



Guideline Handbook

Bachelor of Science in Instrumentation and Control

College of Engineering - University of Bahrain

2025

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Bachelor of Science in Instrumentation and Control Engineering

1. Program Description:

The Bachelor of Science in Instrumentation and Control Engineering provides students with a strong foundation in instrumentation, automation, measurement systems, and process control engineering. The program meets growing industrial demand for engineers who can design, operate, maintain, and improve modern automated systems used in sectors such as oil and gas, petrochemicals, manufacturing, power generation, water treatment, and smart industries. The qualification has been offered since the academic year 2022-2023 by the Department of Chemical Engineering.

The program emphasizes both theoretical knowledge and practical engineering skills through a combination of mathematics and basic sciences, engineering sciences, laboratory experience, industrial training, engineering design projects, and senior project work. Students develop competencies in sensors and transducers, measurement systems, analytical instrumentation, process modeling and simulation, digital control systems, programmable logic controllers (PLC), distributed control systems (DCS), supervisory control and data acquisition (SCADA), microprocessors, and modern automation technologies. Extensive use of industry-standard software and computational tools, including MATLAB, SIMULINK, LabVIEW, Python, PLC programming platforms, and industrial automation systems, enables students to solve real engineering problems and gain hands-on experience.

Through laboratory work, industrial training, teamwork activities, and open-ended design projects, the program systematically develops critical thinking, problem-solving, communication, leadership, data analysis, and lifelong learning skills. Students learn to apply engineering standards, safety practices, and professional ethics while working within realistic **economic, environmental, operational, and technical constraints**.

Graduates are well prepared for careers in industrial automation, instrumentation engineering, process control engineering, maintenance and reliability engineering, control system design, and industrial digitalization. They are also equipped to pursue postgraduate studies and professional certifications in instrumentation, control, automation, artificial intelligence, advanced process control, and related engineering disciplines. The program consists of 44 courses totaling 139 University of Bahrain credit hours, equivalent to 600 NQF credits, and is normally completed over four years (eight semesters) of full-time study.

2. Program Educational Objectives (PEOs):

The program seeks to achieve the following objectives:

1. Engage in productive careers in a broad range of instrumentation and control engineering profession in both the public and private sectors;

2. Engage in ongoing professional development activities by pursuing graduate studies and /or other learning opportunities;
3. Advance in responsibility and leadership in their careers.

3. Program Intended Learning Outcomes (PILOS):

Upon graduation, graduates of the Bachelor of Science in Instrumentation and Control Engineering will be able to:

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.

4. Admission Requirements:

The target learners of the program are applicants who meet the general admission requirements of the University of Bahrain as stated in the Study and Examinations Regulation.

5. Graduation Requirements:

To graduate, students must:

1. Successfully complete all courses in the study plan, totaling 139 credit hours, within the maximum period specified in the University regulations.
2. Achieve a minimum cumulative GPA of 2 out of 4.

3. Achieve a minimum cumulative Major GPA of 2 out of 4.
4. Complete all program-specific requirements, including [graduation project / internship / comprehensive exam].
5. Fulfil all other requirements stipulated in the University of Bahrain Study and Examinations Regulation.

5.1. Exit Degrees:

(Keep the applicable degrees for the qualification)

In accordance with the University of Bahrain regulations, the program includes the following exit degrees:

1. Diploma in Instrumentation and Control Engineering:
 - Minimum required credit hours: 60 credits
 - Minimum cumulative GPA: None
 - Notes (if any):
2. Associate Degree in Instrumentation and Control Engineering:
 - Minimum required credit hours: 94 credits
 - Minimum cumulative GPA: None
 - Notes (if any): None

6. Program Duration

The normal duration of the program is 4 years (8 semesters).

Students are expected to complete the program within this period, with the possibility of extension in accordance with the University of Bahrain Study and Examinations Regulation.

7. Language of Instruction

The language of instruction for the Instrumentation and Control Engineering (ICENG) is English.

8. Career Opportunities and Graduate Destinations

Those graduating with Instrumentation and Control Engineering (ICENG) degree can pursue careers such as:

- *Instrumentation and control engineering in process industries*
- *Instrumentation and control engineering in oil & gas sector*
- *Instrumentation and control engineering in energy sector*
- *Instrumentation and control engineering in manufacturing industries*
- *Maintenance Engineer.*
- *Consulting and Project Management Engineer.*
- *Sales and Technical Support Engineer.*
- *Research and Development (R&D) Engineer.*
- Academic and Trainer in instrumentation and control engineering

9. Attendance and Learning Mode

The program follows a full-time attendance system.

The primary mode of teaching and learning is **Traditional Education** delivery, supported by e-learning tools and digital platforms to enhance the learning experience.

10. Study Methodology

The programme adopts a student-centred, outcomes-based approach to teaching, learning, and assessment. Learning activities are selected according to the nature and level of each course and are aligned with the course intended learning outcomes and the competencies expected of instrumentation and control engineering graduates.

The programme is delivered through lectures, tutorials, laboratory sessions, computer-based exercises, design activities, individual and group projects, case studies, problem-based learning, independent study, and supervised industrial training. These methods integrate scientific and mathematical foundations with practical work in measurement, instrumentation, automation, process dynamics, control, communication networks, programmable logic controllers, digital control, SCADA, and distributed control systems.

Practical and technology-enhanced learning is embedded throughout the curriculum. Students use relevant engineering software, simulation environments, programming tools, laboratory instruments, data-acquisition systems, PLC platforms, and industrial control technologies to model, analyse, design, implement, test, and evaluate instrumentation and control solutions.

Learning progresses from foundational science, mathematics, computing, circuits, and signals to increasingly complex measurement and control applications. In the advanced stages, students integrate knowledge and skills through industrial training, instrumentation and control design, major electives, and the two-stage senior project.

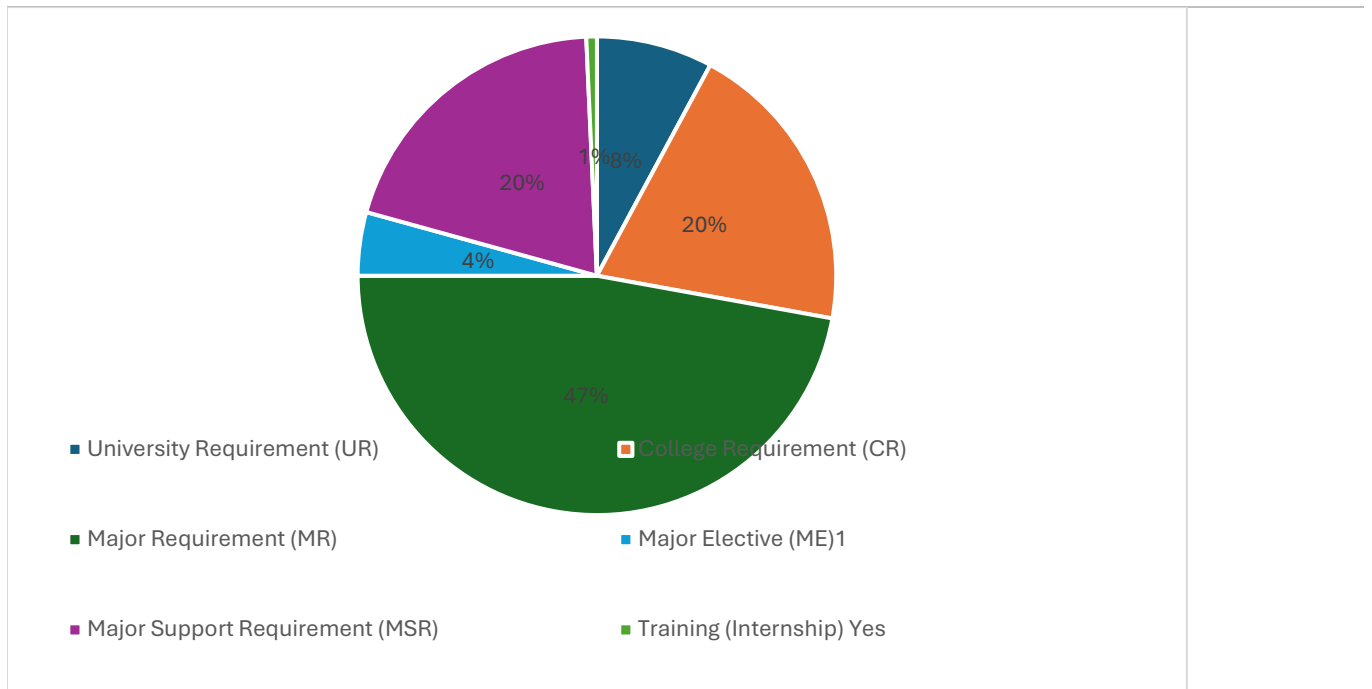
Students are assessed through appropriate combinations of examinations, quizzes, assignments, laboratory work and reports, programming and simulation exercises, design tasks, projects, presentations, industrial-training evaluation, and other approved methods. Assessment tasks are aligned with the intended learning outcomes and become progressively more complex across the programme.

Teaching, learning, and assessment practices are reviewed periodically using course reports, attainment results, student feedback, external and industrial input, and programme quality-assurance processes to support continuous improvement.

11. Academic Probation and Dismissal

1. A student is placed on academic probation when the cumulative grade point average falls below 2.00 at the end of a semester, in accordance with the University of Bahrain Study and Examinations Regulations. The student is notified of the academic status and is expected to work with the academic adviser to improve performance and select an appropriate study load.
2. If the student does not raise the cumulative GPA to at least 2.00 by the end of the following regular semester, a second academic probation is issued.
3. A student may be permanently dismissed from the University in the following cases:
4. Failure to raise the cumulative GPA to the required minimum after receiving a second academic probation.
5. Exceeding the maximum study period of 14 semesters for completion of the bachelor's degree.
6. Any other circumstance warranting dismissal under the applicable University of Bahrain regulations.
7. Academic probation, dismissal, appeal, and reinstatement cases are administered in accordance with the latest approved University of Bahrain Study and Examinations Regulations.
8. Where those regulations are amended, the current approved regulations take precedence over this summary.

Program Components



University Requirement (UR)	11
College Requirement (CR)	28
Major Support Requirement (MSR)	28
Major Requirement (MR)	66
Major Elective (ME)¹	6
Training (Internship)	Yes
Total Credit (CRD)	139

1. Students must select five (3XX & 4XX) courses from Major Elective (ME) List. Additional to this, two courses must be selected from ME list as Job Placement Courses. This needs consultation and approval of the department.

Detailed Study Plan

Year 1 - Semester 1

Course Code	Course Title	Course Hours			Course Type (as shown in credit hours distribution)	Pre-Requisite; specify if there is grade for completion	Major CGPA	Regular Mode of Teaching and Learning
		LEC	PRAC/ CLIN/ STUD	CRD				
CHEMY 101	General Chemistry I	3	2	4	CR	-----	NO	Traditional Education
ITCS 110	Computer Programming for Engineers	3	2	4	MSR	-----	NO	Traditional Education
ENGL 101	Communication Skills I	3	0	3	CR	-----	NO	Traditional Education
MATHS 101	Calculus I	3	0	3	CR	-----	NO	Traditional Education
PHYCS 101	General Physics I	3	2	4	MSR	-----	NO	Traditional Education
Total	15	6	18					

Year 1 - Semester 2

Course Code	Course Title	Course Hours			Course Type (as shown in credit hours distribution)	Pre-Requisite; specify if there is grade for completion	Major CGPA	Regular Mode of Teaching and Learning
		LEC	PRAC/ CLIN/ STUD	CRD				
EENG 100	Circuit Theory I	2	2	3	MSR	MATHS 101	NO	Traditional Education

ENGL 242	Report Writing and Presentation	3	0	3	CR	ENGL 101	NO	Traditional Education
HRLC 107	Human Rights	2	0	2	UR	-----	NO	Traditional Education
ICENG 111	Introduction to Instrumentation and Control Engineering	2	2	3	MR	MATHS 101 & PHYCS 101	YES	Traditional Education
MATHS 102	Calculus II	3	0	3	CR	MATHS 101	NO	Traditional Education
PHYCS 102	General Physics II	3	2	4	MSR	PHYCS 101	NO	Traditional Education
Total	15	6	18					

Year 2 - Semester 3

Course Code	Course Title	Course Hours			Course Type (as shown in credit hours distribution)	Pre-Requisite; specify if there is grade for completion	Major CGPA	Regular Mode of Teaching and Learning
		LEC	PRAC / CLIN/ STUD	CRD				
ICENG 202	Thermofluids	2	2	3	MR	PHYCS 101	YES	Traditional Education

EENG 251	Digital Systems I	2	2	3	MSR	EENG 100	YES	Traditional Education
EENG 261	Electronic Devices and Circuits	2	2	3	MSR	EENG 100	NO	Traditional Education
MATHS 205	Differential Equations	3	0	3	CR	MATHS 102	NO	Traditional Education
PHYCS 206	Bulk Properties of Matter	3	2	4	MSR	PHYCS 101	NO	Traditional Education
Total	12	8	16					

Year 2 - Semester 4

Course Code	Course Title	Course Hours			Course Type (as shown in credit hours distribution)	Pre-Requisite; specify if there is grade for completion	Major CGPA	Regular Mode of Teaching and Learning
		LEC	PRAC / CLIN/STUD	CRD				
ICENG 220	Measurement Systems I	2	2	3	MR	ICENG 111, EENG 261 & PHYCS 102	YES	Traditional Education
EENG 271	Signals and Systems	3	0	3	MSR	EENG 100 & MATHS 102	YES	Traditional Education
ICENG 208	Computer Applications for Instrumentation and Control Engineering	0	6	3	MR	MATHS 205 & ITCS 110	YES	Traditional Education

ICENG 217	Data Communicatio n Networks	3	2	4	MR	ITCS110	YES	Traditional Education
MATHS 203	Calculus III	3	0	3	CR	MATHS 102	NO	Traditional Education
STAT 276	Statistical Data Analysis for Engineering	3	0	3	CR	MATHS 102	NO	Traditional Education
Total	14	10	19					

Year 3 - Semester 5

Course Code	Course Title	Course Hours			Course Type (as shown in credit hours distribution)	Pre-Requisite; specify if there is grade for completion	Major CGPA	Regular Mode of Teaching and Learning
		LEC	PRAC / CLIN/ STUD	CRD				
ARAB 110	Arabic Language Skills	3	0	3	UR	-----	NO	Traditional Education
ICENG 304	Linear Algebra and Numerical Methods	2	2	3	MR	ICENG 208 & STAT 276	YES	Traditional Education
ICENG 318	Microprocessors in Process Automation	3	2	4	MR	ITCS110 & EENG 251	YES	Traditional Education
ICENG 324	Signal Conditioning and Electronic Instruments	2	2	3	MR	ICENG 220	YES	Traditional Education
ICENG 332	Process Dynamics and Simulation	2	2	3	MR	ICENG 208 & ICENG 202	YES	Traditional Education
Total	12	8	16					

Year 3 - Semester 6

Course Code	Course Title	Course Hours			Course Type (as shown in credit hours distribution)	Pre-Requisite; specify if there is grade for completion	Major CGPA	Regular Mode of Teaching and Learning
		LEC	PRAC / CLIN/	CRD				

			STUD					
ICENG 325	Measurement Systems II	3	2	4	MR	ICENG 324 & EENG 271	YES	Traditional Education
ICENG 326	Analytical Instrumentation	2	2	3	MR	ICENG 324 & PHYCS 206	YES	Traditional Education
ICENG 333	Process Control I	3	2	4	MR	ICENG 304 & ICENG 332	YES	Traditional Education
ICENG 334	Programmable Logic Controller	2	2	3	MR	ICENG 217 & ICENG 318	YES	Traditional Education
MENG 302	Engineering Economics	3	0	3	CR	Completion of 70 credits	NO	Traditional Education
Total	13	8	17					

Training Requirement

Course Code	Course Title	Course Hours			Course Type (as shown in credit hours distribution)	Pre-Requisite; specify if there is grade for completion	Major CGPA
		LEC	PRAC/CLIN/STUD	CR D			
ICENG 396	Industrial Training	0	6	3	MR	Completion of 85 credits	YES

* 300 hours of supervised training.

Year 4 - Semester 7

Course Code	Course Title	Course Hours			Course Type (as shown in credit hours distribution)	Pre-Requisite; specify if there is grade for completion	Major CGPA	Regular Mode of Teaching and Learning
		LEC	PRA C/ CLIN/ STU D	CR D				
HIST 122	Modern History of Bahrain and Citizenship	3	0	3	UR	----	NO	Traditional Education
ICENG 424	Final Control Elements and Actuators	3	2	4	MR	ICENG 220 & EENG 271	YES	Traditional Education
ICENG 435	Digital Control Systems	2	2	3	MR	ICENG 333 & ICENG 318	YES	Traditional Education
ICENG 436	Process Control II	2	2	3	MR	ICENG 333 & MATHS 203	YES	Traditional Education
ICENG 497	Senior Project I	0	3	1	MR	Completion of 90 credits	YES	Traditional Education
ICENG 4xx	Elective I	2	2	3	ME	Completion of 90 credits	YES	Traditional Education
Total	12	11	17					

Year 4 - Semester 8

Course Code	Course Title	Course Hours		Pre-Requisite; specify if there	Major CGPA	Regular Mode of
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		LEC	PRA C/ CLIN/ STU D	CRD	Course Type (as shown in credit hours distribution)	is grade for completion		Teachin g and Learning
ICENG 439	SCADA and Distributed Control Systems	2	2	3	MR	ICENG 334	YES	Tradition al Educatio n
ICENG 438	Instrumentati on and Control Design Project	0	6	3	MR	ICENG 436 & ICENG 424	YES	Tradition al Educatio n
ICENG 498	Senior Project II	0	9	3	MR	ICENG 497	YES	Tradition al Educatio n
ICENG 4xx	Elective II	2	2	3	ME	Completion of 90 credits	YES	Tradition al Educatio n
ISLM 101	Islamic Culture	3	0	3	UR	-----	NO	Tradition al Educatio n
Total	7	19	15					

Major Elective Courses

Course Code	Course Title	Course Hours			Course Type (as shown in credit hours distribution)	Pre-Requisite; specify if there is grade for completion	Major CGPA	Regular Mode of Teaching and Learning
		LEC	PRA C/ CLIN/ STU D	CRD				
ICENG 441	Safety Instrumented Systems	2	2	3	ME	ICENG 325 & ICENG 334	YES	Traditional Education
ICENG 442	Virtual Instrumentation	2	2	3	ME	ICENG 325 & ICENG 208	YES	Traditional Education
ICENG 443	Digital Signal Processing	2	2	3	ME	EENG 271	YES	Traditional Education
ICENG 444	Biomedical Instrumentation Systems	2	2	3	ME	ICENG 326	YES	Traditional Education
ICENG 445	Advanced Sensor Systems	2	2	3	ME	ICENG 325	YES	Traditional Education
ICENG 451	Optimization Techniques	2	2	3	ME	ICENG 304	YES	Traditional Education
ICENG 452	Model Predictive Control and Adaptive Control	2	2	3	ME	ICENG 333	YES	Traditional Education

ICENG 453	Artificial Intelligence in Instrumentation and Control Systems	2	2	3	ME	ICENG 333	YES	Traditional Education
ICENG 454	Embedded Control Systems	2	2	3	ME	ICENG 318 & ICENG 333	YES	Traditional Education
ICENG 455	System Identification	2	2	3	ME	STAT 276, EENG 271 & ICENG 304	YES	Traditional Education
ICENG 461	Special Topics	2	2	3	ME	Completion of 90 credits	YES	Traditional Education
ICENG 462	Big Data Analytics	2	2	3	ME	STAT 276 & ICENG 304	YES	Traditional Education
ICENG 463	Industrial Cyber Security	2	2	3	ME	ICENG 217	YES	Traditional Education
ICENG 464	Wireless Sensor Technology	2	2	3	ME	ICENG 217 & ICENG 325	YES	Traditional Education
CHEN 477	Quality Assurance and Reliability Engineering	2	2	3	ME	Completion of 90 credits	YES	Traditional Education

Course Description

Major Courses Descriptions

Course Code: ICENG 111 **Course Title:** Introduction to Instrumentation and Control Engineering **NQF Level:** (6)

Concept of control systems through daily life examples. Basic terminology and symbols in control systems. Benefits of control systems: social, economic, environmental, and safety impacts. Basic components of an Instrumentation and Control System. Physical systems classification: mechanical, chemical, electrical, biomedical, etc. Units and standards. Signals classification: analog and digital. Sensing element classification. Signal conditioning. Final control element types. Controller: electronic and digital. Examples of modern control-systems applications. Hierarchy of instrumentation and control system activities. Tasks and responsibilities of control and instrumentation engineers, and career opportunities.

Course Code: ICENG 202 **Course Title:** Thermofluids **NQF Level:** (6)

Basic concepts of thermodynamics. Energy, energy transfer, and general energy analysis, properties of pure substances. The first law of thermodynamics. Mass and Energy analysis of closed systems, mass and energy analysis of open systems. The second law of thermodynamics. Introduction and properties of fluids. Bernoulli and energy equations, momentum analysis of flow systems. Internal flow. Tools: spreadsheet software (e.g., Microsoft® Excel).

Course Code: ICENG 208 **Course Title:** Computer Applications for Instrumentation and Control Engineering **NQF Level:** (6)

Classification of engineering software. MATLAB: programming environment, array and matrix operations, graphing, variables and text string manipulation, files and I/O statements, control flow and looping, functions, script files, symbolic processing. Simulink and MATLAB M-files, S-function. Selected toolboxes. Instrumentation and control applications using available software. Tools: programming environment for calculation and simulation (e.g., MATLAB®/Simulink).

Course Code: ICENG 217 **Course Title:** Data Communication Networks **NQF Level:** (6)

Concepts and techniques of host-to-host computer networks and data communication. Topics include: the basics of network models, standards, and protocols, data communication systems and schemes implemented at physical and data link layers.

Course Code: ICENG 220 **Course Title:** Measurement Systems I

Importance of measurement in process control and monitoring. Components of a measurement system. Static and dynamic characteristics of measurement systems. Error analysis and data representation. Sensors: resistive, inductive and capacitive sensors. Resistance strain gauge,

piezoelectric/piezoresistive sensors, and miscellaneous sensors. Calibration of measurement systems. Tools: spreadsheet software (e.g., Microsoft® Excel).

Course Code: ICENG 304 **Course Title:** Linear Algebra and Numerical Methods **NQF Level:** (7)

Linear algebraic equations and selected matrix operations (e.g., Reduced row echelon form, Eigenvalues, etc.). Numerical methods and errors. Numerical solution of systems of linear equations: elimination and iterative methods. Numerical solution of nonlinear equations: bracketed and open methods. Open methods for simultaneous nonlinear equations. Interpolation and curve-fitting. Finite difference methods. Numerical differentiation and integration. Solution of ODEs - Initial Value Problems. Applications related to instrumentation and control engineering. Tools: spreadsheet software (e.g., Microsoft® Excel), programming and computing environment (e.g., MATLAB®).

Course Code: ICENG 318 **Course Title:** Microprocessors in Process Automation **NQF Level:** (7)

Introduction to microcontroller architecture: CPU, RAM, ROM and flash memory. Microcontroller programming (Assembly and C languages). Interrupts, analog to digital conversion, digital to analog conversion. Universal asynchronous receiver transmitter. Tools: programming environment for calculation and simulation (e.g., Assembly and C language).

Course Code: ICENG 324 **Course Title:** Signal Conditioning and Electronic Instruments **NQF Level:** (7)

Signal conditioning elements and schemes: amplifiers, AC/DC bridges, grounding, shielding, current loop, opto-isolator, V/I, F/V converters, etc. Data acquisition and telemetry systems: multiplexing, telemetry signals, transmission modes, modulation, analog to digital and digital to analog converters. Electronic Instrument (e.g., voltmeter, ohmmeter, ammeter, power meter, frequency meter, etc.): principles of operation, applications, etc. Related laboratory experiments.

Course Code: ICENG 325 **Course Title:** Measurement Systems II **NQF Level:** (7)

Measurement of displacement, strain, force and torque. Pressure, level, temperature and flow rate measurement systems. Measurement of velocity and vibration. Physical property measurements: density, specific gravity, humidity, viscosity, thermal conductivity and refractive index. Smart sensors and transmitters. Related laboratory experiments.

Course Code: ICENG 326 **Course Title:** Analytical Instrumentation **NQF Level:** (7)

Introduction to composition measurement and process analyzers. Spectroscopy: principles and specific types (e.g., ultra-violet/visible, infrared, X-ray mass and nuclear techniques). Chromatography: theory, data handling and calibration of gas, high performance liquid

chromatography. Substance-specific methods: carbon, oxygen, nitrogen, etc. Electrochemical systems (e.g., principles and measurements, electrodes for pH and conductivity, ion-specific electrodes). Requirement for on-line analysis: sample handling and conditioning. Related laboratory experiments.

Course Code: ICENG 332 **Course Title:** Process Dynamics and Simulation **NQF Level:** (8)

Role of process dynamics and control. Development of dynamic models of several simple processes. Review of Laplace transforms. Linearization. Transfer function and state space models. Transient behavior of first- and second order systems. Dynamic behavior of more complicated processes: high-order, time delays, inverse response, lead-lag. Frequency response analysis. Multivariable process modelling. Simulation of the transient response. Related laboratory experiments. Tools: programming environment for process simulation and dynamic analysis (e.g., MATLAB®/Simulink and Control Station).

Course Code: ICENG 333 **Course Title:** Process Control I **NQF Level:** (8)

Elements of a control loop, classification of control strategies. P&I Diagrams. Block diagrams. PID controllers and features. Transient behavior of closed-loop systems. Stability analysis. Root locus diagrams. Controller tuning. Design based on frequency response. Feedforward, cascade, inferential, override and selective control. Time delay compensation. Related laboratory experiments. Tools: programming environment for process control analysis and design (e.g., MATLAB®/Simulink and Control Station).

Course Code: ICENG 334 **Course Title:** Programmable Logic Controller **NQF Level:** (8)

Introduction to PLC-Relay Sequencer. PLCs architecture and components. PLC operation. PLC programming languages (LAD, FBD, Statement List, SFC-Grafcet, etc.). PLC Programming-bit logic operations, flip-flop, timers and counters, special instructions. Analog PLC operations and networking. PID Instructions. Developing Human Machine Interface (HMI) (alarm and tag management, display, etc.). Batch process control. PLCs selection, installation, troubleshooting, and maintenance. Related laboratory experiments. Tools: programming using PLC simulator software (e.g., Allen Bradley PLC simulator, Siemens PLC simulator, etc.).

Course Code: ICENG 396 **Course Title:** Industrial Training **NQF Level:** (8)

All students in the program must participate in an approved training program in the relevant industry. At the completion of 300 hours of supervised training, each student must submit a formal report and conduct an oral presentation.

Course Code: ICENG 424 **Course Title:** Final Control Elements and Actuators **NQF Level:** (8)

Final control element types (relays, valves, pumps, etc.). Pneumatic control valves, types, selection, sizing, inherent/installed characteristics, dynamics, installation, and maintenance.

Pneumatic actuator (e.g., diaphragm and pistons). I/P converter. Introduction to solid state devices, power electronic devices. Electrical actuators: Solenoid, DC/AC motors, stepping motors. Analysis and design of drive circuits: Variable frequency drive (VFD), DC choppers, etc. Speed control of DC, AC and Stepping motors. Other common industrial valves, proportional valves, safety valves, smart valves, variable speed pumps, etc. Related laboratory experiments.

Course Code: ICENG 435 **Course Title:** Digital Control Systems **NQF Level:** (8)

Digital control schemes, including DDC, DCS, and data logging. Sampling, signal reconstruction, aliasing, and anti-aliasing filters. Topics include Z-transformation, block diagrams, pulse transfer functions, difference equations, and time response analysis. Stability analysis, discrete PID controllers, and tuning methods. Design techniques include direct synthesis, pole placement, and minimum variance controllers. State-space models, controllability, observability, and control design (pole placement, state/output feedback, observer design). Laboratory Experiments. Tools like MATLAB®/SIMULINK for analysis and design of digital control systems.

Course Code: ICENG 436 **Course Title:** Process Control II **NQF Level:** (8)

Mathematical descriptions of process models: classification of models (e.g., first-principles vs. empirical, parametric/non-parametric, deterministic/stochastic, etc.). Multivariable Control. Relative gain analysis. Singular value analysis. Multiloop controller tuning. Decoupling Control. Basic formulations of predictive control (e.g., state space, transfer function, etc.). Constrained and unconstrained control problems. Dynamic Matrix Control. Related laboratory experiments. Tools: programming environment for MPC and MIMO control analysis and design (e.g., MATLAB®/Simulink/System identification toolbox/MPC system toolbox).

Course Code: ICENG 439 **Course Title:** SCADA and Distributed Control Systems **NQF Level:** (8)

SCADA system. Basic DCS components. Redundancy concept. Hardware configuration (FCS, HIS, ENG), networking configuration, industrial communication protocols, OPC DCS programming (using different function blocks and faceplates), running and testing, and sequencing control. Configuring process trends and alarm messages and developing interactive graphics. Emergency shutdown system. Related laboratory experiments.

Course Code: ICENG 438 **Course Title:** Instrumentation and Control Design Project **NQF Level:** (8)

Design of control systems for real industrial applications, preferably from local industry. The students will perform the following: Define the design objectives and requirements, literature review, propose different instrumentation and/or control configurations, criteria of selection of best configuration, explanation for the reason of selecting the system configuration(s), specify the measurement systems and final control elements; criteria would include types of instruments

(transmitters, controllers, sensors) and their prices (economical constraint), instrumentation and control standards, observability, controllability/operability issues, select and tune the process controllers, safety considerations, performance evaluation of the designed system. Written design reports and oral presentations are required.

Course Code: ICENG 497 **Course Title:** Senior Project I

NQF Level: (8)

In this 1st phase of the project, a preliminary study is carried out in teams under the supervision of a faculty member on an approved proposal of a research project relevant to the field. The research project may be of experimental or theoretical nature, where the application of engineering knowledge towards the development of the project is demonstrated. This phase involves a thorough literature review, development of a detailed implementation plan, as well as the conduction of any preliminary studies and preparation needed for the execution of the 2nd phase of the project in the subsequent course (Senior Project II). An end-of-term written report is required.

Course Code: ICENG 498 **Course Title:** Senior Project II

NQF Level: (8)

In this 2nd phase of the project, the development and implementation of the research project is continued by the same team under the supervision of the same faculty member. This phase involves accurate implementation and completion of the project tasks, deep analysis of the results, logical and evident-based reasoning of the outcomes and drawn conclusions. End-of-term written formal report, poster, and oral presentation are required.

Major Electives Courses Descriptions

Course Code: ICENG 441 **Course Title:** Safety Instrumented Systems

NQF Level: (8)

Definition of functional safety and safety challenges in industry. Hazard and risk analysis and prevention. Standards for risk assessment and safety instrumented systems (safety instrumented functions). Failure analysis, safety reliability analysis, safety standards and regulations (IEC 61508 and IEC 61511), fault evaluation technique (fault tree analysis) and fault tolerance. Protection layer and explosion protection. Safety instrumented system required for low level buses, and safety integrity levels.

Course Code: ICENG 442 **Course Title:** Virtual Instrumentation

NQF Level: (8)

Virtual Instrumentation (VI). Block diagram and architecture of virtual instruments. Programming techniques: VIs and sub-VIs, loops and conditional statements, data display, arrays, case and sequence structures and clusters, string and file I/O. Data acquisition basics: ADC, DAC, DIO, counters and timers, interrupt, software and hardware installation. VI applications in measurement and control. Tools: graphical programming environment for virtual instrumentation design and data acquisition (e.g., LABVIEW).

Course Code: ICENG 443 **Course Title:** Digital Signal Processing

NQF Level: (8)

Time and frequency analysis of signals and systems Z-transform and its applications to the analysis of LTI systems, DFT, properties of the DFT, use of DFT in linear filtering, filtering of long data sequences, DFT as linear transformation, efficient computation of the DFT- FFT algorithms, Radix 2 DITFFT and DIFFFT. Design of IIR filters, butterworth, chebyshev, design of FIR filters, linear phase FIR Filters, implementation of discrete time systems: Structures for FIR, IIR systems, lattice ladder structures. Finite word length effects. Power spectrum estimation, parametric methods of PSD estimation. Tools: programming environment for designing, simulating, and analyzing signal processing systems (e.g., MATLAB®/Simulink/DSP system toolbox, SciPy, etc.)

Course Code: ICENG 444 **Course Title:** Biomedical Instrumentation Systems **NQF Level:** (8)

Biomedical sensors classification and selection. Bioelectric potentials and electrodes. Heart system and Electrocardiogram (ECG). Blood pressure measurements. Blood flow measurements. Oximeters. Blood glucose measurement and artificial pancreas. Nervous system, synapse, EEG recording techniques, and wave types. Heart pacemakers and defibrillators, and Heart-lung machine. Hemodialysis and peritoneal dialysis, artificial respirator, nerve stimulator, diathermy. Bionic ear. Endoscopes, incubators, apnoea monitor, lithotripsy. Intensive Care Unit (ICU), bedside and central monitoring systems. Imaging: MRI, ultrasonography, X-ray instrumentation, CT.

Course Code: ICENG 445 **Course Title:** Advanced Sensor Systems

NQF Level: (8)

Review of sensor principles. Overview of advancing sensing techniques. Sensor classifications in advanced sensing techniques. MEMS. Micro-machined sensors, fiber optical sensors, laser sensors, ultrasonic sensors, acoustic sensors, Nuclear Magnetic Resonance (NMR) sensors, soft-sensing techniques, and Micro-Computed Tomography (CT) sensors, nano sensors, and biosensors. Examples of industrial applications of advanced sensors. Latest development and technology trends.

Course Code: ICENG 451 **Course Title:** Optimization Techniques

NQF Level: (8)

Formulation of the optimization problem. Linear optimization, interior-point methods, mixed integer programming, global optimization. Nonlinear constrained optimization problems. Genetic algorithm. Application to process design, planning, scheduling and advanced process control using available software tools. Tools: programming environment for modelling and solving optimization problems (e.g., GAMS).

Course Code: ICENG 452 **Course Title:** Model Predictive Control and Adaptive Control
NQF Level: (8)

Concept of model predictive control (MPC). MPC versus classical control systems. Predictions

for single-input and single-output (SISO) models. Predictions for multi-input and multi-output (MIMO) models. Model predictive control calculations. Tuning MPC parameters. Online process identification techniques. Introduction to adaptive control. Model reference adaptive control. Self-tuning regulators. Adaptive MPC control system. MPC implementation. MPC control of selected unit operation models. Tools: programming environment for designing advanced control schemes (e.g., MATLAB®/Simulink/MPC system toolbox/Adaptive Control toolbox and blockset).

Course Code: ICENG 453 **Course Title:** Artificial Intelligence in Instrumentation and Control Systems **NQF Level:** (8)

Introduction to intelligent systems and soft computing. Fundamentals of fuzzy logic systems. Fuzzy logic control. Fundamentals of artificial neural networks. Dynamic neural networks and their applications to control. Neuro-fuzzy systems. Applications of soft computing tools to Instrumentation and control systems. Tools: programming environment for simulation of intelligent control strategies (e.g., MATLAB®/Simulink and Fuzzy Logic and Neural Network Toolboxes).

Course Code: ICENG 454 **Course Title:** Embedded Control Systems **NQF Level:** (8)

Basic Concepts of embedded systems. Main architecture of embedded control systems. Microcontrollers. Communication networks in embedded systems: features of a Controller Area Network (CAN) Communication, CAN message frames, Error detection and signaling, CAN controller modes. Multi-tasking embedded control systems. Embedded control system design: system identification, controllers design.

Course Code: ICENG 455 **Course Title:** System Identification **NQF Level:** (8)

Introduction to system identification procedure, dynamical systems and models. Models of LTI Systems: identification of parametric models, transfer function models, state-space models, model structure selection, model Validation. Identification of non-parametric models: impulse response, step response models. Parameter estimation methods: minimizing prediction errors, linear regression and least-squares. Subspace identification method of state-space models: observability and controllability, Kalman filter. Closed-loop identification of multivariable systems. Recursive estimation methods. Tools: programming environment for system identification, modeling, and simulation (e.g., MATLAB®/Simulink and System Identification Toolbox).

Course Code: ICENG 461 **Course Title:** Special Topics **NQF Level:** (8)

Any important, relevant topic that is not covered in the given elective list. Topics may be varied subject to students' interest and availability of staff.

Course Code: ICENG 462 **Course Title:** Big Data Analytics

NQF Level: (8)

Data management tools and techniques. Modern relational DBMS and NoSQL environments. Data Mining and visualization. Artificial learning systems. Machine learning techniques: classification, clustering, SVM, neural networks, etc. Principles of high-performance computing. Distributed data processing. Overview of the cloud computing architecture.

Course Code: ICENG 463 **Course Title:** Industrial Cyber Security

NQF Level: (8)

The course covers the fundamentals of cyber security, cybercrime investigation, cyber-privacy, cyber operations, and cyber security applications. Topics include cyber security components, cyber security industries, cryptographic algorithms, cyber security architecture, security threat and risk assessment, e-services security, system cyber-security such as embedded systems, cloud computing security, and internet of things security.

Course Code: ICENG 464 **Course Title:** Wireless Sensor Technology

NQF Level: (8)

The course gives an overview of various topics related to wireless sensor networks. Topics include distributed signal processing in large scale sensor networks, energy conservation approaches, node deployment and topology, communication in sensor networks, time synchronization, localization, data fusion and geographical energy aware routing.

Course Code: CHEN 477 **Course Title:** Quality Assurance and Reliability Engineering **NQF Level:** (8)

Quality assurance, understanding, commitment, leadership, and organization. The role of quality system, planning, flow-charting. How to maintain plant quality and operation reliability. Causes and consequences of failure. Reliability of series, parallel, standby, and complex systems. Analytical methods including fault trees. Implementation methods, communication and training for quality. Guidelines for writing a quality manual.

Major Support Requirement Courses Descriptions

Course Code: ITCS 110 **Course Title:** Computer Programming for Engineers

NQF

Level: (5)

Introduction to computers, their uses, development, components, hardware, and software. Internal representation and numbering systems. Algorithmic problem-solving principles. Introduction to a modern programming language (e.g. C++). Input/Output, conditional statements, iteration, files, strings, functions, and arrays. Lab assignments to practice programming.

Course Code: EENG 100 **Course Title:** Circuit Theory I

NQF Level: (6)

Basic quantities of electricity: Charge, Current, Voltage, Power, Energy and Resistance. Basic laws of electricity: Ohm's Law, Kirchhoff's Laws (KVL & KCL). Apply circuit theorems: mesh, nodal, superposition, Thevenin's, Norton's, and maximum power transfer. Capacitors and inductors in DC circuits. Phasors & complex numbers for AC circuits. Sinusoidal steady-state analysis. Power in AC circuits: Complex, Apparent, Real & Reactive Powers and Power Factor.

Course Code: EENG 251 **Course Title:** Digital Systems I **NQF Level:** (6)

Number systems; Basic logic gates; Boolean algebra; Simplification of logic functions: Karnaugh maps, QuineMcCluskey method, NAND and NOR gates networks; Multiple output networks; MSI combinational logic circuits: Multiplexers, Decoders, Adders, Comparators; Tri-State logic; combinational logic circuits design with programmable logic devices: memories, PLA, PAL; FlipFlops; Design and analysis of counters and registers.

Course Code: EENG 261 **Course Title:** Electronic Devices and Circuits **NQF Level:** (6)

Semiconductor fundamentals: carrier transport and recombination, doped materials, physics and applications of pn junction diode, Zener diode characteristics and applications, special purpose diodes, fundamentals of BJTs and FETs, DC analysis of transistors circuits, Transistors as a switch, Transistor as an amplifier, small signal equivalent circuits, Biasing techniques, Basic single stage amplifiers.

Course Code: EENG 271 **Course Title:** Signals and Systems **NQF Level:** (6)

Elementary continuous and discrete-time signals, Signal decomposition and convolution, sampling theory and Nyquist theorem, Laplace and Z transforms, Fourier series and integral with applications, Linear Time-Invariant (LTI) systems:

Properties, impulse and frequency responses, Pole-zero description, input-output difference and differential equations, transient and steady state time responses to elementary signals.

Course Code: PHYCS 101 **Course Title:** General Physics I **NQF Level:** (5)

Units and measurements; brief review of vectors; Newton's laws of motion; projectile motion; work and energy; impulse and momentum; rotational dynamics; equilibrium of a rigid body; periodic motion.

Course Code: PHYCS 102 **Course Title:** General Physics II **NQF Level:** (5)

Electric charges and fields; Coulomb's and Gauss's laws; electric potential; capacitors and dielectrics; direct current circuits; Kirchhoff's rules; magnetic field and flux; ampere's law; induced emf; Lenz's law; mutual and self inductance; AC circuits; RLC circuit.

Course Code: PHYCS 206 **Course Title:** Bulk Properties of Matter **NQF Level:** (6)

Applied general Physics; Bulk Properties of matter for Scientists and Engineers. Elasticity, fluid statistics and dynamics, mechanical waves, vibrating bodies, acoustic phenomena, kinetic theory of gases, first and second law of thermodynamics, geometrical optics.

College Requirement Courses Descriptions

Course Code: CHEMY 101 **Course Title:** General Chemistry I **NQF Level:** (5)

Significant figures, chemical formulas and equations; mass relations, limiting reactions and theoretical yield; Physical behavior of gases; electronic structure, periodic table, covalent bonding; Lewis structures, Molecular structures, hybridization; molecular orbitals, solutions; colligative properties. Related practical work.

Course Code: ENGL 101 **Course Title:** Communication Skills I **NQF Level:** (5)

This course focuses on reading skills and strategies and language development. The reading section concentrates on high-interest contemporary topics and encourages students to increase speed and efficiency. The writing component, integrated to the reading materials, reviews grammatical structures, develops language accuracy and introduces paragraph writing. Students are required to upgrade their grammar, reading, and listening skills on the internet.

Course Code: ENGL 242 **Course Title:** Report Writing and Presentation **NQF Level:** (7)

This course offers theoretical and practical experience in technical report writing. It also introduces the steps involved in writing a report and in presenting its findings. The emphasis throughout is upon practical tasks and assignments, the most important of which is the production of a full-length formal report.

Course Code: MATHS 101 **Course Title:** Calculus I **NQF Level:** (5)

Algebra. Functions and graphs. Trigonometry. Conic sections. Limits and continuity. Derivatives and integrals. Applications of derivatives which include mean value theorem, extrema of functions and optimization. Definite integrals and the Fundamental Theorem of Calculus.

Course Code: MATHS 102 **Course Title:** Calculus II **NQF Level:** (5)

Applications of definite integrals, including areas, volumes and surface areas of solids of revolution, arc length and centroids. Transcendental functions, indeterminate form and L'Hopital's Rule. Techniques of integration and improper integrals. Infinite series, power series. Maclaurin and Taylor Theorem.

Course Code: MATHS 203 **Course Title:** Calculus III **NQF Level:** (6)

Parametric equations and polar coordinates. Vectors and surfaces. Limits, derivatives, and integrals of vector-valued

functions. Partial differentiation. Multiple and line integrals and their applications. Green's and Stokes' Theorems.

Course Code: MATHS 205 **Course Title:** Differential Equations **NQF Level:** (6)

Differential equations of first order and their solution. Separable and exact equations. Equations convertible to separable type. Higher order linear equations with constant coefficients (homogeneous and non-homogeneous). Power series method for second order linear equations. Variation of parameters. Laplace transform technique. Applications of differential equations.

Course Code: MENG 302 **Course Title:** Engineering Economics **NQF Level:** (7)

Fundamentals of engineering economy. Time value of money. Present worth analysis. Annual worth analysis. Rate of return analysis. Replacement and retention analysis. Capital rationing. Breakeven analysis. Payback period analysis. Depreciation methods.

Course Code: STAT 276 **Course Title:** Statistical Data Analysis for Engineering **NQF Level:** (6)

Introduction to statistical methods for data analysis and interpretation. Statistical concepts, probability distributions, descriptive statistics and data visualization, confidence intervals, significance tests, Analysis of Variance (ANOVA), linear and nonlinear regression analysis. Principles of design of experiments, full factorial and fractional designs, statistical quality control. Tools: spreadsheet software (e.g., Microsoft® Excel) and programming environment (e.g., MATLAB®).

University Requirements Courses Descriptions

Course Code: ARAB 110 **Course Title:** Arabic Language Skills **NQF Level:** (6)

This course focuses on basic Arabic skills including form, function, and meaning. It also helps the student to appreciate and understand structures and approach them from a critical point of view, through various genres in literature.

Course Code: HIST 122 **Course Title:** Modern History of Bahrain and Citizenship **NQF Level:** (6)

Spatial identity of Bahrain: Brief history of Bahrain until the 18th century; the historical roots of the formation of the national identity of Bahrain since the 18th century; the modern state and evolution of constitutional life in Bahrain; the Arabic and Islamic dimensions of the identity of Bahrain; the core values of Bahrain's society and citizenship rights (legal, political, civil and economic); duties; responsibilities and community participation; economic change and development in Bahrain; Bahrain's Gulf, Arab and international relations.

Course Code: HRLC 107 **Course Title:** Human Rights Principles **NQF Level:** (5)

This course deals with the principles of human rights in terms of the definition of human rights, scope, sources with a focus on the International Bill of Human Rights; The Charter of the United Nations; Universal Declaration of Human Rights; The International Covenant on Economics, Social and Culture rights; Convention against Torture and other Cruel, Inhuman or Degrading Treatment or Punishment; Mechanics and the Constitutional Protection of Rights and Public Freedoms in Kingdom of Bahrain.

Course Code: ISLM 101 **Course Title:** Islamic Culture **NQF Level:** (6)

An introduction to the general outline and principles of Islamic culture, its general characteristics, its relationships with other cultures, general principles of Islam in beliefs, worship, legislation and ethics.

Mapping Courses to PILOs:

Course Code	Course Title	Course Type	PILOs						
			1	2	3	4	5	6	7
CHEMY 101	General Chemistry I	CR	✓	✓					
ITCS 110	Computer Programming for Engineers	MSR	✓	✓					
ENGL 101	Communication Skills I	CR							✓
ENGL 242	Report Writing and Presentation	CR							✓
MATHS 101	Calculus I	CR	✓						
MATHS 102	Calculus II	CR	✓						
MATHS 205	Differential Equations	CR	✓						
MATHS 203	Calculus III	CR	✓						
STAT 276	Statistical Data Analysis for Engineering	CR	✓	✓					
PHYCS 101	General Physics I	MSR	✓	✓					
PHYCS 102	General Physics II	MSR	✓	✓					
PHYCS 206	Bulk Properties of Matter	MSR	✓	✓					
HRLC 107	Human Rights	UR							✓
ARAB 110	Arabic Language Skills	UR							✓
HIST 122	Modern History of Bahrain and Citizenship	UR							✓
ISLM 101	Islamic Culture	UR							✓
EENG 100	Circuit Theory I	MSR	✓					✓	
EENG 251	Digital Systems I	MSR	✓	✓	✓	✓	✓	✓	✓
EENG 261	Electronic Devices and Circuits	MSR	✓					✓	
EENG 271	Signals and Systems	MSR	✓					✓	
MENG 302	Engineering Economics	CR	✓			✓			

ICENG 111	Introduction to Instrumentation and Control Engineering	MR	✓						
ICENG 202	Thermofluids	MR	✓						
ICENG 208	Computer Applications for Instrumentation and Control Engineering	MR	✓			✓		✓	✓
ICENG 220	Measurement Systems I	MR	✓						
ICENG 304	Linear Algebra and Numerical Methods	MR	✓	✓					
ICENG 318	Microprocessors in Process Automation	MR	✓	✓					
ICENG 325	Measurement Systems II	MR	✓	✓				✓	
ICENG 324	Signal Conditioning and Electronic Instruments	MR		✓					
ICENG 326	Analytical Instrumentation	MR	✓	✓				✓	
ICENG 332	Process Dynamics and Simulation	MR	✓	✓					
ICENG 333	Process Control I	MR	✓	✓				✓	
ICENG 334	Programmable Logic Controller	MR	✓	✓				✓	
ICENG 424	Final Control Elements and Actuators	MR		✓					
ICENG 435	Digital Control Systems	MR	✓						
ICENG 436	Process Control II	MR	✓	✓		✓			
ICENG 439	SCADA and Distributed Control Systems	MR	✓	✓				✓	
ICENG 438	Instrumentation and Control Design Project	MR		✓	✓	✓	✓		✓
ICENG 441	Safety Instrumented Systems	ME	✓	✓				✓	
ICENG 442	Virtual Instrumentation	ME		✓					
ICENG 443	Digital Signal Processing	ME		✓					

ICENG 444	Biomedical Instrumentation Systems	ME	✓	✓					
ICENG 445	Advanced Sensor Systems	ME	✓	✓				✓	✓
ICENG 451	Optimization Techniques	ME	✓	✓				✓	✓
ICENG 452	Model Predictive Control and Adaptive Control	ME	✓	✓				✓	
ICENG 453	Artificial Intelligence in Instrumentation and Control Systems	ME	✓	✓				✓	
ICENG 454	Embedded Control Systems	ME	✓	✓				✓	✓
ICENG 455	System Identification	ME	✓	✓					
ICENG 462	Big Data Analytics	ME	✓	✓				✓	✓
ICENG 463	Industrial Cyber Security	ME	✓	✓				✓	✓
ICENG 464	Wireless Sensor Technology	ME	✓	✓		✓			✓
CHEN 477	Quality Assurance and Reliability Engineering	ME	✓	✓		✓			✓
ICENG 396	Industrial Training	MR	✓			✓	✓		✓
ICENG 497	Senior Project I	MR	✓	✓	✓	✓	✓		✓
ICENG 498	Senior Project II	MR	✓	✓	✓	✓	✓	✓	✓