هيئة تقويم التعليم والتدريب
Education & Training Evaluation Commission
اعتماد
NCAAA

Key Learning Outcomes for Electrical Engineering Program

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Introduction

Based on the mandate of the Education and Training Evaluation Commission (ETEC), by virtue of Council of Ministers decision No. 108, dated 14/2/1440 AH, which included the Commission competencies amongst which is "building systems for evaluation and accreditation - including institutional and programmatic - in education and training, encompassing rules, standards, frameworks and indicators and related terms, procedures, approval, and application" and with the same concern to build and develop high-quality national academic programs, the ETEC worked on preparing specialized academic standards for Electrical Engineering Programs. This document aims to contribute to the establishment of minimum requirements for Bachelor's programs in Electrical Engineering specialization to achieve the academic quality of programs and to ensure that graduates are highly qualified in the field of Electrical Engineering, possessing the knowledge, skills, and values required by the labor market, and national trends, in line with the best practices required for the academic and professional of the field.

Goals

The purpose of this work is to develop the minimum number of knowledge units (KUs) in the field of Electrical Engineering, specifying a set of Specialized Learning Outcomes (SLOs) that students are expected to acquire after completing their studies. This document lays the foundations for the design of the academic program and the study plans. It facilitates selecting the appropriate teaching methods and the proper evaluation strategies and tools, which should contribute toward aligning the academic programs with the labor market.

Methodology

This document describes minimum General and Specific Knowledge Units (GKUs & SKUs) in the Electrical Engineering field. The Learning Outcomes (LOs) of each Knowledge Unit (KU) set the threshold for what the students are expected to learn and be able to do after successfully completing that Knowledge Unit. Educational institutions should take into account the depth and breadth of these Knowledge Units so that learning outcomes integrate communication skills and values into the curriculum. Institutions can also offer additional knowledge units that are consistent with their objectives. It should also be noted that the knowledge unit is not necessarily an independent course; one or more courses can cover a single knowledge unit. Likewise, one course could also cover one or more knowledge units entirely or partially.

The methodology follows the following phases:

I- Survey and benchmarking:

- Benchmarking with International learned society and professional body.
- Benchmarks with top-rated international and local Universities.
- Identification of national labor market requirements.
- Incorporating specialists and experts' input from different sectoral groups.

II - Preparation of the contents of the Specialized Standards document:

- Identifying Program Key Learning Outcomes (KLOs).
- Defining the general characteristics of the curriculum.
- Development of General Knowledge Units (GKUs) and Specific Knowledge Units (SKUs) for each GKU.
- Formulation of Specialized Learning Outcomes (SLOs) for each Specific Knowledge Unit (SKU).
- Determine the minimum topics required for each Specific Knowledge Unit (SKU).
- Describe the methodology for aligning academic content with the National Qualification Framework (NQF).

The Knowledge Units (KUs) are derived from analyzing several high-ranked QS Universities and international regularity bodies/associations (see Appendix A).

The ETEC developed this document in cooperation and coordination with different entities in Electrical Engineering, such as the Saudi Council of Engineers, and with the involvement of different stakeholders from government bodies, the private sector, and academia.

Scope and Uses

This document covers the Bachelor's degree programs in Electrical Engineering. The document can be applied to Electrical Engineering programs offered by public and private higher education institutions in Saudi Arabia.

Terms

Education and Training Evaluation Commission (ETEC): competent and independent body aimed at evaluating, assessing, and accrediting qualifications in education and training in both public and private sectors, raising the quality and efficiency of those qualifications and ensuring they contribute to the national economy and development.

National Qualifications Framework (NQF): A comprehensive and uniform structure for building, organizing, and categorizing qualifications into levels based on learning outcomes.

Learning Outcomes (LOs): Description of what a learner is expected to know, understand, and be able to do, which is represented in his/her behavior at the end of a specific educational program.

Key Learning Outcomes (KLOs): The minimum required Learning Outcomes (LOs) in the discipline students are expected to obtain.

Knowledge Units (KUs): mandatory multiple related topics that must be included in an institution's degree program.

Essential Knowledge Units (EKUs): knowledge units necessary for future learning in a given discipline.

General Knowledge Units (GKUs): Knowledge Units that should be introduced to students majoring in a discipline.

Specific Knowledge Units (SKUs): Knowledge Units derived from a General Knowledge Unit (GKU).

Specific Learning Outcomes (SLOs): Learning Outcomes (LOs) for a Specific Knowledge Unit (SKUs).

Key Learning Outcomes

ETEC published in 2020 the Key Learning Outcomes for Engineering Programs (KLOs). These KLOs for Engineering apply to all engineering disciplines and do not target any specific discipline in engineering alone. KLOs for Engineering are defined so that by successfully completing the engineering program, Engineering Graduates will be able to:

KLO 1: Identify, formulate, solve complex engineering problems using principles of engineering sciences, mathematics, and natural sciences, and to validate the obtained solution.

KLO2: Design solutions for complex engineering problems that meet specified needs with consideration for public health, safety, welfare, and environmental, sustainability, and economic factors, as well as other realistic constraints related to the design solution, while complying with relevant standards and design codes.

KLO3: Conduct investigations of complex engineering problems through developing and executing relevant experiments, and analyzing and interpreting data, supported by engineering judgment to achieve valid conclusions.

KLO4: Create, select, adapt and apply appropriate techniques, resources and modern engineering and IT tools to solve complex engineering problems with understanding of the limitations.

KLO5: Identify and evaluate the issues and constraints of sustainability, economy, environment, politics, health and safety, and society that are relevant to professional solving of complex engineering problems.

KLO6: Recognize ethical and professional responsibilities in engineering situations, and commit to the professional ethics and norms of engineering practice to make informed judgments.

KLO7: Apply modern project management techniques, economic and decision-making techniques, and to work effectively as a member or leader in teams, preferably in a multidisciplinary setting.

KLO8: Communicate effectively on engineering activities with a range of audiences.

KLO9: Engage in life-long learning for acquiring and implementing knowledge, as needed, using suitable learning strategies.

Alignment of the Key Learning Outcomes for Engineering with the NQF

Engineering Learning Outcomes	NQF Learning Areas		
	Knowledge and Understanding	Skills	Values, Autonomy, and Responsibility
1	✓	✓	
2	✓	✓	
3	✓	✓	
4		✓	
5	✓	✓	
6			✓
7		✓	✓
8		✓	
9			✓

Curriculum General Criteria

Based on the benchmarking study of national and international benchmarking and the leading universities (see Appendix A) and analyzing all knowledge units (KUs) and skills for different Electrical Engineering programs, the curriculum should consist of the following:

1. Essential Knowledge Units (EKU), which includes mathematics and basic sciences:
    a. Math: (Calculus (differential, integral, multivariate), Linear algebra, Differential equations, Probability & statistics,.)
    b. Physics: (Mechanics, Electricity & Magnetism, Thermodynamics, Optics, Acoustics).
2. General Knowledge Units (GKU): Mandatory Electrical Engineering Knowledge.
3. Specific Knowledge Units (SKU): Mandatory Electrical Engineering Knowledge derived from GKUs.
4. Experiential Learning
    a. Minimum 3 semester credit hours (or equivalent) of culminating major engineering design experience.
    b. Field training experience of a minimum duration of eight weeks.

Knowledge Units

The following table provides an overall view of the curriculum distribution of general and specific knowledge in the Electrical Engineering major. The table also provides general recommendations on the acceptable range of topic distribution for each knowledge unit, whether general or specific knowledge units.

Knowledge Unites Description and Weighting Distributions

GKU	GKU Description	Wt (%)	SKU	Relative Wt(%)
GKU1 Electrical circuits	Foundations of circuit theory, including basic laws of circuits, circuit analysis, theorems, sinusoids, and phasors	25	SKU1.1 Basic Circuits Laws	50
			SKU1.2 Advanced Circuits Analysis	50
GKU2 Electronics	Foundations of electronics, including Solid-state fundamentals, Discrete devices, including diodes, transistors, BJT, and CMOS, and Integrated Circuits such as operational amplifiers and some of their applications (active filters)	25	SKU2.1 Fundamentals of Electronics	50
			SKU2.2 Integrated Circuits	50
GKU3 Electromagnetics	Foundations of electromagnetics, including electrostatics, magneto-statics, fields, waves, and applications like transmission lines, waveguides, and antennas	15	SKU3.1 Electromagnetics	100
GKU4 Signal and systems	Foundations of Fourier series and transforms.	20	SKU4.1 Signal Transformations	50
			SKU4.2 Linear-time Invariant Systems	50
GKU5 Digital systems	Foundations of Digital logic circuits and design, including number systems, Boolean logic, logic gates and circuits, analysis and design of combinational logic, sequential circuits including state machines, and Programmable logic devices and gate arrays	15	SKU5.1 Digital Systems	100

Appendix A: Benchmarking Analysis

The KUs are derived from the following sources:

1. ABET
   a. ABET is a nonprofit, non-governmental agency accrediting applied and natural science, computing, engineering, and engineering technology programs.
   b. ABET published criteria for accrediting engineering programs.
2. Saudi Council of Engineers (SCE)
   a. SCE sets standards for practicing and developing the engineering profession in Saudi Arabia, including licensure terms and conditions, and prescribes necessary rules, regulations, and examinations for obtaining professional degrees.
3. Education and Training Evaluation Commission (ETEC):
   a. ETEC is the authority in charge of the evaluation, assessment, and accreditation of qualifications in the field of education and training in the public and private sectors in Saudi Arabia.
   b. ETEC published learning outcomes for engineering and learning outcomes assessment in higher education for various disciplines, including engineering.
4. The National Council of Examiners for Engineering and Surveying (NCEES):
   a. NCEES is a nonprofit organization dedicated to advancing professional licensure for engineers and surveyors.
   b. NCEES published the Engineering Education Standard.
5. Best Practices in Top Universities

#	University	Program	Link	QS ranking
1	National University of Singapore	Electrical Engineering	Link	11
2	University of Toronto	Electrical & Computer Engineering	Link	34
3	Cornell University	Electrical & Computer Engineering	Link	20
4	University of California, Los Angeles	Electrical Engineering	Link	44
5	California Institute of Technology	Electrical Engineering	Link	6
6	Yale University	Bachelor of Electrical Engineering and Computer Science	Link	18
7	Imperial College London	Department of Electrical and Electronic Engineering	Link	6
8	Swiss Federal Institute of Technology Zurich	Information Technology and Electrical Engineering	Link	9
9	King Fahd University of Petroleum & Minerals	Electrical Engineering	Link	160
10	University College London	Electronic and Electrical Engineering	Link	8

(*) Private University

Required Courses in Top Universities in 2022

#	Topic Group	Topics	count	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10
Topic #1	Mathematics	A. Algebra and trigonometry	8	C	√	C	√	√	√	√	√	√	√
		B. Complex numbers	9	√	√		√	√	√	√	√	√	√
		C. Discrete mathematics	3								√	√	√
		D. Analytic geometry	7		√	√		√	√		√	√	√
		E. Calculus (e.g., differential, integral, single-variable, multivariable)	10	√	√	√	√	√	√	√	√	√	√
		F. Ordinary differential equations	10	√	√	√	√	√	√	√	√	√	√
		G. Linear algebra	10	√	√	√	√	√	√	√	√	√	√
		H. Vector analysis	8	√	√			√	√	√	√	√	√
Topic #2	Probability & Statistics	A. Probability distributions	9	√		√	√	√	√	√	√	√	√
		B. Measures of central tendencies and dispersion	9	√		√	√	√	√	√	√	√	√
		C. Expected value	9	√		√	√	√	√	√	√	√	√
Topic #3	Ethics and Professional Practice	A. Codes of ethics	1	√									
		B. Public health, safety, and welfare	1	√									
		C. Intellectual property	0										
Topic #4	Engineering Economics	A. Time value of money	1									√	
		B. Cost types and breakdowns	1									√	
		C. Economic analyses	1									√	
		D. Analysis (e.g., cost-benefit, trade-off, break-even)	0										
Topic #5	Properties of Electrical Materials	A. Semiconductor materials	2				√				√		
		B. Electrical	2				√				√		
		C. Thermal	1								√		
Topic #6	Circuit Analysis	A. KCL, KVL	9		√	√	√	√	√	√	√	√	√
		B. Series/parallel equivalent circuit	8		√	√	√	√	√		√	√	√
		C. Thevenin and Norton theorems	8		√	√	√	√	√		√	√	√
		D. Node and loop analysis	8		√	√	√	√	√		√	√	√
		E. Waveform analysis	9		√	√	√	√	√	√	√	√	√
		F. Phasors	9		√	√	√	√	√	√	√	√	√
		G. Impedance	9		√	√	√	√	√	√	√	√	√
Topic #7	Linear Systems	A. Frequency/transient response	9	√	√		√	√	√	√	√	√	√
		B. Resonance	5				√	√	√			√	√
		C. Laplace transforms	10	√	√	√	√	√	√	√	√	√	√
		D. Transfer functions	8	√			√	√	√	√	√	√	√
Topic #8	Signal Processing	A. Sampling (e.g., aliasing, Nyquist theorem)	9	√	√	√		√	√	√	√	√	√
		B. Analog filter	7	√	√				√	√	√	√	√
		C. Digital filters (e.g., difference equations, Z-transforms)	7	√	√		√	√			√	√	√
Topic #9	Electronics	A. Models, biasing, and performance of discrete devices (e.g., diodes, transistors, thyristors)	9	√	√	√		√	√	√	√	√	√
		B. Amplifiers (e.g., single-stage/common emitter, differential, biasing)	9	√	√	√		√	√	√	√	√	√
		C. Operational amplifiers (e.g., ideal, nonideal)	9	√	√	√		√	√	√	√	√	√
		D. Instrumentation (e.g., measurements, data acquisition, transducers	0										
		E. Power electronics (e.g., rectifiers, inverters, converters)	2							√			√
Topic #10	Power Systems	A. Power theory (e.g., power factor, single and three phase, voltage regulation)	2							√		√	
		B. Transmission and distribution (e.g., real and reactive losses, efficiency, voltage drop, delta and wye connections)	3	√						√		√	
		C. Transformers (e.g., single-phase and three-phase connections, reflected impedance)	3				√			√		√	
		D. Motors and generators (e.g., synchronous, induction, dc)	2							√		√	

Topic #11	Electromagnetics	A. Electrostatics/magnetostatics (e.g., spatial relationships, vector analysis)	9	√	√	√	√	√	√	√		√	√
		B. Electrodynamics (e.g., Maxwell equations, wave propagation)	9	√	√	√	√	√	√	√		√	√
		C. Transmission lines (high frequency)	7	√		√		√	√	√		√	√
Topic #12	Control Systems	A. Block diagrams (e.g., feedforward, feedback)	4					√		√		√	√
		B. Bode plots	4	√				√				√	√
		C. Closed-loop response, open-loop response, and stability	4	C	C	C	C	√	C	√	C	√	√
		D. Controller performance (e.g., steady-state errors, settling time, overshoot)	4	C	C	C	C	√	C	√	C	√	√
Topic #13	Communications	A. Basic modulation/demodulation concepts (e.g., AM, FM, PCM)	5	√	C	C	C	C	√	√	C	√	√
		B. Fourier transforms/Fourier series	9	C	√	√	√	√	√	√	√	√	√
		C. Multiplexing (e.g., time division, frequency division, code division)	2	√	√	√	√	√	√	√	C	C	√
		D. Digital communications	3	C	C	C	C	C	C	√	C	√	√
Topic #14	Computer Networks	A. Routing and switching	1	C	C	C	C	C	√	C	C	C	C
		B. Network topologies (e.g., mesh, ring, star)	1	C	C	C	C	C	√	C	C	C	C
		C. Network types (e.g., LAN, WAN, internet)	1	C	C	C	C	C	√	C	C	C	C
		D. Network models (e.g., OSI, TCP/IP)	0	C	C	C	C	C	C	C	C	C	C
		E. Network intrusion detection and prevention (e.g., firewalls, endpoint detection, network detection)	0	C	C	C	C	C	C	C	C	C	C
		F. Security (e.g., port scanning, network vulnerability testing, web vulnerability testing, penetration testing, security triad)	0	C	C	C	C	C	C	C	C	C	C
Topic #15	Digital Systems	A. Number systems	8	C	√	√	C	√	√	√	√	√	√
		B. Boolean logic	8	C	√	√	C	√	√	√	√	√	√
		C. Logic gates and circuits	8	C	√	√	C	√	√	√	√	√	√
		D. Logic minimization (e.g., SOP, POS, Karnaugh maps)	8	C	√	√	C	√	√	√	√	√	√
		E. Flip-flops and counters	8	C	√	√	C	√	√	√	√	√	√
		F. Programmable logic devices and gate arrays	7	C	√	√	C	√	√	√	√	√	C
		G. State machine design	7	C	√	√	C	√	√	√	√	√	√
		H. Timing (e.g., diagrams, asynchronous inputs, race conditions, and other hazards)	1	C	C	C	C	C	√	C	C	C	C
Topic #16	Computer Systems	A. Microprocessors	5	C	√	C	C	C	C	√	√	√	√
		B. Memory technology and systems	5	C	√	C	C	C	C	√	√	√	√
		C. Interfacing	2	C	√	C	C	C	C	C	C	√	C
Topic #17	Software Engineering	A. Algorithms (e.g., sorting, searching, complexity, big-O)	1	C	C	C	C	C	C	C	C	C	√
		B. Data structures (e.g., lists, trees, vectors, structures, arrays)	1	C	C	C	C	C	C	C	C	√	C
		C. Software implementation (e.g., iteration, conditionals, recursion, control flow, scripting, testing)	0	C	C	C	C	C	C	C	C	C	C

Appendix B: Learning Outcomes and Topics for Knowledge Units

GKU 1 Electrical circuits

SKU 1.1: Basic Circuits Laws

Description	This SKU discusses various network reduction techniques, including resistive, inductive, and capacitive networks. It also introduces basic electric circuit analysis and the fundamentals and principles of DC and AC circuits.
Topics	The following topics must be included in this SKU: 1. Equivalent circuits and basic laws 2. Basic Circuit laws
Learning Outcome	By completing this SKU, students should be able to: SLO1.1.1: Apply mathematics, science, and engineering to the analysis and design of electrical circuits. SLO1.1.2: Apply basic knowledge of network reduction techniques-resistive networks, inductive networks, and capacitive networks- series, parallel, series-parallel combinations, star–to-delta, and delta-to-star transformation to the analysis and design of electric circuits. SLO1.1.3: Apply Ohm's law, voltage divider, and current divider rules to a series-parallel circuit. SLO1.1.4: Apply Kirchhoff's Laws (voltage and current) for circuit analysis

SKU 1.2: Advanced Circuits Analysis

Description	This SKU introduces advanced circuit analysis and theorems, including voltage divider rule, power, superposition, network theorems, Thevenin's and Norton's Theorems, and introduction to AC, capacitors, and inductors.
Topics	The following topics must be included in this SKU: 1. Circuit Analysis and Theorems 2. Sinusoids and Phasors
Learning Outcome	By completing this SKU, students should be able to: SLO1.2.1: Apply Thevenin and Norton theorems for circuit simplification SLO1.2.2: Analyze electric circuits using Mesh, Nodal, and superposition methods. SLO1.2.3: Determine node voltages and branch currents by applying the node and loop analysis SLO1.2.4: Identify the RMS, average, frequency, phase, and wavelength from the waveforms of the current and voltage in the time domain. SLO1.2.5: Analyze AC circuits using phasor analysis methods, including start-delta and delta-star transformation SLO1.2.6: Solve balanced three-phase circuits SLO1.2.7: Calculate AC power and power factor correction

GKU 2 Electronics

SKU 2.1: Fundamental Electronics

Description	The foundations of this SKU introduce the fundaments of Solid-state and integrated circuits. The focus of this KU will include discrete devices, e.g., diodes, transistors, BJT, and CMOS.
Topics	The following topics must be included in this SKU: 1. Solid-state fundamentals 2. Discrete devices, including diodes, transistors, BJT, and CMOS
Learning Outcome	By completing this SKU, students should be able to: SLO2.1.1: Define the main components of semiconductors and electronic devices. SLO2.1.2: Model and apply basic solid-state fundamentals, including diffusion/drift current, energy bands, doping bands, and p-n theory SLO2.1.3: Analyze components and formulate relationships of discrete devices, including diodes, transistors, BJT, and CMOS

SKU 2.2: Integrated Circuits

Description	The foundations of this SKU introduce the basic principles of amplifiers for different configurations, frequency response, and multistage amplifiers.
Topics	The following topics must be included in this SKU: 1. Design of operational amplifiers 2. Application of operational amplifiers
Learning Outcome	By completing this SKU, students should be able to: SLO2.2.1: Apply design concepts to optimize the performance of operational amplifiers SLO2.2.2: Calculate parameters and recognize the differences between different amplifiers (gains and frequency response, etc.…) SLO2.2.3: Design optimal performance active filters SLO2.2.4: Evaluate applications of Op-Amp SLO2.2.5: Explain the concept of analog-to-digital converters (ADC) and digital-to-analog converters (DAC)

GKU 3 Electromagnetics

SKU 3.1: Electromagnetics

Description	Foundations of electromagnetics, including electrostatics, magneto-statics, fields, waves, and applications like transmission lines, waveguides, and antennas
Topics	The following topics must be included in this SKU: 1. Electrostatics and magnetostatics 2. Electrodynamics 3. High-frequency transmission lines
Learning Outcome	By completing this SKU, students should be able to: SLO3.1.1: Apply electrostatics laws and theorems, including Coulomb's law, Gauss' law, electric field boundary conditions, and electrostatic potential, in basic electric field and potential calculations. SLO3.1.2: Explain magnetostatics, including magnetic forces and torques, BiotSavart's and Ampere's laws, magnetic field boundary conditions, and vector magnetic potential, in basic magnetic field and potential calculations. SLO3.1.3: Apply EM wave propagation laws and theorems, including Faraday's Law, Displacement current, and Maxwell's Equations, in the analysis of EM wave propagation in various medium SLO3.1.4: Analyze high-frequency transmission lines SLO3.1.5: Design high-frequency transmission lines

GKU 4 Signal and systems

SKU 4.1: Signal Transformations

Description	Foundations of Fourier series and transforms.
Topics	The following topics must be included in this SKU: 1. Fourier Series 2. Fourier transforms 3. Sampling theorem
Learning Outcome	By completing this SKU, students should be able to: SLO4.1.1: Perform Fourier Series Analysis on periodic signals SLO4.1.2: Apply Fourier transform in the analysis of signals SLO4.1.3: Apply Z-transforms and difference equations in the analysis of discrete-time systems SLO4.1.4: Apply sampling theorems on continuous-time signals and identify the conditions needed for perfect reconstruction

SKU 4.2: Linear-time Invariant Systems

Description	Foundations of systems considering both continuous-time and discrete-time forms.
Topics	The following topics must be included in this SKU: 1. Analog and digital LTI systems 2. Analog and digital filters
Learning Outcome	By completing this SKU, students should be able to: SLO4.2.1: Analyze LTI systems using the acquired knowledge about frequency response, transient response, transfer functions, Fourier transform and Laplace transform SLO4.2.2: Explain the properties of LTI systems SLO4.2.3: Analyze continuous-time signals and LTI systems for designing analog filters SLO4.2.4: Analyze discrete-time signals and LTI systems for designing digital filters

GKU 5 Digital systems

SKU 5.1: Digital Systems

Description	Foundations of Digital logic circuits and design, including number systems, Boolean logic, logic gates and circuits, analysis and design of combinational logic, sequential circuits including state machines, and Programmable logic devices and gate arrays
Topics	The following topics must be included in this SKU: 1. Number Systems, Boolean Logic, and logic gates 2. Digital Combinational circuits analysis and design 3. Sequential logic circuits analysis and design 4. Programmable logic devices and gate arrays
Learning Outcome	By completing this SKU, students should be able to: SLO5.1.1: Perform arithmetic operations in various number systems. SLO5.1.2: Apply Boolean algebra to perform simplifications and algebraic manipulations of Boolean expressions. SLO5.1.3: Simplify functions using the K-map method SLO5.1.4: Design efficient combinational circuits utilizing basic functional blocks such as multiplexors, encoders, decoders, adders, and comparators. SLO5.1.5: Design registers and counters for applications using the Flip-flops SLO5.1.6: Analyze and design efficient sequential circuits using state machine models SLO5.1.7: Analyze and design Digital circuits using programmable logic devices

Appendix C: Guidelines for Key Learning Outcomes for Engineering Programs.

Guidelines for Key Learning Outcomes for Engineering Programs.

No.	Engineering Learning Outcome	Guidelines
KLO1	Identify, formulate, and solve complex engineering problems using principles of engineering sciences, mathematics, and natural sciences, and validate the obtained solution	To identify the problem, the student shall investigate the situation to determine the root cause of the problem, not the perceived problem or the problem's symptoms. If there is more than one cause of the problem, the student must include all of them in the problem statement or definition. To formulate the problem, the student shall collect all relevant information or data. If there is any missing data, then the student shall refer to the national and international standards, or the best practices used in similar applications, to assume the missing data. The student then shall formulate the problem mainly by applying the knowledge of mathematics, natural sciences, statistics, engineering fundamentals, and engineering specialized knowledge. To solve complex engineering problems, the student shall plan a strategy for the solution starting with the end in mind; the desired objectives. The student then shall validate the correctness of the solution by: - Alignment with the national, or international, standard range of the parameters' values - If no standard ranges of the values are available, then the solution is checked versus the best practices of a similar application - Results shall always be examined by intuition and engineering sense as well

No.	Engineering Learning Outcome	Guidelines
KLO2	Design solutions for complex engineering problems that meet specified needs with consideration for public health, safety, welfare, and environmental, sustainability, and economic factors, as well as other realistic constraints related to the design solution, while complying with relevant standards and design codes	The student shall apply the design process to develop the solution (e.g., part, system, or process) that meets the client's specified needs. Public health, safety, welfare, environmental, sustainability, and economic factors should be given the top priority in the design. Other realistic constraints related to the design may include but are not limited to global, cultural, societal, reliability, and ethical factors. To identify the needs that must be met, the student shall perform a need analysis and then convert the identified needs into well-defined specifications, and design parameters that may be minimized or maximized. The same is to be done for all the applicable realistic constraints. The student then shall apply the design process; - Identify the client's needs and applicable realistic constraints mentioned above - Develop a selection criteria based on the specifications and design parameters identified above - Develop alternative conceptual designs such that each alternative satisfies the minimum requirements of the selection criteria - Use a decision analysis technique to select the best design alternative based on the merits and drawbacks of all alternatives - Carry out a detailed design of the selected best alternative - Perform iterative analysis, by minimizing or maximizing the design parameters, to achieve potential improvements. The Quality Function Deployment (QFD) method, or any other optimization methods, may be used. Modern engineering software would help students to come up with optimized designs based on international standards in less time, however, the limitations of the software should be well considered - Communicate the design using technical drawings standards. The design should comply with the national standards and design codes. If the national standards and design codes are not available, then the design should comply with the international standards and design codes, or best practices in similar applications.

No.	Engineering Learning Outcome	Guidelines
KLO3	Conduct investigations of complex engineering problems through developing and executing relevant experiments, and analyzing and interpreting data, supported by engineering judgment to achieve valid conclusions	If the experiment to be conducted follows national, or international, standards, then the students shall perform literature review on the related standards and identify the following items of the experiment: - Objectives of the experiment - Variables/parameters to be measured before, during, and after the experiment, along with their range and required accuracy. - Setup needed for the experiment - Test procedure - Results interpretation, restrictions, or indicators (if east). If the experiment does not follow any standards, the student shall identify the items above based on the best practice. To analyze the data, the student shall identify the formulae relating the variables to each other. The data must be prepared in well-defined tables/charts to facilitate the analysis and interpretation of the data to develop useful information and decisions. The student then shall compare the experimental results with the national/international standards' corresponding values. The percentage error/difference of the results compared to the standards values are to be calculated. Finally, the student shall write valid conclusions of the experimental results with clear recommendations for using the test results or ignoring them. This would mainly depend on the mistakes that occurred while preparing the sample, setting up the experiment, conducting the experiment, or the error percentage compared to the standards values.

KLO4	Create, select, adapt and apply appropriate techniques, resources and modern engineering and IT tools to solve complex engineering problems with understanding of the limitations	The student shall use relevant professional techniques, resources and modern engineering and IT tools to a range of engineering activities. However, the limitations of these modern tools and resources should be well considered. Common engineering practices where the student may apply, and not limited to, these resources: - Modeling and analysis of complex engineering problems using professional engineering modeling and simulation software - Design solutions of complex engineering problems using professional engineering software with embedded international standards and design codes - Experimentation solutions of complex engineering problems using modern measurement and testing tools - Oral or written communication using modern Information and Communications Data Technology (ICDT) tools - Management of projects using traditional or agile techniques through the use of desktop applications or web-based applications known as Software as a Service (SaaS) - Internet browsing to search for new knowledge and to learn new skills to be engaged in life-long learning
KLO5	Identify and evaluate the issues and constraints of sustainability, economy, environment, politics, health and safety, and society that are relevant to professional solving of complex engineering problems.	In the course of solving complex engineering problems, the student shall identify the relevant issues and constraints of economy, environment, politics, health and safety, and society. The student then shall analyze and accordingly evaluate these issues with solid reasoning. As a result of these constraints' evaluation, the student shall make his/her judgment based on professional engineering practice. In particular, the student shall apply professional engineering values to promote the environment and the related Sustainable Development Goals (SDGs) to transform our world.

KLO6	Recognize ethical and professional responsibilities in engineering situations, and commit to the professional ethics and norms of engineering practice to make informed judgments	The student shall demonstrate the awareness of relevant national values, legal obligations governing engineering activities, including welfare, health & safety, contracts, intellectual property rights, and liability issues. The student shall make his/her judgment based on the professional ethics and norms of engineering practice.
KLO7	Apply modern project management techniques, economic and decision-making techniques, and to work effectively as a member or leader in teams, preferably in a multidisciplinary setting	Student application of project management techniques involves practicing various project management components, e.g., planning, scheduling, budgeting, allocation of resources, and risk assessment. The student shall apply engineering economy principles to facilitate the decision-making in various projects. The student shall effectively work as a team member or a leader in a team with full awareness of his/her roles and responsibilities with consideration given to the diverse nature of the team specialties within the engineering discipline or across the engineering disciplines. The student shall constructively contribute to the project delivery by completing individual and common activities in a collaborative, honest, and trustful environment.

KLO8	Communicate effectively on engineering activities with a range of audiences	Audiences may include faculty, students, clients, technical, and non-technical public sector. The student shall communicate fluently orally and in writing, both in native and English languages. The student shall write effective reports and design documentation, make effective presentations, and give and receive clear instructions. In the reports, design documentation, and other written communication, the student shall present the ideas in an organized manner, in a suitable style to the audience with minimal errors (e.g., spelling, grammar,). Only added-value visual aids shall be used (e.g., tables, figures, videos, posters, etc.) In presentations and other oral communication, the student shall address the audience interest in an organized manner within the time limitations. The student shall communicate in correct language, use effective body language, and shall listen carefully to the audience's questions and respond to them properly. The student shall use and cite only credible references, both in written and oral communication.
KLO9	Engage in life-long learning for acquiring and implementing knowledge, as needed, using suitable learning strategies	Lifelong learning ensures that the students gain the required skills of employing self-learning in future life settings, e.g., new developments in engineering tools, materials, systems, as well as new versions of software, design codes, and standards. The student shall be an independent learner in choosing suitable learning strategies, among which is searching credible sources, for finding, acquiring, and effectively utilizing the required information.

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