جامعة الملك فهد للبترول والمعادن
King Fahd University of Petroleum & Minerals

ARE
Revised Program Courses and Courses Descripton

2021

Degree Requirements for the B.S. in ARE (Summer Training) Option

Each student majoring in **ARE** following the **Summer Training** Option must complete the following courses:

General Education Requirements	Courses	Credit Hours
English	ENGL 101, 102, 214	9
Islamic and Arabic Studies	IAS 111, 121, 212, and IAS XXX	8
General Studies	CGS 392, GS XXX	4
Mathematics	MATH 101, 102, 201, 208, STAT 319	17
Natural Sciences	PHYS 101, 102, CHEM 101	12
Mathematics or Science Elective	MATH XXX or Basic Science XXX Elective	3
Physical Education	PE 101	1
Digital Foundation & Business	ICS 104, ISE 291, COE 292, BUS 200	12
		66
Core Requirements		
Graphics/Arch. Design	ARE 201, 202, 301	8
Bldg. Materials & Constr. Sys / Working Drawings	ARE 230, 303	7
Building Structural Systems	CE 202, 305, 315	9
Building Electrical systems and Lighting	EE 204, 312	7
Building Mechanical Systems	ARE 220, 322, 323	9
Construction/Construction Management	ARE 330, 331	6
Senior Design Project	ARE 410, 411	4
		50
Electives		
ARE Electives	Two ARE Electives	6
Building Structural Systems	ARE 416, 417, 418 or CE 354, 408, 415	
Building Mechanical systems	ARE 420, 421, 422, 423, 424, 425, 426, 427, 428, 429	
Construction/Construction Management	ARE 430, 432, 433, 434, 435, 436, 437, 438, 439, 465	
Building Electrical systems	ARE 445, 446, 447	
Sustainable Buildings (+Others)	ARE 460, 461, 463, 490, 492, 497 or ARC 419, 457	
Eng. Elective	One Eng. XXX 4xx	3
Free Elective	One Free XXX 4xx	3
		12
Summer Training		
Summer Training	ARE 399	**0**
Total Requirements	The total number of credit hours required is	**128**

Degree Requirements for the B.S. in ARE (Internship) Option

Each student majoring in **ARE** following **Internship** Option the must complete the following courses:

General Education Requirements	Courses	Credit Hours
English	ENGL 101, 102, 214	9
Islamic and Arabic Studies	IAS 111, 121, 212, and IAS XXX	8
General Studies	CGS 392, GS XXX	4
Mathematics	MATH 101, 102, 201, 208, STAT 319	17
Natural Sciences	PHYS 101, 102, CHEM 101	12
Mathematics or Science Elective	MATH XXX or Basic Science XXX Elective	3
Physical Education	PE 101	1
Digital Foundation & Business	ICS 104, ISE 291, COE 292, BUS 200	12
		66
Core Requirements		
Graphics/Arch. Design	ARE 201, 202, 301	8
Bldg. Materials and Constr. Sys./ Working Drawings	ARE 230, 303	7
Building Structural Systems	CE 202, 305, 315	9
Building Electrical systems and Lighting	EE 204, 312	7
Building Mechanical Systems	ARE 220, 322, 323	9
Construction/Construction Management	ARE 330, 331	6
Senior Design Project	ARE 410, 411	4
		50
Electives		
ARE Electives	One ARE Electives (from):	3
Building Structural Systems	ARE 416, 417, 418 or CE 354, 408, 415	
Building Mechanical systems	ARE 420, 421, 422, 423, 424, 425, 426, 427, 428, 429	
Construction/Construction Management	ARE 430, 432, 433, 434, 435, 436, 437, 438, 439, 465	
Building Electrical systems	ARE 445, 446, 447	
Sustainable Buildings (+Others)	ARE 460, 461, 463, 490, 492, 497 or ARC 419, 457	
Free Elective	One Free XXX 4xx	3
		6
Internship		
Arch. Engineering Internship	ARE 398	**6**
Total Requirements	The total number of credit hours required is	**128**

LIST OF COURSES

List of all courses (Course Title and Number)

List of Core Courses and Credits

	Core Courses					
No	**COURSE**		**TITLE**	**LT**	**LB**	**CR**
1	**ARE**	**201**	Architectural Graphics	**0**	**6**	**2**
2	**ARE**	**202**	Architectural Design and History	**1**	**6**	**3**
3	**ARE**	**220**	Fundamentals of Thermal Science	**3**	**0**	**3**
4	**ARE**	**230**	Building Materials & Construction Systems	**3**	**3**	**4**
5	**ARE**	**301**	Architectural Design	**0**	**9**	**3**
4	**ARE**	**303**	Working Drawings	**0**	**9**	**3**
7	**ARE**	**322**	Building Mechanical Systems	**2**	**3**	**3**
8	**ARE**	**323**	Principles of Heating, Ventilation & Air Conditioning	**3**	**0**	**3**
9	**ARE**	**330**	Construction Management and Estimation	**3**	**0**	**3**
10	**ARE**	**331**	Construction Economy and Equipment	**3**	**0**	**3**
11	**ARE**	**398**	Architectural Engineering Internship	**0**	**0**	**6**
12	**ARE**	**399**	Summer Training	**0**	**0**	**0**
13	**ARE**	**410**	Introduction to Senior Design Project	**1**	**0**	**1**
14	**ARE**	**411**	Senior Design Project	**0**	**9**	**3**
			Total	**19**	**45**	**40**

List of **Areas of Study** and Corresponding ARE **Elective Courses**
Course Credits for all (**3-0-3**)

Elective Courses		
Area of Study	**No.**	**ARE Elective Courses**
Building Structural Systems (BSS)	**1**	**ARE 416** Planning and Design of Structural Sys.
	2	**ARE 417** Innovative Building Structures
	3	**ARE 418** Structural Design of High-Rise Buildings
Building Mechanical Systems (BMS)	**1**	**ARE 420** Solar Energy in Buildings
	2	**ARE 421** Building Energy Analysis
	3	**ARE 422** Advanced Building Envelopes
	4	**ARE 423** Building Performance Evaluation
	5	**ARE 424** Indoor Air Quality and Ventilation
	6	**ARE 425** Architectural Acoustics
	7	**ARE 426** Room Acoustics
	8	**ARE 427** Noise Control in Buildings
	9	**ARE 428** Design of Plumbing & Fire Supp Systems
	10	**ARE 429** Safety and Security Systems in Buildings
Const/Construction Management (C/ CM)	**1**	**ARE 430** Contracts and Specifications
	2	**ARE 465** Construction Processes and Methods
	3	**ARE 432** Construction Planning and Scheduling
	4	**ARE 433** Building Cost Estimation
	5	**ARE 434** Building Economy
	6	**ARE 435** Construction Safety
	7	**ARE 436** Fire Safety Management
	8	**ARE 437** Decisions Analysis and Modeling
	9	**ARE 438** Facilities Planning and Management
	10	**ARE 439** Intro. to Bldg. Maintenance Management
Building Electrical Sys. & Lighting (BES/L)	**1**	**ARE 445** Artificial Lighting Systems Design
	2	**ARE 446** Daylighting Analysis and Design
	3	**ARE 447** Automation and Control of Bldg. Systems
Others	**1**	**ARE 460** Green and Sustainable Buildings
	2	**ARE 461** Applications of AI in Smart Buildings
	3	**ARE 463** Sustainable Energy Solutions
	4	**ARE 490** Special Topics in Arch. Engineering
	5	**ARE 492** Mosque Systems and Operation
	6	**ARE 497** Undergraduate Research

Elective Courses from **Other Programs**

Elective Courses from Other Programs		
Area of Study	**No.**	**ARE Elective Courses**
Architecture	**1**	**ARC 419** Parametric Design (1-4-**3**)
Civil Engineering	**1**	**CE 354** Intro. to Geotechnical Engineering (3-0-**3**)
	2	**CE 408** Steel Design I (2-3-**3**)
	3	**CE 415** Reinforced Concrete II (2-3-**3**)

Bulletin Description of all Courses

Bulletin Description of Courses: **Core Courses**

ARE 201	**Architectural Graphics**	**(0-6-2)**
Introduction to **Architectural Engineering**; G**raphical** methods and techniques in architectural design and presentation; drawing tools and materials; architectural drafting conventions; orthographic projections and views, their types and use in building presentation. Shades and shadows techniques. Freehand sketching and model-making techniques .**Computer graphics** using simple software tools, 2D- drawings, 3D-modeling, rendering, and image processing. Major CAD drafting, and presentation software tools will be used with emphasis on the production, management, and presentation of project information.		
Prerequisite:	None	
ARE 202	**Architectural Design and History**	**(1-6-3)**
The course includes two inter-related parts: Part-I: The social and cultural factors and use of materials that contributed to the development of the unique architecture such as Egyptian, Greek, Roman, Gothic, Renaissance, Baroque, Islamic, Industrial Revolution and Contemporary architecture. Part-II: The process of architectural design in the form of phases, objectives, activities, and parties involved. Models for design problem-solving utilizing graphic thinking are exercised through both abstract sketches and definitive designs to tackle simple design problems. The building function, construction materials and systems, cultural and environmental constraints, and climatic influences are emphasized.		
Prerequisite	**ARE 201**	
ARE 220	**Fundamentals of Thermal Science**	**(3-0-3)**
Introduction to ***Thermal Science***, basic concepts of ***Thermodynamics***, First and second laws of thermodynamics, application to system control, volume, internal energy and enthalpy. ***Fluid Mechanics***, properties of fluids, forces and motion, fluid hydrostatic, dynamic equations of continuity, energy, and linear momentum with application to flow situations and measurements. ***Heat Transfer*** fundamentals and their application in buildings.		
Prerequisite	**MATH 102: Calculus II** **PHYS 102: General Physics II**	
ARE 230	**Building Materials and Construction Systems**	**(3-3-4)**
Introduction to building materials and construction systems. Properties and usage of building materials such as wood, steel, masonry, cement, concrete, glass, plastics and others. Modern and smart building materials. Construction systems including sub and super structural, wall, floor and roof systems. Building water, vapor proofing and thermal insulation. Innovative and emerging construction systems and methods. The course lab covers conducting standard tests on the properties and behavior of samples of various building materials.		
Prerequisite	**Sophomore Standing**	
ARE 301	**Architectural Design**	**(0-9-3)**
Continuation of higher-level practice of the design process through the design of more complex buildings and larger project sites. The concept of building design in a multi-disciplinary and		

integrative approach is adopted. Basic elements of architectural form and space and how they can be manipulated, organized in the development of architectural design concept and their visual implications are explored. The integration and interfaces of the inter-related and mutual impact of building structural and environmental control systems within the building design concept, function, form and spatial organization is emphasized.

Prerequisite	**ARE 202**

ARE 303	**Working Drawings**	**(0-9-3)**

Introduction to construction documents, divisions, and graphical standards developed to clearly communicate architectural designs for their proper execution. Students are required to produce a full set of working drawings drawn in 2D using proper CAD software, for a small or medium-scale building. The drawing set focuses on presenting technically precise architectural working and shop drawings with proper sequence and graphical standards covering the different components of the building such as *layout* (site plan), *floor plans*, *sections*, *elevations* and necessary architectural *details* as well as required door and window *schedules*. Management of drawings in the workplace and Building Information Modeling (BIM) issues are introduced.

(The course is equivalent to ARC 345)

Prerequisite	**ARE 230 and ARE 301.**

ARE 322	**Building Mechanical Systems**	**(2-3-3)**

Introduction to the basic concepts, terminology and design methods for building mechanical systems. Thermal comfort, building thermal performance, and heating and cooling load calculation procedures. Fire protection systems and smoke control. Water supply and distribution systems; Waste and drainage systems. Vertical transportation systems. Computer applications.

Prerequisite	**ARE 220 or PHYS 133**

ARE 323	**Principles of Heating, Ventilating, and Air-Conditioning**	**(3-0-3)**

Fundamental principles and engineering procedures for the design of Heating, Ventilating, and Air-Conditioning systems (HVAC); HVAC system characteristics; system and equipment selection; duct design and layout. Energy conservation techniques. Computer applications.

Prerequisite	**ARE 322**

ARE 330	**Construction Management and Estimating**	**(3-0-3)**

Construction management fundamentals, preparing the bid package, general conditions, special conditions and contract specifications and documents, issues during construction phase, construction contracts, construction labor, materials management, cost estimating, including determination of materials, labor, equipment, overhead, profit, and other construction costs, cost controls. Project planning and scheduling, project cash flow and funding, and construction safety.

Prerequisite	**ARE 230** or **CE 204**

ARE 331	**Construction Economy and Equipment**	**(3-0-3)**

Basic concepts of building economics including time value of money, life cycle costing, cost and benefit ratio analysis, depreciation, and depletion. Fundamental concepts of equipment economics and cost: the owning and operating costs of equipment and determining the economic life of equipment. Estimating productivity of the different categories of the construction

equipment such as: excavating and lifting, loading and hauling, compacting and finishing, Evaluation and selection of equipment. Construction engineering design within economic constraints including design of temporary support systems. Computer Applications.

Prerequisite	**ARE 330**

ARE 398	**Architectural Engineering Internship**	**(0-0-6)**

A continuous period of fifteen weeks is spent in the industry to acquire practical experience in the field of Architectural Engineering under the supervision and guidance of the employer and the academic advisor. During this period the student gains an in-depth exposure and appreciation of the Architectural Engineering profession. The student is required to write a technical report and conduct an oral presentation about his practical work experience. The report should emphasize duties assigned and completed by the student and the gained skills, abilities and values

Prerequisite	**ENGL 214, Junior Standing, Departmental Requirement**

ARE 399	**Summer Training**	**(0-0-0)**

A continuous period of eight weeks of summer working in the building industry to gain exposure and appreciation of the Architectural Engineering profession. On-the-job training needs to be acquired in one of the areas related to architectural engineering. The student is required to write a brief report and conduct an oral presentation about his practical work experience. The report should emphasize duties assigned and completed by the student and the gained skills, abilities and values

Prerequisite	**ENGL 214, Junior Standing, Departmental Requirement**

ARE 410	**Introduction to Senior Design Project**	**(1-0-1)**

Introduction to the approach and procedure of system, component, or process design to meet desired needs; types and impact of design constraints; requirements of the senior design project; topic selection, scope and limitations; collection of data, literature review; codes and standards identification; computing essentials, recognition of ethical responsibilities of the professional practice. A technical report and public oral presentation documenting the proposal of the senior project are fundamental requirements for completing the course. Teamwork is emphasized and greatly encouraged.

Prerequisite	**ENGL 214, Junior Standing**

ARE 411	**Senior Design Project**	**(0-9-3)**

A capstone course integrating various components of the curriculum in a comprehensive engineering design project. The project includes integrative design and analysis techniques in the curriculum areas of ***Building Structures***, ***Building Mechanical Systems***, ***Building Electrical Systems***, and ***Construction/Construction Management***. Students are required to reach the ***synthesis*** level in one of these four curriculum areas, the ***application*** level in a second area, and show ***comprehension*** of the remaining two areas. The design of a system, component, or process to meet desired needs should be within proper and realistic constraints. The use of software tools, applicable codes and standards is essential. A technical report and public oral presentation addressing the final design are required. Teamwork is emphasized and greatly encouraged.

Prerequisite	**ARE 410**

EE 312	Electrical Systems and Lighting	(3-3-4)
Part-I: Electrical symbols and wiring layout. Conductors, switches, fuses, and circuit breakers. Building wiring system: design elements, procedures and calculations. Types and number of branch circuits required for a basic electrical system design for residential, office and commercial buildings. Building Management Systems (BMS). Electrical design project for a medium-sized building. **Part-II:** Concept of light and vision. Lamps and luminaries, Lighting system design procedure; calculation control and measurement techniques, evaluation of interior lighting quality, and daylighting integration. Digital technologies and applications in artificial and day-lighting analysis, design and control in buildings.		
Prerequisite	**EE 204**	

ARE 416	**Planning and Design of Structural Systems**	**(3-0-3)**
Fundamental concepts in the planning, design, and construction of complete structures. Design philosophies and criteria. The nature of loads and probabilistic determination of design loads. Selection of structural systems for buildings. Approximate analysis for preliminary design. Utilization of computers in structural engineering. Special problems in tall building.		
Prerequisite	**CE 305 or ARC 232**	
ARE 417	**Innovative Building Structures**	**(3-0-3)**
Innovation in architectural and structural design. Architectural form and structural function; interpretation of basic and advanced structural principles with an intuitive graphical method. Case studies; biomimetics; bioinspired structures to increase structural efficiency. Innovative structural materials: the use of glass as structural material, innovative reinforcements for composite structures, smart and nanostructured materials; kinetic architecture. Innovations in digital media and factors contributing to innovative structural solutions. Recent developments in the field of adaptive structures.		
Prerequisite	**CE 305 or ARC 232**	
ARE 418	**Structural Design of High-Rise Buildings**	**(3-0-3)**
Concepts and design of complex structures including high-rise buildings, long-span structures and advanced seismic systems .Functional requirements, technologies and processes used in high-rise building construction. Foundation systems; typical vertical and horizontal loads on high-rise buildings, structural steel and reinforced concrete construction. Planning, system selection, modeling, analysis and design of high-rise buildings. The design process of a typical high-rise building project. design procedures, codes of practice and computer software to design steel and concrete high-rise buildings .Sustainability features in modern high-rise buildings.		
Prerequisite	**CE 315 or CE 408**	
ARE 420	**Solar Energy in Buildings**	**(3-0-3)**
Concepts and design of complex structures including high-rise buildings, long-span structures and advanced seismic systems .Functional requirements, technologies and processes used in high-rise building construction. Foundation systems; typical vertical and horizontal loads on high-rise buildings, structural steel and reinforced concrete construction. Planning, system selection, modeling, analysis and design of high-rise buildings. The design process of a typical high-rise building project. Design procedures, codes of practice and computer software to design steel and concrete high-rise buildings .Sustainability features in modern high-rise buildings.		
Prerequisite	**Senior Standing or Department's Approval**	
ARE 421	**Building Energy Analysis**	**(3-0-3)**
Concepts and design of complex structures including high-rise buildings, long-span structures and advanced seismic systems .Functional requirements, technologies and processes used in high-rise building construction. Foundation systems; typical vertical and horizontal loads on high-rise buildings, structural steel and reinforced concrete construction. Planning, system selection, modeling, analysis and design of high-rise buildings. The design process of a typical		

high-rise building project. Design procedures, codes of practice and computer software to design steel and concrete high-rise buildings .Sustainability features in modern high-rise buildings.		
Prerequisite	**Senior Standing**	
ARE 422	**Advanced Building Envelopes**	**(3-0-3)**
Concepts and practices of advanced building envelopes. Engineering materials used in the building envelope, mechanical, chemical and physical properties, and durability performance. Components of building envelopes, dynamic and interactive facades. Environmental-response and adaptive facades. "Glass walls" technologies, chromogenic, mechanical, thermal collecting and power producing, thermal storage and insulation, active coating. Innovative technologies for building skins, New and smart materials for intelligent building envelopes, architectural membranes, and phase change material. Eco-materials for a sustainable building skin. Integrating photovoltaics and solar thermal technologies into facades. Double skin and cavity facades. Kinetic skins, biomimicry and biomimetics. Intelligent sensing and control. High-tech lightweight building envelopes. Green walls and roofs.		
Prerequisite	**Senior Standing or Department's Approval**	
ARE 423	**Building Performance Evaluation**	**(3-0-3)**
Building performance, definition and aspects of evaluation. Feedback to building designers and operators. ASHRAE's Performance Measurement Protocols (PMP). Performance of measured energy, water, and indoor environmental quality: thermal comfort, indoor air quality (IAQ), visual comfort, and acoustical comfort. Acceptable levels of building service for the building occupants. Measure category and level: objectives of the measurement, metrics to be used, available instrumentation and spatial resolution and units of measure. Analysis procedures. Performance evaluation and benchmarks. Measurement and Verification (M&V) Protocol.		
Prerequisite	**Senior Standing or Department's Approval**	
ARE 424	**Indoor Air Quality and Ventilation**	**(3-0-3)**
Sources, properties, transport and fate, human exposure, and adverse responses to indoor air pollutants. Factors affecting the levels of air pollutants in the indoor environment. Indoor Air Quality (IAQ) control strategies and engineered technologies to mitigate impacts of gaseous and particulate phase of air pollutants indoors. The impact of equipment, floor coverings, furnishings, cleaning practices, and human activities on IAQ including carbon dioxide, VOCs, re-suspended dust, and airborne molds and fungi. Principles of ventilation in buildings. The influence of different ventilation strategies on IAQ in Buildings.		
Prerequisite	**ARE 322 or Department's Approval**	
ARE 425	**Architectural Acoustics**	**(3-0-3)**
Introduction to architectural acoustics, basic theory; sound behavior; sound quantities, units and measurements; noise sources; sound absorption, sound reflection, transmission; sound isolation methods, design and control techniques, room acoustics, quality indicators, principles of room design for good hearing and freedom from noise in buildings. Digital technologies in sound measurements, computer utilization in acoustical modeling and simulation. Emerging technologies and contemporary issues.		
Prerequisite	**Senior Standing or Department's Approval**	

ARE 426	**Room Acoustics**	**(3-0-3)**
Sound propagation in rooms and reverberation. Requirements for the acoustical design of space for speech, and/or music, (e.g. studios, auditorium and multipurpose halls). Acoustical indicators and techniques for evaluating room acoustics quality. Sound Reinforcement Systems (SRS), functions, basic components and types. Functional diagrams and loudspeaker systems. Microphone analysis and microphone types. Other sound sensors, transducers and devices. SRS layouts. Calculations for an efficient SRS in enclosures. Electronic background masking systems. Modeling and simulation of room acoustics.		
Prerequisite	**Senior Standing or Department's Approval**	
ARE 427	**Noise Control in Buildings**	**(3-0-3)**
Noise sources and their effect. Transmission of noise in buildings; air-borne and structure-borne noise. Sound isolation and sound insulating construction. Mechanical systems noise and vibration. Active and passive noise control techniques. Vibration control methods. Digital technology and computer utilization in noise control in buildings.		
Prerequisite	**Senior Standing or Department's Approval**	
ARE 428	**Design of Pluming and Fire Suppression Systems**	**(3-0-3)**
Plumbing systems components including water treatment, heating and pumping equipment, plumbing fixtures, plumbing piping, and installation materials. Design standards and plumbing codes and specifications. Fire suppression systems, components including standpipes and hose systems, gaseous fire suppression systems, wet sprinkler systems, pumping equipment, piping, and installation. Design standards using NFPA codes and specifications. The design of fire sprinkler system, layout and specifications using computer applications.		
Prerequisite	**ARE 322**	
ARE 429	**Safety and Security Systems in Buildings**	**(3-0-3)**
Building perimeter protection, attack alarm systems, alarm transfer systems (equipment fault and lift alarms), video surveillance (CCTV) monitoring systems, access control systems, fire detection and warning systems, sprinkler systems and smoke exhaust and control systems. Intrusion detection system. Data communication systems, emergency lighting and signage systems. Time tracking, UPS systems, PA and audio evacuation systems. Safety issues in the design of escape exits, safe design of staircases and horizontal circulations (pathways and corridors). Building Management Systems (BMS). Innovative technologies. Case Studies		
Prerequisite	**Senior Standing or Department's Approval**	
ARE 430	**Contracts and Specifications**	**(3-0-3)**
Contract documents, divisions of specifications, types of specifications, technical divisions options and alternatives, contracts, time and money, changes bonds liens, government contracts, general conditions, special conditions, proposal form, instruction to bidders, invitations to bid, checking, interpretation of specifications, and computerized specifications. Saudi standard public works contract.		
Prerequisite	**Senior Standing**	
ARE 465	**Construction Processes and Methods**	**(3-0-3)**

Current construction processes; construction material selection; construction methods, materials and equipment; current field practice and safety considerations; Planning and scheduling of construction operations; project cost estimation and control; project contracts and specifications; claims and dispute resolution.

Prerequisite	**Senior Standing**

ARE 432	**Construction Planning and Scheduling**	**(3-0-3)**

Planning, scheduling, and control of construction projects using: Critical Path Method (CPM), The precedence diagram method (PDM), Project Evaluation and Review Technique (PERT); and scheduling of repetitive projects (LOB), Resource leveling and allocation, Scheduling with limited resources; and Time-cost trade-off and Integrated project time and cost control (Earned value).

Prerequisite	**ARE 330**

ARE 433	**Building Cost Estimation**	**(3-0-3)**

The cost estimate, overhead and contingency, labor, equipment, excavation, concrete, masonry, metals, wood, thermal and moisture protection, doors and windows, finishes, electrical, plumbing, heating, ventilating and air-conditioning, profit.

Prerequisite	**ARE 330**

ARE 434	**Building Economy**	**(3-0-3)**

Life cycle costing, applications of economic evaluation methods and risk analysis techniques, selection of building designs and building components, decision to accept or reject a project, decisions on building location, lease or buy decisions, allocating limited budgets among competing projects, decisions on timing of equipment replacements, selecting combinations of interdependent systems.

Prerequisite	**ARE 331**

ARE 435	**Construction Safety**	**(3-0-3)**

Fundamentals of construction safety; causes of accidents; accident investigation; techniques of safety management; the safety policy; risk assessment, monitoring and control; the health and safety plan; training; safety meetings; construction hazards; construction health and safety law; the use of virtual / augmented reality, wearable sensors / IoT and virtual construction / BIM (Building Information Modeling) for construction safety; applications of machine learning and data analytics for construction safety.

Prerequisite	**Senior Standing**

ARE 436	**Fire Safety Management**	**(3-0-3)**

Fire safety objectives; fire inception and propagation in buildings; factors controlling fire severity; the role of fire protection engineers; fire detection and notification systems; fire suppression systems; means of egress and evacuation systems; smoke management and ventilation techniques; hazard and risk assessment procedures; fire stopping; fire proofing and fire retardant treatments; fire resisting elements separating buildings or compartments within buildings; fire hazards common in the workplace; post-fire activities in the workplace; fire

problems in high-rise buildings; IoT-based architecture for fire prevention; potentials of IoT technologies for fire prevention in smart buildings and cities: hazardous source monitoring and early fire warnings, on-site situational assessment, management of fire safety equipment; case studies.

Prerequisite **Senior Standing**

ARE 437 Decision Analysis and Modeling (3-0-3)

Introduction to decision analysis, the application of structured techniques for organizing and analyzing complex decisions to assist decision makers. Modeling and structuring decisions. The techniques and methods used in multi-criteria decision analysis including the *law of comparative judgment*, *pairwise comparison*, *decision trees*, *influence diagrams*, value of information, sensitivity analysis, and *Monte Carlo simulation*, the *Analytic Network Process* (ANP), *Analytic Hierarchy Process* (AHP), *Multi-Attribute Utility Theory* (MAUT), *Simple Multi-attribute Rating Technique* (SMART). Examples and case studies covering multi-criteria decision problems in architectural engineering with multiple non-conflicting and/or conflicting objectives. "Decision Support" calculators and software tools.

Prerequisite **Senior Standing**

ARE 438 Facilities Planning and Management (3-0-3)

Overview of facilities planning and management, facilities management (FM) skills and functions, operation and maintenance management, building performance, outsourcing FM services, space management and utilization, business continuity during facility renovations, facilities obsolescence and refurbishment, facilities quality management, asset management, human resource management, FM information systems, benchmarking performance, risk management, facilities resource efficiency.

Prerequisite **Senior Standing**

ARE 439 Introduction to Building Maintenance Management (3-0-3)

Introduction to basic concepts of building maintenance management. Classification of maintenance types, Work order types, Planning and scheduling of maintenance works using arrow notation, Maintenance contract documents and types, Maintenance Management Systems, Estimating maintenance manpower requirements, Computerized Maintenance Management Systems.

Prerequisite **ARE 230 or CE 204**

ARE 445 Artificial Lighting Systems Design (3-0-3)

Introduction to lighting systems. Lighting requirements under different working conditions. Detailed understanding of artificial lighting sources. Quantity and quality of light for various architectural spaces. Polar curves for various artificial lighting sources. Design of artificial lighting systems for avoiding glare. Lighting control techniques. Artificial lighting design of outdoor spaces. Computer applications.

Prerequisite **EE 312 or Department's Approval**

ARE 446 Daylighting Analysis and Design (3-0-3)

Introduction to daylighting. Sources of daylighting. Solar spectrum and its relationship to daylight availability. Weather phenomenon and daylighting. Concepts of cloudiness and design sky. Performance of building materials with respect to daylighting such as reflectivity and absorption. Detailed study of daylight transmission through openings with shading devices. Solar geometry and design of sun-shading devices. Design of openings in desert areas with respect to glare and overheating. Computer and lab methods for the study of daylight in buildings.

Prerequisite	**EE 312 or Department's Approval**

ARE 447	**Automation and Control of Building Systems**	**(3-0-3)**

Introduction to building automation systems, (BAS). BAS hardware, sensors and control devices. Surveillance systems, fire alarm systems, access control systems. Control of HVAC system. Control of electrical and lighting systems. Automation of building systems integration and the construction process. Energy management systems. Common BAS protocols. BAS upgrading and management. Post occupancy evaluation and emerging automation trends.

Prerequisite	**ARE 322 or Department's Approval**

ARE 460	**Green and Sustainable Buildings**	**(3-0-3)**

The concept of sustainability in the building sector. Green and sustainable buildings (GSBs), definitions, objectives, elements and characteristics of GSBs. Sustainability implications of the practice of engineering solutions in the built environment. Environmental, social and economic benefits of GSB. Occupant health, comfort, productivity, energy efficiency, pollution reduction. Active vs. passive design strategies. Sustainable and integrated building design (SIBD). Examples of GSBs practices. Green building materials and systems. GSBs local and international organizations, standards. Assessment, rating systems and certification of GSBs. Case studies. Introduction and preparation towards the LEED Green Associate (GA) Exam.

Prerequisite	**Senior Standing**

ARE 461	**Applications of AI in Smart Buildings**	**(3-0-3)**

The concept of smart buildings, definition and characteristics. Automation technologies, cognitive automation (CA), digital direct controls (DDC) and Artificial Intelligence (AI) - their capabilities, future potential, and application to smart building design, construction and operation. IoT and ML in smart space design, construction and operation. AI utilization in sustainable energy management; safety and security. Inter-building/space communication and collaboration. Occupant comfort, personalization and interactions. Obstacles to change and adoption of IoT and AI solutions. Best practices and strategies to bring IoT and AI into smart buildings. The impact of AI and ML on the future of buildings, communities and cities. Case studies, lessons learned, challenges, and future directions of research in the field.

Prerequisite	**COE 292**

ARE 463	**Sustainable Energy Solutions**	**(3-0-3)**

Fundamentals of sustainable and smart energy systems. Energy Efficiency (EE), definition, importance, and critical factors. Sustainable energy solutions for energy-efficient buildings. Energy auditing; testing, and measurements. Building management systems. Energy retrofitting. Maintenance and commissioning. Renewable energy sources. Solar and wind power solutions for buildings. Assessment of renewable energy systems. Smart meters. Hybrid energy systems. Energy performance and renewable energy modeling tools. Sustainable energy policies

Prerequisite	**Senior Standing**	
ARE 490	**Special Topics in Architectural Engineering**	**(3-0-3)**
Variable contents. State-of-the-art advanced topics in the field of Architectural Engineering		
Prerequisite	**Senior Standing**	
ARE 492	**Mosque Systems and Operation**	**(3-0-3)**
Introduction to mosque functional requirements and Indoor Environmental Quality (IEQ); mosque standards, and design Criteria; Heating , Ventilation and Air-Conditioning (HVAC) systems, requirements for intermittent operation, mosque zoning; Air quality and ventilation; Energy efficiency measures; Sound quality and acoustical guidelines; Safety issues; Mosque lighting systems, lighting control; Exterior and interior finishes and furniture; Ablution area; Operational strategies, Assessment of existing mosques.		
(NOT Credited for ARE Students)		
Prerequisite	**Senior Standing or Department's Approval**	
ARE 497	**Undergraduate Research**	**(1-6-3)**
Selection and development of a research topic in one of the curriculum areas of Architectural Engineering, namely Building Structures, Building Mechanical Systems, Building Electrical Systems, and Construction/Construction Management, developing a successful proposal, including research objectives and methodology, managing and carrying out research tasks, communicating the research findings via effective technical report.		
Prerequisite	**Department's Approval**	