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

CHED MEMORANDUM ORDER (CMO)
No. **12**
Series of 2008

SUBJECT : **POLICIES AND STANDARDS (PS) FOR THE DEGREE OF BACHELOR OF SCIENCE IN GEODETIC ENGINEERING (BSGE)**

In accordance with the pertinent provisions of Republic Act (RA) No. 7722, otherwise known as the "Higher Education Act of 1994," and by virtue of Resolution No. 143-2008 of the Commission en banc dated 24th day of March 2008 and for the purpose of rationalizing geodetic engineering education in the country, the following policies and standards shall hereby be adopted and promulgated by the Commission:

ARTICLE I - INTRODUCTION

Section 1. Rationale

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.

The Policies and Standards (PS) for Bachelor of Science in Geodetic Engineering (BSGE) program have been reviewed in accordance with recently approved CMOs, industry needs, latest trends and technology in the field of geodetic engineering. This guidelines emerged as a result of the consolidated efforts of the academe, industry and other concerned agencies.

ARTICLE II - AUTHORITY TO OPERATE

Section 2. The BSGE program shall be operated only by HEIs with proper authority granted by the Commission on Higher Education (CHED) or by the respective Boards in case of chartered State Universities and Colleges (SUCs) and Local Colleges and Universities (LCUs)

ARTICLE III - PROGRAM SPECIFICATIONS

Section 3. Degree Name

The degree program herein shall be called **BACHELOR OF SCIENCE IN GEODETIC ENGINEERING (BSGE)**

5/F Upper DAP Bldg., San Miguel Avenue, Ortigas Center, Pasig City 1605 Philippines
Web Site: www.ched.gov.ph, Tel. Nos. 633-27-13, 634-68-36, 638-58-35, 636-16-94, Fax No. 635-58-29

Section 4. Program Description

4.1 Nature of the Program

This program trains the students in the major fields of Geodetic Engineering. It enables them to attain the basic competencies such as establishment of geodetic control network; collection of ground data using various methodologies and techniques; processing, evaluation and analysis of collected data; quality assurance of outputs in accordance with the accepted standards and specifications; conduct of research and development activities; and development of business entrepreneurial skills. It likewise upholds the dignity and integrity of the Geodetic Engineering profession.

4.2 Program Objectives (as is)

The BSGE program must produce graduates possessing the following:

a. Ability to apply knowledge of mathematics, physical sciences, and engineering sciences to the practice of geodetic engineering.
b. Ability to 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. Ability to design, improve, innovate, and to supervise systems or procedures to meet desired needs within realistic constraints.
d. Ability to work effectively in multi-disciplinary and multi-cultural teams in diverse fields of practice.
e. Ability to identify, formulate, and solve geodetic engineering problems.
f. Understand the effects and impact of the geodetic engineering profession on the environment and the society, as well as the social and ethical responsibilities of the profession.
g. Specialized knowledge in at least one focus area of geodetic engineering practice and the ability to apply such knowledge to provide solutions to actual problems.
h. Ability for effective oral and written communications particularly in the English language.
i. Ability to engage in life-long learning and to keep current of the development in a specific field of specialization.
j. Ability to use the appropriate techniques, skills and tools necessary for the practice of geodetic engineering.
k. Gain knowledge in contemporary issues under the program.

4.3 Specific Professions/ Careers/ Occupations or Trades that the graduates may go into:

4.3.1 Surveyor/Geodetic Engineer
4.3.2 Photogrammetrist
4.3.3 Cartographer
4.3.4 GIS Specialist
4.3.5 Remote Sensing Specialist
4.3.6 Academician
4.3.7 Consultancy
4.3.8 Government Technical Service
4.3.9 Quality Assurance Engineer
4.3.10 Project Manager
4.3.11 Hydrographer
4.3.12 Information Systems Analyst
4.3.13 Assessor, Realtor, Appraiser

Section 5. Allied Programs

The BSGE allied programs are Civil Engineering, Geology, Information and Communications Technology

ARTICLE IV – COMPETENCY STANDARDS

Section 6. This section defines the entry level competency standards, knowledge, attitudes, values and skills applicable to the BS Geodetic Engineering graduate, which are contained in **ANNEX I** of this Memorandum Order.

ARTICLE V – CURRICULUM

Section 7. Curriculum Description

The BSGE curriculum has been designed specifically to meet the educational challenge by emphasizing fundamental knowledge, transferable skills, and lifelong learning.

7.1 The BS Geodetic Engineering program has a total of 203 credit units. The program includes general education, basic engineering, professional, allied and elective courses.
7.2 The general education courses conform to the provisions of CHED Memorandum Order No. 59, s. 1996 "*The New General Education Curriculum (GEC)*".
7.3 The technical courses include Mathematics with a total of 26 units, Physical Sciences with a total of 12 units, and Basic Engineering Sciences with a total of 21 units; PE/NSTP with a total of 14 units and electives of 6 units.
7.4 There are 24 professional courses with a total of 76 units.
7.5 There are 3 allied courses with a total of 9 units

Section 8. Curriculum Outline

Classification/ Course	Minimum No. of Hours per week		Minimum Credit Units
	Lecture	Laboratory	
I. TECHNICAL COURSES			
A. Mathematics			
College Algebra	3	0	3
Advanced Algebra	2	0	2
Plane and Spherical Trigonometry	3	0	3
Analytic Geometry	2	0	2
Solid Mensuration	2	0	2
Differential Calculus	4	0	4
Integral Calculus	4	0	4
Differential Equations	3	0	3
Probability and Statistics	3	0	3
Sub-Total	**26**	**0**	**26**
B. Natural/Physical Sciences			
General Chemistry	3	3	4
Physics 1	3	3	4
Physics 2	3	3	4
Sub-Total:	**9**	**9**	**12**
C. Basic Engineering Sciences			
Computer Fundamentals & Programming	0	6	2
Engineering Drawing	0	3	1
Computer–Aided Drafting	0	3	1
Statics of Rigid Bodies	3	0	3

Classification/ Course	Minimum No. of Hours per week		Minimum Credit Units
	Lecture	Laboratory	
Dynamics of Rigid Bodies	2	0	2
Mechanics of Deformable Bodies	3	0	3
Engineering Economy	3	0	3
Engineering Management	3	0	3
Environmental Engineering	2	0	2
Safety Management	1	0	1
Sub-Total:	**17**	**12**	**21**
D. Allied Courses			
Principles of Geology	3	0	3
Basic Electrical Engineering	3	0	3
Information & Communications Technology	3	0	3
Sub-Total:	**9**	**0**	**9**
E. Professional Courses			
General Surveying 1	2	3	3
General Surveying 2	2	6	4
Property Survey	3	6	5
Construction & Industrial Surveying	2	6	4
Cartography	1	3	2
Geodetic Engineering Laws, Contracts and Ethics	2	0	2
Public Land Laws & Laws on Natural Resources	3	0	3
Laws on Property	1	0	1
Land Registration Laws	2	0	2
Photogrammetry 1	2	3	3
Photogrammetry 2	2	6	4

Classification/Course	Minimum No. of Hours per week		Minimum Credit Units
	Lecture	Laboratory	
Remote Sensing	2	3	3
Geometric Geodesy	3	0	3
Physical Geodesy	3	0	3
Satellite Geodesy	3	0	3
Geodetic Surveying	2	6	4
Mine Surveying	1	3	2
Hydrography	2	3	3
Geodetic Astronomy	2	3	3
Geodetic Computations & Adjustments	2	6	4
Development Planning	2	3	3
Special Studies in Geodetic Engineering	1	6	3
Land Management	3	0	3
Geographic Information Systems (GIS)	1	6	3
Theory of Errors & Adjustments	3	0	3
On the Job Training (OJT)		240 hours (6 weeks)	
	52	**72**	**76**
F. Electives			
Elective 1	3	0	3
Elective 2	3	0	3
Sub-Total:	**6**	**0**	**6**
II NON-TECHNICAL COURSES			
A. Social Sciences			
Social Science 1	3	0	3
Social Science 2	3	0	3
Social Science 3	3	0	3

Classification/Course	Minimum No. of Hours per week		Minimum Credit Units
	Lecture	Laboratory	
Social Science 4	3	0	3
Sub-Total:	**12**	**0**	**12**
B. Humanities			
Humanities 1	3	0	3
Humanities 2	3	0	3
Humanities 3	3	0	3
Sub-Total:	**9**	**0**	**9**
C. Languages			
English 1	3	0	3
English 2	3	0	3
English 3 (Technical Communication)	3	0	3
Pilipino 1	3	0	3
Pilipino 2	3	0	3
Sub-Total:	**15**	**0**	**15**
D. Mandated Course			
Life and Works of Rizal	3	0	3
Sub-Total:	**3**	**0**	**3**
E. Physical Education			
P.E. 1			2
P.E. 2			2
P.E. 3			2
P.E. 4			2
Sub-Total:			**8**
F. National Service Training Program			
NSTP 1			3
NSTP 2			3
Sub-Total:			**6**

GRAND TOTAL			**203**

Suggested Electives:

Marine Cadastre	3	0	3
Accounting 1	3	0	3
Business Entrepreneurship	3	0	3
Languages (French, German, Mandarin & others)	3	0	3
Advanced ICT	3	0	3

Note: The student is required to take 6 units from the allowed electives

SUMMARY

Classification/ Course	Total No. of Hours per week		Total No. of Units
	Lecture	Laboratory	
I. TECHNICAL COURSES			
A. Mathematics	26	0	26
B. Natural Sciences	9	9	12
C. Basic Engineering Sciences	17	12	21
D. Allied Courses	9	0	9
E. Professional Courses	52	72	76
F. Electives	6	0	6
Sub- Total	***119***	***93***	***150***
II. NON- TECHNICAL			
A. Social Sciences	12	0	12
B. Humanities	9	0	9
C. Languages	15	0	15
D. Life and Works of Rizal	3	0	3
Sub-Total	**39**	**0**	**39**
Total	**158**	**93**	**189**
Physical Education			8
NSTP			6
Grand Total			**203**

Section 9. Relationship of the Courses to the Program Outcomes

The relationship of the identified courses in section 8 to the identified program outcomes in section 4 – 4.2 are contained in **ANNEX II** of this Memorandum

Section 10. Sample/ Model 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/ competencies required in the curriculum outlines are offered and pre-requisites and co-requisites are observed.

Bachelor of Science in Geodetic Engineering

FIRST YEAR

1st Year – First Semester

Courses	No. of Hours		Units	Pre-requisites
	Lec.	Lab		
College Algebra	3	0	3	None
Plane and Spherical Trigonometry	3	0	3	None
Social Science 1	3	0	3	None
English 1	3	0	3	None
Pilipino 1	3	0	3	None
Humanities 1	3	0	3	None
PE 1			2	None
NSTP 1			3	None
TOTAL	**18**	**0**	**23**	

1st Year – Second Semester

Courses	No. of Hours		Units	Pre-requisites
	Lec.	Lab		
Advanced Algebra	2	0	2	College Algebra
Analytic Geometry	2	0	2	College Algebra, Plane & Spherical Trigonometry
General Chemistry	3	3	4	None
Social Science 2	3	0	3	None
English 2	3	0	3	None
Pilipino 2	3	0	3	None
Humanities 2	3	0	3	None
PE 2			2	None

NSTP 2			3	None
TOTAL	**19**	**3**	**25**	

SECOND YEAR

1st Year – First Semester

Courses	No. of Hours		Units	Pre-requisites
	Lec.	Lab		
Solid Mensuration	2	0	2	Plane & Spherical Trigonometry
Differential Calculus	4	0	4	Analytic Geometry, Advanced Algebra
Physics 1	3	3	4	College Algebra, Plane & Spherical Trigonometry
English 3	3	0	3	English 2
Social Science 3	3	0	3	None
General Surveying 1	2	3	3	College Algebra; Plane & Spherical Trigonometry
PE 3			2	None
TOTAL	**17**	**6**	**21**	

2nd Year – Second Semester

Courses	No. of Hours		Units	Pre-requisites
	Lec.	Lab		
Integral Calculus	4	0	4	Differential Calculus
Probability and Statistics	3	0	3	College Algebra
General Surveying 2	2	6	4	General Surveying 1
Engineering Drawing	0	3	1	None
Physics 2	3	3	4	Physics 1
Computer Fundamentals & Programming	0	6	2	2nd year standing
PE 4			2	None
TOTAL	**12**	**18**	**20**	

THIRD YEAR

3rd Year – First Semester

Courses	No. of Hours		Units	Pre-requisites
	Lec.	Lab		
Differential Equations	3	0	3	Integral Calculus
Humanities 3	3	0	3	None
Computer-Aided Drafting	0	3	1	3rd year standing
Statics of Rigid Bodies	3	0	3	Physics 1, Integral Calculus
Cartography	1	3	2	General Surveying 2, Integral Calculus
Mine Surveying	1	3	2	General Surveying 2
Social Science 4	3	0	3	None
TOTAL	**14**	**9**	**17**	

3rd Year – Second Semester

Courses	No. of Hours		Units	Pre-requisites
	Lec.	Lab		
Theory of Errors & adjustments	2	3	3	Differential Equations; Computer Fundamentals & Programming
Dynamics of Rigid Bodies	2	0	2	Statics of Rigid Bodies
Principles of Geology	3	0	3	None
Geometric Geodesy	3	0	3	Cartography; Integral Calculus
Remote Sensing	2	3	3	Cartography
Land Registration Laws	2	0	2	Senior Standing
GE Laws, Contracts and Ethics	2	0	2	Senior Standing
Information and Communications Technology	3	0	3	Computer Fundamentals & Programming
TOTAL	**19**	**6**	**21**	

FOURTH YEAR

4th Year – First Semester

Courses	No. of Hours		Units	Pre-requisites
	Lec.	Lab		
Mechanics of Deformable Bodies	3	0	3	Statics of Rigid Bodies
Engineering Economy	3	0	3	3rd year standing
Construction & Industrial Surveys	2	6	4	General Surveying 2
Physical Geodesy	3	0	3	Geometric Geodesy
Hydrography	2	3	3	General Surveying 2
Geodetic Surveying	2	6	4	Geometric Geodesy
TOTAL	**15**	**15**	**20**	

4th Year – Second Semester

Courses	No. of Hours		Units	Pre-requisites
	Lec.	Lab		
Basic Electrical Engineering	3	0	3	None
Property Survey	3	6	5	General Surveying 2 Co-requisite: Map Projections
Laws on Property	1	0	1	Senior Standing/ Consent of Instructor
Geodetic Astronomy	2	3	3	Geometric Geodesy
Photogrammetry 1	2	3	3	General Surveying 2
Geographic Information Systems (GIS)	1	6	3	Cartography
Elective 1	3	0	3	None
TOTAL	**15**	**18**	**21**	

On the Job Training (OJT) – 240 hours (6 weeks)

FIFTH YEAR

5th Year – First Semester

Courses	No. of Hours		Units	Pre-requisites
	Lec.	Lab		
Photogrammetry 2	2	6	4	Photogrammetry 1
Public Land Laws & Laws on Natural Resources	3	0	3	Senior Standing/Consent of Instructor
Satellite Geodesy	3	0	3	Geometric Geodesy
Geodetic Computations & Adjustments	2	6	4	Geometric Geodesy, Advanced Engineering Mathematics
Life and Works of Rizal	3	0	3	None
Environmental Engineering	2	0	2	General Chemistry
Safety Management	1	0	1	3rd year standing
TOTAL	**16**	**12**	**20**	

5th Year – Second Semester

Courses	No. of Hours		Units	Pre-requisites
	Lec.	Lab		
Special Studies in GE	1	6	3	5th year standing
Development Planning	2	3	3	GIS, Remote Sensing, Photogrammetry 2
Land Administration and Management	3	0	3	All G.E. Law Subjects
Engineering Management	3	0	3	3rd year standing
Elective 2	3	0	3	None
TOTAL	**12**	**9**	**15**	

Section 11. <u>Thesis/Research/ Project Requirement</u>

11.1 Suggested topics maybe of the following:

11.1.1 Research work on any of the specialized fields of Geodetic Engineering

11.1.2 Participation in an Industry–based project related to Geodetic Engineering

Section 16. For violation of this Order, the Commission may impose such administrative sanction as it may deem appropriate pursuant to the pertinent provisions of Republic Act No. 7722, in relation to Section 69 of BP 232 otherwise known as the Higher Education Act of 1982, and Sections 24 and 101 of the Manual of Regulations for Private Schools (MRPS), and other related laws.

ARTICLE X – SEPARABILITY AND REPEALING CLAUSE

Section 17. Any provision of this Order, which may thereafter be held invalid, shall not effect the remaining provisions.

Section 18. All issuances, including but not limited to CMO No. 49, s. 1997, and CMO 34, s. 2001 and/ or any part thereof inconsistent herewith, are deemed repealed or modified accordingly.

ARTICLE X – EFFECTIVITY CLAUSE

Section 17. This CMO shall take effect starting 1st semester of SY 2008-2009, after publication in an official gazette or in a newspaper of general circulation.

Section 18. An education institution applying to offer new BSGE program shall likewise comply with all the provisions of this CMO.

Pasig City, Philippines _____

For the Commission:

ROMULO L. NERI
Chairman

ANNEX I

COMPETENCY STANDARDS FOR BS GEODETIC ENGINEERING

TECHNICAL PANEL FOR ENGINEERING, TECHNOLOGY AND ARCHITECTURE
PROFILE OF DUTIES AND COMPETENCIES OF A GEODETIC ENGINEER

	DUTIES	Skills/Competencies						
1	**Design and establish Geodetic/Project control network**	*Conduct research and reconnaisance*	Understand the Design of reference systems	Establish geodetic/project control networks	Develop and implement network maintenance programs			
2	**Collect Geodetic/Geomatics Data and information**	Apply technical, legal and ethical standards and procedures in the collection of data and information	Plan and coordinate collection of new and existing data and information	Collect data and information by using various methodologies and techniques e.g. field measurement, hydrography, remote sensing		*Manage and maintain data and information in accordance with accepted practices*	Prepare and submit reports on data and information collection	
3	**Process and Analyze Data**	Recognize & comprehend principles & standards pertinent to processing & analyzing data and information	Plan & coordinate processing & analysis of spatial data	Process data and information using appropriate & accepted technologies & methodologies	Evaluate & analyze results	Prepare and submit reports		
4	**Assure *Completeness* and Quality of Data and Information**	Understand the concepts and principles in production processes	Determine quality standards	Measure and compare quality of outputs against established standards	*Ensure completeness of output*	Prepare and submit reports		
5	**Present and Communicate Data and information**	Recognize and comprehend principles and standards for effective presentation of data and information	Plan and coordinate presentation and communication of data and information	Assemble data and information in appropriate formats	Produce analogue/digital maps, charts, graphs, statistics and models	Present data and information based on accepted standards and specifications	*Respect intellectual property rights*	Prepare and submit reports on presented data and information

TECHNICAL PANEL FOR ENGINEERING, TECHNOLOGY AND ARCHITECTURE
PROFILE OF DUTIES AND COMPETENCIES OF A GEODETIC ENGINEER

	DUTIES		Skills/Competencies						
6	**Manage Program /Project activities**		Understand the concepts & principles of Project Management (PM) & PM Cycle	Define, plan, and organize the program/project/ activities	Implement project activities on time and within budget	Monitor and evaluate quality of data, procedures and outputs.	Prepare and submit reports		
7	**Conduct Research and Development (R&D) Activities**		Identify needs for research and development	Formulate research and development program	Implement R&D programs	Analyze and evaluate results	Prepare reports and make recommendations		
8	**Develop business entrepreneurial skills**		Practice team playing skills	Employ effective marketing strategies	*Develop and learn how to maintain good client/ customer relationship*				
9	**Uphold the dignity and integrity of the professional and promote the highest ethical standards in the practice of the profession**		Observe and abide by the code of ethical conduct and standards of professional practice	Accept responsibilities to and exercise fair dealings with the clients/colleagues and other professionals	Recognize unprofessional and unethical conduct and their corresponding penalties/ sanctions	Develop Social, Professional and Corporate Responsibility	Maintain active membership in the Accredited Professional Organization (APO) to establish linkages /networks		

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.

Defined during the workshop/seminar on the Development of Core Competency Standards for the Geodetic Engineering
June 21-22, Fontana Leisure Park, Clark Field, Pampanga

ANNEX II

PROGRAM OUTCOMES FOR BS GEODETIC ENGINEERING

PROGRAM OUTCOMES FOR BS GEODETIC ENGINEERING

The Bachelor of Science in Geodetic Engineering (B.S.GE) program must produce graduates possessing the following:

a. An ability to apply knowledge of mathematics, physical sciences, and engineering sciences to the practice of geodetic engineering.
b. An ability to 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. An ability to design, improve, innovate, and to supervise systems or procedures to meet desired needs within realistic constraints.
d. An ability to work effectively in multi-disciplinary and multi-cultural teams in diverse fields of practice.
e. An ability to identify, formulate, and solve geodetic engineering problems.
f. An understanding of the effects and impact of the geodetic engineering profession on the environment and the society, as well as the social and ethical responsibilities of the profession.
g. A specialized knowledge in at least one focus area of geodetic engineering practice, and the ability to apply such knowledge to provide solutions to actual problems.
h. An ability for effective oral and written communications particularly in the English language.
i. An ability to engage in life-long learning and to keep current of the development in a specific field of specialization.
j. An ability to use the appropriate techniques, skills and tools necessary for the practice of geodetic engineering.
k. A knowledge of contemporary issues under the program.

Relationship of the Courses to the Program Outcomes

I. TECHNICAL COURSES	a	b	c	d	e	f	g	h	i	j	k
A. Mathematics											
College Algebra	x	x	x		x		x		x	x	x
Advanced Algebra	x	x	x		x		x		x	x	x
Plane and Spherical Trigonometry	x	x	x		x		x		x	x	x
Analytic Geometry	x	x	x		x		x		x	x	x
Solid Mensuration	x	x	x		x		x		x	x	x
Differential Calculus	x	x	x		x		x		x	x	x

Integral Calculus	X	X	X		X		X		X	X	X
Differential Equations	X	X	X		X		X		X	X	X
Probability and Statistics	X	X	X		X		X		X	X	X
B. Natural/Physical Sciences	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
General Chemistry 1	X	X	X	X		X	X	X			
Physics 1	X	X	X	X		X	X	X			
Physics 2	X	X	X	X		X	X	X			
C. Basic Engineering Sciences	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
Computer Fundamentals and Programming	x	x	x	x	X		X	X	X	X	X
Engineering Drawing	x	x	x	X	X		X		X	X	X
Computer-Aided Drafting	x	x	x	x	X		X		X	X	X
Statics of Rigid Bodies	X	X									
Dynamics of Rigid Bodies	X	X									
Mechanics of Deformable Bodies	X	X									
Engineering Economy	X	X		X	X	X		X	X	X	X
Engineering Management	X	X		X	X	X		X	X	X	X
Environmental Engineering	X	X		X	x	X		X	X		X
Safety Engineering	X	X		X	x	X		X	X	X	X
D. Allied Courses	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
Principles of Geology	X	X	X	X	x	x	x	x	x	X	
Basic Electrical Engineering	x	x	x	x	x			x		X	
Information & Communications Technology	x	x	x	x	x	x	x	x	x	X	x
E. Professional Courses	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
General Surveying 1	X	X	X	X	X	X	X	X	X	X	X
General Surveying 2	X	X	X	X	X	X	X	X	X	X	X
Property Survey	X	X	X	X	X	X	X	X	X	X	X
Construction & Industrial Surveys	X	X	X	X	X	X	X	X	X	X	X
Cartography	X	X	X	X	X	X	X	X	X	X	X

Is there a differe

Geodetic Engineering Laws, Contracts Ethics			X	X	X	X	X	X	X	X	X
Public Land Laws & Laws on Natural Resources			X	X	X	X	X	X	X	X	X
Laws on Property			X	X	X	X	X	X	X	X	X
Land Registration Laws			X	X	X	X	X	X	X	X	X
Photogrammetry 1	X	X	X	X	X	X	X	X	X	X	X
Photogrammetry 2	X	X	X	X	X	X	X	X	X	X	X
Remote Sensing	X	X	X	X	X	X	X	X	X	X	X
Geometric Geodesy	X	X	X	X	X	X	X	X	X	X	X
Physical Geodesy	X	X	X	X	X	X	X	X	X	X	X
Satellite Geodesy	X	X	X	X	X	X	X	X	X	X	X
Geodetic Surveying	X	X	X	X	X	X	X	X	X	X	X
Mine Surveying	X	X	X	X	X	X	X	X	X	X	X
Hydrography	X	X	X	X	X	X	X	X	X	X	X
Geodetic Astronomy	X	X	X	X	X	X	X	X	X	X	X
Geodetic Computations & Adjustments	X	X	X	X	X	X	X	X	X	X	X
Development Planning	x	x	X	X	X	X	X	X	X	X	X
Special Studies in Geodetic Engineering	x	x	X	X	X	X	X	X	X	X	X
Land Administration & Management			X	X	X	X	X	X	X	X	X
Geographic Information Systems (GIS)	x	x	x	x	x	x	x	x	x	x	x
F. Elective	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
Elective 1 - Marine Cadastre	x	x	x	x	x	x	x	x	x	x	x
Elective 2 - Accounting 1										x	
Elective 3 - Business Entrepreneurship										x	
Elective 4 - Languages (French, German, Mandarin & others)											
Elective 5 – Advanced ICT	x	x	x	x	x	x	x	x	x	x	x
The student is required to take only 6 units out of all allowed electives											
II. NON-TECHNICAL COURSES	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
Social Science 1,2,3,4				x		x		x	x		x
Humanities 1,2,3				x		x		x	x		x
English 1,2,3				x		x		x	x		x
Pilipino 1, 2				x		x		x			x
Life and Works of Jose Rizal				x				x			x
P.E. 1, 2, 3, 4				x							x

NSTP 1, 2				X							x

ANNEX III

COURSE SPECIFICATIONS FOR BS GEODETIC ENGINEERING

ANNEX III
COURSE SPECIFICATIONS FOR THE BSGE

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ANNEX III
COURSE SPECIFICATIONS FOR THE BSGE

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I. TECHNICAL COURSES

A. MATHEMATICS

Course Name	**COLLEGE ALGEBRA**
Course Description	Algebraic expressions and equations; solution sets of algebraic equations in one variable: linear, quadratic, polynomial of degree *n*, fractional, radical equations, quadratic in form, exponential and logarithmic equations; decomposition of fractions into partial fractions; solution sets of systems of linear equations involving up to three variables.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	None
Course Objectives	After completing this course, the student must be able to: 1. Operate and simplify algebraic expressions; 2. Determine the solution sets of all types of algebraic equations, exponential and logarithmic equations; and inequalities; 3. Use the manipulative and analytical skills acquired in Objectives 1 to 2 to solve word problems; and 4. Identify the domain and range of a given relation/function.
Course Outline	1. The Set of Real Numbers 1.1. Integer Exponents 1.2. Polynomials, Operations, Special Products 1.3. Binomial Expansion (Binomial Theorem) 1.4. Factoring Polynomials 2. Rational Expressions 2.1. Rules of Exponents; Simplification of Rational Expressions; Operations on Rational Expressions 2.2. Properties of Radicals; Simplification of Radicals 2.3. Operations on Radicals 2.4. Complex Numbers 3. Equations in One Variable 3.1. Linear Equations; Literal Equations 3.2. Quadratic Equations in One Variable 3.3. Word Problems 3.4. Other Equations in One Variable: Radical, Fractional, Quadratic in Form 3.5. Polynomial Equation of Degree n 4. Functions 4.1. Inverse Functions 4.2. Exponential and Logarithmic Functions 4.3. Exponential and Logarithmic Equations 5. Systems of Linear Equations (by Elimination Methods) 6. Decomposition of Rational Expressions into Partial Fractions

Laboratory Equipment	None

Course Name	**ADVANCED ALGEBRA**
Course Description	Matrices and determinants; arithmetic and geometric series; solution sets of different types of inequalities and systems involving quadratics; solution of linear equations using determinants and matrices.
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours per Week	2 hours lecture
Prerequisites	College Algebra
Course Objectives	After completing this course, the student must be able to: 1. Determine the solution sets of inequalities; 2. Determine the solution sets of systems involving quadratics; 3. Use the manipulative and analytical skills acquired in Objective 2 to solve word problems; 4. Operate and manipulate matrices and determinants; 5. Solve systems of linear equations using matrices and determinants; and 6. Determine the indicated sum of the elements in an arithmetic and geometric sequence.

Course Outline	1. Inequalities 1.1. Linear, Quadratic, and Polynomial Inequality 1.2. Linear Inequalities with Absolute Value 2. Ratio, Proportion, and Variation 3. Determinants 3.1. Expansion by Minors 3.2. Solution of Linear Systems by Cramer's Rule 4. Matrices 4.1. Identity Matrix 4.2. Cofactor Matrix 4.3. Transpose of a Matrix 4.4. Adjoint Matrix 4.5. Inverse of a Matrix 4.6. Algebra on Matrices (Sum and Difference, Scalar Multiplication, Matrix Multiplication) 4.7. Solution of Linear Systems Using Matrices 5. Sequence and Series 5.1. Arithmetic and Geometric Means 5.2. Arithmetic and Geometric Sequences 5.3. Arithmetic and Geometric Series 5.4. Infinite Series 6. Combinatorial Mathematics 6.1. Sequences 6.2. The Factorial of a Number 6.3. Fundamental Principles of Counting, Permutation, and Combination 6.4. Binomial Theorem 6.5. Mathematical Induction
Laboratory Equipment	None

Course Name	**PLANE AND SPHERICAL TRIGONOMETRY**
Course Description	Trigonometric functions; identities and equations; solutions of triangles; law of sines; law of cosines; inverse trigonometric functions; spherical trigonometry
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	None

Course Objectives	After completing this course, the student must be able to: 1. Define angles and how they are measured; 2. Define and evaluate each of the six trigonometric functions; 3. Prove trigonometric functions; 4. Define and evaluate inverse trigonometric functions; 5. Solve trigonometric equations; 6. Solve problems involving right triangles using trigonometric function definitions for acute angles; and 7. Solve problems involving oblique triangles by the use of the sine and cosine laws.
Course Outline	1. Trigonometric Functions 1.1. Angles and Measurement 1.2. Trigonometric Functions of Angles 1.3. Trigonometric Function Values 1.4. The Sine and Cosine of Real Numbers 1.5. Graphs of the Sine and Cosine and Other Sine Waves 1.6. Solutions of Right Triangle 2. Analytic Trigonometry 2.1. The Eight Fundamental Identities 2.2. Proving Trigonometric Identities 2.3. Sum and Difference Identities 2.4. Double-Measure and Half-Measure Identities 2.5. Inverse Trigonometric Functions 2.6. Trigonometric Equations 2.7. Identities for the Product, Sum, and Difference of Sine and Cosine 3. Application of Trigonometry 3.1. The Law of Sines 3.2. The Law of Cosines 4. Spherical Trigonometry 4.1. Fundamental Formulas 4.2. Spherical Triangles
Laboratory Equipment	None

Course Name	**ANALYTIC GEOMETRY**
Course Description	Equations of lines and conic sections; curve tracing in both rectangular and polar coordinates in two-dimensional space.
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours per Week	2 hours lecture
Prerequisites	College Algebra Plane and Spherical Trigonometry

Course Objectives	After completing this course, the student must be able to: 1. Set up equations given enough properties of lines and conics; 2. Draw the graph of the given equation of the line and the equation of the conic section; and 3. Analyze and trace completely the curve, given their equations in both rectangular and polar coordinates, in two-dimensional space.
Course Outline	1. Plane Analytic Geometry 1.1. The Cartesian Planes 1.2. Distance Formula 1.3. Point-of-Division Formulas 1.4. Inclination and Slope 1.5. Parallel and Perpendicular Lines 1.6. Angle from One Line to Another 1.7. An Equation of a Locus 2. The Line 2.1. Point-Slope and Two-Point Forms 2.2. Slope-Intercept and Intercept Forms 2.3. Distance from a Point to a Line 2.4. Normal Form 3. The Circle 3.1. The Standard Form for an Equation of a Circle 3.2. Conditions to Determine a Circle 4. Conic Sections 4.1. Introduction 4.2. The Parabola 4.3. The Ellipse 4.4. The Hyperbola 5. Transformation of Coordinates 5.1. Translation of Conic Sections 6. Curve Sketching 6.1. Symmetry and Intercepts 6.2. Sketching Polynomial Equations 6.3. Asymptotes (Except Slant Asymptotes) 6.4. Sketching Rational Functions 7. Polar Coordinates 7.1. Polar Coordinates 7.2. Graphs in Polar Coordinates 7.3. Relationships Between Rectangular and Polar Coordinates
Laboratory Equipment	None

Course Name	**SOLID MENSURATION**
Course Description	Concept of lines and planes; Cavalieri's and Volume theorems; formulas for areas of plane figures, volumes for solids; volumes and surfaces areas for spheres, pyramids, and cones; zone, sector and segment of a sphere; theorems of Pappus.

Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours per Week	2 hours lecture
Prerequisite	College Algebra, Plane and Spherical Trigonometry
Course Objectives	After completing this course, the student must be able to: 1. Compute for the area of plane figures; 2. Compute for the surface areas and volumes of different types of solids; and 3. Determine the volumes and surface areas of solids using other methods such as the theorems of Pappus.
Course Outline	1. Plane Figures 1.1. Mensuration of Plane Figures 2. Lines and Planes in Space 2.1. Typical Proofs of Solid Geometry 2.2. Angles 3. Solids for which V = Bh 3.1. Solid Sections 3.2. Cubes 3.3. Rectangular Parallelopiped 3.4. Cavalieri's Theorem 3.5. Volume Theorem 3.6. Prism 3.7. Cylindrical Surface 3.8. Cylinder (Circular and Right Circular) 4. Solids for which V = ⅓Bh 4.1. Pyramids 4.2. Similar Figures 4.3. Cones 4.4. Frustrum of Regular Pyramid 4.5. Frustrum of Right Circular Cone 5. Sphere 5.1. Surface Area and Volume 5.2. Zone 5.3. Segment 5.4. Sector 6. Theorems of Pappus
Laboratory Equipment	None

Course Name	**DIFFERENTIAL CALCULUS**
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	4 units lecture
Number of Contact Hours per Week	4 hours lecture
Prerequisites	Advanced Algebra Analytic Geometry Solid Mensuration
Course Objectives	After completing this course, the student must be able to: 1. Have a working knowledge of the basic concepts of functions and limits; 2. Differentiate algebraic and transcendental functions with ease; 3. Apply the concept of differentiation in solving word problems involving optimization, related rates, and approximation; and 4. Analyze and trace transcendental curves.
Course Outline	1. Functions 1.1. Definitions 1.2. Classification of Functions 1.3. Domain and Range of a Function 1.4. Graph of a Function 1.5. Functional Notation 1.6. Evaluation of a Function 1.7. Combinations of Functions 1.8. One-Valued and Many-Valued Functions 1.9. Odd and Even Functions 1.10. Special Function Types 1.11. Functions as Mathematical Models 2. Continuity 2.1. Definition 2.2. Properties of Continuous Functions 3. Limits 3.1. Notion of a Limit 3.2. Definition 3.3. Properties of Limits 3.4. Operations with Limits 3.5. Evaluation of Limits 3.6. One-Sided Limits 3.7. Unbounded Functions 4. The Derivative 4.1. Notion of the Derivative 4.2. Definition 4.3. Determination of the Derivative by Increments 4.4. Differentiation Rules 5. The Slope 5.1. Definition of Slope as the Derivative of a Function 5.2. Determination of the Slope of a Curve at a Given Point

	6. Rate of Change 6.1. Average Rate of Change 6.2. Instantaneous Rate of Change 7. The Chain Rule and the General Power Rule 8. Implicit Differentiation 9. Higher-Order Derivatives 10.Polynomial Curves 10.1. Generalities About Straight Lines 10.2. Tangents and Normal to Curves 10.3. Extrema and the First Derivative Test 10.4. Concavity and the Second Derivative Test 10.5. Points of Inflection 10.6. Sketching Polynomial Curves 11.Applications of the Derivative: Optimization Problems 12.Applications of the Derivative: Related Rates 13.The Differential 13.1. Definition 13.2. Applications of the Differential—Comparison of Δx and dx 13.3. Error Propagation 13.4. Approximate Formulas 14.Derivatives of Trigonometric Functions 14.1. Elementary Properties 14.2. Definition 14.3. Graphs of Trigonometric Functions 14.4. Applications 15.Derivatives of Inverse Trigonometric Functions 15.1. Elementary Properties 15.2. Definition 15.3. Graphs of Inverse Trigonometric Functions 15.4. Applications 16.Derivatives of Logarithmic and Exponential Functions 16.1. Elementary Properties 16.2. Definition 16.3. Graphs of Logarithmic and Exponential Functions 16.4. Applications 17.Derivatives of Hyperbolic Functions 17.1. Elementary Properties 17.2. Definition 17.3. Graphs of Hyperbolic Functions 17.4. Applications 18.Solution of Equations 18.1. Newton's Method of Approximation 18.2. Newton-Raphson Law 19.Transcendental Curve Tracing 19.1. Logarithmic and Exponential Functions 20.Parametric Equations 21.Partial Differentiation
Laboratory Equipment	None

Course Name	**INTEGRAL CALCULUS**
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	4 units lecture
Number of Contact Hours per Week	4 hours lecture
Prerequisite	Differential Calculus
Course Objectives	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. Simple Power Formula 1.3. Simple Trigonometric Functions 1.4. Logarithmic Function 1.5. Exponential Function 1.6. Inverse Trigonometric Functions 1.7. Hyperbolic Functions 1.8. General Power Formula 1.9. Constant of Integration 1.10. 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. Application 3.1. Improper Integrals 3.2. Plane Area 3.3. Areas Between Curves 4. Other Applications 4.1. Volumes 4.2. Work 4.3. Hydrostatics Pressure and Force 5. Surfaces Multiple Integral as Volume

	5.1. Surface Tracing: Planes 5.2. Spheres 5.3. Cylinders 5.4. Quadratic Surfaces 5.5. Double Integrals 5.6. Triple Integrals 6. Multiple Integral as Volume 6.1. Double Integrals 6.2. Triple Integrals
Laboratory Equipment	None

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	Integral Calculus
Course Objectives	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
Laboratory Equipment	None

Course Name	**PROBABILITY AND STATISTICS**
Course Description	Basic principles of statistics; presentation and analysis of data; averages, median, mode; deviations; probability distributions; normal curves and applications; regression analysis and correlation; application to engineering problems.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	College Algebra
Course Objectives	After completing this course, the student must be able to: 1. Define relevant statistical terms; 2. Discuss competently the following concepts: 2.1. Frequency distribution 2.2. Measures of central tendency 2.3. Probability distribution 2.4. Normal distribution 2.5. Inferential statistics 3. Apply accurately statistical knowledge in solving specific engineering problem situations.
Course Outline	1. Basic Concepts 1.1. Definition of Statistical Terms 1.2. Importance of Statistics 2. Steps in Conducting a Statistical Inquiry 3. Presentation of Data 3.1. Textual 3.2. Tabular 3.3. Graphical 4. Sampling Techniques 5. Measures of Central Tendency 5.1. Mean 5.2. Median 5.3. Mode

	5.4. Skewness and Kurtosis 6. Measures of Variation 6.1. Range 6.2. Mean Absolute Deviation 6.3. Variance 6.4. Standard Deviation 6.5. Coefficient of Variation 7. Probability Distributions 7.1. Counting Techniques 7.2. Probability 7.3. Mathematical Expectations 7.4. Normal Distributions 8. Inferential Statistics 8.1. Test of Hypothesis 8.2. Test Concerning Means, Variation, and Proportion 8.3. Contingency Tables 8.4. Test of Independence 8.5. Goodness-of-Fit Test 9. Analysis of Variance 10. Regression and Correlation
Laboratory Equipment	None

B. NATURAL/PHYSICAL SCIENCES

Course Name	**GENERAL CHEMISTRY**
Course Description	Basic concepts of matter and its classification; mass relationships in chemical reactions; properties of gases, liquids, and solids; concepts of thermochemistry; quantum theory and electronic behavior; periodic relationship of elements in the periodic table; intramolecular forces; and solutions.
Number of Units for Lecture and Laboratory	4 units: 3 units lecture, 1 unit laboratory
Number of Contact Hours per Week	6 hours: 3 hours lecture, 3 hours laboratory
Prerequisite	None
Course Objectives	After completing this course, the student must be able to: 1. Apply significant figures and appropriate units in all measurements and calculations; 2. Classify matter; distinguish between physical and chemical properties/changes; 3. Define and explain the concepts of atomic mass, average atomic mass, mole, molar mass and perform calculations involving these; 4. Balance and interpret chemical equations and perform stoichiometric calculations;

	5. Write, explain and apply the gas laws; 6. Discuss the kinetic molecular theory (KMT) of gases and use the KMT to qualitatively explain the gas laws; argue the differences between ideal and non-ideal gas behavior; 7. Define enthalpy; classify common processes as exothermic or endothermic and know the sign conventions; 8. Trace the various atomic theories; discuss the Bohr model; and explain the line spectra of hydrogen; Discuss the concept of electron density; contrast the Bohr's orbits with orbitals in the quantum theory; 9. Write electron configurations and orbital diagrams for multi electron atoms; 10. Use the periodic table to classify elements and predict trends in properties; 11. Write Lewis dot symbols and Lewis structure; 12. Explain valence bond theory, hybrid orbitals, and hybridization in common compounds 13. Distinguish between inter- and intramolecular forces; give examples of intramolecular forces and how they relate to physical properties; 14. Distinguish between crystalline and amorphous solids 15. Discuss various physical changes and interpret phase diagrams; 16. Distinguish different types of solutions; work with different concentration units; Understand the effect of temperature and pressure on solubility; and 17. Explain and apply colligative properties to determine molar mass.
Course Outline	1. The Study of Change 1.1. Introduction to Chemistry 1.2. Matter: Classification, States, Physical, and Chemical Properties 1.3. Measurement and Handling of Numbers 2. Atoms, Molecules, and Ions 2.1. The Atomic Theory 2.2. The Structure of the Atom 2.3. Atomic Number, Mass Number, Isotopes 2.4. The Periodic Table 2.5. Molecules and Ions 2.6. Chemical Formulas 2.7. Naming Compounds 3. Mass Relationships in Chemical Reaction 3.1. Atomic Mass 3.2. Molar Mass of an Element and Avogadro's Number 3.3. Molecular Mass 3.4. Percent Composition of Compounds 3.5. Chemical Reactions and Chemical Equations 3.6. Amounts of Reactants and Products 3.7. Limiting Reagents 3.8. Reaction Yield 4. Gases 4.1. Substances That Exist as Gases 4.2. Pressure of a Gas

4.3. The Gas Laws
4.4. The Ideal Gas Equation
4.5. Gas Stoichiometry
4.6. Dalton's Law of Partial Pressure
4.7. The Kinetic Molecular Theory of Gases
4.8. Deviation from Ideal Behavior

5. Thermochemistry
   5.1. Energy Changes in Chemical Reactions
   5.2. Introduction to Thermodynamics
   5.3. Enthalpy
6. Quantum Theory and the Electronic Structure of Atoms
   6.1. From Classical Physics to Quantum Theory
   6.2. Bohr's Theory of the Hydrogen Atom
   6.3. The Dual Nature of the Electron
   6.4. Quantum Mechanics
   6.5. Quantum Numbers
   6.6. Atomic Orbitals
   6.7. Electron Configuration
   6.8. The Building-Up Principle
7. Periodic Relationships Among the Elements
   7.1. Periodic Classification of the Elements
   7.2. Periodic Variation in Physical Properties
   7.3. Ionization Energy
   7.4. Electron Affinity
8. Chemical Bonding: Basic Concepts
   8.1. Lewis Dot Structure
   8.2. The Ionic Bond
   8.3. The Covalent Bond
   8.4. Electronegativity
   8.5. Writing Lewis Structure
   8.6. The Concept of Resonance
   8.7. Bond Energy
9. Chemical Bonding: Molecular Geometry and Hybridization
   9.1. Molecular Geometry
   9.2. Dipole Moments
   9.3. The Valence Bond Theory
   9.4. Hybridization of Atomic Orbitals
   9.5. Hybridization in Molecules Containing Double and Triple Bonds
10. Intermolecular Forces in Liquids and Solids
   10.1. The KMT of Liquids and Solids
   10.2. Intermolecular Forces
   10.3. Properties of Liquids
   10.4. Crystalline vs. Amorphous Solids
   10.5. Phase Changes
   10.6. Phase Diagrams
11. Physical Properties of Solutions
   11.1. Types of Solutions
   11.2. A Molecular View of the Solution Process
   11.3. Concentration Units
   11.4. Effect of Temperature and Pressure on Solubility

	11.5. Colligative Properties
Laboratory Equipment	Chemistry Laboratory(see attached)

Course Name	**PHYSICS 1**
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	4 units: 3 units lecture, 1 unit laboratory
Number of Contact Hours per Week	6 hours: 3 hours lecture, 3 hours laboratory
Prerequisites	College Algebra Plane and Spherical Trigonometry
Course Objectives	After completing this course, the student must be able to: 1. Differentiate a vector from a scalar; 2. Determine the resultant of concurrent vectors; 3. Solve problems in kinematics; 4. Apply Newton's Laws of Motion; 5. Determine the gravitational force between different masses; 6. Solve problems involving centripetal force for horizontal and vertical curves; 7. Compute the work done on a given body; 8. Relate work and energy; 9. Solve problems by applying the law of conservation of energy; 10. Solve problems in impulse and momentum and collisions; 11. Determine the stress and strain on a body; and 12. Determine the period of a body in simple harmonic motion.
Course Outline	1. Work, Energy and Power 1.1. Definition of Work, Energy and Power 1.2. Conservation of Energy 2. Impulse and Momentum 2.1. Definition of Impulse and Momentum 2.2. Conservation of Momentum 3. Vector 3.1. Vectors and Scalars 3.2. Graphical Method 3.3. Analytical Method 4. Vector Subtraction 5. Kinematics 5.1. Equations of Kinematics 5.2. Freely Falling Bodies 5.3. Projectile Motion 6. Dynamics 6.1. Newton's Laws of Motion

	6.2. Friction 6.3. First Condition of Equilibrium 7. Work, Energy and Power 7.1. Definition of Work, Energy and Power 7.2. Conservation of Energy 8. Impulse and Momentum 8.1. Definition of Impulse and Momentum 8.2. Conservation of Momentum 8.3. Collisions, Coefficient of Restitution 9. Rotation 9.1. Definition of torque 9.2. Second Condition of Equilibrium 9.3. Center of Gravity 10. Dynamics of Rotation 10.1. Kinematics of Rotation 10.2. Dynamics of Rotation 10.3. Center of Gravity 11. Elasticity 11.1. Hooke's Law 11.2. Stress and Strain 11.3. Modulus of Elasticity 12. Oscillations 12.1. Definition of Vibration Motion and Simple Harmonic Motion 12.2. Kinematics of Simple Harmonic Motion 12.3. Simple Pendulum
Laboratory Equipment	Physics Laboratory (see attached)

Course Name	**PHYSICS 2**
Course Description	Fluids; thermal expansion, thermal stress; heat transfer; calorimetry; waves; electrostatics; electricity; magnetism; optics; image formation by plane and curved mirrors; and image formation by thin lenses.
Number of Units for Lecture and Laboratory	4 units: 3 units lecture, 1 unit laboratory
Number of Contact Hours per Week	6 hours: 3 hours lecture, 3 hours laboratory
Prerequisite	Physics 1
Course Objectives	After completing this course, the student must be able to: 1. Describe the characteristics of fluids at rest and in motion; 2. Compute the buoyant force on an object immersed in a fluid; 3. Compute the pressure and flow speed of a fluid at any point in a flow tube; 4. Determine the amount of expansion of a given material in relation to temperature change; 5. Determine the change in temperature of a given amount of material

	that loses or gains; 6. Solve problems about the law of heat transfer; 7. Describe the three methods of heat transfer; 8. Discuss the properties of waves; 9. Describe the modes of vibration of strings and air columns; 10. Solve problems on Doppler Effect; 11. Compute the electric force between electric charges; 12. Compute the electric field due to electric charges; 13. Compute the electric potential due to a charge and electric potential energy of charges; 14. Define electric current, electric resistance and voltage; 15. Solve problems on resistance and cells in series and parallel; 16. State Kirchhoff's rules and apply them in a given circuit; 17. Compute the magnetic field of a given current-carrying conductors; 18. Compute the magnetic torque on a current conductor in a magnetic field; and 19. Describe image formation by mirrors and lenses.
Course Outline	1. Fluids 1.1. Pressure, Specific Gravity, Density 1.2. Archimedes' Principle 1.3. Rate of Flow and Continuity Principle 1.4. Bernoulli's Principle 1.5. Torricelli's Theorem 2. Thermal Expansion, Thermal Stress 3. Heat Transfer 4. Calorimetry 4.1. Specific Heat 4.2. Law of Heat Exchange 4.3. Change of Phase 5. Waves 5.1. Types of Waves and Their Properties 5.2. Sounds 6. Electrostatics 6.1. Charge 6.2. Coulomb's Law 6.3. Superposition Principle 6.4. Electric Field Intensity 6.5. Work and Potential 6.6. Capacitors, Dielectrics 7. Electricity 7.1. Current 7.2. Resistance 7.3. EMF 7.4. Ohm's Law 7.5. Energy and Power in Circuits 7.6. Series and Parallel Connections 7.7. Kirchhoff's Rules 8. Magnetism 8.1. Magnetic Field of Moving Changes 8.2. Magnetic Filed of Current Element

	8.3. Motion of a Charge in a Magnetic Field 8.4. Biot-Savart Law 8.5. Force on a Moving Charge in a Magnetic Field 8.6. Torque on a Current-Carrying Loop 9. Optics 9.1. Light as Electromagnetic Waves 9.2. Properties of Reflection and Refraction 10. Image Formation by Plane and Curved Mirrors 10.1. Graphical Methods 10.2. Mirror Equation 11. Image Formation by Thin Lenses 11.1. Graphical Methods 11.2. Lens Equation
Laboratory Equipment	Physics Laboratory (see attached)

C. BASIC ENGINEERING SCIENCES

Course Name	**ENGINEERING DRAWING**
Course Description	Practices and techniques of graphical communication; application of drafting instruments, lettering scale, and units of measure; descriptive geometry; orthographic projections; auxiliary views; dimensioning; sectional views; pictorial drawings; requirements of engineering working drawings; and assembly and exploded detailed drawings.
Number of Units for Lecture and Laboratory	1 unit laboratory
Number of Contact Hours per Week	3 hours laboratory
Prerequisite	None
Course Objectives	After completing this course, the student must be able to: 1. Understand the importance of technical drawing knowledge and skills as applied to the various areas of engineering; 2. Apply the basic concepts of technical drawing and sketching; and 3. Prepare technical drawings.
Course Outline	1. Engineering Lettering 2. Instrumental Figures 3. Geometric Construction 4. Orthographic Projection 5. Dimensioning 6. Orthographic Views with Dimensions and Section View 7. Sectional View 8. Pictorial Drawing 9. Engineering Working Drawings 10. Assembly and Exploded Detailed Drawings

Laboratory Equipment	1. Drafting table 2. Drawing instruments 2.1. One 30-60 degree triangle 2.2. One 45 degree triangle 2.3. One technical compass 2.4. One protractor

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	2 units laboratory
Number of Contact Hours per Week	6 hours laboratory
Prerequisite	Second Year Standing
Course Objectives	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	**COMPUTER-AIDED DRAFTING**
Course Description	Concepts of computer-aided drafting (CAD); introduction to the CAD environment; terminologies; and the general operating procedures and techniques in entering and executing basic CAD commands.
Number of Units for Lecture and Laboratory	1 unit laboratory
Number of Contact Hours per Week	3 hours laboratory
Prerequisite	Third Year Standing
Course Objectives	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	**STATICS OF RIGID BODIES**
Course Description	Force systems; structure analyses; friction; centroids and centers of gravity; and moments of inertia.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisites	Physics 1 Integral Calculus

Course Objectives	After completing this course, the student must be able to: 1. Understand the principles of equilibrium of particles; 2. Undertake vector operations such as vector cross and dot product; 3. Determine forces of 2D and 3D structures; 4. Understand the principles of static, wedge and belt friction; 5. Determine centroids, center of mass and center of gravity of objects; 6. Determine moment of inertia, mass moment of inertia; and 7. Analyze the stresses of trusses, beams and frames.
Course Outline	1. Introduction to Mechanics; Vector Operations 2. Force Vectors and Equilibrium of Particles 3. Vector Cross and Dot Product 4. Moment of a Force 5. Couples; Moment of a Couple 6. Equivalent Force Systems in 2D and 3D 7. Dry Static Friction, Wedge and Belt Friction 8. Centroid; Center of Mass; and Center of Gravity 9. Distributed Loads and Hydrostatic Forces; Cables 10. Moment of Inertia; Mass Moment of Inertia 11. Trusses; Frames and Machines; Internal Forces 12. Beams; Shear and Bending Moment Diagrams
Laboratory Equipment	None

Course Name	**DYNAMICS OF RIGID BODIES**
Course Description	Kinetics and kinematics of a particle; kinetics and kinematics of rigid bodies; work energy method; and impulse and momentum.
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours per Week	2 hours lecture
Prerequisite	Statics of Rigid Bodies
Course Objectives	After completing this course, the student must be able to: 1. Understand the principles governing the motion of particles, velocity and acceleration; 2. Understand the principles of Newton's Second Law and its applications; 3. Understand kinetics of particles in particular energy and momentum methods; and 4. Understand kinematics of rigid bodies, its energy and momentum.
Course Outline	1. Introduction to Dynamics 2. Position, Velocity, and Acceleration 3. Determination of the Motion of the Particles 4. Uniform Rectilinear Motion 5. Uniformly Accelerated Rectilinear Motion 6. Position Vector, Velocity, and Acceleration

7. Derivatives of Vector Functions
8. Rectangular Components of Velocity and Acceleration
9. Motion Relative to a Frame in Translation
10. Tangential and Normal Components
11. Radial and Transverse Components
12. Motion of Several Particles (Dependent Motion)
13. Kinetics of Particles: Newton's Second Law
    - 13.1. Newton's Second Law of Motion
    - 13.2. Linear Momentum of the Particle, Rate of Change of Linear Momentum
    - 13.3. System of Units
    - 13.4. Equation of Motion
    - 13.5. Dynamic Equilibrium
    - 13.6. Angular Momentum of Particle, Rate of Change of Angular Momentum
    - 13.7. Equations in Terms of Radial and Transverse Components
    - 13.8. Motion Under a Central Force
14. Kinetics of Particles: Energy and Momentum Methods
    - 14.1. Work of Force
    - 14.2. Kinetic Energy of a Particle, Principle of Work and Energy
    - 14.3. Applications of the Principle of Work and Energy
    - 14.4. Potential Energy
    - 14.5. Conservative Forces
    - 14.6. Conservation of Energy
    - 14.7. Principle of Impulse and Momentum
    - 14.8. Impulsive Motion
    - 14.9. Impact
    - 14.10. Direct Central Impact
    - 14.11. Oblique Central Impact
    - 14.12. Problems Involving Energy and Momentum
15. Systems of Particles
    - 15.1. Application of Newton's Second Laws to Motion of a System of Particles
    - 15.2. Linear and Angular Momentum of a System of Particles
    - 15.3. Motion of Mass Center of a System of Particles
    - 15.4. Angular Momentum of a System of Particles About Its Mass Center
    - 15.5. Conservation of Momentum for a System of Particles
    - 15.6. Kinetic Energy of a System of Particles
    - 15.7. Work-Energy Principle. Conservation of Energy for a System of Particles
    - 15.8. Principle of Impulse and Momentum for a System of Particles
16. Kinematics of Rigid Bodies
    - 16.1. Translation
    - 16.2. Rotation About a Fixed Axis
    - 16.3. Equations Defining the Rotation of a Rigid Body About a Fixed Axis
    - 16.4. General Plane Motion
    - 16.5. Absolute and Relative Velocity in Plane Motion
    - 16.6. Instantaneous Center of Rotation in Plane Motion
    - 16.7. Absolute and Relative Acceleration

	16.8. Rate of Change of a Vector with Respect to a Rotating Frame 16.9. Plane Motion of a Particle Relative to a Rotating Frame; Coriolis Acceleration 16.10. Motion About a Fixed Point 16.11. General Motion 16.12. Three-Dimensional Motion of a Particle Relative to a Rotating Frame; Coriolis Acceleration 16.13. Frame of Reference in General Motion 17. Plane Motion of Rigid Bodies: Forces and Accelerations 17.1. Equation of Motions 17.2. Angular Momentum of a Rigid Body in Plane Motion 17.3. Plane Motion of a Rigid Body. D' Alembert's Principle 17.4. Solution of Problems involving the Motion of a Rigid Bodies 17.5. Systems of Rigid Bodies 17.6. Constrained Plane Motion 18. Plane Motion of Rigid Bodies: Energy and Momentum Methods 18.1. Principle of Work and Energy for a Rigid Body 18.2. Work of Forces Acting on a Rigid Body 18.3. Kinetic Energy of a Rigid Body in Plane Motion 18.4 Systems of Rigid Bodies 18.5 Conservation of Energy 18.6 Principle of Impulse and Momentum 18.7 Conservation of Angular Momentum 18.8 Impulsive Motion 18.9 Eccentric Impact
Laboratory Equipment	None

Course Name	**MECHANICS OF DEFORMABLE BODIES**
Course Description	Axial stress and strain; stresses for torsion and bending; combined stresses; beam deflections; indeterminate beams; and elastic instability.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	Statics of Rigid Bodies
Course Objectives	After completing this course, the student must be able to: 1. Understand the concepts of stress and strain; 2. Calculate stresses due to bending, shears, and torsion under plain and combined loading; 3. Analyze statically determinate and indeterminate structures; and 4. Determine the elastic stability of columns.
Course Outline	1. Load Classification 2. Concept of Stress, Normal and Shear Stress

	3. Stresses under Centric Loading 4. Stress Concentration 5. Plane Stress 6. Principal Stresses for Plane Stress 7. Mohr's Circle for Plane Stress 8. Deformations, Normal and Shear Strains 9. Material Properties 10. Working Stresses 11. Deformation in a System of Axially Loaded Members 12. Temperature Effects on Axially Loaded Members 13. Statically Indeterminate Members 14. Thin-Walled Pressure Vessel 15. Torsional Stresses; Elastic Torsion Formula 16. Torsional Deformation; Power Transmission 17. Flexural Stresses by the Elastic Curve 18. Moment Equation Using Singularity Function 19. Beam Deflection by the Double Integration Method 20. Area Moment Theorems 21. Moment Diagram by Parts 22. Beam Deflection by Area Moment Method 23. Statically Indeterminate Beams 24. Buckling of Long Straight Columns 25. Combined Loadings 26. Analysis of Riveted Connections by the Uniform Shear Method 27. Welded Connections
Laboratory Equipment	None

Course Name	**ENGINEERING ECONOMY**
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	Third Year Standing
Course Objectives	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 Economy 1.3. Engineering Economy and the Design Process 1.4. Cost Concepts for Decision Making 1.5. Present Economy 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. Basic Economy Study Methods 3.1. The Minimum Attractive Rate of Return 3.2. The Present Worth Method 3.3. The Future Worth Method 3.4. The Annual Worth Method 3.5. The Internal Rate of Return Method 3.6. The External Rate of Return Method 3.7. The Payback Period Method 3.8. The Benefit/Cost Ratio Method 4. Decisions Under Certainty 4.1. Evaluation of Mutually Exclusive Alternatives 4.2. Evaluation of Independent Projects 4.3. Depreciation and After-Tax Economic Analysis 4.4. Replacement Studies 4.5. Break win Analysis 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
Laboratory Equipment	None

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

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

Course Name	**ENVIRONMENTAL ENGINEERING**
Course Description	Ecological framework of sustainable development; pollution environments: water, air, and solid; waste treatment processes, disposal, and management; government legislation, rules, and regulation related to the environment and waste management; and environmental management system.
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours per Week	2 hours lecture
Course Objectives	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.
Prerequisites	General Chemistry

Course Outline	1. Ecological Concepts 1.1. Introduction to Environmental Engineering 1.2. Ecology of Life 1.3. Biogeochemical Cycles 1.4. Ecosystems 2. Pollution Environments 2.1. Water Environment 2.2. Air Environment 2.3. Solid Environmental 2.4. Toxic and Hazardous Waste Treatment 3. Environmental Management System 3.1. Environmental Impact Assessment 3.2. Environmental Clearance Certificate
Laboratory Equipment	None

Course Name	**SAFETY MANAGEMENT**
Course Description	Evolution of safety management; safety terminology; safety programs adopted by high risk industries; hazards in the construction, manufacturing, gas and power plants, and other engineering industries and how to prevent or mitigate them; techniques in hazard identification and analysis in workplaces; off-the-job safety; disaster prevention and mitigation; and incident investigation.
Number of Units for Lecture and Laboratory	1 unit lecture
Number of Contact Hours per Week	1 hour lecture
Prerequisites	Third Year Standing
Course Objectives	After completing this course, the student must be able to: 1. Understand the importance and the value of safety; 2. Know the health hazards and their prevention; 3. Identify and mitigate or prevent hazards; and 4. Apply the concepts and principles of safety in engineering practice.

Course Outline	1. Overview of Safety 2. Basic Safety Procedures in High Risk Activities and Industries 2.1. Procedure in Hazards Analysis in the Workplace 2.2. Control of Hazardous Energies 2.3. Confined Space Entry 2.4. Basic Electrical Safety 2.5. Fall Protection 2.6. Barricades and Scaffolds 2.7. Fire Safety and the Fire Code 2.8. Industrial Hygiene 2.9. Hazard Communication and Chemical Safety 3. Value Based Safety and Off-the-Job Safety 3.1. Safety as a Value; Choice vs. Compliance 3.2. Off-the-Job Safety (Residences and Public Places) 3.3. Safety as Related to Health Practices 4. Disaster Prevention and Mitigation 4.1. Rationale for Disaster Prevention and Loss Control 4.2. Planning for Emergencies 4.3. Emergency Response Procedures 5. Incident Investigation and Reporting 5.1. Accident Escalation, Incident Investigation and Reporting 5.2. Causal Analysis; Recognition of Root Cause 5.3. Identification of Corrective or Preventive Actions
Laboratory Equipment	None

D. ALLIED COURSES

Course Name	**PRINCIPLES OF GEOLOGY**
Course Description	Study of earth materials, the nature and consequences of endogenic and exogenic geologic processes; Plate Tectonics
Number of Units for Lecture and Laboratory	3 unit lecture
Number of Contact Hrs per Week	3 hrs lecture
Prerequisite	General Chemistry or Instructor's Consent

Course Objectives	At the end of the course, the student must be able to: 1. To provide the fundamental concepts and basic understanding of the geological science. 2. To provide a basic and first hand appreciation of the materials that make up the earth, their characteristics, uses and behavior. 3. To develop an appreciation of the world we live in and how to adapt to hazards posed by natural geological processes. 4. To prepare the students in their undertaking of subjects that use basic geological knowledge, upon which more advanced concepts are based. 5. To inculcate and develop the ability of deductive reasoning. 6. To develop the ability in conducting scientific literature research. 7. To provide the students interest in economic, environmental and societal issues related to Geology and Geological Engineering. 8. To instill the desire towards continuous learning.
Course Outline	Orientation and introduction to the course. Definitions How the Earth was formed. Introduction to Plate Tectonics and the Geologic Time Scale Materials of the Earth – Elements, Minerals and Rocks The Rock Cycle Igneous Rocks and Processes Sedimentary Rocks and Processes Metamorphic Rocks and Processes Earthquakes The Earth's interior Crustal Deformation Plate Tectonics Weathering and Erosion Mass Wasting Landforms The Hydrologic Cycle Streams Groundwater Oceans and shorelines Geologic Time Environment and Earth resources Beyond Earth (The Universe and the Solar System)
Laboratory Equipment	N/a

Course Name	**INFORMATION & COMMUNICATIONS TECHNOLOGY**
Course Description	Introduction to information and communications technology (ICT); use of internet; ethical and social issues in ICT
Number of Units for Lecture and Laboratory	3 units lecture

Number of Contact Hrs per Week	3 hours laboratory
Prerequisite	None
Course Objectives	1. To introduce Information and Communications Technology to Geodetic Engineering students 2. To use the WWW through the Internet for research, problem solving and other relevant endeavors 3. To discuss ethical and social issues in computing
Course Outline	Introduction to Computer Systems Hardware Input/Output Devices Processors Storage Devices Software Operating Systems Software Applications Internet and Data Communications Computer Networks World Wide Web Multi Media Computer Graphics and Animation Streaming Media Software Development Programming Systems Analysis and Design Programming Languages Social and Ethical Issues Computer Security Invasion of Privacy Intellectual Property
Laboratory Equipment	PC

Course Name	**BASIC ELECTRICAL ENGINEERING**
Course Description	This course provides the students a sound background in the theory and concepts of the fundamental and basic laws of electricity and magnetism. Practical applications such as electrical equipment, electrical safety, blueprint reading, house wiring, and lighting are introduced
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per week	3 hours lecture

Prerequisite	College Algebra, Plane Trigonometry, Physics 2
Course Objectives	At the end of the course, the student must be able to: 1. Develop understanding and appreciation about electric circuits. 2. Know the operating principles of AC-DC equipment. 3. Familiarized the basic electrical blueprint reading, house wiring and lighting and electrical safety. 4. Appreciation in the importance of the course to the student's field of study.
Course Outline	1. DIRECT CURRENT. Ohm's Law, Series, Parallel Connections, Batteries and Power. 2. ALTERNATING CURRENT. Voltage, Current & Phase, Peak, rms, Average Values. 3. MAGNETISM. Fundamentals, Magnetic Circuits, Units of Magnetics. 4. ELECTRICAL MATERIALS. Conductors, Insulators, Semiconductors. 5. DC MACHINES / EQUIPMENT. Fundamental Concepts, Motors, Meters. 6. AC MACHINES / EQUIPMENT. Fundamental Concepts, Motors, Transformers. 7. ELECTRICAL SAFETY. Equipment Protection, Personnel Protection. 8. BLUEPRINT READING. Electrical Symbols, Electrical Diagrams. 9. COMMERCIAL AND INDUSTRIAL ELECTRICAL FACILITIES
Laboratory Equipment	N/a

E. PROFESSIONAL COURSES

Course Name:	**CARTOGRAPHY**
Course Description	Cartography is the fundamental geographic discipline of mapping. This course will introduce the basic principles of digital map design and production to include map classification and standards. Lectures and reading assignments will address the science of established cartographic design principles, including page layout, scale and projection, generalization, simplification, classification and symbolization, color, tone, and techniques for representing surfaces. Cartography will also include map projections: properties, errors, distortion and construction of the UTM and PTM and other projections; nautical and aeronautical charts: design and construction, map manuscript and reproduction and modern cartographic techniques.
Number of Units for Lecture and Laboratory	2 units: 1 unit lecture, 1 unit laboratory

Number of Contact Hours per week	4 hours: 1 hour lecture, 3 hours laboratory
Prerequisite	General Surveying 2, Integral Calculus
Course Objectives	At the end of the course the student must be able to: 1. Understand and apply the principles of cartography with particular emphasis on map design, construction and reproduction. 2. Understand the principles of map projections. 3. Develop the skills in the design and construction of nautical and aeronautical charts.
Course Outline	1. Introduction and history of cartography 2. Introduction to thematic mapping : types of maps, basic principles of generalization, thematic map design 3. Basic principles of map projections 4. Thematic map symbols: spatial dimensions, measurement scales, characteristics of thematic map symbols 5. Databases for creating thematic map: topographic, cadastral and other survey maps 6. Processing geographic data: statistical methods, summarizing distributions, areal concentration and association 7. Processing geographic data (linear data) 8. Base maps (scale, scale bars, page size, grid size, north arrow, title and text) 9. Graduated point mapping: proportionality, symbol scaling, graphic design strategies 10. Topography (3D and 2D) - Digital Elevation Modelling 11. Graphs and maps 12. Annotations in maps 13. Nautical charting 14. Aeronautical charting **15.** Final project: designing the map
Laboratory Equipment	Appropriate CAD/GIS/RS Software and Hardware

Course Name:	**CONSTRUCTION & INDUSTRIAL SURVEYING**
Course Description	The course focus is on the application of surveying principles to construction and industrial works with emphasis on the geometry and layout of road and railway curves and earthworks.
Number of Units for Lecture and Laboratory	4 units: 2 units lecture, 2 units laboratory

Number of Contact Hours per week	8 hours: 2 hours lecture, 6 hours laboratory
Prerequisite	General Surveying 2
Course Objectives	At the end of the course the student must be able to: 1. Understand the basic procedures involved in conducting surveys for the construction and industrial works; 2. Understand the geometry employed in the design and layout of both horizontal and vertical curves; 3. Conduct survey work and prepare survey plans for engineering works; 4. Compute and analyze earthworks quantities; 5. Layout several types of contruction works.
Course Outline	1. Introduction: 1.1 Definition of terms 1.2 Controls (horizontal and vertical) 1.3 Equipment 2. Horizontal Route Alignment a. Circular Curves b. Spiral easement curves and superelevation 3. Vertical Route Alignment a. Profiles b. Vertical curves c. Sight Distances d. Cross – section 4. Earthworks a. Areas of Cross-sections b. Volume Computation c. Earthwork Distribution Analysis 5. Construction Surveys 5.1. Line and Grade 5.1.1. Highways 5.1.2. Sewers, pipelines and culverts 5.1.3. Tunnels 5.1.4. Bridges 5.1.5. Buildings 5.1.6. Dams 5.2. As-built surveys
Laboratory Equipment	1. Electronic total station 2. Automatic level

Course Name:	**DEVELOPMENT PLANNING**
Course Description	Concepts and elements of urban planning; nature and scope of planning; role of planners; urban planning process models; urban patterns; steps in the planning process and basic plan formulation/preparation

Number of Units for Lecture and Laboratory	3 units: 2 units lecture, 1 unit laboratory
Number of Contact Hours per week	5 hours: 2 hours lecture, 3 hours laboratory
Prerequisite	GIS, Remote Sensing, Photogrammetry 2
Course Objectives	At the end of the course, the students should be able to: 1. Understand the concepts, principles and fundamentals of urban planning; 2. Know the role and relevance of the Geodetic Engineer in the planning profession; 3. Know the various urban patterns and planning process models; 4. Know the planning process and formulate a basic planning program.
Course Outline	1. Introduction and overview of urban planning Definition of terms Concepts and elements of an area Nature and scope of planning 1.1 Role of planners: The Geodetic Engineer's role in planning 2. Fundamentals of urban planning Types of planning The concept of ekistics The prime city 3. Urban patterns Linear development Grid development Concentric development Central and nodal development Radial and circumferential development 4. Planning process models Static model: Patrick Geddes' Model Systems model Strategic planning models 5. The planning process (planning program preparation) Problem identification Listing of goals and objectives Data collection and analysis Establishing planning criteria and standards 5.1 Presentation of schematic diagrams and alternative schemes
Laboratory Equipment	Personal Computer

Course Name:	**GENERAL SURVEYING 1**
Course Description	Use of principal surveying instruments; surveying measurements and error theory; basic plane surveying operations and computational method of position, traverses and areas; basic cartography
Number of Units for Lecture and Laboratory	3 units: 2 units lecture, 1 unit laboratory
Number of Contact Hours per week	5 hours: 2 hours lecture, 3 hours laboratory
Prerequisite	Algebra & Plane Trigonometry
Course Objectives	At the end of the course, the students must be able to: 1. understand the theory and use of surveying instruments; 2. know the field procedures of executing plane surveys; 3. compute traverses, areas and subdivision problems; 4. prepare survey plans.
Course Outline	1. General concepts of surveying 1.1 Introduction to surveying and mapping 1.1.1 Definition of terms 1.1.2 Purpose of surveys 1.1.3 Uses and/or applications of surveys 1.1.4 Classification of surveys 1.1.5 Drawings of surveys 1.2 Survey measurements and adjustments 1.2.1 Observations and measurements 1.2.2 The mathematical order 1.2.3 Classification of errors 1.2.4 Basic statistics 2. Basic survey measurements 2.1 Distance measurements 2.1.1 Methods 2.1.2 Instruments 2.1.3 Errors and corrections 2.2 Angle and direction measurements 3. Definition of terms 4. Methods 5. Instruments 6. Field procedures and the field notebook 7. Errors 8. Survey Operations 8.1 Traverse and areas 9. Definition of terms 10. Types of traverse 11. Traverse computations and adjustment 12. Linear error of closure

	13. Methods of area computation 14. Area subdivision 14.1 Land surveys 15. Introduction to land surveys 16. Organization and equipment 17. Kinds of boundary surveys 18. Technical description of a property 19. Legal aspects of land surveys 20. Mapping (map and plan drafting) 20.1 Methods of plotting 20.2 Preparation of plans of land surveys
Laboratory Equipment	Theodolite or Transit, Steel Tape

Course Name:	**GENERAL SURVEYING 2**
Course Description	Concepts, techniques and processes on vertical and horizontal control surveying, mine surveying and geodetic astronomy; survey applications.
Number of Units for Lecture and Laboratory	4 units: 2 units lecture, 2 units laboratory
Number of Contact Hours per week	2 hours: 2 hours lecture, 6 hours laboratory
Prerequisite	General Surveying 1
Course Objectives	By the end of the semester, students must be able to: 1. Understand the concepts, principles and instruments used in vertical and horizontal control surveys, mine surveying and geodetic astronomy. 2. Understand the concepts, principles, uses and applications of topographic surveying. 3. Know the construction of topographic maps and hydrographic charts.
Course Outline	1. Introduction 1.1 Review of GE 10 (General Surveying 1) 1.2 Fundamentals of higher surveying 2. Vertical Surveying/Leveling 1.1 Type of leveling that includes trigonometric, geodetic/precise, barometric and profile leveling. 1.2 Stadia and tacheometry 3. Horizontal controls 1.1 Intersection and resection 1.2 Triangular and trilateration 1.3 Global Positioning System

	4. Mine surveying 4.1 Definition and concepts related to mine surveying 4.2 Horizontal and vertical controls for mine surveying 4.3 Underground surveying equipment 4.4 Underground traversing 4.5 Underground leveling 5. Geodetic Astronomy 1.1 The celestial sphere 1.2 Coordinate system 1.3 Astronomic triangle 1.4 Time system, azimuth, latitude and longitude 1.5 Computation of time and azimuth from solar observation 6. Applications 6.1 Topographic surveying-definition, uses, control establishment, contour lines and contour map construction 6.2 Hydrographic surveying – principles/definition, controls, soundings and charts, current and level observation
Laboratory Equipment	Electronic Total Station, Theodolite Automatic Level

Course Name:	**GEODETIC ASTRONOMY**
Course Description	Precise determination in time, longitude , latitude and time, Bessel and other interpretation methods: establishment of Laplace station; field practice on solar and stellar observations for geodetic surveying.
Number of Units for Lecture and Laboratory	3 units: 2 units lecture, 1 unit laboratory
Number of Contact Hours per week	5 hours: 2 hours lecture, 3 hours lecture
Prerequisite	Geometric Geodesy
Course Objectives	At the end of the course, the students must be able to: 1. Have basic knowledge on spherical and geodetic astronomy; 2. Know astronomic methods of determining geographical coordinates and azimuths; 3. Know the celestial and the use of earth satellites for surveying.
Course Outline	1. Introduction 1.1 Geodetic astronomy: definition 1.2 Reference surface 2. Celestial sphere and its coordinate systems 2.1 Fundamental definitions 2.2 Celestial coordinate systems ➢ Horizon system

	➢ Hour-angle system ➢ Right-ascension system ➢ Ecliptic system 2. Transformation of coordinate systems 3. Special star position 4. Time system 4.1 Definitions 4.2 Different time systems ➢ Sidereal time system ➢ Solar (Universal) time system ➢ Atomic time system ➢ Other time system 6.3 Time conversion 5. Variation on the celestial coordinates 5.1 Motions to the coordinate systems 5.2 Physical effects 6. Determination of geographic coordinates with astronomic observations 6.1 Latitude determination 6.2 Longitude determination 6.3 Determination of astronomic azimuth 7. Field procedures in Geodetic Engineering 8. Introduction to satellite geodesy. 8.1 Artificial earth satellites used for geodetic purposes. 8.2 Basics of celestial mechanics, Keppler's Law, movement of artificial earth satellites.
Laboratory Equipment	Theodolite, One-second least reading

Course Name:	**GEODETIC SURVEYING**
Course Description	Principles of the establishment and densification of horizontal geodetic control networks ; triangulation; trilateration; traverse; total station systems; global position systems; accuracy standards and specifications; the Philippine Reference System of 1992.
Number of Units for Lecture and Laboratory	4 units: 2 units lecture, 2 units laboratory
Number of Contact Hours per week	8 hours: 2 hours lecture, 6 hours laboratory
Prerequisite	Geometric Geodesy
Course Objectives	At the end of the course the student must have: 1. Developed skills in complying with accepted standards of accuracy and specifications for horizontal controls 2. Become familiar with state-of the-art total station system and satellite-based global positioning systems.

Course Outline	1. Geodetic datum; Luzon datum; reference ellipsoids 2. Horizontal positioning methods: triangulation, trilateration, traverse, intersection, resection 3. Steps in triangulation; baselines; station marks; reduction to ellipsoid; reduction center; intervisibility between stations; accuracy standards and specifications. 4. Direction and angle measurement with direction theodolite. 5. Definitions, earth curvature and atmospheric refraction, direct/spirit leveling 6. Geodetic leveling: team organization, procedures, instrumentation, benchmarks, computations 7. Vertical control networks: classifications, accuracy standards. 8. Leveling errors: sources, elimination 9. Simple adjustment methods for leveling loops.
Laboratory Equipment	Electronic Total Station, Automatic Level

Course Name:	**GEODETIC ENGINEERING LAWS, CONTRACTS AND ETHICS**
Course Description	Private and public engineering contracts; preparation and writing of specifications and proposals; procedures and instruments in bidding; code of ethics for Geodetic Engineers; scope and application of Geodetic Engineering laws; e-commerce law; intellectual property rights.
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours per week	2 hours lecture
Prerequisite	Senior Standing
Course Objectives	At the end of the semester the students must be able to: provide an understanding of the different laws governing professional engineers, gain knowledge on specification writing, understand contract documents, learn the code of ethics for Geodetic Engineers and apply the GE laws.
Course Outline	1. Contracts 1.1 Elements of contracts 1.2 Fundamentals of a survey contract 1.3 Contract documents 1.4 Survey jobs 2. Specifications 2.1 Preparation of specifications 2.2 Technical specifications 2.3 Minimum standards and specifications for the different

	land surveys 3. Ethics 1.1 Code of ethics 1.2 Purpose of the Code of Ethics 1.3 Unprofessional acts 4. The Geodetic Engineering Law and its implementing rules and regulations 5. Engineering e-commerce law 6. Intellectual property rights
Laboratory Equipment	N/A

Course Name:	**GEODETIC COMPUTATIONS AND ADJUSTMENT**
Course Description	Geodetic computation and adjustment of the common types of horizontal and vertical control networks such as systems of triangles, quadrilaterals, central-point polygons, traverses, precise level networks.
Number of Units for Lecture and Laboratory	4 units: 2 units lecture, 2 units laboratory
Number of Contact Hours per week	8 hours: 2 hours lecture, 6 hours laboratory
Prerequisite	Theory of Errors and Least Squares
Course Objective	At the end of the course, the students must be able to apply the methods of least squares in the adjustment of various types of horizontal and vertical control networks.
Course Outline	1. Introduction 1.1 Review of least squares 1.2 Review of linearization of non-linear models 1.3 Review of statistics 2. Statistical testing for samples/observations 2.1 The chi-square test 2.2 The t-student test 3. Generalized least squares 4. Application of least squares in plane coordinate surveys 5. Least squares adjustment of horizontal controls 5.1 The braced quadrilateral adjustment 5.2 The central-point polygon adjustment 5.3 The adjustment of systems of triangles, quadrilaterals and central-point polygons 6. Least squares adjustment of other horizontal controls and geodetic models 6.1 The traverse adjustment 6.2 The triangulation control adjustment 6.3 The trilateration adjustment

	6.4 The broken baseline adjustment 6.5 The intersection and resection computation and adjustment 7. Least squares adjustment of vertical controls 7.1 The adjustment of the elevations of triangulation control 7.2 The precise adjustment of weighted level control 7.3 The adjustment of the system of level networks 8. Adjustment of GPS observations
Laboratory Equipment	PC with relevant survey software

Course Name:	**GEOGRAPHIC INFORMATION SYSTEMS (GIS)**
Course Description	Introduction to Geographic Information Systems (GIS) focusing on the understanding of what a GIS is all about, its historical development, the different components and its practical application to the different fields or disciplines. The GIS course will be a combination of lectures, laboratory exercise, and workshops, attendance to GIS-related conferences / symposium and visits to different institutions using GIS.
Number of Units for Lecture and Laboratory	3 units: 1 unit lecture, 2 units laboratory
Number of Contact Hours per week	7 hours: 1 hour lecture, 6 hours laboratory
Prerequisite	Cartography
Course Objectives	At the end of the course the student must be able to: 1. To introduce GIS as an important tool for management. 2. To familiarize students with GIS, its components and its importance in the area of environment and natural resources management. 3. To gain hands-on experience in the use of GIS as a management tool.
Course Outline	1. Introduction 1.1 GIS definition 1.2 Historical roots 1.3 Early systems 1.4 Basic concepts 1.5 System components 2. Spatial awareness 2.1 Spatial elements 2.2 Spatial reference systems 2.3 Spatial patterns 3. Data modeling - mapping reality 3.1 Conceptual modeling 3.2 Functional modeling 3.3 Operational modeling

	4. Cartographic and GIS data structures 1.1 Basic file structures 1.2 Tabular databases 1.2.1 Advantages of databases 1.2.2 Database operations 1.2.3 Types of databases 4.3 Structures 1.3.1 Raster structures 1.3.2 Topological vector structures 1.3.3 Hybrid model 5. Project design 5.1 Objective 5.2 Database design 5.3 Database automation 5.4 Database management 5.5 Data analysis 5.6 Presentation of results 6. Data collection and analysis 6.1 GIS data collection 6.2 GIS data input 6.3 Modes of data input 6.4 Conversion from other digital sources 6.5 GPS 7. Topology and spatial relationships 7.1 Topological relationships 7.2 Basic steps in the creation of topology and error correction 7.3 Constructing topology 7.4 Identify digitizing errors 7.5 Spatial relationships in vector systems 7.6 Spatial relationships in raster systems 8. Examples of GIS analysis 8.1 GIS analysis in LGU operations 8.2 GIS analysis in transportation 8.3 GIS analysis in water management 8.4 GIS analysis for urban development 8.5 GIS analysis in economic and social sciences 8.6 GIS analysis in environmental management 8.7 Other GIS applications 9.GIS on the Internet 9.1 GIS and the Internet 10.Conference / study tour/visits 10.1 NAMRIA, DENR, DA, PHIVOLCS 10.2 LGUs 11.Final GIS project 11.1 Objective 11.2 Database design 11.3 Database automation 11.4 Database management 11.5 Data analysis 11.6 Presentation of results

Laboratory Equipment	Appropriate GIS Software and Hardware

Course Name:	**GEOMETRIC GEODESY**
Course Description	History and development of Geodesy; geometry of reference ellipsoid; normal section curves; geodesics; computation of ellipsoidal coordinates; direct and inverse problems; reduction to the reference ellipsoid.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per week	3 hours lecture
Prerequisite	Cartography, Integral Calculus
Course Objectives	At the end of the course, the students must be able to: 1. Learn the fundamental properties of a reference ellipsoid, its geometry and formulation. 2. Know about curves on the surfaces in a reference ellipsoid, their measurement properties and computation. 3. Reduce measurements from geodetic surveys to the reference ellipsoid. 4. Compute problems on the determination of geodetic positions of a point on a reference ellipsoid. 5. Discuss different kinds of reference systems and their transformations. 6. Discuss different reference systems being used by different countries.
Course Outline	1.1 Introduction to Geodesy 1.2 Definition, history and objectives 1.3 Branches of Geodesy 1.4 Reference of ellipsoids 1.5 Properties of the ellipsoid 1.6 Fundamental parameters of an ellipse 1.7 Coordinate systems 1.8 Meridian ellipse 1.9 Relationship between the various latitudes 1.10 Coordinate conversion 1.11 Radii of curvature on the ellipsoids 1.12 Length of arcs on the surface of the ellipsoids 1.13 Calculation of areas on the surface of the ellipsoid 1.14 Radii of spherical approximation of the earth 1.15 Curves on the surface of the ellipsoid 1.16 Normal sections 1.17 The separation between the reciprocal normal sections 1.18 The elliptic arc of the normal section 1.19 The azimuth and chord of the normal section 1.20 The geodesic curve

	1.21 Comparison of geodesic with normal section 1.22 Computations for geodetic positions 1.23 Reduction of measurements from geodetic survey to ellipsoid 1.24 Azimuth correction due to height of observed points 1.25 Correction for going from a normal section to geodesic 1.26 Astro-geodetic deflection of the vertical 1.27 Reduction of distance to the ellipsoid 1.28 Spherical and ellipsoidal trigonometry 1.29 Solutions to spherical triangles 1.30 Solution to ellipsoidal triangles 1.31 Computations for geodetic positions 1.32 Solutions to direct problems 1.33 Solutions to inverse problems 1.34 Reference systems and datums 1.35 Different kinds of datum 1.36 Global or geocentric datum 1.37 Regional and local geodetic datum 1.38 Datum transformation 1.39 Three–parameter transformation 1.40 Five-parameter transformation 1.41 Seven-parameter transformation 1.42 Reference systems 1.43 Reference frames and reference systems 1.44 The World Geodetic System of 1984 1.45 The Philippine Reference System of 1992 (PRS 92) 1.46 Coordinate transformation from WGS84 to PRS 92 and vice versa
Laboratory Equipment	N/A

Course Name:	**LAND MANAGEMENT**
Course Description	Land management concepts and principles; land-use; land valuation and appraisal.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per week	3 hours lecture
Prerequisites	Property surveys; relevant Geodetic Engineering Laws
Course Objectives	At the end of the course, the students must be able to: 1. Apply the concepts, principles, framework and processes in recording, disseminating and managing information about the ownership, value and use of land and its associated resources; 2. Apply property surveying principles to land management

	and land economics; 3. Understand the legal, institutional, operational and technical aspects of land management and land economics.
Course Outline	1. Land management system 1.1 Basic framework of land management 1.1.1 Land tenure 1.1.2 Land ownership and title 1.1.3 Land titling and registration 1.1.4 Land subdivision 1.2 Government land management activities 2.2.1 Land use allocation 2.2.2 Land conversion or reclassification 2.2.3 Land acquisition 2.2.4 Land disposition 2.2.5 Land development and its regulation 2.2.6 Conservation ofILands 2. Institutional arrangements 2.1 Role of government 2.2 Role of private sector and non-government organizations 2.3 Critical issues and areas for improvement 3. Land economics: valuation and appraisal
Laboratory Equipment	N/A

Course Name:	**LAND REGISTRATION LAWS**
Course Description	Laws applicable to ordinary and cadastral land registration proceedings under the Torrens System and the Spanish Mortgage Law; Indigenous Peoples' Rights Act
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours per week	2 hours lecture
Prerequisite	Senior Standing
Course Objectives	At the end of the course, the student must be able to: 1. Know and distinguish between the different registration proceedings in bringing lands under the Torrens System; 2. Learn the various requirements in applying for land titles including the provision of IPRA Law.
Course Outline	1. Land registration: definition 2. Functions of land registration 3. Benefits of land registration

	4. Elements or attributes of ownership 5. Modes of acquiring ownership 6. Land titles under the Spanish regime 7. Modes of acquiring land titles 8. Torrens System of registration 8.1 Origin and nature 8.2 Purpose 8.3 Advantages 9. Basic Laws under the Torrens System of registration 9.1 Land Registration Act (Act No. 496) 9.2 Cadastral Act (Act No. 2259) 9.3 Public Land Act (Commonwealth Act No. 141) 9.4 System of recording for unregistered lands 9.5 Property Registration Decree (Presidential Decree No. 1529) 10. Lands not subject to registration by any person 11. Ordinary land registration proceedings 11.1 Application forms and content 11.2 General procedure 12. Remedies available to aggrieved parties in registration proceedings 13. Difference between ordinary registration under the Land Registration Act and judicial confirmation of imperfect titles under the Public Land Act 14. Differences between proceedings in the Land Registration Act and the Cadastral Act **15.** Provision of the Indigenous Peoples Right Act (IPRA)
Laboratory Equipment	N/A

Course Name:	**MINE SURVEYING**
Course Description	Principles of underground surveying; transferring meridians from surface to underground; locating and laying out of mining works such as shafts, winzes, levels and connections; regulations governing mineral land surveys.
Number of Units for Lecture and Laboratory	2 unit: 1 unit lecture, 1 unit laboratory
Number of Contact Hours per week	4 hours: 1 hour lecture, 3 hours laboratory
Prerequisite	General Surveying 2
Course Objectives	At the end of the course, the student must be able to: 1. Know the theories, principles, strategies, techniques, and procedures of underground surveys as well as surface

	operations associated with underground works. 2. Learn the different regulations and standard requirements in the practice and operation of a mine.
Course Outline	1. Mine surveying: definition 1.1 Mining terminologies 2. Design of control network in underground mines 3. Monuments and markings underground 4. Angle and distance measurements 5. Traverse computations 6. Problem solving 6.1 Bearing of strike 6.2 Angle of dip 6.3 Percent grade of dip 6.4 Determining horizontal and vertical angles using top and side telescope 7. Boreholes 8. Elevations of underground mines 9. Mining Act of 1995 9.1 Classification of mineral lands 9.2 Lands prohibited from mining exploration 9.3 Mining claims 9.4 Survey returns
Laboratory Equipment	Engineer's Transit/Total Station/Theodolite Tape Range Poles

Course Name:	**PHOTOGRAMMETRY 1**
Course Description	Introduction to photogrammetry; study of aerial photography, differential-GPS assisted aerial photography (using analogue and digital cameras) and flight planning, principles of stereoscopy; properties of single photographs, photogrammetric optics; properties of single photographs; rectification; construction of photo-mosaics; simple mapping methods
Number of Units for Lecture and Laboratory	3 units: 2 units lecture, 1 unit laboratory
Number of Contact Hours per week	5 hours: 2 hours lecture, 3 hours laboratory
Prerequisite	General Surveying 2
Co-Requisite	Theory of Errors and Adjustments

Course Objectives	At the end of the course, the student must have 1. Acquired a general view of photogrammetry and its application to mapping; 2. Developed the ability to design, process, and evaluate aerial photography (both analogue and digital) for surveying and mapping. 3. Performed digital scanning and orthophoto mapping. 4. Understood the advantages of using differential-GPS assisted aerial photography. 5. Learned the principles of stereoscopy and photogrammetric optics as bases for the photogrammetric method. 6. Understood the geometry of a single photograph, its properties and limitations; rectification to correct its errors; and its application to mapping. 7. Acquired the capability for simple mapping methods.
Course Outline	1. Introduction to Photogrammetry 1.1 Definition and types/kinds of photogrammetry 1.2 Types/kinds of aerial photographs 1.3 Elements of a single photograph; photo scale 1.4 Applications of photogrammetry; types of terrain 2. Principles of stereoscopy 2.1 Definitions 2.2 Study of the human eye 2.3 Conditions for recreation of stereo model - methods and instruments for stereoscopic observations 3. Photogrammetric Optics 3.1 Types/kinds of optics 3.2 Optical elements used in photogrammetry - lens laws, law of refraction, ray tracing 4. Aerial Photography 4.1 Specifications (Digital and Analogue) 4.2 Flight planning and conditions for flying - aerial cameras & accessories 4.3 Aircraft's and photographic crew 4.4 Principles of photography 4.5 Photo processing 4.6 Photo evaluation 4.7 Photo indexing 5. Aerial Camera and other Photogrammetric Sensors and Scanners 6. Types/kinds of Cameras 7. Sensors and Scanners 8. Optical elements used in photogrammetry - lens laws, law of refraction, ray tracing 9. Geometry of a single photograph 10. Tilt and Tilt Determination 11. Principles of Rectification: Simple Mapping Methods 11.1 Basic principles 11.2 Graphical rectification 11.3 Optho-mechanical rectification 11.4 Photo mosaics

	11.5 Introduction to stereo-photogrammetry 11.6 The stereoscopic parallax formula and its use in mapping **Laboratory Exercises:** - Stereovision Test - Photo Scale Determination - Tilt Determination - Flight Planning - Orientation of a stereopair under a mirror stereoscope - Construction of a Photo-mosaic (optional) - Simple Mapping Method Using Parallax Bar
Laboratory Equipment	Appropriate Photogrammetric/GIS/RS Equipment A3 Scanner Stereoscope with parallax bar

Course Name:	**PHOTOGRAMMETRY 2**
Course Description	Principles of stereo photogrammetry; theory of orientation; collinearity and coplanarity equations, aerial triangulation measurement and adjustment, coordinate transformations; terrain and feature extraction, Digital Terrain Modeling (DTM) collection and processing; Image/Photo rectification and mosaicking; Digital orthophoto and semi-rectified map mapping procedures and integration with other systems/applications.
Number of Units for Lecture and Laboratory	4 units: 2 units lecture, 2 units laboratory
Number of Contact Hours per week	8 hours: 2 hours lecture, 6 hrs. laboratory
Prerequisite	Photogrammetry 1
Course Objectives	At the end of the course the student must understand a holistic concept of stereo photogrammetry as applied to surveying and mapping, and specifically to be able to: 1. Understand the principles and procedures for analog and digital stereo and mono photogrammetric mapping. 2. Differentiate between line and image mapping (i.e. vector and raster data). 3. Know the theory of, and analog and, digital stereo model orientation and adjustment and how these are performed. 4. Know the different methods of establishing control points for and by photogrammetry. 5. Know how to apply digital photogrammetry to surveying, mapping and GIS applications. 6. Be familiar with the operation of several analog and digital mapping equipment (e.g. Stereoplotter, photograph scanners,

	digital photogrammetric workstations and plotters
Course Outline	1. Introduction to photogrammetry and history 1.1 Raster Mapping 1.2 Vector Mapping 2. Review of tilted photography and introduction to relief displacement. 3. Mathematical development of collinearity / coplanarity equations and rotation matrices,. 1.1 Two-dimensional coordinate transformation 1.2 The three-dimensional coordinate transformations 4. Principles of stereophotogrammetry 1.1 Coordinate systems 1.2 Elements of orientation 1.3 Parallax in the stereomodel 5. Theory of Orientation 5.1 Inner Orientation 5.2 Relative Orientation 5.3 Absolute Orientation 6 Aerial Triangulation 6.1 Ground controls 6.2 Photo controls 7 Incomplete Models and Model Deformations 8 Principles of Rectification 8.1 Basic principles 8.2 Digital Terrain Model 8.3 Photo mosaics 8.4 Orthophoto Maps 9 Application of Photogrammetry in Topographic, Cadastral and Engineering Surveys and GIS Applications **Exercises** 1. Photo control point selection 2. Numerical relative orientation 3. Computations in absolute orientation 4. Coordinate transformation
Laboratory Equipment	Mirror stereoscope and parallaxbar

Course Name:	**PHYSICAL GEODESY**
Course Description	Focus on the concepts in the study of the Earth's gravity field
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per week	3 hours lecture

Prerequisite	Geometric Geodesy
Course Objectives	At the end of the course, the students must be able to: 1. Recognize the relevance of the studying the Earth's gravity field in geodetic practice 2. Explain conceptual and mathematical background of potential theory 3. Understand and assess the different methods of determining the Earth's gravity field 4. Identify potential research areas and perform literature and information searches in relation to Physical Geodesy
Course Outline	1. Introduction 2. Geodesy, Geodetic Datum, and Coordinate Systems 3. Vector Analysis: Line, Surface and Volume Integrals and Harmonic Functions 4. Gravity, Level Surfaces, Plumb lines and Natural Coordinates 5. Fundamental of Potential Theory 6. Gauss and Green's Integral Formulas 7. Laplace's Equation and the Boundary Value Problems in Geodesy 8. Spherical and Ellipsoidal Harmonic Functions, and the Legendre Functions 9. Potential of the earth in Spherical Harmonics 10. Normal and Anomalous Field 11. International Ellipsoidal Systems 12. Geoidal Undulations and the Deflections of the Vertical 13. Poisson's Integral, Stokes' Formula and Vening Meinesz' Formula 14. Geoid Height Modelling: Gravimetric Methods, Interpolation Methods and Astro-geodetic Methods 15. Geopotential Models and Satellite Altimetry 16. Gravity Networks and Reduction of Astronomical Observations 17. Reduction of the Horizontal and Vertical Angles and Distance to the Ellipsoid 18. Philippine Geoid Model 19. Current Research in Physical Geodesy
Laboratory Equipment	N/A

Course Name:	**PROPERTY SURVEYS**
Course Description	Survey project controls; comparative equipment, procedures precision; regulations governing property surveys in the country; survey adjustment in cadastral survey; political boundary survey's; transformation of coordinates to the Philippine Plane Coordinate System (PPCS) and Philippine Reference System of 1992 (PRS'92);

Number of Units for Lecture and Laboratory	5 units: 3 units lecture, 2 units laboratory
Number of Contact Hours per week	9 hours: 3 hours lecture, 6 hrs laboratory
Prerequisite	General Surveying 2 Co – requisite : Map Projections
Course Objectives	At the end of the course, the students must be able to: 1. recognize the importance of property surveys in the context of land administration and sustainable development; 2. fix the position of surveys in the Philippine Plane Coordinate System / PNS 92 3. identify the class of controls to be applied for a particular survey and the corresponding standards of accuracy to be applied; 4. recommend the steps in conducting a property survey based on the governing rules and regulations; 5. perform the field work and prepare survey documents for different property surveys; and 6. prepare maps/plans for property surveys; preparation of survey returns. (Cadastral and is dated surveys).
Course Outline	1. Introduction 1.1 The Concept of Land and Land Administration 1.2 Overview of the Torrens System of Land Registration in the Philippines 1.3 Land Information Management 1.4 Sources of Land Information in the Philippines 1.5 Overview of Property Surveys 2. Position of Surveys 2.1 Points of Reference 2.2 The Philippine Reference System of 1992 2.3 Philippine Plane Coordinate System 2.4 Review of Astronomic Observations 2.5 Geodetic and Project Control Surveys 2.6 Overview of Geodetic Controls 2.7 Project Controls 2.8 Position and Base Meridian of a Cadastral Project 2.9 Grid Azimuths 2.10 Standards of Accuracy for Project Controls 3. Isolated Land Survey Procedures 1.1 General Procedures 1.1.1 Authority and Order to Execute Surveys 1.1.2 Notice of Survey 1.1.3 Position of Surveys: The Common Point 1.1.4 Adverse Claims 1.1.5 Survey Documents and Plan Preparation
Laboratory Equipment	Computer Aided Design (CAD) Software Computer Hardware, Electronic Total Station

Course Name:	**REMOTE SENSING**
Course Description	Principles of remote sensing: identification of geomorphological and cultural features using airborne and satellites imageries; sensors and platforms; digital image processing; thematic mapping applications.
Number of Units for Lecture and Laboratory	3 units: 2 units lecture, 1 unit laboratory
Number of Contact Hours per week	5 hours: 2 hours lecture, 3 hours laboratory
Prerequisite	Cartography
Course Objectives	At the end of the course, the students must be able to: 1. Understand the principles and theories of remote sensing. 2. Perform image identification, analysis and interpretation. 3. Be knowledgeable on several digital image processing techniques involved in the analysis of remotely sensed data. 4. Make a distinction on the use of different sources of remotely sensed data (i.e. optical, thermal and radar) in the production of thematic maps.
Course Outline	1. Introduction: definition, overview of remote sensing, fundamental considerations, electromagnetic spectrum, energy sources and radiation principles. 2. Energy interaction with earth surface features: models for remote sensing, spectral reflectance, spectral signatures, and radiometer. 3. Sensor and Satellite Systems: history, type and major categories; optical, thermal and radar. 4. Digital Image Processing: spatial / spectral / radiometric / temporal characteristics of digital data, broad types of computer-assisted operations, advantages / disadvantages of machine processing 5. Image Restoration and Registration: sources of geometric distortions, ground control points, resampling methods, radiometric corrections and noise removal. 6. Image Enhancement: Linear contrast stretching, Gaussian stretch, density slicing, spatial filtering. 7. Information Extraction: Principal component image, ratio images, supervised and unsupervised classification 8. Accuracy Assessment: error/confusion matrix, sampling methods/strategies, ground sample collection 9. Remote sensing applications: land use /cover mapping, geological application, disaster monitoring, coastal zone management **Laboratory Exercises:** 1. Remote sensing tutorial

	2. Spectral signature analysis 3. Mapping homogenous areas 4. Surface drainage delineation 5. Introduction to RS software 6. Satellite image contrast enhancement 7. Geo-referencing of satellite image 8. Supervised/unsupervised classification 9. Field verification of satellite data 10. Accuracy assessment
Laboratory Equipment	1. Remote Sensing / Image Processing Software 2. Computer

Course Name:	**SATELLITE GEODESY**
Course Description	Geometric and dynamic applications of artificial satellites in Geodesy; determination of station positions and the gravity field of the earth; evaluation of the Doppler effect of tracking data; inferometry
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per week	3 hours lecture
Prerequisite	Geometric Geodesy
Course Objectives	At the end of the course, the student must be able to: Learn the different geometric and dynamic applications of artificial satellites in Geodesy; 1. Understand the effect of the gravity field of the earth and be able to determine station positions; 2. Evaluate the Doppler effect of tracking data; 3. Know the principles and uses of interferometry
Course Outline	Artificial Satellites Types: Communication, Navigation, Weather, Military and Scientific Launches Operations in Space:Power,Orientation,Heat Dissipation Cosmic Radiation and Micrometeoroid Protection Reentry and Satellite Disposal Orbit Decay and Reentry Disposal of Satellites Satellite Orbits:Geostationary Equatorial Orbit, Low-Earth Orbit, Medium-Earth Orbit, Polar Orbits, Sun-Synchronous Orbits The First Satellites Gravity Field of the Earth Gravitation and the Gravity Field of the Earth Escape Velocity

	Free Fall Gravity Throughout the Universe Tracking Satellite Signals: The Doppler Effect Interferometry Concepts and Principles Applications
Laboratory Equipment	N/A

Course Name:	**SPECIAL STUDIES IN GEODETIC ENGINEERING**
Course Description	Research work applied to special problems in Geodetic Engineering or survey project engagement to gain on the job experience.
Number of Units for Lecture and Laboratory	3 units: 1 unit lecture, 2 units laboratory
Number of Contact Hours per week	7 hours: 1 hour lecture, 6 hours laboratory
Prerequisite	5th year standing
Course Objectives	At the end of the course the student must be able to: Organize systematic approaches to solve or have been able to solve survey problems or have been able to gain experience in surveying through actual field work and related data processing techniques.
Course Outline	Introduction to research methods of applicable to surveying Organization of systematic research work Analyze of survey problem and solution Research report preparation Familiarize with procedures with on the job project work On-the-job work End of project report preparation
Laboratory Equipment	n/a

Course Name:	**PUBLIC LAND LAWS & LAWS ON NATURAL RESOURCES**
Course Description	Public Land Laws and Laws on Natural Resources including Agrarian Reform Law, Forestry Code, Fishery Code, Mining Act, and other related laws.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per week	3 hours lecture

Prerequisite	Senior Standing/Consent of Instructor
Course Objectives	At the end of the course the student must be able to know various public land laws and laws on natural resources and their application to the Geodetic Engineering profession.
Course Outline	1. Constitutional Provisions in the classification of Lands in the Public Domain and Natural Resources 2. Agrarian Reform Laws 3. Public Land Act (CA 141), as amended 4. Forestry Code (PD 705) 5. Philippine Fisheries Code/Municipal Waters Law 6. Philippine Mining Act (RA 7942), Small Scale Mining Act (RA 7076) 7. Indigenous People Right Act (IPRRA Law) 8. United Nations Convention on the Law of the Sea (UNCLOS), RA 3046 as Amended by RA 5446 (Archipelagic baseline law) 9. Other related Laws
Laboratory Equipment	N/A

Course Name:	**LAWS ON PROPERTY**
Course Description	Real Property (or Immovable Property) and Personal Property (or Movable Property)
Number of Units for Lecture and Laboratory	1 unit lecture
Number of Contact Hours per week	1 hour lecture
Prerequisite	Senior Standing/Consent of Instructor
Course Objectives	To familiarize the students with the Laws on Properties in accordance with provisions of the Civil Code as amended.
Course Outline	1. Definition of Real Property 2. Classification: 2.1 Public Dominion 2.2 Private Ownership 3. Modes of Acquiring Ownership 4. Right of Accession with respect to the fruits produced by the property 5. Right of Accession with respect to Immovable Property 6. Quieting of Title 7. Co-ownership 8. Easement or Servitudes 1.1. Legal Easement 1.1.1. Easements relating to water 1.1.2. Easement of Right of Way

	2. Registry of Property 3. Succession
Laboratory Equipment	N/A

Course Name:	**HYDROGRAPHY**
Course Description	Tidal datum planes; depth sounding and position determination; hydrographic survey systems; measurement of stream velocity/discharge and reservoir capacity; electronic nautical charting; introduction to physical oceanography
Number of Units for Lecture and Laboratory	3 units: 2 units lecture, 1 unit laboratory
Number of Contact Hours per week	5 hours: 2 hours lecture, 3 hours laboratory
Prerequisite	General Surveying 2
Course Objectives	1. To develop skills in complying with accepted standards of accuracy and specifications for hydrographic surveys; 2. To learn the use of acoustic instruments (echo-sounders and swathe sounders/multi-beam sounders); 3. To learn methods of computing stream velocity/discharge and reservoir capacity.
Course Outline	1. Definitions; scope of hydrograph. 2. Planning the hydrographic survey. 3. Hydrographic positioning methods. 4. Underwater sensors, acoustic instruments. 5. Stream flow measurements, current meters, mean velocity; water discharge measurement; reservoir capacity measurement. 6. Electronic nautical charting 7. Introduction to physical oceanography
Laboratory Equipment	Electronic total station or theodolite, echosounding equipment or equivalent, current meter

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: 2 units lecture, 1 units laboratory

Number of Contact Hours per week	5 hours: 2 hours lecture, 3 hours laboratory
Prerequisite	Differential Equations & Computer Fundamentals & Programming
Course Objectives	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 5. The principles of object-oriented programming (OOP) paradigm and visual C++ Integrated Development Environment (IDE).
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
Laboratory Equipment	PC with least square adjustment software

II. NON-TECHNICAL COURSES

A. SOCIAL SCIENCES (Please refer to CMO 59., s. 1996)
B. HUMANITIES (Please refer to CMO 59., s. 1996)
C. LANGUAGES (Please refer to CMO 59., s. 1996 for English 1 and 2)

Course Name	**ENGLISH 3 (TECHNICAL COMMUNICATION)**
Course Description	The nature of technical communication; skills and strategies for reading and writing literature reviews, journal articles, and technical reports; making oral presentations.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisites	English 2
Course Objectives	After completing this course, the student must be able to: 1. Differentiate technical writing from other types of writing; 2. Engage him/herself critically in the reading of a specialized text; 3. Write a summary and review of a journal article; 4. Write a research paper on a technical topic; and 5. Properly acknowledge sources by using a prescribed citation format; 6. Prepare an oral presentation on a technical topic; and 7. Deliver properly an oral technical presentation.
Course Outline	1. The Nature of Technical Communication 2. Technical Writing 2.1. Introduction to Technical Writing 2.2. Library Orientation 2.3. Technical Writing: Formal Schema/Style; Word Choice 2.4. Types of Text Structure in Technical Writing 2.5. Introduction to Research: Choosing a Topic, Outlining 2.6. Skills and Strategies for Reading and Writing Journal Articles, Literature Reviews, and Technical Reports 2.7. Evaluating Sources and Preparing a Preliminary Bibliography 2.8. Preparing and Interpreting Non-Prose Forms 2.9. Summarizing and Analyzing a Journal Article 2.10. Preparing the Different Parts of the Research Paper or Technical Report 2.11. Writing Bibliographies Using a Prescribed Format 2.12. Independent Study 3. Oral Technical Presentations 3.1. Preparing the Presentation Materials 3.2. Delivering the Technical Presentation
Laboratory Equipment	None

ANNEX IV - A

LABORATORY REQUIREMENTS
for
CHEMISTRY & PHYSICS

GENERAL CHEMISTRY LABORATORY

Exercise	Required Equipment	Required Quantity*
1. Basic Laboratory Techniques a. Use of burner b. Preparation of solutions • Determination of mass • Measurements of volume • Calculation of density	 Burner Beaker Graduated cylinder Triple beam balance NaCl solution $Pb(NO_3)_2$ solution	 5 pcs. 5 pcs. 5 pcs. 5 pcs. 25 mL 25 mL
2. Separation techniques a. Filtration/decantation b. Sublimation c. Adsorption d. Distillation	Glass funnel Beaker Evaporating dish Filter stand Distillation apparatus Activated charcoal Staple wire Food color $KMnO_4$ solution	5 pcs. 5 pcs. 5 pcs. 5 pcs. 1 set-up 5 g 25 pcs. 5 g 25 mL
3. Classification of matter a. Differentiation of elements, compounds mixtures, colloids b. Differentiation of electrolyte from non-electrolyte c. Differentiation of acid, bases, salts.	Test tube pH paper Conductivity apparatus I_2 crystals $KClO_3$ solid NaOH solution HCl solution NaCl solution Sugar solution	50 pcs. 20 pcs. 1 set-up 3 g 3 g 25 mL 25 mL 25 mL 25 mL
4. Changes of matter and energy transformation a. Differentiation of physical from chemical change b. Law of conservation of mass c. Types of chemical reactions	Test tube Burner Evaporating dish Beaker Alcohol I_2 crystals Zn strips HCl solution Staple wire $CuSO_4$ solution	50 pcs. 5 pcs. 5 pcs. 5 pcs. 5 mL 5 g 5 pcs. 25 mL 25 pcs. 25 mL
5. Gas Laws a. Boyle's Law b. Charles's Law c. Graham's Law	Beaker Thermometer Syringe Glass tubing Sand bag NH_4OH solution HCl solution	5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 mL 5 mL
6. Solutions a. Factors affecting solubility b. Colligative properties	Test tube Beaker Alcohol	50 pcs. 5 pcs. 25 mL

	Hexane Sugar NaCl Urea Oil	25 mL 5 g 5 g 5 g 5 mL
7. Rates of chemical reactions, chemical equilibrium	Test tube Beaker Mg ribbon HCl solution $FeCl_3$ solution KSCN solution KCl solution Fe $(NO_3)_3$ solution	50 pcs. 5 pcs. 5 pcs. 25 mL 25 mL 25 mL 25 mL 25 mL
8. Redox reaction and electrochemistry	Battery Test tube Zn strips Cu strips Pb strips Pb $(NO_3)_2$ solution Zn $(NO_3)_2$ solution Alligator clip	5 pcs. 50 pcs. 5 pcs. 5 pcs. 5 pcs. 25 mL 25 mL 10 pcs.
9. Corrosion	Petri dish Battery Alligator clip Cu strips Zn strips Al strips Mg strips Electrolyte solution	5 pcs. 5 pcs. 10 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 25 mL

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

PHYSICS 1 LABORATORY

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	5 pcs. 20 pcs. 5 sets 5 pcs. 5 pcs.

	Alternate apparatus: Force frame Spring balance Weight holder Masses Ruler	 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 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 pcs. 5 pcs. 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	5 pcs. 5 sets 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.

	String Clamp	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, 5-500g	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 Masses Meter stick	5 pcs. 5 pcs. 5 pcs. 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.

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

PHYSICS 2 LABORATORY

Exercise	Required Equipment	Required Quantity*
1. 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	5 pcs. 5 pcs. 5 sets 5 pcs. 5 pcs. 5 pcs.

	Ice Water	5 sets
2. An exercise to measure the coefficient of linear expansion	Thermal expansion apparatus Steam generator Ohmmeter/VOM Connectors Basin/container Hot and cold water	5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.
3. 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.
4. 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
5. 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
6. 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

7. 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
8. An exercise to verify the relationship among the electromotive force, current, and resistance of cells in series and parallel	Dry cells Switch VOM or multitester Resistors Panel board/circuit board Bridging plugs/connecting wires *Alternate apparatus:* Bread board Jumper	10 pcs. 5 pcs. 5 pcs. 10 pcs. 5 pcs. 5 sets 5 pcs. 5 sets
9. 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
10. An exercise to determine the electrical equivalent of heat	Electric calorimeter Thermometer Beam balance Masses Stop watch 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.
11. 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.
12. An exercise to observe the principle of magnetic field	Natural magnets Horseshoe magnets Bar magnets	5 pcs. 5 pcs. 10 pcs.

	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. 5 sets 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 2 sets
13. 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.
14. An exercise to verify the law of reflection and refraction	Optics bench Light source, sodium/mercury lamps 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. 5 pcs. 5 pcs.
15. 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 -15cm focal length concave lens 10cm/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

ANNEX IV - B

LABORATORY REQUIREMENTS
for
BS GEODETIC ENGINEERING

MINIMUM LABORATORY REQUIREMENTS FOR BACHELOR OF SCIENCE IN GEODETIC ENGINEERING

LIST OF LABORATORY EQUIPMENT

Quantity	Description
1 set	Electronic Total Station, 1-km range, with at least 2 single prisms
1 set	Theodolite, 1" least reading
5 set	Transit, 1' or 20" least reading
2 pcs	Steel tape, 100m
3 pcs	Steel tape, 50m
5 sets	Chaining pins
10 pcs	Range poles
5 sets	Leveling instrument
10 pcs	Leveling rod
5 pcs	Stadia rod
2 pcs	Thermometer
2pcs	Spring balance
1pc	Programmable calculator
1 pc	PC, Pentium 4
1 set	Survey software
5 sets	Drafting machine
5 sets	Pantograph
2 sets	Mirror stereoscope with parallax bar
10 sets	Pocket stereoscope
1 set	Planimeter
5 pcs	Plumb bob
5 pcs	3 – arm protractor
5 pcs	Leadline
2 pcs	Prismatic eyepiece
2 pcs	Aneroid barometer
5 sets	GIS software
	Aerial photograps (as needed)
	Topographic maps, scale 1:50,000 (as needed)
	LMS survey returns forms (as needed)

General Surveying 1

Laboratory/Field Exercises	Specifications	Minimum Required Quantity (*)	Units
1. Determination of Pace Factor	Steel tape, 50m	1	pc
	Steel tape, 100m	1	pc
	Chaining pins	5	sets
	Range poles	2	pcs
2. Measuring Distances on Horizontal and Inclined Surfaces Using Pacing or Chaining	Steel tape, 50m	3	pcs
	Steel tape, 100m	2	pcs
	Chaining pins	5	sets
	Range poles	10	pcs
	Plumb bob	5	pcs
3. Use, Care, Adjustment and Operating Principles of a Transit	Engineer's transit, 1' least reading	5	units
	Range poles	10	pcs
4. Prolonging a Line by the Use of Tape or Transit	Engineer's transit, 1' least reading	5	units
	Steel tape, 50m	3	pcs
	Steel tape, 100m	2	pcs
	Chaining pins	5	sets
	Range poles	10	pcs
5. Measuring Obstructed Distance by Transit and Tape	Engineer's transit, 1' least reading	5	units
	Steel tape,50m	3	pcs
	Steel tape, 100m	2	pcs
	Chaining pins	5	sets
	Range poles	10	pcs
6. Determination of an Area by Tape	Steel tape,50m	3	pcs
	Steel tape, 100m	2	pcs
	Chaining pins	5	sets
	Range poles	10	pcs
7. Measurement of Horizontal & Vertical Angles Using Transit	Engineer's transit	5	units
	Chaining pins	5	sets
	Range poles	10	pcs

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8. Running a Traverse by Measuring Azimuth or Reading Interior or Deflection Angles	Engineer's transit, 1' least reading	5	units
	Steel tape, 50m	3	pcs
	Steel tape, 100m	2	pcs
	Chaining pins	5	units
	Range poles	10	pcs
9. Differential Leveling by Single and Double - Rodded Method	Level, wye or dumpy	5	units
	Leveling/stadia rod	10	pcs

*** Note:**

- The equipment used in one exercise may be used in other exercises.
- The minimum requirement is for a class of about 25 students.

General Surveying 2

Laboratory Exercises	Specifications	Minimum Required Quantity	Units
1. Stadia Constant Determination	Engineer's transit 1' least reading	5	units
	Steel tape, 100 m	2	pcs
	Steel tape, 50 m	3	pcs
	Leveling/stadia rod	5	pcs
2. Transit Stadia Traversing	Engineer's transit, 20" least reading with stadia rods	10	pcs
3. Base-Line Measurement	Steel tape, 100 m	2	pcs
	Thermometer, chaining	2	pcs
	Spring balance	2	pcs
	Engineer's transit	2	units
4. Angular Measurement by: a. Direction Method b. Repetition Method	Theodolite, 1"least reading	1	unit
	Engineer's transit, 20" least reading	2	units
	Range poles	2	pcs
5. Topographic Survey	Engineer's transit, 1' or 20" least reading	5	units
	Steel tape, 100 m	2	pcs
	Steel tape, 50 m	3	pcs
	Stadia rods	10	pcs

6. Determination of Azimuth by Observation of the Sun	Engineer's transit, 1' or 20" least reading	5	units
	Solar eyepiece	5	pcs
7. Trigonometric Leveling	Engineer's transit, 1' or 20" least reading	5	units
	Steel tape, 100m	3	pcs
	Steel tape, 50m	2	pcs
	Range poles	10	pcs

*** Note:**

- Alternate Specifications for items (1) and (7)
  Electronic Total station with 2 Single Prisms 1 unit

- Alternate Specifications for items (3), (4), (5), (6), (9), (12), (13) and (14)
  Survey software 1 set

- (*) same unit

Property Surveys

Laboratory Exercises	Specifications	Minimum Required Quantity	Units
1. Field Survey in Original Land Survey	Engineer's transit, 1' or 20" least reading	5	units
	Steel tape, 50m	3	pcs
	Steel tape, 100m	2	pcs
	Stadia rods	10	pcs
2. Azimuth Observation and Computation: 1. Solar 2. Stellar	Engineer's transit, 20" least reading	5	units
	Theodolite, 1' least reading	1	unit
	Programmable calculator (*)	1	unit
3. Traverse Computation and Determination of Common Points	Programmable calculator (*)	1	unit
	Traverse sheets	(As needed)	
4. Lot Data Computation	Computation Sheets	(As needed)	
5. Preparation of Isolated Survey Plan	LMS-format tracing paper	(As needed)	

6.Completion of Survey Returns	LMS Forms	(As needed)	
7. Field Survey for Project Control by: Traverse/Triangulation/GPS (optional)	Engineer's transit, 20" least reading	5	units
	Theodolite, 1"	1	unit
	Steel tape, 50m	3	pcs
	Steel tape, 100m	2	pcs
8. Stellar Computation for the Establishment of Base Meridian	Programmable calculator (*)	(same unit as in item 3)	
9. Project Control Traverse Computation	Programmable calculator (*)	(same unit as in item 3)	
10. Computation and Adjustment of a Quadrilateral	Programmable calculator (*)	(same unit as in item 3)	
11. Adjustment of Old Surveys	Programmable calculator (*)	(same unit as in item 3)	
12. Lot Data Computation for Cadastral Survey	LMS Computation Sheets	(as needed)	
13. Preparation of Cadastral Maps	Tracing paper (LMS Format)	(as needed)	
14. Preparation of Complete Cadastral Survey Returns	LMS Forms	(as needed)	

Cartography

Laboratory Exercises	**Specifications**	**Minimum Required Quantity**	**Units**
1. Plotting of Points a. by polar coordinates b. by plane coordinates	Drafting Machine	5	units
	Pantograph	5	units
2. Preparation of Mining Survey Plan	Programmable Calculator (*)		
3. Methods of Construction of Relief Map			
4. Preparation of Hydrographic Map			
5. Preparation of Boundary and Index Map	Tracing Paper (LMS Format)	(as needed)	
6. Preparation of Thematic Map			
8. Use of Tools and Equipment			

Photogrammetry 1

Laboratory Exercises	Specifications	Minimum Required Quantity	Units
1. Photo Scale Determination	Topographic maps, 1:50,000	(as needed)	
	Aerial photographs (*)	(as needed)	
2. Photo Tilt Determination	Aerial photographs (*)	(as needed)	
3. Flight Planning	Topographic maps, 1:50,000	(as needed)	
4. Photo Evaluation	Crab and overlap templet	(as needed)	
5. Use of Stereoscope	Pocket stereoscope	10	pcs
	Mirror Stereoscope with parallax bar	2	pcs
	Aerial photographs (*)	(as needed)	
6. Photo Processing (optional)			
7. Construction of an Uncontrolled Photo Mosaic (optional)	Aerial photographs (*)	(as needed)	
	Photomaterials		

*** Note:**

- (*) maybe acquired from NAMRIA

Photogrammetry 2

Laboratory Exercises	Specifications	Minimum Required Quantity	Units
1. Simulated Empirical Relative Orientation			
2. Photo Control Point Selection	Aerial photographs (*)	(as needed)	
3. Graphical Absolute Orientation			
4. Coordinate Transformation	Programmable	1	

a. Helmert b. Affine	Calculator		
5. Simple Mapping Exercise	Mirror stereoscope and parallax bar	1	pc
6. Aerial Triangulation Adjustment			

Remote Sensing

Laboratory Exercises	Specifications	Minimum Required Quantity	Units
1. Stereophoto Orientation and Delineation of Project Area	Mirror stereoscope	1	pc
2. Recognition of Ground Cover Condition	Mirror stereoscope	1	pc
	Dot grid templet	1	pc
	Planimeter	1	pc
3. Determination of Area (Hectarage on the Aerial Photo)	Mirror/Pocket stereoscope	1/5	pc
4. Surface Drainage Pattern Analysis	Mirror/Pocket Stereoscope	1/5	pc
5. Slope Analysis and Plotting	Mirror Stereoscope	1	pc
6. Land Use Mapping			

Geodetic Surveying

Laboratory Exercises	Specifications	Minimum Required Quantity	Units
1. Design of a Triangulation Network	Topo map, scale 1:50,000 (as needed)	(as needed)	
2. Baseline Measurement	Level, precision,	1	unit
	Theodolite, 1"	1	unit
	Steel tape, 100m	2	pcs
	Spring balance	2	pcs
3. Observation of Horizontal Direction,	Theodolite, 1"	1	unit
	Plumb bob		

	Target tripod		
4. Reciprocal Zenith Distance Observation	Theodolite, 1"	1	unit
	Target tripod		
5. Computation of Field Data (Quadrilateral or Polygon)	Programmable Calculator (*)		

Mine Surveying

Laboratory Exercises	Specifications	Minimum Required Quantity	Units
1. Location Surveys Using One of the following: a. Lode patent survey b. Lode location survey c. Mill site patent survey d. Placer location survey e. Placer patent survey f. Mine boundary survey	Engineer's transit 1' least reading	5	units
	Stadia rod	10	pcs
	Steel tape, 50m	3	pcs
	Plumb bob	5	pcs
2. Discovery and Location Post Surveys	Engineer's transit 1' least reading	5	Units
	Stadia rods	10	pcs
	Steel tape, 50m	3	pcs
	Plumb bob	5	pcs
3. Surface to Underground Survey	Engineer's transit 1' least reading	5	units
	Stadia rods	10	pcs
	Plumb bob	5	pcs
4. Tunnel Location Survey	Engineer's transit 1' least reading	5	units
	Stadia rods	10	pcs
	Steel tape, 50m	3	pcs
	Plumb bob	5	pcs

Hydrography

Laboratory Exercises	Specifications	Minimum Required Quantity	Units
1. Test of Leveling Instrument	Precise Level	5	units
	Leveling rods	10	pcs
2. Running a Level Line and Field Computation	Precise Level	5	units
	Leveling rods	10	pcs
3. River Crossing Method	Precise Level	5	units
	Leveling rods	10	pcs
	Lead line	5	pcs
4. Hydrographic Survey	Transit, 1' or theodolite, 1"	5 or 1	unit
	Sextant	5	pcs
	3 arm protractor	5	pcs
	Levelling rods	5	pcs
	Precise Level	5	unit
	Sextant	5	pcs
	Lead line	5	pcs
5. Preparation of Hydrographic Map	3 arm Protractor	5	pcs

*** Note:**

- For Item 4 (alternate requirements)

Hydrographic Survey	Electronic Total Station	1	unit
	Single-prison (1-km range)	2	pcs
	Echo sounder	1	unit
	Lead line	1	unit

- For Item 5 (alternate requirements)

Preparation of Hydrograhic Map	Computer (PC) Pentium 4	1	unit
	Survey Software	1	set

Geodetic Astronomy

Laboratory Exercises	Specifications	Minimum Required Quantity	Units
1. Determination of Azimuth by:	Theodolite, 1"	2	pcs
a. Zenith distance of a star	Prismatic eyepiece	2	pcs
b. Circumpolar star at greatest elongation	Striding level (optional)	2	pcs

	Air thermometer	2	pcs
	Aneroid barometer	2	pcs
2. Determination of Latitude by: a. Meridian zenith distance of a star b. Circum-meridian zenith distance of a star	Theodolite, 1"	2	pcs
	Prismatic eyepiece	2	pcs
	Striding level (optional)	2	pcs
	Air thermometer	2	pcs
	Aneroid barometer	2	pcs
3. Determination of Time by: a. Zenith distance of star b. Star transit using theodolite	Theodolite 1"	2	pcs
4. Determination of Longitude by: a. Chronometer time or radio time signals b. Transportation of time pieces		2	pcs

Construction and Industrial Surveys

Laboratory Exercises	Specifications	Minimum Required Quantity	Units
1. Laying Out of: a. simple curve b. compound and reverse curve c. spiral curve	Engineer's transit, 1'	5	units
2. Laying Out Vertical Parabolic Curves	Steel tape, 50m	3	pcs
	Steel tape, 100m	2	pcs
	Range poles	10	pcs
	Chaining pins	5	sets
3. Profiling & Cross Sectioning	Engineer's transit, 1'	5	units
	Precision Level	5	units
	Range poles	10	pcs
	Leveling rods	10	pcs
4. Slope Staking	Engineer's transit, 1'	5	pcs
	Precision Level	5	units
	Range poles	10	pcs

	Leveling rods	10	pcs
	Steel tape, 30 m or 50 m	5	pcs
5. Laying Out of Drainage Facilities Building, Pipeline Canals, Underground Conduits, and other Infrastructural Projects	Engineer's transit, 1'	5	units
	Plumb bob	5	pcs
	Steel tape, 50 m or 100 m	3 2	pcs pcs
	Range poles	10	pcs
	Chaining pins	5	sets
	Precision Level	5	units
	Stadia rods	10	pcs
6. Determination of Areas of Cross-Section and Volumes of Earthwork	Programmable calculator (*)		
7. Preparation of Mass Diagram			

Geodetic Computations & Adjustments

Laboratory Exercises	Specifications	Minimum Required Quantity	Units
1. Least squares adjustment by observation equations/indirect method	Programmable Calculator	(as needed)	
2. Least squares adjustment by condition equations/direct method	Programmable Calculator	(as needed)	
3. Curve fitting	Programmable Calculator	(as needed)	
4. Adjustment of level networks	Programmable Calculator	(as needed)	
5. Adjustment of triangulation networks	Programmable Calculator	(as needed)	
6. Adjustment of traverse	Programmable Calculator	(as needed)	

Development Planning

Laboratory Exercises	Specifications	Minimum Required Quantity	Units
Project or Research	Computer (PC) Pentium 4	1	set

Special Studies in Geodetic Engineering

Laboratory Exercises	Specifications	Minimum Required Quantity	Units
Project or Research	Computer (PC)	1	set
	Programmable Calculator	1	set

Geographic Information System

Laboratory Exercises	Specifications	Minimum Required Quantity	Units
1. Introduction to GIS software	Computer (PC) Pentium 4	1	set
	GIS Software	1	set
2. Spatial data preparation			
3. Spatial data querying and display	Computer (PC) Pentium 4	1	set
	GIS Software	1	set
4. Database design			
5. Spatial Analysis	Computer (PC) Pentium 4	1	set
	GIS Software	1	set
6. Visualization in GIS	Computer (PC) Pentium 4	1	set
	GIS Software	1	set