Republic of the Philippines
OFFICE OF THE PRESIDENT
COMMISSION ON HIGHER EDUCATION

CHED MEMORANDUM ORDER
No. 88
Series of 2017

SUBJECT: POLICIES, STANDARDS AND GUIDELINES FOR THE BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING (BSEE) PROGRAM EFFECTIVE ACADEMIC YEAR (AY) 2018-2019

In accordance with the pertinent provisions of Republic Act (RA) No. 7722, otherwise known as the "*Higher Education Act of 1994*," in pursuance of an outcomes-based quality assurance system as advocated under CMO 46 s. 2012 (Policy-Standard to Enhance Quality Assurance (QA) in Philippine Higher Education through an Outcomes-Based and Typology-Based Quality Assurance) and as addendum to CMO 37, s. 2012 (Establishment of an Outcomes-Based Educational System in Higher Education Institutions offering Engineering Programs), and by virtue of Commission en banc Resolution No. 788-2017 dated October 24, 2017 the following Policies, Standards and Guidelines (PSG) are hereby adopted and promulgated by the Commission.

ARTICLE I
INTRODUCTION

Section 1. Rationale

Based on the Guidelines for the Implementation of CMO No. 46 series of 2012 and CMO 37 s. 2012, this PSG implements the shift to outcomes-based education leading to competency-based standards. It specifies the core competencies expected of BS Electrical Engineering graduates regardless of the type of Higher Education Institutions (HEI) they graduate from. However, in recognition of outcomes-based education (OBE) and the typology of HEIs, this PSG also provides ample space for HEIs to innovate in the curriculum in line with the assessment of how best to achieve learning outcomes in their particular contexts and their respective missions.

ARTICLE II
AUTHORITY TO OPERATE

Section 2. Government Recognition

All private higher education institutions (PHEIs) intending to offer BS Electrical Engineering shall first secure proper authority from the Commission in accordance with this PSG. All PHEIs with an existing BSEE program are required to shift to an outcomes-based approach based on CMO 37 s. 2012 and guided by this PSG. State universities and colleges (SUCs), and local universities and colleges (LUCs) shall likewise strictly adhere to the provisions in these policies and standards.

ARTICLE III
GENERAL PROVISIONS

Per Section 13 of RA 7722, the higher education institution shall exercise academic freedom in its curricular offerings but must comply with the minimum requirements for specific academic programs, the general education distribution requirements and the specific professional courses.

Section 3. Minimum Standards

The Articles that follow give minimum standards and other requirements and guidelines. The minimum standards are expressed as a minimum set of desired program outcomes which are given in Article IV Section 6. CHED designed a curriculum to attain such outcomes. This curriculum is shown in Article V Section 10 and Section 11 as **sample curriculum**. The number of units of this curriculum is here prescribed as the "minimum unit requirement" under Section 13 of RA 7722. To assure alignment of the curriculum with the program outcomes, this PSG provides a sample curriculum map for the HEI to refer to in compliance with the implementing guidelines of CMO 37 s. 2012.

Using a learner-centered/outcomes-based approach, CHED provided a description of Outcomes-Based Teaching and Learning delivery method in Article V Section 13. A sample course syllabus is also given in Article V Section 14 as support to the outcomes-based delivery method. Based on the curriculum and the means of its delivery, CHED determined the physical resource requirements for the library, laboratories and other facilities and the human resource requirements in terms of administration and faculty. These are provided for in Article VI.

Section 4. Curriculum Design

HEIs are allowed to design curricula suited to their own contexts and missions provided that they can demonstrate that the same leads to the attainment of the required minimum set of outcomes, albeit by a different route. In the same vein, they have latitude in terms of curriculum delivery and in terms of specification and deployment of human and physical resources as long as they can show that the attainment of the program outcomes and satisfaction of program educational objectives can be assured by the alternative means they propose.

The HEIs may use the **CHED Implementation Handbook for Outcomes-Based Education (OBE) and the Institutional Sustainability Assessment (ISA)** as a guide in making their submissions for Sections 19 to 21 of Article VII.

ARTICLE IV
PROGRAM SPECIFICATIONS

Section 5. Program Description

5.1 Degree Name

The degree program described herein shall be called Bachelor of Science in Electrical Engineering (BSEE).

5.2 Nature of the Field of Study

Electrical Engineering is a profession that involves the conceptualization, development, design and application of safe, healthy, ethical, economical and sustainable generation, transmission, distribution and utilization of electrical energy for the benefit of society and the environment through the knowledge of mathematics, physical sciences, information technology and other allied sciences, gained by study, research and practice.

Electrical Engineering is one of the broader fields of the engineering disciplines both in terms of the range of problems that fall within its purview and in the range of knowledge required to solve these problems.

5.3 Program Educational Objectives (PEOs)

Program educational objectives are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve within three to five years from graduation. PEOs are based on the needs of the program's constituencies and these shall be determined, articulated, and disseminated to the general public by the unit or department of the HEI offering the program. The PEOs shall also be assessed and evaluated periodically for continuing quality improvement.

5.4 Specific Professions/Careers/Occupations for Graduates

The scope of practice of Electrical Engineering is defined in Section 2a of the prevailing Electrical Engineering Law or RA 7920 and pertains to professional services and expertise including, but not limited to:

a. Consultation, investigation, valuation and management of services requiring electrical engineering knowledge;
b. Design and preparation of plans, specifications and estimates for electric power systems, power plants, power distribution systems including power transformers, transmission lines and network protection, switchgear, building wiring, electrical machines, equipment and others;
c. Supervision of erection, installation, testing and commissioning of power plants, substations, transmission lines, industrial plants and others;
d. Supervision of operation and maintenance of electrical equipment in power plants, industrial plants, watercrafts, electric locomotives and others;
e. Supervision in the manufacture and repair of electrical equipment including switchboards, transformers, generators, motors, apparatus and others;
f. Teaching of electrical engineering professional courses; and
g. Taking charge of the sale and distribution of electrical equipment and systems requiring engineering calculations or applications of engineering data.

The fields of specialization may include, but not limited to, the following: power system operation and protection, power plant operation and maintenance, advanced electrical systems design and inspection, sales and entrepreneurship, engineering education and research, instrumentation and control systems, construction and project management, software development, electricity market, and safety engineering.

5.5 Allied Programs

The following programs, among others, may be considered as allied to Electrical Engineering:

1. Computer Engineering
2. Electronics Engineering
3. Mechanical Engineering
4. Civil Engineering
5. Chemical Engineering
6. Industrial Engineering
7. Computer Science
8. Information Technology

Section 6. Institutional and Program Outcomes

The minimum standards for the **BSEE** program are expressed in the following minimum set of institutional and program outcomes.

6.1 Institutional Outcomes

a) Graduates of professional institutions shall be able to demonstrate a service orientation in one's profession.
b) Graduates of colleges shall be able to participate in various types of employment, development activities, and public discourses, particularly in response to the needs of the communities one serves.
c) Graduates of universities shall be able to participate in the generation of new knowledge or in research and development projects.
d) Graduates of state universities and colleges shall, in addition, have the competencies to support "national, regional and local development plans." (RA 7722).
e) Graduates of higher educational institutions shall preserve and promote the Filipino historical and cultural heritage. (based on RA 7722)

6.2 BSEE Program Outcomes

By the time of graduation, students of the program shall have developed the ability to:

a) Apply knowledge of mathematics and sciences to solve complex engineering problems;
b) Develop and conduct appropriate experimentation, analyze and interpret data;

c) Design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability, in accordance with standards;
d) Function effectively on multi-disciplinary and multi-cultural teams that establish goals, plan tasks, and meet deadlines; *(based on **PQF Level 6 descriptor**)*
e) Identify, formulate and solve complex problems in electrical engineering;
f) Recognize ethical and professional responsibilities in engineering practice;
g) Communicate effectively with a range of audiences;
h) Understand the impact of engineering solutions in a global, economic, environmental, and societal context;
i) Recognize the need for additional knowledge and engage in lifelong learning;
j) Articulate and discuss the latest developments in the field of electrical engineering; ***(PQF Level 6 descriptor)***
k) Apply techniques, skills, and modern engineering tools necessary for electrical engineering practice; and
l) Demonstrate knowledge and understanding of engineering and management principles as a member and/or leader in a team to manage projects in multidisciplinary environments.

A PHEI, SUC or LUC, at its option, may adopt mission-related program outcomes that are not included in the minimum set as specified above. Accordingly, PHEIs, SUCs, and LUCs may rewrite the program outcomes as stated above, provided that the meaning and essentials of the (a) to (l) program outcomes are substantially covered.

Annex I presents the Competency Standards, Attributes and Competencies of an Electrical Engineer which should result from the program outcomes stated above.

HEIs may also consider the International Engineering Alliance (IEA) graduate attributes and professional competency profiles for three professional tracks: engineer, engineering technologist and engineering technician. Refer to Annex IA or to the IEA website: http://www.ieagreements.org.

Section 7. Sample Performance Indicators/Criteria

Performance Indicators are specific, measurable statements identifying the performance(s) required to meet the outcome; confirmable through evidence(s).

Table 1. Sample Performance Indicators of a Program Outcome

Program Outcome		Sample Performance Indicators	
g	Communicate effectively with a range of audiences.	g.1	Discuss the analysis of an electrical circuit problem with his/her fellow students.
		g.2	Write a comprehensive laboratory report.
		g.3	Defend satisfactorily his/her thesis or design project from a panel of experts.

Section 8. Program Assessment and Evaluation

8.1 **Program Assessment** refers to one or more processes that identify, collect, and prepare data to evaluate the attainment of Program Outcomes and Program Educational Objectives.

8.2 **Program Evaluation** pertains to one or more processes for interpreting the data and evidence(s) accumulated from the assessment. Evaluation determines the extent at which the Program Outcomes and the Program Educational Objectives are achieved by comparing actual achievements versus set targets and standards. Evaluation results in decisions and actions to be implemented for the continuous improvement of the program.

All HEIs are encouraged to form a Consultative Body, represented by the stakeholders, to be part of the assessment and evaluation processes.

8.3 Assessment and Evaluation of PEOs

The assessment and evaluation of Program Educational Objectives may include feedback from the stakeholders of the program through surveys or focus group discussions to obtain data on the extent of achievement of the PEOs.

8.4 Assessment and Evaluation of POs

In the case of program outcomes assessment, the defined performance indicators shall be connected to key courses (usually the Demonstrating or "D" courses in the curriculum map), and appropriate assessment methods may be applied. These methods may be direct or indirect depending on whether the demonstration of learning was measured by actual observation and authentic work of the student or through gathered opinions from the student or his/her peers. Refer to Table 2.

Table 2. Sample Matrix Linking Performance Indicators with Key Courses and Assessment Methods

	Performance Indicators	Key Course(s)	Assessment Methods
g.1	Discuss the analysis of an electrical circuit problem with his/her fellow students.	Electrical Circuits 2	Recitation; oral exam
g.2	Write a comprehensive laboratory report.	Electric Machinery 2	Laboratory report
g.3	Defend satisfactorily his/her thesis or design project from a panel of experts.	Thesis/Design Project	Thesis/design project presentation

Table 3. Sample Matrix Linking Assessment Methods with Set Targets and Standards

Key Course(s)	Assessment Methods	Targets and Standards
Electrical Circuits 2	Recitation; oral exam	90% of the class gets a rating of at least 70%
Electric Machinery 2	Laboratory report	90% of the class gets a rating of at least 70%
Thesis/Design Project	Thesis/design project presentation	75% of the class gets a rating of at least 70%

Other methods of Program Assessment and Evaluation may be found in the **CHED Implementation Handbook for Outcomes-Based Education (OBE)** and **Institutional Sustainability Assessment (ISA)**.

Section 9. Continuous Quality Improvement

There shall be a documented process for the assessment and evaluation of program educational objectives and program outcomes.

The comparison of achieved performance indicators with declared targets or standards of performance shall serve as basis for the priority projects or programs for improving the weak performance indicators. Such projects and programs shall be documented as well as the results of their implementation. This regular cycle of documentation of projects, programs for remediation and their successful implementation shall serve as the evidence for Continuous Quality Improvement.

ARTICLE V
CURRICULUM

Section 10. Curriculum Description

The Electrical Engineering curriculum is designed to meet the BSEE program outcomes stated in Article IV Section 6.2. The curriculum shall develop electrical engineers who have a background in mathematics, natural, physical and allied sciences. As such the curriculum contains courses in college-level mathematics, calculus-based physics, chemistry, materials and environmental sciences with emphasis on the development of analytical and creative abilities. The curriculum also contains mandated general education and elective courses as connected to the desired program outcomes. This is to ensure that the electrical engineering graduates can understand and articulate the nature of their special role in society and the impact of their work on the environment. The curriculum is designed to guarantee a certain breadth of knowledge of the Electrical Engineering discipline through a set of core courses and to ensure depth and focus in certain specializations through track elective courses. A minimum of 240 hours of immersion in electrical engineering activities outside the institution and a capstone design project or a research project in electrical engineering are the final requirements of the curriculum.

The curriculum has a minimum total of 168 credit units, comprising of 118 units of technical courses. These technical courses include 12 units of mathematics, 8 units of natural/physical sciences, 7 units of basic engineering sciences, 34 units of allied courses, 51 units of professional courses (common), and 6 units of professional courses (specialized) or electives.

The non-technical courses in accordance with CMO 20 s. 2013 - the new General Education Curriculum (GEC) - consists of 36 units of general education courses distributed as follows: 24 units of core courses, 9 units of GEC electives, and 3 units of Life and Works of Rizal.

The new GEC also includes 8 units of Physical Education (PE), and 6 units of National Service Training Program (NSTP).

Section 11. Minimum Curriculum

11.1 Components

Below is the minimum curriculum of the BSEE program. The institution may enrich the minimum curriculum depending on the needs of the industry and community, provided that all prescribed courses are offered and pre-requisites and co-requisites are observed.

Classification/ Field / Course	Minimum No. of Hours/week		Credit Units
	Lecture	Lab/Field/ Design/Drafting	
I. TECHNICAL COURSES			
A. Mathematics			
Calculus 1	3	0	3
Calculus 2	3	0	3
Engineering Data Analysis	3	0	3
Differential Equations	3	0	3
Sub – total	**12**	**0**	**12**
B. Natural/Physical Sciences			
Chemistry for Engineers	3	3	4
Physics for Engineers	3	3	4
Sub – total	**6**	**6**	**8**
C. Basic Engineering Sciences			
Computer-aided Drafting	0	3	1
Engineering Mechanics	3	0	3
Engineering Economics	3	0	3
Technopreneurship 101	3	0	3
Sub – total	**9**	**3**	**10**
D. **Allied Courses**			
Fundamentals of Deformable Bodies	2	0	2
Materials Science and Engineering	2	0	2
Electronic Circuits: Devices and Analysis	3	3	4
Basic Thermodynamics	2	0	2
Industrial Electronics	3	3	4
Electromagnetics	2	0	2
Fluid Mechanics	2	0	2
Fundamentals of Electronic Communications	3	0	3
Logic Circuits and Switching Theory	2	0	2
Microprocessor Systems	2	0	2
Computer Programming	0	3	1

Classification/ Field / Course	Minimum No. of Hours per week		Credit Units
	Lecture	Lab/Field/ Design/Drafting	
Basic Occupational Safety and Health	3	0	3
Environmental Science and Engineering	2	0	2
Sub - total	**28**	**9**	**31**
E. Professional Courses			
Numerical Methods and Analysis	2	3	3
EE Law, Codes, and Professional Ethics	2	0	2
Electrical Standards and Practices	0	3	1
Electrical Circuits 1	3	3	4
Electrical Circuits 2	3	3	4
Electrical Apparatus and Devices	2	3	3
Electrical Machines 1	2	0	2
Electrical Machines 2	3	3	4
Engineering Mathematics for EE	3	0	3
Electrical Systems and Illumination Engineering Design	3	6	5
Power System Analysis	3	3	4
Fundamentals of Power Plant Engineering Design	0	3	1
Distribution Systems and Substation Design	2	3	3
Management of Engineering Projects	2	0	2
Research Methods	0	3	1
Research Project or Capstone Design Project	0	3	1
Instrumentation and Control	2	3	3
Feedback Control Systems	2	0	2
Seminars/Colloquia	0	3	1
On-the-job Training	2	(240 hours)	2
ELECTIVES 1, 2	6	0	6
Sub – total	42	45	57

Classification/ Field / Course	Minimum No. of Hours per week		Credit Units
	Lecture	Lab/Field/ Design/Drafting	
II. NON-TECHNICAL COURSES - New General Education Curriculum (GEC)			
A. GE Core Courses			
Science, Technology and Society	3	0	3
Contemporary World	3	0	3
Readings in Philippine History	3	0	3
Understanding the Self	3	0	3
Art Appreciation	3	0	3
Purposive Communication	3	0	3
Mathematics in the Modern World	3	0	3
Ethics	3	0	3
B. Electives / Mandated Course			
GEC Elective 1	3	0	3
GEC Elective 2	3	0	3
GEC Elective 3	3	0	3
Life and Works of Rizal	3	0	3
Physical Education 1, 2, 3, 4 (2 units each)			8
National Service Training Program 1 & 2 (3 units each)			6
Total (Non-technical Courses)	**50**		**50**
GRAND TOTAL	**147**	**63**	**168**

Suggested Track Elective Courses

Other specialized courses may be offered, developed and described by the HEIs in accordance with their needs.

As much as possible, the track elective courses shall be designed and developed by HEIs to be about 70% hands-on and 30% theoretical as almost all industries require graduates ready to start working with very short training about company processes.

1. Power System Protection – protection of generators, transformers, bus-bars and lines; protective relaying; surge protection in power systems
2. Advanced Power System Analysis and Design - transmission and distribution; power substation; industrial and commercial power systems

3. Advanced Electrical Systems Design – high rise building design; substation design; high-voltage underground cable design (AC/DC systems)
4. Entrepreneurship – project management; project acceptance, testing and documentation; sales and marketing management
5. Machine Automation and Process Control – pneumatics and process control; electro pneumatics; PLC in manufacturing
6. Special Studies in Renewable Energy Resources – solar and wind energy; waves/ocean energy; biomass energy
7. Substation maintenance – testing of power transformers, power circuit breakers, PT and CT, surge arresters, grounding grid, and lightning arresters; shall cover specific IEEE methodologies such as insulation power factor, over-all winding resistance, and leakage reactance, among others
8. Maintenance of power generators, using latest technologies to determine stator breakdowns, partial discharge for isolated phase bus, etc.
9. Testing and commissioning for electrical systems, compliant to NETA (National Electrical Testing Association) Standards, IEC Standards, and other standards recognized by the industry worldwide
10. Electrical audit evaluation that includes power system simulations to determine the required short circuit analysis, protection coordination, load flow, arc flash, harmonics determination and mitigation including high frequency noise presence in the system in addition to low frequency harmonics
11. Electrical estimating for power system, distribution system, commercial, industrial and high-rise building designs with project components to report

Summary of the BSEE Curriculum

Classification/ Field / Course	Minimum No. of Hours/Week		Minimum Credit Units
	Lecture	Lab/Field/ Design/Drafting	
I. Technical Courses			
A. Mathematics	12	0	12
B. Natural Sciences	6	6	8
C. Engineering Sciences	6	3	7
D. Allied Courses	31	9	34
E. Professional Courses	36	45	51
F. Electives	6	0	6
TOTAL (TECHNICAL)	**97**	**63**	**118**
II. Non-Technical Courses			
A. Core Courses	24	0	24
B. Electives	9	0	9
C. Mandated Course	3	0	3
D.Physical Education			8
E.NSTP			6
TOTAL (NON-TECHNICAL)	**50**		**50**
GRAND TOTAL	**147**	**63**	**168**

11.2 Program of Study

The institution may enrich the **sample** model of program of study depending on the needs of the industry, provided that all prescribed courses required in the curriculum outline are offered and pre-requisites and co-requisites are complied with.

The sample Program of Study listed below is meant for HEIs operating on a semestral system. HEIs with CHED - approved trimestral or quarter systems may adjust their courses and course specifications accordingly to fit their delivery system, as long as the minimum requirements are still satisfied.

The HEIs are also encouraged to include other courses to fulfill their institutional outcomes, as long as the total units for the whole program shall not be less than **168 units**, including PE and NSTP.

Sample Program of Study

FIRST YEAR

First Year - First Semester

Courses/Subjects	Minimum No. of Hours		Total units	Pre-Requisite
	Lec	L/F/D		
Calculus 1	3	0	3	
Chemistry for Engineers	3	3	4	
Computer-aided Drafting	0	3	1	
Mathematics in the Modern World	3	0	3	
Understanding the Self	3	0	3	
Science, Technology and Society	3	0	3	
NSTP 1	3	0	3	
PE 1	2	0	2	
SUB-TOTAL	**20**	**6**	**22**	

Note: L/F/D stands for Laboratory, Field Work, Design or Drafting

First Year - Second Semester

Courses/Subjects	Minimum No. of Hours		Total Units	Pre-Requisite
	Lec	L/F/D		
Calculus 2	3	0	3	Calculus 1
GEC Elective 1	3	0	3	
Computer Programming	0	3	1	
Physics for Engineers	3	3	4	Co-requisite: Calculus 2
Purposive Communication	3	0	3	
Contemporary World	3	0	3	
NSTP 2	3	0	3	
PE 2	2	0	2	
SUB-TOTAL	**20**	**6**	**22**	

SECOND YEAR

Second Year - First Semester

Courses/Subjects	Minimum No. of Hours		Total Units	Prerequisite
	Lec	L/F/D		
Differential Equations	3	0	3	Calculus 2
Electrical Circuits 1	3	3	4	Physics for Engineers; Calculus 2
Engineering Mechanics	3	0	3	Physics for Engineers
GEC Elective 2	3	0	3	
Art Appreciation	3	0	3	
Engineering Data Analysis	3	0	3	Calculus 1
PE 3	2	0	2	
SUB-TOTAL	**20**	**3**	**21**	

Second Year - Second Semester

Courses/Subjects	Minimum No. of Hours		Total Units	Prerequisite
	Lec	L/F/D		
Engineering Math for EE	3	0	3	Differential Equations
Fundamentals of Deformable Bodies	2	0	2	Engineering Mechanics
Electrical Circuits 2	3	3	4	Electrical Circuits 1
Electronic Circuits: Devices and Analysis	3	3	4	Electrical Circuits 1
Basic Thermodynamics	2	0	2	Physics for Engineers
GEC Elective 3	3	0	3	
Electromagnetics	2	0	2	Physics for Engineers; Differential Equations
PE 4	2	0	2	
SUB-TOTAL	**20**	**6**	**22**	

THIRD YEAR

Third Year - First Semester

Courses/Subjects	Minimum No. of Hours		Total Units	Pre-Requisite
	Lec	L/F/D		
Numerical Methods and Analysis	2	3	3	Engineering Math for EE
Logic Circuits and Switching Theory	2	0	2	Electronic Circuits: Devices and Analysis
Engineering Economics	3	0	3	Engineering Data Analysis
Industrial Electronics	3	3	4	Electronic Circuits: Devices and Analysis
Fundamentals of Electronic Communications	3	0	3	Electronic Circuits: Devices and Analysis
Electrical Machines 1	2	0	2	Electromagnetics; Electrical Circuits 2
Ethics	3	0	3	
SUB-TOTAL	**18**	**6**	**20**	

Third Year - Second Semester

Courses/Subjects	Minimum No. of Hours		Total Units	Pre-Requisite
	Lec	L/F/D		
Microprocessor Systems	2	0	2	Logic Circuits and Switching Theory
Electrical Apparatus and Devices	2	3	3	Electrical Circuits 2
Electrical Machines 2	3	3	4	Electrical Machines 1
Basic Occupational Safety and Health	3	0	3	
Fluid Mechanics	2	0	2	Physics for Engineers
Environmental Science and Engineering	2	0	2	
EE Law, Codes, and Professional Ethics	2	0	2	Ethics
Feedback Control Systems	2	0	2	Engineering Math for EE; Electronic Circuits: Devices and Analysis
SUB-TOTAL	**18**	**6**	**20**	

SUMMER				
On-the-Job Training	2	240 hrs	2	4th year standing
SUB-TOTAL	**2**		**2**	

FOURTH YEAR

Fourth Year - First Semester

Courses/Subjects	Minimum No. of Hours		Total Units	Pre-Requisite
	Lec	L/F/D		
Materials Science and Engineering	2	0	2	Chemistry for Engineers; Fundamentals of Deformable Bodies
Electrical Standards and Practices	0	3	1	EE Law, Codes, and Professional Ethics
Electrical Systems and Illumination Engineering Design	3	6	5	Electrical Machines 2
EE Elective 1	3	0	3	4th year standing
Management of Engineering Projects	2	0	2	Engineering Economics
Research Methods	0	3	1	Engineering Data Analysis
Instrumentation and Control	2	3	3	Feedback Control Systems
Technopreneurship	3	0	3	4th year standing
SUB-TOTAL	**15**	**15**	**20**	

* The nth Year Standing means that the student shall have completed at least 75% of the load requirements of the previous year level.

Fourth Year - Second Semester

Courses/Subjects	Minimum No. of Hours		Total Units	Pre-Requisite
	Lec	L/F/D		
Power Systems Analysis	3	3	4	Electrical Standards and Practices
Fundamentals of Power Plant Engineering Design	0	3	1	Co-requisite: Power Systems Analysis
Distribution Systems and Substation Design	2	3	3	Co-requisite: Power Systems Analysis
EE Elective 2	3	0	3	EE Elective 1
Research Project or Capstone Design Project	0	3	1	Research Methods
Seminars/Colloquia	0	3	1	4th year standing
Life and Works of Rizal	3	0	3	
Readings in Philippine History	3	0	3	
SUB-TOTAL	**14**	**15**	**19**	

Research Project or Capstone Design Project – shall focus on the established program research agenda of the HEI and may involve, among others, any of the following areas:

1. Alternative Energy Resources
2. Innovative Electrical Equipment Design
3. Development of software for Electrical Circuit Analysis and Design, Electrical Systems Analysis and Design, and Power System Analysis and Design
4. Design of means of transportation using electricity
5. Development of low-cost sustainable eco-materials for electrical installations
6. Other projects related to the practice of the Electrical Engineering profession

On-the-job-training / practicum – shall require a minimum of 240 hours. At the discretion of the HEIs, industry immersion may be substituted with student projects that will enhance, modernize, and elevate the level of effectiveness and relevance of electrical engineering education.

NOTE: PHEIs, SUCs, LUCs shall see to it that the institution has very strong linkage programs with industry and the government to ensure that all qualified EE students can be accommodated when they take their on-the-job training (OJT) program.

Seminars/Colloquia – seminars shall involve relevant topics and latest developments in the electrical engineering field. This course also includes attendance/participation of the students and/or presentation of student research project or capstone design project in a research colloquium or forum.

Section 12. Curriculum Map

As per CMO 37 s. 2012, a curriculum map is a matrix relating all the courses listed in the program curriculum with one or more of the declared program outcomes.

HEIs/LUCs/SUCs shall develop a complete curriculum map for their current or existing BSEE curriculum. Refer to Annex II for a **sample** curriculum map that demonstrates the extent of relationships between the courses and the program outcomes.

Section 13. Description of Outcomes-Based Teaching and Learning (OBTL) System

Outcomes-based teaching and learning (OBTL) is an approach where teaching and learning activities are developed to support the learning outcomes (University of Hong Kong, 2007). OBTL is a student-centered approach where the courses contained in the program curriculum are designed to achieve intended student outcomes. It is an approach in which teachers facilitate and students find themselves actively engaged in their learning.

Its primary focus is on the clear statements of what students should be able to do with what they know after completing a course (intended learning outcomes). These are statements, written from the students' perspective, indicating the level of understanding and performance they are expected to achieve as a result of engaging in teaching and learning experience (Biggs and Tang, 2007). Once these intended learning outcomes or course outcomes (ILOs or COs) have been established, appropriate teaching/learning activities (TLAs) are developed. A TLA is any activity which stimulates, encourages or facilitates learning of one or more ILOs. The final OBTL component involves the Assessment Tasks (ATs), which measure how well students can use their new abilities to solve real-world problems, design, demonstrate creativity and logical thinking, and communicate effectively, among others. An AT can be any method of assessing how well a set of ILOs has been achieved.

A key component of a course design using OBTL is the constructive alignment of ILOs, TLAs, and ATs. This design methodology requires the Intended Learning Outcomes to be developed first. Then the Teaching / Learning Activities and Assessment Tasks are developed based on the ILOs. (Biggs, 1999)

"Constructive" refers to the idea that students construct meaning through relevant learning activities; "alignment" refers to the situation when teaching and learning activities, and assessment tasks, are aligned to the Intended Learning Outcomes by using the verbs stipulated in the ILOs. Constructive alignment provides the "how-to" by stating that the TLAs and the assessment tasks activate the same verbs as in the ILOs. (Biggs and Tang, 1999)

The OBTL approach shall be reflected in all course syllabi to be implemented by the faculty.

Section 14. Course Syllabus and Course Specifications:

The course syllabus shall contain at least the following components:

1. General Course Information (Title, Description, Code, Credit Units, Prerequisites)
2. Links to Program Outcomes
3. Course Outcomes
4. Course Outline (Including Unit Outcomes)
5. Teaching and Learning Activities
6. Assessment Methods
7. Final Grade Evaluation

8. Learning Resources
9. Course Policies and Standards
10. Effectivity and Revision Information

Refer to **Annex III** for sample course specifications and Annex V for a sample course syllabus.

ARTICLE VI
REQUIRED RESOURCES

This article covers the specific required resources for the BS Electrical Engineering program. All other requirements on Administration, Library and Laboratory facilities, and buildings for the BS Engineering Programs are contained in CMO No. 86 s. 2017 - Policies, Standards and Guidelines for Requirements Common to all BS Engineering Programs issued by the Commission.

Section 15. Administration

The administration of the college of engineering must provide academic governance and leadership to engineering programs by exerting efforts to achieve program educational objectives and program outcomes. As such, the college shall have a full-time dean and a full-time department head or program chair/coordinator who are adept in the principles of outcomes-based education and are trained to implement the elements of OBE and OBTL as required in CMO 37 s 2012.

There shall be a full-time Department Head or Program Chair/Coordinator who shall lead in curriculum planning, implementation, monitoring, review, and evaluation of the BSEE program. If the College Dean is a licensed Electrical Engineer, he may serve as concurrent Department Head or Program Chair/Coordinator in extreme cases such as low enrollment.

The Department Head or Program Chair/Coordinator of the BSEE program:

a) shall be a holder of a baccalaureate degree in Electrical Engineering and a master's degree in electrical engineering, engineering education, or allied program;
b) shall be a registered Electrical Engineer with valid PRC license; and
c) shall have a teaching experience of not less than three years and at least three years of experience in industry practice or academic administration

To ensure the effectiveness and efficiency of his/her work, the Department Head or Program Chair/Coordinator may be given a teaching load of not more than 50% of the regular teaching load.

Section 16. Faculty

16.1 Requirements

Faculty members handling the professional courses shall be registered electrical engineers with valid PRC license. In addition, faculty handling professional design courses shall have industry design experience.

To effectively implement the curricular requirements of the program there shall be an adequate number of competent and qualified faculty to handle the professional courses. The program shall not be dependent on one faculty member handling the professional courses.

By AY 2018-2019 all full-time faculty members teaching the professional courses in the BSEE curriculum shall be holders of a master's degree in Electrical Engineering or allied program.

16.2 Duties

The faculty shall sustain active participation and involvement in the following:

a. Curriculum review and revision, decision-making, and implementation of the academic program;
b. Program assessment and evaluation, and implementation of continuous improvement of the program;
c. Development, improvement, and achievement of the course outcomes (COs);
d. Enrichment of teaching and learning activities (TLAs);
e. Development and improvement of assessment tasks, constructively aligned with COs and TLAs;
f. Student advising activities;
g. Linkages, professional/community extension services and community outreach programs;
h. Review and recommendations with regards to the library and other learning resources and the modernization/upgrading of the laboratory equipment and facilities; and
i. Professional development in research, scholarly work, and electrical engineering practice.

Section 17. Library and Other Learning Resources

The library services and other learning resources shall be adequate to support the scholarly and professional activities of the students and faculty. A progressive development plan and implementation report shall be periodically prepared as evidence in this regard.

The library collection and other learning resources shall be adequate and regularly updated to support the achievement of all program and course outcomes.

Details of the library services and other learning resources are covered in Section 2.3 of CMO No. 86 s. 2017.

Section 18. Laboratory Equipment and Resources

18.1 Facilities

Facilities are covered in Section 5.4 (2.4) of CMO No. 86 s. 2017

The program shall provide laboratories for the following courses:

1. Chemistry for Engineers
2. Physics for Engineers
3. Electrical Circuits 1, 2
4. Electronic Circuits: Devices and Analysis; Industrial Electronics
5. Electrical Machines 2; Electrical Apparatus and Devices
6. Instrumentation and Control

The program shall also provide computing facilities and licensed software and or freeware for the following courses: computer-aided drafting, computer programming, numerical methods and analysis, power systems analysis, and electrical systems and illumination engineering design.

Refer to **Annex IV** for the minimum laboratory equipment and resources required for the program.

The institution shall provide access to modern tools in EE. Examples of these tools are spreadsheet software, graphing software, mathematical software, statistical software, programming language environment, open or commercial simulation tools in EE, computer-aided circuit analysis design software, illumination engineering and design software, and power system analysis software. These modern tools shall be sufficient so that students can achieve the course outcomes.

18.2 Calibration of Equipment

The program shall ensure that there is a calibration program for all measuring instruments in its laboratories to ensure that they are working according to specifications. The date of the last calibration of each measuring instrument shall be indicated on each instrument.

18.3 Modernization of Equipment and Facilities

Each Department of the college of engineering shall have a program for the continuing modernization and upgrading of its instructional laboratories, facilities, and equipment. The said program shall have an adequate annual allocation in accordance with the financial capability of the school. Refer to CMO No. 86 s. 2017.

ARTICLE VII
COMPLIANCE OF HEIs

Section 19. Full Compliance with CMO 37 s. 2012

Before the start of AY 2018-2019, all HEIs offering the BSEE program must show evidence of full compliance with CMO 37 s. 2012 (Establishment of an Outcomes-Based Education System) by the following actions:

19.1 CMO 37 Monitoring Workbook and Self-Assessment Rubric

The Commission, through its Regional offices or the TPET Website shall make available to all HEIs currently offering or applying to offer the BS Electrical Engineering program a Monitoring Workbook (CMO 37-MW-2017-HEI-BSEE) and Self-Assessment Rubric (SAR) (CMO-37-HEI-SAR-2017-BSEE).

The five-year BSEE Curriculum shall be the basis of the monitoring. The completed Monitoring Workbook with a List of Supporting Evidences and Self-Assessment Rubric shall be submitted to CHED or online through the CHED TPET website (www.ched-tpet.org) within 30 working days after the effectivity of this CMO. Failure to submit these documents will disqualify the concerned HEIs from continuing or starting their BSEE program in AY 2018-2019.

19.2 Review of Submitted Forms by CHED

CHED shall review the submitted Monitoring Workbooks and Self-Assessment Rubrics, and may schedule monitoring visits to the HEI thereafter. These visits shall determine the extent of compliance of the concerned HEI with CMO 37 s. 2012. HEIs whose BSEE program incurs low SAR total scores shall be asked to submit a one- or two-year development plan to CHED before they shall be allowed to apply to continue their BSEE program for AY 2018-2019.

19.3 Exemptions

HEIs with BSEE programs that have applied as COEs/CODs during AY 2015-2016 and whose applications have been approved as COE or COD shall not be required to comply with Section 19.1 and 19.2. Instead, these HEIs must submit only their proposed four-year curriculum, corresponding curriculum map, and program of study using the Application Workbook for AY 2018-2019 (AW-2018-HEI-BSEE). See Section 20. Those HEIs whose COD/COE applications were disapproved for AY 2018-2019 must still comply with Sections 19.1 and 19.2.

Section 20. Application Workbook for AY 2018-2019

HEIs that will offer or continue to offer the BSEE program for AY 2018-2019 shall be made to complete a new Application Workbook (AW-2018- HEI-BSEE) which shall be made available through CHED or downloadable from the CHED-TPET website. The Application Workbook shall be completed and submitted to CHED or uploaded to the CHED-TPET website before the start of AY 2018-2019.

Section 21. Approval of Application

All HEIs whose BSEE program has a COE or COD status and has submitted the completed Application Workbook shall automatically receive certifications from CHED and shall be given approval to implement their BSEE program beginning AY 2018-2019.

Other concerned HEIs which have submitted their CMO Monitoring Workbook, Self-Assessment Rubrics, and Application Workbook shall be given conditional approval by CHED to start offering their new BSEE Curriculum following this CMO effective AY 2018-2019. However, CHED shall conduct monitoring of HEIs to assure complete compliance of this PSG within the transitory period, during which the HEI whose implementation of the BSEE program is weak shall be required to submit developmental plans.

ARTICLE VIII

TRANSITORY, REPEALING and EFFECTIVITY PROVISIONS

Section 22. Transitory Provision

All private HEIs, state universities and colleges (SUCs) and local universities and colleges (LUCs) with existing authorization to operate the BSEE program are hereby given a period of **three (3) years** from the effectivity thereof to fully comply with all the requirements in this CMO. However, the prescribed minimum curricular requirements in this CMO shall be implemented starting AY 2018-2019.

Section 23. Repealing Clause

Any provision of this Order, which may hereafter be held invalid, shall not affect the remaining provisions.

All CHED issuances or part thereof inconsistent with the provisions in this CMO shall be deemed modified or repealed.

Section 24. Effectivity Clause

This CMO shall take effect fifteen (15) days after its publication in the Official Gazette or in a newspaper of general circulation. This CMO shall be implemented beginning **AY 2018-2019**.

Quezon City, Philippines December 4, 2017

For the Commission:

PATRICIA B. LICUANAN, Ph.D.

Chairperson

Attachments:

Annex I – Competency Standards
Annex IA – IEA Graduate Attributes and Professional Competencies
Annex II – Minimum Program Outcomes and a Sample Curriculum Map
Annex III – Sample Course Specifications
Annex IV – Recommended Laboratory Equipment
  A. Natural/Physical Sciences
  B. Professional Courses
Annex V – Sample Course Syllabus

Electrical Engineer *(noun)* – is a professional who conceptualizes, develops, designs, improves and applies safe, healthy, ethical, economical and sustainable generation, transmission, distribution and utilization of electrical energy for the benefit of society and the environment through the knowledge of mathematics, physical sciences, information technology and other allied sciences, gained by study, research and practice.

ANNEX I - COMPETENCY STANDARDS
ATTRIBUTES AND COMPETENCIES OF AN ELECTRICAL ENGINEER

	ATTRIBUTES	COMPETENCY LEVEL		
		NEW GRADUATE	1 - 7 YEARS ENGG. EXPERIENCE	GLOBALLY QUALIFIED ENGINEER (APEC/ASEAN)
1	Apply knowledge of mathematics, chemistry, physics, Information Technology and other engineering principles	Understand the principles of mathematics, chemistry, physics, natural and applied sciences including information technology. Determine relevant and appropriate applied science, engineering principles and techniques that can be used to address engineering concerns related to the generation, transmission, distribution and utilization of electrical energy.	Use relevant and appropriate applied science, engineering principles and techniques in formulating electrical systems design and operations improvement and optimization. Develop simple computer programs to solve electrical engineering problems.	Propose innovations in electrical systems design and operations improvement and optimization and impart these to peers. Develop and continually upgrade proficiency in numerical and computational modeling in solving electrical engineering problems.
2	Identify, formulate, research literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.	Use relevant information gathered from research literature and other available technological information sources in coming out with solutions to complex engineering problems.	Apply results of research literature and other technological advances in electrical systems design and operations improvement and optimization. Propose changes in parameter settings used in electrical systems operations or lab-scale set-ups to achieve the desired outputs.	Consolidate results of research and technical information in formulating solutions to electrical engineering systems and adapt these into systems to achieve energy and process efficiency targets. Impart these technological advances to peers.

3	Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.	Study, investigate and gather data related to complex engineering problems and propose solutions based on the fundamentals of engineering principles while incorporating ethics, safety and environmental considerations.	Study, investigate and gather data related to problems in electrical systems and operations and prepare proposals to implement solutions while incorporating ethics, safety and environmental considerations. Conduct test runs and prepare final recommendations based on results gathered.	Consolidate studies made on problems in electrical systems and operations and propose changes in operational parameters. Specialize in specific fields of practice in the Electrical Engineering Profession and use the technical expertise in the design of solutions to applicable compex engineering problems. Prepare project proposals, budget and reports related to improvements and optimizatin of electrical systems and operations. Impart learnings to peers.
4	Conduct investigations of complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.	Conceptualize, formulate and implement design of experiments in a standard scientific manner in conducting investigations of complex engineering problems with consideration of cost, quality, security, and environmental impact. Recommend valid conclusions based on gathered information and results of investigation.	Use available database information, coordinate with other technical experts, plan and design experiments in conducting investigations of complex engineering problems. Conduct labscale and plant scale trials as may be deemed necessary to validate conclusions. Prepare reports and make presentations to concerned entities on the proposed solutions to the complex engineering problems.	Organize teams of experts, plan and design experiments in conducting investigations of complex engineering problems. Conduct labscale and plant scale trials as may be deemed necessary to validate conclusions. Prepare feasibility, optimization reports, implementation plans and make presentations to the concerned entities on the proposed solutions to the complex engineering problems.

5	Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to solve complex engineering problems, with an understanding of the limitations.	Be familiar with the appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering problems, with an understanding of the limitations. Recommend the applicable modern tools that can be used to solve complex engineering problems.	Be familiar with the appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering problems, with an understanding of the limitations. Consolidate applicable techniques and modern tools that can be used to solve complex engineering problems. Prepare recommendations based on results considering optimization, practical applications and limitations of systems parameters and equipment.	Be familiarized with the systems operations and applicable modern tools and techniques to solve operational problems taking into consideration process limitations. Use industrial experience in conjunction with technical expertise and appropriate modern tools in solving complex engineering problems. Prepare reports and recommendations and present these to the concerned entities.
6	Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solutions to complex engineering problems.	Be familiar with relevant policies, laws, regulations and technical standards locally in conjunction with the Electrical Engineering Professional Practice. Make a personal commitment to societal, health, safety, legal and cultural issues recognising obligations to society, subordinates, and the environment.	Be familiar with relevant policies, laws, regulations and technical standards both locally and internationally in conjunction with the Electrical Engineering Professional Practice. Prepare plans and designs to address electrical systems problems while taking into consideration moral, ethical and environmental concerns. Impart learning to peers.	Be familiar with relevant policies, laws, regulations and technical standards both locally and internationally in conjunction with the electrical Engineering Professional Practice. Be familiar with specific country regulations on professional engineering practice in implementing solutions to complex engineering problems. Prepare plans and designs to address electrical systems problems while taking into consideration moral, ethical and environmental concerns. Impart learning to peers.

7	Understand and evaluate the sustainability and impact of professional engineering work in the solution of complex engineering problems in societal and environmental contexts.	Be familiar with relevant applicable technical and engineering standards that can be applied in professional electrical engineering practice. Assess the effects of professional engineering work on electrical systems operational problems. Gather relevant data in relation to the professional engineering work.	Be familiar with relevant applicable technical and engineering standards that can be applied in professional electrical engineering practice. Use gained experience in industrial professional practice to measure impacts on society and environment. Be familiar with carbon footprint calculations, life cycle assessment, green technologies and other upcoming standards. Impart learning to peers.	Be familiar with relevant applicable technical and engineering standards that can be applied in professional electrical engineering practice. Use gained experience in industrial professional practice to measure impacts on society and environment. Be familiar with carbon footprint calculations, life cycle assessment, green technologies and other upcoming standards. Do research, develop projects and prepare implementation plans to implement and assess professional engineering works in relation to complex engineering problems. Impart learning to peers.
8	Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.	Be familiar with the Code of Ethics for Engineers and apply and behave according to this code in professional practice. Apply ethical principles in conjunction with engineering practice.	Be familiar with the Code of Ethics for Engineers and apply and behave according to this code in professional practice. Be familiar with corporate and industrial policies. Apply ethical principles in conjunction with engineering practice incorporating public safety as a priority. Be an example to upcoming engineers in terms of integrity, morality and ethics.	Be familiar with the Code of Ethics for Engineers and apply and behave according to this code in professional practice. Be familiar with corporate and industrial policies. Apply ethical principles in conjunction with engineering practice incorporating public safety as a priority. Be an example to upcoming engineers in terms of integrity, morality and ethics. Exemplify ethical and moral values through participation in socially relevant projects that contribute to national development. Impart learning to peers.

9	Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.	Perform functions required in the completion of a task as part of a project or endeavor or as an employee of a company. Interact with peers and higher levels in a professional manner. Participate in activities either as a team leader or member and perform designated tasks.	Plan, lead, coordinate and implement designated tasks either as a team leader or member. Interact with a network of professionals and participate in projects or activities. Handle small to medium-sized projects.	Supervise and manage electrical systems, people and facilities locally or internationally enabling efficiency, improved performance, business profitability and safety. Train other engineers.
10	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	Prepare reports, presentations and other engineering documents in an organized way and relay information related to these effectively. Communicate clearly both verbally and in written form all instructions to peers, subordinates and superiors as may be deemed necessary. Organize, coordinate and implement activities or projects in a clear way.	Prepare reports, presentations and other engineering documents in an organized way and relay information related to these effectively. Prepare policies, procedures and other documents related to an activity or project and cascade to subordinates, peers and superiors effectively. Conduct trainings to subordinates and peers. Communicate clearly with legal entities/ authorities regarding engineering activities.	Consolidate reports and make presentations to peers and superiors on projects or on assigned endeavors . Conduct trainings to subordinates, peers and superiors. Communicate and coordinate clearly and act as liaison officer on matters concerning legal or regulatory issues. Prepare policies, rules, regulations, instructions, procedures and implements them.
11	Demonstrate knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	Plan, lead, organize and control small projects or tasks as may be deemed necessary in the practice of electrical engineering.	Plan, lead, organize and control small to medium-sized projects or tasks as may be deemed necessary in the practice of electrical engineering. Manage financial aspects of the project. Supervise subordinates and peers when needed. Prepare reports related to projects.	Manage and implement medium-sized to major projects or tasks as may be deemed necessary in the practice of electrical engineering. Manage financial aspects of the project. Manage supervisors and peers. Prepare reports related to projects.

12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	Attend trainings, seminars, conferences or participate in projects that encourage continued learning in the electrical engineering profession. Pursue graduate studies.	Attend trainings, seminars, conferences and participate in professional organizations that encourage continued learning in the electrical engineering profession Pursue graduate studies. Comply with CPD units required annually. Conduct research studies and impart results to peers.	Attend trainings, seminars, conferences and participate in professional organizations that encourage continued learning in the electrical engineering profession. Prepare modules for training peers, subordinates and students. Organize seminars, trainings or conferences. Publish research papers.

Graduate Attributes and Professional Competencies

Version 3: 21 June 2013

This document is available through the IEA website: http://www.ieagreements.org.

Executive Summary

Several accrediting bodies for engineering qualifications have developed outcomes-based criteria for evaluating programmes. Similarly, a number of engineering regulatory bodies have developed or are in the process of developing competency-based standards for registration. Educational and professional accords for mutual recognition of qualifications and registration have developed statements of graduate attributes and professional competency profiles. This document presents the background to these developments, their purpose and the methodology and limitations of the statements. After defining general range statements that allow the competencies of the different categories to be distinguished, the paper presents the graduate attributes and professional competency profiles for three professional tracks: engineer, engineering technologist and engineering technician.

1 Introduction

Engineering is an activity that is essential to meeting the needs of people, economic development and the provision of services to society. Engineering involves the purposeful application of mathematical and natural sciences and a body of engineering knowledge, technology and techniques. Engineering seeks to produce solutions whose effects are predicted to the greatest degree possible in often uncertain contexts. While bringing benefits, engineering activity has potential adverse consequences. Engineering therefore must be carried out responsibly and ethically, use available resources efficiently, be economic, safeguard health and safety, be environmentally sound and sustainable and generally manage risks throughout the entire lifecycle of a system.

Typical engineering activity requires several roles including those of the engineer, engineering technologist and engineering technician, recognized as professional registration categories in many jurisdictions[1]. These roles are defined by their distinctive competencies and their level of responsibility to the public. There is a degree of overlap between roles. The distinctive competencies, together with their educational underpinnings, are defined in sections 4 to 6 of this document.

The development of an engineering professional in any of the categories is an ongoing process with important identified stages. The first stage is the attainment of an *accredited educational qualification*, the graduate stage. The fundamental purpose of *engineering education* is to build a

[1] The terminology used in this document uses the term *engineering* as an activity in a broad sense and *engineer* as shorthand for the various types of professional and chartered engineer. It is recognized that *engineers*, *engineering technologists* and *engineering technicians* may have specific titles or designations and differing legal empowerment or restrictions within individual jurisdictions.

knowledge base and attributes to enable the graduate to continue learning and to proceed to formative development that will develop the competencies required for independent practice. The second stage, following after a period of formative development, is *professional registration*. The fundamental purpose of formative development is to build on the educational base to develop the competencies required for independent practice in which the graduate works with engineering practitioners and progresses from an assisting role to taking more individual and team responsibility until competence can be demonstrated at the level required for registration. Once registered, the practitioner must maintain and expand competence.

For engineers and engineering technologists, a third milestone is to qualify for the *international register* held by the various jurisdictions. In addition, engineers, technologists and technicians are expected to maintain and enhance competency throughout their working lives.

Several international accords provide for recognition of graduates of accredited programmes of each signatory by the remaining signatories. The Washington Accord (WA) provides for mutual recognition of programmes accredited for the engineer track. The Sydney Accord (SA) establishes mutual recognition of accredited qualifications for engineering technologist. The Dublin Accord (DA) provides for mutual recognition of accredited qualifications for engineering technicians. These accords are based on the principle of substantial equivalence rather than exact correspondence of content and outcomes. This document records the signatories' consensus on the attributes of graduates for each accord.

Similarly, the International Professional Engineers Agreement[2] (IPEA) and the International Engineering Technologists Agreement[3] (IETA) provide mechanisms to support the recognition of a professional registered in one signatory jurisdiction obtaining recognition in another. The signatories have formulated consensus competency profiles for the registration and these are recorded in this document. While no competence forum currently exists for technicians, competency statements were also formulated for completeness and to facilitate any future development.

Section 2 give the background to the graduate attributes presented in section 5. Section 3 provides background to the professional competency profiles presented in section 6. General range statements are presented in section 4. The graduate attributes are presented in section 5 while the professional competency profiles are defined in section 6. Appendix A defines terms used in this document. Appendix B sketches the origin and development history of the graduate attributes and professional competency profiles.

2 Graduate Attributes

2.1 Purpose of Graduate Attributes

Graduate attributes form a set of individually assessable outcomes that are the components indicative of the graduate's potential to acquire competence to practise at the appropriate level. The graduate attributes are exemplars of the attributes expected of graduate from an accredited programme. Graduate attributes are clear, succinct statements of the expected capability, qualified if necessary by a range indication appropriate to the type of programme.

The graduate attributes are intended to assist Signatories and Provisional Members to develop outcomes-based accreditation criteria for use by their respective jurisdictions. Also, the graduate attributes guide bodies developing their accreditation systems with a view to seeking signatory status.

Graduate attributes are defined for educational qualifications in the engineer, engineering technologist and engineering technician tracks. The graduate attributes serve to identify the distinctive

[2] Formerly the Engineers Mobility Forum (EMF).

[3] Formerly the Engineering Technologists Mobility Forum (ETMF)

characteristics as well as areas of commonality between the expected outcomes of the different types of programmes.

2.2 Limitation of Graduate Attributes

Each signatory defines the standards for the relevant track (engineer, engineering technologist or engineering technician) against which engineering educational programmes are accredited. Each educational level accord is based on the principle of *substantial equivalence*, that is, programmes are not expected to have identical outcomes and content but rather produce graduates who could enter employment and be fit to undertake a programme of training and experiential learning leading to professional competence and registration. The graduate attributes provide a point of reference for bodies to describe the outcomes of substantially equivalent qualification. The graduate attributes do not, in themselves, constitute an "international standard" for accredited qualifications but provide a widely accepted common reference for bodies to describe the outcomes of substantially equivalent qualifications.

The term graduate does not imply a particular type of qualification but rather the exit level of the qualification, be it a degree or diploma.

2.3 Graduate Attributes and the Quality of Programmes

The Washington, Sydney and Dublin Accords "recognise the substantial equivalence of … programmes satisfying the academic requirements for practice …" for engineers, engineering technologists and engineering technicians respectively. The Graduate Attributes are assessable outcomes, supported by level statements, developed by the signatories that give confidence that the educational objectives of programmes are being achieved. The quality of a programme depends not only on the stated objectives and attributes to be assessed but also on the programme design, resources committed to the programme, the teaching and learning process and assessment of students, including confirmation that the graduate attributes are satisfied. The Accords therefore base the judgement of the substantial equivalence of programmes accredited by signatories on both the Graduate Attributes and the best practice indicators for evaluating programme quality listed in the Accords' Rules and Procedures[4].

2.4 Scope and Organisation of Graduate Attributes

The graduate attributes are organized using twelve headings shown in section 5.2. Each heading identifies the differentiating characteristic that allows the distinctive roles of engineers, technologists and technicians to be distinguished by range information.

For each attribute, statements are formulated for engineer, engineering technologist and engineering technician using a common stem, with ranging information appropriate to each educational track defined in sections 4.1 and 5.1. For example, for the **Knowledge of Engineering Sciences** attribute:

Common Stem: Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization …

> **Engineer Range:** … as described in the engineer knowledge profile to the solution of complex engineering problems.
> **Engineering Technologist Range:** … as described in the engineering technologist knowledge profile to defined and applied engineering procedures, processes, systems or methodologies.
> **Engineering Technician Range:** … as described in the engineering technician knowledge profile to wide practical procedures and practices.

[4] Accord Rules and Procedures. June 2012, section C.4.8. Available at www.ieagreements.org.

The resulting statements are shown below for this example:

... for Washington Accord Graduate	... for Sydney Accord Graduate	... for Dublin Accord Graduate
Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization as specified in WK1-WK4 respectively to the solution of complex engineering problems.	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization as specified in SK1-SK4 respectively to defined and applied engineering procedures, processes, systems or methodologies.	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization as specified in DK1-DK4 respectively to wide practical procedures and practices.

The range qualifier in several attribute statements uses the notions of *complex engineering problems*, *broadly-defined engineering problems* and *well-defined engineering problems*. These shorthand level descriptors are defined in section 4.1.

The attributes are chosen to be universally applicable and reflect acceptable minimum standards and be capable of objective measurement. While all attributes are important, individual attributes are not necessarily of equal weight. Attributes are selected that are expected to be valid for extended periods and changed infrequently only after considerable debate. Attributes may depend on information external to this document, for example generally accepted principles of ethical conduct.

The full set of graduate attribute definitions is given in section 5.

2.5 Contextual Interpretation

The graduate attributes are stated generically and are applicable to all engineering disciplines. In interpreting the statements within a disciplinary context, individual statements may be amplified and given particular emphasis but must not be altered in substance or individual elements ignored.

2.6 Best Practice in Application of Graduate Attributes

The attributes of Accord programmes are defined as a *knowledge profile*, an indicated volume of learning and the attributes against which graduates must be able to perform. The requirements are stated without reference to the design of programmes that would achieve the requirements. Providers therefore have freedom to design programmes with different detailed structure, learning pathways and modes of delivery. Evaluation of individual programmes is the concern of national accreditation systems.

3 Professional Competency Profiles

3.1 Purpose of Professional Competency Profiles

A professionally or occupationally *competent person* has the attributes necessary to perform the activities within the profession or occupation to the standards expected in independent employment or practice. The *professional competency profiles* for each professional category record the elements of competency necessary for competent performance that the professional is expected to be able to demonstrate in a holistic way at the stage of attaining registration.

Professional competence can be described using a set of attributes corresponding largely to the graduate attributes, but with different emphases. For example, at the professional level, the ability to take responsibility in a real-life situation is essential. Unlike the graduate attributes, professional competence is more than a set of attributes that can be demonstrated individually. Rather, competence must be assessed holistically.

3.2 Scope and Organisation of Professional Competency Profiles

The professional competency profiles are written for each of the three categories: engineer, engineering technologist and engineering technician at the point of registration[5]. Each profile consists of thirteen elements. Individual elements are formulated around a differentiating characteristic using a stem and modifier, similarly to the method used for the graduate attributes described in section 2.3.

The stems are common to all three categories and the range modifiers allow distinctions and commonalities between categories to be identified. Like their counterparts in the graduate attributes, the range statements use the notions of complex engineering problems, broadly-defined engineering problems and well-defined engineering problems defined in section 4.1. At the professional level, a classification of engineering activities is used to define ranges and to distinguish between categories. Engineering activities are classified as *complex*, *broadly-defined* or *well-defined*. These shorthand level descriptors are defined in section 4.2.

3.3 Limitations of Professional Competency Profile

As in the case of the graduate attributes, the professional competency profiles are not prescriptive in detail but rather reflect the essential elements that would be present in competency standards.

The professional competency profiles do not specify performance indicators or how the above items should be interpreted in assessing evidence of competence from different areas of practice or for different types of work. Section 3.4 examines contextual interpretation.

Each jurisdiction may define *performance indicators*, that is actions on the part of the candidate that demonstrate competence. For example, a design competency may be evidenced by the following performances:

1: Identify and analyse design/ planning requirement and draw up detailed requirements specification
2: Synthesise a range of potential solutions to problem or approaches to project execution
3: Evaluate the potential approaches against requirements and impacts outside requirements
4: Fully develop design of selected option
5: Produce design documentation for implementation

3.4 Contextual Interpretation

Demonstration of competence may take place in different areas of practice and different types of work. Competence statements are therefore discipline-independent. Competence statements accommodate different types of work, for example design, research and development and engineering management by using the broad phases in the cycle of engineering activity: problem analysis, synthesis, implementation, operation and evaluation, together the management attributes needed. The competence statements include the personal attributes needed for competent performance irrespective of specific local requirements: communication, ethical practice, judgement, taking responsibility and the protection of society.

The professional competency profiles are stated generically and are applicable to all engineering disciplines. The application of a competency profile may require amplification in different regulatory, disciplinary, occupational or environmental contexts. In interpreting the statements within a particular context, individual statements may be amplified and given particular emphasis but must not be altered in substance or ignored.

3.5 Mobility between Professional Categories

The graduate attributes and professional competency for each of three categories of engineering practitioner define the benchmark route or vertical progression in each category. This document does

[5] Requirements for the IEPA and IETA International Registers call for enhanced competency and responsibility.

not address the movement of individuals between categories, a process that usually required additional education, training and experience. The graduate attributes and professional competencies, through their definitions of level of demand, knowledge profile and outcomes to be achieved, allow a person planning such a change to gauge the further learning and experience that will be required. The education and registration requirements of the jurisdiction should be examined for specific requirements.

4 Common Range and Contextual Definitions

4.1 Range of Problem Solving

References to the Knowledge Profile are shown thus: (WK3, WK4 ...)

In the context of both Graduate Attributes and Professional Competencies:			
Attribute	***Complex Engineering Problems*** have characteristic WP1 and some or all of WP2 to WP7:	***Broadly-defined Engineering Problems*** **have characteristic SP1 and some or all of SP2 to SP7:**	***Well-defined Engineering Problems***have characteristic DP1 and some or all of DP2 to DP7:
Depth of Knowledge Required	**WP1:** Cannot be resolved without in-depth engineering knowledge at the level of one or more of WK3, WK4, WK5, WK6 or WK8 which allows a fundamentals-based, first principles analytical approach	**SP1:** Cannot be resolved without engineering knowledge at the level of one or more of SK 4, SK5, and SK6 supported by SK3 with a strong emphasis on the application of developed technology	**DP1:** Cannot be resolved without extensive practical knowledge as reflected in DK5 and DK6 supported by theoretical knowledge defined in DK3 and DK4
Range of conflicting requirements	**WP2:** Involve wide-ranging or conflicting technical, engineering and other issues	**SP2:** Involve a variety of factors which may impose conflicting constraints	**DP2:** Involve several issues, but with few of these exerting conflicting constraints
Depth of analysis required	**WP3:** Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models	**SP3:** Can be solved by application of well-proven analysis techniques	**DP3:** Can be solved in standardised ways
Familiarity of issues	**WP4:** Involve infrequently encountered issues	**SP4:** Belong to families of familiar problems which are solved in well-accepted ways	**DP4:** Are frequently encountered and thus familiar to most practitioners in the practice area
Extent of applicable codes	**WP5:** Are outside problems encompassed by standards and codes of practice for professional engineering	**SP5:** May be partially outside those encompassed by standards or codes of practice	**DP5:** Are encompassed by standards and/or documented codes of practice
Extent of stakeholder involvement and conflicting requirements	**WP6:** Involve diverse groups of stakeholders with widely varying needs	**SP6:** Involve several groups of stakeholders with differing and occasionally conflicting needs	**DP6:** Involve a limited range of stakeholders with differing needs
Interdependence	**WP 7:** Are high level problems including many component parts or sub-problems	**SP7:** Are parts of, or systems within complex engineering problems	**DP7:** Are discrete components of engineering systems
In addition, in the context of the Professional Competencies			
Consequences	**EP1:** Have significant consequences in a range of contexts	**TP1:**Have consequences which are important locally, but may extend more widely	**NP1:** Have consequences which are locally important and not far-reaching
Judgement	**EP2:** Require judgement in decision making	**TP2:** Require judgement in decision making	

4.2 Range of Engineering Activities

Attribute	Complex Activities	Broadly-defined Activities	Well-defined Activities
Preamble	**Complex activities** means *(engineering)* activities or projects that have some or all of the following characteristics:	**Broadly defined activities** means *(engineering)* activities or projects that have some or all of the following characteristics:	**Well-defined activities** means *(engineering)* activities or projects that have some or all of the following characteristics:
Range of resources	**EA1:** Involve the use of diverse resources (and for this purpose resources includes people, money, equipment, materials, information and technologies)	**TA1:** Involve a variety of resources (and for this purposes resources includes people, money, equipment, materials, information and technologies)	**NA1:** Involve a limited range of resources (and for this purpose resources includes people, money, equipment, materials, information and technologies)
Level of interactions	**EA2:** Require resolution of significant problems arising from interactions between wide-ranging or conflicting technical, engineering or other issues,	**TA2:** Require resolution of occasional interactions between technical, engineering and other issues, of which few are conflicting	**NA2:** Require resolution of interactions between limited technical and engineering issues with little or no impact of wider issues
Innovation	**EA3:** Involve creative use of engineering principles and research-based knowledge in novel ways.	**TA3:** Involve the use of new materials, techniques or processes in non-standard ways	**NA3:** Involve the use of existing materials techniques, or processes in modified or new ways
Consequences to society and the environment	**EA4:** Have significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation	**TA4:** Have reasonably predictable consequences that are most important locally, but may extend more widely	**NA4:** Have consequences that are locally important and not far-reaching
Familiarity	**EA5:** Can extend beyond previous experiences by applying principles-based approaches	**TA5:** Require a knowledge of normal operating procedures and processes	**NA5:** Require a knowledge of practical procedures and practices for widely-applied operations and processes

5 Accord programme profiles

The following tables provides profiles of graduates of three types of tertiary education engineering programmes. See section 4 for definitions of complex engineering problems, broadly-defined engineering problems and well-defined engineering problems.

5.1 Knowledge profile

A Washington Accord programme provides:	**A Sydney Accord programme** provides:	**A Dublin Accord programme** provides:
WK1: A systematic, theory-based understanding of the **natural sciences** applicable to the discipline	**SK1:** A systematic, theory-based understanding of the **natural sciences** applicable to the sub-discipline	**DK1:** A descriptive, formula-based understanding of the **natural sciences** applicable in a sub-discipline
WK2: Conceptually-based **mathematics**, numerical analysis, statistics and formal aspects of computer and information science to support analysis and modelling applicable to the discipline	**SK2:** Conceptually-based **mathematics**, numerical analysis, statistics and aspects of computer and information science to support analysis and use of models applicable to the sub-discipline	**DK2:** Procedural **mathematics**, numerical analysis, statistics applicable in a sub-discipline
WK3: A systematic, theory-based formulation of **engineering fundamentals** required in the engineering discipline	**SK3:** A systematic , theory-based formulation of **engineering fundamentals** required in an accepted sub-discipline	**DK3:** A coherent procedural formulation of **engineering fundamentals** required in an accepted sub-discipline
WK4: Engineering **specialist knowledge** that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.	**SK4:** Engineering **specialist knowledge** that provides theoretical frameworks and bodies of knowledge for an accepted sub-discipline	**DK4:** Engineering **specialist knowledge** that provides the body of knowledge for an accepted sub-discipline
WK5: Knowledge that supports **engineering design** in a practice area	**SK5:** Knowledge that supports **engineering design** using the technologies of a practice area	**DK5:** Knowledge that supports **engineering design** based on the techniques and procedures of a practice area
WK6: Knowledge of **engineering practice** (technology) in the practice areas in the engineering discipline	**SK6:** Knowledge of **engineering technologies** applicable in the sub-discipline	**DK6:** Codified **practical engineering knowledge** in recognised practice area.
WK7: Comprehension of the role of engineering in society and identified issues in engineering practice in the discipline: ethics and the professional responsibility of an engineer to public safety; the impacts of engineering activity: economic, social, cultural, environmental and sustainability	**SK7: Comprehension of** the role of technology in society and identified issues in applying engineering technology: ethics and impacts: economic, social, environmental and sustainability	**DK7: Knowledge** of issues and approaches in engineering technician practice: ethics, financial, cultural, environmental and sustainability impacts
WK8: Engagement with selected knowledge in the **research literature** of the discipline	**SK8:** Engagement with the **technological literature** of the discipline	
A programme that builds this type of knowledge and develops the attributes listed below is typically achieved in 4 to 5 years of study, depending on the level of students at entry.	A programme that builds this type of knowledge and develops the attributes listed below is typically achieved in 3 to 4 years of study, depending on the level of students at entry.	A programme that builds this type of knowledge and develops the attributes listed below is typically achieved in 2 to 3 years of study, depending on the level of students at entry.

5.2 Graduate Attribute Profiles

References to the Knowledge Profile are shown thus: (WK1 to WK4)

Differentiating Characteristic	... for Washington Accord Graduate	... for Sydney Accord Graduate	... for Dublin Accord Graduate
Engineering Knowledge:	**WA1:** Apply knowledge of mathematics, natural science, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to the solution of complex engineering problems.	**SA1:** Apply knowledge of mathematics, natural science, engineering fundamentals and an engineering specialization as specified in SK1 to SK4 respectively to defined and applied engineering procedures, processes, systems or methodologies.	**DA1:** Apply knowledge of mathematics, natural science, engineering fundamentals and an engineering specialization as specified in DK1 to DK4 respectively to wide practical procedures and practices.
Problem Analysis Complexity of analysis	**WA2:** Identify, formulate, research literature and analyse *complex* engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences. (WK1 to WK4)	**SA2:** Identify, formulate, research literature and analyse *broadly-defined* engineering problems reaching substantiated conclusions using analytical tools appropriate to the discipline or area of specialisation. (SK1 to SK4)	**DA2:** Identify and analyse *well-defined* engineering problems reaching substantiated conclusions using codified methods of analysis specific to their field of activity. (DK1 to DK4)
Design/ development of solutions: Breadth and uniqueness of engineering problems i.e. the extent to which problems are original and to which solutions have previously been identified or codified	**WA3:** Design solutions for *complex* engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations. (WK5)	**SA3:** Design solutions for *broadly- defined* engineering technology problems and *contribute to* the design of systems, components or processes to meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations. (SK5)	**DA3:** Design solutions for *well-defined* technical problems and *assist with* the design of systems, components or processes to meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations. (DK5)
Investigation: Breadth and depth of investigation and experimentation	**WA4:** Conduct investigations of *complex* problems using research-based knowledge (WK8) and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.	**SA4:** Conduct investigations of *broadly-defined* problems; locate, search and select relevant data from codes, data bases and literature (SK8), design and conduct experiments to provide valid conclusions.	**DA4:** Conduct investigations of *well-defined* problems; locate and search relevant codes and catalogues, conduct standard tests and measurements.
Modern Tool Usage: Level of understanding of the appropriateness of the tool	**WA5:** Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to *complex* engineering problems, with an understanding of the limitations. (WK6)	**SA5:** Select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to *broadly-defined* engineering problems, with an understanding of the limitations. (SK6)	**DA5:** Apply appropriate techniques, resources, and modern engineering and IT tools to *well-defined* engineering problems, with an awareness of the limitations. (DK6)

The Engineer and Society: Level of knowledge and responsibility	**WA6:** Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solutions to complex engineering problems. (WK7)	**SA6:** Demonstrate understanding of the societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to engineering technology practice and solutions to broadly defined engineering problems. (SK7)	**DA6:** Demonstrate knowledge of the societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to engineering technician practice and solutions to well defined engineering problems. (DK7)
Environment and Sustainability: Type of solutions.	**WA7:** Understand and evaluate the sustainability and impact of professional engineering work in the solution of complex engineering problems in societal and environmental contexts. (WK7)	**SA7:** Understand and evaluate the sustainability and impact of engineering technology work in the solution of broadly defined engineering problems in societal and environmental contexts. (SK7)	**DA7:** Understand and evaluate the sustainability and impact of engineering technician work in the solution of well defined engineering problems in societal and environmental contexts. (DK7)
Ethics: Understanding and level of practice	**WA8:** Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice. (WK7)	**SA8:** Understand and commit to professional ethics and responsibilities and norms of engineering technology practice. (SK7)	**DA8:** Understand and commit to professional ethics and responsibilities and norms of technician practice. (DK7)
Individual and Team work: Role in and diversity of team	**WA9:** Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.	**SA9:** Function effectively as an individual, and as a member or leader in diverse teams.	**DA9:** Function effectively as an individual, and as a member in diverse technical teams.
Communication: Level of communication according to type of activities performed	**WA10:** Communicate effectively on *complex* engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	**SA10:** Communicate effectively on *broadly-defined* engineering activities with the engineering community and with society at large, by being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	**DA10:** Communicate effectively on *well-defined* engineering activities with the engineering community and with society at large, by being able to comprehend the work of others, document their own work, and give and receive clear instructions
Project Management and Finance: Level of management required for differing types of activity	**WA11:** Demonstrate knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	**SA11:** Demonstrate knowledge and understanding of engineering management principles and apply these to one's own work, as a member or leader in a team and to manage projects in multidisciplinary environments.	**DA11:** Demonstrate knowledge and understanding of engineering management principles and apply these to one's own work, as a member or leader in a technical team and to manage projects in multidisciplinary environments.
Lifelong learning: Preparation for and depth of continuing learning.	**WA12:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	**SA12:** Recognize the need for, and have the ability to engage in independent and life-long learning in specialist technologies.	**DA12:** Recognize the need for, and have the ability to engage in independent updating in the context of specialized technical knowledge.

6 Professional Competency Profiles

To meet the minimum standard of competence a person must demonstrate that he/she is able to practice competently in his/her practice area to the standard expected of a reasonable Professional Engineer/Engineering Technologist/Engineering Technician.

The extent to which the person is able to perform each of the following elements in his/her practice area must be taken into account in assessing whether or not he/she meets the overall standard.

Differentiating Characteristic	Professional Engineer	Engineering Technologist	Engineering Technician
Comprehend and apply universal knowledge: Breadth and depth of education and type of knowledge	**EC1:** Comprehend and apply advanced knowledge of the widely-applied principles underpinning good practice	**TC1:** Comprehend and apply the knowledge embodied in widely accepted and applied procedures, processes, systems or methodologies	**NC1:** Comprehend and apply knowledge embodied in standardised practices
Comprehend and apply local knowledge: Type of local knowledge	**EC2:** Comprehend and apply advanced knowledge of the widely-applied principles underpinning good practice specific to the jurisdiction in which he/she practices.	**TC2:** Comprehend and apply the knowledge embodied procedures, processes, systems or methodologies that is specific to the jurisdiction in which he/she practices.	**NC2:** Comprehend and apply knowledge embodied in standardised practices specific to the jurisdiction in which he/she practices.
Problem analysis: Complexity of analysis	**EC3:** Define, investigate and analyse complex problems	**TC3:** Identify, clarify, and analyse broadly-defined problems	**NC3:** Identify, state and analyse well-defined problems
Design and development of solutions: Nature of the problem and uniqueness of the solution	**EC4:** Design or develop solutions to complex problems	**TC4:** Design or develop solutions to broadly-defined problems	**NC4:** Design or develop solutions to well-defined problems
Evaluation: Type of activity	**EC5:** Evaluate the outcomes and impacts of complex activities	**TC4:** Evaluate the outcomes and impacts of broadly defined activities	**NC5:** Evaluate the outcomes and impacts of well-defined activities
Protection of society: Types of activity and responsibility to public	**EC6:** Recognise the reasonably foreseeable social, cultural and environmental effects of complex activities generally, and have regard to the need for sustainability; recognise that the protection of society is the highest priority	**TC6:** Recognise the reasonably foreseeable social, cultural and environmental effects of broadly-defined activities generally, and have regard to the need for sustainability; take responsibility in all these activities to avoid putting the public at risk.	**NC6:** Recognise the reasonably foreseeable social, cultural and environmental effects of well-defined activities generally, and have regard to the need for sustainability; use engineering technical expertise to prevent dangers to the public.

Legal and regulatory: No differentiation in this characteristic	**EC7:** Meet all legal and regulatory requirements and protect public health and safety in the course of his or her activities	**TC7:** Meet all legal and regulatory requirements and protect public health and safety in the course of his or her activities	**NC7:** Meet all legal and regulatory requirements and protect public health and safety in the course of his or her activities
Ethics: No differentiation in this characteristic	**EC8:** Conduct his or her activities ethically	**TC8:** Conduct his or her activities ethically	**NC8:** Conduct his or her activities ethically
Manage engineering activities: Types of activity	**EC9:** Manage part or all of one or more complex activities	**TC9:** Manage part or all of one or more broadly-defined activities	**NC9:** Manage part or all of one or more well-defined activities
Communication: No differentiation in this characteristic	**EC10:** Communicate clearly with others in the course of his or her activities	**TC10:** Communicate clearly with others in the course of his or her activities	**NC10:** Communicate clearly with others in the course of his or her activities
Lifelong learning: Preparation for and depth of continuing learning.	**EC11:** Undertake CPD activities sufficient to maintain and extend his or her competence	**TC11:** Undertake CPD activities sufficient to maintain and extend his or her competence	**NC11:** Undertake CPD activities sufficient to maintain and extend his or her competence
Judgement: Level of developed knowledge, and ability and judgement in relation to type of activity	**EC11:** Recognize complexity and assess alternatives in light of competing requirements and incomplete knowledge. Exercise sound judgement in the course of his or her complex activities	**TC12:** Choose appropriate technologies to deal with broadly defined problems. Exercise sound judgement in the course of his or her broadly-defined activities	**NC12:** Choose and apply appropriate technical expertise. Exercise sound judgement in the course of his or her well-defined activities
Responsibility for decisions: Type of activity for which responsibility is taken	**EC12:** Be responsible for making decisions on part or all of complex activities	**TC13:** Be responsible for making decisions on part or all of one or more broadly defined activities	**NC13:** Be responsible for making decisions on part or all of all of one or more well-defined activities

Appendix A: Definitions of terms

Note: These definitions apply to terms used in this document but also indicate equivalence to terms used in other engineering education standards.

Branch of engineering: a generally-recognised, major subdivision of engineering such as the traditional *disciplines* of Chemical, Civil, or Electrical Engineering, or a cross-disciplinary field of comparable breadth including combinations of engineering fields, for example Mechatronics, and the application of engineering in other fields, for example Bio-Medical Engineering.

Broadly-defined engineering problems: a class of problem with characteristics defined in section 4.1.

Broadly-defined engineering activities: a class of activities with characteristics defined in section 4.2.

Complementary (contextual) knowledge: Disciplines other than engineering, basic and mathematical sciences, that support engineering practice, enable its impacts to be understood and broaden the outlook of the engineering graduate.

Complex engineering problems: a class of problem with characteristics defined in section 4.1.

Complex engineering activities: a class of activities with characteristics defined in section 4.2.

Continuing Professional Development: the systematic, accountable maintenance, improvement and broadening of knowledge and skills, and the development of personal qualities necessary for the execution of professional and technical duties throughout an engineering practitioner's career.

Engineering sciences: include engineering fundamentals that have roots in the mathematical and physical sciences, and where applicable, in other natural sciences, but extend knowledge and develop models and methods in order to lead to applications and solve problems, providing the knowledge base for engineering specializations.

Engineering design knowledge: Knowledge that supports engineering design in a practice area, including codes, standards, processes, empirical information, and knowledge reused from past designs.

Engineering discipline: synonymous with *branch of engineering.*

Engineering fundamentals: a systematic formulation of engineering concepts and principles based on mathematical and natural sciences to support applications.

Engineering management: the generic management functions of planning, organising, leading and controlling, applied together with engineering knowledge in contexts including the management of projects, construction, operations, maintenance, quality, risk, change and business.

Engineering problem: is a problem that exists in any domain that can be solved by the application of engineering knowledge and skills and generic competencies.

Engineering practice area: a generally accepted or legally defined area of engineering work or engineering technology.

Engineering speciality or specialization: a generally-recognised practice area or major subdivision within an engineering discipline, for example Structural and Geotechnical Engineering within Civil Engineering; the extension of engineering fundamentals to create theoretical frameworks and bodies of knowledge for engineering practice areas.

Engineering technology: is an established body of knowledge, with associated tools, techniques, materials, components, systems or processes that enable a family of practical applications and that relies for its development and effective application on engineering knowledge and competency.

Forefront of the professional discipline/branch[6]**:** defined by advanced practice in the specialisations within the discipline.

Formative development: the process that follows the attainment of an accredited education programme that consists of training, experience and expansion of knowledge.

Manage: means planning, organising, leading and controlling in respect of risk, project, change, financial, compliance, quality, ongoing monitoring, control and evaluation.

Mathematical sciences: mathematics, numerical analysis, statistics and aspects of computer science cast in an appropriate mathematical formalism.

Natural sciences: Provide, as applicable in each engineering discipline or practice area, an understanding the physical world including physics, mechanics, chemistry, earth sciences and the biological sciences,

Practice area: *in the educational context:* synonymous with generally-recognised engineering speciality; *at the professional level:* a generally recognised or distinctive area of knowledge and expertise developed by an engineering practitioner by virtue of the path of education, training and experience followed.

Solution: means an effective proposal for resolving a problem, taking into account all relevant technical, legal, social, cultural, economic and environmental issues and having regard to the need for sustainability.

Subdiscipline: Synonymous with *engineering speciality.*

Substantial equivalence: applied to educational programmes means that two or more programmes, while not meeting a single set of criteria, are both acceptable as preparing their respective graduates to enter formative development toward registration.

Well-defined engineering problems: a class of problem with characteristics defined in section 4.1.

Well-defined engineering activities: a class of activities with characteristics defined in section 4.2.

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[6] This should be distinguished from: **Forefront of knowledge in an engineering discipline/speciality**: defined by current published research in the discipline or speciality.

Appendix B: History of Graduate Attributes and Professional Competency Profiles

The signatories to the Washington Accord recognized the need to describe the attributes of a graduate of a Washington Accord accredited program. Work was initiated at its June 2001 meeting held at Thornybush, South Africa. At the International Engineering Meetings (IEM) held in June 2003 at Rotorua, New Zealand, the signatories to the Sydney Accord and the Dublin Accord recognized similar needs. The need was recognized to distinguish the attributes of graduates of each type of programme to ensure fitness for their respective purposes.

The Engineers Mobility Forum (EMF) and Engineering Technologist Mobility Forum (ETMF)[7] have created international registers in each jurisdiction with current admission requirements based on registration, experience and responsibility carried. The mobility agreements recognize the future possibility of competency-based assessment for admission to an international register. At the 2003 Rotorua meetings, the mobility fora recognized that many jurisdictions are in the process of developing and adopting competency standards for professional registration. The EMF and the ETMF therefore resolved to define assessable sets of competencies for engineer and technologist. While no comparable mobility agreement exists for technicians, the development of a corresponding set of standards for engineering technicians was felt to be important to have a complete description of the competencies of the engineering team.

Version 1

A single process was therefore agreed to develop the three sets of graduate attributes and three professional competency profiles. An International Engineering Workshop (IEWS) was held by the three educational accord and the two mobility fora in London in June 2004 to develop statements of Graduate Attributes and International Register Professional Competency Profiles for the Engineer, Engineering Technologist and Engineering Technician categories. The resulting statements were then opened for comment by the signatories. The comments received called for minor changes only.

The Graduate Attributes and Professional Competencies were adopted by the signatories of the five agreements in June 2005 at Hong Kong as version 1.1.

Version 2

A number of areas of improvement in the Graduate Attributes and Professional Competencies themselves and their potential application were put to the meetings of signatories in Washington DC in June 2007. A working group was set up to address the issues. The IEA workshop held in June 2008 in Singapore considered the proposals of the working group and commissioned the Working Group to make necessary changes with a view to presenting Version 2 of the document for approval by the signatories at their next general meetings. Version 2 was approved at the Kyoto IEA meetings, 15-19 June 2009.

Version 3

Between 2009 and 2012 a number of possible improvements to the graduate attributes were recorded. During 2012 signatories performed an analysis of gaps between their respective standards and the Graduate Attribute exemplars and by June 2013 most signatories reported substantial equivalence of their standards to the Graduate Attributes. This will be further examined in periodic monitoring reviews in 2014 to 2019. In this process a number of improvements to the wording of the Graduate Attributes and supporting definitions were identified. The signatories to the Washington, Sydney and Dublin Accords approved the changes resulting in this Version 3 at their meetings in Seoul 17-21 June 2013. Signatories stated that the objectives of the changes were to clarify aspects of the Graduate Attribute exemplar. There was no intent to raise the standard. The main changes were as follows:

- New Section 2.3 inserted;
- Range of problem solving in section 4.1 linked to the Knowledge Profiles in section 5.1 and duplication removed;
- Graduate Attributes in section 5.2: cross-references to Knowledge Profile elements inserted; improved wording in attributes 6, 7 and 11;
- Appendix A: definitions of *engineering management* and *forefront of discipline* added.

[7] Now the IEPA and IETA respectively.

ANNEX II - *SAMPLE* Curriculum Mapping

LEGEND	
Code	**Description**
I	An **introductory** course to an outcome
E	An **enabling** course that strengthens the outcome
D	A course that **demonstrates** an outcome

Program Outcomes

By the time of graduation, students of the program shall have developed the ability to:

a) Apply knowledge of mathematics and sciences to solve complex engineering problems;
b) Develop and conduct appropriate experimentation, analyze and interpret data;
c) Design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability, in accordance with standards;
d) Function effectively on multi-disciplinary and multi-cultural teams that establish goals, plan tasks, and meet deadlines; *(based on **PQF Level 6 descriptor**)*
e) Identify, formulate and solve complex problems in electrical engineering;
f) Recognize ethical and professional responsibilities in engineering practice;
g) Communicate effectively with a range of audiences;
h) Understand the impact of engineering solutions in a global, economic, environmental, and societal context;
i) Recognize the need for additional knowledge and engage in lifelong learning;
j) Articulate and discuss the latest developments in the field of electrical engineering; ***(PQF Level 6 descriptor)***
k) Apply techniques, skills, and modern engineering tools necessary for electrical engineering practice; and
l) Demonstrate knowledge and understanding of engineering and management principles as a member and/or leader in a team to manage projects in multidisciplinary environments.

Courses	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
Mathematics												
Calculus 1	I											
Calculus 2	I											
Engineering Data Analysis			I		I						I	
Differential Equations	I				I							
Physical Sciences												
Chemistry for Engineers	I	I										
Physics for Engineers	I	I										
Engineering Sciences												
Computer-aided Drafting			I				I				I	
Engineering Mechanics	I											
Engineering Economics					I						I	
Allied Courses												
Fundamentals of Deformable Bodies	I											
Electronic Circuits: Devices and Analysis		E			E		I					
Basic Thermodynamics	I											
Industrial Electronics		E			E		I					
Electromagnetics	I				I		I					
Fluid Mechanics	I											
Fundamentals of Electronic Communications							E					
Logic Circuits and Switching Theory			I		I		I					
Microprocessor Systems			I		I		I				I	
Computer Programming											E	
Basic Occupational Safety and Health			I			E		E				
Environmental Science and Engineering						E	I	E				
Materials Science and Engineering						E	I	E		I		
Technopreneurship			I	I		I	E	I	I			I
Professional Courses												
Engineering Mathematics for EE	D				E						I	
Numerical Methods and Analysis	D				E		I				E	
Fundamentals of Power Plant Engineering Design			E			E	E					
Management of Engineering Projects				I		E	E			I		E
Distribution Systems and Substation Design			D		E	I	E	E				
Feedback Control Systems	D				I		E				I	
EE Law, Codes, and Professional Ethics						D	E	E				I
Electrical Standards and Practices			E			D	E		E			
Electrical Circuits 1		E			E		E					
Electrical Circuits 2		E			E		E					

Electrical Apparatus and Devices		E			E		E					
Electrical Machines 1					E		E					
Electrical Machines 2		E			E		E					
Electrical Systems and Illumination Engineering Design			D	I	D	E	D			E		
Power Systems Analysis			E		D		D			E	D	
Research Methods							D	E	E	E		
Research Project or Capstone Design Project			D	E		D	D	D		E	E	
Instrumentation and Control		D					E					
Seminars/Colloquia							D	D	D	E		
On-the-job Training				D		D	D	D		E		E
ELECTIVES 1, 2					E	E	D	D	D	E	E	

Courses	**Program Outcomes**											
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**
Non-Technical Courses												
Science, Technology and Society						I	I	I		I		
Contemporary World							I	I				
Readings in Philippine History							I					
Understanding the Self				I		I	E					
Art Appreciation							I					
Purposive Communication							D					
Mathematics in the Modern World	I							I				
Ethics				I		E	I					
GEC Elective 1							E					
GEC Elective 2							E					
GEC Elective 3							E					
Life and Works of Rizal							E					
Physical Education												
NSTP												

ANNEX III – SAMPLE COURSE SPECIFICATIONS

Bachelor of Science in Electrical Engineering

Table of Contents

5.11. Electrical Systems and Illumination Engineering Design
5.12. Power Systems Analysis
5.13. Fundamentals of Power Plant Engineering Design
5.14. Distribution Systems and Substation Design
5.15. Research Methods
5.16. Research Project or Capstone Design Project
5.17. Instrumentation and Control
5.18. Feedback Control Systems
5.19. Seminars/Colloquia
5.20. On-the-job Training
5.21. Elective 1
5.22. Elective 2

6. General Education Courses
7. Technopreneurship Course

1. MATHEMATICS

Course Name	**CALCULUS 1**
Course Description	Basic concepts of calculus such as limits, continuity and differentiability of functions; differentiation of algebraic and transcendental functions involving one or more variables; applications of differential calculus to problems on optimization, rates of change, related rates, tangents and normals, and approximations; partial differentiation and transcendental curve tracing.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	Algebra and Trigonometry (as needed)
Program Outcome	a. ability to apply knowledge of mathematics and sciences to solve complex engineering problems
Course Outcomes	After completing this course, the student shall be able to: 1. Differentiate algebraic and transcendental functions. 2. Apply the concept of differentiation in solving word problems. 3. Analyze and trace transcendental curves.
Course Outline	1. Functions 2. Continuity and Limits 3. The Derivative 4. The Slope 5. Rate of Change 6. The Chain Rule and the General Power Rule 7. Implicit Differentiation 8. Higher-Order Derivatives 9. Polynomial Curves 10. Applications of the Derivative 11. The Differential 12. Derivatives of Trigonometric Functions 13. Derivative of Inverse Trigonometric Functions 14. Derivative of Logarithmic and Exponential Functions 15. Derivative of the Hyperbolic Functions 16. Solutions of Equations 17. Transcendental Curve Tracing 18. Parametric Equations 19. Partial Differentiation

Course Name	**CALCULUS 2**
Course Description	Concept of integration and its application to physical problems such as evaluation of areas, volumes of revolution, force, and work; fundamental formulas and various techniques of integration applied to both single variable and multi-variable functions; tracing of functions of two variables.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	Calculus 1
Program Outcome	a. ability to apply knowledge of mathematics and sciences to solve complex engineering problems
Course Outcomes	After completing this course, the student shall be able to: 1. Properly carry out integration through the use of the fundamental formulas and/or the various techniques of integration for both single and multiple integrals; 2. Correctly apply the concept of integration in solving problems involving evaluation of areas, volumes, work, and force; 3. Sketch 3-dimensional regions bounded by several surfaces; and 4. Evaluate volumes of 3-dimensional regions bounded by two or more surfaces through the use of the double or triple integral.
Course Outline	1. Integration Concept / Formulas 1.1. Anti-Differentiation 1.2. Indefinite Integrals 1.3. Simple Power Formula 1.4. Simple Trigonometric Functions 1.5. Logarithmic Function 1.6. Exponential Function 1.7. Inverse Trigonometric Functions 1.8. Hyperbolic Functions 1.9. General Power Formula 1.10. Constant of Integration 1.11. Definite Integral 2. Integration Techniques 2.1. Integration by Parts 2.2. Trigonometric Integrals 2.3. Trigonometric Substitution 2.4. Rational Functions 2.5. Rationalizing Substitution 3. Improper Integrals 4. Applications of Definite Integral 4.1. Plane Area 4.2. Areas Between Curves 5. Other Applications

	5.1. Volumes 5.2. Work 5.3. Hydrostatic Pressure 6. Multiple Integral (Inversion of Order / Change of Coordinates) 6.1. Double Integrals 6.2. Triple Integrals 7. Surfaces Tracing 7.1. Planes 7.2. Spheres 7.3. Cylinders 7.4. Quadratic Surfaces 7.5. Intersection of Surfaces 8. Multiple Integral as Volume 8.1. Double Integrals 8.2. Triple Integrals

Course Name	**DIFFERENTIAL EQUATIONS**
Course Description	Differentiation and integration in solving first order, first-degree differential equations, and linear differential equations of order *n*; Laplace transforms in solving differential equations.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	Calculus 2
Program Outcome	a. ability to apply knowledge of mathematics and science to solve complex engineering problems
Course Outcomes	After completing this course, the student must be able to: 1. Solve the different types of differential equations; and 2. Apply differential equations to selected engineering problems.
Course Outline	1. Definitions 1.1. Definition and Classifications of Differential Equations (D.E.) 1.2. Order Degree of a D.E. / Linearity 1.3. Solution of a D.E. (General and Particular) 2. Solution of Some 1st Order, 1st Degree D.E. 2.1. Variable Separable 2.2. Homogeneous 2.3. Exact 2.4. Linear 2.5. Equations Linear in a Function 2.6. Bernoulli's Equation 3. Applications of 1st Order D.E. 3.1. Decomposition / Growth 3.2. Newton's Law of Cooling

	3.3. Mixing (Non-Reacting Fluids) 3.4. Electric Circuits 4. Linear D.E. of Order *n* 4.1. Standard Form of a Linear D.E. 4.2. Linear Independence of a Set of Functions 4.3. Differential Operators 4.4. Differential Operator Form of a Linear D.E. 5. Homogeneous Linear D.E. with Constant Coefficients 5.1. General Solution 5.2. Auxiliary Equation 6. Non-Homogeneous D.E. with Constant-Coefficients 6.1. Form of the General Solution 6.2. Solution by Method of Undetermined Coefficients 6.3. Solution by Variation of Parameters

Course Name	**ENGINEERING DATA ANALYSIS**
Course Description	This course introduces different methods of data collection and the suitability of using a particular method for a given situation. It includes a coverage and discussion of the relationship of probability to statistics, probability distributions of random variables and their uses, linear functions of random variables within the context of their application to data analysis and inference, estimation techniques for unknown parameters, and hypothesis testing used in making inferences from sample to population, inference for regression parameters and build models for estimating means and predicting future values of key variables under study. Statistically based experimental design techniques and analysis of outcomes of experiments are discussed with the aid of statistical software.
Number of Units for Lecture	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	Calculus 1
Program Outcomes	To be identified by the program.
Course Outcomes	To be identified by the program.
Course Outline	1. Obtaining Data 1.1. Methods of Data Collection 1.2. Planning and Conducting Surveys 1.3. Planning and Conducting Experiments: Introduction to Design of Experiments 2. Probability 2.1. Sample Space and Relationships among Events 2.2. Counting Rules Useful in Probability 2.3. Rules of Probability 3. Discreet Probability Distributions 3.1. Random Variables and their Probability Distributions 3.2. Cumulative Distribution Functions 3.3. Expected Values of Random Variables 3.4. The Binomial Distribution 3.5. The Poisson Distribution 4. Continuous Probability Distribution

	4.1. Continuous Random Variables and their Probability Distribution 4.2. Expected Values of Continuous Random Variables 4.3. Normal Distribution 4.4. Normal Approximation to the Binomial and Poisson Distribution 4.5. Exponential Distribution 5. Joint Probability Distribution 5.1. Two or Random Variables
	5.1.1. Joint Probability Distributions 5.1.2. Marginal Probability Distribution 5.1.3. Conditional Probability Distribution 5.1.4. More than Two Random Variables 5.2. Linear Functions of Random Variables 5.3. General Functions of Random Variables 6. Sampling Distributions and Point Estimation of Parameters 6.1. Point Estimation 6.2. Sampling Distribution and the Central Limit Theorem 6.3. General Concept of Point Estimation 6.3.1. Unbiased Estimator 6.3.2. Variance of a Point Estimator 6.3.3. Standard Error 6.3.4. Mean Squared Error of an Estimator 7. Statistical Intervals 7.1. Confidence Intervals: Single Sample 7.2. Confidence Intervals: Multiple Samples 7.3. Prediction Intervals 7.4. Tolerance Intervals 8. Test of Hypothesis for a Single Sample 8.1. Hypothesis Testing 8.1.1. One-sided and Two-sided Hypothesis 8.1.2. P-value in Hypothesis Tests 8.1.3. General Procedure for Test of Hypothesis 8.2. Test on the Mean of a Normal Distribution, Variance Known 8.3. Test on the Mean of a Normal Distribution, Variance Unknown 8.4. Test on the Variance and Statistical Deviation of a Normal Distribution 8.5. Test on a Population Proportion 9. Statistical Inference of Two Samples 9.1. Inference on the Difference in Means of Two Normal Distributions, Variances Known 9.2. Inference on the Difference in Means of Two Normal Distributions, Variances Unknown 9.3. Inference on the Variance of Two Normal Distributions 9.4. Inference on Two Population Proportions 10. Simple Linear Regression and Correlation 10.1. Empirical Models 10.2. Regression: Modelling Linear Relationships – The Least-Squares Approach 10.3. Correlation: Estimating the Strength of Linear Relation 10.4. Hypothesis Tests in Simple Linear Regression 10.4.1. Use of t-tests

	10.4.2. Analysis of Variance Approach to Test Significance of Regression 10.5. Prediction of New Observations 10.6. Adequacy of the Regression Model 10.6.1. Residual Analysis 10.6.2. Coefficient of Determination 10.7. Correlation

2. NATURAL/PHYSICAL SCIENCES

Course Name	**CHEMISTRY FOR ENGINEERS**
Course Description	Basic concepts of matter and its classification; mass relationships in chemical reactions; properties of gases, liquids, and solids; concepts of thermochemistry; quantum theory and electronic behavior; periodic relationship of elements in the periodic table; intramolecular forces; and solutions.
Number of Units for Lecture and Laboratory	3 units lecture and 1 unit laboratory
Number of Contact Hours per Week	3 hours lecture and 3 hours laboratory
Prerequisite	None
Program Outcomes	a. ability to apply knowledge of mathematics and sciences to solve complex engineering problems b. ability to develop and conduct appropriate experimentation, analyze and interpret data
Course Outcomes	After completing this course, the student shall be able to: 1. Discuss the application of chemistry in relation to the generation of energy 2. Explain the chemical principles and concepts of structures and bonding of common materials 3. Discuss the chemical processes that takes place in the environment 4. Identify key chemistry concepts related to the specific field of engineering
Course Outline	1. Energy 1.1. Electrochemical Energy 1.2. Nuclear Chemistry and Energy 1.3. Fuels 2. The Chemistry of Engineering Materials 2.1. Basic Concepts of Crystal Structure 2.2. Metals 2.3. Polymers 2.4. Engineered Nanomaterials 3. The Chemistry of the Environment 3.1. The Chemistry of the Atmosphere

	3.2. The Chemistry of Water 3.3. Soil Chemistry 4. Chemical Safety 5. Special Topics Specific to the Field of Expertise
Laboratory Equipment	Refer to Annex IV-A – Recommended Laboratory Requirements for Chemistry/Physics for Engineers

Course Name	**PHYSICS FOR ENGINEERS**
Course Description	Vectors; kinematics; dynamics; work, energy, and power; impulse and momentum; rotation; dynamics of rotation; elasticity; and oscillation.
Number of Units for Lecture and Laboratory	3 units lecture and 1 unit laboratory
Number of Contact Hours per Week	3 hours lecture and 3 hours laboratory
Prerequisite	Calculus 1; Co-requisite: Calculus 2
Program Outcomes	a. ability to apply knowledge of mathematics and sciences to solve complex engineering problems b. ability to develop and conduct appropriate experimentation, analyze and interpret data
Course Outcomes	After completing this course, the student must be able to: 1. Use calculus to solve problems in force statics and kinematics; 2. Apply the Newton's Laws of Motion; 3. Use calculus to solve work and energy problems; 4. Apply the law of conservation of energy to problems; 5. Solve problems on impulse and momentum and collisions; 6. Determine the stress and strain on a body; 7. Solve simple harmonic motion applications; 8. Describe the characteristics of fluids at rest and in motion; 9. Solve basic problems in fluid statics and kinematics 10. Describe the three methods of heat transfer; 11. Solve basic problems in heat transfer; 12. Discuss the properties of waves, modes of vibration of strings and air columns; 13. Define electric current, electric resistance and voltage; 14. Compute the electric force between electric charges; 15. Solve problems on resistance and cells in series and parallel; 16. State Kirchhoff's rules and apply them in a given circuit; 17. Describe electromagnetism and apply its principles to problem on magnetic field and torque. 18. Describe image formation by mirrors and lenses and solve basic optics problems
Course Outline	1. Work, Energy and Power 2. Impulse and Momentum 3. Kinematics

	4. Dynamics 5. Rotation 6. Dynamics of Rotation 7. Elasticity 8. Oscillations 9. Fluids 10. Heat Transfer 11. Waves 12 Electrostatics 13. Magnetism 14. Optics
Laboratory Equipment	Refer to Annex IV-A – Recommended Laboratory Requirements for Chemistry/Physics for Engineers

3. BASIC ENGINEERING SCIENCES

Course Name	**COMPUTER-AIDED DRAFTING**
Course Description	Concepts of computer-aided drafting (CAD); introduction to the CAD environment; terminologies; and the general operating procedures and techniques in entering and executing basic CAD commands.
Number of Units for Lecture and Laboratory	1 unit laboratory
Number of Contact Hours per Week	3 hours laboratory
Prerequisite	None
Program Outcomes	c. ability to design a system, component, or process to meet desired needs within realistic constraints g. ability to communicate effectively with a range of audiences k. ability to apply techniques, skills, and modern engineering tools necessary for electrical engineering practice

Course Outcomes	After completing this course, the student must be able to: 1. Define the terms related to computer-aided drafting systems; 2. Identify the important tools used to create technical drawings in CAD; 3. Create electronic drawings (e-drawing) using CAD; and 4. Appreciate the usefulness of the knowledge and skills in computer aided drafting as applied in his/her professional development.
Course Outline	1. Introduction to CAD Software 2. CAD Drawing 3. Snapping, Construction Elements 4. Dimensioning 5. Plotting, Inputting Images 6. 3D and Navigating in 3D 7. Rendering
Laboratory Equipment	1. Personal computer with: 1.1. Operating system 1.2. CAD software 2. Printer or plotter

Course Name	**ENGINEERING MECHANICS**
Course Description	Force, moment, and motion concepts. Newton's Laws of Motion. Analysis of particles and rigid bodies in static and dynamic equilibrium using vector mechanics and energy and momentum methods. Geometric properties of lines, areas, and volumes.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisites	Physics for Engineers
Program Outcome	a. ability to apply knowledge of mathematics and science to solve complex engineering problems

Course Outcomes	After completing this course, the student must be able to: 1. Explain the fundamental concepts related to engineering mechanics; 2. Solve for the components and resultants of force, moment, and motion vectors; 3. Analyze static and dynamic equilibrium of particles and rigid bodies; 4. Analyze particles and rigid bodies in motion using energy and momentum methods; and 5. Compute the geometric properties (centroids and moments) of lines, areas, and volumes.
Course Outline	1. Introduction to Mechanics, Discussion on Newton's Laws of Motion, Concept of Particles and Rigid Body; Review of Vector Operations 2. Motion Concepts; Definition of Position, Velocity and Acceleration of a Particle, Equations of Motion, Rectilinear Motion 3. Concept of a Force, Components and Resultants of Forces, Concurrent Force Systems 4. Equilibrium of Particles, Concepts of Static Equilibrium, Free Body Diagram, Analysis of Particles in Static Equilibrium 5. Equilibrium of Particles, Static, Kinetic and Limiting Friction Concepts, Belt Friction, Wedges 6. Rectilinear Motion 7. Curvilinear Motion of Particles 8. Relative Motion and Moving Frames of Reference 9. Concept of Dynamic Equilibrium, Concept of Inertia, Force and Inertia, Effective Force Diagram for Particles 10. Dependent Motion 11. Work and Energy Principle for Particles; Concepts of Work and Energy, Conservative Forces, Conservation of Mechanical Energy 12. Principle of Impulse and Momentum for Particles, Concepts of Impulse and Momentum 13. Analysis of Impact of Colliding Particles 14. Moment of a Force About a Point, Moment of a Force About a Line, Noncurrent Forces in Space 15. Couples and their Moments, Components and Resultants of Moment Vectors 16. Reduction of Force-Couple Systems, Coplanar Force Systems 17. Equivalent Force-Couple Systems 18. First Moment of Lines and Areas, Centroid and Center of Gravity of Lines and Areas (Centroids of Common Shapes, Centroid and Center of Gravity of Composite Figures) 19. Equilibrium of Rigid Bodies 20. First Moment of Volumes, Centroid and Center of Gravity of Volumes (Centroids of Common Shapes, Centroid and Center of Gravity of Composite Shapes and Volumes) 21. Analysis of Rigid Bodies in Static Equilibrium; Three Dimensional Problems on Static Equilibrium 22. Types of Plane Motion, Analysis of a Rigid Body in Translation, Rotation about a Fixed Axis

	23. Absolute and Relative Velocity in General Planar Motion (Pole Method for Velocity Analysis) 24. Absolute and Relative Acceleration in General Planar Motion (Pole Method for Acceleration Analysis) 25. Mass Moment of Inertia of Shapes 26. Plane Motion of a Rigid Body: Forces and Accelerations 27. Instantaneous Center Method for Velocity Analysis 28. Work and Energy Principle for Rigid Body Motion; Concepts of Work and Energy, Conservative Forces, Conservation of Mechanical Energy 29. Principle of Impulse and Momentum for Rigid Bodies, Concepts of Impulse and Momentum 30. Analysis of Impact of Colliding Particles and Rigid Bodies

Course Name	**ENGINEERING ECONOMICS**
Course Description	Concepts of the time value of money and equivalence; basic economy study methods; decisions under certainty; decisions recognizing risk; and decisions admitting uncertainty.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	Engineering Data Analysis
Program Outcomes	e. ability to identify, formulate, and solve complex problems in electrical engineering k. ability to apply techniques, skills, and modern engineering tools necessary for electrical engineering practice
Course Outcomes	After completing this course, the student must be able to: 1. Solve problems involving interest and the time value of money; 2. Evaluate project alternatives by applying engineering economic principles and methods and select the most economically efficient one; and 3. Deal with risk and uncertainty in project outcomes by applying the basic economic decision making concepts.
Course Outline	1. Introduction 1.1. Definitions 1.2. Principles of Engineering Economics 1.3. Engineering Economics and the Design Process 1.4. Cost Concepts for Decision Making 1.5. Present Economic Studies 2. Money-Time Relationships and Equivalence 2.1. Interest and the Time Value of Money

	2.2. The Concept of Equivalence 2.3. Cash Flows 3. Economic Study Methods 3.1. The Minimum Attractive Rate of Return 3.2. Basic Economic Study Methods: Present Worth, Future Worth, Annual Worth, Internal Rate of Return, External Rate of Return 3.3. Other Methods: Discounted Payback Period, Benefit/Cost Ratio 4. Decisions Under Certainty 4.1. Evaluation of Mutually Exclusive Alternatives 4.2. Evaluation of Independent Projects 4.3. Effects of Inflation 4.4. Depreciation and After-Tax Economic Analysis 4.5. Replacement Studies 5. Decisions Recognizing Risk 5.1. Expected Monetary Value of Alternatives 5.2. Discounted Decision Tree Analysis 6. Decisions Admitting Uncertainty 6.1. Sensitivity Analysis 6.2. Decision Analysis Models

4. ALLIED COURSES

Course Name	**FUNDAMENTALS OF DEFORMABLE BODIES**
Course Description	The course deals with the study of strength of materials where the understanding of how bodies and materials respond to applied loads is the main emphasis. The course covers the fundamental concepts of stresses and strains experienced and/or developed by different materials in their loaded state and subjected to different conditions of constraint that includes axial stress, shearing stress, bearing stress, torsion, flexural stress, and stress-strain relationships.
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours per Week	2 hours lecture
Prerequisite	Engineering Mechanics
Program Outcomes	To be identified by the program
Course Outcomes	After completing this course, the student must be able to: 1. Apply the concepts of stress and strain; 2. Calculate stresses due to bending, shears, and torsion under plain and combined loading; 3. Analyze statically determinate and indeterminate structures; and 4. Determine the elastic stability of columns.

Course Outline	1. Load Classification 2. Concept of Stress, Normal and Shear Stress 3. Stresses under Centric Loading 4. Stress Concentration 5. Plane Stress 6. Principal Stresses for Plane Stress 7. Mohr's Circle for Plane Stress 8. Deformations, Normal and Shear Strains 9. Material Properties 10. Working Stresses 11. Deformation in a System of Axially Loaded Members 12. Temperature Effects on Axially Loaded Members 13. Statically Indeterminate Members 14. Thin-Walled Pressure Vessel 15. Torsional Stresses; Elastic Torsion Formula 16. Torsional Deformation; Power Transmission 17. Flexural Stresses by the Elastic Curve 18. Moment Equation Using Singularity Function 19. Beam Deflection by the Double Integration Method 20. Area Moment Theorems 21. Moment Diagram by Parts 22. Beam Deflection by Area Moment Method 23. Statically Indeterminate Beams 24. Buckling of Long Straight Columns 25. Combined Loadings 26. Analysis of Riveted Connections by the Uniform Shear Method 27. Welded Connections

Course Name	**ELECTRONIC CIRCUITS: DEVICES AND ANALYSIS**
Course Description	The course covers the fundamentals of electronics and electronic circuits with their basic applications. This includes diode and transistor characteristics necessary for elementary analysis of electronic circuits with discrete components. The second half of the course covers integrated circuits commonly used in electrical engineering. The course introduces students to the design of electronic circuits for basic applications such as filters, power supplies and op amp signal processors.
Number of Units for Lecture and Laboratory	3 units lecture and 1 unit lab
Number of Contact Hours per Week	3 hours lecture 3 hours lab
Prerequisite	Electrical Circuits 1
Program Outcomes	To be identified by the program
Course Outcomes or Learning Outcomes	To be identified by the program
Course Outline	1. Semiconductor fundamentals 2. Diodes, v-i characteristics, diode circuits 3. Transistors: bipolar junction transistors, field-effect transistors

	4. Transistor biasing, transistor circuits 5. Basic transistor applications: amplifier, switch 6. Integrated circuits 7. Operational amplifiers, op amp circuits 8. Passive and active filters 9. Voltage regulation and power supplies
Laboratory Equipment	Refer to Annex IV-B – Recommended Laboratory Requirements

Course Name	**BASIC THERMODYNAMICS**
Course Description	Thermodynamic properties of pure substances, ideal and real gases and the study and application of the laws of thermodynamics in the analysis of processes and cycles; introduction to vapor and gas cycles.
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours per Week	2 hours lecture
Prerequisite	Physics for Engineers
Program Outcome	To be identified by the program
Course Outcomes	After completing this course, the student must be able to: 1. Understand the principles underlying the utilization of energy in thermal systems, open and closed systems; and 2. Know the vapor and gas cycles.
Course Outline	1. Introduction 2. Basic Principles, Concepts, and Definitions 3. First Law of Thermodynamics 4. Ideal Gases 4.1. Ideal Gas Laws 4.2. Processes of Ideal Gases 5. Pure Substances 5.1. Properties of Pure Substances 5.2. Processes of Pure Substances 6. Introduction to Cycle Analysis: Second Law of Thermodynamics 7. Introduction to Gas and Vapor Cycles

Course Name	**INDUSTRIAL ELECTRONICS**
Course Description	This course teaches the theory and operation of solid-state devices and control circuits for industrial processes; industrial control applications; electronics instrumentation; transducers; data acquisition system, power supply and voltage regulator. It also covers photo electronics, sensors and instruments used in industrial applications. It includes variable-frequency drives, DC motor, servomotors and stepper motor drives; application of relay logic circuits; and interfacing and programming of PLCs
Number of Units for Lecture and Laboratory	3 units lecture and 1 unit laboratory
Number of Contact Hours per Week	3 hours lecture and 3 hours laboratory
Prerequisite	Electronic Circuits: Devices and Analysis
Program Outcomes	To be identified by the program
Course Outcomes	To be identified by the program
Course Outline	1. Steady- State Equivalent Circuit Modeling, Losses and Efficiency 1.1 The DC Transformer Model 1.2 Inductor Copper Loss 1.3 Design of Equivalent Circuit Model 2. Switch Realization 2.1 Single-Quadrant Switches 2.2 Current-Bidirectional Two-Quadrant Switches 2.3 Voltage-Bidirectional Two-Quadrant Switches 2.4 Four Quadrant Switches 2.5 Synchronous Rectifiers 2.6 Power Diodes 2.7 Metal-Oxide-Semiconductor Field-Effect Transistor 2.8 Bipolar Junction Transistor 2.9 Insulated Gate Bipolar Transistor 2.10 Wide bandgap devices 2.11 Transistor Switching with Clamped Inductive Load 2.12 Diode Recovered Charge 2.13 Device Capacitances, and Leakage, Package and Stray Inductances 2.14 Efficiency vs Switching Frequency 3. Discontinuous Conduction Mode 3.1 Discontinuous Conduction Mode 3.2 Mode Boundary 3.3 Analysis of the Conversion Ratio 4. Converter Circuits 4.1 Inversion of Source and Load 4.2 Cascade Connection of Converters 4.3 Rotation of Three-Terminal Cell 4.4 Differential Connection of the Load 4.5 List of Converters 4.6 Transformer Isolation • Full-Bridge and Half-Bridge Isolated Buck Converters • Forward Converter • Push-Pull Isolated Buck Converter • Flyback Converter

	• Boost-Derived Isolated Converters • SEPIC and Cuk Converter 4.7 Switch Stress and Utilization 5. Converter Dynamics and Control 5.1 AC Modeling Approach 5.2 State-Space Averaging 5.3 The Canonical Circuit Model 5.4 Modeling the Pulse-Width Modulator 5.5 Bode Plots 5.6 Analysis of Converter Transfer Functions 5.7 Construction of Impedances and Transfer Functions 5.8 Measurement of AC Transfer Functions and Impedances 5.9 Effect of Negative Feedback on the Network Transfer Functions 5.10 Stability 5.11 Regulator Design 5.12 Measurement of Loop Gains 5.13 Devices, Their B-H Loops, and Core vs Copper Loss 6. Inductor Design 6.1 Filter Inductor Design Constraints 6.2 The Core Geometrical Constant Kg 6.3 Multiple-Winding Magnetics Design vs the Kg Method 7. Transformer Design 7.1 Transformer Design: Basic Constraints 7.2 Optimum Flux Density 7.3 Transformer Design Procedure 7.4 AC Inductor Design
Laboratory Equipment	Refer to Annex IV-B – Recommended Laboratory Requirements

Course Name:	**ELECTROMAGNETICS**
Course Description	The course deals with the study of electric and magnetic fields; resistive, dielectric and magnetic materials, coupled circuits, magnetic circuits and fields, and time-varying electromagnetic fields. It involves a review of vector analysis and types of coordinate system (Cartesian, cylindrical and spherical coordinate systems). Topics covered are dot and cross products of vector, Coulomb's law and electric field intensity of different charge configuration (volume, point, line sheet charge), electric flux density, Gauss's Law, divergence, Maxwell's equations and energy and potential.
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours Per Week	2 hours lecture
Prerequisite	Physics for Engineers, Differential Equations
Program Outcomes	To be identified by the program
Course Outcomes	To be identified by the program

Course Outline	1. Vector Analysis 2. Coulomb's Law 3. Electric Field Intensity 4. Electric Flux density 5. Gauss's Law 6. The Line Integral 7. The vector operator ∇ 8. Divergence 9. Energy and Potential 10. Potential Gradient 11. Electrostatic Field 12. Dielectric Materials 13. Capacitance 14. Physical Models

Course Name	**FLUID MECHANICS**
Course Description	The course deals with the nature and physical properties of fluids as well as the identification and measurement of fluid properties. It emphasizes the application of conservation laws on mass, energy and momentum to fluid systems either incompressible or compressible flow, inviscid or viscous flow as well as head loss calculation on pipes and fittings.
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours per week	2 hours lecture
Prerequisite	Physics for Engineers
Program Outcomes	To be identified by the program
Course Outcomes	After completing this course, the student must be able to: 1. Identify the different fluid properties and the methods of measuring them. 2. Apply the principles of conservation of mass, momentum and energy to fluid systems. 3. Explain the concept of dimensional analysis. 4. Apply the concept of Steady Incompressible Flow in Conduits
Course Outline	1. Introduction 2. Properties of Fluids Compressible and Incompressible Fluids, Differential and Integral form of the Fluid Dynamic Equation, Bulk Modulus of Elasticity, Gas Equation of State, Compressibility of Gases, Inviscid and Viscous Fluids, Surface Tension. 3. Fluid Statics Pressure Variation in Static Fluid, Absolute and Gage Pressures, Pressure Measuring Devices, Force on Plane Area, Center of Pressure, Force on Curved Surface, Buoyancy and Stability of Submerged and Floating Bodies, Fluid Masses Subjected to Acceleration

	4. Conservation of Energy Equation of Steady Motion along a Streamline for an Ideal Fluid (Bernoulli's Equation) and Real Fluid, Energy Equation for Steady Flow of Incompressible Fluids, Power Considerations in Fluid Flow, Cavitation, Hydraulic Grade Line and Energy Line, Stagnation Pressure, Flow in a Curved Path, Forced Vortex, Free or Irrotational Vortex 5. Basic Hydrodynamics Differential Equation of Continuity, Rotational and Irrotational Flow, Circulation and Vorticity, Stream Function, Velocity Potential, Orthogonality of Streamlines and Equipotential Lines 6. Similitude and Dimensional Analysis Geometric Similarity, Kinematic Similarity, Dynamic Similarity, Scale Ratios, Dimensional Analysis and Buckingham II Theorem 7. Momentum and Forces in Fluid Flow Impulse-Momentum Principle, Force Exerted on Pressure Conduits, Force Exerted on a Stationary Vane or Blade, Relation between Absolute and Relative Velocities, Force upon a Moving Vane or Blade, Torque in Rotating Machines and Head Equivalent of Mechanical Work, Momentum Principle applied to Propellers and Windmills 8. Steady Incompressible Flow in Pressure Conduits Critical Reynolds Number, Hydraulic Radius, General Equation for Conduit Friction, Laminar Flow in Circular Pipes, Turbulent Flow, Pipe Roughness, Friction Factor, Fluid Friction in Noncircular Conduits, Different types of Losses, Branching Pipes, Pipes in Series and Parallel. 9. Fluid Measurements Measuring Devices for Static Pressure and Velocity, Venturi Tube, Orifice Meter, Weirs 10. Multi-Phase Flow 11. Special Topics (Basic Hydraulic Calculation for Fire Sprinkler Lay-out System Using Haze – Williams Equations

Course Name	**FUNDAMENTALS OF ELECTRONIC COMMUNICATIONS**
Course Description	Fundamental principles of electronic communications theory and its applications. Emphasis is on the introduction of electronic communication systems, analysis and calculations of analog and digital modulation, transmission and reception. Provides insights, framework, knowledge and competencies necessary in analyzing basic communication system as a preparation for electronics engineering profession.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture

<table>
<tr><td>Prerequisite</td><td>Electronic Circuits: Devices and Analysis</td></tr>
<tr><td>Program Outcomes</td><td>To be identified by the program</td></tr>
<tr><td>Course Outcomes</td><td>To be identified by the program</td></tr>
<tr><td>Course Outline</td><td>1. Introduction to Communication System and Noise Analysis
a. Communication Systems
b. Types of Electronic Communication
c. Electromagnetic Spectrum
d. Bandwidth
e. Careers in the Communication Industry
f. Modulation and Multiplexing
g. Survey of Communications Applications
h. Information Capacity
i. Information Theory
2. Amplitude Modulation
a. AM Fundamentals
b. AM Principles
c. Modelling an Equation
d. Amplitude Modulation
3. Fundamentals of Electronics
a. Gain, Attenuation, and Decibels
b. Tuned Circuits
c. Filters
d. Fourier Theory
e. Single-Sideband Modulation
f. AM Modulators
g. AM Demodulators
h. Radio
Emission
4. Frequency Modulation
a. FM Fundamentals
b. Frequency Modulators
c. Phase Modulators
d. Frequency Demodulators
e. Double Sideband System
f. Single-Sideband System
g. Envelope Detection
h. Frequency Modulation System
i. FM Generation
j. Project Prototyping
k. Practical Exam
5. Radio Transmitters
a. Transmitter Fundamentals
b. Carrier Generators
c. Power Amplifiers
d. Impedance Matching Networks
e. Typical Transmitter Circuits
6. Communications Receivers
a. Principles of Signal Reproduction
b. Superheterodyne Receivers
c. Frequency Conversion
d. Intermediate Frequency and Images
e. Noise
f. Typical Receiver Circuits
g. Receivers and Transceivers</td></tr>
</table>

	7. Analog Pulse Modulation a. Pulse Amplitude Modulation b. Pulse Width Modulation c. Pulse Position Modulation d. Pulse Code Modulation e. Frequency Demodulators

Course Name	**LOGIC CIRCUITS AND SWITCHING THEORY**
Course Description	This course provides a review of number systems, coding and Boolean algebra; inputs and outputs; gates and gating networks; combinational circuits; standard form; minimization; sequential circuits; state and machine equivalence; asynchronous sequential circuits; race conditions; algorithmic state machines; and design of digital sub-systems.
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours per Week	2 hours lecture
Prerequisite	Electronic Circuits: Devices and Analysis
Program Outcomes	To be identified by the program
Course Outcomes	To be identified by the program
Course Outline	1. Introduction to Digital System 1.1 Number System 1.2 Introduction to Logic Gates 1.3 Boolean Algebra Theorems 1.4 Boolean Functions 1.5 Canonical and Standard Forms 1.6 Representation of Boolean 1.7 Functions using Logic Circuits 1.8 The Map Method 1.9 NAND and NOR Implementation 2. Introduction to Combinational Logic 2.1 Design Procedure 2.2 Adders and Subtracter 2.3 Code Conversion 2.4 Decoders and Encoder 2.5 Multiplexers and Demultiplexer 2.6 Comparator 2.7 Read-Only Memory (ROM) 2.8 Programmable Logic Array 3. Introduction to Digital Concept 3.1 Digital Concept 3.2 HDL 3.3 Levels of Modeling or Abstraction in Verilog 3.4 Verilog Model Components or Structural Elements 3.5 Logic Functions 3.6 Introduction to Boolean 3.7 Basic Schematic Logic Symbols 4. Hardware Description Language 4.1 Discrete Integrated Circuit Logic Chip

	4.2 Circuit Development with MultiSim software 4.3 Characteristic of Logic Families 4.4 Introduction to PLDs

Course Name	**MICROPROCESSOR SYSTEMS**
Course Description	The course includes history and evolution, principles, and applications of microprocessors. The focus is on the basic understanding of the architectural design, functional parts, operations, function and programming. It also covers the study of various types of microprocessors and the fundamental concepts of microcontrollers.
Number of Units for Lecture and Laboratory	2 units lecture
Number of lecture hours per week	2 hours lecture
Prerequisites	Logic Circuits and Switching Theory
Program Outcomes	To be identified by the program.
Course Outcomes	To be identified by the program.
Course Outline	1. Structural Components of Microprocessor/Microcontroller 1.1 Internal CPU Interconnection 1.2 ALU 1.3 CU 1.4 Registers 1.5 Other Peripherals 2. Fetch-Decode-Execute Cycle 3. Functional Operations of Microprocessor/Microcontroller 3.1 Data Movement 3.2 Data Processing 3.3 Control 3.4 Data Storage 4. Instruction Set 5. I/O Interfacing 5.1 Interfacing of Input/Output Devices 5.2 Interface Devices 5.3 Time-Based I/O 5.4 Handshaking

Course Name	**COMPUTER PROGRAMMING**
Course Description	Basic information technology concepts; fundamentals of algorithm development; high-level language and programming applications
Number of Units for Lecture and Laboratory	1 unit laboratory

Number of Contact Hours per Week	3 hours laboratory
Prerequisite	None
Program Outcome	k. ability to apply techniques, skills, and modern engineering tools necessary for electrical engineering practice
Course Outcomes	After completing this course, the student must be able to: 1. Understand basic information technology concepts; 2. Use application software and the Internet properly; 3. Acquire proficiency in algorithm development using a high-level programming language; 4. Use high level language and programming applications in solving electrical engineering problems
Course Outline	1. Introduction to Computers 1.1. Computer Organization 1.2. Number Systems and Data Representation 1.3. Application Software: Word Processing and Spreadsheet 1.4. The Internet 2. Programming 2.1. Algorithm Development 2.2. Programming Fundamentals
Laboratory Equipment	1. Personal computer with: 1.1. Operating system 1.2. Word processing software 1.3. Spreadsheet software 1.4. High-level programming language 1.5. Internet browser and Internet connection

Course Name	**BASIC OCCUPATIONAL SAFETY AND HEALTH**
Course Description	The course tackles key Occupational, Health and Safety (OSH) concepts, principles and practices that are foundational knowledge requirements acceptable in almost all industries; determination of existing and potential safety and health hazards; identification of control measures; provisions of Philippine laws that refer to occupational safety and health
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	none

Program Outcomes	f. ability to recognize ethical and professional responsibilities in engineering practice h. ability to understand the impact of engineering solutions in a global, economic, environmental, and societal context
Course Outcomes	After completing this course, the student must be able to: 1. Discuss the health and safety concerns in an industrial setting and the importance of promoting safety and health as an engineer's professional and ethical responsibility. 2. Perform safety audit of any of the following: a process, equipment, or an industrial plant. 3. Apply the concepts and principles of industrial safety and health to case studies.
Course Outline	1. Introductory Concepts: Promoting Safety and Health as an Engineer's Professional and Ethical Responsibility 2. Occupational Safety 3. Industrial Hygiene 4. Control Measures for OSH hazards 5. Occupational Health 6. Personal Protective Equipment 7. OSH Programming 8. Training of Personnel on OSH 9. OSH Legislation 10. Plant Visit Simulation

Course Name	**ENVIRONMENTAL SCIENCE and ENGINEERING**
Course Description	Ecological framework of sustainable development; pollution environments: water, air, and solid; waste treatment processes, disposal, and management; government legislation, rules, and regulation related to the environment and waste management; and environmental management system.
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours per Week	2 hours lecture
Prerequisite	None
Program Outcome	h. ability to understand the impact of engineering solutions in a global, economic, environmental, and societal context
Course Outcomes	After completing this course, the student must be able to: 1. Understand the various effects of environmental pollution; 2. Know the existing laws, rules, and regulations of the government on environmental issues; 3. Identify, plan, and select appropriate design treatment schemes for waste disposal; and 4. Understand the importance of waste management and its relevance to the engineering profession.
Course Outline	1. Ecological Concepts

	1.1. Introduction to Environmental Engineering 1.2. Ecology of Life 1.3. Biogeochemical Cycles 1.4. Ecosystems 2. Pollution Environments 2.1. Water Environment 2.2. Air Environment 2.3. Solid Environment 2.4. Toxic and Hazardous Waste Treatment
	3. Environmental Management System 3.1. Environmental Impact Assessment 3.2. Environmental Clearance Certificate

Course Name	**MATERIALS SCIENCE AND ENGINEERING**
Course Description	The course deals with the properties of engineering materials including mechanical, acoustical, electrical, magnetic, chemical, optical and thermal properties
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours per week	2 hours lecture
Prerequisite	Chemistry for Engineers; Fundamentals of Deformable Bodies
Program Outcomes	To be identified by the program
Course Outcomes	After completing this course, the student must be able to: 1. Evaluate the types, properties and characteristics of engineering materials 2. Identify the different new engineering materials and their industrial usage 3. Evaluate the behavior of materials subject to different kinds of testing
Course Outline	1. Nature of materials 1.1 Types of Engineering Materials 1.2 Engineering Materials Composition 1.3 Chemical Bonding 2. Properties and characteristics of materials 2.1 Physical 2.2 Mechanical 2.3 Chemical 2.4 Thermal 2.5 Electrical 2.6 Magnetic 2.7 Optical 3. Material Testing 3.1 Tension Test 3.2 Compression Test 3.3 Coefficient of Thermal Expansion 3.4 Beam Deflection 3.5 Shear/ Torsion Test

	4. Fracture Toughness and Fatigue and Engineering materials 4.1 Impact Testing 4.2 Destructive Testing 4.3 Fatigue Testing 5. Corrosion Prevention and Control 1.1 Significance and Purpose 1.2 Electrochemical nature of aqueous corrosion 1.3 Corrosion rate determinates 1.4 Galvanic and concentration cell corrosion
	6. Non-Destructive Testing 6.1 Magnetic Particle 6.2 Ultrasonic Testing 6.3 Penetrant Testing 6.4 Radiographic Testing 7. Ferrous and Non – ferrous Metals 8. Ceramics 9. Polymers 10. Composite Materials 11. Nano and Bio Materials 12. Selection / Re – use and Recycling of Materials

5. PROFESSIONAL COURSES

Course Name	NUMERICAL METHODS AND ANALYSIS
Course Description	This course covers the concepts of numerical analysis and computer software tools in dealing with engineering problems. It includes techniques in finding the roots of an equation, solving systems of linear and non-linear equations, eigenvalue problems, polynomial approximation and interpolation, ordinary and partial differential equations. The Monte-Carlo method, simulation, error propagation and analysis, the methods of least squares and goodness-of-fit tests are also covered.
Number of Units for Lecture and Laboratory	2 units lecture and 1 unit laboratory
Number of Contact Hours per Week	2 hours lecture and 3 hours laboratory
Prerequisites	Engineering Math for EE
Program Outcomes	To be identified by the program.
Course Outcomes	To be identified by the program.
Course Outline	1. Introduction 2. Non Linear Transcendental and Polynomial Function Techniques 3. Iterative Bracketing Method 4. Iterative Non-Bracketing/Open Method 5. Iterative Polynomial Function Techniques 6. System of Linear Equations 7. Direct Methods 8. Iterative Methods

	9. Curve Fitting Techniques 10. Least Square Regression 11. Interpolation Techniques 12. Numerical Integration Techniques 13. Numerical Differentiation 14. Ordinary Differential Equations

Course Name	**MANAGEMENT OF ENGINEERING PROJECTS**
Course Description	The course covers the principles of management, theory and practice, various approaches to decision making, managing production and services operations; and project management. Emphasis is also given on the managerial functions of planning, organizing, staffing, leading and controlling.
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours Per Week	2 hours lecture
Prerequisite	Engineering Economics
Program Outcomes Link(s)	To be identified by the program
Course Outcomes or Learning Outcomes	To be identified by the program
Course Outline	1. Engineering Management principles 2. Decision Making 3. Root Cause Analysis a. 4Ms b. 4Ps c. 5 Whys d. Ishikawa e. Fish Bone Diagram 4. Planning and Organizing Technical Activities 5. Staffing the engineering organization 6. Communicating, controlling and leading 7. Managing Service Operations 8. PERT/CPM 9. Project Management a. Organization Strategy and Project Selection b. Defining the project c. Developing a Project Plan d. Managing Risk e. Project schedules and resources f. Bill of Quantities g. Interpretation architectural, structural and fire protection plan and other working drawings

Course Name	**EE LAW, CODES, AND PROFESSIONAL ETHICS**
Course Description	The course is designed to prepare electrical engineering students for professional practice. Topics include education and practice of the New Electrical Engineering Law and other laws governing the profession, Philippine Grid Code, Philippine Distribution Code, Basic Contracts and ethics in relation to the practice of the electrical engineering profession.
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours Per Week	2 hours lecture
Prerequisite	Ethics
Program Outcome	To be identified by the program
Course Outcomes	Students successfully completing this course will be able to: 1. Discuss the existing laws, codes, and guidelines in the practice of the electrical engineering profession 2. Explain the basic concept of contracts and obligations and ethical standards in the practice of the electrical engineering profession 3. Analyze and present case studies related to Electrical Engineering Laws, NBC, PGC, PDC, PFPC, Contracts and Ethics
Course Outline	1. The New Electrical Engineering Law (RA 7920) of 1995 2. Anti-Electricity Pilferage Act (RA 7832) of 1994 3. EPIRA Law (RA 9136) of 2001 4. Code of Ethics for Electrical Engineers 5. Magna Carta for Residential Electricity Consumer 6. Warranties, Liabilities, Patents, Bids, and Insurance 7. Philippine Grid Code 8. Philippine Distribution Code 9. National Building Code 10. Philippine Fire Protection Code 11. Energy Regulatory Commission 12. Wholesale Electricity Spot Market Rules 13. Performance Base Rate (PBR) 14. Power Supply Agreement 15. Feed in Tariff (FIT) 16. Guidelines for Energy Conserving Design of Buildings and Utility Systems 17. Other relevant laws, codes and standards in the energy and power industry

Course Name	**ELECTRICAL STANDARDS AND PRACTICES**
Course Description:	This course provides the different electrical practices in accordance to local and international standards.
Number of Units for Lecture and Laboratory	1 unit field

Number of Contact Hours Per Week	3 hours field
Prerequisite	EE Law, Codes, and Professional Ethics
Program Outcomes	To be identified by the program
Course Outcomes	To be identified by the program
Course Outline	Electrical Practices in accordance to local and International standards: 1. Philippine Electrical Code 1 and 2 2. National Electrical Code 3. National Fire Protection Association (NFPA) 4. Japanese Industrial Standard (JIS) 5. International Electrotechnical Commission (IEC) 6. National Electrical Manufacturers Association (NEMA) 7. American National Standard Institute (ANSI) 8. International Electrical Testing Association (NETA) 9. National Electrical Contractor Association (NECA) 10. Telecommunication Industry Association (TIA) 11. Underwriter's Laboratory (UL) 12. American Society for Testing and Materials (ASTM) 13. IEEE Standards

Course Name	**ELECTRICAL CIRCUITS 1**
Course Description	The course covers nodal and mesh analysis; application of network theorems in circuit analysis; analysis of circuits with controlled sources and ideal op-amps; fundamentals of capacitors and inductors; analysis of dc-driven RL, RC, and RLC circuits; sinusoidal steady-state analysis of general RLC circuits
Number of Units for Lecture and Laboratory	3 units lecture; 1 unit laboratory
Number of Contact Hours Per Week	3 hours lecture; 3 hours lab
Prerequisite	Physics for Engineers; Calculus 2
Program Outcomes	To be determined by the program
Course Outcomes	To be determined by the program
Course Outline	1. DC/AC Sources and Electrical Circuit Components, Voltage and Current Laws 2. Nodal and Mesh Analysis a. General nodal analysis b. General mesh analysis 3. Circuit Analysis Techniques a. Linearity and superposition b. Source transformation c. Thevenin and Norton equivalent circuits d. Maximum power transfer e. Delta-wye conversion f. Circuits with controlled sources and the ideal op amp 4. Characteristics of Energy-storing Elements a. Capacitors and capacitance b. Inductors and inductance 5. Analysis of RL and RC Circuits

	a. Source-free RL and RC circuits b. Driven RL and RC circuits 6. Analysis of RLC circuits a. Source-free series and parallel RLC circuits b. Complete response of RLC circuits 7. Sinusoidal Steady-state Analysis in the Frequency Domain a. The phasor concept and phasor diagram b. Concept of Impedance and admittance c. Nodal and mesh analysis
Laboratory Equipment	Refer to Annex IV-B – Recommended Laboratory Requirements

Course Name	**ELECTRICAL CIRCUITS 2**
Course Description	The course deals with sinusoidal steady-state analysis in the frequency domain; AC circuit power analysis; analysis of polyphase circuits and magnetically-coupled circuits; frequency response; per unit system and symmetrical components; and two-port networks
Number of Units for Lecture and Laboratory	3 units lecture; 1 unit laboratory
Number of Contact Hours Per Week	3 hours lecture; 3 hours lab
Prerequisite	Electrical Circuits 1
Program Outcomes	To be determined by the program
Course Outcomes	To be determined by the program
Course Outline	1. Sinusoidal Steady-state Analysis in the Frequency Domain a. Nodal and mesh analysis b. Superposition, Thevenin's and Norton's theorems 2. AC circuit power analysis a. Average power b. Apparent power c. Power factor and power factor correction d. Maximum power transfer principle 3. Analysis of Polyphase Circuits a. 3-phase, 3-wire systems b. 3-phase, 4-wire systems c. Power measurement in 3-phase systems d. Unbalanced loading in 3-phase systems 4. Analysis of Magnetically-coupled Circuits a. Mutual inductance b. Energy considerations c. Analysis of circuits with magnetically-coupled coils d. The ideal transformer 5. Frequency Response a. Parallel resonance b. Series resonance c. Basic filter design 6. Per Unit System 7. Symmetrical Components of Unbalanced 3-phase Voltages and Currents 8. Analysis of Two-port Networks a. Network parameters b. Network responses

	c. Network interconnection
Laboratory Equipment	Refer to Annex IV-B – Recommended Laboratory Requirements

Course Name	**ELECTRICAL APPARATUS AND DEVICES**
Course Description	This course provides characteristics, principle of operation, and applications of single-phase and three-phase transformers, and protective devices such as fuses and circuit breakers. It includes various types of transformers based on different criteria, types of fuses and circuit breakers, parallel operation of transformers, and standard ratings.
Number of Units for Lecture and Laboratory	2 units lecture; 1 unit laboratory
Number of Contact Hours Per Week	2 hours lecture; 3 hours laboratory
Prerequisite	Electrical Circuits 2
Program Outcomes	To be identified by the program
Course Outcomes	To be identified by the program
Course Outline	1. Characteristics of the practical transformer 2. Standard ratings of transformers 3. Transformer tests and principle of operation 4. Calculations of power losses and efficiency 5. Three-phase transformers 6. Parallel operation of transformers 7. Various types of transformers and their applications 8. Protective devices: characteristics, principle of operation and applications a. Fuses b. Breakers c. Lightning arresters 9. Standard ratings of protective devices
Laboratory Equipment	Refer to Annex IV-B – Recommended Laboratory Requirements

Course Name	**ELECTRICAL MACHINES 1**
Course Description	The course deals with the fundamentals of DC machinery; DC motors and generators
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours Per Week	2 hours lecture
Prerequisite	Electromagnetics; Electrical Circuits 2
Program Outcomes	To be determined by the program
Course Outcomes	To be determined by the program
Course Outline	1. DC machinery fundamentals a. Commutation and armature construction in real DC machines b. Problems with commutation in real machines c. Internal generated voltage and induced torque equations of real DC machines

	d. Construction of DC machines e. Power flow and losses in DC machines 2. DC motors a. Equivalent circuit of a DC motor b. Magnetization curve of a DC machine c. Separately excited and shunt DC motors d. Permanent magnet DC motor e. Series motor f. Compounded DC motor g. DC motor starters h. Ward-Leonard system and solid-state speed controllers i. DC motor efficiency calculations 3. DC generators a. Separately excited generator b. Shunt DC generator c. Series DC generator d. Cumulatively compounded DC generator e. Differentially compounded DC generator

Course Name	**ELECTRICAL MACHINES 2**
Course Description	The course deals with the fundamentals of AC machinery; synchronous generators and motors; induction motors; single-phase and special-purpose motors
Number of Units for Lecture and Laboratory	3 units lecture; 1 unit laboratory
Number of Contact Hours Per Week	3 hours lecture; 3 hours lab
Prerequisite	Electrical Machines 1
Program Outcomes	To be determined by the program
Course Outcomes	To be determined by the program
Course Outline	1. AC machinery fundamentals a. Rotating magnetic field b. Magnetomotive force and flux distribution on AC machines c. Induced voltage and induced torque in AC machines d. Winding insulation in an AC machine e. AC machine power flows and losses, voltage regulation and speed regulation 2. Synchronous generators a. Equivalent circuit and phasor diagram b. Power and torque c. Measuring synchronous generator model parameters d. Synchronous generator operating alone e. Parallel operation of AC generators f. Synchronous generator transients g. Synchronous generator ratings 3. Synchronous motors a. Steady-state synchronous motor operation b. Starting synchronous motors c. Synchronous motor ratings 4. Induction motors a. Equivalent circuit of an induction motor

	b. Power and torque in induction motors c. Induction motor torque-speed characteristics d. Trends in induction motor design e. Starting induction motors f. Speed control of induction motors g. Solid-state induction motor drives h. Determining circuit model parameters i. Induction generator j. Induction motor ratings 5. Single-phase and special-purpose motors a. Universal motor b. Single-phase induction motors – starting and speed control c. Circuit model of a single-phase induction motor d. Other types of motors – reluctance motor, hysteresis motor, stepper motors, brushless DC motors
Laboratory Equipment	Refer to Annex IV-B – Recommended Laboratory Requirements

Course Name	**ENGINEERING MATHEMATICS FOR EE**
Course Description	The study of mathematical methods for solving engineering problems such as complex number, complex variables, Cauchy-Riemann equations, Laplace transformation and Laplace transform analysis, Fourier series and Fourier transform, z transform, power series solutions of ordinary differential equations, partial differential equation, and hypergeometric equations such as Legendre and Bessel functions
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours Per Week	3 hours lecture
Prerequisite	Differential Equations
Program Outcomes	To be identified by the program
Course Outcomes	To be identified by the program
Course Outline	1. Complex number system and complex variables 2. The Laplace Transform Method of solving differential equations 3. Applications of the Laplace Transform 4. Fourier Series and the Fourier Transform 5. Application of the Fourier Transform 6. The Z transform and its application 7. Power series solutions of Ordinary Differential Equations 8. Partial Differential Equations 9. Hypergeometric equations and their applications

Course Name	**ELECTRICAL SYSTEMS and ILLUMINATION ENGINEERING DESIGN**
Course Description	The course provides knowledge, understanding and skills in designing electrical wiring system for residential, commercial

	buildings, and industrial facilities through the specifications and standards mandated by the Philippine Electrical Code and provisions from the Local Government on electrical wiring installation. The course includes illumination design and cost estimation; energy-efficient lighting systems for residential, commercial, and industrial establishments; roadway lighting, and lighting maintenance.
Number of Units for Lecture and Laboratory	3 units lecture; 2 units design
Number of Contact Hours Per Week	3 hours lecture; 6 hours design
Prerequisite	Electrical Machines 2
Program Outcomes	To be identified by the program
Course Outcomes	To be identified by the program
Course Outline	1. Interpretation of the provisions of the Philippine Electrical Code and other electrical codes 2. Design of the electrical systems of residential, commercial, and industrial buildings a. Lighting layout b. Power layout c. Electrical loads, ratings of branch circuit wiring, and specifications of protective devices 3. Basics of cost estimation 4. Lighting design principles, including lighting calculations 5. Energy-efficient lighting systems for residential, commercial, and industrial establishments 6. Roadway lighting 7. Lighting maintenance principles

Course Name	**POWER SYSTEMS ANALYSIS**
Course Description	This course deals with the study on the basic structure of power systems, recent trends and innovations in power systems, transmission line parameters, network modeling and calculations, load flow studies, short circuit calculations and use of computer software for simulation
Number of Units for Lecture and Laboratory	3 units lecture; 1 unit design
Number of Contact Hours Per Week	3 hours lecture; 3 hours design
Prerequisite	Electrical Standards and Practices
Program Outcomes	To be identified by the program
Course Outcomes	To be identified by the program
Course Outline	1. Elements of Power System Analysis 2. Economic operation of power systems 3. Modelling power system components 4. Load flow analysis 5. Short circuit analysis and calculations 6. Power system protection: selection and coordination of protection system

Course Name	**FUNDAMENTALS OF POWER PLANT ENGINEERING DESIGN**
Course Description	It covers topics on load graphics, types of power plants, power plant operation and protection, interconnections, economics of electric service, and arrangement of equipment for modern plants and includes the design of a power plant, its interconnection, operation, economics, and protection.
Number of Units for Lecture and Laboratory	1 unit design
Number of Contact Hours Per Week	3 hours design
Prerequisite	Co-requisite: Power Systems Analysis
Program Outcomes	To be identified by the program
Course Outcomes	To be identified by the program
Course Outline	1. Power and sources of energy 2. Energy Conservation 3. Renewable Energy 4. Load Profiling 5. Demand Factor 6. Plant Load Factor 7. Diversity Factor 8. Used Factor 9. Capacity Factor 10. Switchgear and Metering 11. Grounding 12. Electronic system for power plant operations 13. Mechanical System for power plant operation 14. Power Plant Economics 15. Net Metering for Customers 16. Demand Side Management 17. Substation layout and design

Course Name	**DISTRIBUTION SYSTEMS AND SUBSTATION DESIGN**
Course Description	The course deals with study and design of primary and secondary distribution networks, load characteristics, voltage regulation, metering techniques and systems, and protection of distribution systems.
Number of Units for Lecture and Laboratory	2 units lecture; 1 unit design
Number of Contact Hours Per Week	2 hours lecture; 3 hours design
Prerequisite	Co-requisite: Power Systems Analysis
Program Outcomes	To be identified by the program
Course Outcomes	To be identified by the program

Course Outline	1. Overview of Distribution Systems Primary Distribution, Radial System, Loop/Ring System, Secondary Distribution 2. Load Characteristics Load Graph, Maximum Demand, Average Demand, Demand Factor, Utilization Factor, Load Factor, Diversity Factor, Load Diversity 3. Distribution Transformer Applications Load Management of Transformers 4. Distribution Lines Overhead and Underground 5. Voltage Regulators Voltage Drop Calculations, Shunt Capacitor Placement, Voltage Regulating Transformers, Tap Changers 6. Distribution Over-current Protection and Coordination Surge Protection, Zones of Protection, Transformer Protection, Bus Protection, Differential Relaying 7. Substations Layout: Ring Bus, Breaker and a Half, Double Bus-Double Breaker Components: Primary/Secondary Power Lines, Auxiliary Transformer, Disconnect Switch, Circuit Breaker, Current Transformer, Lightning Arrester, Main Transformer 8. Power Quality Fourier Series, Symmetrical Components, Total Harmonic Distribution, IEEE Std. Harmonic Mitigation Transformers

Course Name	**RESEARCH METHODS**
Course Description	This course covers the study of the methodologies used in conducting an engineering research. It includes the types and application of research, characteristics of a good research, research design, research instrument and data gathering procedures. It also deals with the study of writing a research proposal and various formats.
Number of Units for Lecture and Laboratory	1 unit laboratory
Number of Contact Hours per Week	3 hours laboratory
Prerequisite	Engineering Data Analysis
Program Outcome/s Addressed by the Course	To be determined by the program
Course Outcomes	After completing this course, the student must be able to: 1. Explain the research methods and procedures 2. Write a research proposal 3. Formulate a research problem 4. Prepare research proposal
Course Outline	1. Nature and characteristics of Research

	2. Types of research 2.1 Basic 2.2 Applied 2.3 Pure 2.4 Characteristics of research 3. Research Problems and Objectives 3.1 Purpose of research 3.2 Developing research objectives 4. Review of Related Literature 1.1 Conceptual Literature 1.2 Research Literature 1.3 Referencing 5. Research Design 7.1 Experimental Design 7.2 Descriptive 6. Research Paradigm 6.1 Dependent Variable 6.2 Independent Variable 7. Data Processes and Statistical Treatment 7.1 T-test 7.2 Z-test 7.3 ANOVA 7.4 Regression 7.5 Hypothesis Testing 8. Writing Research Proposal 8.1 The Problem and Its Background 8.2 Review of Related Literature 8.3 Research Methods and Procedure 9. Ethical Issues on Research

Course Name	**INSTRUMENTATION AND CONTROL**
Course Description	The course deals with the study on control and testing: electromechanical, analog and digital measuring and testing instruments; R, L and C measurements: calibration; graphic and waveform analyzing instruments; detectors for the measurements of process variables; analysis of performance characteristics of control systems; electronics, magnetic, hydraulic and mechanical control. It includes principles of controls and test measurements involving sensors, pneumatic controls, actuators, thermal detectors, thermocouples, thermistors, transducers, PID controllers.
Number of Units for Lecture and Laboratory	2 units lecture; 1 unit laboratory
Number of Contact Hours Per Week	2 hours lecture; 3 hours laboratory
Prerequisite	Feedback Control Systems
Program Outcomes	To be identified by the program
Course Outcomes	To be identified by the program

Course Outline	1. Process and instrumentation diagram 2. Open and close loop system 3. P & ID 4. Level and Fluid flow measurements 5. Mechanical and electrical pressure elements 6. Compressor System 7. Hydraulics 8. Pneumatics 9. Thermocouples 10. Transducers 11. PLC Programming 12. PLC Thyristor 13. Auxilliary System a. Fire Detection and Alarm System (FDAS) b. Closed Circuit Television (CCTV) c. Background Music Paging System d. Telephone System e. Structured Cabling f. Security Alarm System 14. Electrical Test Equipment
Laboratory Equipment	Refer to Annex IV-B – Recommended Laboratory Requirements

Course Name	**FEEDBACK AND CONTROL SYSTEM**
Course Description	This course deals with the basics of control systems; terminologies and diagrams; homogeneous and transient responses of systems; systems representation such as transfer functions, state-space analysis of phase variables and techniques, nth order linear differential equations; modeling, pole-zero gain data and frequency response data; Laplace transforms; block diagrams interconnections and simplifications; signal flow graphs; conversion of block diagrams to signal flow graphs and vice versa; root locus; Bode, Nyquist and Polar plots; PID controllers; sensitivity and stability criteria; linear feedback systems; and compensation techniques
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours Per Week	2 hours lecture
Prerequisite	Engineering Math for EE; Electronic Circuits: Devices and Analysis
Program Outcomes	To be identified by the program
Course Outcomes	To be identified by the program

Course Outline	1. Laplace Transform 15. Transfer Function 16. Electrical network transfer function 17. Electromechanical system transfer function 18. Time Response 19. Block Diagrams 20. Design of feedback system 21. Stability 22. Steady-state errors 23. Root locus techniques

SEMINARS AND COLLOQUIA

The course involves the attendance and participation of EE graduating students in technical seminars/workshops related to the field of Electrical Engineering. Students are also required to attend non-technical seminars and training for the enhancement of their personality. It also involves short lectures on current trends and recent developments in the EE field. It may include educational visits to selected companies and manufacturing plants.

ON-THE-JOB TRAINING

Industry exposure of students for them to match school acquired competencies and knowledge with the realities and problems of industry. This may include involvement in industry manpower requirements, development and research concerns, training, and applications of principles, environmental concerns, ethical and behavioral concerns, decision-making, equipment and materials management. The student shall prepare a thesis on a topic covered by his/her experiences.

SAMPLE DESCRIPTIONS OF ELECTIVES

PATENT LAW AND INTELLECTUAL PROPERTY RIGHTS
The course involves the general introduction to patent law, and the basic legal rules and policies that constitute the important field of intellectual property law. The substance of the course will be on the specific requirements for patentable subject matter, such as the utility, disclosure, enablement, novelty, and non-obviousness requirements, and the statutory bars of public use, sale and abandonment.

RENEWABLE ENERGY FOR SUSTAINABLE DEVELOPMENT
This course deals with the introduction to alternative energy, the usefulness of various types of energies as they relate to sustainable development. Topics include the types of PV cells, its systems, components, operation and its applications; biofuel derived from biological sources and their applications as an energy source for homes, industry and other various applications; hydroelectric power; geothermal energy; and the design, & control of all sub-components of a wind turbine.

ELECTIVE 1. POWER SYSTEM PROTECTION 1
This course deals with the study on the protection of alternators and transformers connected to the electric system at various conditions.

A course involving a study of relay operating principles and characteristics, types of protective relays, applications of protective relaying, and selection of protective relays for transmission and distribution substations/switchgears.

ELECTIVE 2. POWER SYSTEM PROTECTION 2
Electrical surges including traveling waves due to lightning and switching. Topics to be discussed include principles of lightning protection, multi-velocity waves, insulation coordination, application of surge protection devices and power system grounding.

The course will cover insulations in electric field, electrical discharges and insulation systems, calculation of transient voltages, overvoltage, overvoltage protection and insulation coordination, and testing and measuring techniques.

ELECTIVE 1. POWER SYSTEMS – GENERATION AND TRANSMISSION
This course as part of the Electric Power Distribution System will familiarize the students with current engineering trends and the latest development in technology. It covers the different types of power plants, generation rates and pricing, operation and control systems, and others. The course will also deal with real life applications.

This course covers the basic operation of power transmission systems including substation facilities, operating voltages, applicable rules and regulation, and transmission rates and pricing. It will also give an overview on how power flows using a single line diagram of the existing Luzon Grid, Visayas Grid and Mindanao Grid. In addition the course will also familiarize the students with computation of rates and pricing using the latest applicable rules and regulation (EPIRA).

ELECTIVE 2. POWER SYSTEMS – DISTRIBUTION SYSTEM AND SUPPLY
This course covers the different levels of distribution voltages, different types of substations installed in a distribution utility, substation major equipment and their functions; overview of power system protection, overview of SCADA, applicable rules and regulations in distribution systems, and distribution rates and pricing.

This course covers the integration of generation, transmission, and distribution sectors in order to provide electric supply for end-use. Also covered is an illustration of the whole power industry and the complex relationship of its players; strategies on how to maximize spot market benefits involving pricing and other related factors; value-added topics related to electric supply, including self-generation and Smart Grid; and applicable rules and regulations to provide an up-to-date regulatory environment

6. GENERAL EDUCATION COURSES - REFER TO CMO No. 20, s. 2013 – NEW GENERAL EDUCATION CURRICULUM

7. TECHNOPRENEURSHIP COURSE

Course Name	TECHNOPRENEURSHIP 101
Course Description	*Technopreneurship is a philosophy, a way of building a career or perspective in life.* The course covers the value of professional and life skills in entrepreneurial thought, investment decisions, and action that students can utilize in starting technology companies or executing R&D projects in companies as they start their careers. The net result is a positive outlook towards wealth creation, high value adding, and wellness in society.
Number of Units for Lecture and Laboratory	Lecture - 3 units
Number of Contact Hours per week	Lecture - 3 hours
Prerequisite	none
Course Learning Outcomes	The course should enable the student to: 1) evaluate and define the market needs 2) solicit and apply feedback from mentors, customers and other stakeholders 3) experience the dynamics of participating on a business team, 4) pitch a business plan for a technology idea 5) develop an initial idea into a "pretotype"
Course Outline	1. Introduction o Entrepreneurial Mindset o Innovation and Ideas o Products and Services o Team Formation 2. Customers 3. Value Proposition 4. Market Identification and Analysis 5. Creating Competitive Advantage 6. Business Models 7. Introduction to Intellectual Property 8. Execution and Business Plan 9. Financial Analysis and Accounting Basics 10. Raising Capital 11. Ethics, social responsibility, and Globalization
Laboratory Equipment	None

Sample Syllabus

Course Title : TECHNOPRENEURSHIP 101

Course Description : *Technopreneurship is a philosophy, a way of building a career or perspective in life.* The course covers the value of professional and life skills in entrepreneurial thought, investment decisions, and action that students can utilize in starting technology companies or executing R&D projects in companies as they start their careers. The net result is a positive outlook towards wealth creation, high value adding, and wellness in society.

Course Code : TECHNOP 101

Course Units : 3 units

Pre-requisites : none

Course Outcomes and Relationships to Student/Program Outcomes

Course Intended Learning Outcomes After completing the course, the student must be able to:	Student/Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1. Define market needs					/							
2. Define competitive and differentiated product			/									
3. Identify strategies to form design and execution team				/								
4. Design Strategic Plan and initial year operational plan											/	
5. Pitch idea to raise funds enough to create first product and perform validation							/					

Learning Plan

Week	CILO	Topics	Teaching and Learning Activities	Assessment Tasks
1	1,2,3	Introduction: Entrepreneurial Mindset, Team Formation, Innovation and Ideas, Products and Services	Team formation, Lecture Environmental Scanning and Ideation	Individual/ Group Presentation, video presentation, reflection
2	1,2	Customers	Technology Focus (invited speakers and/ or videos)	Reflection/ Journal/ Video Blog
3	1,2	Value Proposition	Lecture	Group presentation
4	1,2	Market Identification and Analysis	Competitive Market Survey	Group presentation
5	2	Creating Competitive Advantage	Competitive Market Analysis	Group presentation/ product comparison matrix
6	2,3,4	Business Models	Business Model Workshop, Product Attribute and Value Map	Group Presentation
7	2,4	Introduction to Intellectual Property	Patent Search	Patent Search Report
8	4,5	Execution and Business Plan	Project Management/ Planning, SCRUM,	Milestone/Work Breakdown Structure
9	4,5	Financial Analysis and Accounting	Basic Finance and Accounting Workshop, Cash Flow Board Game	Balance Sheet, Cashflow Statements, 3-year projection
10	4,5	Raising Capital	Demo Day, Start Up Weekend, Pitching Activity	Elevator Pitch, Venture Pitch

11	2	Ethics and social responsibility & globalization	Case Studies	Case Study Report

Grading System:

(Include standard grading system of HEI and rubrics (if applicable)

References:

The Art of the Start: The time-tested, battle-hardened guide for anyone starting anything, Kawasaki, Guy; ISBN: 1591840562, Portfolio — a member of Penguin Group; 2004
Technology Ventures: From Idea to Enterprise, Dorf, Richard, Byers, Thomas, and Nelson, Andrew; ISBN 978-0073380186; 3rd Edition, 2009
C. R. Carlson and W.W. Wilmot, "Innovation. The five disciplines for creating what customers want", Crown Business (August 8, 2006).
Rich Dad Series by Robert Kiyosaki
The Start-Up Playbook by David S. Kidder
Go Negosyo by Joey Concepcion: 21 steps on how to start your own business By Dean Pax Lapid and Ping Sotto
The Lean Startup by Eric Ries
Zero to One by Peter Thiel
Market Research on a Shoestring by Naeem Zafar

On – line Resources:

Technopreneurial.com

Course Policies and Standards:

(Include policies regarding deadline of submission of requirements, absences and tardiness in attending classes, missed exams, etc.)

ANNEX IV-A – RECOMMENDED LABORATORY REQUIREMENTS for Chemistry/Physics for Engineers

Chemistry for Engineers Laboratory - *based on a class size of 25 students with a maximum of 5 students per group.*

Required Tools/Equipment	Required Quantity
Activated charcoal	5 g
Al strips	5 pieces
Alcohol	30 mL
Alligator clip	10 pieces
Battery	5 pieces
Beaker	5 pieces
Burner	5 pieces
Conductivity apparatus	1 set-up
Cu strips	10 pieces
$CuSO_4$ solution	25 mL
Distillation apparatus	1 set-up
Electrolyte solution	25 mL
Evaporating dish	5 pieces
$Fe(NO_3)_3$ solution	25 mL
$FeCl_3$ solution	25 mL
Filter stand	5 pieces
Food color	5 g
Glass funnel	5 pieces
Glass tubing	5 pieces
Graduated cylinder	5 pieces
HCl solution	80 mL
Hexane	25 mL
I_2 crystals	8 g
KCl solution	25 mL
$KClO_3$ solid	3 g
$KMnO_4$ solution	25 mL
KSCN solution	25 mL
Mg strips	10 pieces
NaCl	5 g
NaCl solution	50 mL
NaOH solution	25 mL
NH_4OH solution	5 mL
Oil	5 mL
$Pb(NO_3)_2$ solution	50 mL
Pb strips	5 pieces
Petri dish	5 pieces
pH paper	20 pieces
Sand bag	5 pieces
Staple wire	50 pieces
Sugar	5 g

Sugar solution	25 mL
Syringe	5 pieces
Test tube	50 pieces
Thermometer	5 pieces
Triple beam balance	5 pieces
Urea	5 g
$Zn(NO_3)_2$ solution	25 mL
Zn strips	15 pieces

Physics for Engineers Laboratory - *based on a class size of 25 students with a maximum of 5 students per group.*

Required Tools/Equipment	Required Quantity
Atwood's machine	5 pieces
Bar magnets	10 pieces
Beaker	5 pieces
Beam balance	5 pieces
Blackwood ballistic pendulum	5 pieces
Bridging plugs/connecting wires	5 sets
Calorimeter	5 pieces
Centripetal force apparatus	5 pieces
Clamp	5 pieces
Coil	5 pieces
Compass	5 pieces
Component holder	15 pieces
Concave lens	5 pieces
Connecting wires	5 sets
Convex lens	5 pieces
Crossed arrow target	5 pieces
Cylindrical lens	5 pieces
DC power supply	5 pieces
Demonstration balance	5 pieces
Dynamic cart	5 pieces
Electric calorimeter	5 pieces
Field mapper kit/mapping Apparatus	5 pieces
Fixed capacitor (330 microfarad)	5 pieces
Fixed resistors	15 pieces
Fluorescent lamps	2 sets
Force table Set	5 pieces
Frame for bar magnets	5 pieces
Free fall apparatus	5 pieces
Friction block with different surfaces	5 pieces
Friction board with pulley	5 pieces
Frictionless dynamic track	5 pieces
Galvanometer	5 pieces
Glass plate	5 pieces
Glass plate of size similar to friction board	5 pieces

Horseshoe magnets	5 pieces
Hydrometer jar	5 pieces
Inclined plane	5 pieces
Inverted U-tube	5 pieces
Light source	5 pieces
Light source, sodium/mercury lamps	5 pieces
Linear air track with blower and trolley	5 pieces
Mass with hook	5 pieces
Masses	5 sets
Mechanical equivalent of heat apparatus	5 pieces
Metal ball	5 pieces
Metal balls of different sizes	12 pieces
Metal conductor with insulated handle	2 sets
Metal stand	5 pieces
Meter stick	5 pieces
Micrometer caliper	5 pieces
Natural magnets	5 pieces
Ohmmeter/VOM	5 pieces
Optics bench	5 pieces
Panel board/circuit board	5 pieces
Parallel ray lens	5 pieces
Platform/triple beam balance	5 pieces
Potentiometer	5 pieces
Ramp/launcher	5 pieces
Ray optics mirror	5 pieces
Ray table and base	5 pieces
Reversing switch	5 pieces
Rheostat	5 pieces
Ring	5 pieces
Rubber hammer	5 pieces
Set of Weights	5 sets
Slide wire/ Wheatstone bridge	5 pieces
Slit mask	5 pieces
Slit plate	5 pieces
Slotted masses, 5-500g	5 sets
Solenoid	5 pieces
Sonometer	5 pieces
SPDT switch	5 pieces
Specimen for shot	5 sets
spherical mirror	5 pieces
Spring	5 pieces
SPST switch	5 pieces
Steam generator	5 pieces
Stirrer for shot	5 pieces
Stopwatch	5 pieces
Support rod	5 pieces
Switch	5 pieces
Thermal expansion apparatus	5 pieces
Thermometer	5 pieces

Timer/stopwatch	5 pieces
Tuning forks of three different frequencies	5 sets
U-tube	5 pieces
Van de Graff generator	2 sets
Vernier caliper	5 pieces
VOM or multitester	5 pieces
Weight holder	5 pieces

ANNEX IV-B – RECOMMENDED LABORATORY EQUIPMENT/APPARATUS for the ALLIED and PROFESSIONAL COURSES

I - ALLIED COURSES

ELECTRONIC CIRCUITS: DEVICES AND ANALYSIS

Recommended Laboratory Exercises	Required Equipment/Apparatus
1. Diode Characteristics	DC Power Supply Digital Multimeter (DMM) Breadboard Oscilloscope Desktop Computer
2. The Diode Limiter, Diode Clamper, Rectifiers and Filters, Voltage Doubler	Function Generator Semiconductor Devices Circuit Board with Power Supply Oscilloscope Digital Multimeter (DMM) Desktop Computer
3. Zener Diode and Voltage Regulation	Digital Multimeter (DMM) Breadboard Semiconductor Devices Circuit board with Power Supply DC Supply Desktop computer
4. BJT Characteristics and Biasing	Digital Multimeter (DMM) Semiconductor Devices Circuit board with Power Supply Desktop computer
5. Small-signal Amplifier a. Common-Base b. Common-Emitter c. Common-Collector	Digital Multimeter (DMM) Transistor Amplifier Circuit board with Power Supply Function Generator Oscilloscope
6. JFET Amplifier	Digital Multimeter (DMM) FET Fundamentals Circuit board with Power Supply Function Generator Oscilloscope
7. BJT/JFET Frequency Response	Digital Multimeter (DMM) Transistor Power Amplifier Circuit board Function Generator Oscilloscope
8. BJT/JFET Frequency Response	Digital Multimeter (DMM) Transistor Power Amplifier circuit board Function Generator Oscilloscope

9. Cascaded Amplifier	Digital Multimeter (DMM) Transistor Amplifier Circuit board Function Generator Oscilloscope
10. Power Amplifier	Digital Multimeter (DMM) Transistor Power Amplifier Circuit board Function Generator Oscilloscope
11. Differential Amplifier, Inverting/Non-inverting Operational Amplifiers, Operational Amplifier Applications	Digital Multimeter Function Generator Digital Oscilloscope Operational Amplifier Circuit Board
12. Feedback Amplifier	Digital Multimeter Transistor Feedback Circuit circuit board Function Generator Oscilloscope
13. Square Wave Oscillators	Digital Multimeter DC power supply Digital Oscilloscope Breadboard
14. Familiarization with Digital Circuits	DC power supply VOM Digital Oscilloscope Digital Circuit Training Module

Note: maximum of 5 students per group

NDUSTRIAL ELECTRONICS

Recommended Laboratory Exercises	Required Equipment/Apparatus
1. Filters	Filter Experimental Module Oscilloscope Multimeter DC Supply Function Generator
2. Voltage Multiplier	Filter Experimental Module Oscilloscope Multimeter DC Supply Function Generator
3. Voltage Regulator	Filter Experimental Module Oscilloscope Multimeter DC Supply Function Generator

4. DC Characteristics of Thyristors and other Switching Devices, Thyristors and Phase Control Circuits	Multimeter Oscilloscope Signal Generator Regulated, variable DC power supply SCRs TRIACs UJTs Capacitors, Resistors, Potentiometers Breadboard SPST Switches Lamp DC Motor
5. Optoelectronic Devices	Oscilloscope Function Generator Multimeter LED, Laser Diode, Photodiode Photodetector Power Supply
6. Transducers and Transmitters	Multimeter Oscilloscope Signal Generator Regulated, variable DC supply Transducer and Transmitter Training Module
7. Programmable controllers – PLC Basics	PC Workstation PLC Training Module with simulation software for PLC
8. PLC timers, counters, and applications	PC Workstation PLC Training Module with simulation software for PLC

Note: maximum of 5 students per group

II- PROFESSIONAL COURSES

ELECTRICAL CIRCUITS I

Recommended Laboratory Exercises	Required Equipment/Apparatus
1. Familiarization with electrical measuring instruments and devices	Circuit Training kit / Module Analog/digital Multimeter Analog/digital milliammeter Analog/digital ammeter Analog/digital voltmeter Variable/fixed regulated power supply Analog/digital wattmeter Rheostat (variable resistor)
2. Design of voltage divider circuits	Multimeter DC ammeter DC voltmeter Variable/fixed DC regulated power supply Calibrated potentiometer Variable resistive load Connecting wires
3. Complete response of first-order dynamic circuits	Computer system Computer-aided circuit analysis software
4. Voltage-current relationships in resistive, inductive, and capacitive circuits wit sinusoidal excitation	Multimeter AC ammeter AC voltmeter Function generator Dual trace oscilloscope Variable resistive load Variable inductive load Variable capacitive load Connecting wires
5. At least two design experiments on selected topics	Combination of existing lab apparatus, instruments, devices; Available freeware for circuit analysis (capable of doing DC analysis, transient analysis, AC analysis)

Note: maximum of 5 students per group

Recommended Laboratory Exercises	Required Equipment/Apparatus
1. Design and applications of impedance bridge circuits	AC ammeter AC voltmeter Function generator Calibrated potentiometer Variable resistor Variable Inductor/capacitor Inductive load Capacitive load Connecting wires
2. Power in AC circuits; maximum power transfer principle	AC ammeter AC voltmeter Function generator Wattmeter Variable resistive, inductive, capacitive load Connecting wires
3 Power factor correction	AC ammeter AC voltmeter Function generator Wattmeter Variable resistive, inductive, capacitive load Connecting wires
4. Series-tuned and parallel-tuned circuits	AC ammeter AC voltmeter Function generator Variable resistor Variable Inductor Variable capacitor Connecting wires
5. Two-port network analysis of RLC circuits	Circuit training kit / module Analog/digital Multimeter AC milliammeter AC ammeter AC voltmeter Function generator Variable resistor, variable resistive load Variable Inductive load, variable capacitive load Connecting wires
6. Voltage and current relationships in balanced three-phase systems	Three-phase power supply Analog/Digital Multimeter AC ammeter AC voltmeter Fixed resistor, inductor, and capacitor Connecting wires

7. Power measurement in balanced three-phase, 3-wire and 4-wire systems	Three-phase power supply Analog/Digital Multimeter AC ammeter AC voltmeter Single-phase wattmeter Lamp loads 3-phase inductive load Connecting wires
8. Analysis of three-phase systems with unbalanced loading	Three-phase power supply Analog/Digital Multimeter AC ammeter AC voltmeter Single-phase wattmeter Single-phase inductive load Single-phase capacitive load Lamp load 3-phase inductive load Connecting wires
9. Power factor correction in three-phase systems	Three-phase power supply Multimeter AC ammeter AC voltmeter Variable capacitor 3-phase inductive load Connecting wires
10. Analysis of circuits with magnetically coupled-coils	AC power supply Multimeter AC ammeter AC voltmeter Rheostat Two-winding transformer Variable resistive load Connecting wires
11. At least four design experiments on selected topics	Combination of existing lab apparatus, instruments, devices; Available freeware for circuit analysis (capable of doing DC analysis, transient analysis, AC analysis)

Note: maximum of 5 students per group

ELECTRICAL CIRCUITS 2

AC APPARATUS AND DEVICES

Recommended Laboratory Exercises	Required Equipment/Apparatus
1. Characteristic tests of a single-phase two-winding transformer: polarity test, open circuit test, short circuit test	Single-phase AC power supply Multimeter AC ammeter AC voltmeter Wattmeter Variable autotransformer (VARIAC) Connecting wires
2. Voltage regulation and efficiency of a transformer	Single-phase AC power supply Multimeter Variable autotransformer (VARIAC) AC ammeter AC voltmeter Power factor meter Two-winding transformer Variable resistive load Variable inductive load Variable capacitive load Connecting wires
3. Conversion of a two-winding transformer into an autotransformer	Single-phase AC power supply Multimeter Variable autotransformer (VARIAC) AC ammeter AC voltmeter Two-winding transformer Variable resistive load Variable inductive load Variable capacitive load Connecting wires

4. Parallel operation of single-phase transformers	Single-phase AC power supply Multimeter Variable autotransformer (VARIAC) AC voltmeter Power factor meter Two-winding transformer Variable resistive load Variable inductive load Variable capacitive load Connecting wires
5. The three-phase transformer and the three-phase transformer bank	Three-phase power supply Multimeter AC ammeter AC voltmeter Three-phase transformer Single-phase two-winding transformer Three-phase inductive load Connecting wires
6. The open delta or V – V connection of single-phase transformers	Three-phase power supply AC ammeter AC voltmeter Single-phase two-winding transformer Three-phase inductive load Connecting wires
7. The Scott-connection or T-T connection of two single- phase transformers	Three-phase power supply Multimeter AC ammeter AC voltmeter Single-phase two-winding transformer (with 50% and 86.6% taps on both primary and secondary) Three-phase inductive load Connecting wires
8. Parallel operation of three- phase transformers or three- phase banks	Three-phase power supply Multimeter AC ammeter AC voltmeter Power factor meter Three-phase transformer Single-phase two-winding transformer Three-phase inductive load Connecting wires

ELECTRICAL MACHINES 2

Recommended Laboratory Exercises	Required Equipment/Apparatus
1. Familiarization with electromechanical energy conversion equipment	DC compound machine Multimeter Cage rotor induction machine Slip ring machine DC ammeter DC voltmeter Rheostat DC power supply Connecting wires
2. Characteristics of the DC shunt, series, compound motor	Multimeter DC compound machine DC power supply DC ammeter DC voltmeter Torque meter Rheostat Variable resistive load General purpose rheostat Connecting wires
3. Parallel operation of DC generators	Multimeter DC compound machine DC power supply DC ammeter DC voltmeter Rheostat Variable resistive load General purpose rheostat Connecting wires
4. The squirrel-cage induction motor (SCIM) and the wound-rotor induction motor	Cage-rotor induction machine Slip ring machine Three-phase power supply Multimeter AC voltmeter AC ammeter AC wattmeter Torque meter Connecting wires

5. The synchronous motor	Slip-ring machine DC power supply DC compound machine DC voltmeter Three-phase power supply AC voltmeter AC ammeter AC wattmeter Torque meter Variable resistive load Connecting wires Multimeter
6. External characteristics of a three-phase alternator	Slip ring machine DC compound machine DC power supply Rheostat AC voltmeter AC ammeter DC voltmeter Wattmeter Variable resistive load Three-phase resistive load Three-phase inductive load Three-phase capacitive load Connecting wires Multimeter
7. Synchronization and parallel operation of three-phase alternators	Slip ring machine DC compound machine DC power supply Rheostat Direct-on-line starter Synchroscope DC ammeter DC voltmeter AC ammeter AC voltmeter Variable resistive load Three-phase resistive load Phase sequence indicator Data management system Connecting wires Multimeter
8. At least two design experiments to illustrate the industrial applications of Ac machines	Available freeware for analysis of AC machine characteristics and performance

INSTRUMENTATION AND CONTROL

Recommended Laboratory Exercises	Required Equipment/Apparatus
1. Measurement of Electric and Magnetic quantities and analysis of measurement error	Adjustable DC Power Supply Oscilloscope with connectors Digital Multi-meter VOM RLC meter Power meter Signal generator
2. Sensors, transducers, transmitters, and actuators	Experimental Module for sensors, transducers, transmitters, and actuators
3. Data acquisition, ADC/DAC conversion, signal conditioning, recording and retrieval	Training Module for analog Data acquisition, conversion, and digital data recording and retrieval
4. Temperature Measurement	Temperature Control Training Module
5. Measurement of Pressure	Pressure Control Training Module
6. Measurement of flow rate and liquid level	Flow rate and Level Measurement Training Module
7. On-off Control	On-off control Training Module
8. PID control	PID Controller Training Module
The remaining meetings shall be allotted for the presentation of a project related to Instrumentation and Control, and completion of other course requirements such as practical, oral, or written examinations, where applicable.	

Note: maximum of 5 students per group

ANNEX V – SAMPLE COURSE SYLLABUS

Bachelor of Science in Electrical Engineering

***Note:** This sample course syllabus contains only the minimum requirements. HEIs may enrich this sample depending on their requirements and needs.*

Title	**Electrical Circuits 2 (Lecture)**
Description	The course covers sinusoidal steady-state analysis in the frequency domain; AC circuit power analysis; analysis of polyphase circuits and magnetically-coupled circuits; frequency response; per unit system and symmetrical components; and two-port networks.
Course Code	To be determined by the program
Credit Units	3
Prerequisites	Electrical Circuits 1
Links to Program Outcomes	Program outcomes (b), (e), and (g) This serves as an introductory course that supports the attainment of program outcomes (c), (e), and (k) and as an enabling course for outcomes (a), (b), and (g).
Course Outcomes	After completion of the course, the student shall be able to: CO1. Discuss and apply mesh/nodal analysis and use appropriate network theorems in the frequency-domain analysis of AC circuits CO2. Explain the concept of power in AC systems and solve power flow problems CO3. Analyze and determine the response of three-phase circuits, with balanced and unbalanced loading CO4. Analyze circuits containing magnetically-coupled coils CO5. Analyze the behavior and determine the response from RL, RC, and RLC circuits driven by a variable-frequency source CO6. Explain the per unit system and determine the symmetrical components of unbalanced three-phase voltages/currents CO7. Analyze and solve problems involving two –port networks.

Course Outline

Week	COURSE OUTCOMES	TOPICS	TLA	AT
1 – 3 (3 weeks)	**CO1.** Discuss and apply mesh/nodal analysis and use appropriate network theorems in the frequency-domain analysis of AC circuits	1. Orientation and discussion about course outcomes, course coverage, teaching learning activities and assessment tasks, classroom policies, grading system 2. Sinusoidal steady-state analysis in the frequency-domain 3. Mesh and nodal analysis 4. Application of Superposition, Thevenin's and Norton's theorems in AC circuit analysis	Class discussion; Problem solving	Recitation; Seatwork; homework; quiz
4 – 6 (3 weeks)	**CO2.** Explain the concept of power in AC systems and solve power flow problems	1. AC circuit power analysis 2. Average power 3. Apparent power and reactive power 4. Power factor and power factor correction	Class discussion; Problem solving	Recitation; Seatwork; quiz
7 – 9 (3 weeks)	**CO3**. Analyze and determine the response of three-phase circuits, with balanced and unbalanced loading	1. Analysis of 3-phase, 3-wire and 4-wire AC systems with balanced loading 2. Power measurement in 3-phase systems 3. Effects of unbalanced loading in 3-phase systems	Class discussion; Problem solving	Recitation; Seatwork; homework; quiz
10 – 11 (2 weeks)	**CO4.** Analyze circuits containing magnetically-coupled coils	1. Concept of mutual inductance 2. Analysis of circuits containing magnetically-coupled coils 3. The ideal transformer	Class discussion; Problem solving	Recitation; Seatwork; quiz
12 – 14 (3 weeks)	**CO5**. Analyze the behavior and determine the response from RLC circuits driven by a variable-frequency source	1. Parallel resonant circuits 2. Series resonant circuits 3. Basic passive filter design	Class discussion; Problem solving	Recitation; Seatwork; homework; quiz
15 (1 week)	**CO6**. Explain the per unit system and determine the symmetrical components of unbalanced three-phase voltages/currents	1. Per unit system 2. Symmetrical components of unbalanced 3-phase voltages/currents	Class discussion; Problem solving	Recitation; Seatwork; quiz
16 – 17 (2 weeks)	**CO7**. Analyze and solve problems involving two – port networks	1. Two-port network parameters 2. Network responses 3. Network interconnection	Class discussion; Problem solving	Recitation; Seatwork; quiz
Last week	**CO1 – CO7**	Summative assessment – written final examination		

Final Grade Evaluation

Results from the seatwork, homework, quizzes and recitation shall be considered in the computation of the final grade. The grading system shall reflect the degree by which the stated course outcomes are achieved and this system shall be discussed during the orientation (first meeting).

Suggested Learning Resources:

1. Textbook - to be determined by the program
2. References, e-books, e-journals, websites – to be determined by the program

Course Policies and Standards

Course policies and standards as stated in the student handbook and specific course policies may be discussed during the orientation (first meeting).

Effectivity and Revision Information

The date of last revision and the date of effectivity shall be indicated. Also, the group/individual who prepared and the person who reviewed and approved the syllabus shall be identified.