

# ARCHITECTURAL ENGINEERING - BACHELOR OF SCIENCE (BSARE)

Architectural engineering is the application of engineering principles and technology to building design and construction. Architectural engineering combines aspects of electrical, mechanical, and civil engineering to design integrated systems for buildings. Building systems include heating, ventilating and air conditioning (HVAC) systems; illumination and electrical systems; materials and structural systems; and construction methods applied to buildings.

The Bachelor of Science degree program is administered by the Department of Civil, Environmental and Architectural Engineering. Students also take a course in architectural history and theory from the Environmental Design (ENVD) Program.

## Requirements

### Program Requirements

To earn a bachelor's degree in architectural engineering, students must complete the curriculum in the undergraduate major program as outlined below. For up-to-date program requirements, visit the Bachelor of Science in Architectural Engineering (<https://www.colorado.edu/ceae/current-students/undergraduate-studies/architectural-engineering/>) webpage. *Note:* Some variations may be possible; see an architectural engineering academic advisor.

In addition, students must meet the general undergraduate degree requirements of the College of Engineering and Applied Science (<https://www.colorado.edu/engineering-advising/get-your-degree/graduation-requirements/>) and all graduation requirements specified on the CEAE Department website.

Students may earn a Bachelor of Science in Architectural Engineering and a Bachelor of Science in Integrated Design Engineering with an architectural engineering emphasis.

### Prerequisites and Passing Grades

The minimum passing grade for a course that is a prerequisite or corequisite for another required course is C-. The minimum passing grade for a course that is not specifically a prerequisite or corequisite for another required course is D-.

It is the student's responsibility to communicate with the department if summer coursework and/or transfer credit will be used to meet a prerequisite requirement.

### Required Courses and Credits

| Code                    | Title   | Credit Hours |
|-------------------------|---|--------------|
| <b>Required Courses</b> |   |              |
| AREN 1027               | Engineering Drawing                                 | 3            |
| AREN 1316               | Introduction to Architectural Engineering           | 1            |
| or ASEN 1000            | Introduction to Aerospace Engineering Sciences      |              |
| or BMEN 1000            | Exploring Biomedical Engineering                    |              |
| or CHEN 1300            | Introduction to Chemical and Biological Engineering |              |
| or CSCI 1000            | Computer Science as a Field of Work and Study       |              |

|                          |  |   |
|--------------------------|--|---|
| or CVEN 1317             | Introduction to Civil and Environmental Engineering      |   |
| or ECEN 1100             | Exploring ECE  |   |
| or EVEN 1000             | Introduction to Environmental Engineering                |   |
| AREN 2050                | Building Materials and Systems                           | 3 |
| AREN 2110                | Thermodynamics   | 3 |
| or ASEN 2702             | Introduction to Thermodynamics and Aerodynamics          |   |
| or EVEN 3012             | Thermodynamics for Environmental Science and Engineering |   |
| or GEEN 3852             | Thermodynamics for Engineers                             |   |
| or MCEN 3012             | Thermodynamics   |   |
| AREN 2120                | Fluid Mechanics and Heat Transfer                        | 3 |
| or CVEN 3313 & AREN 2121 | Theoretical Fluid Mechanics and Heat Transfer            |   |
| AREN 3010                | Energy Efficient Buildings                               | 3 |
| AREN 3040                | Circuits for Architectural Engineers                     | 3 |
| AREN 3080                | Architectural Design Studio 1                            | 3 |
| AREN 3540                | Illumination I   | 3 |
| AREN 4110                | Building Energy Systems Engineering                      | 3 |
| AREN 4318                | Architectural Engineering Design 1                       | 5 |
| AREN 4319                | Architectural Engineering Design 2                       | 2 |
| AREN 4506                | Pre-construction Estimating and Scheduling               | 3 |
| AREN 4550                | Illumination 2   | 3 |
| AREN 4570                | Building Electrical Systems Design 1                     | 3 |
| CSCI 1200                | Introduction to Computational Thinking                   | 3 |
| or ASEN 1320             | Aerospace Computing and Engineering Applications         |   |
| or CHEN 1310             | Introduction to Engineering Computing                    |   |
| or CSCI 1300             | Computer Science 1: Starting Computing                   |   |
| or ECEN 1310             | C Programming for ECE                                    |   |
| or MCEN 1030             | Introduction to Engineering Computing                    |   |
| CVEN 2017                | Excel Matlab R Primer                                    | 1 |
| CVEN 2121                | Analytical Mechanics 1                                   | 3 |
| or ASEN 2401             | Statics  |   |
| or ASEN 2701             | Introduction to Statics, Structures, and Materials       |   |
| or GEEN 2851             | Statics for Engineers                                    |   |
| or MCEN 2023             | Statics and Structures                                   |   |
| CVEN 3161                | Mechanics of Materials 1                                 | 3 |
| or MCEN 2063             | Mechanics of Solids                                      |   |
| CVEN 3246                | Introduction to Construction                             | 3 |
| CVEN 3525                | Structural Analysis                                      | 3 |
| CVEN 4545                | Steel Design   | 3 |
| or CVEN 4555             | Reinforced Concrete Design                               |   |
| GEEN 1400                | Engineering Projects <sup>1</sup>                        | 3 |
| or ASEN 1400             | Gateway to Space   |   |
| or ASEN 1403             | Introduction to Rocket Engineering                       |   |
| or CHEN 1400             | Drugs, Driving and Dynamic Processes                     |   |
| or ECEN 1400             | Introduction to Digital and Analog Electronics           |   |

### Technical Electives

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At least two technical electives must be selected from the specialization lists below. The remaining technical electives may be any upper-division AREN or CVEN course or any course on the approved Technical Elective List.<sup>2</sup>

#### Construction Engineering & Management

|           |   |
|-----------|---|
| AREN 4315 | Design of Masonry Structures                                      |
| AREN 4606 | Construction Project Execution and Control (strongly recommended) |
| CVEN 3256 | Construction Equipment and Methods (strongly recommended)         |
| CVEN 3708 | Geotechnical Engineering 1  |
| CVEN 3718 | Geotechnical Engineering 2  |
| CVEN 4565 | Design of Wood Structures   |

#### Lighting & Electrical Systems

|           |  |
|-----------|--|
| AREN 4130 | Optical Design for Illumination and Solid State Lighting |
| AREN 4530 | Advanced Lighting Design                                 |
| AREN 4560 | Luminous Radiative Transfer                              |
| AREN 4580 | Daylighting  |
| AREN 4620 | Adaptive Lighting Systems                                |

#### Mechanical Systems

|           |   |
|-----------|---|
| AREN 4010 | Energy System Modeling and Control                            |
| AREN 4040 | Building Energy Audits  |
| AREN 4890 | Sustainable Building Design                                   |
| AREN 4990 | Compu Fluid Dynamics (CFD) Analysis for Built/Natural Envmnts |
| AREN 5080 | Computer Simulation of Building Energy Systems                |

#### Structural Systems

|              |                              |
|--------------|------------------------------|
| AREN 4315    | Design of Masonry Structures |
| AREN 5660    | Embodied Carbon in Buildings |
| CVEN 4161    | Mechanics of Materials 2     |
| CVEN 4545    | Steel Design <sup>3</sup>    |
| or CVEN 4555 | Reinforced Concrete Design   |
| CVEN 4565    | Design of Wood Structures    |
| CVEN 4728    | Foundation Engineering       |

#### Required Mathematics Courses

|                          |   |   |
|--------------------------|---|---|
| APPM 1350                | Calculus 1 for Engineers  | 4 |
| or MATH 1300             | Calculus 1  |   |
| or APPM 1345             | Calculus 1 with Algebra, Part B   |   |
| APPM 1360                | Calculus 2 for Engineers  | 4 |
| or MATH 2300             | Calculus 2  |   |
| APPM 2350                | Calculus 3 for Engineers  | 4 |
| or MATH 2400             | Calculus 3  |   |
| APPM 2360                | Introduction to Differential Equations with Linear Algebra                                    | 4 |
| or MATH 2130 & MATH 3430 | Introduction to Linear Algebra for Non-Mathematics Majors and Ordinary Differential Equations |   |
| or MATH 2135 & MATH 3430 | Introduction to Linear Algebra for Mathematics Majors and Ordinary Differential Equations     |   |

#### Required Science Courses

|           |                                   |   |
|-----------|-----------------------------------|---|
| CHEM 1114 | Laboratory in General Chemistry 1 | 1 |
|-----------|-----------------------------------|---|

|              |  |   |
|--------------|--|---|
| or CHEM 1221 | Engineering General Chemistry Lab          |   |
| or PHYS 1140 | Experimental Physics 1                     |   |
| CHEN 1201    | General Chemistry for Engineers 1          | 4 |
| or ASEN 1022 | Materials Science for Aerospace Engineers  |   |
| or CHEN 1211 | Accelerated Chemistry for Engineers        |   |
| or CHEM 1113 | General Chemistry 1                        |   |
| or MCEN 1024 | Chemistry for Energy and Materials Science |   |
| PHYS 1110    | General Physics 1                          | 4 |
| or PHYS 1115 | General Physics 1 for Majors               |   |
| PHYS 1120    | General Physics 2                          | 4 |
| or PHYS 1125 | General Physics 2 for Majors               |   |

#### Humanities, Social Sciences and Writing

|  |                                      |    |
|--|--------------------------------------|----|
| Writing  |                                      | 3  |
| College-approved writing course. <sup>4</sup>  |                                      |    |
| Humanities & Social Sciences   |                                      | 15 |
| ARCH 3214  | History and Theory of Architecture 2 |    |
| Other approved Humanities & Social Sciences Electives. At least 6 credits (including ARCH 3214) must be at the upper-division level (3000 level or higher). <sup>4</sup> |                                      |    |

#### Free Electives

|  |  |   |
|--|--|---|
|  |  | 3 |
|--|--|---|

#### Total Credit Hours

128

- Students who do not take a first-year projects course may substitute a basic engineering elective: any 3-credit technical course offered in ASEN, AREN, APPM, CHEN, COEN, CVEN, CSCI, ECEN, EMEN, EVEN, GEEN, MCEN, or other course approved by the CEAE Curriculum Committee. Remedial courses (such as precalculus) or courses approved as Humanities & Social Sciences electives may not be used.
- The approved Technical Elective List can be found on the CEAE Department website (<https://www.colorado.edu/ceae/current-students/undergraduate-studies/architectural-engineering/>).
- Either CVEN 4545 or CVEN 4555 may be taken as a technical elective—whichever course is *not* used to fulfill the required structural design course.
- Refer to the College's approved list of courses that fulfill the Humanities, Social Sciences and Writing Requirement (<https://www.colorado.edu/engineering-advising/get-your-degree/degree-requirements/humanities-social-sciences-and-writing-requirements/>).

## Sample Four-Year Plan of Study

### Year One

| Fall Semester                                      |  | Credit Hours |
|--|--|--------------|
| APPM 1350  | Calculus 1 for Engineers                       | 4            |
| AREN 1316  | Introduction to Architectural Engineering      | 1            |
| CHEM 1114  | Laboratory in General Chemistry 1 <sup>3</sup> | 1            |
| or PHYS 1140                                       | or Experimental Physics 1                      |              |
| CHEN 1201  | General Chemistry for Engineers 1              | 4            |
| CSCI 1200  | Introduction to Computational Thinking         | 3            |
| COEN 1830  | Special Topics (First-Year Seminar)            | 1            |
| Humanities & Social Sciences elective <sup>1</sup> |  | 2            |
| <b>Credit Hours</b>                                |  | <b>16</b>    |

### Spring Semester

|           |                          |   |
|-----------|--------------------------|---|
| APPM 1360 | Calculus 2 for Engineers | 4 |
|-----------|--------------------------|---|

|  |                     |           |
|--|---------------------|-----------|
| AREN 1027  | Engineering Drawing | 3         |
| PHYS 1110  | General Physics 1   | 4         |
| First-Year Projects course or Basic Engineering Elective |                     | 3         |
| Humanities & Social Sciences elective <sup>1</sup>       |                     | 3         |
| <b>Credit Hours</b>                                      |                     | <b>17</b> |

### Year Two

#### Fall Semester

|                     |                                |           |
|---------------------|--------------------------------|-----------|
| APPM 2350           | Calculus 3 for Engineers       | 4         |
| AREN 2050           | Building Materials and Systems | 3         |
| AREN 2110           | Thermodynamics                 | 3         |
| CVEN 2121           | Analytical Mechanics 1         | 3         |
| PHYS 1120           | General Physics 2              | 4         |
| <b>Credit Hours</b> |                                | <b>17</b> |

#### Spring Semester

|                     |  |           |
|---------------------|--|-----------|
| APPM 2360           | Introduction to Differential Equations with Linear Algebra | 4         |
| AREN 2120           | Fluid Mechanics and Heat Transfer                          | 3         |
| AREN 3080           | Architectural Design Studio 1                              | 3         |
| AREN 3540           | Illumination I   | 3         |
| CVEN 2017           | Excel Matlab R Primer                                      | 1         |
| CVEN 3161           | Mechanics of Materials 1                                   | 3         |
| <b>Credit Hours</b> |  | <b>17</b> |

### Year Three

#### Fall Semester

|  |                              |           |
|--|------------------------------|-----------|
| AREN 3010                                    | Energy Efficient Buildings   | 3         |
| AREN 4550                                    | Illumination 2               | 3         |
| CVEN 3246                                    | Introduction to Construction | 3         |
| CVEN 3525                                    | Structural Analysis          | 3         |
| College-approved writing course <sup>2</sup> |                              | 3         |
| <b>Credit Hours</b>                          |                              | <b>15</b> |

#### Spring Semester

|                        |  |           |
|------------------------|--|-----------|
| ARCH 3214              | History and Theory of Architecture 2       | 3         |
| AREN 3040              | Circuits for Architectural Engineers       | 3         |
| AREN 4110              | Building Energy Systems Engineering        | 3         |
| AREN 4506              | Pre-construction Estimating and Scheduling | 3         |
| CVEN 4545 or CVEN 4555 | Steel Design or Reinforced Concrete Design | 3         |
| <b>Credit Hours</b>    |  | <b>15</b> |

### Year Four

#### Fall Semester

|  |                                      |           |
|--|--------------------------------------|-----------|
| AREN 4318  | Architectural Engineering Design 1   | 5         |
| AREN 4570  | Building Electrical Systems Design 1 | 3         |
| Humanities & Social Sciences elective <sup>1</sup> |                                      | 3         |
| Technical elective                                 |                                      | 3         |
| Technical elective                                 |                                      | 3         |
| <b>Credit Hours</b>                                |                                      | <b>17</b> |

#### Spring Semester

|  |                                    |   |
|--|------------------------------------|---|
| AREN 4319  | Architectural Engineering Design 2 | 2 |
| Free elective                                      |                                    | 3 |
| Humanities & Social Sciences elective <sup>1</sup> |                                    | 3 |
| Technical elective                                 |                                    | 3 |

|                           |            |
|---------------------------|------------|
| Technical elective        | 3          |
| <b>Credit Hours</b>       | <b>14</b>  |
| <b>Total Credit Hours</b> | <b>128</b> |

<sup>1</sup> Students may choose courses from the list of college-approved humanities and social sciences (HSS) electives (<http://www.colorado.edu/engineering/academics/policies/hss/>).

<sup>2</sup> Students may choose a course from the list of college-approved writing courses (<http://www.colorado.edu/engineering/academics/policies/hss/>).

<sup>3</sup> Students who choose PHYS 1140 will take it in Year Two or later (with or after PHYS 1120)

## AREN Electives and Opportunities for Specialization

Upon consultation with their advisors, students select technical elective courses applicable to their areas of interest and specialization. The areas of specialization are construction engineering and management, mechanical systems, structural systems, and lighting and electrical systems.

Courses may be chosen from any emphasis area. At least two technical electives must be selected from this list. Some technical electives are offered intermittently and are not guaranteed to be offered every year.

| Code   | Title   | Credit Hours |
|--|---|--------------|
| <b>Construction Engineering &amp; Management</b>   |   |              |
| AREN 4315  | Design of Masonry Structures                                  | 3            |
| AREN 4606  | Construction Project Execution and Control                    | 3            |
| CVEN 3256  | Construction Equipment and Methods                            | 3            |
| CVEN 3708  | Geotechnical Engineering 1                                    | 3            |
| CVEN 3718  | Geotechnical Engineering 2                                    | 3            |
| CVEN 4565  | Design of Wood Structures                                     | 3            |
| Students with an interest in construction are also encouraged to take CVEN 2012 as a Basic Engineering Elective or Free Elective |   |              |
| <b>Mechanical Systems</b>  |   |              |
| AREN 4010  | Energy System Modeling and Control                            | 3            |
| AREN 4040  | Building Energy Audits  | 3            |
| AREN 4890  | Sustainable Building Design                                   | 3            |
| AREN 4990  | Compu Fluid Dynamics (CFD) Analysis for Built/Natural Envmnts | 3            |
| AREN 5080  | Computer Simulation of Building Energy Systems                | 3            |
| <b>Structural Systems</b>  |   |              |
| AREN 4315  | Design of Masonry Structures                                  | 3            |
| AREN 5660  | Embodied Carbon in Buildings                                  | 3            |
| CVEN 4161  | Mechanics of Materials 2                                      | 3            |
| CVEN 4545  | Steel Design <sup>1</sup>                                     | 3            |
| or CVEN 4555   | Reinforced Concrete Design                                    |              |
| CVEN 4565  | Design of Wood Structures                                     | 3            |
| CVEN 4728  | Foundation Engineering  | 3            |
| <b>Lighting &amp; Electrical Systems</b>   |   |              |
| AREN 4130  | Optical Design for Illumination and Solid State Lighting      | 3            |

|           |                             |   |
|-----------|-----------------------------|---|
| AREN 4530 | Advanced Lighting Design    | 3 |
| AREN 4560 | Luminous Radiative Transfer | 3 |
| AREN 4580 | Daylighting                 | 3 |
| AREN 4620 | Adaptive Lighting Systems   | 3 |

<sup>1</sup> CVEN 4545 or CVEN 4555, whichever course is *not* used to fulfill the required course in spring semester of year 3, may be taken as a technical elective.

## Learning Outcomes

### 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:

- Our alumni will build on the educational foundation gained through our program by establishing themselves in engineering, science or other professional careers.
- 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.
- Our alumni will exercise leadership in their field.
- Our alumni will enhance the sustainability of the built environment.

### Student Outcomes

The outcomes that students are expected to have attained upon graduation with the bachelor of science degree in Architectural Engineering are:

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.

### Areas of Knowledge

The areas of knowledge that define these objectives include both technical and non-technical areas.

Technical areas are:

- Elementary: The fundamentals for architectural engineering, including basic science and mathematics, building design and construction processes, overview of building systems, elementary principles and processes of architecture, and laboratory measurement and data analysis.
- Intermediate: Introduction to building systems and their components, with corresponding analysis of electrical, HVAC and lighting systems, as well as structural elements and components.
- Proficiency: Design, integration and advanced analysis of electrical, HVAC, lighting and structural systems, as well as the standards, codes and recommended practices that govern these building systems.
- Specialization: Advanced design, coupled with industry experience via internships, for building lighting and electrical system design, building HVAC systems design, building structural system design, and construction engineering and management.

Non-technical areas include:

- Professional life, including methods of time and resource management and professional ethics.
- Processes and requirements of written and oral communication.
- Broad areas in the humanities and social sciences, including architectural history and language.

## Bachelor's–Accelerated Master's Degree Program(s)

The bachelor's–accelerated master's (BAM) degree program options offer currently enrolled CU Boulder undergraduate students the opportunity to receive a bachelor's and master's degree in a shorter period of time. Students receive the bachelor's degree first but begin taking graduate coursework as undergraduates (typically in their senior year).

Because some courses are allowed to double count for both the bachelor's and the master's degrees, students receive a master's degree in less time and at a lower cost than if they were to enroll in a stand-alone master's degree program after completion of their baccalaureate degree. In addition, staying at CU Boulder to pursue a bachelor's–accelerated master's program enables students to continue working with their established faculty mentors.

### BS in Architectural Engineering, MS in Architectural Engineering or Civil Engineering

#### Admissions Requirements

In order to gain admission to the BAM programs named above, a student must meet the following criteria:

- Have a cumulative GPA of 3.000 or higher.
- Completion of all MAPS requirements and no deficiencies remaining (students admitted to CU Boulder prior to Summer 2023 only).
- Have at least junior status within the bachelor's degree program.

#### Program Requirements

Students may take up to and including 12 hours while in the undergraduate program which can later be used toward the master's degree. However, only 6 credits may be double counted toward the bachelor's degree and the master's degree. Students must apply to graduate with the bachelor's degree, and apply to continue with the

master's degree, early in the semester in which the undergraduate requirements will be completed.

Please see the BAM degree program (<https://www.colorado.edu/ceae/current-students/undergraduate-studies/bsms-program/>) webpage for more information.