brief description of the content of the course (catalog description)**: Continuation of APPM 1350. Focuses on applications of the definite integral, methods of integration, improper integrals, Taylor's theorem, and infinite series.
   B. **Prerequisites or co-requisites**: Requires prerequisite course of APPM 1345 or APPM 1350 or MATH 1300 (minimum grade C-).
   C. **Indicate whether a required, elective, or selected elective:** Required

6. **Specific goals for the course:**
   A. **Specific outcomes of instruction:** This course extends the concepts and techniques of single-variable Calculus. The main objectives are to (1) improve integration techniques and applications of differential and integral calculus, (2) understand sequences and series, and (3) improve problem solving and critical thinking skills. This class will form the basis of your set of everyday working skills required for math, engineering, and the sciences.
   B. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course**.

7. **Brief list of topics covered:** Integration, sequences, series

APPM 2350 Course Syllabus

1. **Course Number and Name:** APPM 2350 Calculus 3 for Engineers

2. **Credits, contact hours, and categorization of credits in Table 5-1**: 4 credit hours; 3x50 minute lecture and 1x50 minute recitation weekly; Math and Basic Science

3. **Course Coordinator:** Anne Dougherty (anne.dougherty@colorado.edu)

4. **Textbook:** Essential Calculus, Second Edition by James Stewart, March 2006

5. **Specific course Information:**
   A. **Brief description of the content of the course (catalog description)**: Covers multivariable calculus, vector analysis, and theorems of Gauss, Green, and Stokes.
   B. **Prerequisites or co-requisites**: Requires prerequisite course of APPM 1360 or MATH 2300 (minimum grade C-).
   C. **Indicate whether a required, elective, or selected elective:** Required

6. **Specific goals for the course:**
   A. **Specific outcomes of instruction:** This course extends the ideas of single-variable calculus (e.g. limits, differentiation, integration, optimization, fundamental theorems) to functions of several variables. Topics include vectors and vector operations, vector-valued functions and curves in space, multivariable functions, partial differentiation, multiple integrals, line integrals, surface integrals, and the theorems of Green, Stokes and Gauss. These concepts form the mathematical basis for many areas in science and engineering. The aim is for you to learn these concepts and to critically and creatively solve problems.
   B. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course**.

7. **Brief list of topics covered:** Vectors and vector operations, vector-valued functions and curves in space, multivariable functions, partial differentiation, multiple integrals, line integrals, surface integrals, and the theorems of Green, Stokes and Gauss.

APPM 2360 Course Syllabus

1. **Course Number and Name:** APPM 2360 Introduction to Differential Equations with Linear Algebra

2. **Credits, contact hours, and categorization of credits in Table 5-1**: 4 credit hours, 3 x 50 minute lectures weekly, 1 x 50 minute recitations weekly; Math and Basic Science

3. **Course Coordinator:** Anne Dougherty (anne.dougherty@colorado.edu)

4. **Textbook:** Differential Equations and Linear Algebra, Second Edition by Farlow, Hall, McDill, and West, February 2017

5. **Specific course Information:**
   - A. **Brief description of the content of the course (catalog description)**: Introduces ordinary differential equations, systems of linear equations, matrices, determinants, vector spaces, linear transformations, and systems of linear differential equations.
   - B. **Prerequisites or co-requisites**: Requires prerequisite course of APPM 1360 or MATH 2300 (minimum grade C-).
   - C. **Indicate whether a required, elective, or selected elective:** Required

6. **Specific goals for the course:**
   - A. **Specific outcomes of instruction:** This course provides an introduction to ordinary differential equations and linear algebra. Topics include both qualitative and quantitative methods of solving differential equations, Laplace transforms, systems of first order equations, matrices, determinants, eigenvalues/eigenvectors and vector spaces.
   - B. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course**.

7. **Brief list of topics covered:** Qualitative and quantitative methods of solving differential equations, Laplace transforms, systems of first order equations, matrices, determinants, eigenvalues/eigenvectors and vector spaces.

<u>AREN 1027 Course Syllabus</u>

1. **Course number and name**: AREN 1027 - Engineering Drawing

2. **Credits, contact hours, and categorization of credits in Table 5-1:**
   3 Credits, 3 contact hours, Engineering Topics

3. **Instructor's or course coordinator's name**: Alex Gore

4. **Textbook:**
   The "LIFT" - Revit Content Creation Package
   The Creativity Code by Alex Gore

5. **Specific course information:**
   a. B**rief description of the content of the course (catalog description):** Develops drawing and drafting skills for civil engineering projects in both hand drawing and software tools. Students will learn to read and interpret design and construction drawings.
   b. **Prerequisites or co-requisites:**
      Requisites: Restricted to Engineering Physics (EPEN), Architectural (AREN), Integrated Design Engineering (IDEN) or Civil (CVEN) Engineering majors only.
   c. **Indicate whether a required, elective, or selected elective**: Required for AREN, Selected Elective for CVEN

6. **Specific goals for the course**:
   a. **Specific outcomes of instruction:** The student will be able to understand and find information in drawings. Will be able to communicate their ideas via drawings, and with visual / oral presentations
   b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course**: Outcome 3, An ability to apply oral communications to communicate effectively with a range of audiences

7. **Brief list of topics covered:** Freehand Sketching, Hand Drafting Exercise, Reading Construction Documents, Simple Revit Families, Advanced Revit Families, Revit Cabin Re-drafting Exercise, Design Case-Study, Final Design Project

AREN 1316 Course Syllabus
1. **Course number, name**: AREN 1316 Introduction to Architectural Engineering

2. **Credits and contact hours, and categorization of credits in Table 5-1**: 1-credit, 1 contact hour, engineering topic

3. **Instructor(s)**: Jay Arehart, PhD

4. **Textbook:** None

5. **Specific course information:**
   a. **Brief description of the content of the course (catalog description):**What is architectural engineering? What do architectural engineers study and how do they use their degrees after graduation? How does architectural engineering as a discipline integrate structural, mechanical, electrical, illumination, and construction engineering? *Introduction to Architectural Engineering* introduces first- and second-year undergraduate students to the architecture, engineering, and construction discipline through the lens of an architectural engineer.
   In this course, we will explore the different focus areas of architectural engineering, namely structural, mechanical, electrical, illumination, and construction engineering & management. We will investigate career paths, highlighting the broad application of skills acquired by an architectural engineer and dispel the myth that the architectural engineering profession is narrow and limited. Through a combination of seminars, guest lectures, workshops, assignments, and independent learning, we will establish a solid foundation for you to successfully complete a world-class architectural engineering education at the University of Colorado Boulder.
   b. **Prerequisites or co-requisites:** None
   c. **Indicate whether a required, elective, or selected elective**: Required

6. **Specific goals for the course:**
   a. **Specific outcomes of instruction:**
      - Describe what architectural engineering is and what you may do as an architectural engineer.
      - Explain the process and skills required to graduate with an architectural engineering degree.
      - Relate the importance of professional licensure for architectural engineers.
      - Apply the code of engineering ethics to evaluate professional situations you may encounter.
      - Define resilience, sustainability, and their metrics as they pertain to architectural engineering.
      - Communicate effectively through professional technical writing.

   b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course**: Outcome 4, An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

7. **Brief list of topics covered**: Overview of the architectural engineering field; the architectural design process; introduction to the five sub-disciplines: structural design, mechanical system designs, construction engineering and management, illumination engineering, and electrical engineering; sustainability and resilience in the built environment; engineering ethics; professional licensure; industry professionals and case study career and projects.

AREN 2050 Course Syllabus

1. **Course number and name**: AREN 2050 Building Systems and Materials

2. **Credits, contact hours, and categorization of credits in Table 5-1**: 3 credits, 3 contact hours, Engineering Topic

3. **Instructor's or course coordinator's name**: Amelia Celoza

4. **Textbook**: Fundamentals of Building Construction Materials and Methods (5th Edition), Edward Allen and Joseph Iano, 2009

5. **Specific course information:**
   a. **Brief description of the content of the course (catalog description)**: Covers the broad subject of building materials and systems. Includes a practical approach to assembly details, methods of construction, codes, foundations, steel, concrete, masonry, cladding, doors and windows, interiors, finishes, mechanical, plumbing, electrical, life safety and conveyance. Includes investigation of an existing facility along with a team presentation trends in commercial building construction.
   b. **Prerequisites or co-requisites**: Restricted to students with 27-180 credits (Sophomores, Juniors or Seniors) Civil (CVEN) or Architectural (AREN) or Integrated Design Engineering (IDEN) or Applied Mathematics (AMEN) majors only.
   c. **Indicate whether a required, elective, or selected elective**: Required for AREN, elective for CVEN

6. **Specific goals for the course:**
   a. **Specific outcomes of instruction**:
      - Identify the numerous building components, materials, and systems
      - Understand the sequent and relationship between building assemblies
      - Develop industry vocabulary.
   b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course**: Outcome 2, Ability to apply engineering design to produce solutions that meet specified needs, Ability to apply engineering design with consideration of safety, social, environmental and economic factors; Outcome 7, Ability to acquire and apply new knowledge as needed, using appropriate learning strategies

7. **Brief list of topics to be covered**: Codes and classifications, foundations, wood, steel, concrete, masonry, cladding, doors and windows, interiors, finishes, mechanical, electrical, plumbing, life safety and conveyance systems

AREN 2110 Course Syllabus

1. **Course Number and Name:** AREN 2110 Thermodynamics

2. **Credits, Contact Hours, and Categorization of Credits in Table 5-1:**
3 credits, 3 contact hours at 50 min each per week, engineering topics

3. **Instructor's Name:** Gregor P. Henze, Ph.D., P.E.

4. **Textbook:** Moran, M.J., Shapiro, H.N., Boettner, D.D., and Bailey, M.B. (2018). *Fundamentals of Engineering Thermodynamics, Enhanced eText, 9th Edition*. John Wiley & Sons, Inc, ISBN-13:978-1-119-39138-8.

5. **Specific course information:**
   a. **Brief description of f description of the content of the course (catalog description):** The objectives of this course are 1) to introduce fundamental concepts of properties of materials, work, heat, internal energy, entropy, equilibrium, and relations derived from the first and second laws of thermodynamics, and 2) to learn how to apply these principles towards civil, environmental, and architectural engineering applications. Example applications include renewable energy production; power plants; fluid flow in ducts/pipes; thermal properties of building/construction materials and processes; geothermal systems; heating, ventilation, and air conditioning (HVAC) processes; energy balances in buildings; refrigeration; contaminant transport in air, water, and soil; climate change; the urban heat island effect; and energy use in transportation.
   b. **Prerequisites or co-requisites**: None
   c. **Indicate whether a required, elective, or selected elective**: Required

6. **Specific Goals for the Course:**
   a. **Specific outcomes of instruction**:
      Upon completion of this course, students will be able to:
      - Explain the principles of mass and energy conservation and their use in AREN applications.
      - Evaluate thermodynamic systems and several forms of work, energy, and heat transfer.
      - Apply conservation of mass and energy for closed systems and control volume processes.
      - Explain the second law of thermodynamics, entropy changes, and device efficiencies.
   b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course**: Outcome 1, An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

7. **Brief List of Topics to be Covered:** Introduction to thermodynamics terminology; processes, properties, and units; mechanical concepts of energy; additional forms of work and energy; heat transfer and energy balances; thermodynamics cycles; evaluating

thermodynamics properties; specific heats; real and ideal gases; conservation of mass for control volumes; conservation of energy for control volumes; analyzing control volumes at steady state; transient control volumes and system integration; introduction to idea gas mixtures and psychrometrics; psychrometric parameters; psychometric chart; dehumidification and humidification in HVAC systems; the second law of thermodynamics; entropy; the second law of thermodynamics for closed systems and control; steady-state entropy balance, isentropic processes, and isentropic efficiencies; entropy balance

<u>AREN 2120 Course Syllabus</u>

1. **Course number and name**: AREN 2120 FLUID MECHANICS AND HEAT TRANSFER

2. **Credits, contact hours, and categorization of credits in Table 5-1**: 3 credits, 3 contact hours, engineering topic

3. **Instructor's or course coordinator's name**: Prof. John Zhai, Ph.D.

4. **Textbook**:Cengel, Y.A., Cimbala, J.M., and Turner, R.H. Fundamentals of Thermal-Fluid Sciences, 5th Edition, McGraw-Hill, 2016, ISBN-13: 978-0078027680, ISBN-10: 0078027683.

5. **Specific course information**:
    a. **Brief description of f description of the content of the course (catalog description):** The course has two basic objectives: (i) to teach the fundamentals of engineering fluid mechanics and heat transfer and (ii) to present selected applications related to building energy systems.
    Fluid mechanics is the science of fluids at rest and in motion and the interaction of fluids with solids at boundaries. In this class we will focus on the fundamentals of fluid mechanics and application of fluid mechanics to real systems.
    Heat transfer is the science that deals with the rate of energy transfer as a result of temperature differences between objects. We will draw upon our knowledge of thermodynamics and fluid mechanics to learn about the basic mechanisms of heat transfer and apply that knowledge to real systems.
    Throughout the class we will emphasize topics and problems that are important to Architectural Engineers including flow of fluids in pipes and ducts, heat transfer in buildings and building systems.
    b. **Prerequisites or co-requisites**: AREN 2110 Thermodynamic; co-requisite: APPM 2360 Introduction to Differential Equations with Linear Algebra
    c. **Indicate whether a required, elective, or selected elective**: Required

6. **Specific goals for the course:**
    a. **Specific outcomes of instruction** Students who successfully complete the course will demonstrate the following abilities:
        - Ability to apply their knowledge of math, science and engineering to problems in fluid mechanics and heat transfer
        - Ability to identify, formulate and solve realistic Architectural Engineering problems
        - Ability to use modern engineering tools through computer-based assignments
        - Ability to use a technical book as a primary source of information through reading and homework assignments

    Students who successfully complete the course will have learned the following broad education goals:
        - Learn the importance of fluid mechanics and heat transfer in science history

- Learn the importance of fluid mechanics and heat transfer in Architectural Engineering
- Learn the importance of work done on-time and neatly presented
- Learn how to take notes and develop your own study process
- Learn the importance of correct answers as well as correct methods
- Learn the importance of energy and energy systems in sustainable engineering design
- Learn some of the impacts engineering design has on the environment

Specific technical outcomes of the course include the following:

Fluid Mechanics:

- Compute pressure and force of static and dynamic fluids on solids
- Compute energy flow and loss of fluids in pipes
- Compute required pumping power and pump heating
- Compute head and power loss during pumping
- Identify the differences between laminar and turbulent flow
- Compute laminar flow profiles in pipes
- Compute Reynolds number for flow over plates and in pipes
- Compute laminar and turbulent drag coefficients and head loss in pipes
- Compute minor losses in laminar and turbulent flows

Heat Transfer

- Compute thermal conduction through plates, cylinders and spheres
- Compute thermal conduction through uniform and composite structures
- Compute transient heat conduction in lumped systems
- Compute forced convection coefficients over plates and in pipes
- Compute natural convection coefficients over plates and in pipes
- Compute radiation emissions from gray bodies
- Compute radiation transmission through partially absorbing materials
- Compute view factors for common geometries
- Compute radiation between elements of an enclosure

b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course:** Outcome 5, Ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks and meet objectives; Outcome 6, An ability to develop and conduct appropriate experimentation, An ability to analyze and interpret data, and use engineering judgment to draw conclusions

7. **Brief list of topics to be covered**: Intro to Fluid Mechanics; Fluid Statics; Energy Equation; Bernoulli Equation; Momentum Equation; Laminar and Turbulent Internal Flow; Minor Losses and Networks; Drag and Lift; Intro to Heat Transfer; Steady Heat Conduction; Cylinders, Spheres, Insulators; Transient Heat Conduction; Forced Convection; Natural Convection; Radiation Heat Transfer

AREN 3010 Course Syllabus

1. **Course number and name**: AREN 3010 ENERGY EFFICIENT BUILDINGS

2. **Credits, contact hours, and categorization of credits in Table 5-1**: 3 credits, 3 contact hours, engineering topic

3. **Instructor's or course coordinator's name**: Prof. John Zhai, Ph.D.

4. **Textbook**: Zhai Z. 2022. Energy Efficient Buildings: Fundamentals of Building Science and Thermal Systems, 1st Edition [ISBN-13: 9781119881933]
   References: 1. ASHRAE Handbook: Fundamentals, 2021. Free eBook from CU library (In either IP or SI units); 2. Achieving Zero Energy: Advanced Energy Design Guide for Small to Medium Office Buildings. ASHRAE, 2019. Free download from https://www.ashrae.org/technical-resources/aedgs/zero-energy-aedg-free-download

5. **Specific course information:**
   a. **Brief description of the content of the course (catalog description)**: This is a required entry course for AREN on the basic knowledge, calculation, analysis, and design of buildings and their thermal systems to meet the requirements of designing a comfortable, healthy and energy-efficient building. The course examines critical elements such as standards and codes, psychrometrics, thermal comfort, indoor air quality, solar conditions, envelope heat transfer, building heating and cooling loads, and HVAC components and systems.
   b. **Prerequisites or co-requisites**: AREN 2120 Fluid Mechanics and Heat Transfer; AREN 2050 Engineering Systems for Buildings
   c. **Indicate whether a required, elective, or selected elective**: Required

6. **Specific goals for the course**:
   a. **Specific outcomes of instruction:** The overall objective of this course is to introduce students to the principles and techniques for analysis and design of energy-efficient buildings and thermal systems for maintaining a comfortable, healthy, and productive indoor environment in buildings. Upon successful completion of the course, students will have:
      - The ability to identify the criteria, metrics, and mechanisms for a <u>comfortable and healthy indoor environment</u>. The criteria and metrics are determined by human <u>physiology</u>, but for practical design purposes, are also dictated by <u>building codes and standards</u>.
      - The ability to identify and analyze the characteristics of <u>weather, building construction, and building operations</u> as they define the requirements for comfortable and healthy indoor environment.
      - The ability <u>to analyze the heating, ventilating, and air conditioning requirements</u> of residential and small commercial buildings. Given the need to maintain a comfortable and healthy indoor environment, students will be able to determine <u>HVAC loads</u> (i.e., the requirements) as a function of a building's physical characteristics, its use, and its climatic location. The analyses will be

performed by applying basic engineering knowledge with hand calculations and computer simulation.

- The ability to evaluate the impact of building design decisions (e.g., passive techniques) on HVAC equipment size and cost, annual HVAC energy consumption and cost, and environmental impact of energy consumption on power plant emissions.

b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course:** Outcome 2, Ability to apply engineering design with consideration of safety, social, environmental and economic factors.

7. **Brief list of topics to be covered**: Sustainable Building; Life-Cycle Cost Analysis; Codes and Standards; Air Properties and Psychrometric Chart; Climate and Site Analysis; Indoor Thermal Comfort; Indoor Air Quality and Ventilation; Infiltration and Blow Door Test; Heat Transfer in Building; Lab: Blow Door Test; Field Trip; Sun and Solar Radiation; Heating Load Calculation; Cooling Load Calculation; Typical Mechanical Systems; Heating and Cooling on Psychrometric Chart; Mechanical System Sizing; Building Energy Consumption: Hand Calculation; Building Energy Consumption: Computer Simulation.

AREN 3040 Course Syllabus

1. **Course number and name**: AREN 3040, Circuits for Architectural Engineers

2. **Credits, contact hours, and categorization of credits in Table 5-1:** 3 Credits, 3 contact hours, Engineering Topic

3. **Instructor**: Kyri Baker

4. **Textbook**: Cogdell, J.R., Foundations of Electrical Engineering, 2nd Edition (1995)

5. **Specific course information:**
    a. **Brief description of the content of the course (catalog description)**: This course will cover the basics of DC and AC circuit theory relevant to the modeling, design, and control of residential and commercial building systems, including Kirchoff's laws, Thevenin/Norton theorems, transient analysis of DC systems, three phase analysis, induction and synchronous motors, AC power (including real and reactive power analysis), power factor correction, and transformers.
    b. **Prerequisites or co-requisites**: Requires prerequisite courses of (APPM 2360 or (MATH 2130 and 3430)) and PHYS 1120 (all minimum grade C-). Restricted to AREN, CVEN, and EVEN majors only.
    c. **Indicate whether a required, elective, or selected elective**: Required for AREN majors

6. **Specific goals for the course**:
    a. **Specific outcomes of instruction**: The students should have the foundational groundwork for understanding the basics of circuit analysis, electricity, power, and energy. The students should be adequately prepared for the next course in the series which is designing building electrical systems that adhere to the National Electric Code.
    b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course:** Outcome 1, Ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

7. **Brief list of topics to be covered:** the basics of DC and AC circuit theory, Basic Concepts of electrical circuits and current flows, Steady-State Analysis of DC Circuits including Ohm's law, Kirchhoff's current and voltage laws and principle of superposition, Thevenin's theorem, Norton's theorem, Transient Analysis of DC Circuits, AC Steady-State Analysis including phasors, Steady-State Power Analysis including reactive power, power factor, single-phase, three-phase, Transformers, including three-phase transformers, Induction motors, a brief introduction to synchronous and DC motors, An introduction into digital logic

<u>AREN 3080 Course Syllabus</u>

1. **Course number, name:** AREN 3080 Architectural Design Studio 1

2. **Credits, contact hours, and categorization of credits in Table 5-1**: 3 credits, 3 contact hours, engineering topic

3. **Instructor(s)**: Jay Arehart, PhD & Jennifer Scheib

4. **Textbook, other materials**: Ching, F. D. (2014). Architecture: Form, space, and order. 4th ed. John Wiley & Sons; Physical model making materials (varies).

5. **Specific course information:**
   a. **Brief description of the content of the course (catalog description)**: Course description: Why Architecture? We propose to you this semester that a building without the presence of architecture is virtually impossible to achieve. If Architecture is understood as the physical result of the intent to house, enable, defend, or organize, then your toolshed is as much a piece of architecture as your temple. The question that results from this understanding isn't, "Is that building Architecture?" but rather, "Is that good Architecture?" Does it work? Does it fulfill Program? Does it provide proper shelter for people? This is a conversation that moves beyond the technical. In this mode of thinking, we never "simply build". We build well, we build for people, we build for energy performance, we build for context, and we build for sustainability.
   You will be introduced to the architectural design process through a series of assignments leading to a design of a low-rise multi-use building. By the end of the semester, you will be thinking like a designer to compliment the ways in which you are training to think as an engineer. Why is this important? Well, as a professional engineer you will be working with a team of people. You will be more desirable if you understand the design process as it pertains to the built environment (*e.g.*, it is not linear). And the design process is one that is applicable across disciplines.
   This architectural design studio is the first of two which you will take as part of your architectural engineering education. The second, AREN 4080 (Architectural Design Studio 2) will be taken during the Fall of your senior semester where you will complete an integrated design project of a commercial building for your senior capstone project.
   b. **Prerequisites or co-requisites**: AREN 1027; sophomore standing
   c. **Indicate whether a required, elective, or selected elective**: Required

6. **Specific goals for the course**:
   a. **Specific outcomes of instruction**: This is a unique class in that we are covering the fundamentals of a field (architecture) that is different from the discipline of architectural engineering. The goal of the course is to both familiarize you with the design processes and fundamentals of architecture as well as to equip you with ways of thinking and working that will benefit your careers as engineers, builders, or designers in any field.

Broadly, this course aims to train you in (*i*) fundamentals of design and architecture; (*ii*) methods of analysis and research in architecture; and (*iii*) techniques and tools for communicating design. Specifically, these aims correspond to the following learning outcomes:

- Familiarity with the elements of architecture
- Exposure to precedent research and architectural analysis
- An understanding of architectural tectonics
- An understanding of ordering systems in design
- Practice in the design process and design thinking
- Exposure to fundamental components of site and user analysis
- Practice in physical and virtual model making
- Communication of design through presentations, posters, and drawings.

b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course:** Outcome 3, An ability to apply oral communications to communicate effectively with a range of audiences.

7. **Brief list of topics to be covered**: Elements of architecture; precedent research, architectural tectonics; ordering systems; program design; sketch models; design process; site & user analysis; concept development; architectural diagramming; oral presentations; poster board presentation.

AREN 3540 Course Syllabus

1. **Course number, name:** AREN 3540, Illumination 1

2. **Credits, contact hours, and categorization of credits in Table 5-1**: 3-credit course, 3 contact hours, engineering topic

3. **Instructor**: Jennifer Scheib

4. **Textbook**: No required text; Supplementary materials from the Illuminating Engineering Society's Handbook 10th Edition, posted to Canvas

5. **Specific course information:**

   a. **Brief description of the content of the course (catalog description):** This course is about the fundamentals of illumination and lighting systems. The emphasis is on the technical foundations for the generation and distribution of light. This course is a fundamentals course that focuses on the physics of illumination with respect to lighting technology and the quantitative aspects of lighting design. For those students interested in a technically intensive career in lighting this course will be the basis for all illumination calculations. For those students more interested in the lighting design for buildings, this course will give them the technical knowledge necessary to effectively create installed lighting systems that meet the design expectations.

   b. **Prerequisites or co-requisites**: CSCI 1200 (or CHEN 1310, ASEN 1320, ECEN 1310, and CSCI 1300) APPM 2350 (or MATH 2400)

   c. **Indicate whether a required, elective, or selected elective**: Required

6. **Specific goals for the course**:

   a. **Specific outcomes of instruction**: Upon successful completion of this course, the student will be able to:
      - Define light using an understanding of radiant power and human physiology
      - Discuss the behavior of lighting using professional terminology
      - Predict light reflection, transmission, and diffraction through physical media
      - Predict the steady-state distribution of light in an architectural space
      - Use a simple design process to develop and validate a lighting solution
      - Describe the various career pathways in lighting.

   b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course:** Outcome 1, Ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics; Outcome 7, Ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

7. **Brief list of topics to be covered:** Spectral power distributions, Action spectra, Efficacy, Photometric quantities (lumen, illuminance, intensity, exitance, luminance), Design analysis process and tool development, Simple design documentation, Psychrometric quantities, Form and configuration factors, Interreflection and flux balance, The lumen method, Lighting technology, Careers in lighting

<u>AREN 4080 Course Syllabus</u>

1. **Course number, name** AREN 4080, Architectural Design Studio 2

2. **Credits, contact hours, and categorization of credits in Table 5-1:** 2 credits, 2 contact hours, engineering topic

3. **Instructor:** Jay Arehart, Ph.D.

4. **Textbook**: None

5. **Specific course information:**

   a. **Brief description of the content of the course (catalog description):** Provide an architectural design studio to accompany the integrated capstone design experience for architectural engineering students. In teams, students will build upon their architectural design knowledge to define the architectural program, analyze the site, and produce a schematic level architectural design for a commercial building.

   b. **Prerequisites or co-requisites**: Pre-requisite of AREN 3080

   c. **Indicate whether a required, elective, or selected elective**: Required

6. **Specific goals for the course**:

   a. **Specific outcomes of instruction**: Upon satisfactory completion of this course, you will be able to:

      - Integrate engineering and architectural design to create a professional-level solution to a modest commercial building.
      - Iterate design alternatives to evaluate their feasibility and ability to address an architectural design problem.
      - Communicate effectively through oral presentations, presentation boards, and drawings, the design intent and proposed architectural solutions.
      - Work in multi-disciplinary teams to develop an integrated architectural solution.

   The course will be delivered through both lectures and individual consultation during the studio sessions. During some studio sessions, you will be meeting with faculty and mentors from your respective disciplines to work on the engineering side of your design. The studio periods are meant to serve as the workshop for you and your team to develop your design with guidance from the instructor. There will be many different design activities which you will be assigned on a team-by-team basis, depending upon the status of your project, in consultation with the instructor. As a group, you will give presentations during the semester with varying levels of formality. These presentations will coincide with the completion of the various stages of the design process and take place during the scheduled AREN 4080 studio times. Please review the capstone course schedule to ensure your attendance. Both faculty members and mentors will be present.

   The work and subsequent deliverables for this course will follow the stages of industry practice: programming, conceptual design, and schematic design. Submittals will vary between physical models, virtual models, presentation boards, pin-ups, architectural drawings, and electronic files. The final submissions that document each stage of the design process will be professional quality design documents; therefore, they will demonstrate a unity of presentation style, and be well organized for easy navigation. Students will submit their deliverables to Canvas and late submissions are not accepted.

Assignments

There will be an assignment for each phase of the project with an associated deliverable for the architectural design. Furthermore, each assignment will have sub-deliverables associated with them, noting intermediary due dates.

Sketchbook

Throughout the semester you will be expected to be keeping a record of your architectural ideas through sketches. Periodically, your sketchbooks will be collected. You are expected to produce at least one thumbnail sketch or annotation per studio period. In addition, you will be expected to reflect upon your learning. See the assignment sheet for more details.

Case Study

Each week, one group of 3 will present a case study of an institutional building. These case studies will be of innovative buildings that represent the cutting edge of integrating form, systems, and structure. You are responsible for the research that will typically require you to visit the library for more in-depth information than what is provided on the web.

b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course:** Outcome 1, Ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics; Outcome 2, Ability to apply engineering design to produce solutions that meet specified needs and Ability to apply engineering design with consideration of safety, social, environmental and economic factors; Outcome 3, An ability to apply oral communications to communicate effectively with a range of audiences and An ability to apply written communications to communicate effectively with a range of audiences; Outcome 4, An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts; Outcome 5, Ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks and meet objectives; Outcome 7, Ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

7. **Brief List of Topics Covered**: Architectural Research Methods, Architectural Design Process, Precedent research and analysis, Site and User Analysis, Programming introduction Concept Design, Sustainability, LEED and WBLCA, Revit, Design Communication, Structures Introduction, Lighting Introduction, Electrical Introduction, Mechanical Introduction and Codes and Standards, CEM, Embodied Carbon, Engineering Ethics, FE Exam

AREN 4110 Course Syllabus

1. Course Number and Name: AREN 4110 HVAC System Design

2. Credits, contact hours, and categorization of credits in Table 5-1:
3 credits, 3 contact hours at 50 min each per week, engineering

3. Instructor's Name: Gregor P. Henze, Ph.D., P.E.

4. Textbook: Mitchell, J.W., and J.E. Braun. 2012. *Heating, Ventilating, and Air-Conditioning, First Edition.* John Wiley & Sons, New York.

5. Specific Course Information:

a. **Brief description of the content of the course (catalog description)** This course prepares students for professional practice in building energy and mechanical systems analysis and design for commercial buildings and district energy systems. Upon completion of the course, students will possess the skills to calculate heating, cooling, and ventilation requirements, as well as analyze, design, and evaluate conventional and advanced HVAC systems to meet these requirements in the context of codes and standards, and design and evaluate low-energy systems for sustainable buildings and district systems.

b. **Prerequisites or co-requisites***:* AREN 3100 Energy Efficient Buildings

c. **Indicate whether a required, elective, or selected elective**: Required

6. Specific Goals for the Course:

a. **Specific outcomes of instruction**: Upon completion of this course, students will be able to:

- develop methods for the analysis and design of heating, ventilating, and air conditioning systems in commercial buildings, based on a rigorous understanding of the engineering principles underlying component and system performance and a
- develop a broad desire to achieve optimal energy efficiency in the context of prevailing codes and standards.
- apply engineering fundamentals for heating and cooling load calculations,
- analyze performance of both distribution equipment/systems (e.g., fans, pumps, heat exchangers) as well as primary equipment/systems (e.g., chillers, cooling towers, boilers),
- apply principles of building control and automation.

b**. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course:** Outcome 1, An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics; Outcome 2, An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors; Outcome 5, An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.

7. Brief List of Topics to be Covered: Introduction to HVAC systems, Use of EES, Thermodynamics and Fluid Flow in HVAC Applications, Heat Transfer in HVAC Applications, Psychometrics for HVAC Applications, Overview of HVAC Systems, Thermal Comfort and Air Quality, Weather Data, Components of Building Heat Loss and Gain, Heating and Cooling Loads, Air Distribution Systems, Water Distribution Systems, Heat Exchanges, Cooling Towers and Desiccant Dehumidification, Vapor Compression Systems, Heat Pump Systesm, Building Decarbonization, Thermal Energy Storage Systems, Building and HVAC Energy Use, HVAC Control Principles, HVAC Control and Building Automation

AREN 4318 Course Syllabus

1. **Course number, name**: AREN 4318 Architectural Engineering Design 1

2. **Credits, contact hours, and categorization of credits in Table 5-1**: 3 credits, 3 contact hours, engineering topic

3. **Instructor(s)**: Jay Arehart, Chris Senseney, Moncef Krarti, Sandra Vasconez, Nate Taylor

4. **Textbook**: None

5. **Specific Course Information:**

a. **Brief description of the content of the course (catalog description)**: The Architectural Engineering Capstone is structured in a three-course sequence (AREN 4318, AREN 4080, and AREN 4319). This Fall semester you will enroll concurrently in AREN 4318 and AREN 4080 (a supporting architectural studio course). Together, these courses provide a ***capstone design experience in Architectural Engineering*** through the complete and integrated engineering design of a commercial building. The building design process will be followed through programming, conceptual design, schematic design, and design development. Students will work in teams to create an integrated design that encompasses the subdisciplines of architectural engineering: structural, mechanical, electrical, lighting, and construction engineering & management. This course is supplemented by AREN 4080, a co-requisite architectural studio through which you will develop your architectural design concurrently with your engineering solution to deliver a fully integrated design solution.

b. **Prerequisites or co-requisites**: Prerequisite of AREN 4110, AREN 4506, CVEN 4545 or CVEN 4555. Co-requisite of AREN 4080 and AREN 4570.

c. **Indicate whether a required, elective, or selected elective:** Required

6. **Specific Goals for the Course:**

a. **Specific outcomes of instruction**:

- Integrate the technical sub-disciplines of structural, mechanical, lighting, and electrical, and construction engineering management to create a professional-level solution to a modest commercial building.
- Gather relevant data; understand "client" needs (as defined by Architectural Engineering faculty and industry mentors); identify budgetary, environmental, and ethical constraints; and identify and use applicable regulations, codes, and standards.
- Create feasible alternative designs, where appropriate, and carry out value engineering analysis.
- Prepare increasingly detailed designs and construction planning that satisfies the project's constraints while also conforming to relevant codes, regulations and established sustainable practices.
- Prepare design documentation including design rationale and intent, design details and integrated project planning, scheduling, and construction cost analysis to support each design stage.

- Communicate effectively both through oral presentations and written reports and drawings the design intent, proposed solutions, and engineering details.
- Work in multi-disciplinary teams and in interdisciplinary formats as appropriate during the various phases of the project.

b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course: Outcome 2, Ability to apply engineering design to produce solutions that meet specified needs and Ability to apply engineering design with consideration of safety, social, environmental and economic factors; Outcome 3, An ability to apply oral communications to communicate effectively with a range of audiences and An ability to apply written communications to communicate effectively with a range of audiences; Outcome 4, An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts; Outcome 5, Ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks and meet objectives; Outcome 7, Ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

7. **Brief List of Topics to be Covered:** Precedent analysis; concept design; integrated design of architecture, structures, electrical, mechanical, lighting, and construction engineering & management; time management; sustainability, LEED, life cycle assessment, embodied & operational carbon; resilience; design communication; oral presentation skills; written communication skills; engineering ethics; FE exam preparation; professional development.

<u>AREN 4319 Course Syllabus</u>
1. **Course number, name**: AREN 4319 Architectural Engineering Design 2

2. **Credits, contact hours, and categorization of credits in Table 5-1**: 2 credits, 2 contact hours, engineering topic

3. **Instructor(s)**: Jay Arehart, Chris Senseney, Kyri Baker, Sandra Vasconez, Nate Taylor

4. **Textbook**: None.

5. **Specific Course Information:**

   a. **Brief description of the content of the course (catalog description)**: The Architectural Engineering Capstone is structured in a three-course sequence (AREN 4318, AREN 4080, and AREN 4319). This Spring semester you will enroll in AREN 4319 to complete the sequence, and your project. Together, these courses provide a ***capstone design experience in Architectural Engineering*** through the complete and integrated engineering design of a commercial building. AREN 4319 will focus on the completion of your building design in addition to addressing topics of professionalism and the fundamentals of engineering (FE) exam. The project that was started during the Fall semester will be continued through the first part of the Spring semester in alignment with student design competition.

   b. **Prerequisites or co-requisites**: Prerequisite of AREN 4318

   c. **Indicate whether a required, elective, or selected elective:** Required

6. **Specific Goals for the Course:**

   a. **Specific outcomes of instruction**:

   - Integrate the technical sub-disciplines of structural, mechanical, lighting, and electrical, and construction engineering management to create a professional-level solution to a modest commercial building.
   - Gather relevant data; understand "client" needs (as defined by Architectural Engineering faculty and industry mentors); identify budgetary, environmental, and ethical constraints; and identify and use applicable regulations, codes, and standards.
   - Create feasible alternative designs, where appropriate, and carry out value engineering analysis.
   - Prepare increasingly detailed designs and construction planning that satisfies the project's constraints while also conforming to relevant codes, regulations and established sustainable practices.
   - Prepare design documentation including design rationale and intent, design details and integrated project planning, scheduling, and construction cost analysis to support each design stage.
   - Communicate effectively both through oral presentations and written reports and drawings the design intent, proposed solutions, and engineering details.
   - Work in multi-disciplinary teams and in interdisciplinary formats as appropriate during the various phases of the project.

- Realize the importance of obtaining professional credentials and engaging in life-long learning throughout their careers as engineers.
- Understand the professional and ethical responsibilities they must exercise as students and as future practicing engineers.

b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course: Outcome 2, Ability to apply engineering design to produce solutions that meet specified needs and Ability to apply engineering design with consideration of safety, social, environmental and economic factors; Outcome 3, An ability to apply oral communications to communicate effectively with a range of audiences and An ability to apply written communications to communicate effectively with a range of audiences; Outcome 4, An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts; Outcome 5, Ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks and meet objectives; Outcome 7, Ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

7. **Brief List of Topics to be Covered:** Schematic design; integrated design; clash detection; design development; professional leadership; FE exam preparation; reading construction documents; lifelong learning; professional development topics

<u>AREN 4506 Course Syllabus</u>

1. **Course number and name:** AREN 4506, PRE-CONSTRUCTION ESTIMATING & SCHEDULING

2. **Credits, contact hours, and categorization of credits in Table 5-1**: 3 credits, 3 contact hours, Engineering Topics

3. **Instructor's name**: Amy Javernick-Will, PhD

4. **Textbook**: "Construction Planning and Scheduling- 4th edition." Hinze, Jimmie. Pearson, New Jersey; Construction Cost Estimating: Process & Practices" Holm, Schaufelberger, Griffin and Cole. "Pearson, New Jersey.

5. **Specific Course Information:**

a. **Brief description of the content of the course (catalog description)**: Covers project management estimating and scheduling methods with an emphasis on the techniques used to create pre-construction estimates and schedules for architectural and engineering projects.

b. **Prerequisites or co-requisites**: requires prerequisite course of CVEN 3246

c. **Indicate whether a required, elective, or selected elective:** required for AREN, elective for CVEN

6. **Specific Goals for the Course:**

a. **Specific outcomes of instruction**:

- Identify the concepts and phases of project management and pre-construction planning.
- Describe and differentiate between types of construction estimates and the role they play in the project process.
- Explain the fundamental concepts, tools, and techniques used to organize and develop estimates.
- Perform conceptual estimates for building construction.
- Perform Quantity Takeoffs (QTOs) and detailed estimates for building construction.
- Apply a cost database to perform estimates through software.
- Describe and create a work breakdown structure (WBS) for a project.
- Describe and differentiate between relationship types when ordering activities in a project plan.
- Calculate the early start, early finish, late start and late finish for activities and the early/late finish, total float and free float for a project using the critical path method (CPM).
- Apply Primavera P6, a computer scheduling program, to schedule activities.
- Create project schedules and a bid-day estimate by applying the materials from the class to a project.

b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course:** Outcome 5, Ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks and meet objectives; Outcome 6, An ability to develop and conduct appropriate experimentation and An ability to analyze and interpret data, and use engineering judgment to draw conclusions

7. **Brief list of topics covered**: Scheduling and estimating are fundamental to the construction and engineering industry: being 'on time' and 'within budget' are necessary components for project and organizational success. This course provides an overview of pre-construction scheduling and estimating for construction and engineering projects. We will explore project management methods with an emphasis on the techniques used to estimate and schedule the project prior to construction. We will apply lecture and reading materials to solve basic engineering problems. We will use computer programs, including Primavera, Bluebeam, and WinEst, to perform complex schedules and estimates. The course will culminate in a group project that will simulate a construction bid and schedule.

Company Project: The purpose of this project is to provide an opportunity for you to connect with, and learn from, industry. This group project involves interviewing an industry member about their company, estimating processes, and scheduling processes. It gives you an opportunity to practice professional skills, including corresponding, interviewing, writing, and presenting. Additional information will be provided during the class on this assignment.

Course Project: A semester-long group project involves the development of an estimate and schedule for an actual project. These projects provide opportunities to develop skills for cost engineering in a professional context, as well as working in a project team context and strengthening professional written and oral communication skills. Additional information will be provided during the class on this assignment.

Group Work:
You will be working in groups of approximately four to five students for both the Company Project and Course Project. At the end of the project, group members will rate each other's participation and contribution when prompted. These scores will be used to adjust grades accordingly based upon contributions.

AREN 4550 Course Syllabus

1. **Course number and name**: AREN 4550 Illumination II

2. **Credits, contact hours, and categorization of credits in Table 5-1**: 3 credits, 3 contact hours, engineering topic

3. **Instructor's name**: Sandra L. Vásconez

4. **Textbook**: *Designing with Light, The Art, Science, and Practice of Architectural Lighting Design*, Jason Livingston, 2022.
   Supplemental materials:
      - *Architectural Lighting* Magazine – Selected Articles
      - Architectural Lighting, Designing with Light and Space, Herve Descottes with Cecilia E. Ramos
      - *The Architecture of Light*, Sage Russell
      - Designing Lighting Online Magazine - Selected Articles
      - IES/ASHRAE 90.1 – Lighting Section
      - IESNA Lighting Handbook, 10th ed., David DiLaura, et.al. (editor)
      - LD+A Magazine – Selected Articles
      - Various lighting research organizations websites

5. **Specific course information:**
   a. **Brief description of the content of the course (catalog description):** This course studies the fundamentals of architectural illumination with an emphasis in design and application. The course introduces and applies basic principles and vocabulary to problems in the lighting of environments for the performance of visual work, the proper interaction with architecture, and compliance of energy
   b. **Prerequisites or co-requisites**: Prerequisite: AREN 3450 Illumination I
   c. **Indicate whether a required, elective, or selected elective:** Required

6. **Specific goals for the course**:
   a. **Specific outcomes of instruction**:
      - Acquire and apply the lighting vocabulary used in the architectural lighting field such that even if the student chooses not to become a lighting engineer, they still have the understanding required to work with architectural lighting engineers.
      - Identify the fundamental aspects of vision and use that knowledge to appraise how light/lighting can be applied in architectural settings to improve visual comfort and performance.
      - Identify the metrics of light for the appropriate use of lighting software.
      - Apply the lighting design process and basic lighting techniques to architectural lighting problems.
      - Design architectural lighting solutions for a small building. This means selecting the appropriate lighting equipment that will achieve a desired lighting effect. The student will:

- Determine a viable lighting solution through the application of the visual principles of light and layers of light.
- Present and describe desired lighting effects through light maps and produce lighting-layouts using standard formats and symbols.
- Choose lamps and luminaires that fit the visual, aesthetic, and energy requirements of the building.
- Select and specify lamps and luminaries within a lighting system by assessing advantages and disadvantages of luminaire characteristics and photometric properties.
- Verify using lighting software that the chosen lighting system delivers the desired light distribution as well as the light levels required to meet specific design goals.
- explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course.

b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course:** Outcome 2, Ability to apply engineering design to produce solutions that meet specified needs and Ability to apply engineering design with consideration of safety, social, environmental and economic factors

7. **Brief list of topics to be covered:** Light in Architecture, Metrics of Light, Vision, Color Vision, Visual Performance, Perception, Non-Visual Effects of Light, LEDs, Legacy Sources, Lamp Specification, Color in Light, Lighting Concepts, Luminaires, Specifying and Documenting a Design, Illuminance Compliance, Lighting Controls, Building and Energy Codes, Lighting as a Profession

AREN 4570 Course Syllabus

1. Course number and name: AREN 4570, Building Electrical Systems

2. Credits, Contact hours, and categorization of credits in Table 5-1: 3 credits, 3 contact hours, engineering topic

3. Instructor: Moncef Krarti, Ph.D

4. Textbook: Energy Efficient Electrical Systems for Buildings, M. Krarti, 2017

a. other supplemental materials

- National Electrical Code (NEC)
- Occasional handouts. Copies of handouts will be posted on the class web site

5. Specific course information:

a. **Brief description of the content of the course (catalog description)**: Introduces the generation and distribution of electrical power. Focuses on understanding the loads, control, and protection of secondary electrical distribution systems in building. Applies the national electric code to residential and commercial buildings.

b. **Prerequisites or co-requisites**: AREN 3040, Circuits for Architectural Engineering

c. **Indicate whether a required, elective, or selected elective**: Required

6. Specific goals for the course:

a. **Specific outcomes of instruction:**

- The ability to analyze basic electrical circuits for both AC and DC systems
- The ability to identify basic operation specifications and characteristics of motors and transformers
- The ability to identify protection devices used in an electrical distribution systems for buildings
- The ability to design an electrical system for a residential building and a small office building according to the requirements of the National Electrical Code (NEC)
- The ability to write technical report and communicate the design specifications for an energy efficient electrical systems for commercial buildings

b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course:** Outcome 2, Ability to apply engineering design to produce solutions that meet specified needs

7. Brief list of topics to be covered: Basic Design Procedure, Review of DC and AC Systems, Review of single-phase AC systems, Three-Phase Circuits and Systems, Dwellings Electrical Systems, Service Entrance Design for Residences, Design of Electrical Systems for Dwellings, Transformer Fundamentals, Motor Characteristics, Introduction to Protection Devices, Circuit Breakers, Fuses, and Switches, Grounding, Conductors and Conduits

Design, Conductors and Conduits Design, Feeder Design, Design of Panels, Design of Motor Branch Circuits, Motor Control Center Design, Design of Unit Substations, Short Circuit Calculations, Tour of Electrical Systems at CU

One important objective is to learn how to design electrical systems for typical residential and commercial buildings according to the National Electrical Code (NEC). In order to achieve this, three group projects are planned for this course. The three group projects are briefly described below:

Project # 1: Audit an Electrical System for a Dwelling: Audit and review the electrical installation of an existing single-family dwelling. The report of each group should include one line diagram, panel-board schedule, as well as floor layout of lighting and receptacle outlets. Basic calculations will be requested to check that the installation meets the NEC code.

Project # 2: Design of Electrical Systems for Dwellings: In this project, each group should provide a complete layout of the electrical wiring for a house for which the architectural plans are available (from the Drawing Class for instance). The design can integrate a PV system mounted in the roof. The design for the electrical system including the PV system should follow the NEC requirements.

Project # 3: Electrical System Design for a commercial building: This project should provide the student with the opportunity to use the NEC guidelines to design a typical electrical installation for a commercial building. In particular, each group should provide the electrical drawings that summarize the design. These drawings include the panel-board schedules, the Motor Control Center Specifications, the Unit Substation layout, and the on-line diagram of the electrical distribution system. All the deliverables should be professionally drawn using appropriate CAD software. Moreover, life-cycle analysis will be requested to design energy efficient electrical systems including transformers, motors, lighting systems, and distribution systems.

CSCI 1200 Course Syllabus

1. **Course number and name:** CSCI 1200: Introduction to Computational Thinking

2. **Credits, Contact hours, and categorization of credits in Table 5-1**3 credits (1-50 min lecture, 1-100 minute lab), 37.5 minimum contact hours

3. **Instructor or Course Coordinator Name:** James E. Dykes; Assistant Teaching Professor (instructor)

4. **Text Book and Other Supplemental Materials:** No Text; Uses Department Developed Materials

5. **Specific Course Information:**
    - **a. Brief description of the content of the course (catalog description):** Teaches computational thinking and techniques for writing computer programs using the Python programming language. Intended for students who realize that computational skills are beneficial to all fields of study, but who have little or no experience in programming or are not Computer Science majors. Students will be expected to create computer programs to solve problems in a range of disciplines.
    - **b. Prerequisites or Co-requisites:** None
    - **c. Indicate whether a required, elective, or selected elective**: Required

6. **Specific Goals for the Course**
    - a. **Specific Outcomes of instruction:** In this class, we will teach you about how computer scientists organize the world and talk about computers. We will teach you the computational approach to dealing with problems using the following steps:
        - Learn to take a systematic approach to problem solving and to formulate algorithms and strategies with a computational approach.
            - o To understand the form and function of computer programming languages.
            - o To know the steps in a software development process.
            - o To understand programs following the input, process, output (IPO) pattern.
        - Understand how computing and computational processes interact with the world at large.
            - o Apply computational knowledge to the analysis of current events and innovations.
        - Understand and be able to articulate problems that computer scientists study at a high level.
    - b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course:** Outcome 1, Analyze a complex computing problem and to apply principles of computing and other relevant disciplines to identify solutions; Outcome 2, Design, implement, and evaluate a computing-based solution to meet a given set of computing requirements in the context of the program's discipline; Outcome 3, Communicate effectively in a

variety of professional contexts; Outcome 6, Apply computer science theory and software development fundamentals to produce computing-based solutions.

7. **Brief list of topics to be covered:**

- Programming
  - Print / input functions
  - Data types, variables
  - Functions, parameters, returns
  - Iteration
  - Lists
  - Booleans, conditionals
  - File input / output
  - Using modules and libraries
  - Using objects in programs
- Computing in the World
  - User tracking and privacy
  - Data and scale
  - Data visualization
  - Artificial intelligence
  - Algorithmic bias
- Computer Science
  - Searching
  - Sorting Runtime
  - Graphs
  - Classic Computer Science Problems

<u>CVEN 2017 Course Syllabus</u>

1. **Course number and name:** CVEN 2017 Excel Matlab R Primer

2. **Credits, contact hours, and categorization of credits in Table 5-1**: 1 credit, 1 contact hour, engineering topic

3. **Instructor or Course Coordinator Name:** Yu-Hsuan Lee

4. **Textbook:** N/A
   a. other supplemental materials – course lecture notes written by the instructor

5. **Specific course information:**
   a. **Brief description of the content of the course (catalog description):** Introduction to basic usage of Excel, Matlab and R software programs. Includes overview of fundamental operations such as data input and output, arithmetic, graphics, and programming syntax; more specific operations such as algebraic functions, linear algebra, plotting, loops, conditional statements, statistics and data analysis. Students will complete a final programming project with one of the software programs.
   b. **Prerequisites or Co-requisites:** Pre-Requisite: CSCI 1200 Introduction to Computational Thinking
   Recommended Co-Requisite: APPM 2360 Introduction to Linear Algebra & Diff. Equations
   c. **Indicate whether a required, elective, or selected elective**: Required

6. **Specific goals for the course**:
   a. **Specific Outcomes of instruction:** Students will gain the skills required for basic problem solving and typical applications in engineering using all three software programs, finishing the course with sufficient fluency to make further advances on their own.
   b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course**: Outcome 6, An ability to analyze and interpret data, and use engineering judgment to draw conclusions.

7. **Brief list of topics to be covered:** Overview of software programs, Basic architecture and purpose of the three software, with attention to common properties and differences; Fundamental operations, including data input and output, basic computation, and graphics. Overview of built-in high level operations and basic syntax of programming; Specific operations, including algebraic functions, linear algebra, plotting, loops, conditional statements, statistics and data analysis; Problem solving projects: students choose from a range of problems in engineering.

CVEN 2121 Course Syllabus

1. **Course number and name**: CVEN 2121: Analytical Mechanics I (Statics)

2. **Credits, contact hours, and categorization of credits in Table 5-1:**
   3 Credits, 3 contact hours, Engineering topic

3. **Instructor's or course coordinator's name**: Jeong-Hoon Song

4. **Textbook**: Engineering Mechanics-Statics, R. C. Hibbeler, 14th Edition

5. **Specific course information:**
   a. **Brief description of the content of the course (catalog description):** Applies mechanics to the study of static equilibrium of rigid and elastic bodies. Includes composition/resolution of forces; moments/couples; equivalent force systems; free-body diagrams; equilibrium of particles and rigid bodies; forces in trusses/beams; frictional forces; first/second moments of area; moments and products of inertia.
   b. **Prerequisites or Co-requisites:** PHYS 1110 (min grade C-) / APPM 2350 or MATH 2400 (min grade C-)
   c. **Indicate whether a required, elective, or selected elective**: Required

6. **Specific goals for the course**:
   a. **Specific Outcomes of instruction:**
      The following course objectives are met by this course:
      • an ability to apply knowledge of mathematics, science, and engineering
      • an ability to identify, formulate, and solve engineering problems
      • an ability to communicate effectively through writing and drawings
   b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course:** Outcome 6, An ability to analyze and interpret data, and use engineering judgment to draw conclusions.

7. **Brief list of topics to be covered**: Mechanics, Fundamental Concepts, Unit of Measurement, Force Vectors, Equilibrium of a Particle, Force System Resultants, Equilibrium of a Rigid Body, Structural Analysis, The method of Sections, Space Trusses, Frames and Machines, Internal Forces, Characteristics of Dry Friction, Center of Gravity and Centroid, Moments of Inertia

CVEN 3161 Course Syllabus

1. **Course number and name**: CVEN 3161, Mechanics of Materials I

2. **Credits, contact hours, and categorization of credits in Table 5-1:**
   3 credits, 3 hours per week, engineering

3. **Instructor's or course coordinator's name**: Yunping Xi

4. **Textbook**: Roy R. Craig, Jr. (2011) "Mechanics of Materials", 3rd Edition, John Wiley & Sons, New York.

5. **Specific course information:**
   a. **Brief description of the content of the course (catalog description):** Addresses concepts of stress and strain; material properties, axial loading, torsion, simple bending, and transverse shear; analysis of stress and strain; and deflections of beams. Includes selected experimental and computational laboratories.
   b. **Prerequisites or Co-requisites:** Requires
   prereq CVEN 2121 or GEEN 2851 or ASEN 2001 or MCEN 2023 (all min grade C-). Requires coreq APPM 2360 or (MATH 2130 3430).
   Restricted to Arch (AREN) or Civil (CVEN) or Environ (EVEN) or Integ Design (IDEN) majors with a CIV, ENR or ARC subplan
   c. **Indicate whether a required, elective, or selected elective**: Required

6. **Specific goals for the course**:
   a. **Specific outcomes of instruction**: Students will be able to conduct structural analyses (stress, strain, and deformations) of simple structural members under various loadings including tension/compression, torsion, bending and shear.
   b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course:** Outcome 3, Ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics; Outcome 6, An ability to develop and conduct appropriate experimentation and An ability to analyze and interpret data, and use engineering judgment to draw conclusions.

7. **Brief list of topics to be covered**: Deformable bodies, Equilibrium equations, Free body diagrams, Normal stress and normal strain, Shear stress and shear strain, General definitions of stress and strain, Mechanical properties of materials, Stress-stain diagrams, Hooke's law, Generalized Hooke's law, Basic mechanical properties, Tension and compression, Elastic behaviors of axially loaded members, and temperature effect, Inelastic behaviors, Torsion of circular bars, Linear elastic torsion of circular bars, Inelastic torsion of circular bars, Bending and shear, Equilibrium in beams, Shear force diagrams and bending moment diagrams, Flexural stress in linear elastic beams, Shear stress in beams, Differential equations of beams, Deflection of beams, Inelastic beam analyses, Transformations of stress and strain, Principal stresses and principal strains, Mohr's circle for stress and strain transformation

CVEN 3246 COURSE SYLLABUS

1. **Course number and name:** CVEN 3246 Introduction to Construction

2. **Credits, contact hours, and categorization of credits in Table 5-1** Three (3) credits, 3 contact hours, engineering topic

3. **Instructor/Course Coordinator name:** Matt Morris

4. **Textbook**: No textbook required

5. **Specific course information**:
    a. **Brief description of the content of the course (catalog description):** Provides a broad view of concerns, activities, and objectives of people involved in construction: the owner, architect/engineer, contractor, labor and inspector. Interactive gaming situation relates these people to the construction contract, plans/specifications, estimates/bids, scheduling, law and financial management.
    b. **Prerequisites or Co-requisites:** No pre-requisites
    c. **Indicate whether a required, elective, or selected elective**: Required

6. **Specific goals for the course**:
    a. **Specific outcomes of instruction:**
        - Describe the roles of key project players
        - Evaluate and select an appropriate project delivery method for a construction project
        - Estimate the cost of a basic structure or earthwork project
        - Calculate the equivalence of a series of economic investments
        - Schedule a series of construction tasks using the critical path method
        - Establish a project cash flow projection
        - Identify the requisite elements of a contract
        - Identify and analyze project risks
        - Identify and assess safety hazards on construction projects

    b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course:** Outcome 1, Ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics; Outcome 5, Ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks and meet objectives.

7. **Brief list of topics to be covered**: Project key players, Delivery Systems, Procurement Methods, Master Planning, Project Planning, Cost Estimating fundamentals, Scheduling fundamentals, Estimating earthwork, Insurance and Bonds, Risk , Contracts, Engineering Econ

<u>CVEN 3525 Course Syllabus</u>

1. **Course number and name**: CVEN 3525: Structural Analysis

2. **Credits, contact hours, and categorization of credits in Table 5-1:**

3 Credits, 3 contact hours, Engineering topic

3. **Instructor's or course coordinator's name**: Jeong-Hoon Song

4. **Textbook**: Structural Analysis, R. C. Hibbeler, 10^{th} Edition.

5. **Specific course information**:
    a. **Brief description of the content of the course (catalog description):** Studies structural analysis of statically determinate and indeterminate systems, deflections, energy methods, and force and stiffness methods.
    b. **Prerequisites or co-requisites:** CVEN 3161 or MCEN 2063 (min grade C-)
    c. **Indicate whether a required, elective, or selected elective**: Required

6. Specific goals for the course
    a. **Specific outcomes of instruction:**
    The following course objectives are met by this course:
        - an ability to apply knowledge of mathematics, science, and engineering
        - an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
        - an ability to communicate effectively through writing and drawings
        - an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

    b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course:** Outcome 1, Ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

7. **Brief list of topics to be covered**: Types of structures and loads, analysis of statically determinate structures, analysis of statically determinate trusses, internal loadings, deflections, energy methods: deflections, force method: statically indeterminate structures, displacement method: slope-deflection equations, stiffness method: truss analysis, stiffness method: beam analysis, stiffness method: plane frame analysis

<u>CVEN 4545 Course Syllabus</u>

1. **Course number and name:** CVEN 4545 Steel Design

2. **Credits, contact hours, and categorization of credits in Table 5-1**: 3 credit-hours, 3 contact hours, Engineering Topic

3. **Instructor's or course coordinator's name**: George Hearn

4. **Textbook**: AISC, Steel Construction Manual, 15th edition, (2017)
    a. other supplemental materials

5. **Specific course information**:
    a. **Brief description of the content of the course (catalog description)**: Applies basic principles of structural engineering and mechanics to the design of steel structures, including design of joists, beams, columns, tension member, bolted connections and welded connections.
    b. **Prerequisites or co-requisites**: Prereq, CVEN 3525 Structural Analysis
    c. **Indicate whether a required, elective, or selected elective**: Selected Elective

6. **Specific goals for the course**:
    a. **Specific outcomes of instruction**: Learning outcomes: Students are prepared to design steel structures to meet current building code requirements for structural safety. Students are prepared to design steel structures to meet current building code requirements for structural safety.
    b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course**: Outcome 2, Ability to apply engineering design to produce solutions that meet specified needs.

7. Brief list of topics to be covered: Steel building, loads, load combinations, roof plan, floor deck, floor pan and slab, open web joist, deck design, rolled shapes, making structural steel, beams, plastic moment, LTB, lateral torsional buckling, flange local buckling, beam selection, deflection, beam sheer strength, column buckling, columns, AISC E3, column selection, multi-story column, tension members, Ag, An, Ae, Tension Member selection, High-strength bolts, Bolts, Single shear, Double shear, Beam design, Lap joints, Block shear, Selection of braces, Gusset plane, Column design, types and processes of welds, strength of welds, lap joint welds, frame connection, braces design

<u>CVEN 4555 Course Syllabus</u>

1. **Course number and name**: CVEN 4555 (3) Reinforced Concrete Design

2. **Credits, contact hours, and categorization of credits in Table 5-1**: 3 credit hours, 3 contact hours, engineering topic

3. **Instructor's or course coordinator's name**: George Hearn

4. **Textbook**: ACI 318-19 Building Code Requirements for Structural Concrete
   a. other supplemental materials

5. **Specific course information**:
   a. **Brief description of the content of the course (catalog description)**: Applies basic principles of structural engineering and mechanics to the design of reinforced concrete structures, including design of beams, columns, slabs, and footings; continuous beams and frames; cast-in-place buildings.
   b. **Prerequisites or co-requisites**: CVEN 3525 Structural Analysis
   c. **Indicate whether a required, elective, or selected elective**: required

6. **Specific goals for the course**:
   a. **Specific outcomes of instruction**: Learning outcomes: Students are prepared to design reinforced concrete structural systems to meet current building code requirements for structural safety.
   b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course**: Outcome 2, Ability to apply engineering design to produce solutions that meet specified needs and Ability to apply engineering design with consideration of safety, social, environmental and economic factors

7. **Brief list of topics to be covered**: load combinations, load example slab, load example joist, load example column, material properties, concrete mixes, rebars, rebar areas, flexure, mechanics, assumptions, strain relations, positive moment, negative moment, two layers of steel, one way slab, singly reinforced slab, varied depth, varied As. ACL limits for steel, effect on φ, approximate moments in slabs, φMn for +/- with single reinforcement, shear in slabs, approximate Vu. Standard Vc for slabs, M+, M- Shear in joists, Vc for joists, ACI requirements for one way slab, one way joist, desk design, beams, beam shear, beam design for moment, beam check for shear, beam design, columns, 1D interaction, basic relations, distributed steel, short column design, slender columns, columns: unsymmetric rebar group, development length, development in compression

GEEN 1400 Course Syllabus

1. **Course number and name:** GEEN 1400 Engineering Projects

2. **Credits, contact hours, and categorization of credits in Table 5-1:** 3 credits, 5 contact hours/week, engineering design

3. **Instructor**: Joan Tisdale (Angela Bielefeldt, Mike Soltys, Katherine Ramos, Melissa Davis, Dan Godrick, Malinda Zarske)

4. **Textbook**: *Introductory Engineering Design: A Projects-Based Approach*. Abarca, Javier; Bedard, Al; Carlson, Denise; Carlson, Larry; Hertzberg, Jean; Louie, Bev; Milford, Jana; Reitsma, Rene; Schwartz, Trudy; Sullivan, Jackie. 2000. (Optional)

5. **Specific course information**:
   a. **Brief description of the content of the course (catalog description)**: First-year students solve real engineering design problems in interdisciplinary teams. Design projects vary by section. Curriculum focuses on iterative design process, teamwork and team dynamics, supporting design with testing and analysis, and technical writing. Completed projects are exhibited at an end-of-semester design expo.
   b. **Prerequisites or co-requisites**: none
   c. **Indicate whether a required, elective, or selected elective:** Required

6. **Specific goals for the course**:
   a. **Specific outcomes of instruction**: At the end of this course students can:
      - apply iterative design process to improve design; define functional requirements and specifications; generate alternative design concepts; work within constraints including safety; and appreciate and practice engineering habits of mind (see below).
      - learn and practice effective teamwork skills; learn how to rely on other team members to give and receive help; demonstrate increased understanding of diversity, equity, and inclusion; and practice conflict resolution.
      - develop a professional relationship with an engineering faculty member; develop technical writing and oral presentation skills; effectively communicate final designs to a range of audiences; and learn and practice active listening skills.
      - build hands-on engineering skills for prototyping and manufacturing; practice the role of analysis in the design process; solve engineering problems with appropriate tools; and effectively apply technical skills to produce prototypes/design artifacts that consider a range of economic, environmental, and societal contexts.

- understand the importance of an ethical code for the practice of engineering; appreciate that difficult, ‘gray’ situations arise in engineering practice; and develop an ethical process that will yield appropriate decisions when needed.

b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course:** Outcome 2, An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors; Outcome 3, an ability to communicate effectively with a range of audiences; Outcome 4, an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts; Outcome 5, an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.

7. **Brief list of topics to be covered**: Engineering Design Process, Engineering Tools including Computer Aided Design (CAD), Electronics, Arduino, Laser Cutting, Social Styles/Strengths, Team Dynamics and Growth, Engineering Ethics, Evaluating Design Alternatives, Prototyping, Project Management

<u>PHYS 1110 COURSE SYLLABUS</u>

1. **Course number and name**: PHYS 1110

2. **Credits, contact hours, and categorization of credits in Table 5-1**: 4 credit hours, 4 contact hours, basic science

3. **Instructor's or course coordinator's name**: Two faculty are assigned to this course and the faculty change every semester. In Fall 22, the instructors were Dr. Michael Dubson and Prof. Kathy Perkins. In Spring 23, it was Dr. Daniel Bolton and Prof. Tobin Munsat.

4. **Textbook**: Richard Wolfson, Essential University Physics, Volume 1. (2007). We use the inexpensive eText version which is budled with the online homework system Mastering Physics.
    a. other supplemental materials: Online PhET simulations at phet.colorado.edu

5. **Specific course information**:
    a. **Brief description of the content of the course (catalog description)**: **PHYS 1110 (4). General Physics 1.** Three lect., one rec. per week, plus three evening exams in the semester. First semester of three-semester sequence for science and engineering students. Covers kinematics, dynamics, momentum of particles and rigid bodies, work and energy, gravitation, simple harmonic motion, fluid statics, and sound waves.
    b. **Prerequisites or co-requisites**: Knowledge of algebra, geometry and trigonometry. Coreq: APPM 1345 or APPM 1350 or MATH 1300. (minimum grade C-). Credit not granted for this course and PHYS 1115.
    c. **Indicate whether a required, elective, or selected elective:** Required

6. **Specific goals for the course**:
    a. **Specific outcomes of instruction:** Students should understand that learning does not mean memorizing answers to specific questions; instead, learning means understanding general strategies, and developing robust internal models which permit one to recognize which strategy is appropriate and how to apply it. In this course, there are two broad strategies that students should master. 1) Newton's Laws. Given appropriate initial conditions of a classical mechanical system, the student should be able to compute the subsequent motion by applying Newton's Laws. This requires mastery of concepts in kinematics and dynamics, and knowing how to apply Newton's Laws in for both translational and rotational motions. 2) Conservation Laws. By comparing a known initial state of a system and a partly-known final state, the student should be able to apply one of the conservation laws (energy, momentum, or angular momentum) to determine the final state of the system.
    b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course**.

7. **Brief list of topics to be covered**: 1D kinematics, Vector Math and 2D motion, Newton's Laws intro, Applications of Newton's Laws, Work, Energy, and Power, Gravity and

orbits, Momentum, Center of mass, Rotations, Angular momentum, Static Equilibrium, Simple Harmonics Motion, Fluid Statics, Waves and Sound

<u>PHYS 1120 COURSE SYLLABUS</u>

1. **Course number and name**: PHYS 1120

2. **Credits, contact hours, and categorization of credits in Table 5-1**: 4 credit hours, 4 contact hours, basic science

3. **Instructor's or course coordinator's name**: Two faculty are assigned to this course and the faculty change every semester. In Fall 2022, the instructors were Dr. Daniel Bolton and Prof Ed Kinney. In Spring 23, it is Dr. Michael Dubson and Prof..Ed Kinney

4. **Textbook**: Richard Wolfson, Essential University Physics, Volume 2. (2007). We use the inexpensive eText version which is bundled with the online homework system Mastering Physics. Also, we always use: McDemott et al., Tutorials in Introductory Physics, Prentiss (Pearson), 2002
   a. other materials: CUClicker, Online PhET simulations at phet.colorado.edu

5. **Specific course information**:
   a. **Brief description of the content of the course (catalog description)**: PHYS 1120 (4). General Physics 2. Three lect., one rec. per week, plus three evening exams in the semester. Second semester of three-semester introductory sequence for science and engineering students. Covers electricity and magnetism, wave motion, and optics. Normally is taken concurrently with PHYS 1140.
   b. **Prerequisites or co-requisites**: PHYS 1110. Coreqs: MATH 2300 or APPM 1360. Credit not granted for this course and PHYS 1125.
   c. **Indicate whether a required, elective, or selected elective:** Required

6. **Specific goals for the course**:
   a. **Specific outcomes of instruction**:Students should understand that learning does not mean memorizing answers to specific questions; instead, learning means understanding general strategies, and developing robust internal models which permit one to recognize which strategy is appropriate and how to apply it. In this course, the general strategy is application of Maxwell's equations. There are two broad categories for applications of Maxwell's equations: 1) Charges, currents, and fields. Given a known distribution of charges and/or currents, students should be able to compute the electric and magnetic fields. Similarly, given the fields, students should be able to compute the forces on and motion of charges. 2) Circuit analysis. Students should be able to understand and analyze simple DC and AC circuits containing batteries, resistors, capacitors, and inductors.
   b. **Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course**.

7. **Brief list of topics to be covered**: Static Electric fields, Gauss's Law, Voltage and capacitance, DC Circuits, Magnetic fields: Biot-Savart Law and Ampere's Law, Faraday's Law, inductance, Electromagnetic waves and Maxwell's equations, Ray Optics

APPENDIX B – FACULTY VITAE

ABET CV for Jay Arehart

1. **Name**: Jay H. Arehart

2. **Education**:

   University of Colorado Boulder | Boulder, CO 2021
   Ph.D. Architectural Engineering
   Thesis: *Multi-scale Modeling of Carbon Sequestration and Storage in the Built Environment*

   University of Colorado Boulder | Boulder, CO 2017
   M.S. Architectural Engineering
   Thesis: *Energy Performance Analysis of Transparent Wood Composite-Based Glazing Systems in Commercial Buildings*

   University of Colorado Boulder | Boulder, CO 2016
   B.S. Architectural Engineering, *summa cum laude*
   Minor: *Applied Mathematics*

3. **Academic Experience**:

   University of Colorado Boulder, *Assistant Teaching Professor* 2020 – Present

4. **Non-Academic Experience:**

   Preoptima Ltd., *Co-Founder* 2021 – Present
   Part-time. Consultant performing life cycle assessments of buildings and cities.

   Project Drawdown, *Research Fellow* 2018 – 2020
   Part-time. Consultant responsible for modeling impact of climate solutions that relate to the building sector.

5. **Certifications or Professional Registrations**:

   State of Colorado Engineer-in-Training

6. **Current Membership in Professional Organizations:**

   A.M. American Society of Civil Engineers: Structural Engineering Institute
   A.M. American Society of Civil Engineers: Architectural Engineering Institute

7. **Honors and Awards**:

   Temple Hoyne Buell Ambassadorial Fellow | Rotary International 2018
   Honorable Mention | NSF Graduate Research Fellowship Program 2018

8. **Service Activities**:

   ASCE Committee on Sustainability Technical Working Group Member
   Structural Engineering Institute (SEI) Committee Co-Chair
   Engineers in Action Bridge Builder Conference 2021, 2022, 2023 Chair
   CU Boulder Solar Decathlon 2023 Build Challenge Faculty Lead

CU Boulder Architectural Engineering Institute Student Chapter Faculty Advisor

9. **Selected Publications & Presentations**:

- Göwein V., Arehart J.H., Phan-huy, C., Pomponi F., Habert G. (2022). "Barriers and opportunities of fast-growing biobased material use in buildings". *Buildings and Cities*, 3(1), 745-755, https://doi.org/10.5334/bc.254.
- Arehart J. H., Pomponi F., D'Amico B., Srubar, W.V. (2022). "Structural material demand and associated embodied carbon emissions of the United States building sock: 2020-2100". *Resources, Conservation and Recycling*, 186, 106583, https://doi.org/10.1016/j.resconrec.2022.106583.
- Arehart J. H.[2], Hart J.[1], Pomponi F., D'Amico B. (2021). "Carbon sequestration and storage in the built environment". *Sustainable Production & Consumption*, 27, 1047-1063. https://doi.org/10.1016/j.spc.2021.02.028.
- Arehart J. H., Langenfeld K., Kreiger B., (2021, July). "Engagement in practice: pedestrian bridges as engineering service-learning projects". In *2021 ASEE Virtual Annual Conference*, Long Beach, CA.

10. **Recent Professional Development Activities**:

Active Learning Faculty Fellow (Fall 2021)
KEEN Engineering Unleashed Faculty Fellow: Problem Solving Studio (Fall 2020)

[2] Co-first author

ABET CV for Kyri Baker

1. **Name**: Kyri Baker

2. **Education**:
   PhD Electrical and Computer Engineering (2014), Carnegie Mellon University.
   MS Electrical and Computer Engineering (2010), Carnegie Mellon University.
   BS Electrical and Computer Engineering (2009), Carnegie Mellon University.

3. **Academic Experience**:
   Assistant Professor, University of Colorado Boulder, Civil, Environmental, and Architectural Engineering (CEAE) (2017-present) and Electrical, Computer, and Energy Engineering (by courtesy) (2017-present)
   Fellow of the Renewable and Sustainable Energy Institute (RASEI) (2020-present)
   Faculty Director for Architectural Engineering (2022 – present)
   Lewis-Worcester Faculty Fellow (2022-present)

4. **Non-Academic Experience**:
   Postdoctoral Researcher, National Renewable Energy Laboratory (2015-2016). Conducted research in the Residential Buildings group designing intelligent, energy efficient home algorithms.
   Research Engineer, National Renewable Energy Laboratory (2016-2017). Conducted research in the Power Systems Engineering Center designing algorithms to operate assets in power grids.

5. **Certifications or professional registrations**: N/A

6. **Current memberships in professional organizations**: IEEE Member

7. **Honors and Awards**:
   - Outstanding Young Investigator Award Runner Up, Institute of Industrial and Systems Engineers, Energy Systems Division 2022
   - John and Mercedes Peebles Innovation in Education Award, 2022
   - Architectural Engineering Faculty Appreciation Award, 2022
   - CEAE Teaching Award 2022
   - CU Boulder Outstanding Mentor Award, 2021
   - National Science Foundation CAREER Award, 2021
   - CEAE Early Career Researcher Award 2021
   - Dean's Faculty Fellowship 2021
   - Outstanding Associate Editor, IEEE Transactions on Smart Grid 2021
   - Best Paper Runner-up, ACM e-Energy 2021
   - Top Five Performer, DOE ARPA-E Grid Optimization (GO) Competition 2021
   - Best Paper Award, two papers, IEEE Transactions on Power Systems 2020
   - Top Ten Performer, DOE ARPA-E Grid Optimization (GO) Competition 2020
   - Architectural Engineering Faculty Appreciation Award, 2020
   - Best Paper Finalist, IEEE Power & Energy Society General Meeting 2019
   - Best Paper Award Honorable Mention, International Workshop on NILM 2018
   - R&D 100 Award, 2018
   - Best Paper Award, Power and Energy Conference at Illinois (PECI) 2017

- Employee of the Month, National Renewable Energy Lab. 2016

8. **Service Activities (within and outside of the institution)**:
   - Search committees (for faculty and staff): 2018, 2019, 2021-2023
   - Faculty advisor for the University of Colorado Energy Club: 2019 – present
   - Education and Outreach committee for RASEI: 2021-present
   - Graduate committee (department): 2019-present
   - Associate Editor for IEEE Transactions on Smart Grid: 2020-present
   - Editor, Springer Current Sustainable/Renewable Energy Reports, 2022 – Present
   - Editorial Board, Elsevier Sustainable Energy, Grids and Networks, 2021 - Present
   - Guest Editor, IET Cyber-Physical Systems: Theory & Applications, 2022-Present
   - Various conference session chairs, panel organization, paper reviews, 2017-present
   - Seminars and Conference committee for RASEI: 2020-2021
   - Curriculum committee (department): 2018-2019
   - Guest Editor, Journal of Modern Power Systems and Clean Energy: 2020-2021
   - Vice Chair, IEEE Smart Buildings, Loads, and Customer Services (SBLC) Loads subcommittee, 2019 - 2021.
   - Faculty advisor for the IEEE student branch at CU Boulder: 2017-2019
   - Steering Committee/Moderator, NSF/PSERC Workshop: Grid at the Edge, 2021.
   - Panel Reviewer, National Science Foundation (NSF), 2015, 2016, 2021.

9. **Selected Publications & Presentations:**
   - Kyri Baker, *Emulating AC OPF Solvers with Neural Networks,* IEEE Transactions on Power Systems, vol. 37, no. 6, 2022.
   - Kyri Baker, *Solutions of DC OPF are Never AC Feasible,* ACM e-Energy 2021.
   - Kyri Baker, *Learning Warm-Start Points for AC Optimal Power Flow,* IEEE 29th Intl. Workshop on Machine Learning for Signal Processing, Pittsburgh, PA 2019.
   - Joshua W. Busby, Kyri Baker, Morgan D. Bazilian, Alex Q. Gilbert, Emily Grubert,Varun Rai, Joshua D. Rhodes, Sarang Shidore, Caitlin A. Smith, Michael E. Webber, *Cascading risks: Understanding the 2021 winter blackout in Texas,* Energy Research & Social Science, vol. 77, 2021.
   - Kyri Baker, Andrey Bernstein, Emiliano Dall'Anese, Changhong Zhao, *Network-Cognizant Voltage Droop Control for Distribution Grids,* IEEE Transactions on Power Systems, vol. 33, no. 2, 2018.
   - Ahmed Zamzam and Kyri Baker, *Learning Optimal Solutions for Extremely Fast AC Optimal Power Flow,* IEEE International Conference on Communications, Control, and Computing Technologies for Smart Grids (SmartGridComm), Tempe, AZ, 2020.

10. **Briefly list the most recent professional development activities**:

I have been participating in a Faculty Fellows program through the Research and Innovation Office at the University of Colorado Boulder to improve my leadership skills. I have additionally taken media training and active learning training through the university to improve my communication and teaching skills. I have also given over 30 invited talks at various venues in the past 4 years to increase awareness about my research and improve my public speaking skills.

ABET CV for Amelia Celoza

1. **Name**: Amelia Celoza

2. **Education**:
   PhD, Civil, Architectural and Environmental Engineering, 2022, The University of Texas at Austin
   MS, Civil and Environmental Engineering, Stanford University, 2014
   BSE, Civil Engineering, Arizona State University, 2013

3. **Academic experience:**
   University of Colorado Boulder, Assistant Professor, 2022-present, full-time

4. **Non-academic experience**:
   Tesla, Inc., Senior Construction Contracts Manager, managed contracts and partnerships for major projects in NV and CA, 2016-2018, full-time
   Tesla, Inc., Construction Contracts Manager, managed contracts and partnerships for major projects in NV and CA, 2015-2018, full-time

5. **Certifications or professional registrations:**
   OSHA 30-hour certification, Issued October 2015
   Engineer in Training (EIT), Issued August 2014

6. **Current membership in professional organizations**:
   American Society of Civil Engineers (ASCE)
   Chi Epsilon Civil Engineering Honor Society
   Tau Beta Pi Engineering Honor Society

7. **Honors and awards:**
   - Cullen M. Crain Endowed Scholarship in Engineering, University of Texas at Austin, 2021–2022
   - Construction Law Foundation of Texas Fellowship, University of Texas at Austin, 2020 & 2021
   - Engineering Foundation Endowed Graduate Presidential Fellowship, University of Texas at Austin, 2020 – 2021
   - AGC Education and Research Graduate Scholarship, Associated General Contractors Education and Research Foundation, 2019 – 2020
   - Tucker Hudson Kumar Endowed Presidential Fellowship, University of Texas at Austin, 2018 – 2019
   - Graduate School Mentoring Fellowship, University of Texas at Austin, 2018 – 2019

8. **Service activities (within and outside of the institution):**
   - ASCE Visualization, Information Modeling, and Simulation (VIMS) Committee
   - Construction Industry Institute, Supply Chain Management Community of Business Advancement, Academic Advisor

- Search Committee, Tenure-Track Position in Construction Engineering and Management within the Department of Civil, Environmental and Architectural Engineering, University of Colorado Boulder
- Graduate Recruiting and Admissions Committee, Department of Civil, Environmental and Architectural Engineering, University of Colorado Boulder

9. **Selected Publications & Presentations:**
   - Role of BIM Contract Practices in Stakeholder BIM Implementation on AEC Projects, Celoza, A., de Oliveira, D. P., and Leite, F., Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, 2023, https://doi.org/10.1061/JLADAH/LADR-916.
   - Qualitative Analysis of the Impact of Contracts on Information Management in AEC Projects, Celoza, A., de Oliveira, D. P., and Leite, F., Journal of Construction Engineering and Management, 2023, https://doi.org/10.1061/JCEMD4/COENG-12359.
   - Longitudinal Study of Information Management in University Construction Contracts, Celoza, A., de Oliveira, D. P., and Leite, F., Construction Research Congress 2022, https://doi.org/10.1061/9780784483978.008.
   - Construction Industry Institute's Impact on Construction Engineering and Management Academic Publications, Celoza, A., Leite, F, and de Oliveira, D. P., Construction Research Congress 2022, https://doi.org/10.1061/9780784483985.005.
   - Identification and Ranking of Legal Factors Impacting Information Management in the AEC Industry Using the Delphi Method, Celoza, A., de Oliveira, D. P., and Leite, F., Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, 2021, https://doi.org/10.1061/(ASCE)LA.1943-4170.0000494.
   - Impact of BIM-related Contract Factors on Project Performance, Celoza, A., Leite, F., and de Oliveira, D. P., Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, 2021 https://doi.org/10.1061/(ASCE)LA.1943-4170.0000478.

10. **Briefly list the most recent professional development activities**:

SafeZone Training, Center for Inclusion and Social Change, University of Colorado Boulder, October 2022
Principal Investigator Academy, Research & Innovation Office, University of Colorado Boulder
Thriving at CU, Office of Faculty Affairs, University of Colorado Boulder
Fall Center for Teaching and Learning Intensive, University of Colorado Boulder, August 2022
Autodesk Construction School, August 2022
Course Design and Academic Technology Overview for New Faculty, Center for Teaching and Learning, University of Colorado Boulder, July 2022
Construction Faculty Teaching Excellence Program, July 2022
Advanced Teaching Preparation Certification, Faculty Innovation Center, University of Texas at Austin, 2020

<u>ABET CV for Alex Gore</u>

1. **Name**: Alex Gore

2. **Education**:

    North Dakota State University, Fargo, ND
    Master of Construction Management May 2011
    Master of Architecture - May 2008
    B.S. of Environmental Design - May 2007

3. **Academic experience**:

    University of Colorado Boulder, Lecturer, Part Time, 2013-2023
    Architectural Engineering Drawing-AREN 1027 | CEAE Department
    Advanced Design Lab 1 - ENVD 4100 | Environmental Design Department
    Computational Methods - ENVD 4352 | Environmental Design Department

4. **Non-academic experience**:

    Owner/Co-Founder |F9 Productions Inc., Longmont, CO (02/10 - Present)
    Currently responsible for obtaining and managing multiple commercial and residential architecture and construction projects by means of recurring clientele and new solicitations for business.

    Owner/Co-Founder |F14 Productions Inc., Longmont, CO Construction Company (11/18 - Present). With 20+ years of construction experience, and a Class B General Contractor's license this experience allows me to provide clients with construction incite from the inception of the project in order to create a more on-budget, on-time solution that meets their programmatic and aesthetic goals.

    Junior Architect|Studio Daniel Libeskind (10/08-07/09)

    - Helped develop the masterplan and landmark tower for the Yongsan Development project in Seoul Korea.
    - Modeler, highrise designer, and conducted daily meetings with Daniel Libeskind while in office
    - Researched sustainable methods for Maya Island project in Abu Dhabi
    - Coordinated presentation graphics, planning concepts, and schematic layouts for all projects

    Independent Architectural Consultant | Fargo, ND (04/06-09/07)

    - Spearheaded masterplan and development coordination for Underwood, ND
    - Developed architectural identity of $88 million Educational Campus Center in Minneapolis, MN.

    Community Planner | Ulteig Engineers, Fargo, ND (01/07-05/07)

    - Researched city economics and city development
    - Strategized South Dakota's capital future development: Pierre, SD
    - Reorganized strip-mall planning into walkable city extension for Sabin, MN

Army National Guard | Fargo, ND (09/01-09/10)

- Obtained Corporal Rank
- Basic Training Top Graduate
- Advanced Individual Training Top Graduate
- Heavy Equipment Operator
- Construction work on Alaskan highway, CMU facility in Germany, and flood protection dikes in Fargo, North Dakota

5. **Certifications or professional registrations:**
   Registered Architect

6. **Current membership in professional organizations:**
   National Council of Architectural Registration Boards

7. **Honors and awards:**
   - Horizon Award Winner: The Horizon Award recognizes alumni who have graduated within the past 15 years and have attained great success in their profession or have been engaged in outstanding community service.
   - 1st Place|Architizer A+ Award|Architecture+Living Small 2016
   - 1st Place|Dreamhub Competition|Team Studio Daniel Libeskind 2008
   - 1st Place|Alpha Rho Chi|Awarded to the student who best exemplifies leadership, service, & professional merit 2008
   - 1st Place|NDSU sustainable skyscraper competition 2007
   - 1st Place NDSU Concrete Inc. 2006
   - ASLA Merit Award|Underwood, ND 2007
   - Notable Entry Award|Re:Connect competition for visionary thinkers 2007

8. **Service activities (within and outside of the institution):**
   Volunteer architecture services for local Parks and Recreation Department

9. **Selected Publications & Presentations:**
   - Mercury 100 - 3rd Fastest Growing Private Companies in the Boulder Valley Tier V |2017
   - Mercury 100 - 6th Fastest Growing Private Companies in the Boulder Valley Tier IV |2018
   - Mercury 100 - Fastest Growing Private Company in the Boulder Valley Tier III |2020
   - Cover of Builder Magazine | Jan. 2021 - Colorado custom home embodies efficiency, longevity, and functionality.
   - Modern in Denver Magazine|Spring 2018 – Master of Disaster
   - HGTV |Tiny House Big Living Season 1 Episode 13 - Alex and Lance's Amazing Unfoldable Tiny House

10. **Briefly list the most recent professional development activities:**
    Co-Host of Inside the Firm Podcast – Topics: Architecture/Construction

ABET CV for George Hearn

1. **Name**: George Hearn

2. **Education:**
   D.E.S, Civil Engineering, Columbia University, 1989

3. **Academic experience**:
   Associate Professor, University of Colorado, Full time

4. **Non-academic experiencee**:
   Structural engineer in various consulting firms.

5. **Certifications or professional registrations**:
   PE New York, Colorado

6. **Current membership in professional organizations**:
   AISC
   ASCE
   TRB

7. **Honors and awards:** none recent

8. **Service activities (within and outside of the institution)**:
   - Chair, National Academies, Review of Federal Highway Administration Infrastructure R&D - Expert Task Group on Bridges
   - Member, National Academies, Review of Federal Highway Administration Infrastructure R&D
   - Member, FHWA Expert Task Group on Bridge Preservation

9. **Selected Publications & Presentations:**
   - (2021) Guide to Bridge Preservation Actions, 1st Edition, ISBN 978-1-56051-745-0, 375p.
   - (2022) Guide to Preservation of Highway Bridge Decks, 1st Edition, ISBN 978-1-56051-786-3, 186p.

10. **Briefly list the most recent professional development activities**:
   Faculty Diversity Search – Web training

ABET CV for Gregor Henze

1. **Name**: Gregor P. Henze, Ph.D., P.E.

2. **Education**:

Technical University of Berlin, Germany, Mechanical Engineering, B.S.	1989
Oregon State University, Mechanical Engineering, M.S.	1991
Technical University of Berlin, Germany, Mechanical Engineering, Dipl.-Ing.	1992
University of Colorado Boulder, Civil Engineering, Ph.D.	1995

3. **Academic Experience:**

University of Colorado Boulder, Professor, 2008 - today, FT
Universidad de Sevilla, Andalusia, Spain, Visiting Professor, 2014 – 2015, FT
University of Nebraska-Lincoln, Assistant and Associate Professor, 1999 - 2008, FT

4. **Non-Academic Experience:**

National Renewable Energy Laboratory, Golden, Co., 2013-today, Joint Professor, PT
CSIRO Energy Centre, Newcastle, Australia, Jan.-June 2022, Visiting Scientist, FT
Eurac Research Institute for Renewable Energy, Jul-Dec. 2021, Visiting Scientist, FT
Fraunhofer Solar Energy Systems, Germany, Oct 2005-July 06, Visiting Scientist, FT
Johnson Controls, Essen, Germany, Jan. 1996-Aug. 1999, Engineering Manager, FT

5. **Certifications or Professional Registrations:**

ASHRAE-certified High-Performance Building Design Professional
Licensed professional mechanical engineer in Nebraska

6. **Current Membership in Professional Organizations:**

ASHRAE
International Building Performance Simulation Association USA

7. **Honors and Awards**

- Fulbright Distinguished Chair in Science, Technology, and Innovation at CSIRO in Newcastle, New South Wales, Australia 2022
- Interim Co-Director Renewable and Sustainable Energy Institute 2020-2021
- RASEI Associate Director for Energy Systems for the Built Environment 2017
- Charles Victor Schelke Endowed Chair 2017
- University of Colorado Architectural Engineering Appreciation Award 2015
- University of Colorado CEAE Department Distinguished Achievement Award 2012
- Colorado Cleantech Industry Association Research &Commercialization Award 2011
- University of Colorado CEAE Department Research Development Award 2011
- Best Paper Awards, ASME International Solar Energy Conferences 1996, 2002, 2004
- Full Fulbright Scholarship for graduate study at Oregon State University 1990-1991

8. **Service Activities (within and outside of the institution)**:

- Chair-Workshop on Intelligent Building Operations, Univ. of Colorado, Aug 2019
- Co-Chair-Workshop on Intelligent Building Operations, Purdue Univ., June 2018

- Associate Editor for IEEE Control Systems Letters 2017 – 2020
- Co-Chair-Workshop on Intelligent Building Operations, Purdue Univ., June 2016
- Editorial Board Member for Journal Building Performance Simulation since 2015
- Associate Editor for ASCE Journal of Architectural Engineering 2015 – 2019
- Associate Editor of Elsevier Journal *Renewable Energy* for 2014 – 2015.
- Renewable and Sustainable Energy Institute (RASEI) Associate Director, 2017-2021
- Chair for Workshop on Intelligent Building Operations, Boulder, June 2013
- Chair for Workshop on Model Predictive Control in Buildings, Montreal, June 2011.
- American Society of Mechanical Engineers Solar Energy Division Technical Committee Chair for Conservation and Solar Buildings for 2008-2014.
- Associate Editor of the *Journal of Solar Energy Engineering* in the topical area of "Conservation and Solar Buildings" for 2008-2014.
- Member of ASHRAE committee charged with developing a certification program on Sustainable Building Design and Operation
- ASHRAE: Technical Committee 7.5 Smart Building Systems, 1.4 Control Theory

9. **Selected Publications & Presentations:**

- Allen, A., Henze, G., Baker, K., Pavlak, G., & Murphy, M. (2022). An optimization framework for the network design of advanced district thermal energy systems. *Energy Conversion and Management*, *266*, 115839.
- Marzullo, T., Dey, S., Long, N., Leiva Vilaplana, J., & Henze, G. (2022). A high-fidelity building performance simulation test bed for the development and evaluation of advanced controls. *Journal of Building Performance Simulation*, *15*(3), 379-397.
- Tan, S. Y., Jacoby, M., Saha, H., Florita, A., Henze, G., & Sarkar, S. (2022). Multimodal sensor fusion framework for residential building occupancy detection. *Energy and Buildings*, *258*, 111828.
- Jacoby, M., Tan, S. Y., Katanbaf, M., Saffari, A., Saha, H., Kapetanovic, Z., Garland, J., Florita, A., Henze, G., Sarkar, S. & Smith, J. (2021). WHISPER: Wireless Home Identification and Sensing Platform for Energy Reduction. *J Sensor and Actuator Networks*, *10*(4), 71.
- Cruickshank, R., Henze, G., Florita, A., Corbin, C., & Stone, K. (2022). Estimating the value of jointly optimized electric power generation and end use: a study of ISO-scale load shaping applied to the residential building stock. *J Build Perf Simulation*, *15*(4), 507-535.
- Jacoby, M., Tan, S. Y., Henze, G., & Sarkar, S. (2021). A high-fidelity residential building occupancy detection dataset. *Scientific Data*, *8*(1), 1-14.
- Mosiman, C., Henze, G., & Els, H. (2021). Development and Application of Schema Based Occupant-Centric Building Performance Metrics. *Energies*, *14*(12), 3513.
- Fleschutz, M., Bohlayer, M., Braun, M., Henze, G., & Murphy, M. D. (2021). The effect of price-based demand response on carbon emissions in European electricity markets: The importance of adequate carbon prices. *Applied Energy*, *295*, 117040.

10. **Recent Professional Development Activities:**

Time Series Analysis with a Focus on Modeling and Forecasting in Energy Systems, Danish Technological University, Copenhagen, Denmark, August 15-19, 2022.

ABET CV for Amy Javernick-Will

1. **Name:** Amy Javernick-Will, PhD

2. **Education:**
   Ph.D. (2009) Civil Engineering, Stanford University
   M.S. (2001) Civil Engineering, University of Colorado at Boulder
   B.S. (1999) Civil Engineering, University of Colorado at Boulder

3. **Academic experience:**
   Professor Dept. of Civil, Environmental, and Architectural Engineering 2021 – Present University of Colorado at Boulder
   Associate Professor Dept. of Civil, Environmental, and Architectural Engineering 2016 – 2021 University of Colorado at Boulder
   Assistant Professor Dept. of Civil, Environmental, and Architectural Engineering 2010 – 2016 University of Colorado at Boulder
   Research Assistant Dept. of Civil and Environmental Engineering 2006 – 2009 Stanford University, Stanford, CA
   Teaching Assistant Department of Civil, Environmental and Architectural Engineering 2000 University of Colorado at Boulder, Boulder, CO

4. **Non-academic experience:**
   Project Manager Opus Northwest, L.L.C, 2005 – 2006 Denver, Colorado
   Ast Project Manager Opus Northwest, L.L.C, 2001 – 2004 Denver, Colorado
   Project Engineer Neenan Company, 2000 – 2001 Fort Collins, Colorado
   Project Engineer Turner Construction Company, 1999 Denver, Colorado

5. **Certifications or professional registrations**: LEED AP

6. **Current membership in professional organizations:** Editorial Board member, Construction Management and Economics; Editor, PLOS Water; Advisory Board Member, Project Leadership Institute, Department of Energy; ASCE Construction Research Congress; Engineering Project Organizations Society

7. **Honors and awards:**
   - American Society of Civil Engineering (ASCE) Journal of Management in Engineering Best Peer Reviewed Paper Award (2021)
   - Outstanding Teacher Award, Department of Civil, Environmental, and Architectural Engineering, University of Colorado—Boulder (2021)
   - American Society of Civil Engineering (ASCE) Daniel W. Halpin Award for Scholarship in Construction (2018)
   - Outstanding Service Award, Department of Civil, Environmental, and Architectural Engineering, University of Colorado—Boulder (2018)
   - Distinguished Professor Award, Construction Industry Institute (2016)
   - American Society of Civil Engineering (ASCE) Excellence in Civil Engineering Education (ExCEEd) New Faculty Excellence in Teaching Award (2014)
   - Outstanding Advisor, CEAS, University of Colorado—Boulder (2014)

8. **Service activities (within and outside of the institution):**
- Excellence in Leadership Program, University of Colorado, 2022-2023.
- Search Chair, Construction Engineering & Management, CEAE dept. (2022-present)
- Justice, Equity, Diversity, and Inclusion Committee, CEAE dept. (2021-present)
- Inclusive Culture Council (2021-present)
- Executive Committee, Department of Civil, Environmental, and Architectural Engineering, University of Colorado (2020-present)
- Assoc. Director, Mortenson Center Global Engineering & Resilience (2015-present)
- Mentoring Committee, Department of Civil, Environmental, and Architectural Engineering, University of Colorado (2017-present)
- National Science Foundation Workshops and Review Panels (multiple)

9. **Selected Publications & Presentations:**
- Murray, P., Feliciano, D., Goldwyn, B., Liel, A., Arroyo, O., and A. Javernick-Will. (2022). "Seismic safety of informally-constructed reinforced concrete houses in Puerto Rico. Earthquake Spectra. 10.1177/87552930221123085
- Cord, C., Fink, E., Javernick-Will, A., Mukanga, J., Bergeron, F., Harvey, A., and K. Linden. (2022). "A multi-method analysis of factors for reliable and sustainable rural water infrastructure". Environmental Science and Technology Water. 10.1021/acsestwater.2c00181
- Goldwyn, B., Vega, Y., Javernick-Will, A., and A. Liel (2022). "Identifying Misalignments between the Informal Construction Sector's Perceptions and Engineering Assessments of Housing Safety in Future Disasters for Capacity Development". International Journal of Risk Reduction. 10.1016/j.ijdrr.2022.103105
- Pugel, K., Javernick-Will, A., Peabody, S., Nyaga, C., Mussa, M., Mekonta, L., Dimtse, D., Watsisi, M., Buhungiro, E., Mulatu, T., Annis, J., Jordan, E., Sandifer, E., Linden, K., (2022). "Pathways for collaboratively strengthening water and sanitation systems" Science of The Total Environment 149854.10.1016/j.scitotenv.2021.149854

10. **Briefly list the most recent professional development activities:**
Excellence in Leadership Program, *University of Colorado*, 2022-2023.
Academic Leaders Institute Training, *University of Colorado Boulder*, 2020.
In-depth Media Coaching, *University of Colorado Strategic Communications*, 2019
NSF Coastlines & People Workshop, *San Diego, CA*, September 2018
NSF Research in Engineering Practice Workshop, October 2018.
Crucial Accountability Course, *Boulder, CO,* June 2018.
Crucial Conversations Course, *Boulder, CO*, June 2017.
Philippines Shelter Cluster Meeting, *Tacloban, Philippines,* November 2016.
United Nation's Habitat 3 Conference, *Quito, Ecuador,* October 2016.
PACE, Innovation Research Roadmapping Workshop, *Pennsylvania,* June 2015
National Science Foundation IDEAS Lab, *Virginia,* March 2014.

ABET CV for Moncef Krarti

1. **Name**: Moncef Krarti, Ph.D.

2. **Education**:

Diplôme d'Ingénieur, Ecole Polytechnique, Palaiseau, France, 1982
BS, Diplôme d'Ingénieur, Ecole des Ponts et Chaussées, Paris, 1984
MS, Civil Engineering, University of Colorado, 1985
Ph.D., Civil Engineering, University of Colorado, 1987

3. **Academic Experience**:

2012-2013 Nanyang Technological University, Singapore (sabbatical)
1998-Present Ecole des Mines de Paris, Adjoint Professor
1986-1988 Texas A&M University, Post-doctoral Fellow
University of Colorado Boulder:
2004-present: Professor; 1998-2004: Assoc. Professor; 1991-1998: Asst. Professor
2006-2008 Associate Chair CEAE
1997-1998 Director JCEM program

4. **Non-Academic Experience:**

1988-1991 Associate, Steven Winter Associates, Norwalk, CT

5. **Certifications or professional registrations**:

1998-present P.E., Colorado
2009-present LEED-AP, Green Building Certification Institute

6. **Current membership in professional organizations**:

American Society for Mechanical Engineers (ASME), Fellow
American Society of Heating, Refrigerating, and Air Conditioning (ASHRAE)
American Solar Energy Society (ASES)

7. **Honors and awards**:

- Keynote speaker award for ASHRAE Middle East Conference, Beirut, Lebanon, 2022.
- Best Paper, ASME Energy Sustainability Conference 2021 with Jordan Thompson.
- Founder and Editor of ASME Journal of Engineering for Sustainable Buildings and Cities, New York City, NY, 2020.
- Distinguished Achievement Award, CEAE Department, 2016.
- New Inventor Award, University of Colorado at Boulder, 2013.
- Eckel Award for Excellence, University of Colorado at Boulder, 2012.
- Service Award, Solar Energy Division Chair, ASME, New York, NY, 2011.
- Keynote Speaker Award, ASME Conference, San Francisco, CA, 2009.
- Best Presentation for a Panelist, ASHRAE Chapter in Hong-Kong, 2008.
- Service Award, CEAE department, University of Colorado, Boulder, Colorado, 2008.
- Service Award, ASME, for organizing the technical program for the Solar Energy Conference, Denver, Colorado, 2006.
- Best paper Award, International Solar Energy Conference, Portland, Oregon, 2004.
- Best paper Award, 3 rdWorld Conference on Photovoltaic Energy Conversion, Osaka, 2003.
- Best ASHRAE Paper Award at the annual meeting for (ASHRAE), 2000.
- Best Paper Award, Solar Conference, American Society of Mechanical Engineers, 1998.

- Research Development Award, 1995, CEAE department

8. **Service activities (within and outside the institution)**:
- American Society for Mechanical Engineers (ASME): Co-director of Integrated and Sustainable Building Equipment and Systems (ISBES). Environmental Division director (2011-13); Editor of ASME Handbook on ISBES, Editor of Monographs. Chair and co-chair of several ASME Energy sustainability conferences, 1992-present.
- American Society of Heating, Refrigerating, and Air Conditioning (ASHRAE): Voting member of several technical committees on Thermal Energy Storage, Intelligent Buildings, and Building Thermal Load Calculations, 1992-present. of the Civil Engineering Program Criteria Task Committee, 2013.
- American Solar Energy Society: Technical Chair of two annual ASES conferences
- Editorial Member of Journal of Solar Energy Engineering (JSEE), published by ASME, Chair of Energy Fundamentals Section, 2006-2012.
- Building Energy Efficient Systems editorial board, Francis&Taylor publishing, 2012-present
- Dept. of Civil, Environmental, & Architectural Engineering (CEAE)
- Executive Committee: 2010-2013 and 2015-present.
- Graduate Committee: 1998-2002, 2006-2015
- Chair of CEAE Faculty Search Committees: 2002-2003, 2006-2007, 2008-2009, 2013-2014
- Coordinator of High School Honor Institute: 2002-2005
- College of Engineering at the University of Colorado - Boulder
- First Level Review Committee, Chair, Engineering College, 2007-2008.
- First Level Review Committee, Member, Engineering College, 2004-2008.
- CU-Campus Carbon Neutral Committee, Member, Campus wide Committee, since 2008

9. **Selected Publications & Presentations:**
- "Energy Audit for Building Systems: An Engineering Approach- third Edition", M. Krarti, textbook, CRC Press, Francis and Taylor Group, 635 pages, 2021.
- "Optimal Design and Retrofit of Energy Efficient Buildings, Communities, and Urban Centers", Krarti, M., Book, 416 pages, Butterworth-Heinemann Elsevier, Oxford, UK, 2018.
- M. Krarti, Optimal energy performance of dynamic sliding and insulated shades for residential buildings, Energy, 263(B), 125699 (2023).
- M. Krarti, Design optimization of smart glazing optical properties for office spaces, Applied Energy, 308, 118411 (2022).
- M. Krarti, Energy Performance of Control Strategies for Smart Glazed Windows Applied to Office Buildings, Journal of Building Engineering, 45, 103462, (2022).
- M. Krarti, and M. Aldubyan, Review analysis of COVID-19 impact on electricity demand for residential buildings, Renewable and Sustainable Energy Reviews, 110888 (2021).
- M. Krarti, Evaluation of occupancy-based temperature controls on energy performance of KSA residential buildings, Energy and Buildings, 220, 110047, (2020).
- M. Krarti, Multiple-Benefit Analysis of Scaling-Up Building Energy Efficiency Programs: The Case Study of Tunisia, ASME JESBC 1(1): 011008, (2020).

10. **Briefly list the most recent professional development activities**:
DOE Conference on Collaboration between Universities and DOE Research Laboratories, Washington DC, April 1-2, 2015.
ASES Workshop, on Energy Efficient Residential Buildings, Phoenix, Aug. 5-6, 2014.

ABET CV for Yu-Hsuan Lee

1. **Name:** Yu-Hsuan Lee

2. **Education:**
   Ph.D., Civil Engineering, University of Colorado Boulder, 2017-Present

3. **Academic experience**:
   University of Colorado Boulder, Instructor, 2021-2022, part-time
   University of Colorado Boulder, Teaching Assistant, 2017-2020, part-time

4. **Non-Academic experience:**
   Los Alamos National Laboratory, Intern, 2019, 2021, 2022, part-time

5. **Certifications or professional registrations**: N/A

6. **Current membership in professional organizations**: N/A

7. **Honors and awards**: N/A

8. **Service activities (within and outside of the institution)**: N/A

9. **Selected Publications & Presentations:**
   - DEM Study of Two Types of Direct Simple Shear and Stress Tensor Computation, Beichuan Yan, Zhou Lei, Richard Regueiro, Engineering Mechanics Institute Conference 2022

10. **Briefly list the most recent professional development activities:**

Engineering Mechanics Institute Conference 2022
Research of DEM simulations and constitutive analysis of hyper-velocity penetration

ABET CV for Matthew Morris

1. **Name:** Matt Morris

2. **Education:** B.S. Civil Engineering (CU Boulder 1999)
   M.S. Civil Engineering (CU Boulder 2022)

3. **Academic experience**: CU Boulder Teaching Professor / Sr. Instructor (2012-2023)

4. **Non-academic experience:**
   U.S. Air Force, Captain, civil engineer officer (1999-2006)
   Mortenson Construction, Project Manager, (2006-2012)

5. **Certifications or professional registrations:**
   Professional Engineer, Colorado

6. **Current membership in professional organizations**: N/A

7. **Honors and awards**:
   - 2022 Civil Engineering Faculty Appreciation Award
   - 2021 Civil Engineering Faculty Appreciation Award
   - 2020 College of Engineering and Applied Science Charles A. Hutchinson Memorial Teaching Award
   - 2020 Civil Engineering Faculty Appreciation Award
   - 2019 College of Engineering and Applied Science Max S. Peters Faculty Service Award
   - 2019 Civil Engineering Faculty Appreciation Award
   - 2018 Top 20 Teaching Performers, College of Engineering and Applied Science
   - 2018 Civil Engineering Faculty Appreciation Award
   - 2018 Architectural Engineering Faculty Appreciation Award
   - 2017 Teaching Award, CEAE Department
   - 2016 Service Award, CEAE Department
   - 2016 Civil Engineering Faculty Appreciation Award
   - 2014 Architectural Engineering Faculty Appreciation Award
   - 2013 Marinus Smith Award, University of Colorado

8. **Service activities (within and outside of the institution)**:
   - Enrichment Program Director
   - Student Pathways Committee

9. **Selected Publications & Presentations:** N/A – teaching faculty

10. **Briefly list the most recent professional development activities**:

Organization of Construction Diversity Summit
Discussion of Marshall Fire experience and rebuilding, “Concrete Credentials” podcast

ABET CV for Jennifer Scheib

1. **Name:** Jennifer Scheib

2. **Education:**

   M.S. Civil Engineering – building systems emphasis, University of Colorado Boulder, 2004

   M.S. Architectural Engineering - illumination engineering emphasis, University of Colorado Boulder, 2003

3. **Academic experience:**

   University of Colorado Boulder, Assistant Teaching Professor, Fall 2017-present, FT

4. **Non-academic experience:**

   National Renewable Energy Laboratory, Multidisciplinary Engineer III, Commercial Buildings Research Group researcher, 2009 – Fall 2017, full-time

   Architectural Energy Corporation, Project Engineer, Daylighting Analysis Group analyst, 2006 – 2009, full-time

   National Institute of Standards and Technology, Optical Radiation Group intern, June – August 2003, full-time

   HLB Lighting Design, lighting design intern, June – August 2002, full-time

5. **Certifications or professional registrations**:

   LEED accredited professional

6. **Current membership in professional organizations:**

   Illuminating Engineering Society, 2002 to present
   International Association of Lighting Designers, 2016 to present
   American Society of Civil Engineers/Architectural Engineering Institute, 2021-present

7. **Honors and awards**:

- U.S. Department of Energy Zero Energy Design Designation, department, 2022
- Solar Decathlon 2020 Build Challenge first place overall, faculty lead, 2021
- Architectural Engineering Student Appreciation Award, 2019, 2021
- CEAE Department Teaching Award, 2020
- National Renewable Energy Laboratory Outstanding New Partnership Award, 2015
- NREL President's Award for Excellence in Campus Development, team, 2014
- LightFair International's Most Innovative Product of the Year, team, 2008
- College of Engineering and Applied Science Outstanding Graduate Research, 2004
- CEAE department Clarence Eckel outstanding graduate award, Fall 2004

8. **Service activities (within and outside of the institution)**:

Department

- Board member, Rocky Mountain Lighting Academy, 2017 – present
- Member/Chair, Undergraduate Student Pathways Committee, 2020/2022 – present
- Member, Justice, Equity, Diversity, and Inclusion Committee, 2021 – present

National

- Member, Illuminating Engineering Society: Education, Library, Office Committee 2019-present
- Board member, Building a Legacy in Engineering, 2023
- Peer reviewer, Journals and programs including Solar Energy, Energy and Buildings, U.S. Department of Energy Solid State Lighting Program, 2018 – present
- Joint Appointment, National Renewable Energy Laboratory, 2017 – present

9. **Selected Publications & Presentations:**

- **Scheib, J.**, Taddonio, K., Smyth, J. (2022). *Affordable, All-Electric Cold-Climate Homes: A Look Inside the Winning 2020/2021 Solar Decathlon Build Challenge House: Preprint*. In Proceedings of the 2022 ACEEE Summer Study on Energy Efficiency in Buildings. Washington, DC: ACEEE.
- AEDG. (2019). *Advanced Energy Design Guide for Zero Energy Office Buildings*. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, Georgia. https://www.ashrae.org/technical-resources/aedgs/zero-energy-aedg-free-download
- Kung, T., Frank, S., **Scheib, J**., Heredia, W.B., Pless, S. (2016). *Supervisory Control of Loads and Energy Storage in Next-Generation Zero Energy Buildings*. NREL/TP-5500-67007, National Renewable Energy Laboratory, Golden, Colorado. http://www.nrel.gov/docs/fy16osti/67007.pdf
- Walker, A., **Scheib, J**., Turchi, C., Robi, R., Tomberlin, G., Burman, K., Hillesheim, M., Kroposki, B., Qu., M. (2016). *Integration of Renewable Energy Systems*. American Society of Mechanical Engineers Technologies for Sustainable Life (TSL) – Concise Monograph Series. ISBN: 9780791861240. 150 pages. https://www.asme.org/products/books/ingegration-of-renewable-energy-systems

10. **Briefly list the most recent professional development activities:**

Community-Based Participatory Research semester course, 2022

Climate Across the Curriculum two-day pedagogy workshop, 2022

Learning by Design semester course on active student-centered learning, 2021

Supporting Student Resiliency workshop series, 2020

Course consultation and student interviews for AREN 3540 (ABET-tracked course), 2019

ABET CV for Jeong-Hoon Song

1. **Name**: Jeong-Hoon Song

2. **Education**:
   Ph.D., Theoretical and Applied Mechanics, Northwestern University, USA, 2008
   M.S., Civil Engineering, Yonsei University, Korea, 2003
   B.S., Civil Engineering, Yonsei University, Korea, 2001

3. **Academic experience**:
   University of Colorado Boulder, Associate Professor (08/2021-Present) Full-time
   University of Colorado Boulder, Assistant Professor (08/2014-08/2021) Full-time
   University of South Carolina, Assistant Professor (01/2011-08/2014) Full-time
   Northwestern University, Post-doctoral Fellow (06/2008-12/2010) Full Time

4. **Non-academic experience**: None

5. **Certifications or professional registrations**: None

6. **Current membership in professional organizations:**
   Member, ASCE/EMI Computational Mechanics Committee
   Member, American Society of Mechanical Engineers (ASME)
   Member, American Society of Civil Engineers (ASCE)
   Member, U.S. Association for Computational Mechanics (USACM)
   Member, International Association for Computational Mechanics (IACM)

7. **Honors and awards:**
   - U.S. Naval Research Laboratory, ONR Research Faculty Fellow (2014-2016)

8. **Service activities (within and outside of the institution)**:
   - Service to the scientific and engineering community: Dr. Song has organized, co-organized and chaired a number of conference mini-symposia. Most recently, in 2022, he co-organized the mini-symposium, entitled "Data-driven approaches to engineering mechanics", American Society of Civil Engineers (ASCE) - Engineering Mechanics Institute Conference, Baltimore, Maryland.
   - Dr. Song has been organized several special journal issues in the area of computational mechanics as guest and co-guest editors. Most recently, in 2017, he organized a special issue on "Computational modeling of material deterioration at various length scales" at International Journal of Fracture.

9. **Selected Publications & Presentations:**
   - "A strong-form meshfree collocation method for modeling stationary cracks with frictional contact," A. Almasi, Y.C. Yoon, T.Y. Kim, T. A. Laursen, J.H. Song, International Journal of Non-Linear Mechanics, 2023, 148: 10429.
   - "Strong form meshfree collocation method for frictional contact between a rigid pile and an elastic foundation," A. Almasi, T.Y. Kim,and J.H. Song, Engineering with Computers, 2022, doi: 10.1007/s00366-022-01673-y.

- “Strong form collocation method for solidification and mechanical analysis of polycrystalline materials,” A. Almasi, A. Beel, T.Y. Kim, J. G. Michopoulos and J.H. Song, ASCE Journal of Engineering Mechanics, 2019, 145, 04019082.
- “Non-nodal extended finite element method (NXFEM) for modeling crack with four-node quadrilateral elements,” I. Asareh and J.H. Song, ASCE Journal of Engineering Mechanics, 2019, 145, 04019081.
- “Phase field simulations of coupled microstructure solidification problems via the strong form particle difference method,” J.H. Song, Y. Fu, T.Y. Kim, Y.C. Yoon, J.G. Michopoulos, and T. Rabczuk, International Journal of Mechanics and Materials in Design, 2018, 14, 491-509.

10. **Briefly list the most recent professional development activities:**
Contributions to the engineering science: Dr. Song’s research is based on strong computational efforts combined with theoretical and applied mechanics of solids and material science. He has published over 55 peer-reviewed journal publications in this area with an h-index of 23 (ISI Web of Science, 2022).
Service to the scientific and engineering community: Dr. Song has organized, co-organized and chaired a number of conference mini-symposia. Most recently, in 2022, he co-organized the minisymposium, entitled “Data-driven approaches to engineering mechanics”, American Society of Civil Engineers (ASCE) - Engineering Mechanics Institute Conference, Baltimore, Maryland.
Dr. Song has been organized several special journal issues in the area of computational mechanics as guest and co-guest editors. Most recently, in 2017, he organized a special issue on "Computational modeling of material deterioration at various length scales" at International Journal of Fracture.
Dr. Song has been awarded for the office of naval research (ONR) summer faculty fellowship in 20142016, and worked at the Center for Computational Materials Science at the U.S. Naval Research Laboratory to establish the integrated computational materials engineering (ICME) approach for metal powder-based additive manufacturing.

ABET CV for Sandra Vásconez

1. **Name**: Sandra L. Vásconez

2. **Education**:
   M.A. Art History and Museum Studies, University of Denver, 2005
   M.S. in Lighting, 2000, LRC, Rensselaer Polytechnic Institute, 2000

3. **Academic experience**:
   University of Colorado Boulder, Teaching Professor, 2007-2023, full-time.
   Rensselaer Polytechnic Institute – Lighting Research Center, Adjunct Assistant Professor, 1988-2002

4. **Non-academic experience**:
   Quenroe Associates, Project Manager and Assistant Designer, Managed design and installation of museum exhibits; assisted with design services and consultation on museum planning, museum exhibition, and lighting design, 2004 – 2007, full-time.
   Lighting Research Center (LRC), Rensselaer Polytechnic Institute (RPI), Manager of Program Development, Managed the Demonstration and Evaluation of Lighting Technologies and Applications (DELTA) Program, and the Lighting Research Center Partner's Program,1998 – 2002, full-time.
   MCI Customer Delivery Services, Systems Security Administrator, Provided customer service to internal clients; authorized access to company's system applications; coordinated flow of information between customers and advanced support technicians to drive timely problem resolution, 1994 – 1995, full-time.

5. **Certifications or professional registrations**:
   National Council on Qualifications for the Lighting Professions (NCQLP) Lighting Certified, 2002–2022

6. **Current membership in professional organizations**:
   International Association of Lighting Designers, Educator Member, 2015-present
   Illuminating Engineering Society of North America (IES), 1998-present

7. **Honors and awards**:
   - The Max S. Peters Faculty Service Award, CEAS, CU Boulder, 2018
   - Architectural Engineering Faculty Appreciation Award, 2017
   - Chair, David L. DiLaura Faculty Fellowship in Architectural Engineering, 2013-Present
   - Marinus Smith Award 2013, University of Colorado Boulder
   - Architectural Engineering Faculty Appreciation Award, 2013
   - Service Award; Civil, Environmental and Architectural Engineering, 2012
   - Outstanding Faculty Advisor, Civil, Environmental and Architectural Engineering, 2011 Award of Merit, Lighting Education Online, Society for Technical Communication, 2003 Buell Scholarship 2003, University of Denver
   - Award of Merit, Outdoor Lighting DELTA Snapshot, Society for Technical Communication, 2001

- Distinguished Technical Communication Award, Energy-Efficient Ceiling Mounted Residential Luminaires Specifier Report, Society for Technical Communication, 1999
- Award of Merit, Energy-Efficient Ceiling Mounted Residential Luminaires Specifier Report, International Technical Publications Competition 1999
- Litecontrol Scholarship, 1996
- National Collegiate Minority Leadership Award, 1992

8. **Service activities (within and outside of the institution):**

College of Engineering and Applied Science, University of Colorado Boulder
- Teaching Faculty Advisory Committee, 2021 – Present
- Undergraduate Education Council, 2013 – 2014

Civil, Environmental and Architectural Engineering Department
- Scholar in Residence Targeted Hire Lead - 2022
- Search Committee Chair for Architectural Engineering Instructor - 2019
- CEAE Governance and Climate Committee – 2019
- Architectural Engineering ABET Coordinator – 2016-2018
- IES Student Chapter Advisor, 2007 – present
- Curriculum Committee, 2017 – 2018, 2010 – 2012, 2019-Present
- Operations Committee, AY 2016, 2009 – 2013, [co-chair 2011-2012]
- Curriculum Committee Chair, 2013 – 2015
- Environmental Engineering Search Committee, 2013
- CEAE Cooperative Representative, 2011-2013
- Building Systems Search Committee, 2010, 2011
- Computer Committee, 2008 – 2010
- Freshman Advising, 2008 – 2009; 2013 – 2014
- AEI Student Chapter Advisor 2007 – 2013
- AEI Academic Council Member, Represented CU Architectural Engineering, 2010-11

Lighting Industry
- IES Research Symposium Committee Member, 2016 – 2020
- IALD Education Trust Board of Directors, 2018-2019
- CLUE (Community Lighting for the Urban Environment) Competition Judge, 2018
- Groundwork Ranch, Member of Board of Directors, 2021 – Present
- NCQLP, Member of Board of Directors, 2000 – 2002
- PVShares, Member of Board of Directors, 2020 – Present

9. **Selected Publications & Presentations:** N/A

10. **Briefly list the most recent professional development activities**:

Lightfair International, 2018
International Association of Lighting Designers, Enlighten Americas Conference, 2019

<u>ABET CV for Yunping Xi</u>

1. **Name**: Yunping Xi

2. **Education**:
   Ph.D. in Structural Engineering, Northwestern University, Evanston, IL. (1991)
   M.S. in Structural Engineering, Central Research Inst. of Building and Construction, Beijing, China (1985)
   B.S. in Civil Engineering, Beijing Institute of Civil Engineering and Architecture, Beijing, China (1982)

3. **Academic experience**:
   2005 – Present Professor, University of Colorado at Boulder
   2000– 2005 Associate professor, University of Colorado at Boulder
   1997– 2000 Assistant professor, University of Colorado at Boulder
   1993– 1996 Assistant professor, Drexel University
   1991– 1993 Research Scientist, Northwestern University
   1987– 1988 Visiting Scholar, Northwestern University

4. **Non-academic experience**:
   1985-1987 Structural engineer, Beijing Central Research Inst of Bldg & Construction
   1982-1983 Structural engineer, Beijing Design Institute of Building and Construction

5. **Certifications or professional registrations**: None

6. **Current membership in professional organizations**:
   A member of the committee on Properties of Materials, Engineering Mechanics Institute (EMI), American Society of Civil Engineers (ASCE).
   Member of committee on Experimental Analysis and Instrumentation, EMI, ASCE.
   A member of the International Committee on Irradiated Concrete (ICIC).

7. **Honors and awards**:
   - *Eckel Award 2018*. Department of Civil, Environmental and Architectural Engineering (CEAE), University of Colorado Boulder (CU-Boulder).
   - Recipient of *2010 Faculty Fellowship* at CU-Boulder.
   - *Research development award 2004***.** Department of CEAE, CU-Boulder.
   - *Young Researcher's award* 1998-1999. Department of CEAE, CU-Boulder.

8. **Service activities (within and outside of the institution):**
   - The chair of the committee on Properties of Materials (2003-2007), EMI, ASCE.
   - The chair (2013-2014), vice chair (2012), and past chair (2015) of the committee on Experimental Analysis and Instrumentation, EMI, ASCE.
   - The administrator of Colorado Local Technical Assistance Program (sponsored by the U.S. Federal Highway Administration, Colorado Department of Transportation, and University of Colorado at Boulder) (1998-2019).The coordinator of SESM Group (2002-2003 and 2022-present) in Dept. of CEAE at CU- Boulder.
   - A co-director of The Center for Infrastructure, Energy, and Space Testing (CIEST) at

CU- Boulder (2022-present).

- A member of First Level Review Committee of College of Engineering (2012 – 2015 and 2022-present) at CU-Boulder.
- A member of Program & Students Committee, Dept. of CEAE at CU-Boulder (2021- present).
- The executive committee member of Dept. of CEAE representing Structural Engineering and Structural Mechanics (SESM) Group (2005 – 2011).

9. **Selected Publications & Presentations:**

- Li, L., Hubler, M., Abdelrahman, M., and Xi, Y. (2021) "Numerical Modeling of the Injection of Nanoparticles in Saturated Cementitious Materials by Using Electromigration Method". *J. of Eng. Mech.,*ASCE, 147(9), https://doi.org/10.1061/(ASCE)EM.1943- 7889.0001954.
- Wang, Y., Bai, Y., and Xi, Y. (2021) "Analytical solutions of moisture-chloride ion coupled transport in unsaturated concrete", *Journal of the American Ceramic Society*, 104(11), 5883-5897, https://doi.org/10.1111/jace.17973.
- Li, L., Zhang, Y., Hubler, M., and Xi, Y. (2021) "Experimental Study on Nanoparticle Injection Technology for Remediating Leaks of CO2 Storage Formation", *Journal of Petroleum Science and Engineering*, https://doi.org/10.1016/j.petrol.2021.108829.
- Jing, Y., and Xi, Y. (2021) "Modeling long-term distribution of fast and thermal neutron fluence in degraded concrete biological shielding walls", *Construction and Building Materials,* https://doi.org/10.1016/j.conbuildmat.2021.123379.
- Li, L., Hubler, M., and Xi, Y. (2020) "Theoretical Modelling on Chemical Composition and Mechanical Properties of Well Cement under Carbonation Reactions", *Journal of Cleaner Production*, 276, 124270, https://doi.org/10.1016/j.jclepro.2020.124270.
- Li, L., Hubler, M., and Xi, Y. (2020) "Modelling the Corrosion of Steel Casing and the Damage of Well Cement in a Borehole System", *Construction and Building Materials*, https://doi.org/10.1016/j.conbuildmat.2020.119701.
- Damien, D., Wang, Y., and Xi, Y. (2019) "Prediction of Modulus of Elasticity of Cementitious Materials Based on Multiphase and Multiscale Micromechanics Theory", *J. of Eng. Mech*., ASCE, 145(10): 04019074, DOI: 10.1061/(ASCE)EM.1943-7889.0001650.
- Jing, Y., and Xi, Y. (2019) "Long-term Neutron Radiation Levels in Distressed Concrete Biological Shielding Walls", *Journal of Hazardous Materials,* 363, 376-384.
- Abdelrahman, M., and Xi, Y. (2018) "The Effect of w/c Ratio and Aggregate Volume Fraction on Chloride Penetration in Nonsaturated Concrete", *Construction and Building Materials*, 191, 260-269.

10. **Briefly list the most recent professional development activities**:

ICIC virtual webinar, Nov. 16-17, 2021
International conf. On plasticity, damage & fracture, Punta Cana, Dominican Rep, Jan., 2023

<u>ABET CV for John Zhai</u>

1. **Name**: Zhiqiang (John) Zhai

2. **Education**:

   Ph.D. Building Technology Program, Department of Architecture, Massachusetts Institute of Technology (MIT), Cambridge, MA, USA. 2003

   Dr.Eng. Fluid Mechanics Program, Department of Engineering Mechanics, Tsinghua University, Beijing, China. 1999

3. **Academic experience**:

   2015-Present: Professor, Department of Civil, Environmental, and Architectural Engineering (CEAE), University of Colorado at Boulder (CUB), CO. Full-Time

   2010-2015: Associate Professor, CEAE, CUB, Boulder, CO. Full-Time

   2003-2010: Assistant Professor, CEAE, CUB, Boulder, CO. Full-Time

4. **Non-academic experience**:

   2010-2011: Senior Fellow, Rocky Mountain Institute (RMI), Boulder, CO, USA. Managed, supervised, and advised over a dozen design and consulting projects. FT

5. **Certifications or professional registrations**: N/A

6. **Current membership in professional organizations**:

   Fellow, The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), 2020

   Fellow, The International Building Performance Simulation Association, 2019

   Fellow, The International Academy of International Society of Indoor Air Quality and Climate (ISIAQ), 2018

7. **Honors and awards**:
   - The Distinguished Achievement Award, CEAE, CUB, 2020
   - The College of Engineering & Applied Science (CEAS) Faculty Research Award, CUB, 2019
   - 2017 Best Paper Award, International Journal of Building Simulation, 2018
   - The JSPS Invitational Fellowship for Research, The Japan Society for the Promotion of Science, 2018
   - The Gold Award of New Product & Technology, The 2016 World Internet of Things (IoT) Conference and Exposition, China, Oct 30-Nov 1, 2016

8. **Service activities (within and outside of the institution)**:
   - Executive Committee of CEAE department at CUB, 2018-2023
   - The First-Level Review Committee (FLRC) of Engineering College at CUB, 2020-2023
   - Associate Editor, Guest Editor and Editorial Board Member for over 20 journals such as Energy and Buildings, Sustainable Cities and Society, Building and Environment, Applied Energy etc.
   - Vice-President of Commission, The International Institute of Refrigeration (IIR), 2020-

2023
- Vice-President, The International Society of Energy and Built Environment (ISEBE), 2020-2023
- Vice Chair for ASHRAE Standard 200 "Methods of Testing Chilled Beams", 2016-2023
- Voting member and ASHRAE Learning Institute Coordinator of ASHRAE Technical Committee 4.10 – Indoor Environmental Modeling, 2004-2023
- Co-Author and Voting Member, ASHRAE GPC 33: Guideline for Documenting Indoor Airflow and Contaminant Transport, The PCVM- Project Committee, 2010-2012
- Conference Chair and Scientific Committee for over 100 international conferences

9. **Selected Publications & Presentations:**
- Zhai Z. 2022. Energy Efficient Buildings: Fundamentals of Building Science and Thermal Systems Wiley, New York, NY. [ISBN: 978-1-119-88193-3]
- Zhai Z. 2020. Computational Fluid Dynamics for Built and Natural Environments. Springer, Singapore. [ISBN: 978-981-329-819-4]
- Zhai Z, Bahl R, Trace K, Gupta B, and Li He. 2021. Mitigating COVID-19 in Public Spaces. ASHRAE Journal, 63(10), October.
- Zhai Z, Li H, Bahl R, and Trace K. 2021. Application of Portable Air Purifiers for Mitigating COVID-19 in Large Public Spaces. Buildings, 11(8), 329.
- Sun C and Zhai Z. 2020. The Efficacy of Social Distance and Ventilation Effectiveness in Preventing COVID-19 Transmission. Sustainable Cities and Society, 62, 102390.
- Yu J, Kang YM, Zhai Z. 2020. Advances in Research for Underground Buildings: Energy, Thermal Comfort and Indoor Air Quality. Energy and Buildings, 215, 109916.
- Liu L, Zhang Q, Zhai Z, Yue C, Ma X. 2020. State-of-the-Art on Thermal Energy Storage Technologies in Data Center. Energy and Buildings, 226, 110345.
- Huang L and Zhai Z. 2020. Critical Review and Quantitative Evaluation of Indoor Thermal Comfort Indices and Models Incorporating Solar Radiation Effects. Energy and Buildings, 224, 110204.
- Zhai Z and Metzger ID. 2019. Insights on Critical Conditions and Parameters for Personalized Ventilation. Sustainable Cities and Society, Volume 48, July, 101584.
- Zhai Z and Helman JM. 2019. Implications of Climate Changes to Building Energy and Design. Sustainable Cities and Society, 44: 511-519.

10. **Briefly list the most recent professional development activities**:
Has been actively engaged in developing new curriculum in sustainable building development for both developed and developing countries, which led to the successful establishment of several international post-graduate programs (e.g., for Brazil, Mexico, Indonesia, and China).
Has an established track record of collaboration with specialists in different engineering and non-engineering areas, such as, architecture, ecology, evolutionary biology, and public health etc. These collaborations have led to a specialization in interdisciplinary research topics.
Has been actively involved in several professional societies (as the Fellow of ASHRAE, ISIAQ, IBPSA), promoting effective communications between academia and industry.

APPENDIX C – EQUIPMENT

The major pieces of equipment used by the architectural engineering program in courses to support instruction are summarized in the tables below.

Course	Major Equipment Used
AREN 2120 – Fluid Mechanics & Heat Transfer	-20+ Hobos for air temperature, relative humidity and lighting test
AREN 3010 – Energy Efficient Building	-Complete blower-door test kits (2 sets) -Microenvironment test stations (2 sets), with each including: o 5 temperature sensors (TMC6-HD) o 1 temperature sensor (TMC20-HD) o 4 solar radiation shields (RS3-B) o 2 data loggers (UX120-006M) o 1 weatherproof box o 1 mounting pole (EZ NP 72-200)
AREN 3540 – Illumination I	- Extech illuminance meters EA-33 (20) - Konica Minolta luminance meter LS-100 (1) - Konica Minolta spectrophotometer CL-500 (1)
AREN 4110 – HVAC Design	- IR thermographic camera - Blower door
AREN 4550 – Illumination II	- Minolta illuminance meters T-1 (10) - Minolta luminance meter LS-100 (1) - Spectrometer - Various lamps and lamp holders - Manual dimmers (1)

AREN 4010 –HVAC System Modeling and Control	-Direct digital control (DDC) modules to teach development of HVAC control strategies for air handling units and chilled water plants
AREN 4830 – Sustainable Materials & Structures	-Instron machine in CIEST laboratory
AREN 4130 – Optical Design	- Konica Minolta illuminance meters T-10 - Konica Minolta luminance meter LS-100 - CL-500A Konica Minolta Spectrometer - Omega HH309A digital thermometer - 36” Integrating sphere - Optical bench & various mounting hardware - Manually operated, 8’ arm, goniophotometer - Various LED modules and luminaires - Lambda 0-150V DC power supply - Interpower 500VA multi-frequency AC power supply - Elgar 120V AC power supply - Laser cutters in ITLL - 3D printer in ITLL
AREN 4350 – Advanced Lighting Design	- Moveable ceiling in lighting lab - ETC programmable 7-color LED theatrical luminaires (4) - ETC Source Four Mini theatrical luminaires (6) - Theatrical tripod stands with T-Bar (8) and floor stands (8) - Theatrical lamp holders with options for gels and gobos (24) - Various beam-angle lamps and lamps holders - Manual dimmers (10)

AREN 4620 Adaptive Lighting Systems	● Prototyping kit that includes an Arduino, sensors, LEDs, and connectors (1 kit per student) ● Mock office space with 12 RGBW LED luminaires (1) with a DMX controller (1) and laptop (1) ● Seven-channel theatrical LED luminaires (6) with DMX controllers (3) ● Proprietary control system setups that include luminaires, sensors, and controllers (4 unique systems) ● Miscellaneous switches, sensors, and luminaires for in-class demonstrations
AREN 4850, Daylighting	● Illuminance meters (1 per student) ● Luminance meter (1) ● Spectrometer (1) ● DSLR camera and tripod (1 each) ● Virtual reality headset and gaming laptop (1 each)
CVEN 2012 Geomatics	-Tripods – ca. 10 Wild type (5/8X11 screw), ca. 4 Kern type -Automatic Levels – 8, including Leica, K&E, Wild types -Theodolites – 8 electronic theodolites -Total Stations: 6 Leica: 4 "Builder," 2 earlier models, 4 Nikon -Corner prism EDM reflectors – ca. 8 useable -Stadia Rods – 7 -Range poles/reflector poles - 3 -Tapes: 6 fiberglass, 100' and 200' -Tapes: 4 metal, mostly with broken tips but still usable -Metal detector -Misc. Flagging and marking equipment -GPS: 24 Leica GS14 antennas and one Leica CS20 controller, plus accessories for base station/RTK rover configuration -Leica 3D Laser Scanner

CVEN 3161- Mechanics of Materials I	-MTS universal testing machine for tension and compression testing of structural and geological materials, with capacities of 500 kN -Tinus Olsen Torsional Testing Machine with 2000 in-lb capacity -Concrete mixer, scale -Whitemann displacement gage, dial gages, strain gages
CVEN 3313 Fluids	-Hydrostatic force on plane surface apparatus -Vertical tank with orifice apparatus -Venturi, orifice flow meter, manometer -Jet apparatus with target and weights
CVEN 3424 Water & Wastewater Treatment	-Phipps & Bird jar test apparatus -Turbidimeter
CVEN 3323 Hydraulics	-rod, tape measure, waders, flow meters -Armfield hydraulics bench with energy losses apparatus, bicycle pump -Armfield hydraulics bench with weir module, hook and point gauge -Armfield multi-purpose teaching flume, broad-crested weir

CVEN 4414 Water Chemistry Lab	-Electronic balance, high range (Ohaus model Navigator NOB110) - 1 -Electronic balance, low range (Ohaus model Navigator NO2120) – 1 -Inductively coupled plasma-atmoic emission spectrophotometer (Vairan model Liberty Series II Axial) – 1 -Visible spectrophotometers (Spectronic model 20D+) – 4 -Coagulation Jar Testers (Phipps & Bird model Standard) - 4 -pH meters (Thermo-Orion model 250Aplus) – 4 -pH electrodes (Thermo-Irion triode combination) – 4 -Colorimetric Test Kits (Hach model DR/890) - 4 -Conductivity meters (Thermo-Orion model 115Aplus) - 4 -Drying oven (Fisher model Isotemp 506G) – 1 -Muffle furnace (Fisher model Iostemp programmable) – 1 -Microscopes (Leitz model IN200) – 2 -Heated stir plates (Corning model PC-420) – 4 -Computers (Dell Optiplex GX270) – 5 -Data acquisition boards (National Instruments) - 4 -20 Augmented reality Goggles (Merge Headsets, location: SEEC S274)
CVEN 4161 – Mechanics of Materials II	-MTS universal testing machine for tension and compression testing of structural and geological materials, with capacities of 500 kN. -Beam testing setup. -Whitemann displacement gage, dial gages, strain gages.

CVEN 3708 Geotechnical Engineering 1	-Triaxial cells and consolidometers -Proctor and modified Proctor test equipment -Atterberg limit apparatus -Constant head and falling head permeability setup -Mechanical sieve shaker, sieve stacks, and hydrometers
CVEN 3718 Geotechnical Engineering 2	-Direct shear test machine with shear box, weights, displacement gauges -Triaxial test cells with load cells, pressure gauges, LVDT, computer -Instructional Centrifuge and demonstration models, data acquisition system

APPENDIX D – INSTITUTIONAL SUMMARY

A. The Institution

a. Name and address of the institution:

The University of Colorado Boulder
College of Engineering and Applied Science
422 UCB
Boulder, Colorado 80309-0422

b. Name and title of the chief executive officer of the institution:

Todd Saliman - President of the University of Colorado System
Philip P. DiStefano - Chancellor of the Boulder Campus
Russell L. Moore - Provost and Executive Vice Chancellor for Academic Affairs
Keith Molenaar - Dean of the College of Engineering and Applied Science

c. Name and title of the person submitting the self-study report:

Submitted by:

Wil V. Srubar III, Associate Professor and Associate Chair of Undergraduate Education
Department of Civil, Environmental, and Architectural Engineering
College of Engineering and Applied Sciences
University of Colorado Boulder
Boulder, Colorado 80309
wsrubar@colorado.edu

Karl Linden, Professor and Chair
Department of Civil, Environmental, and Architectural Engineering
College of Engineering and Applied Sciences
University of Colorado Boulder
Boulder, Colorado 80309
karl.linden@colorado.edu

Keith Molenaar, Dean
College of Engineering and Applied Science
University of Colorado Boulder
Boulder, Colorado 80309-0422
303-735-4276
keith.molenaar@colorado.edu

Contact for ABET matters:
Vanessa Dunn
Director of Assessment, Analytics and Accreditation

College of Engineering and Applied Science
Boulder, CO 80309-0422
303-492-8849
Vanessa.Dunn@colorado.edu

Rhonda Hoenigman, Associate Dean for Education
College of Engineering and Applied Science
University of Colorado Boulder
Boulder, Colorado 80309-0422
303-492-0084
Rhonda.Hoenigman@colorado.edu

d. Name the organizations by which the institution is now accredited and the dates of the initial and most recent accreditation evaluations:

The University of Colorado Boulder is accredited by the Higher Learning Commission (HLC), which is part of the North Central Association of Colleges and Schools (NCA). The NCA is a membership organization of colleges and schools in nineteen states ranging from Michigan to Arizona, including Colorado. The HLC is recognized by the US Department of Education (USDE) to accredit degree-granting higher education institutions. The University of Colorado at Boulder has been accredited since 1913. Every ten years, a team of leading external educators visit the University's campus to evaluate programs, policies, and practices and to provide recommendations for continuous improvement. The most recent review took place in December 2019 and the Institutional Actions Council of the Higher Learning Commission voted to continue accreditation for the University of Colorado Boulder. For more information, see Institutional Accreditation | Accreditation & State Authorization | University of Colorado Boulder. The most recent self-study is at University of Colorado Final Report

B. Type of Control

The University of Colorado is a state-supported institution governed by an elected Board of Regents under the Colorado Commission on Higher Education.

C. Educational Unit

a. Campus Administration

The Dean of the College of Engineering and Applied Science reports to the Provost and Executive Vice Chancellor for Academic Affairs, who reports to the Chancellor and Chief Executive Officer of the Boulder Campus. The Chancellor and Chief Executive Officer report to the President of the University of Colorado system. Additional details can be found at [Chancellor's Administrative Organization | Office of the Chancellor | University of Colorado Boulder]

b. College Administration

The Chief Executive Officer of the College of Engineering and Applied Science is the Dean, Keith Molenaar. Additional College Leadership:

- Associate Dean for Undergraduate Education, Rhonda Hoenigman
- Associate Dean for Students, Mary Steiner
- Assistant Dean for Access, Inclusion, and Student Programs, Terri Wright
- Associate Dean for Research, Shideh Dashti
- Associate Dean for Graduate Education, Charles Musgrave
- Associate Dean for Faculty Advancement, Fernando Rosario-Ortiz
- Assistant Dean of Strategic Initiatives, Medford Moorer
- Assistant Dean for Operations, Cherie Summers
- Associate Dean for Digital Education, William Kuskin
- Senior Director of Alumni Engagement and Donor Relations/Interim Advancement Lead, Kevin Lobdell

D. Academic Support Units

Several other departments and programs, including Applied Mathematics, Physics, Chemistry, the Herbst Program of Ethics and Society, and the Program for Writing and Rhetoric, support the degree programs in the College. These supporting units also teach courses for other majors throughout the University. The names and titles of the individuals responsible for these units are as follows:

- Applied Mathematics, Keith Julien, Department Chair
- Physics, Michael Ritzwoller, Department Chair
- Chemistry, Wei Zhang, Department Chair
- Herbst Program for Engineering, Ethics & Society, Diane Sieber, Program Director
- Program for Writing and Rhetoric, John Stevenson, Director

The courses provided by these academic support units are regularly reviewed by the Undergraduate Education Council (UEC), chaired by the Associate Dean for Undergraduate Education. The Council is composed of the associate chairs (or curriculum committee chairs) or their designee for each program, the undergraduate staff advisors for each department, and other program directors and Dean's office representatives. This group meets regularly throughout the year to coordinate matters of common interest and concern for the College's undergraduate programs.

E. Non-academic Support Units

There are several programs in the College of Engineering and Applied Science that support student success, including:

- Broadening Opportunity through Leadership and Diversity (BOLD) provides scholarship, resources, and community for students who are underrepresented in STEM (Amy Moreno, Director)
- Academic Coaching supports the academic, personal, and career success of engineering students (Alana Davis-Delaria, Assistant Director)
- Engineering Ambassadors supports new and prospective students (Chris Anderson, Director of Transfer Pathways and Amanda Parker, Senior Director of Enrollment Management)
- The Engineering Residential Community is a living-learning community for all first-year engineering students that emphasizes academics, belonging and wellness (Scot Douglas, Faculty Director)

Several campus-wide support units also serve undergraduate students and programs in the College of Engineering and Applied Science, including:

- Gemmill Engineering, Math and Physics Library (Emily Dommermuth, Engineering, Science and Design Librarian)
- Career Services (Lisa Lovett, Director)
- Office of the Registrar (Kristi Wold-McCormick, Assistant Vice Provost) and Office of Financial Aid (Ofeila Morales, Director)
- Center for Inclusion and Social Change (Amanda Linsenmeyer, Director)

F. Credit Unit

One semester credit normally represents one class hour or two laboratory hours per week. The campus operates year-round, with fall and spring semesters of 16 weeks each, a 10-week summer session, a three-week "Maymester" academic period between the spring semester and summer session, and a three-week "Augmester" academic period between the summer session and fall semester. All programs require 128 semester hours to graduate.

G. Tables

Table D-1. Program Enrollment and Degree Data

Name of the Program: Architectural Engineering

	Academic Year		Enrollment Year Class variable in census 1st	2nd	3rd	4th	5th	Total Undergrad	Total Grad	Degrees Awarded Associates	Bachelors	Masters	Doctorates
Current Year	22-23	FT	33	34	35	35	11	148	32		31	19	1
		PT	0	1	0	1	2	4	1				
1 year prior to current year	21-22	FT	32	41	35	35	18	161	46		44	17	5
		PT	0	0	1	1	1	3	2				
2 years prior to current year	20-21	FT	36	25	31	39	19	150	44		34	10	2
		PT	0	2	0	2	1	5	1				
3 years prior to current year	19-20	FT	33	30	32	38	23	156	36		37	8	6
		PT	0	0	1	0	2	2	1				
4 years prior to current year	18-19	FT	28	33	34	38	17	150	31		40	13	2
		PT	0	1	1	0	2	4	3				

* Counts of active majors for students enrolled at fall census, over time. These are counts for major codes, NOT departments.
** Students with two majors are counted twice (once in each major).
*** Students in a combined bachelor's/master's program are counted only once and in the career for which they're enrolled for the term (these students were previously once in each career). Other students enrolled in multiple careers are counted in each career.
Give official fall term enrollment figures (head count) for the current and preceding four academic years and undergraduate and graduate degrees conferred during each of those years. The "current" year means the academic year preceding the on-site visit.

FT—full-time
PT—part-time

Table D-2. Personnel

Name of the Program: Architectural Engineering

Year[1]: 2023

	HEAD COUNT		FTE[2]
	FT	PT	
Administrative[2]	0	5	5
Faculty (tenure-track)[3]	44	0	44
Other Faculty (excluding student Assistants)	37	41	78
Student Teaching Assistants[4]	30	1	31
Technicians/Specialists	1	0	1
Office/Clerical Employees	9	2	11
Others[5]			

Report data for the program being evaluated.

1. Data on this table should be for the fall term immediately preceding the visit. Updated tables for the fall term when the ABET team is visiting are to be prepared and presented to the team when they arrive.

2. Persons holding joint administrative/faculty positions or other combined assignments should be allocated to each category according to the fraction of the appointment assigned to that category.

3. For faculty members, 1 FTE equals what your institution defines as a full-time load

4. For student teaching assistants, 1 FTE equals 20 hours per week of work (or service).

5. Specify any other category considered appropriate, or leave blank.

APPENDIX E – 2022-23 SENIOR DESIGN PROMPT

AEI International Student Design Competition
Competition Program

Addendum 2023

The Challenges

The competition will challenge the student teams to address the design, integration, and construction issues associated with this project. Please keep in mind that the Challenges presented have been created for the sole purpose of the International Student Design Competition. Submissions should address the following challenges:

1. **Educational Exhibit: Green Design Considerations.** The Kaleideum stands as a monument to cultural change, continuous learning, and facilitation of knowledge from generation to generation. An immersive, enhanced visitor experience can be an incredible tool to illustrate diverse educational opportunities to all levels of visitor. As the green design considerations will be abundant throughout the project, it is important that patrons and professionals alike recognize the individuality and intricacies of the building. The challenge requires an educational exhibit to be located within the building. The educational exhibit should be accessible to all ages of visitors and focus on teaching with an interactive framework, showcasing what green design challenges were involved, what makes the building unique, and what the future holds using a cutting-edge vision which should set the exhibit apart from typical museum topics. This challenge requires:
   - For this exhibit, ownership would like to utilize the existing roof levels or add an additional roof level which would seamlessly connect to the existing roof levels by to designing new, sustainable amenities and modifications to the building. This may require moving existing roof equipment and egress routes.
   - Ownership would like to create an educational exhibit that outlines any unique green design considerations used in the building, and accessible to all ages of visitors using interactive framework so that patrons are able to read and experience the living building.

2. **Envelope: Performance Optimization.** There was a time when constructing a new facility was based simply on how many square feet the operation required. Those days are long gone. Today, successful facility development and management involves deftly understanding the importance of the building envelope, energy efficiency and local energy codes. Energy management is now no longer a “nice-to-have” but rather a “must-have” to be competitive in the marketplace. The building envelope significantly impacts a company’s energy use and maintenance requirements. It should be a top concern when looking to reduce total cost of ownership and future operating expenditures. Making the right material decisions for the building envelope is vital to any energy management strategy.
   - Provide an energy model that depicts a significant improvement over IECC 2021 and ASHRAE 90.1 2019. A minimum of 30% improvement of these standards is acceptable. Additionally, ownership would also like to track the performance of the envelope throughout the lifespan of the project, particularly as it relates to IECC 2021 and ASHRAE 90.1-2019. Please provide a life cycle cost analysis focusing on the envelope.
   - Ownership would like to minimize the maintenance requirements and costs with an emphasis on how daylight, thermal comfort, acoustical performance, and other environmental factors provide a competitive edge with regards to typical building practices.

3. **Sustainability: Embodied Carbon and Recyclability.** Incorporating sustainable materials and processes in 21st century buildings call for an urgent and strategic review of raw material usage, energy-efficiency strategies, and waste reduction practices that begin at a projects inception and carry through to the operation and maintenance of the completed building. With ever increasing consumer and regulatory demands, the present sustainability imperative requires careful selection of materials with higher recyclability and lower carbon and embodied energy footprints. This challenge requires teams to track, calculate and document the impact of materials and construction processes deployed to minimize the overall amount of carbon embodied in the building.
   - Ownership would like to reduce the embodied carbon of the building materials to the smallest value possible (lbsC0_2/sqft^2). (Use of a carbon calculator for materials such as EC3 hosted by buildingtransparency.org is encouraged.)
   - Ownership would also like to track and minimize the carbon emissions throughout the construction period from the project's initial groundbreaking through to the grand opening.
   - Acoustical Ownership would like a separate report on the incorporation of recycled content of materials and the recyclability of the materials utilized within the project.

Building Information

Kaleideum North, Formerly SciWorks of Winston-Salem, Winston-Salem, North Carolina
Kaleideum is a five-story, 70,000-square-foot building in downtown Winston-Salem that will be home to an innovative children's museum by Kaleideum, a merger of the Children's Museum of Winston-Salem and Sci-Works. Conceptualized as a "living building," the museum will incorporate interactive elements at the colorful, eye-catching building envelope while harnessing the natural environment as an opportunity to educate visitors about the interconnection of humanity.

A document with applicable codes will be provided to registered teams with the other project documents.

Competition Timeline

Student Team Registration begins	**Monday, August 16, 2022**
Student Team Registration ends	**Wednesday, January 11, 2023, 11:00pm EST**
Deadline for Written Submissions	**Monday, February 20, 2023, 11:00pm EST**
Notify Finalist Teams	**Monday, March 6, 2023**
Finalist Presentations	**Thursday, April 13, 2023 (Denver, CO)**

All teams may continue to work on their projects after the written submission in anticipation of possible selection as a finalist team and in preparation for the finalist presentations. The architectural engineering programs are encouraged to have competing students present their projects to their peers and faculty. It is also encouraged that they receive comments and suggestions from these individuals at multiple instances throughout the project.

SUPPLEMENTAL MATERIALS

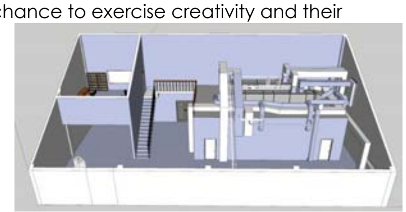
Civil, Environmental and Architectural Engineering
UNIVERSITY OF COLORADO BOULDER

Civil and Architectural Engineering Laboratories

Lighting Lab

- The Lighting Lab supports lighting curricula through active learning, testing, and experimentation.
- The lab is equipped with a goniophotometer, an integrating sphere, and luminance and illuminance meters that students use to perform light measurements.
- Lighting demonstrations and a variety of lighting equipment such as LED lamps and lighting controls help cement theorical knowledge while at the same time afford students the chance to exercise creativity and their engineering skills.

Larson Lab: air flow room, sensor room, heat retention research



- The Larson Building Systems Laboratory permits the study of entire HVAC systems in a controlled dynamic environment, providing repeatable test conditions that have been previously unavailable.
- The facility consists of two configurable roof-top commercial HVAC systems that can be used to test a wide range of operational strategies of HVAC systems and subsystems with sophisticated data acquisition and control systems.
- Activities in the lab include the dynamic interactions between building thermal response and HVAC systems controls, ventilation control for indoor air quality, HVAC system diagnostics, and interactions between multiple control functions of HVAC systems.
- The lab houses 2 full-sized test chambers that can be used to model a large variety of indoor environment conditions, like offices, data centers, and hospital operating rooms.
- Through the Larson Laboratory, our students have unique learning opportunities, positioning them for successful careers in HVACR. Internship opportunities with the lab are also available for students to further advance their knowledge and practical experience.

Living Materials Laboratory

- *The Living Materials Laboratory (LML) focuses on creating new, sustainable building materials.*
- *Undergraduate and graduate student researchers in the LML create new materials using wood, cement, bacteria, and algae and study their engineering properties.*
- *Experimental capabilities of the lab include mechanical testing to measure load-bearing capacity, thermal conductivity analysis to measure insulation properties, thermogravimetric analysis to measure thermal stability, X-ray diffraction to characterize mineral phases, Fourier-transform infrared spectroscopy to analyze chemical bonding, and a variety of cement and concrete characterization instruments.*
- *Computational capabilities include life cycle assessment to measure the environmental impacts of building materials and whole buildings.*

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CIEST lab: Geotechnical, Seismic/Structural Testing, & Materials testing

- The Center for Infrastructure, Energy, and Space Testing (CIEST), is an experimental testing facility with geotechnical centrifuge, structural dynamics, and materials testing.
- The geotechnical facility houses three centrifuges, including a 400 g-ton centrifuge that is amongst the most powerful in the United States, that is, used for research, industry, and educational purposes related to the characterization of geotechnical engineering systems (e.g. dams, foundations, pipelines) and the fundamental mechanical, hydraulic, and thermal properties of soil.

- The center includes multi-scale shake tables, strong floor, load reaction blocks, and hydraulic equipment capable of applying up to 1 million lb (4450 kN) and loading rates up to 100 in./sec (2.5m/sec).
- Our lab can conduct combined mechanical and environmental loadings (variations of temperature, pressure, humidity, and chemicals) to simulate actual service conditions of structures.

Always hiring interested UG/Grad research assistants. Check us out at: www.colorado.edu/center/ciest/

Construction Safety Research Alliance (CSRA)
- The Construction Safety Research Alliance (CSRA) is a unique community of industry practitioners and academic researchers who collaborate to create and share new knowledge about construction worker safety.
- The Mission of CSRA is to eliminate serious incidents and fatalities in the construction industry with transformative research and defendable science.
- The CU team includes an Executive Director (professor), Assistant Research Professor, Senior Research Associate, an Operations Manager, and over a dozen funded students
- The CSRA has over 300 active industry partners who represent all major sectors of the North American Construction Industry
- Our research is co-created with our industry partners; over 80 firms from across the US and Canada including Kiewit, CAT and Skanska.
- We publish and present our work on a global stage and host an annual CSRA Safety Summit at CU which in 2022 hosted 200+ safety professionals on campus, and broadcasted to a further 300+ across the world.
- Find out more here: Home | Construction Safety Research Alliance (colorado.edu)

Student Involvement in CEAE

Kiewit Design-Build Scholars Program
- The Kiewit Design Build Scholars Program is a corporate funded opportunity for any full-time engineering student who is interested in infrastructure design and construction.
- The program has four main pillars – financial aid, a mentorship program, site tours and events, and opportunities for internship. We are in the third year of the program and typically have around 40 students in the cohort each academic year.
- Kiewit hopes to guide more students to choose heavy-civil and infrastructure design as a career path and support them holistically through their academic experience.

Civil, Environmental and Architectural Engineering
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Student Societies:

Architectural Engineering Institute (AEI)

The AEI Chapter is a student organization dedicated to understanding and advancing the state-of-the-art of the architecture, engineering, and construction (AEC) profession through networking, design competitions, & learning experiences in the AEC community.

Associated General Contractors (AGC)

We strive to promote the construction industry in three areas which include education, service, and networking, and we have construction professionals speak at every weekly meeting to present on a specific project or on their company.

American Society of Civil Engineers (ASCE)

Our chapter coordinates with industry members to learn about opportunities within Civil Engineering, and compete in the Concrete Canoe, Innovation, Sustainability, Surveying, and Steel Bridge competitions through the ASCE Rocky Mountain Regional Symposium.

American Society of Heating, Refrigeration and Air Conditioning Engineers

Our chapter coordinates events, including industry expert talks/presentations, innovative academic research talks, technical workshops, site visits, and social events, helping you to network with industry professionals, stay up to date with research and industry best practices, and offer hands-on experience with HVAC equipment.

Bridge Buffs

Bridge Buffs is the CU Chapter of a national NGO called Engineers in Action, a non-profit organization that designs and builds pedestrian footbridges, and is dedicated to reducing poverty created by rural isolation by building pedestrian bridges over impassable rivers in communities that would otherwise be unable to afford them.

Engineers Without Borders (EWB)

EWB's mission is to partner with developing communities to improve quality of life through environmentally sustainable, equitable, and economical engineering projects. Our chapter was the first chapter of EWB-USA.

Illuminating Engineering Society

The CU IES Chapter is a community committed to inspiring those interested in lighting by providing tools for career success and building a shared knowledge base, while promoting engagement with industry professionals and each other.

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Interested in learning more? Contact the CEAE office at: ceae@colorado.edu

For scholarship information: CU Boulder has automatic consideration for some scholarships, and an application for others, including Engineering scholarships: www.colorado.edu/finaid

Departmental career fairs are held in both the fall and spring.
The following companies have hired our undergraduate students:

Adolfson & Peterson Construction
AECOM
AEI | Affiliated Engineers, Inc.
Air Force Civilian Service
Alfred Benesch & Company
Ames Construction Inc
Apex Engineers, Inc.
Arcadis
ARCO/MURRAY Natl. Construction Company
Barnard Construction
Big-D Construction
BranchPattern
Brinkmann Constructors
Bureau of Reclamation
CannonDesign
Cator Ruma & Associates
City and County of Denver
Colorado DOT
Condon-Johnson and Assoc.
Confluence Builders, LLC
CU Facilities Management
EXP
FCI Constructors, Inc.
Flatiron Construction
Fransen Pittman
Galloway & Company
Garney Construction
GBA, Inc.
GEI Consultants, Inc.
GH Phipps Construction Cos.
AE Design
Horton Lees Brogden Lighting Design
Visual Interest
Greystar
Group 14 Engineering
Hathaway Dinwiddie
Hayward Baker
Henderson Engineers, Inc.
Hensel Phelps
Holder Construction Company
Holland Partner Group
Howell Construction
HPM, Inc.
Hyder Construction
J.R. Butler, Inc.
Jacobs
JE Dunn Construction
JVA, Inc.
Keller North America, Inc.
Kiewit
KL&A
Kraemer North America LLC
Manhard Consulting
Martin/Martin Consulting Engineers
Mazzetti
MB BIM Solutions
McKinstry
ME Engineers
MEP Engineering, Inc.
Merrick & Company
Milender White
Mortenson Construction
MTech Mechanical
NREL
BEGA North America
Lighting Design Alliance
SmithGroup
NewFields Mining Design & Technical Services
Opus Holding, L.L.C.
Otak, Inc.
Parsons
PCL
PG Arnold Construction
Pinkard Construction Co.
Rick Engineering Company
Rider Levett Bucknall
RJH Consultants, Inc.
The Weitz Company
Turner Construction Company
Vertix Builders, Inc.
W.E. O'Neil Construction Co.
Waner Construction Co., Inc
Whiting-Turner Contracting Co
Wright Water Engineers, Inc
WSP
Fisher Marantz Store
The Lighting Agency
RockSol Consulting Group, Inc.
Ryan Companies US, Inc.
S. A. Miro, Inc.
Saunders Construction, Inc.
Shaw Construction LLC
Shimmick Construction/AECOM Civil Construction
Shrewsberry & Associates, LLC
Simpson Gumpertz & Heger
Skanska USA, Inc.
Southland Industries
Stantec
Swinerton Builders
The RMH Group Incy

SUBMISSION ATTESTING TO COMPLIANCE