AC 2010-1088: A GEOMATICS ENGINEERING CURRICULUM FOR ENHANCING THE PROFESSIONAL CAPACITY OF THE GRADUATE SURVEYOR AT THE UNIVERSITY OF LAGOS, NIGERIA

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Dr. James Olaleye enrolled on the Surveying Degree program at the University of Lagos, Nigeria in 1976. As a result of his brilliant academic performance, Dr. Olaleye became a shell scholar in 1976 and graduated in 1981 with a first class degree in Surveying. In 1987, he was awarded the prestigious commonwealth scholarship for doctoral studies in Canada. With a brilliant record of graduate work, Dr. Olaleye obtained his Ph.D degree in 1992 from the University of New Brunswick, Canada. He has continued the pursuit of academic excellence through the publications of his research findings in mapping in both national and international Journals. He has authored or co-authored over forty publications. He was awarded the prestigious" Talbart Abrams Medal" by the American Society for Photogrammetry and Remote sensing in recognition of his outstanding Publication in Geoinformatics in 1994. Dr. Olaleye is an Associate Professor in the Department of Surveying & Geoinformatics, University of Lagos. He is also the immediate past Head of Department. He teaches Digital Mapping and GIS.

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Mr. Abiodun worked briefly as Assistant Manager, GIS Research and Development with Anthony Adeoye and Co. (now AAC Consulting) in 2002. He was appointed Lecturer III in the Department of Surveying and Geoinformatics, Osun State College of Technology, Esa Oke, Nigeria in 2004. From there, he was appointed as Assistant Lecturer in the Department of Surveying and Geoinformatics at the University of Lagos.

Mr. Abiodun emerged as the best graduating student in the Department of Surveying, Federal Polytechnic, Idah in 1994 and the best graduating M.Sc. student, Department of Surveying and Geoinformatics, University of Lagos in 2004. He has many papers to his credit both local and international. He is a member of many professional organizations in Nigeria. He is married with children.

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Dr. J. O. Olusina worked between 1989 and 1997 with the Survey Department of the Federal Government of Nigeria's Ministry of Works and Housing. He afterwards joined Yaba College of Technology, Lagos, as Lecturer II between 1997 and 1998. From there he joined the University of Lagos as Lecturer II in the Department of Surveying and Geoinformatics in 1998.

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A Geomatics Engineering Curriculum for Enhancing the Professional Capacity of the Graduate Surveyor at the University of Lagos, Nigeria

Abstract

Advances in land surveying technology and instrumentation now make it possible for less qualified surveyors to produce maps and determine positions with relative ease. The professional surveyor, whose career has been the production of maps at varying scales and accuracies, now faces real challenges in keeping abreast with the technological advances. Surveyors in Nigeria are burdened by:

- new and changing user demand for products in varying formats,
- inadequate knowledge to explore or venture into new and emerging areas of opportunities,
- diminishing career opportunities.

Although new and emerging technological innovations are creating new opportunities for surveyors many feel unprepared to explore or to venture into these new technologies.

To reverse the trend, a committee from the Department of Surveying & Geoinformatics at the University of Lagos in Nigeria, was set up to analyze the problem and recommend remedial actions. The committee identified, among other things, that the structure of the surveying program be redesigned into a North American brand of surveying engineering, and to revise existing surveying curriculum so as to include courses in emerging technologies. It was the belief of the committee that these changes would enhance the capabilities of the Geomatics engineer, not only to carry out engineering and cadastral surveys, but to adapt and expand his activities into the newer areas of geospatial information systems engineering.

This paper presents a discussion of current institutional and administrative challenges confronting the professional surveyor and the philosophy underlying the development of the revised curriculum. Whereas the university was in agreement with the recommendations, there were institutional challenges such as acceptance by the Licensing Board regarding curriculum content and licensure requirements. The paper concludes with the view that the Geomatics Engineering program will enhance the capabilities of the new graduate and reinstate the surveyor as a respectable and indispensable professional.

Introduction

Land surveying, as presently perceived and practiced, appears to be one of the most vulnerable in this digital technology era. Other than human and material resources needed to conduct surveys, the procedures are the same, irrespective of the scope of the project. The computer has become the best tool for performing routine computationally intensive aspects of the surveyor's activities. Given the unabated advances in technological revolution, applications of the computer and digital technology in surveying are inevitable. Already, computerized instrumentation has facilitated surveying operations to the extent that non-surveyors, more than ever before, are now

able to produce maps and determine positions on the Earth's surface. Equipment manufacturers now use innovation as a means to boost sales by embedding the scientific and mathematical aspects of surveying into their products and thereby making it possible for untrained persons to conduct surveys without necessarily understanding the underlying science. Threats to the survival of the surveying profession in Nigeria are identified as follows:

- tools of the trade are now easily used by non-surveyors
- other professionals now encroach into Surveying with ease and confidence,
- the pool of "Do-It-Yourself" surveyors is increasing, not by accredited specialists but by technological converts,
- inadequate training of the surveyor imposes limitation the scope of his/her competence, adaptability and of course, opportunities,
- dwindling enrolment into surveying program,
- perceived unattractiveness of the profession by high school students and the public in general.

This paper proposes a need to rediscover the surveying profession in the context of today's technological and geospatial needs. The authors contend that the surveyor's work does not end at the point of submitting map data, rather where data is turned into information to support decision making.

With the aim of modernizing the surveying curriculum to meet market needs, this paper examines legal, educational and professional strategies in support of the proposal. An outline of the curriculum for the proposed Geomatics Engineering program at the Department of Surveying and Geoinformatics at the University of Lagos, Nigeria is also presented.

Current Status of Surveying

Traditional surveying curricula are designed to enable graduate surveyors to precisely locate positions on the surface of the Earth. The building block of the land surveying is geodesy; the science that deals with the shape, size and gravity field of the earth. The profession required physical fitness, high mental capacity, inquisitiveness, constructive imagination, flair for mathematical calculations, and an ability to work in harsh weather and rugged terrain. However, the advent of digitalization has brought revolutionary changes to the methods and instrumentation for surveying and it appears that these initial and special qualities of the surveyor are no longer a pre-condition. Recently, many tools and techniques for acquiring survey data with a high degree of accuracy, flexibility, and at reduced cost have been developed or improved upon. For instance, ground surveys are now performed using electronic total stations and Total Scan (SmartStation) systems which provide direct geometric observations to determine the spatial locations of physical features. Added to this is the revolution introduced by the Global Positioning System (GPS) which enables the relative coordinates of points to be computed without the usual need for intervisibility between stations. More astonishing is the fact that in the past, the coordinates of a point on the Earth's surface could only result from extensive calculations by the surveyor after rigorous field data acquisition. Today, the GPS enables positions to be computed instantaneously, even while in motion, to desired accuracy without any need for calculation by the user and with very little or no training.

In a similar manner, significant improvements have been made in the method of mapping from images. Orbiting remote sensing satellites now provide high resolution images of the earth, which when coupled with GPS derived coordinates can be used to produce maps more easily, more quickly, and more cheaply. Of greater significance is the development of digital image processing techniques and intelligent software packages which have made the extraction of spatial information from such data by the computer a reality, thus making the method a rather useful tool for monitoring the earth's resources. Because of the vantage orbital position, the multi-channel design, operational flexibility, and improved resolution of many remote sensor systems, this technique is proving to be a cost-effective method for collecting a variety of information over large areas of the earth. Furthermore, sophisticated camera systems are now carried in low flying aircrafts for high resolution images which can be used for large scale maps. From simple desktop devices for plannimetric map production to full photogrammetric workstation for 3D data capture, the impact of technology is immense. In both methods, the skill and learning time required by the surveyor to produce a map is just a fraction of what he needed for the traditional methods [Olaleye][8]. Also, the turn-around time and cost of making maps are comparatively low. Perhaps the more recent and noteworthy development is the possibility of integrating image data with position data in an application. The operations of the instruments are so simple that even self-learning is sufficient to get the user up and running in a short time.

Huge advances have also been made in hydrographic methods for mapping water bodies. The sextant lead line approach of the past has been replaced with digital multi-beam echo sounders and side scan sonar systems which can produce depth profile and image data of areas of the seabed in a single pass. When coupled with a real-time GPS system and communication facilities, charting of large areas of the seabed can be quickly and cheaply accomplished.

Undoubtedly, one of the greatest achievements of modern technology is the analytical capabilities of geospatial technologies to support decision making. The success of this technology has led to the emergence and popularity of the all-pervading Geospatial Information System (GIS) – a tool which permits the integration and analysis of different kinds of co-located (tangible or intangible) data for use in all matters relating to an environment.

But what role does the surveyor play in all these or what role does emerging technology have for the surveyor? The skills of the surveyor have become keyboard skills which can be possessed by anyone [Jupe][5]. According to [Smith][11], "the surveyor needs only to press a button and read displays and no doubt engineers, geologists, even lawyers may want to do it for themselves". The question to the surveyor is clear and loud enough- will surveying of the future require the surveyor? Indeed, we are in an era where survey operation requires little observational skills. If the skills and knowledge developed through long years of training and experience appear no longer to be needed, does the surveying profession have a future?

The way out is that the challenges of modern geospatial technology have to be recognized, properly assessed with a view to designing appropriate strategies to capitalize on the opportunities that they offer. The many challenges can be summarized into a few key issues listed below.

Current Challenges Facing the Surveying Profession in Nigeria

To many surveyors, computer technology is like a two-edged sword because the changes it has brought obvious benefits as well as costs to the profession. Computers provide more options to the surveyor, in terms of equipment and data processing methods, and offers easy and cost effective ways to perform tasks. Computers have also created new ways for users to employ the surveyor's maps in their operations and facilitated access and acquisition of digital graphical data. Such benefits have come to the surveyor in addition to a number of big challenges. Some of the important ones are mentioned in what follows:

i. Erosion public perception of the professional surveyor's status as a result of simplification of equipment and processing methods. Advances in geodetic methods and instrumentation which empower other professionals to conduct surveying activities with relative ease and confidence. In other words, extensive computerization has produced simple methods and instrumentation, which enable non-professionals in surveying to produce maps and determine positions.
ii. Reduced revenue for services. Technological advances in data acquisition and processing methods have empowered clients to demand accurate, comprehensive, flexible and up-to-date maps at very affordable cost. Some even want the job done at a price which they themselves dictate.
iii. Inability of surveyors to provide services for products in newer formats and varieties. The requirements of clients are changing rapidly to the extent that old methods and instruments are not able to cope. Many surveyors in Nigeria have not been trained in the newer instrumentation, data acquisition and processing techniques. Thus, the surveyor's realization of the need to improve his/her skills and be able to add value to his/her maps in order to survive and remain relevant.
iv. Inadequate knowledge of data utilization techniques due to limitation of skill. One of the greatest achievements of modern technology is the development of Geospatial Information System (GIS); a computer-based tool which allows the direct integration of maps into business decision making process. GIS technology has caused users to place high premium on professionals who are not only able to conduct surveys, but are able to develop information from map-based data files with the help of user-friendly interfaces.

The challenge before the surveyor is therefore not just how best to meet data needs of clients, but also to recognize the fact that the requirements of the clients are changing and so are the capabilities and options for meeting them. Therefore, it has become necessary for the surveyor to expand or adapt his/her skills in order to achieve a rewarding career in today's socio-economic and information technology environment. The surveyor must evolve and reoccupy his/her leadership role in all aspects of location-based resource management.

Certainly, computerization has had a profound effect on geodesy and traditional land surveying. To address these challenges, the surveyor must update his skills to conform with modern or current developments in technology and changing societal needs. Innovative adaptation will equip the surveyor with the resources to operate effectively in modern socio-economic order.

Re-Professionalization

Responding to the new ways in which clients acquire and use geospatial information requires the surveyor to be innovative and resourceful. For example, recent increased awareness of the need to use the Earth's resources in a sustainable manner presents new challenges to the surveying profession. In addition to providing the traditional services, surveyors must now be able to provide comprehensive and accurate information which will show, possibly through modeling and prediction, the effects or impacts of all engineering, social, cultural and political activities on the environment. This task calls for new knowledge from the surveyors. Furthermore, in today's corporate world, information is a critical resource. More than ever before, private and public concerns are realizing the benefits when business-related information is presented in the context of the geographic environment of their operations. The implication is that geospatial information adds value to business. If the surveyor is the professional who will provide the enabling data sets that will produce such information in the right volume and format, then the surveyor will require new skills to perform these tasks efficiently. This requirement places the responsibility on institutions of higher education to provide such training.

The Department Of Surveying and Geoinformatics at the University of Lagos

The Department of Surveying and Geoinformatics (Formally known as Department of Surveying), started as a sub-department of Civil Engineering Department in 1970. The initial program of the sub-department at that time was a two-year postgraduate course of studies and research leading to a Master of Science degree in surveying (M.Sc. (Surveying)).

Prior to the establishment of the sub-department, four final year students, who withdrew from University of Nigeria, Nsukka, as a result of civil disturbances in the country in 1966, were absorbed by the Department of Civil Engineering at the University of Lagos (UNILAG) to complete their degree program in surveying. This decision was made through special arrangements with the Federal Surveys Department of Nigeria. The students graduated with B.Sc. degree in Surveying in 1967 as the first undergraduate class of the department. In October 1973, a full-fledged Department of Surveying was established. The first set of undergraduate students in surveying was admitted in October 1974. Today, the Department also runs postgraduate programmes leading to the M.Sc., Master of Philosophy (M.Phil.) and Doctor of Philosophy (Ph.D.) degrees in Surveying and Geoinformatics as well as Master of Geoinformatics (MGIT-Executive programme) and a Postgraduate Diploma programme in Surveying and Geoinformatics (PGD).

The need to change the name of the department was firstly due to the very narrow interpretation given the term "surveying" by the general public and the resulting difficulties in student recruitment. Secondly, to reflect the tremendous impacts that advances in technology and modern surveying techniques have had on the surveying profession. The first concerted effort at realizing this goal was made at a Faculty of Engineering Board of Studies meeting in the 1996/97 session, in which many names were proposed. However, the department was able to arrive at a unanimous decision on this name at a departmental meeting held on 15th January 1998. The name Surveying and Geoinformatics portrays a discipline that deals with acquisition, analysis, storage, distribution, management and application of spatially-referenced data. However, the

name Surveying and Geoinformatics has not actually defined the programme in its entirety. The need for planning, modelling and analysis of geospatial systems is very crucial to meet the daily challenges of human beings in their environment.

A New Geomatics Engineering Curriculum for Training the Surveyor in Nigeria

A review of the curriculum content showed that less time had been allotted to data capture and management courses. A need to emphasize courses relating to applications in engineering and environmental data modelling, monitoring and predictions was identified. Similarly, applications of data in socio-economic studies, population dynamics, disaster monitoring, water supply, desertification, flooding, eradication of poverty, and other areas of human development are very crucial nowadays. For all these applications, geospatial information is the key requirement. The principle is to develop an adaptable educational model as the most potent way for the surveying profession to adequately respond to the challenges of globalization. Different programs of study were designed to address specific societal needs. The new curriculum for undergraduate studies is shown in Appendix A.

Geomatics Engineering (GME) program covers state of the art surveying, ubiquitous positioning, sensor networks, image interpretation, spatiotemporal databases, and the generation of spatiotemporal information products to address issues that deal with location and time. Research activities will include spatiotemporal measurement science, spatial data infrastructures, and geographic information science. This is the scientific discipline that deals with the realization/creation of Geospatial Information Products (GIPs) and systems(GIS) needed to simplify, improve reliability, and reduce costs of a multitude of land & land–related processes, operations or procedures including planning, management and administration of projects in Civil Engineering, Space Exploration, Civil Aviation, Mining, Navigation, Architecture, Physical Planning, National Defence, Mapping, Archeology, Oceanography, Tourism, Land Use & Allocation, Land Administration, and Political Administration at all levels of Government.

A Geomatics Engineer, as the graduate may be called, employs the principles of mathematical physics, mathematical statistics, mathematical geometries, socio-economic methods, and computing science to conceptualize, design and implement systems that provide information support for location-dependent decision making applications.

A Geomatics Engineer who has completed the curriculum will have the skills and capability, not only to produce maps and determine positions, but also to add value to maps and create tools for applications in diverse areas such as environmental monitoring and impact studies, urban land management, transportation studies and management, real time navigational applications such as oil rig movement and relocation, vehicle fleet management, crime control, etc. Indeed, he will be indispensable in all matters relating to the sustainable and profitable use of scarce resources.

Anticipated Problems and Proposed Solution

Though the change of emphasis from surveying to geomatics at the University of Lagos will broadened the employment opportunities for geomatics graduates, it will require initial investments such as facilities, human resource in terms of the right calibre of faculty, and adequate funding. Two areas of concern are professional accreditation and professional licensing.

Adequate Funding for investments in Facilities

The problem of inadequate funding of tertiary education is critically affecting training in geomatics education in Nigeria. This makes it difficult to purchase the required equipment and facilities for the institution. However, the Department has been able to secure the approval and purchase of equipment worth two hundred and thirteen million Naira (₦215,000,000) (approximately US$1.4 million) from the Federal Government of Nigeria through its Education Tax Fund. This amount will be use be used for the start-up costs of the new program.

Obtaining the Right Calibre of Faculty

One of the problems facing geomatics education at the University of Lagos is the unavailability of the right calibre of faculty to teach or train students in the new technology. Most of the personnel available for teaching are well grounded in the traditional survey techniques. Through Continuous Professional Development Program and other in-house training programs, many of them have grasped the new techniques in geomatics education. The Department also enrolled three of its young faculty members in Ph.D. programs overseas. One of them has already returned while the remaining two will be expected to return upon completing their programs. The Department is also trying to establish collaboration with some Universities in the North America where the programme is already in existence. The number of staff needed for geomatics education is much more than what is available at the moment. Efforts are being made to recruit more faculty members into the new program as soon as it is approved by the University.

Professional Accreditation and Licensure

Institutional problems the new programme may likely face are accreditation and licensure by relevant professional bodies. In Nigeria, Surveyors' Council of Nigeria (SURCON) is responsible for accreditation of surveying program and licensing of graduate surveyors while the Council for the Registration of Engineers (COREN) is responsible for accreditation of engineering programmes and licensing of graduate engineers. To ensure the acceptance of the new program by the councils, the new curriculum has been designed to meet accreditation requirements of both SURCON and COREN. This will make it possible for graduates of the programme to register with either of the two bodies or both of them.

Conclusions

There is no doubt that surveying profession is undergoing major transformation due to improvements in equipment and methodology. The evolution of geospatial information and digital technology are providing decision makers with tremendous opportunities to analyze spatial data in order to make informed decisions about resources and to manage the environment. Through these transformations, the surveyor has been compelled to adapt. Institutions of higher learning are obligated to constantly review the contents of their curricula in order to meet the changing needs of society. In this regard, the Geomatics Engineering Department of the University of Lagos has redesigned their geomatics curriculum from the undergraduate through doctoral levels. In anticipation of potential problems arising from accreditation and licensing bodies, the faculty ensured that the course offerings meet the requirements of both bodies. They have been able to secure funding to provide needed equipment and retrain faculty members. It is anticipated that upon approval by the University the new geomatics engineering program will empower graduates to meet the needs of the geospatial data user community.

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Appendix A

Structure of the Proposed Geomatics Engineering Curriculum

YEAR 1 FIRST SEMESTER

COURSE CODE	COURSE TITLE	LECTURE UNITS	LAB. UNITS	TOTAL UNITS
GME 101	Introduction to Basic Surveying	1	0	1
GEG 101	Pure Maths I	3	0	3
GEG 103	Applied Maths I	3	0	3
MEG 101	Workshop Practice	0	1	1
MEG 103	Technical Drawing I	0	2	2
FSC 105	Introductory Physics I	3	0	3
GST 102	Intro. to Logic and Philosophy	2	0	2
GST 105	Use of English	1	0	1
	Total	**13**	**3**	**16**

YEAR 1 SECOND SEMESTER

COURSE CODE	COURSE TITLE	LECTURE UNITS	LAB. UNITS	TOTAL UNITS
GME 102	Basic Surveying	2	1	3
GEG 102	Pure Maths II	2	0	2
GEG 104	Applied Maths II	2	0	2
MEG 102	Workshop Practice II	0	1	1
MEG 104	Technical Drawing II	0	2	2
PHS 101	Introductory Physics II	2	0	2
PHS 102	Introductory Physics III	2	1	3
PHS 103	Lab (Physics)	0	2	2
GST 104	History & Philosophy of Science	2	0	2
GST 106	Use of English	1	0	1
	Total	**13**	**7**	**20**

YEAR II FIRST SEMESTER

COURSE CODE	COURSE TITLE	LECTURE UNITS	LAB. UNITS	TOTAL UNITS
GME 201	Engineering Surveying	2	1	3
GEG 201	Engineering Maths I	2	1	3
EEG 201	Fund. of Elect. Engr. I	2	1	3
GEG 203	Surveying Mathematics (Systems)	2	1	3
PHS 201	Classical Mechanics I	2	0	2
PHS 219	Practical Physics I	0	1	1
PHS 261	Geophysics I	2	0	2
GAS 201	General African Studies I	2	0	2
PHS 207	Optics	1	1	2
	Total	**15**	**6**	**21**

YEAR II SECOND SEMESTER

COURSE CODE	COURSE TITLE	LECTURE UNITS	LAB. UNITS	TOTAL UNITS
GME 202	Cadastral Surveying I	2	0	2
GEG 202	Intro. Engr. Stat. & Computer System	3	0	3
MEG 202	Fluid Mechanics	2	1	3
PHS 208	Intro. to Astrophysics	2	0	2
GME 210	Photogrammetry I	2	0	2
PHS 220	Practical Physics II	0	1	1
GAS 202	Gen. African Studies II	2	0	2
GRY 203	Cartography	2	0	2
GME 206	Computer Application in Geomatics Engineering	2	1	3
	Total	**17**	**3**	**20**

YEAR III FIRST SEMESTER

COURSE CODE	COURSE TITLE	LECTURE UNITS	LAB. UNITS	TOTAL UNITS
SSG 312	Control Theory	1	0	1
GME 301	Geodetic Surveying	2	1	3
GME 303	Spherical and Field Astronomy	2	1	3
ESM 351	Applied Town Planning	2	0	2
GME 307	Cadastral Surveying II	2	1	3
GME 309	Principles of Geo. Information System I	2	1	3
PHS 301	Classical Mechanics II	2	0	2
	Total	**13**	**4**	**17**

Elective:

PHE 207	Introduction to Swimming I	0	1	1

YEAR III SECOND SEMESTER

COURSE CODE	COURSE TITLE	LECTURE UNITS	LAB. UNITS	TOTAL UNITS
GME 302	Map Projection	2	1	3
GME 304	Remote Sensing	2	1	3
GME 306	Geodetic Astronomy	2	1	3
GME 308	Principles of GPS Surveying	1	1	2
GME 310	Hydrographic Surveying I	2	1	3
GME 312	Principles of Geo. Information System II	2	1	3
GME 314	Digital Mapping	2	1	3
	Total	**13**	**7**	**20**
GME 300	Geomatics Engineering Camp	0	4	4

Plus at least 2 Units of Electives below:

GEG 302	Operational Methods	2	0	2
PHE 207	Introduction to Swimming II	0	1	1
CEG 304	Engineering Geology	2	1	3

YEAR IV FIRST SEMESTER

COURSE CODE	COURSE TITLE	LECTURE UNITS	LAB. UNITS	TOTAL UNITS
GME 401	Data Analysis in Engineering	2	0	2
GME 403	Environmental Modelling	2	1	3
GME 405	Satellite Geodesy I	2	1	3
SSG 307	Operations Research (Systems)	2	1	3
GEG 405	Engineering Statistics	2	0	2
GEG 403	Numerical Methods in Engineering	2	1	3
GEG 401	Tech. Communications	1	0	1
	Total	**13**	**4**	**17**

Plus at least 5 Units of Electives from below:

GME 407	Mining and Underground Survey	2	1	3
GME 409	Potential Theory and Spherical Harmonics	2	0	2
GME 411	Geomatics Design and Modelling	2	1	3

YEAR IV SECOND SEMESTER

GME 400	Industrial Attachment	-	8units

YEAR V FIRST SEMESTER

COURSE CODE	COURSE TITLE	LECTURE UNITS	LAB. UNITS	TOTAL UNITS
GME 501	Adjustment Computation I	2	1	3
GME 503	Survey Laws and Professional Practice	2	0	2
GEG 501	Engineering Economics	2	0	2
GME 511	Project	0	3	3
	Total	**6**	**4**	**10**

Plus at least 7units of Electives below:

GME 505	Special Studies in Photogrammetry and Remote Sensing	2	1	3
GME 507	Geometric Geodesy	2	1	3
SSG 407	Mechanics of Robotics Systems I	3	0	3
GME 509	Marine and Coastal Management	2	0	2
GME 515	Special Topics in Geomatics Engineering I	2	1	3
GEG 503	Surface Water Hydraulics	2	0	2
GEG 519	River Engineering	2	0	2
CEG 513	Transportation Systems Analysis and Design	2	0	2
GME 519	Mathematical Geodesy	2	0	2

YEAR V SECOND SEMESTER

COURSE CODE	COURSE TITLE	LECTURE UNITS	LAB. UNITS	TOTAL UNITS
GME 502	Adjustment Computation II	2	1	3
GME 504	Special Topics in Geomatics Engineering II	2	1	3
GME 512	Project	0	3	3

GEG 502	Engineering Law & Management	2	0	2
	Total	**6**	**5**	**11**
Plus at least 9 units of Electives from below:				
GME 506	Physical Geodesy	2	1	3
GME 508	Hydrographic Surveying II	2	1	3
GME 510	Marine and Coastal Management	2	0	2
GME 504	Special Topics in Geomatics Engineering II	2	1	3
CEG 504	Ground Water Hydrology	2	0	2
SSG 505	Mechanics of Robotics Systems II	2	1	3
GME 514	Satellite Geodesy	2	1	3
GME 516	Applied Geophysics	2	0	2
GME 518	Close-Range Photogrammetry	2	1	3