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

CHED MEMORANDUM ORDER
No. 89
Series of 2017

SUBJECT: POLICIES, STANDARDS AND GUIDELINES FOR THE BACHELOR OF SCIENCE IN GEODETIC ENGINEERING (BSGE) 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 (OBE) leading to competency-based standards. It specifies the "core competencies" expected of Bachelor of Science in Geodetic Engineering (BSGE) graduates "regardless of the type of Higher Education Institutions (HEI) they graduate from." However, in recognition of outcomes-based education and the typology of HEIs, this PSG also provide 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 a BSGE program must first secure proper authority from the Commission in accordance with this PSG. All PHEIs with an existing BSGE 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) should likewise strictly adhere to the provisions in these policies and standards.

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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 a **sample curriculum**. The number of units of this curriculum is herein 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 in Article V Section 12 for the HEI to refer to in compliance with the implementing guidelines of CMO 37, s. 2012.

Using a learner-centered/outcomes-based approach as basis, CHED provided a description of the 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 for 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 given 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 can 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 24 of Article VII.

ARTICLE IV
PROGRAM SPECIFICATIONS

Section 5. Program Description

5.1 Degree Name

The degree program herein shall be called Bachelor of Science in Geodetic Engineering(BSGE).

5.2 Nature of the Field of Study

Geodetic Engineering is that branch of engineering which deals with the collection and measurement of spatial data above, on, or below the surface of the earth using appropriate technologies and the scientific and methodological processing and management of these data for the production of spatial information systems, maps, plans, charts, and other documents.

Geodetic Engineering includes the establishment of geodetic control network; collection of ground data using various methodologies, techniques, platforms and sensors; processing, evaluation and analysis of collected data to generate information for various applications; quality assurance of outputs in accordance with the accepted standards and specifications; development of survey and mapping standards and protocols; conduct of research and development activities; development of spatial information systems; and development of business entrepreneurial skills.

5.3 Program Educational Objectives

Program Educational Objectives (PEOs) are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve within a few years of 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 BSIE program. The PEOs should also be reviewed periodically for continuing improvement.

5.4 Specific Professions/Careers and Entry-Level Competency Standards for BSGE Graduates

The scope of the practice of Geodetic Engineering is defined in the prevailing Philippine Geodetic Engineering Act of 1998 or R.A. 8560, as amended, and pertains to professional services to individuals or organizations in terms of, but not limited to: consultation requiring Geodetic Engineering knowledge, skills and proficiency; professional Geodetic Engineering services with the use of surveying and mapping equipment; conduct of various surveys (e.g., land, control, subdivision, engineering, photogrammetric); mapping activities; development and management of spatial information systems; preparation of maps, charts and other geovisualization products; and among others. The teaching, lecturing, and reviewing of a professional Geodetic Engineering subjects in the curriculum of the BSGE degree or a subject in the Geodetic Engineering licensure examination given in any school, college, university or any other educational institution is also considered as practice of Geodetic Engineering.

Graduates of BSGE can have professions and careers as:

a. Land Surveyor
b. Educator
c. Photogrammetrist/Photogrammetric Engineer
d. GIS specialist
e. Hydrographic Surveyor
f. Remote sensing Specialist
g. Information systems engineer/consultant
h. Land development engineer/manager
i. Land administration specialist
j. Land valuation specialist
k. Project engineer/manager
l. Planning engineer
m. Research engineer
n. Systems analyst/engineer/designer
o. Technopreneur
p. Risk analyst/engineer
q. Construction/industrial surveyor
r. Mine surveyor
s. Mapping specialist

Competency standards for BSGE graduates are given in **Annex I**.

5.5 Allied Programs

The allied programs for Geodetic Engineering are Civil Engineering, Geology and other Earth Sciences, Statistics, Computer Science, and Information and Communications Technology. This list maybe expanded upon review by the Commission.

Section 6 Institutional and Program Outcomes

The minimum standards for the BS in Geodetic Engineering program are expressed in the following minimum set of institutional and BSGE program outcomes.

6.1 Institutional outcomes

a) Graduates of professional institutions must demonstrate a service orientation in one's profession

b) Graduates of colleges must 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 must participate in the generation of new knowledge or in research and development projects
d) Graduates of SUCs must, in addition, have the competencies to support "national, regional and local development plans" (RA 7722)
e) Graduates of HEIs must preserve and promote the Filipino historical and cultural heritage

6.2. BSGE Program Outcomes

The program outcomes for BS in Geodetic Engineering are given in the following minimum set. Graduates of the program must have the ability to:

a) Apply knowledge of mathematics, physical sciences, and engineering sciences to the practice of geodetic engineering;
b) Design and conduct experiments to test hypotheses and verify assumptions, as well as to organize, analyze and interpret data, draw valid conclusions, and develop mathematical models for processes;
c) Design, improve, innovate, and to supervise systems or procedures to meet desired needs within realistic constraints, in accordance with standards;
d) Work effectively in multi-disciplinary and multi-cultural teams in diverse fields of practice;
e) Identify, formulate, and solve geodetic engineering problems;
f) Understand professional, social, and ethical responsibility;
g) Communicate effectively through oral, written, print, and other media;
h) Understand the effects and impact of the geodetic engineering profession on the environment and the society;
i) Engage in life-long learning and to keep current of the developments in a specific field of specialization;
j) Know contemporary issues;
k) Use the appropriate techniques, skills and tools necessary for the practice of geodetic engineering;
l) Know and understand engineering and management principles as a member and leader of a team, and manage projects in a multidisciplinary environment;
m) Understand at least one focus area of geodetic engineering practice and apply such knowledge to provide solutions to actual problems.

Section 7 Sample Performance Indicators

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

Table 1 shows sample performance indicators for Outcome (a) as defined in Section 6.

Table 1. Sample Performance Indicators of a Program Outcome

Program Outcomes		Performance Indicators	
a	apply knowledge of mathematics, physical sciences, and engineering sciences to the practice of geodetic engineering	1	Apply concepts of linear algebra, calculus, and numerical methods to solve geodetic engineering problems.
		2	Apply mathematical and physical principles in understanding processes.
		3	Develop strategies to solve geodetic engineering problems.
		4	Develop methodologies to address issues related to the physical, natural, and socio-economic environment.

Section 8 Program Assessment and Evaluation

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.

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 (AM) 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 the student's peers.

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

Performance Indicators		**Key Courses**	**Assessment Methods**	**Target and Standards**
1	Apply concepts of linear algebra, calculus, and numerical methods to solve geodetic engineering problems.	Advance Engineering Mathematics for Geodetic Engineering	Final Examination	80% of the students get a rating of at least 60%
2	Apply mathematical and physical principles in understanding physical processes affecting locations.	Physical Geodesy	Project Report	80% of the students get a rating of at least 60%

3	Develop strategies to solve geodetic engineering problems.	Satellite Positioning	Final Examination	80% of the students get a rating of at least 60%
4	Develop methodologies to address issues related to the physical, natural, and socio-economic environment.	Undergraduate Project	Student Project on Applications of Geodetic Engineering	80% of the students get a rating of at least 60%

For the Assessment of Program Educational Objectives, the stakeholders of the program have to be contacted through surveys or focus group discussion to obtain feedback data on the extent of the achievement of the PEOs.

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

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 should 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 its implementation. This regular cycle of documentation of projects, programs for remediation and their successful implementation shall serve as the evidence for Continuous Quality Improvement (CQI).

ARTICLE V
CURRICULUM

Section 10 Curriculum Description

The Bachelor of Science in Geodetic Engineering curriculum is designed to develop engineers who have a background in mathematics, natural, physical and allied sciences. As such the curriculum contains courses in mathematics, physics, geology, and environmental sciences.

The BSGE curriculum also contains mandated general education and elective courses as connected to the desired program outcomes. This is to ensure that the Geodetic Engineering graduate is articulate and understands the nature of his/her special role in society and the impacts of his/her work on the environment and society. The curriculum is designed to guarantee a certain breadth of knowledge of Geodetic Engineering disciplines through a set of core courses and to ensure depth and focus in certain disciplines through track specialization elective courses. The curriculum develops the basic tools and techniques necessary to solve problems in the field of Geodetics Engineering. A minimum of 240 hours of immersion in Geodetic Engineering activities outside the institution and a capstone project in Geodetic Engineering design, research and development are the final requirements of the curriculum.

Section 11 Sample Curriculum

11.1 Components

Classification/ Field / Course	**Minimum No. of Hours Lecture/Lab**		**Minimum Credit Units**
	Lecture	**Lab**	
I. TECHNICAL COURSES			
A. Mathematics and Physical Sciences			
Calculus 1	3	0	3
Calculus 2	3	0	3
Engineering Data Analysis	3	0	3
Differential Equations	3	0	3
Physics for Engineers	3	3	4
Sub-Total	**15**	**3**	**16**
B. Basic Engineering Sciences			
Computer Fundamentals & Programming	1	6	3
Computer-Aided Drafting	1	3	2
Engineering Mechanics	3	0	3
Engineering Economics	3	0	3
Engineering Management	3	0	3
Safety Management	1	0	1
Technopreneurship 101	3	0	3
Sub-Total	**15**	**9**	**18**

Classification/ Field / Course	Minimum No. of Hours Lecture/Lab		Minimum Credit Units
	Lecture	Lab	
C. Allied Courses			
Principles of Geology	3	0	3
Electrical and Electronics Engineering for Geodetic Engineers	3	0	3
Advanced Information & Communications Technology	3	0	3
Environmental Science and Engineering	3	0	3
Sub-Total	**12**	**0**	**12**
D. Professional Courses			
General Surveying 1	2	3	3
General Surveying 2	2	6	4
Property Surveys	3	6	5
Engineering Surveys	2	6	4
Cartography	1	6	3
Introduction to the Laws on Private and Public Lands	2	0	2
Geodetic Engineering Laws, Obligations and Contracts, Ethics	2	0	2
Public Land Laws & Laws on Natural Resources	3	0	3
Land Registration Laws	3	0	3
Photogrammetry	2	6	4
Remote Sensing	2	6	4
Geometric Geodesy	3	0	3
Physical Geodesy	3	0	3
Satellite Geodesy	3	0	3
Geodetic Surveying	2	6	4
Hydrographic Surveying	2	3	3
Theory of Errors and Adjustments	3	0	3
Geodetic Computations & Adjustments	2	6	4
Land Use Planning and Development	2	3	3

Classification/ Field / Course	Minimum No. of Hours Lecture/Lab		Minimum Credit Units
	Lecture	Lab	
Land Administration and Management	3	0	3
Geographic Information Systems	1	6	3
Geodetic Engineering Elective	3	0	3
Survey Camp	0	3	1
Geodetic Engineering Immersion/OJT	0	240	2
Methods of Research	1	0	1
Special Studies in Geodetic Engineering	1	6	3
Sub-Total	**53**	**312**	**79**
TOTAL TECHNICAL COURSES	**95**	**324**	**125**
II. NON-TECHNICAL COURSES			
A. Required General Education			
Understanding the Self	3	0	3
Readings in Philippine History	3	0	3
The Contemporary World	3	0	3
Mathematics in the Modern World	3	0	3
Purposive Communication	3	0	3
Ethics	3	0	3
Art Appreciation	3	0	3
Science, Technology, and Society	3	0	3
Sub-Total	**24**	**0**	**24**
B. General Education Electives			
General Education Elective	3	0	3
General Education Elective	3	0	3
General Education Elective	3	0	3
Sub-Total	**9**	**0**	**9**

Classification/ Field / Course	Minimum No. of Hours Lecture/Lab		Minimum Credit Units
	Lecture	Lab	
C. Mandated Courses			
Life and Works of Rizal	3	0	3
Sub-Total	**3**	**0**	**3**
D. Physical Education			
P.E. 1			2
P.E. 2			2
P.E. 3			2
P.E. 4			2
Sub-Total			**8**
E. National Service Training Program			
N.S.T.P. 1			3
N.S.T.P. 2			3
Sub-Total			**6**
TOTAL NON-TECHNICAL COURSES			**50**
GRAND TOTAL			**175**

SUMMARY OF THE BSGE CURRICULUM

Classification/ Field	Total No. of Hours		Total No. of Units
	Lecture	Laboratory	
I. TECHNICAL COURSES			
A. Mathematics and Physical Sciences	15	3	16
B.. Basic Engineering Sciences	15	9	18
C. Allied Courses	12	0	12
D. Professional Courses	53	312	79
Sub- Total	**95**	**324**	**125**

II. NON-TECHNICAL COURSES			
A. Required General Education Courses	24	0	24
B. General Education Electives	9	0	9
C. Mandated Course	3	0	0
D. Physical Education			6
E. National Service Training Program			8
Sub-Total	**36**		**50**
GRAND TOTAL			**175**

11.2 Sample Program of Study

The institution may enrich the sample/model program of study depending on the needs of the industry, provided that all prescribed courses required in the curriculum outlines 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 trimester or quarter term 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 exceed **190 units**, including P.E., and N.S.T.P. courses.

SAMPLE SEMESTRAL PROGRAM OF STUDY

FIRST YEAR

1st Year – First Semester

Courses	No. of Hours		Units	Prerequisite/Co-requisite
	Lecture	Lab		
Calculus 1	3	0	3	
Computer Fundamentals and Programming	1	6	3	
Engineering Data Analysis	3	0	3	
General Surveying 1	2	3	3	
Readings in Philippine History	3	0	3	
Safety Management	1	0	1	
Computer-Aided Drafting	1	3	2	
Introduction to the Laws on Private and Public Lands	2	0	2	
P.E. 1			2	
TOTAL			**22**	

1st Year – Second Semester

Courses	No. of Hours		Units	Prerequisite/Co-requisite
	Lecture	Lab		
Calculus 2	3	0	3	Calculus 1
General Surveying 2	2	6	4	General Surveying 1
Physics for Engineers	3	3	4	Calculus 2
Cartography	1	6	3	
Principles of Geology	3	0	3	
Mathematics in the Modern World	3	0	3	
P.E. 2			2	
TOTAL			**22**	

SECOND YEAR

2nd Year – First Semester

Courses	No. of Hours		Units	Prerequisite/Co-requisite
	Lecture	Lab		
Differential Equations	3	0	3	Calculus 2
Engineering Surveys	2	6	4	General Surveying 2
Geometric Geodesy	3	0	3	General Surveying 2
Theory of Errors and Adjustments	3	0	3	Differential Equations
Art Appreciation	3	0	3	
Engineering Mechanics	3	0	3	Calculus 2
Electrical and Electronics Engineering for Geodetic Engineers	3	0	3	
TOTAL			**22**	

2nd Year – Second Semester

Courses	No. of Hours		Units	Prerequisite/Co-requisite
	Lecture	Lab		
Hydrographic Surveying	3	0	3	General Surveying 2
Physical Geodesy	2	0	2	Geometric Geodesy
Geodetic Engineering Laws, Obligations, and Contracts, Ethics	2	0	2	Introductions to the Laws on Private and Public Lands
Satellite Geodesy	4	0	4	Geometric Geodesy; Physical Geodesy
Geodetic Computations and Adjustments	2	3	3	Theory of Errors and Adjustments
Purposive Communication	3	0	3	
Geodetic Surveying	3	0	3	Geometric Geodesy; Physical Geodesy
TOTAL			**22**	

2nd Year – Summer/Midterm

Courses	No. of Hours		Units	Prerequisite/Co-requisite
	Lecture	Lab		
Survey Camp – 120 Hours	0	3	1	
TOTAL			**1**	

THIRD YEAR

3rd Year – First Semester

Courses	No. of Hours		Units	Prerequisite/Co-requisite
	Lecture	Lab		
Land Registration Laws	3	0	3	Introduction to the Laws on Private and Public Lands
Property Surveys	3	6	5	General Surveying 2
Photogrammetry	2	6	4	Geodetic Computations and Adjustments; Cartography
Remote Sensing	2	6	4	Physics for Engineers
Ethics	3	0	3	
P.E. 3			2	
TOTAL			**21**	

3rd Year – Second Semester

Courses	No. of Hours		Units	Prerequisite/Co-requisite
	Lecture	**Lab**		
Land Use Planning and Development	2	3	3	Geographic Information Systems
Land Administration and Management	3	0	3	
Geographic Information Systems	1	6	3	Cartogrpahy
Environmental Science and Engineering	3	0	3	
General Education Elective	3	0	3	
Understanding the Self	3	0	3	
P.E. 4			2	
TOTAL			**20**	

3rd Year – Summer/Midterm

Courses	No. of Hours		Units	Prerequisite/Co-requisite
	Lecture	Lab		
Geodetic Engineering Immersion / O.J.T (240 Hours)	0	6	2	
TOTAL			**2**	

FOURTH YEAR

4th Year – First Semester

Courses	No. of Hours		Units	Prerequisite/Co-requisite
	Lecture	Lab		
Geodetic Engineering Elective	3	0	3	
Methods of Research	1	0	1	
Technopreneurship 101	3	0	3	
G.E. Elective	3	0	3	
Engineering Economics	3	0	3	
Advanced Information & Communications Technology	3	0	3	
The Contemporary World	3	0	3	
N.S.T.P.1			3	
TOTAL			**22**	

4th Year – Second Semester

Courses	No. of Hours		Units	Prerequisite/Co-requisite
	Lecture	Lab		
Public Land Laws and Laws on Natural Resources	3	0	3	Introduction to the Laws on Private and Public Lands
Special Studies in Geodetic Engineering	1	6	3	Methods of Research
Science, Technology, and Society	3	0	3	
G.E. Elective	3	0	3	
Life and Works of Rizal	3	0	3	
Engineering Management	3	0	3	
N.S.T.P. 2			3	
TOTAL			**21**	

Total = 175 Units

Suggested Geodetic Engineering Elective:

a. Spatial Database
b. Marine Cadastre
c. Geospatial Information Management
d. Building Information Modelling
e. Laser Scanning
f. Unmanned Aerial Systems
g. 3D GIS
h. Location-based Services
i. Geovisualization
j. Land Valuation
k. Disaster Risk Reduction and Management
l. Hydrology

Section 12 Sample Curriculum Map

Refer to **Annex II** for the Minimum Program Outcomes and Sample Curriculum Map. The HEI will have to develop its own Curriculum Map.

Section 13 Description of Outcomes-Based Teaching and Learning

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). It is a student-centered approach for the delivery of educational programs where the curriculum topics in a program and the courses contained in it are expressed as the intended outcomes for students to learn. It is an approach in which teachers facilitate and students find themselves actively engaged in their learning.

Its primary focus is the clear statement of what students should be able to do after taking a course, known as the Intended Learning Outcomes (ILOs). The ILOs describe what the learners will be able to do when they have completed their course or program. 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 the ILOs have been determined, the next step in OBTL is to design the Teaching / Learning Activities (TLAs) which require students to actively participate in the construction of their new knowledge and abilities. A TLA is any activity which stimulates, encourages or facilitates learning of one or more intended learning outcome. The final OBTL component is the Assessment Tasks (ATs), which measure how well students can use their new abilities to solve real-world problems, design, demonstrate creativity, and communicate effectively, among others. An AT can be any method of assessing how well a set of ILO 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, and 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 the Course Syllabus to be implemented by the faculty.

Section 14 Course Syllabus

The Course Syllabus must contain the following minimum components:

14.1 General Course Information (Course Number/Code, Course Title, Course Description, Credit Units, Prerequisites)
14.2 Links to Program Outcomes
14.3 Course Outcomes
14.4 Course Outline (including Unit Outcomes)
14.5 Teaching and Learning Activities
14.6 Assessment Methods
14.7 Final Grade Evaluation
14.8 Learning Resources
14.9 Course Policies and Standards
14.10 Effectivity and Revision Information

See **Annex III** for Sample Course Specifications for the courses listed in the Sample Curriculum Map and **Annex V** for a Sample Course Syllabus.

ARTICLE VI
REQUIRED RESOURCES

This article covers the specific required resources for the BS in Geodetic Engineering program.

All other requirements on administration, library and laboratory facilities, and buildings 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 Program Administration

There shall be a full-time Department/Program Chair/Coordinator who will lead in the curriculum planning, implementation, monitoring, review, and evaluation of the BS in Geodetic Engineering program.

The Geodetic Engineering Department under the College of Engineering shall be administered by a Department/Program Chair who shall have the following qualifications:

a. Holder of a B.S. Geodetic Engineering degree;
b. Registered Geodetic Engineer with valid PRC license;
c. Holder of Master's and preferably Doctoral degree in Geodetic Engineering, Geomatics Engineering, Management, Engineering Education, Natural Science, Mathematics, or other relevant Engineering program and allied or other related allied fields;
d. With at least three (3) years of college-level teaching experience relevant to BS Geodetic Engineering program.

The college dean may serve as concurrent department or program chair in extreme cases of low enrolment. The semestral academic workload of the Department/Program Chair/ Coordinator shall be defined by the HEI.

Section 16 Faculty

16.1 Requirements

There must be an adequate number of competent and qualified faculty to teach all of the curricular areas of the Geodetic Engineering program and appropriate student-faculty ratio to effectively implement dynamic minimum requirements set by CHED.

All faculty members teaching professional courses in BS Geodetic Engineering program must have the following qualifications:

1. Holder of BS Geodetic Engineering degree, Master's degree and preferably Doctoral degree in Geodetic Engineering or allied/related fields
2. Registered Geodetic Engineer with valid PRC ID
3. Must preferably have taken units of principles of teaching or equivalent course (e.g., teaching effectiveness course)

Faculty members teaching Geodetic Engineering Design and Research Project and other professional courses in Geodetic Engineering must preferably have relevant industry training or experience.

The faculty must sustain active participation in professional development in the areas of research, scholarly work, and professional practice in the field of Geodetic Engineering. The faculty must be involved in the curriculum review, decision-making, and implementation of the academic program. The faculty must also contribute to program assessment and evaluation.

16.2 Duties

The faculty must be actively involved in the following areas of implementation of the BSGE program:

a. curriculum review, 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 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 of the program
g. research and scholarly work
h. professional services offered by the program
i. linkage and extension work

Section 17 Library and Other Learning Resources

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

Facilities are covered in Section 2.4 of CMO No. 86, s. 2017.

18.1 Laboratories for the BS in Geodetic Engineering Program

The program must provide survey and mapping equipment and other relevant equipment for the following courses:

a. Surveying courses
b. Geodesy courses
c. Remote Sensing
d. Photogrammetry
e. Special Studies in Geodetic Engineering
f. Basic Electrical and Electronics Engineering

The program must provide computing laboratories for the following courses but the laboratories need not to be separate or under the maintenance of the GE department:

a. Computer-Aided Drafting
b. Cartography
c. Remote Sensing
d. Geographic Information Systems
e. Geodetic Computations and Adjustments
f. Geodesy courses
g. Surveying courses
h. Special Studies in Geodetic Engineering

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

ARTICLE VII
COMPLIANCE OF HEIs

Section 19 Full Compliance with CMO 37, s. 2012

Before the start of AY 2018-2019, all HEIs offering BS in Geodetic Engineering programs 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

BS in Geodetic Engineering programs a Monitoring Workbook (CMO 37-MW-2017-HEI-BSGE) and Self-Assessment Rubric (SAR) (CMO-37-HEI-SAR-2017-BSGE).

The five-year BSGE curriculum shall be the basis of the monitoring. The completed Monitoring Workbook with a List of Supporting Evidences and Self-Assessment Rubric must 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 BSGE programs 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 with BSGE programs with low SAR total scores may be asked to submit a one- or two-year development plan to CHED before they shall be allowed to apply to continue their BSGE program for AY 2018-2019.

19.3 Exemptions

HEIs with BSGE 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-BSGE). 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 currently offering the BSGE program for AY 2018-2019 shall be made to complete a new Application Workbook (AW-2018-HEI-BSGE) 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 with BSGE programs with COE or COD status submitting their completed Application Workbooks shall automatically receive certifications from CHED and shall be given approval to implement their programs beginning AY 2018-2019.

Other concerned HEIs which have submitted their CMO Monitoring Workbooks, Self-Assessment Rubrics, and Application Workbook shall be given conditional approval by CHED to start offering their new BSGE Curriculum following this CMO effective AY 2018-2019. CHED shall, however, conduct monitoring of HEIs to assure complete compliance of this PSG within the transitory period, during which HEIs with BSGE programs with weak implementation may be asked to submit developmental plans, which shall be subject to constant monitoring.

ARTICLE VIII
TRANSITORY, REPEALING and EFFECTIVITY PROVISIONS

Section 22 Transitory Provision

All private HEIs, state universities and colleges, and local universities and colleges with existing authorization to operate the Bachelor of Science in Geodetic Engineering 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 thereafter be held invalid, shall not affect the remaining provisions.

All CHED issuances or part thereof inconsistent with the provision 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 for a Geodetic Engineer
- Annex II – Minimum Program Outcomes and Sample Curriculum Map
- Annex III – Sample Course Specifications
- Annex IV – Laboratory Requirements
  - A. Natural/Physical Sciences
  - B. Professional Courses
- Annex V – Sample Course Syllabus

ANNEX I – COMPETENCY STANDARDS FOR A GEODETIC ENGINEER

ATTRIBUTE		COMPETENCY LEVEL		
		NEW GRADUATE	1 - 7 YEARS ENGINEERING EXPERIENCE	GLOBALLY QUALIFIED ENGINEER
1	Apply knowledge of mathematics, geology, physics, biology, information technology and other engineering principles.	Understand the principles of mathematics, geology, physics, biology, 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 process design and operations.	Use relevant and appropriate applied science, engineering principles and techniques in formulating process design and operations improvement and optimization.Develop simple computer programs to solve geodetic engineering problems.	Propose innovations in geospatial methodologies and solutions and impart these to peers.Develop and continually upgrade proficiency in surveying and mapping, spatial data analysis, geospatial information management, and numerical and computational modeling in solving Geodetic 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 designing, developing, improving and operationalizing geospatial methodologies and solutions. Propose changes in methodologies used in addressing geospatial problems to achieve the desired outputs.	Consolidate results of research and technical information in formulating solutions to geospatial problems and adapt these into systems to achieve required 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 geodetic engineering applications 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 geodetic engineering applications and propose changes for solutions and further improvements. Specialize in specific fields of practice in Geodetic Engineering and use the technical expertise in design of geospatial solutions to applicable complex engineering problems. Prepare project proposals, budget and reports related to improvements and optimization of geospatial applications, processes 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 computational and field scale experiments and 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 methodologies and experiments in conducting investigations of complex engineering problems. Conduct computational and field 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 information technology (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 process parameters and equipment.	Be familiarized with process operations and applicable modern tools and techniques to solve operational problems taking into consideration process limitations. Use industry 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 Geodetic Engineering Professional Practice. Make a personal commitment to societal, health, safety, legal and cultural issues recognizing 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 Geodetic Engineering Professional Practice. Prepare plans and designs to address geospatial 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 Geodetic 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 geospatial 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 geodetic engineering practice. Assess the effects of professional engineering work on process 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 geodetic engineering practice. Use gained experience in professional practice to measure impacts on society and environment. Be familiar with land administration, valuation, and management, geospatial data infrastructure, geospatial information management, developments in datums and transformations, developments in survey and mapping standards and technologies, and other upcoming developments, standards, technologies, and methodologies. Impart learning to peers.	Be familiar with relevant applicable technical and engineering standards that can be applied in professional Geodetic Engineering practice. Use gained experience in professional practice to measure impacts on society and environment. Be familiar with land administration, valuation, and management, geospatial data infrastructure, geospatial information management, developments in datums and transformations, developments in survey and mapping standards and technologies, and other upcoming developments, standards, technologies, and methodologies. 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 Ethical and Professional Standards for the Practice of Geodetic Engineering 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 Ethical and Professional for the Practice of Geodetic Engineering and apply and behave according to this code in professional practice. Be familiar with corporate, industrial, and government 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 Ethical and Professional for the Practice of Geodetic Engineering and apply and behave according to this code in professional practice. Be familiar with corporate, industrial, and government 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 processes, 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 Geodetic Engineering.	Plan, lead, organize and control small to medium-sized projects or tasks as may be deemed necessary in the practice of Geodetic 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 Geodetic 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 geodetic engineering profession. Pursue graduate studies.	Attend trainings, seminars, conferences and participate in professional organizations that encourage continued learning in the Geodetic 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 Geodetic Engineering profession. Prepare modules for training peers, subordinates and students. Organize seminars, trainings or conferences. Publish research papers.

ANNEX II – MINIMUM PROGRAM OUTCOMES AND SAMPLE CURRICULUM MAP

Program Outcomes

Graduates of the BSGE program are able to:

a. Apply knowledge of mathematics, physical sciences, and engineering sciences to the practice of geodetic engineering;
b. Design and conduct experiments to test hypotheses and verify assumptions, as well as to organize, analyze and interpret data, draw valid conclusions, and develop mathematical models for processes;
c. Design, improve, innovate, and to supervise systems or procedures to meet desired needs within realistic constraints, in accordance with standards;
d. Work effectively in multi-disciplinary and multi-cultural teams in diverse fields of practice;
e. Identify, formulate, and solve geodetic engineering problems;
f. Understand professional, social, and ethical responsibility;
g. Communicate effectively through oral, written, print, and other media;
h. Understand the effects and impact of the geodetic engineering profession on the environment and the society;
i. Engage in life-long learning and to keep current of the developments in a specific field of specialization;
j. Know contemporary issues;
k. Use the appropriate techniques, skills and tools necessary for the practice of geodetic engineering;
l. Know and understand engineering and management principles as a member and leader of a team, and manage projects in a multidisciplinary environment;
m. Understand at least one focus area of geodetic engineering practice and apply such knowledge to provide solutions to actual problems.

Legend:

Code	*Descriptor*	*Definition*
I	Introductory	A course that provides foundational understanding of the outcome
E	Enabling	A course that strengthens the outcome
D	Demonstrating	A course that exhibits or shows the outcome

I. Technical Courses

A. Mathematics and Physical Sciences

Course	*Relationship to Program Outcomes*												
	a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*	*L*	*m*
Calculus 1	I				E								
Calculus 2	I				E								
Differential Equations	I				E								
Engineering Data Analysis	I	I	I		E								
Physics for Engineers	I	I											

B. Basic Engineering Sciences

Course	Relationship to Program Outcomes												
	a	b	c	d	e	f	g	h	i	j	k	L	m
Computer-Aided Drafting	I						I				I	D	
Computer Fundamentals and Programming	I	I			E						I	D	
Engineering Mechanics	I	I			E								
Engineering Economics				I								E	
Engineering Management				I								E	
Safety Management			E					E					

D. Allied Courses

Course	Relationship to Program Outcomes												
	a	b	c	d	e	f	g	h	i	j	k	l	m
Principles of Geology				I									
Electrical and Electronics Engineering for Geodetic Engineers				I									
Advanced Information & Communications Technology				I									
Technopreneurship												E	
Environmental Science and Engineering				I									

E. Professional Courses

Course	Relationship to Program Outcomes												
	a	b	c	d	e	f	g	h	i	j	k	l	m
General Surveying 1	E	E		D				E			D		
General Surveying 2	E	E		D				E			D		
Property Surveys	E	E		D				E			D		
Engineering Surveys	E	E		D				E			D		
Cartography	E	E		D				E			D		
Introduction to the Laws on Private and Public Lands					I								
Geodetic Engineering Laws, Obligations and Contracts, Ethics					E								
Public Land Laws & Laws on Natural Resources					E								
Land Registration Laws					E								
Photogrammetry	E	E			D				E		D		
Remote Sensing	E	E			D				E		D		
Geometric Geodesy	E	E			D				E		D		
Physical Geodesy	E	E			D				E		D		
Satellite Geodesy	E	E			D				E		D		
Geodetic Surveying	E	E			D				E		D		
Hydrographic Surveying	E	E			D				E		D		
Theory of Errors and Adjustments	E	E			D								

Geodetic Computations & Adjustments	E	E			D								
Land Use Planning and Development				E									
Land Administration and Management				E									
Geographic Information Systems			I						E		D		
Geodetic Engineering Elective	E	E			D								
Survey Camp	I												
Geodetic Engineering Immersion/OJT											D		
Methods of Research											E		
Special Studies in Geodetic Engineering	E	E			D								D

II. Non-Technical Courses
A. Required General Education

Course	*Relationship to Program Outcomes*												
	a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*	*l*	*m*
Understanding the Self									E				
Readings in Philippine History								I					
The Contemporary World										E			
Mathematics in the Modern World	I												
Purposive Communication							E						
Ethics						E							
Art Appreciation							E						
Science, Technology, and Society								E					

B. General Education Electives

Course	*Relationship to Program Outcomes*												
	a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*	*l*	*m*
GE Elective								I					

C. Mandated Course

Course	*Relationship to Program Outcomes*												
	a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*	*l*	*m*
Life and Works of Rizal							E						

ANNEX III – SAMPLE COURSE SPECIFICATIONS

I. TECHNICAL COURSES

A. MATHEMATICS AND PHYSICAL SCIENCES

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 science to solve complex geodetic engineering problems
Course Outcomes	After completing this course, the student must 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 science to solve complex geodetic engineering problems
Course Outcomes	After completing this course, the student must 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 geodetic 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 is designed for undergraduate engineering students with emphasis on problem solving related to societal issues that engineers and scientists are called upon to solve. It introduces different methods of data collection and the suitability of using a particular method for a given situation. The relationship of probability to statistics is also discussed, providing students with the tools they need to understand how "chance" plays a role in statistical analysis. Probability distributions of random variables and their uses are also considered, along with a discussion of linear functions of random variables within the context of their application to data analysis and inference. The course also includes 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. Finally, statistically based experimental design techniques and analysis of outcomes of experiments are discussed with the aid of statistical software.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours per week
Prerequisites	Calculus 1
Program Outcomes	a. Apply knowledge of mathematics, physical sciences, and engineering sciences to the practice of geodetic engineering; b. Design and conduct experiments to test hypotheses and verify assumptions, as well as to organize, analyze and interpret data, draw valid conclusions, and develop mathematical models for processes; c. Design, improve, innovate, and to supervise systems or procedures to meet desired needs within realistic constraints, in accordance with standards; e. Identify, formulate, and solve geodetic engineering problems;
Course Outcomes	After completing this course, the student must be able to: 1. Apply statistical methods in the analysis of data 2. Design experiments involving several factors
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

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
Corequisite	Calculus 2
Program Outcome	a. ability to apply knowledge of mathematics and science to solve complex geodetic engineering problems b. ability to design and conduct experiments, as well as to 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	Physics Laboratory

B. 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 lecture; 1 unit laboratory
Number of Contact Hours per Week	1 hour lecture; 3 hours laboratory
Prerequisite	None
Program Outcome	a. ability to apply knowledge of mathematics and science to solve complex geodetic engineering problems g. ability to communicate effectively k. ability to use techniques, skills, and modern engineering tools necessary for geodetic 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	**COMPUTER FUNDAMENTALS AND PROGRAMMING**
Course Description	Basic information technology concepts; fundamentals of algorithm development; high-level language and programming applications; computer solutions of engineering problems.
Number of Units for Lecture and Laboratory	1 unit lecture; 2 units laboratory
Number of Contact Hours per Week	1 hour lecture; 6 hours laboratory
Prerequisite	None
Program Outcome	a. ability to apply knowledge of mathematics and science to solve complex geodetic engineering problems k. ability to use techniques, skills, and modern engineering tools necessary for geodetic 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 the computer as a tool in engineering practice.
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	**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 geodetic 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 for 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	Second Year Standing
Program Outcomes	e. Ability to identify, formulate, and solve complex geodetic engineering problems

	k. Ability to use techniques, skills, and modern engineering tools necessary for 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

Course Name	ENGINEERING MANAGEMENT
Course Description	Decision-making; the functions of management; managing production and service operations; managing the marketing function; and managing the finance function.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	Third Year Standing

Program Outcomes	h, i, l
Course Objectives	After completing this course, the student must be able to: 1. Understand the field of engineering management; 2. Know and apply the different functions of management.
Course Outline	1. Introduction to Engineering Management 2. Decision Making 3. Functions of Management 3.1. Planning / Coordinating 3.2. Organizing 3.3. Staffing 3.4. Communicating 3.5. Motivating 3.6. Leading 3.7. Controlling 4. Managing Product and Service Operations 5. Managing the Marketing Function 6. Managing the Finance Function
Laboratory Equipment	None
Suggested References	Eisner, Howard. *Essentials of Project and System Engineering Management*, 2nd ed. John Wiley & Sons, Inc., 2002. Gram, Harold A. *An Introduction to Management.* Holt, Rinehart and Winston of Canada, Limited, 1990. Oberlender, Gerold D. *Project Management for Engineering and Construction*, 2nd ed. McGraw-Hill, 2000. Robbins, Stephen P. and Mary Coulter. *Management*, 6th ed. Prentice Hall, Inc., 1999. Wheeler, Thomas F. *Computer and Engineering Management.* McGraw-Hill, 1990.

Course Name	**BASIC OCCUPATIONAL SAFETY AND HEALTH**
Course Description	Occupational Safety and Health (OSH) concepts, principles and practices; 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	1 unit lecture
Number of Contact Hours per Week	1 hour lecture
Prerequisite	Second Year Standing
Program Outcomes	c. ability to 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

	h. broad education necessary to understand the impact of industrial engineering solutions in a global, economic, environmental, and societal context
Course Outcomes	After completing this course, the students must be able to: 1. Understand the concepts related to occupational safety and industrial hygiene. 2. Identify solutions for occupational safety and health problems 3. Determine causes of occupational health problems 4. Know OSH laws in the Philippines
Course Outline	1. Introductory Concepts 2. Occupational Safety and Health Principles 3. Industrial Hygiene 3.1. Workplace Hazards 3.2. Types of Controls 4. Government Legislation 5. Preventive and Protective Measures 5.1. Engineering Controls 5.2. Administrative Controls 5.3. PPE 6. Management of OSH 6.1. Worker Participation 6.2. Training 6.3. Key Performance Indicators 7. Health Promotion, Education, and Training 8. Plant Visit Simulation

C. ALLIED COURSES

Course Name	**ELECTRICAL AND ELECTRONIC ENGINEERING FOR GEODETIC ENGINEERS**
Course Description	Principles, basic laws and theorems used in analyzing electrical circuits in both direct current and alternating current conditions. Analysis of DC and AC Circuits; characteristics and methods of control; digital circuits and logic gates; Transducers and transducer circuits. Feedback control systems; introduction to digital control; Introduction to Programmable Logic Controllers; A/D-D/A Conversion; process control.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	Physics for Engineers
Program Outcome	m. ability to design, develop, implement, and improve integrated systems that include people, materials, information, equipment and energy

Course Outcomes	After completing this course, the student must be able to: 1. Know the characteristics, uses and application of circuit elements/devices and their parameters; and 2. Apply the fundamental circuit laws, theorems and techniques used in DC and AC circuit analysis.
Course Outline	1. Definitions, Types and Symbols of Circuit Elements, Circuit Variables and Parameters 2. Resistance 2.1. Definitions 2.2. Factors That Affect the Resistance of a Conductor 2.3. Resistivity of Commonly Used Conductors 2.4. Resistance as a Function of Temperature 2.5. Conductance 3. Ohm's Law, Electrical Power, Electrical Energy 4. Heating Effect of Electric Current 5. Resistors 6. Network Reduction (Delta-to-Wye Transformation, Wye-to-Delta Transformation) 7. Maximum Power Transfer in Direct Current Circuits 8. Cells and Batteries 9. Laws, Theorems and Methods Used in Network Analysis 9.1. Kirchhoff's Laws 9.2. Maxwell's Mesh Method 9.3. Superposition Theorem 9.4. Thevenin's Theorem 9.5. Norton's Theorem 10. Inductors 11. Capacitors 12. Alternating Current Circuits 12.1. Definition of AC 12.2. Nomenclature of Periodic Waves 12.3. Equations of Continuous Sinusoidal Current and Voltage Waves 12.4. Phase Angle, Phase Angle Difference, Leading Wave, Lagging Wave 12.5. Impedance Function 13. Voltage and Current Relationships 13.1. Pure Resistive Circuit 13.2. Pure Inductive Circuit 13.3. Pure Capacitive Circuit 13.4. Series RL Circuit 13.5. Series RC circuit 13.6. Series RLC Circuit 14. Effective Value of AC 15. Phasor Algebra 16. Conductance, Susceptance and Admittance of AC Circuits 17. Analysis of DC and AC Circuits 18. Characteristics and methods of control 19. Digital circuits and logic gates 20. Transducers and transducer circuits 21. Feedback control systems 22. Introduction to digital control 23. Introduction to Programmable Logic Controllers 24. A/D-D/A Conversion 25. Process control.

<table>
<tr><td>Course Name</td><td>ENVIRONMENTAL SCIENCE AND ENGINEERING</td></tr>
<tr><td>Course Description</td><td>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.</td></tr>
<tr><td>Number of Units for Lecture and Laboratory</td><td>3 units lecture</td></tr>
<tr><td>Number of Contact Hours per Week</td><td>3 hours lecture</td></tr>
<tr><td>Prerequisite</td><td>None</td></tr>
<tr><td>Program Outcome</td><td>c. ability to 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
h. broad education necessary to understand the impact of geodetic engineering solutions in a global, economic, environmental, and societal context</td></tr>
<tr><td>Course Outcomes</td><td>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.</td></tr>
<tr><td>Course Outline</td><td>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</td></tr>
</table>

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	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	None
Program Outcome	l. knowledge and understanding of engineering and management principles as a member and leader in a team, to manage projects and in multidisciplinary environments
Course Outcomes	After completing this course, the student must be able 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 “prototype.”
Course Outline	1. Introduction 1.1. Entrepreneurial Mindset 1.2. Innovation and Ideas 1.3. Products and Services 1.4. 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

E. PROFESSIONAL COURSES

1. CORE COURSES

Course Title	**GENERAL SURVEYING 1**
Course Description	Use of principal surveying instruments; surveying measurements and error theory; basic plane surveying operations and computational method of position; horizontal and vertical distance measurements; traverse and areas; basic cartography.

Number of Units for Lecture and Laboratory	2 units lecture; 1 unit laboratory
Number of Contact Hours per Week	2 hours lecture; 3 hour laboratory
Prerequisite	None
Program Outcome	a. Apply knowledge of mathematics, physical sciences, and engineering sciences to the practice of geodetic engineering; b. Design and conduct experiments to test hypotheses and verify assumptions, as well as to organize, analyze and interpret data, draw valid conclusions, and develop mathematical models for processes; d. Work effectively in multi-disciplinary and multi-cultural teams in diverse fields of practice; h. Understand the effects and impact of the geodetic engineering profession on the environment and the society; k. Use the appropriate techniques, skills and tools necessary for the practice of geodetic engineering
Course Outcomes	Upon completion of the course, students must be able to: CO 1. Explain the principles and usage of typical surveying instruments CO 2. Discuss field procedures employed in plane surveying CO 3. Identify errors associated with common field operations and adjust field data accordingly CO 4. Demonstrate proper fieldwork procedures and mathematical computations in conducting horizontal and vertical distance measurements CO 5. Execute field computations of traverse, area and simple subdivision problems CO 6. Illustrate correct survey plans CO 7. Develop basic knowledge in cartography
Course Outline	1.0 Class Orientation • Lab Instrument Use Rules and Regulations • Surveying Fieldwork 2.0 Introduction to Surveying and Mapping • Geomatics and Its Disciplines • Surveying, Uses of Surveys and Types of Surveys • Definition of Basic Surveying Terms • Mapping 3.0 Errors and Statistics; Probable Errors • Measurement vs. Observation • Error and Correction, Sources of Errors and Types of Errors • Statistics and Measures of Central Tendency • Precision vs. Accuracy • Probable Errors, Weighted Observations and Interrelationship of Errors 4.0 Horizontal Distance Measurement • Spatial and Horizontal Distances • Methods and Instruments Used to Determine Horizontal Distances

	• Taping, Types of Measuring Tapes, Taping Accessories and Operations in Taping 5.0 Tape Correction • Rules in Tape Corrections • Corrections to Tape EXAMINATION 1 6.0 Angle and Direction Measurements; Compass Traverse • Components of an Angle and Angles in the Vertical Plane • Meridian and Its Types • Units for Measuring Angles • Bearing, Azimuth and Other Angles • Instruments for Angle and Direction Measurements • Magnetic Declination and Its Variations • Closed-Compass Traverse Sample Computation and Adjustment • Lab Exercise: Pacing and Closed-Compass Traverse 7.0 Horizontal Position by Triangulation & Trilateration • Triangulation • Trilateration • Strength of Figure 8.0 Horizontal Position Computation by Traverse and Sideshots • Traverse, Purposes of Traverse, General Classes of Traverse and Types of Traverse • Traverse Computation and Adjustment • Compass Rule and Transit Rule • Sideshots Computation and Adjustment • Coordinates Computation • Total Station Demo • Lab Exercise: Handling and Setting-up the Total Station • Lab Exercise: Closed-Loop Azimuth Traverse • Lab Exercise: Sideshots 9.0 Area Computation Techniques • Methods of Area Computations for Regular Boundaries • Methods of Area Computations for Irregular Boundaries EXAMINATION 2 10.0 Omitted Measurements • Common Types of Omitted Measurements • Sample Computations 11.0 Simple Subdivision • Simple Subdivision Sample Computation and Adjustment • Lab Exercise: Area Computation and Simple Subdivision Computation (Officework) 12.0 Introduction to Vertical Distance Measurements • Definition of Basic Leveling Terms • Leveling and Significance of Leveling Operations • Types of Level and Leveling Rod • Leveling Operations 13.0 Introduction to Cartography; Plotting Guidelines • Cartography and Its Development • Map, Map Elements and Types of Maps • Importance of Maps in Geographic Information Systems (GIS) • Analog vs. Digital Maps • Map Scale and Planning

	• Inside a Lot Plan • Plotting by Coordinate Method • Lot Data Computation Form • Lab Exercise: Plotting EXAMINATION 3 FINAL EXAMINATION

Course Name	**GENERAL SURVEYING 2**
Course Description	Introduction of different surveying operations and techniques: control, topographic, hydrographic and mine surveying, introduction to astronomic and satellite geodesy, introduction to remote sensing and geographic information systems.
Number of Units for Lecture and Laboratory	2 units lecture; 2 units laboratory
Number of Contact Hours per Week	2 hours lecture; 6 hours laboratory
Prerequisites	General Surveying 1
Program Outcome	a. Apply knowledge of mathematics, physical sciences, and engineering sciences to the practice of geodetic engineering; b. Design and conduct experiments to test hypotheses and verify assumptions, as well as to organize, analyze and interpret data, draw valid conclusions, and develop mathematical models for processes; d. Work effectively in multi-disciplinary and multi-cultural teams in diverse fields of practice; h. Understand the effects and impact of the geodetic engineering profession on the environment and the society; k. Use the appropriate techniques, skills and tools necessary for the practice of geodetic engineering
Course Outcomes	Upon completion of the course, students must be able to: CO 1. Explain the principles, concepts and objectives of the different types of surveying and basic geospatial technologies CO 2. Identify the uses or applications of the different types of surveying and basic geospatial technologies CO 3. Use properly the total station, level and theodolite CO 4. Perform properly the different types of surveying from planning to submittal of survey returns CO 5. Construct survey plans and topographic maps
Course Outline	1.0 Class Orientation • Lab Instrument Use Rules and Regulations • Guidelines in Fieldwork Proposal (Outline) 2.0 Review of Horizontal and Vertical Positioning • Recall of Horizontal Positioning, Vertical Positioning • Review of Adjustment • Automatic Level (Demo and Familiarization) • Lab Exercise Prep: Reconnaissance and Recovery of Existing Control Points

	3.0 Techniques for Vertical Distance Measurements • Double Rod, Double Set-Up, Double Run, Three-Wire and Trigonometric Leveling • Errors in Leveling • Adjustment of Intermediate Benchmarks • Automatic Level Demo 4.0 Control Surveying • Definition, Types, and Classes (According to Area and Accuracy) • Control Stations • Process of Control Surveying • Accuracy Standards and Specifications • Philippine Reference Datum • Lab Exercise: Establishment of Vertical Control (Leveling) 5.0 Topographic Surveying • Topography, Topographic Surveying and Maps • Methods of Representing Relief • Characteristics and Types of Contours • Selection of Contour Interval • Applications of Contours • Basic Field Methods for Locating Topographic Details • Locating Contour Lines by Interpolation • Standards for Accuracy of Maps and Map Data • Lab Exercise: Topographic Surveying 6.0 Mine Surveying • Parts of a Mine • Solving for Strike and Dip using Boreholes • Eccentric Telescopes • Control Establishment • Mine Orientation • Lab Exercise: Mine Surveying Examination I 7.0 Hydrographic Surveying • Hydrography, Hydrographic Surveys, and Maps • Operations in Hydro-survey • Tides, Tidal Datums, and Tide Stations • Soundings • Point Fixing • Lab Exercise: Hydrographic Surveying (Bathymetric Mapping) 8.0 Astronomic Observations • Introduction to Geodetic Astronomy • Celestial Sphere • Celestial Coordinate Systems • Astronomic Triangle • Special Star Positions • Astronomic Observations • Azimuth Determination • Errors and Corrections • Lab Exercise: Azimuth Determination from Solar Observations 9.0 Introduction to Geospatial Technologies • Evolution of Navigation and Positioning • The Global Positioning System

	• Positioning using GPS • GPS Sources of Errors • Differential GPS • GPS Equipment • GPS Applications & Developments • Introduction to Geographic Information Systems • Introduction to Remote Sensing • Lab Exercise: GPS Navigation EXAMINATION 2 FINAL EXAMINATION

Course Name	**PROPERTY SURVEYS**
Course Description	Property boundary surveys, survey project controls, comparative equipment, procedures and precision, standards, regulations governing property surveys, transformation of coordinates from different coordinate systems used in the Philippines and current advancements in land surveying.
Number of Units for Lecture and Laboratory	3 units lecture; 2 units laboratory
Number of Contact Hours per Week	3 hours lecture; 6 hours laboratory
Prerequisite	General Surveying 2
Program Outcome	a. Apply knowledge of mathematics, physical sciences, and engineering sciences to the practice of geodetic engineering; b. Design and conduct experiments to test hypotheses and verify assumptions, as well as to organize, analyze and interpret data, draw valid conclusions, and develop mathematical models for processes; d. Work effectively in multi-disciplinary and multi-cultural teams in diverse fields of practice; h. Understand the effects and impact of the geodetic engineering profession on the environment and the society; k. Use the appropriate techniques, skills and tools necessary for the practice of geodetic engineering
Course Outcomes	Upon completion of the course, students must be able to: CO 1. Explain the different classes of land surveys CO 2. Identify the coordinate system used to fix the position of property surveys CO 3. Execute boundary survey CO 4. Recognize the different kinds of property maps/plans CO 5. Generate several property survey maps/ plans CO 6. Identify applicable rules, regulations and procedures prescribed by the Philippine Government in the conduct of property surveys CO 7. Recognize the different advancements in property surveying

Course Outline	1. Course Introduction and Requirements A. Definition of Terms B. Property Surveying General Methodology 2. Scope and Classification of Property Surveying A. Classification of Property Surveying B. Agencies involved in Property Surveying C. Instrumentation 3. Position of Surveys A. Points of References B. Fixing Points of References C. Coordinate Systems D. Control Survey E. Reference Survey/ Common Point Analysis 4. Isolated Surveys A. Different kinds of isolated surveys B. Methodology C. Survey outputs D. Inspection, Verification and Approval of Surveys 5. Subdivision Surveys A. Simple Subdivision B. Complex Subdivision C. Methodology D. Survey outputs 6. Cadastre and Cadastral Survey A. Purposes and Requirement B. Methodology C. Survey Output 7. Technological Advancement in Property Surveying A. Geocentric System B. Non-traditional survey techniques C. Digital survey plan submission

Course Name	**ENGINEERING SURVEYS**
Course Description	The course focuses on the application of surveying principles to construction and industrial works with emphasis on the geometry and layout of road and railway curves, earthworks and lay-out of buildings.
Number of Units for Lecture and Laboratory	2 units lecture; 2 units laboratory
Number of Contact Hours per Week	2 hours lecture; 6 hours laboratory
Prerequisite	General Surveying 2
Program Outcome	a. Apply knowledge of mathematics, physical sciences, and engineering sciences to the practice of geodetic engineering; b. Design and conduct experiments to test hypotheses and verify assumptions, as well as to organize, analyze and interpret data, draw valid conclusions, and develop mathematical models for processes;

	d. Work effectively in multi-disciplinary and multi-cultural teams in diverse fields of practice; h. Understand the effects and impact of the geodetic engineering profession on the environment and the society; k. Use the appropriate techniques, skills and tools necessary for the practice of geodetic engineering
Course Outcomes	By the end of the semester, students must be able: 1. To conduct surveys for the control of construction and industrial works by understanding the basic procedures; 2. To design and layout horizontal and vertical curves by understanding the geometry employed; 3. To conduct survey works and prepare survey plans for engineering works; 4. To compute and analyze earthwork quantities; and 5. To layout several types of construction works.
Course Outline	1. Introduction a. Definition of Terms b. Control c. Topographic Survey/ Equipment 2. Route Surveying: Horizontal Route Alignment a. Circular Curves b. Spiral Easement Curves and Super elevation 3. Route Surveying: Vertical Route Alignment a. Profiles b. Vertical Curves c. Sight Distances 4. Earthworks a. Profiles and Cross-sections b. Areas of Cross-sections c. Volume Computation d. Earthwork Distribution Analysis 5. Construction Surveys a. Line and Grade i. Highways ii. Sewers, Pipelines and Culverts iii. Tunnels iv. Bridges b. Buildings c. Dams d. As-built Surveys e. Construction Management THIRD LONG EXAM: PROJECT

Course Name	**CARTOGRAPHY**
Course Description	Overview of cartography; maps; mapping standards in the Philippines; terrain modeling; computer-aided design (CAD) for survey applications; basic Geographic Information Systems (GIS)
Number of Units for Lecture and Laboratory	1 unit lecture; 2 units laboratory

Number of Contact Hours per Week	1 hour lecture; 6 hours laboratory
Prerequisite	None
Program Outcomes	a. Apply knowledge of mathematics, physical sciences, and engineering sciences to the practice of geodetic engineering; b. Design and conduct experiments to test hypotheses and verify assumptions, as well as to organize, analyze and interpret data, draw valid conclusions, and develop mathematical models for processes; d. Work effectively in multi-disciplinary and multi-cultural teams in diverse fields of practice; h. Understand the effects and impact of the geodetic engineering profession on the environment and the society; k. Use the appropriate techniques, skills and tools necessary for the practice of geodetic engineering
Course Outcomes	Upon completion of the course, students must be able to: CO 1. Explain and illustrate the concepts, principles and applications of cartography CO 2. Apply the different mapping theories and standards in digital map design and layout CO 3. Create and analyze spatial datasets, and prepare maps with the use digital cartographic software, including CAD and GIS CO 4. Implement topographic symbols and plotting of areas from topographic survey CO 5. Generate map visualizations of terrain and other geographic data CO 6. Perform basic surface interpretation for road design and volume computation. CO 7. Prepare documentations of work flows and procedures in performing software-based exercises and provide solutions to possible errors or problems CO 8. Propose, design and create maps of a chosen subject/topic CO 9. Present and interpret the map project in class and/or in the Geomatics Student Project Colloquium at the end of the course
Course Outline	1. Introduction to Cartography (1 week) 1.1 Definition of Cartography 1.2 Characteristics and classifications of maps 1.3 Purpose and application of maps 1.4 Advantages and limitation of maps Lab: Map Template (CAD) 2. Computer-Assisted Cartography (1 week) 2.1 Definition, justification and applications of computer-assisted cartography 2.2 Data acquisition for digital mapping 2.3 Introduction to related software for computer-assisted cartography 2.4 Survey plan preparation, standards and specifications Lab: Survey Plan (CAD) 3. Scale, Coordinate Systems and Projections (1 week)

	3.1 Definition, forms and types of scale 3.2 Definition and difference of coordinate systems and projections 3.3 Four levels of map classification 3.4 Introduction to geographic information systems Lab: Understanding scale and projections 4. Contour Interpretation (1 week) 4.1 Definitions of contour and related terms 4.2 Characteristics and types of contour 4.3 Methods of plotting contour 4.4 Applications and interpretation of contour Lab: Contour Plotting (CAD and Surfer) 5. Surface Interpretation (1 week) 5.1 Definition of surfaces 5.2 Introduction to horizontal and vertical alignments in CAD 5.3 Introduction to volume computation in road alignments Lab: Basic Road Design & Volume Computations (CAD) 6. Map Design and Layout (2 weeks) 6.1 Review of basic map elements 6.2 Types and components of map design 6.3 Typography 6.4 Patterns 6.5 Colors 6.6 Symbolization Lab: Map Layout in GIS 7. Geo-referencing (1 week) 7.1 Definition of geo-referencing 7.2 Related concepts in geo-referencing 7.3 Methods and application of geo-referencing Lab: Georeferencing and Digitization 8. Map Design Process (1 week) 8.1 Purpose of making maps 8.2 Designing maps Lab: Thematic mapping, symbolization and visualization of Geographic Data 1 9. Generalization of Geographic Data (1 week) 9.1 Introduction and definition of generalization 9.2 Elements and controls of generalization Lab: Thematic mapping, symbolization and visualization of Geographic Data 2 10. Map Project Implementation (4 weeks) 10.1 Map project proposal 10.2 Map design and implementation Lab: Map project proposal Lab: Map implementation

Course Title	**PHOTOGRAMMETRY**
Course Description	Mono and Stereo Photogrammetry; principles of vertical photography and stereoscopy; Optics; Image coordinate refinement; theory of orientation and aerial triangulation; digital image processing; DEM, contour and orthophoto generation; principles of satellite photogrammetry; close-range applications

Number of Units for Lecture and Laboratory	2 units lecture; 2 units laboratory
Number of Contact Hours per Week	2 hours lecture; 6 hours laboratory
Prerequisites	Geodetic Computations and Adjustments; Cartography
Program Outcomes	a. Apply knowledge of mathematics, physical sciences, and engineering sciences to the practice of geodetic engineering; b. Design and conduct experiments to test hypotheses and verify assumptions, as well as to organize, analyze and interpret data, draw valid conclusions, and develop mathematical models for processes; e. Identify, formulate, and solve geodetic engineering problems; i. Engage in life-long learning and to keep current of the developments in a specific field of specialization; k. Use the appropriate techniques, skills and tools necessary for the practice of geodetic engineering
Course Outcomes	Upon completion of the course, students must be able to: CO 1. Acquire a general appreciation of photogrammetry and its contribution to Geomatics CO 2. Understand the theoretical principles of digital stereo and mono photogrammetry CO 3. Know the theories behind photo orientation and aerotriangulation CO 4. Produce various photogrammetric products related to surveying, mapping and GIS applications
Course Outline	1. Photogrammetric Optics (0.5 week) 2. Principles of Photography and Digital Cameras (2 weeks) Lab: PhotoScale and Flying Height Determination 3. Photo Processing (0.5 week) 4. Aerial Photography (0.5 week) 5. Relief and Tilt Displacement (0.5 week) 6. Flight Planning (2 weeks) Lab: Flight Planning 7. Stereoscopy and Stereo Photogrammetry (2 weeks) Lab: Stereovision Test and Elevation through Parallax Measurement 8. Review of Least Squares and Coordinate Transformation (1.5 week) Lab: 3D Conformal Coordinate Transformation Calculations 9. Image Coordinate Refinement (2 weeks) 9.1 Collinearity Equations 9.2 Photogrammetric Processes Lab: Photogrammetric Processing using ERDAS 10. Relative and Absolute Orientation (1 week) 11. Rectification and Photogrammetric Control (0.5 week) 12. Aerotriangulation (0.5 week) 13. Close Range Photogrammetry (1.5 weeks) 14. Introduction 14.1 Unmanned Aerial Systems for Mapping

	Lab: Processing of UAV-derived images for orthophoto and DEM generation 14.2 Synthesis (0.5 weeks)
Laboratory Equipment	Computers with photogrammetric processing software

Course Title	**GEOMETRIC GEODESY**
Course Description	The course covers introduction to geodesy, discussions on branches of geodesy; geometry of reference ellipsoids; reference systems and frames; geodetic datums; computations of geodetic positions; reductions of measurements to the ellipsoid; datum transformations and time and time systems.
Number of Units for Lecture and Laboratory	3 units lecture; 0 unit laboratory
Number of Contact Hours per Week	3 hours lecture; 0 hour laboratory
Prerequisites	General Surveying 2
Program Outcomes	a. Apply knowledge of mathematics, physical sciences, and engineering sciences to the practice of geodetic engineering; b. Design and conduct experiments to test hypotheses and verify assumptions, as well as to organize, analyze and interpret data, draw valid conclusions, and develop mathematical models for processes; e. Identify, formulate, and solve geodetic engineering problems; i. Engage in life-long learning and to keep current of the developments in a specific field of specialization; k. Use the appropriate techniques, skills and tools necessary for the practice of geodetic engineering;
Course Outcomes	Upon completion of the course, students must be able to: CO 1. Introduce the concept geodesy and identify the different branches of geodesy and their interrelationships; CO 2. Recognize the concepts, principles and techniques used in astronomical geodesy; CO 3. Explain the fundamental properties of a reference ellipsoid, its geometry and formulation; CO 4. Recognize the use and importance of datum, reference frames and reference systems; CO 5. Identify the different coordinate systems based on the different models of the earth; CO 6. Solve computational problems related to accurate position determination, reduction of measurements and coordinate transformation; and CO 7. Identify and experiment on several reference ellipsoids, geodetic datums that are relevant to the practice of geodetic engineering.
Course Outline	1. Introduction to Geodesy 2. Astronomical Geodesy 3. Reference ellipsoid

	4. Geodetic positions 5. Reference systems and frames 6. Datum and datum transformations 7. Geodetic reference frames/datums

Course Title	**PHYSICAL GEODESY**
Course Description	The course covers introduction to physical geodesy, fundamental of gravity field theory, geometry of the gravity field, spherical harmonic expansion of the gravity potential, residual gravity field, height systems and geoid modeling.
Number of Units for Lecture and Laboratory	3 units lecture; 0 unit laboratory
Number of Contact Hours per Week	3 hours lecture; 0 hour laboratory
Prerequisites	Geometric Geodesy
Program Outcomes	a. Apply knowledge of mathematics, physical sciences, and engineering sciences to the practice of geodetic engineering; b. Design and conduct experiments to test hypotheses and verify assumptions, as well as to organize, analyze and interpret data, draw valid conclusions, and develop mathematical models for processes; e. Identify, formulate, and solve geodetic engineering problems; i. Engage in life-long learning and to keep current of the developments in a specific field of specialization; k. Use the appropriate techniques, skills and tools necessary for the practice of geodetic engineering;
Course Outcomes	Upon completion of the course, students must be able to: CO 1. Recognize the relevance of studying the Earth's gravity field in geodetic practice; CO 2. Understand the conceptual and mathematical background of potential theory; CO 3. Determine geoid height through global geopotential models and gravity data; CO 4. Grasp concepts of regional/local geoid modeling; and CO 5. Understand the effect of the earth's structure and dynamics to the geodetic surveying.
Course Outline	1. Introduction to physical geodesy 2. Gravity field of the earth 3. Gravity reduction 4. Potential heights 5. Gravity field modelling 6. Structure and Dynamics of the Earth

Course Title	**SATELLITE GEODESY**
Course Description	The course covers introduction to satellite geodesy with emphasis on GNSS technology for geodetic measurements. Different techniques and processing methods are included in the course.

	Laboratory exercises introduce the students to instruments and handling and practical surveying applications.
Number of Units for Lecture and Laboratory	3 units lecture; 0 unit laboratory
Number of Contact Hours per Week	3 hours lecture; 0 hour laboratory
Prerequisites	Geometric Geodesy; Physical Geodesy
Program Outcomes	a. Apply knowledge of mathematics, physical sciences, and engineering sciences to the practice of geodetic engineering; b. Design and conduct experiments to test hypotheses and verify assumptions, as well as to organize, analyze and interpret data, draw valid conclusions, and develop mathematical models for processes; e. Identify, formulate, and solve geodetic engineering problems; i. Engage in life-long learning and to keep current of the developments in a specific field of specialization; k. Use the appropriate techniques, skills and tools necessary for the practice of geodetic engineering;
Course Outcomes	Upon completion of the course, students must be able to: CO 1. Appreciate the development of satellite positioning systems; CO 2. Understand the structure, acquisition and processing of SPS signals; CO 3. Solve computational problems in processing SPS observations; and CO 4. Familiarize with SPS applications and prospects of satellite geodesy.
Course Outline	1. Overview of Satellite Geodesy 2. The GNSS signal 3. Biases and Solutions 4. Reference systems 5. Receivers and Methods 6. Static, DGPS and RTK 7. Observing and Processing 8. GNSS Modernization 9. Future of satellite geodesy

Course Name	**HYDROGRAPHIC SURVEYING**
Course Description	This course covers introduction to hydrographic surveying; principles and methods of sounding and bathymetry; precise instrumentations for hydrographic surveying; and applications of hydrographic surveying.
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
Prerequisites	General Surveying 2
Program Outcome	a. Apply knowledge of mathematics, physical sciences, and engineering sciences to the practice of geodetic engineering; b. Design and conduct experiments to test hypotheses and verify assumptions, as well as to organize, analyze and interpret data, draw valid conclusions, and develop mathematical models for processes; e. Identify, formulate, and solve geodetic engineering problems; i. Engage in life-long learning and to keep current of the developments in a specific field of specialization; k. Use the appropriate techniques, skills and tools necessary for the practice of geodetic engineering;
Course Outcomes	At the end of the course, the students should be able to: 1. Gain proficiency in data collection with systematic surveys at different water bodies; 2. Gain the skills to process collected information and produce different thematic maps; 3. Acquire skills in identifying, planning and acquiring information necessary for related marine products for different applications; and 4. Be able to use the theories and applications of hydrographic surveying.
Course Outline	1. Introduction to hydrographic surveying (2 weeks) A. Definitions B. Purposes of hydrographic surveys C. Basic operations 2. Principles of hydrographic surveying (3 weeks) A. Survey specifications B. Hydrographic surveying processes C. Data output 3. Positioning (2 weeks) A. Principles of positioning B. Datums C. Horizontal and vertical control methods in hydrographic surveying 4. Depth Determination (2 weeks) A. Principles of depth determination B. Methods C. Acoustic fundamentals D. Transducers E. Corrections 5. Water Levels and Flows (3 weeks) A. Tides and Water Levels B. Tidal Measurement and Prediction C. Water levels not affected by tides 6. Hydrographic Practice (2 weeks) A. Applications B. Mapping, Volume Computation, Discharge determination etc.

Course Title	**REMOTE SENSING**
Course Description	Fundamental concepts of remote sensing; electromagnetic radiation principles; history of aerial photography and space imaging; elements of visual interpretation; sensors and platform characteristics; digital image processing; information extraction; thermal infrared, microwave and LIDAR remote sensing; thematic mapping applications.
Number of Units for Lecture and Laboratory	2 units lecture; 2 units laboratory
Number of Contact Hours per Week	2 hours lecture; 6 hours laboratory
Prerequisites	Physics for Engineers
Program Outcomes	a. Apply knowledge of mathematics, physical sciences, and engineering sciences to the practice of geodetic engineering; b. Design and conduct experiments to test hypotheses and verify assumptions, as well as to organize, analyze and interpret data, draw valid conclusions, and develop mathematical models for processes; e. Identify, formulate, and solve geodetic engineering problems; i. Engage in life-long learning and to keep current of the developments in a specific field of specialization; k. Use the appropriate techniques, skills and tools necessary for the practice of geodetic engineering
Course Outcomes	Upon completion of the course, students must be able to: CO 1. Explain the concept of remote sensing, including the governing physical principles and energy interactions with features CO 2. Differentiate remote sensing systems and be aware of their characteristics, limitations and potential usefulness in different applications CO 3. Competently use an image processing and analysis software CO 4. Download satellite images from available online sources CO 5. Perform digital image processing, starting from pre-processing, enhancement and display, information extraction, and accuracy assessment CO 6. Extract information from remotely-sensed images using the different elements of interpretation CO 7. Review scientific literatures about advancements in the field of remote sensing CO 8. Participate willingly on focus group discussions on specific applications in our environment and society where remote sensing may be used as a tool for mapping, monitoring and research CO 9. Design a complete workflow that can be implemented to address a specific real-world problem CO 10. Present the project details and results orally in class and/or in the Geomatics Student Project Colloquium

	(GSPC) at the end of the course to share the learnings to fellow students CO 11. Submit a detailed technical documentation of the methods and techniques performed in laboratory exercises and group project, and perform scientific analyses of all the results attained
Course Outline	1. Introduction to Remote Sensing (0.5 week) 1.1 Definition of Remote Sensing 1.2 Scope of Remote Sensing 1.3 Advantages and Limitations of Remote Sensing 1.4 Applications of Remote Sensing Lab: Software Familiarization 2. Physical Principles of Remote Sensing (1 week) 2.1 The Nature of Electromagnetic Radiation 2.2 The Electromagnetic Spectrum 2.3 Radiation Principles Lab: Exploring Remote Sensing Data 3. Energy Interactions with Earth Surface Features (1 week) 3.1 Fundamental EMR-Matter Interactions 3.2 Spectral Signatures 3.3 Spectral Characteristics of Vegetation, Soil, and Water 3.4 Differentiating Classes using Spectral Signatures Lab: Spectral Signatures 4. Sensors and Platform Characteristics (0.5 week) 4.1 Definitions of Sensors and Platforms 4.2 Sensor Categories 4.3 Types of Orbit Patterns 4.4 Remote Sensing Systems Categories 4.5 Common Scanning Modes 4.6 Resolution of Digital Image 4.7 Satellite Sensor Characteristics 5. Digital Image Processing (0.5 week) 5.1 Definition of Digital Images 5.2 Data Formats 5.3 Characteristics of Digital Images 5.4 Image Visualization 5.5 Steps in Digital Image Processing 6. Geometric Corrections and Image Registration (1 week) 6.1 Sensor Geometry 6.2 Geometric Corrections 6.3 Georeferencing 6.4 Ground Control Points and Transformations 6.5 Root Mean Square Error and Accuracy Assessment 6.6 Resampling Algorithms 6.7 Disadvantages of Rectification Lab: Image Registration and Georeferencing 7. Radiometric Calibration (1 week) 7.1 Definition of Radiometric Correction 7.2 Uses of Radiometric Corrections 7.3 Sources of Radiometric Errors 7.4 Atmospheric Effects and Corrections Lab: Radiometric Calibration 8. Image Enhancement (1 week)

	8.1. Definition of Image Enhancement 8.2. Spatial Enhancements 8.3. Spectral Enhancements Lab: Image Enhancement 9. Fundamentals of Image Interpretation (1 week) 9.1. Definition of Image Interpretation 9.2. Spatial Interpretation 9.3. Spectral Interpretation 9.4. Temporal Interpretation Lab: Image Interpretation 10. Information Extraction (0.5 week) 10.1. Introduction on Information Extraction 10.2. Steps in Thematic Information Extraction from Satellite Images 10.3. Image Classification Algorithms Lab: Image Classification 11. Accuracy Assessment (0.5 week) 11.1. Reference Data 11.2. Sampling Methods 11.3. Error Matrix 11.4. Quantifying and Interpreting the Accuracy Lab: Accuracy Assessment of Classified Image 12. Introduction to Thermal Infrared Remote Sensing (0.5 week) 12.1. Thermal Infrared 12.2. Temperature 12.3. Thermal Radiation Laws 12.4. Thermal Properties 12.5. Thermal Energy Detectors 12.6. Applications 13. Introduction to Microwave Remote Sensing (0.5 week) 13.1. Definition of RADAR 13.2. Advantages and Disadvantages of RADAR 13.3. EM Ranges of RADAR 13.4. RADAR Resolution and Polarization 13.5. Types of RADAR 13.6. RADAR Geometry 13.7. Applications 14. Introduction to LiDAR Remote Sensing (0.5 week) 14.1. LiDAR System Overview 14.2. Advantages and Disadvantages of LiDAR 14.3. LiDAR Data and Derivatives 14.4. LiDAR Errors and Accuracy 14.5. Applications 15. Remote Sensing Applications Focus Group Discussion (0.5 week) 16. Group Project (4 weeks)
Laboratory Equipment	Computers with digital image processing software

Course Title	**GEODETIC COMPUTATIONS AND ADJUSTMENTS**
Course Description	Concept of measurement and errors; error propagation in survey measurements; variance-covariance propagation; Theory of Standard and General Least Squares Adjustment; Adjustment of trilateration; triangulation and traverse network; Constraint Equations.
Number of Units for Lecture and Laboratory	2 units lecture; 2 units laboratory
Number of Contact Hours per Week	2 hours lecture; 6 hours laboratory
Prerequisites	Theory of Errors and Adjustments
Program Outcomes	a. Apply knowledge of mathematics, physical sciences, and engineering sciences to the practice of geodetic engineering; b. Design and conduct experiments to test hypotheses and verify assumptions, as well as to organize, analyze and interpret data, draw valid conclusions, and develop mathematical models for processes; e. Identify, formulate, and solve geodetic engineering problems;
Course Outcomes	At the end of the course, the students should be able to: 1. Explain concept of measurement, errors and adjustment 2. Explain concept and methods in probability and statistical testing. 3. Explain concepts and methods of adjustment and linearization, and least squares 4. Understand the underlying condition equations for surveying applications 5. Effectively perform least squares adjustment to various geodetic applications 6. Carry out blunder detection for geodetic adjustment
Course Outline	1. Concept of Measurement and Error (w1) a. Types of Errors b. Sources of Errors c. Reliability of Measurements d. Significant Figures 2. Linearization and Error Propagation (w2) a. Linear and Non-linear Functions b. Error Propagation of Systematic Errors c. Taylor Series d. Linearization of Uni- and Multi-Variate Functions e. Error Propagation of Multivariate Functions (Matrix Approach) f. Jacobian Matrix 3. The Concept of Adjustment (w3) a. Simple Adjustment Methods b. Least Squares Criterion c. Application of Least Squares (Non-matrix Approach) 4. Elementary Probability Theory (w4-5) a. Review of Piece-wise functions and Improper Integrals (optional)

	b. Random Events, Probability and Random Variables c. Probability Distributions d. Expectation e. Measures of Precision and Accuracy f. Covariance and Correlation g. Covariance, Cofactor, and Weigh Matrices 5. Statistical Testing for Samples/Observations (w6-7) a. The chi-square and t-student test b. Estimators of the mean and variance c. Confidence Intervals d. Statistical Testing e. Bivariate normal distribution f. Error ellipses 6. Least Squares Adjustment Techniques (Matrix Approach) (w8-12) a. Concept of Weight b. Adjustment of Indirect Observations i. Triangulation Network Adjustments ii. Trilateration Network Adjustments iii. Traverse Network Adjustments c. Adjustment of Observations Only d. General Least Squares Method i. Curve Fitting ii. Coordinate Transformation 7. Variance-Covariance Propagation (w13) a. Stepwise Propagation b. Propagation for Least Squares Adjustment of Indirect Observations c. Propagation for Least Squares Adjustment of Observations Only 8. Constraint Equations (w14) a. Helmert's Method, b. Constraints Thru weighting 9. Blunder Detection in Horizontal Networks (w15) a. A priori, b. A posteriori

Course Title	**INTRODUCTION TO THE LAWS ON PRIVATE AND PUBLIC LANDS**
Course Description	Introduction to the Philippine Legal System; overview of law in general; laws governing private property; laws governing state-owned natural resources; alienable and disposable lands; lands of public domain; ancestral lands and domains; Indigenous People's Rights Act; relevant provisions of the civil code governing property, its ownership, bundle of rights and easements; Philippine case studies.
Number of Units for Lecture and Laboratory	2 units lecture; 0 unit laboratory
Number of Contact Hours per Week	2 hours lecture; 0 hour laboratory

Prerequisites	None
Program Outcome	e. Identify, formulate, and solve geodetic engineering problems
Course Outcomes	Upon completion of the course, students must be able to: CO 1. Describe the nature of private and private lands as well as ancestral lands CO 2. Explain the difference among lands of the public domain, private lands, and ancestral domains and the attendant rights and obligations as well as limitations attached to these real properties CO 3. Apply the law, policy and principles pertaining to the lands of the public domain, private lands and ancestral lands, particularly within the context of their future roles as geodetic engineers
Course Outline	I. Overview of Law in General – Hierarchy and Dimensions of Law [2 weeks] a. Divine, Natural and Man-Made Laws b. Laws of Nature c. Principles of Law d. Constitution, Statutes, Administrative Issuances, Local Ordinances & Jurisprudence e. Substantive and Remedial Laws f. Political/Administrative, Civil, Criminal, Remedial Laws g. Distinguishing Private Property Laws and Laws Governing State-Owned Resources [focus] h. Institutions dealing with Land Resources [focus] II. Lands of the Public Domain [3 weeks] a. The 1987 Constitution – Limits to Land Ownership b. Classification of Lands of the Public Domain – Forests, Mineral, Agricultural Land & National Parks c. The Regalian Doctrine or State Ownership of Natural Resources III. Private Property/Private Lands [6 weeks] a. Alienable and Disposable Lands – Public and Private b. Ownership of Private Land and Evidence of Ownership (Land Titles and Deeds) c. Civil Code Provisions pertaining to Private Property Ownership i. Bundle of Rights of an Owner ii. Easements to Property IV. Indigenous People's Rights Act and Ancestral Domains [2 weeks] a. Ancestral Domains, Ancestral Lands – Character of Being Private but Communal b. Formal Recognition of Ownership - CADT and CALT c. Rights to Ancestral Domain/Lands, Rights of IPs/ICCs – Ownership, Development, Benefits, etc d. Free and Prior Informed Consent V. Special Issues and Problems on Land in the Philippines Confronting Geodetic Engineers [1 week]

Course Name	THEORY OF ERRORS AND ADJUSTMENTS
Course Description	The probability of the occurrence and propagation of errors; theory of least squares; method of observations and condition equations for the adjustment of linear and non-linear geodetic models; techniques of curve fitting.
Number of Units for Lecture and Laboratory	3 units lecture; 0 unit laboratory
Number of Contact Hours per Week	3 hours lecture; 0 hour laboratory
Prerequisites	Differential Equations
Program Outcomes	a. Apply knowledge of mathematics, physical sciences, and engineering sciences to the practice of geodetic engineering; b. Design and conduct experiments to test hypotheses and verify assumptions, as well as to organize, analyze and interpret data, draw valid conclusions, and develop mathematical models for processes; e. Identify, formulate, and solve geodetic engineering problems;
Course Outcomes	At the end of the course the student must be able to know: 1. The sources, classification, occurrence and propagation of errors. 2. The principles and methods of least squares 3. Observation & condition equitation in the analysis and adjustment of measurements. 4. To know how to solve problems and adjustments using computer programs
Course Outline	1. Basic Concept of Matrices 1.1. Definition and Classification of Matrices 1.2. Algebra of Matrices 1.3. Matrix Methods of Linear Systems 1.4. Method of Symmetric Linear Systems 2. Sources and Classification of Errors 3. Law of Errors 3.1. Quality of measurements 3.2. Probability Function for the Existence of Errors 3.3. Properties of Errors 4. Theory of Least Squares 4.1. Linear and Non-Linear Models 4.2. Principles of Least Squares 4.3. Most Probable Value of Measurements 4.4. Variances and Covariances 4.5. Measures of Errors 5. Propagation of Errors 5.1. Covariance Matrix 5.2. Propagation of Systematic Errors 5.3. Propagation of random Errors 5.4. Error Ellipse

Course Title	GEODETIC SURVEYING
Course Description	The course includes discussions on the principles and methods of the establishment and densification of horizontal and vertical geodetic control networks; accuracy standards and specifications of horizontal and vertical geodetic control networks. Laboratory exercises introduce the students to instruments and handling and practical surveying applications.
Number of Units for Lecture and Laboratory	2 units lecture; 2 units laboratory
Number of Contract Hours Per Week	2 hours lecture; 6 hours laboratory
Prerequisites	Geometric Geodesy; Physical Geodesy
Program Outcome	a. Apply knowledge of mathematics, physical sciences, and engineering sciences to the practice of geodetic engineering; b. Design and conduct experiments to test hypotheses and verify assumptions, as well as to organize, analyze and interpret data, draw valid conclusions, and develop mathematical models for processes; e. Identify, formulate, and solve geodetic engineering problems; i. Engage in life-long learning and to keep current of the developments in a specific field of specialization; k. Use the appropriate techniques, skills and tools necessary for the practice of geodetic engineering;
Course Outcomes	Upon completion of the course, students must be able to: CO 1. Apply the concepts related to geometric geodesy and satellite positioning system as preparation to geodetic control networks; CO 2. Explain the principles governing and procedures involved in the establishment of horizontal and vertical geodetic control networks; CO 3. Comply with the accepted standards of accuracy and specifications for geodetic control network establishment and operating geodetic control survey technology; CO 4. Solve computational problems related to horizontal and vertical control establishment that includes processing of raw data, removal of systematic errors and adjustment and/ or distribution of random errors; and CO 5. Apply knowledge and skills in geodesy needed for the establishment and maintenance of a reference system both local and international.
Course Outline	1. Introduction to Geodetic Control Network 2. Geodetic Control Network (GCN) Establishment and Densification 3. The Horizontal Geodetic Control Network Methodologies 4. Geodetic Levelling 5. Combined Horizontal and Vertical Geodetic Control

Course Name	SURVEY CAMP
Course Description	Concepts, methodologies and technologies used by Geodetic Engineers in field data acquisition. The GE survey camp is a practical course on the application of the different concepts, methodologies and technologies used by Geodetic Engineers in

	field data acquisition. It is one of the high-level courses in surveying that will assess the skills that has been develop which are necessary in the practice of the Geodetic Engineering profession.
Number of Units for Lecture and Laboratory	0 unit lecture; 1 unit laboratory
Number of Contact Hours per Week	0 hour lecture; 3 hours laboratory
Prerequisite	None
Program Outcomes	a. Apply knowledge of mathematics, physical sciences, and engineering sciences to the practice of geodetic engineering
Course Outcomes	Upon completion of the course, students must be able to: CO 1. Perform proper coordination with key agencies to facilitate survey camp activities CO 2. Apply the different concepts, methodologies and technologies related to geodetic engineering in actual field data gathering CO 3. Practice good human relations in a working environment CO 4. Explain the activities performed and the resulting data output
Course Outline	1. Survey Camp Preparation (2 weeks) 1.1. Introduction and survey camp grouping 1.2. Research of relevant data and information 1.3. Coordination with key agencies / LGU 1.4. Reconnaissance on the project area 1.5. Fieldwork planning 1.6. Progress Report 1 2. Survey Camp Proper (3 weeks) 2.1. Fieldwork and data gathering 2.2. Data processing 2.3. Data integration 2.4. Progress Report 2 3. Final Report Preparation (1 week) 3.1. Report preparation and submission 3.2. Final presentation

Course Title	**METHODS OF RESEARCH**
Course Description	Undergraduate research proposal and data gathering
Number of Units for Lecture and Laboratory	1 unit lecture; 0 unit laboratory
Number of Contract Hours Per Week	1 hour lecture; 0 hour laboratory
Prerequisite	None
Program Outcomes	k. Use the appropriate techniques, skills and tools necessary for the practice of geodetic engineering
Course Outcomes	Upon completion of the course, students must be able to: CO 1. To identify gaps in the body of knowledge, particularly for addressing specific, relevant issues

	CO 2. To apply their specialized knowledge in solving real-world problems involving use of acquired knowledge in geodetic engineering, geomatics engineering and geoinformatics CO 3. To develop detailed research proposals and information CO 4. To work in teams in an interdisciplinary/multidisciplinary setting in addressing real-word and research problems CO 5. To develop research communication skill through individual and group presentations and reports
Course Outline	1. Current and emerging research fields in Geomatics (1 weeks) 1.1 Selecting a Research Topic 2. Research Proposal Preparation (2 weeks) 2.1. Problem solving 2.2. Formulating a Research Hypothesis 2.3. Research Proposal Writing 3. Literature Review (3 weeks) 3.1. Literature: definitions and functions 3.2. Taking notes 3.3. Organizing the notes into an outline 3.4. Writing the review of related literature 4. Research Project Management (2 weeks) 4.1. Principles 4.2. Tools 4.3. Methods 4.4. Ethics 5. Conceptual and Methodological Frameworks (2 weeks) 5.1. Conceptual framework 5.2. Methodological framework 6. Research Methods and Statistics (2 weeks) 6.1. Variables and descriptive statistics 6.2. Correlational methods 6.3. Hypothesis testing and inferential statistics 6.4. Experimental Design 7. Disseminating Research Outputs (2 weeks) 7.1. Oral Presentation 7.2. Poster preparation 7.3. Journals 7.4. Other methods 8. Research Report Writing (2 weeks) 8.1. Writing the draft 8.2. Proper Documentation 8.3. Writing the Different Sections 8.4. Preparing the final copy

ANNEX IV – LABORATORY REQUIREMENTS

I. NATURAL/PHYSICAL SCIENCES

A. PHYSICS FOR ENGINEERS LABORATORY

Select 12 Exercises to relate to covered lecture topics

Exercise	Required Equipment	Required Quantity*
1. An exercise to illustrate the principles, use, and precision of the vernier caliper and micrometer caliper	Ruler Vernier caliper Micrometer caliper Objects for measuring	5 pcs. 5 pcs. 5 pcs. 5 sets
2. An exercise to verify the graphical and analytical methods of determining resultant forces.	Force table Weight holder Masses Meter stick Protractor *Alternate apparatus:* Force frame Spring balance Weight holder Masses Ruler	5 pcs. 20 pcs. 5 sets 5 pcs. 5 pcs. 5 pcs. 15 pcs. 15 pcs. 5 sets 5 pcs.
3. An exercise to observe and verify the elements of motion along the straight line	Linear air track with blower and trolley Timer/stopwatch Meter stick Free fall apparatus Metal balls of different sizes Clamp Support rod *Alternate apparatus:* Spark timer/ticker timer Paper tape Stopwatch Plane board with stand Clamp Wooden cart Scissors Carbon paper Masking tape Meter stick	5 pcs. 5 pcs. 5 pcs. 5 pcs. 12 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 1 set 5 pcs.
4. An exercise to observe and verify the elements of motion in two dimensions	Blackwood ballistic pendulum Metal ball Meter stick Carbon paper Inclined plane Protractor *Alternate apparatus:* Projectile apparatus Metal ball/plastic solid ball	5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.

	Photogate Timer/stopwatch Time of flight receptor pad Carbon paper White paper Meter-stick	5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.
5. An exercise to verify the laws of motion	Atwood's machine Masses Stopwatch String *Alternate apparatus:* Frictionless dynamic track Smart pulley Stopwatch Weight holder String Clamp	5 pcs. 5 sets 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.
6. An exercise to determine the coefficients of static and kinetic friction of various surfaces	Friction board with pulley Friction block with different surfaces Glass plate of size similar to friction board Platform/triple beam balance Weight holder Meter stick Slotted masses, 5 - 500 g	5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 sets
7. An exercise to verify the work-energy theorem	Dynamic cart Frictionless dynamic track Masses Weight holder Clamp String Timer/stopwatch Platform/triple beam balance Support rod	5 pcs. 5 pcs. 5 sets 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.
8. An exercise to verify the principles of conservation of mechanical energy	Metal stand Clamp Metal ball String Meter stick Cutter blade Hanging mass Carbon paper White paper Masking tape	5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 10 pcs. 10 pcs. 1 set
9. An exercise to verify the principles of conservation of momentum	Ramp/launcher Metal stand Clamp Metal balls of different sizes Meter stick Carbon paper White paper Masking tape	5 pcs. 5 pcs. 5 pcs. 10 pcs. 5 pcs. 10 pcs. 10 pcs. 1 set
10. An exercise to verify the condition of the body in rotational equilibrium	Demonstration balance Vernier caliper Platform/triple beam balance	5 pcs. 5 pcs. 5 pcs.

	Masses Meter stick	5 sets 5 pcs.
11. An exercise to verify the forces involved in uniform circular motion	Centripetal force apparatus Meter stick Mass with hook Platform/triple beam balance Stopwatch	5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.
12. An exercise to verify the principle of simple harmonic motion	Clamp Masses Weight holder Meter stick Support rod Spring *Alternate apparatus:* Hooke's Law apparatus	5 pcs. 5 sets 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.
13. An exercise to measure specific gravity	*Liquids:* Hydrometer jar U-tube Inverted U-tube Beaker Masses Meter stick Vernier caliper Specimen of liquids *Solids:* Beam balance Hydrometer jar Beaker Thread Thermometer Specimen of solids *Alternate apparatus:* Mohr-Westpal balance	 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 sets 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 sets 5 pcs.
14. An exercise to observe and verify the elements of transverse wave motion	Sonometer Weight holder Set of masses Tuning forks of three different frequencies Rubber hammer Meter stick	5 pcs. 5 pcs. 5 pcs. 5 sets 5 pcs. 5 pcs.
15. An exercise to determine the specific heats of solids by the methods of mixture	Calorimeter Stirrer for shot Specimen for shot Thermometer Platform/triple beam balance Beaker Ice Water	5 pcs. 5 pcs. 5 sets 5 pcs. 5 pcs. 5 pcs. 5 sets
16. An exercise to measure the coefficient of linear expansion	Thermal expansion apparatus Steam generator Ohmmeter/VOM Connectors Basin/container	5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.

	Hot and cold water	
17. An exercise to measure the mechanical equivalent of heat	Mechanical equivalent of heat apparatus Ohmmeter/VOM Mass (10 kg) Thermometer Vernier caliper Platform/triple beam balance	5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.
18. An exercise to observe and verify the elements of electric charge	Van de Graff generator Tissue paper Aluminum foil Metal conductor with insulated handle Fluorescent lamp Masking tape Power source Galvanometer Conducting paper Field mapper kit/mapping apparatus Connectors	2 sets 2 sets 2 sets 2 sets 2 sets 1 set 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 sets
19. An exercise to illustrate Ohm's Law	Panel board/circuit board VOM or multitester DC power supply Bridging plugs/connecting wires Fixed resistor SPST switch SPDT switch *Alternate apparatus:* Bread board Jumper	5 pcs. 5 pcs. 5 pcs. 5 sets 15 pcs. 5 pcs. 5 pcs. 5 pcs. 5 sets
20. An exercise to determine and compare the resistance of different conductors	1-m slide wire/wheatstone bridge Power supply VOM or multitester Galvanometer Potentiometer Fixed resistor Unknown resistor SPST switch Connecting wires	5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 sets
21. An exercise to verify the principles of series and parallel connections	Panel board/circuit board VOM or multitester DC power supply Bridging plugs/connecting wires Fixed resistors *Alternate apparatus:* Bread board Jumper	5 pcs. 5 pcs. 5 pcs. 5 sets 15 pcs. 5 pcs. 5 sets
22. An exercise to verify the relationship among the electromotive force, current, and	Dry cells Switch VOM or multitester Resistors	10 pcs. 5 pcs. 5 pcs. 10 pcs.

resistance of cells in series and parallel	Panel board/circuit board Bridging plugs/connecting wires *Alternate apparatus:* Bread board Jumper	5 pcs. 5 sets 5 pcs. 5 sets
23. An exercise to observe the applications of Kirchhoff's Law	Power supply Fixed resistors VOM or multitester Bridging plugs/connecting wires Panel board/circuit board *Alternate apparatus:* Bread board Jumper	10 pcs. 25 pcs. 10 pcs. 5 sets 5 pcs. 5 pcs. 5 sets
24. An exercise to determine the electrical equivalent of heat	Electric calorimeter Thermometer Beam balance Masses Stopwatch VOM or multitester Rheostat DC power source Connecting wires Switch	5 pcs. 5 pcs. 5 pcs. 5 sets 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 sets 5 pcs.
25. An exercise to observe the relationships between resistance and capacitance in the circuit	Power source Fixed capacitor (330 microfarad) Fixed resistor (100 ohms) Connecting wires VOM or multitester Stopwatch	5 pcs. 5 pcs. 5 pcs. 5 sets 5 pcs. 5 pcs.
26. An exercise to observe the principle of magnetic field	Natural magnets Horseshoe magnets Bar magnets Ring Glass plate Iron fillings Frame for bar magnets Compass Mounted straight wire Coil Solenoid Battery Reversing switch *Alternate apparatus:* Tesla meter / tangent galvanometer	5 pcs. 5 pcs. 10 pcs. 5 pcs. 5 pcs. 5 sets 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 2 sets
27. An exercise to demonstrate the Faraday's law of electromagnetic induction	Coils Galvanometer VOM or multitester AC power supply Bar magnets Connecting wires	5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.
28. An exercise to verify the law of reflection and refraction	Optics bench Light source, sodium/mercury lamps	5 pcs. 5 pcs.

	Ray table and base Component holder Slit plate Slit mask Ray optics mirror Cylindrical lens	5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.
29. An exercise to investigate and study the image formation in mirror and lenses	Optic bench Light source Ray table and base Component holder Parallel ray lens Slit plate Ray optics mirror 5 cm focal length spherical mirror -15 cm focal length concave lens 10 cm/7.5 cm focal length convex lens 15 cm focal length convex lens Viewing screen Crossed arrow target	5 pcs. 5 pcs. 5 pcs. 15 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.

* Required Quantity is based on a class size of 25 students

II. PROFESSIONAL COURSES

A. SURVEYING AND GEODESY LABORATORY

Exercise	Required Equipment	Required Quantity*
General Surveying I 1. An exercise to estimate pace factor and conduct closed compass traverse 2. An exercise on handling and setting up a total station 3. An exercise to conduct close-loop azimuth travers 4. An exercise to conduct side shots 5. An exercise on area computation and simple subdivision 6. An exercise on plotting	Brunton Handheld Compass Range Pole Steel/Nylon tape Total Station Tripod Prism and pole set Scale ruler	4 units 8 units 4 units 4 units 4 units 8 units 4 units
General Surveying II 1. An exercise to establish vertical control (Leveling) 2. An exercise to conduct topographic surveying 3. An exercise on mine surveying 4. An exercise to conduct hydrographic surveying (bathymetric mapping) 5. An exercise to determine azimuth from solar observation 6. An exercise on navigation using GPS	Auto Level Stadia Rod Total Station Tripod Steel/Nylon Tape Prism and Pole Set Theodolite Solar Eyepiece Set Range pole Handheld GPS	4 units 8 units 4 units 4 units 4 units 4 units 4 units 4 units 8 units 4 units
Satellite Geodesy 1. An exercise on handling and operating a GNSS receiver 2. An exercise on planning GNSS observation/data acquisition 3. An exercise on Static and Rapid Static GNSS survey (including processing) 4. An exercise on DGNSS survey (including processing)	Dual frequency GNSS receiver (Base and rover)	At least 1 unit
Geodetic Surveying		

1. An exercise on establishing horizontal geodetic control network 2. An exercise on establishing vertical geodetic control network (Geodetic levelling) 3. An exercise on establishing combined horizontal and vertical control network	Total station Dual frequency GNSS receiver (Base and rover) Automatic/Digital level	4 units 1 set 4 units
Survey Camp 1. Various exercises on survey methodologies applicable to the problem at hand	Various surveying equipment listed in earlier surveying courses	

* Required Quantity is based on a class of 20 students with four (4) groups and five (5) students per group

B. COMPUTER LABORATORY

Exercise	Required Equipment	Required Quantity*
Cartography 1. Exercise on preparing map template (CAD) 2. Exercise on preparing survey plan (CAD) 3. Exercise on scales and projections 4. Exercise on contour plotting (CAD and Surfer) 5. Exercise on basic road design and volume computations (CAD) 6. Exercise on thematic mapping, symbolization and visualization of geographic data 1 7. Exercise on thematic mapping, symbolization and visualization of geographic data 2 8. Map project	For the laboratory exercises: Desktop PCs CAD software; GIS software	20 units 20 (installed on each PC)
Photogrammetry 1. Exercise on photo scale and flying height determination 2. Exercise on flight planning 3. Exercise on stereovision and estimation of elevation using parallax measurement 4. Exercise on 3D conformal coordinate transformation 5. Exercise on aerial triangulation 6. Exercise on generation of digital surface model and digital terrain model 7. Exercise on orthophoto generation 8. Photogrammetric mapping project	For the laboratory exercises: Desktop PCs Flight planning software Photogrammetric mapping software Unmanned aerial system	20 units 20 (installed on each PC) 1 unit
Remote Sensing 1. Exercise on image processing software familiarization 2. Exercise on exploring remote sensing data 3. Exercise on spectral signatures 4. Exercise on image registration and georeferencing	For the laboratory exercises: Desktop PCs Image processing software	20 units 20 (installed on each PC)

5. Exercise on radiometric calibration 6. Exercise on image enhancement 7. Exercise on image interpretation 8. Exercise on image classification 9. Exercise on assessment of image classification accuracy 10. Remote Sensing project		
Geographic Information Systems 1. Exercise on familiarization with GIS software 2. Exercise on working with raster and vector files 3. Exercise on GIS data input techniques 4. Exercise on basic table operations in GIS 5. Exercise on spatial querying 6. Exercise on raster overlay (Boolean mapping) 7. Exercise on raster overlay (Weighted linear combination) 8. Exercise on vector overlay 9. Exercise on spatial analysis workflow development 10. GIS project	For the laboratory exercises: Desktop PCs GIS software	20 units 20 (installed on each PC)

* Required Quantity is based on a class size of 20 students