UNIVERSITY OF GHANA
SCHOOL OF PHYSICAL AND MATHEMATICAL SCIENCES
REVIEW OF STRUCTURE OF UNDERGRADUATE PROGRAMMES

INTRODUCTION

This document presents a review of academic programmes run by the academic units under the School of Physical and Mathematical Sciences (SPMS). This review has been carried out to satisfy the requirements of the University of Ghana Academic Quality Assurance Policy. The Academic Quality Assurance Policy 001 ver.1 07_2009 requires every academic unit to review its programmes at least once every five years. The last time the academic units under the SPMS reviewed their undergraduate programme(s) was in 2010 to coincide with the introduction of the Four Year Undergraduate Degree programme.

The existing programmes in the School have been reviewed to make them more relevant to the needs of the nation. The areas of emphasis of this review are:

- Level 100 students now have a wider field from which to select subjects;
- At Level 200 students now have more options in the selection of programmes;
- Internship/industrial attachment has been introduced as a course in most programmes;
- Students have the opportunity to take elective courses from other related disciplines;
- Duplicate courses have been removed and, where appropriate, courses have been merged;
- New attractive and relevant courses have been introduced.

HIGHLIGHTS OF MAJOR CHANGES

1. The Level 100 programmes have been restructured in such a way that students are grouped into broad areas where they read/take related subjects. This is to afford the students a broad menu of programmes at Level 200 to choose from, depending on their interest and performance at Level 100.
2. The Computer Science and Information Technology programmes have been restructured in a way that enables students from the two programmes to take as many common courses as possible. This has been carried out through merging common courses and the introduction of new courses.
3. Introduction of a combined-major programme in Actuarial Science and Mathematics.
4. Introduction of the Geophysics Programme in the Department of Physics.
5. Earth Science students may graduate with any of the following degrees depending on elective courses taken at Level 300 and Level 400:
    - Geology
    - Applied Geophysics
    - Applied Geology

NUMBER OF CREDITS TO BE TAKEN PER SEMESTER

Level 100
15 – 18 credits per Semester including UGRC courses.

Single-Major
Level 200
15 – 18 credits per Semester

Level 300
15 – 18 credits per Semester
Level 400
15 – 18 credits per Semester

Combined-Major
Level 200
18 – 21 credits per Semester (min of 9 credits per Semester from each subject)

Level 300
18 – 21 credits per Semester (min of 9 credits per Semester from each subject)

Level 400
18 – 21 credits per Semester (min of 9 credits per Semester from each subject)

Major-Minor
Level 200
18 – 21 credits per Semester (min of 9 credits per Semester from each subject)

Level 300
18 – 21 credits per Semester (6 credits per Semester from the minor subject)
Level 400
18 – 21 credits per Semester

JUSTIFICATION FOR INCREASING THE CREDIT LIMITS OF THE UNDERGRADUATE PROGRAMME IN THE SCHOOL OF PHYSICAL AND MATHEMATICAL SCIENCES

The School of Physical and Mathematical Sciences seeks approval to increase the minimum and maximum permissible credits to 18 and 21 respectively for the Undergraduate Program that run **Combine-Major** and **Major-Minor** programmes. For these and any other programme that goes beyond the permissible maximum credits approval is normally sought from the Dean of faculty to grant permission to run these. The re-introduction of the Combine-Major and Major-Minor in our review efforts necessitate for higher credit hours for such courses.

STRUCTURE OF LEVEL 100 PROGRAMME

PHYSICAL SCIENCES

FIRST SEMESTER

Code	Title	Credits	Pre-requisites
Core			
UGRC		3	
PHYS 105	Practical Physics I	1	
PHYS 143	Mechanics and Thermal Physics	3	
CHEM 113	Foundation Chemistry I	3	
CHEM 120	General Chemistry Laboratory I	1	
MATH 121	Algebra and Trigonometry	3	
Total		**14**	
Electives: Select 3 credits			
DCIT 101	Introduction to Computer Sciencen I	3	
EASC 101	Physical Geology	3	
MATH 123	Vectors and Geometry	3	
ABCS 101	Introductory Animal Biology	3	

Students who wish to be considered for Geophysics at Level 200 should take EASC 101

SECOND SEMESTER

Code	Title	Credits	Pre-requisites
Core			
UGRC		3	
PHYS 106	Practical Physics II	1	
PHYS 144	Electricity and Magnetism	3	
CHEM 114	Foundation Chemistry II	3	
*CHEM 122	General Chemistry Laboratory II	1	
MATH 122	Calculus I	3	
Total		**14**	
Electives: Select 3 credits			
DCIT 104	Programming Fundamentals	3	
EASC 104	Historical Geology	2	
EASC 106	Geological Field Excursions	1	
MATH 126	Algebra and Geometry	3	
BOTN 104	Growth of Flowering Plants	3	

Students who wish to be considered for Geophysics at Level 200 should take EASC 104 and EASC 106.

MATHEMATICAL SCIENCES

FIRST SEMESTER

Code	Title	Credits	Pre-requisites
Core			
UGRC		3	
MATH 121	Algebra and Trigonometry	3	
MATH 123	Vectors and Geometry	3	

STAT 111	Introduction to Statistics and Probability I	3	
DCIT 101	Introduction to Computer Science	3	
Total		**15**	
Electives: Select 3 to 4 credits			
PHYS 105	Practical Physics I	1	
PHYS 143	Mechanics and Thermal Physics	3	
ABCS 101	Introductory Animal Biology	3	
ECON 101	Introduction to Economics I	3	
DCIT 103	Office Productivity Tools	3	

Students who wish to be considered for a programme in Actuarial Science and Biomathematics at Level 200 should take ECON 101 and ABC 101, respectively.

SECOND SEMESTER

Code	Title	Credits	Pre-requisites
Core			
UGRC		3	
MATH 122	Calculus I	3	
MATH 126	Algebra and Geometry	3	
STAT 112	Introduction to Statistics and Probability II	3	
DCIT 104	Programming Fundamentals	3	
Total		**15**	
Electives: Select 3 to 4 credits			
DCIT 102	Computer Hardware Fundamentals and Circuits	3	
PHYS 106	Practical Physics II	1	
PHYS 144	Electricity and Magnetism	3	
ECON 102	Introduction to Economics II	3	
BOTN 104	Growth of Flowering Plants	3	

Students who wish to be considered for a programme in Actuarial Science and Biomathematics at Level 200 should take ECON 102 and BOTN 104, respectively. Students who wish to be considered for a programme in Computer Science should select DCIT 102.

EARTH SCIENCES

FIRST SEMESTER

Code	Title	Credits	Pre-requisites
Core			
UGRC		3	
PHYS 105	Practical Physics I	1	
PHYS 143	Mechanics and Thermal Physics	3	
CHEM 113	Foundation Chemistry I	3	
CHEM 120	General Chemistry Laboratory I	1	
EASC 101	Physical Geology	3	
Total		**14**	
Electives: Select 3 credits			
MATH 121	Algebra and Trigonometry	3	
MATH 123	Vectors and Geometry	3	
STAT 111	Introduction to Statistics and Probability I	3	
DCIT 101	Introduction to Computer Science	3	

SECOND SEMESTER

Code	Title	Credits	Pre-requisites
Core			
UGRC		3	
PHYS 106	Practical Physics II	1	
PHYS 144	Electricity and Magnetism	3	
CHEM 114	Foundation Chemistry II	3	
EASC 104	Historical Geology	2	
EASC 106	Geological Field Excursions	1	
Total		**13**	
Electives: Select 3 credits			
MATH 122	Calculus I	3	
MATH 126	Algebra and Geometry	3	
STAT 112	Introduction to Statistics and Probability II	3	
DCIT 104	Programming Fundamentals	3	

INFORMATION TECHNOLOGY

FIRST SEMESTER

Code	Title	Credits	Pre-requisites
Core			
UGRC		3	
DCIT 103	Office Productivity Tools	3	
DCIT 101	Introduction to Computer Science	3	
DCIT 105	Mathematics for IT Professionals	3	
STAT 111	Introduction to Statistics and Probability I	3	
Total		**15**	
Electives: Select 3 to 6 credits			
MATH 123	Vectors and Geometry	3	
ECON 101	Introduction to Economics I	3	Only Single Major IT Students
MATH 121	Algebra and Trigonometry	3	

Students who wish to be considered for Computer Science at Level 200 should take MATH 123 and MATH 121.

SECOND SEMESTER

Code	Title	Credits	Pre-requisites
Core			
UGRC		3	
DCIT 102	Computer Hardware Fundamentals and Circuits	3	
DCIT 104	Programming Fundamentals	3	
MATH 122	Calculus I	3	
Total		**12**	
Electives: Select 6 to 9 credits			
MATH 126	Algebra and Geometry	3	

UGBS 104	Principles of Management	3	
ECON 102	Introduction to Economics II	3	Only Single Major IT
STAT 112	Introduction to Statistics and Probability II	3	

Students who wish to be considered for Computer Science at Level 200 should take MATH 126.

COURSE DESCRIPTIONS

CHEM 113: Foundation Chemistry I

This course is designed to provide students with the fundamental concepts in general chemistry. Topics to be considered will include: measurements and presentation of data, uncertainty in measurements, significant figures; Normal distribution of data, Precision, Accuracy and Propagation of errors in calculations. Acid- base concepts such as Bronsted-Lowry's concept ($\geq 10^{-6}$M); strength of acids and bases; levelling effect of water; pX scale; Hydrolysis of salts (cations and anions) are dealt with. The course concludes with and introduction to redox reactions and its applications; Solubility of sparingly soluble salts and their important terms including ionic product constants; Ksp; common-ion effect and selective precipitation.

Reading List

Atkins, J. W., (1989). *General Chemistry*. Scientific American Books, New York.

Bodner, G. M., & Pardue, H. L., (1995). *Chemistry: An Experimental Science*. John Wiley and Sons, Inc., New York.

Hill, J. W., & Petrucci, R. H., (2002). *General Chemistry: An integrated Approach*. Prentice-Hall Inc., New Jersey.

Kotz, J., & Treichel P., (1999). *Chemistry and Chemical Reactivity.* Saunders College Publishing, New York.

Olmsted, J., & Williams, G., (2002). *Chemistry*. John Wiley and Sons Inc., New York.

Skoog, D., West, D., & Holler, F. J., (1994). *Fundamentals of Analytical Chemistry.* Saunders College Publishing, New York.

Zumdahl, S. S., & Zumdahl, A. S., (2014). *Chemistry (9^{th} Edition)*. Houghton Mifflin Company, Boston, New York.

CHEM 114: Foundation Chemistry II

This course provides a foundation for knowledge in organic chemistry to students. Concepts to be discussed will include structural determination of organic molecules involving the use of major purification techniques, qualitative and quantitative analysis and the use of spectroscopic techniques in structure elucidation. Students will be introduced to the concept of functional groups with a focus on alkanes and cycloalkanes, alkenes and alkynes including for sources, formation, uses and reactions where necessary. Stereochemistry of these hydrocarbons as well as other fundamental organic concepts will be introduced to give a good foundation for subsequent courses in organic chemistry at higher levels.

Reading List

Hill, J. W., & Petrucci, R. H., (2002). *General Chemistry: An integrated Approach*. Prentice-Hall Inc., New Jersey.

Jones, M. Jr., (1997). *Organic Chemistry* (1st Edition). W.W. Norton & Com. Inc.

McMurry, J., (2011). *Fundamentals of Organic Chemistry* (International edition, 7th Edition). Brooks & Cole, Cengage Learning.

Patrick, G. L., (2004). *Organic Chemistry, Instant Notes* (2nd Edition). Bios Scientific Pub.

Zanger, M., & Mckee, J., (1997). *Essentials of Organic Chemistry* (1st Edition). Wm. C. Brown Pub.

Zumdahl, S. S., & Zumdahl, S. A., (2014). Chemistry (9th Edition). Houghton Mifflin Company, Boston, New York.

Hart, D. J., Hadad, M. C., Craine, E. L., & Hart, H., (2012). *Organic Chemistry, A Brief Course* (International edition, 13th Edition). Brooks & Cole, Cengage Learning.

CHEM 120: General Chemistry Laboratory I

This practical course exposes the students to basic techniques in volumetric analysis including: preparation of standard solutions, acid/base titrations; redox titrations involving permanganate, and iodimetry. Applications of volumetric analysis such determination of solubility product constants, purity of reagents, determination of water of hydration will be explored. Throughout the course, attention is drawn to uncertainties in measurements, the use of significant figures, propagation of errors, precision, and accuracy in order to ensure the application of the knowledge gained in the theory.

Reading List

Fifield, F. W., & Kealey, D., (1986). *Principles and practices of analytical chemistry* (2nd edition).

Harris, D. C., (2007). *Quantitative Chemical Analysis* (7th Edition). New York, NY: W.H. Freeman and Co.

John, D., Alan, M. J., David, H., Rob, R., & Jonathan, W., (2010). *Practical Skills in Chemistry.*

Jürg, P. S., (2005). *Good Lab Practice* (2nd edition).

Mendham, J., Denney, R. C, Barnes, J. D., & Thomas, M. J. K., (2000). *Vogel's Quantitative Chemical Analysis* (6th Edition). Prentice Hall.

Vogel, A. I., & Jeffery, G. H., (1989). *Textbook of Quantitative Chemical Analysis*.

CHEM 122: General Chemistry Laboratory II

This laboratory-based course seeks to equip students with further skills in experimental techniques. Qualitative inorganic analysis such as; determination of aluminium, barium, bismuth, calcium, copper, iron, nickel and silver, as well as the identification of halides,

phosphates, sulphates and nitrates; simple organic synthetic preparations such as the synthesis of the analgesic aspirin from salicylic acid and acetic anhydride with exercises in purification and re-crystallization are some of the practical concepts and applications that will be explored.

Reading List

Fabirkiewicz, A. M., & Stowell, J. C, (2015). *Intermediate Organic Chemistry* (3rd Edition). Wiley.

Leonard, J., Lygo, B., & Procter, G., (2013). *Advanced Practical Organic Chemistry* (3rd Edition). CRC press.

Mendlam, J., Denny, R. C., Barnes, J. D., & Thomas, M. J. K., (2000). *Vogel's Quantitative Chemical Analysis* (6th Edition). Prentice Hall.

Suehla, G., (1996). *Vogel's Qualitative Inorganic Analysis* (7th Edition). Prentice Hall.

Vogel, A. I., Tatchell, A. R., Furnis, B. S., Hannaford, A. J., & Smith, P. W. G., (1996). *Vogel Textbook of organic Chemistry* (5th Edition). Pearson.

PHYS 105: Practical Physics I

In this first of a series of practical physics courses, laboratory experiments are conducted to expose students to handling various measuring instruments and to data and error analysis. The course begins with an introduction to physical measurement techniques, data presentation, and error analysis. This is followed by several experiments in mechanics and thermal physics. Additional experiments in other topical areas may be included.

Reading List

Baird, D. C. (1995). *Experimentation: An introduction to measurement theory and experiment design* (3rd Edition). Englewood Cliffs, NJ: Prentice-Hall.

Bennington, P. R., & Robinson, D. K. (2003). *Data reduction and error analysis for the physical sciences*. New York, NY: McGraw-Hill.

Morris, A.S. (2001). *Measurement and instrumentation principles*. Oxford. Butterworth-Heinemann.

Squires, G. L. (2001). *Practical physics* (4th Edition.). Cambridge, UK: Cambridge University Press.

Taylor, J. R. (1982). *An introduction to error analysis.* Mill Valley, CA: University Science Books.

PHYS 106: Practical Physics II

This is the second in a sequence of laboratory courses. PHYS 106 builds on the techniques developed in PHYS 105 and further laboratory experiments are conducted to reinforce data collection and data analysis techniques developed in PHYS 105. Experiments in electricity and magnetism, in optics, electronics, vibrations, oscillations, and waves may be included.

Reading List

Baird, D. C. (1995). *Experimentation: An introduction to measurement theory and experiment design* (3rd Edition). Englewood Cliffs, NJ: Prentice-Hall.

Bennington, P. R., & Robinson, D. K. (2003). *Data reduction and error analysis for the physical sciences*. New York, NY: McGraw-Hill.

Morris, A.S. (2001). *Measurement and instrumentation principles*. Oxford. Butterworth-Heinemann.

Squires, G. L. (2001). *Practical physics* (4th Edition.). Cambridge, UK: Cambridge University Press.

Taylor, J. R. (1982). *An introduction to error analysis.* Mill Valley, CA: University Science Books.

PHYS 143: Mechanics and Thermal Physics

This course is a calculus-based general physics course that introduces students to basic principles in mechanics and thermal physics. Topics covered in the course include the following: vectors and vector algebra; linear momentum; motion; Newton's laws; force; circular motion; work and energy; rotational motion; gravitation; thermodynamic systems; thermal equilibrium; work and heat; First law of thermodynamics; entropy; gas laws; Kinetic theory of gases.

Reading List

Giancoli, D. C. (2016). *Physics: Principles with applications* (7th Edition). Essex, England: Pearson Education Limited.

Halliday, D., Resnick, R., & Walker, J. (2014). *Fundamentals of physics* (10th Edition). Hoboken, NJ: John Wiley & Sons, Inc.

Knight, R. D. (2018). *Physics for scientists and engineers: A strategic approach with modern physics* (4th Edition). Essex, England: Pearson Education Limited.

Tipler, P., & Mosca, G. (2014). *Physics for sscientists and engineers.* New York, NY: W. H. Freeman.

Young, H. D., & Freedman, R. A. (2015). *University physics (with modern physics)* (14th Edition). Essex, England: Pearson Education Limited.

PHYS 144: Electricity and Magnetism

This course is a calculus-based general physics course that introduces students to basic principles in electricity and magnetism. Topics covered in the course include the following: Electric charge and electric field; Gauss' law; electrical potential; capacitance and dielectrics; electric current, resistance and direct-current circuits; magnetic field and magnetic forces; sources of magnetic fields; magnetic materials; electromagnetic induction; displacement current and Maxwell's equations; inductance; alternating current.

Reading List

Giancoli, D. C. (2016). *Physics: Principles with applications* (7th Edition). Essex, England: Pearson Education Limited.

Halliday, D., Resnick, R., & Walker, J. (2014). *Fundamentals of physics* (*extended edition,* 10th Edition). Hoboken, NJ: John Wiley & Sons, Inc.

Knight, R. D. (2018). *Physics for scientists and engineers: A strategic approach with modern physics* (4th Edition). Essex, England: Pearson Education Limited.

Tipler, P. & Mosca, G. (2014). *Physics for sscientists and engineers.* New York, NY: W. H. Freeman.

Young, H. D. & Freedman, R. A. (2015). *University physics (with modern physics)* (14th Edition). Essex, England: Pearson Education Limited.

EASC 101: Physical Geology

This course introduces students to the science of the earth and the processes, both internal and external, that act upon it. The course covers the following topics: minerals; volcanism and extrusive rocks; intrusive activities and origin of igneous rocks; weathering and soil; sediments and sedimentary rocks; metamorphism, metamorphic rocks and hydrothermal rocks; the rock cycle; mass wasting; streams and landscape; groundwater; glaciers and glaciation; deserts and wind action; shorelines and coastal processes; crustal deformation and folds; faults; earthquakes; plate tectonics; mountain building.

Reading List

Busch R.M., & Tasa, D.G. (2014). *Laboratory Manual in Physical Geology* (10th Edition0. Pearson.

Jordan, T.H., & Grotzinger, J. (2014). *Understanding Eart*h (7th Edition). W.H. Freeman.

Monroe, J.S., Wicamber, R., & Hazlet, R. (2006). *Physical Geology: Exploring the Earth*, 6th Edition. *Brooks Cole.*

Plummer, C.C., Carlson, D., & Hammersley, L. (2015). *Physical Geology* (15th Edition). McGraw-Hill Education.

Tasa, D.G., Lutgens, F.K., & Tarbuck, E.J. (2016). *Earth: An introduction to Physical Geology* (12th Edition). Pearson.

EASC 106: Geological Field Excursions

This course allows students to visit appropriate facilities or selected areas of interest and is designed to reinforce geological concepts learnt in class. This presents a useful and interesting way to learn about the environment and geological processes. Study trips may include visits to large and small industrial firms throughout the entire country, or tunnel projects that are underway, as well as natural areas that require special measures with regards to the environment.

Reading List

Busch, R. M., & Tasa, D.G. (2014). *Laboratory Manual in Physical Geology* (10th Edition). Pearson.

Jordan, T.H., & Grotzinger, J. (2014). *Understanding Earth* (7th Edition). W.H. Freeman.

Monroe, J.S., Wicamber, R., & Hazlet, R. (2006). Physical Geology: *Exploring the Earth* (6th Edition). Brooks Cole.

Plummer, C.C., Carlson, D., & Hammersley, L. (2015). *Physical Geology* (15th Edition). McGraw-Hill Education.

Tasa, D.G., Lutgens, F.K., & Tarbuck, E.J. (2016). *Earth: An introduction to Physical Geology* (12th Edition). Pearson.

EASC 104: Historical Geology

The course provides students with an understanding of the principles of historical geology and how these principles are applied in unravelling Earth's history. It begins with discussions on concepts and principles, followed by a chronological discussion of Earth and life history. It then discusses the lessons learned from the geologic past to understand and place in context some of the global issues facing the world today, such as depletion of natural resources, global climate warming, and decreasing biodiversity.

Reading List

Gore, P.W. (2014). *Historical Geology Lab Manual* (1st Edition). Wiley.

Monroe, J.S., & Wicander, R. (2015). *Historical Geology* (8th Edition). Brooks Cole.

Poort, J.M., & Carlson, R.J. (2004). *Historical Geology: Interpretations and Applications* (6th Edition). Pearson.

Ritter, S., & Petersen, M. (2006). *Interpreting Earth History: A Manual of Historical Geology* (8th Edition). Waveland Press, Inc.

Stanley, S.M., & Luczaj, J.A. (2014). *Earth System History* (4th Edition). W.H. Freeman.

DCIT 101 Introduction to Computer Science

This course provides a broad survey introducing the key areas the computer science discipline and information technology discipline. It introduces computers and how they work, their classification and historical development. Topics covered will include Application of computers; Data representation in Computers; Peripherals; Files; Systems Engineering; Databases; Computer architecture; Assembly language; Data Communications and networking; Systems software; Programming concepts in very accessible language Python; Algorithms and data structures; The internet and Web Technology. Programming assignments are inspired by real-world domains of cryptography, forensics, gaming and finance.

Reading List

Heathcote, P., & Bond, K. (2013). *A Level Computing.* London: BPP (Letts Educational).

Brookshear, J. G. (2011). *Computer Science: An Overview* (11th Edition). Boston: Addison Wesley.

Geoffrey, S. (2008). *Introduction to Computer Information System* (2nd Edition.). Iowa: Kendall Hunt Publishing.

Kamaljeet, S. (2013). *Fundamentals of Computing* (2nd Edition). Iowa: Kendall Hunt Publishing.

Miller, M. (2011). *Absolute Beginner's Guide to Computer Basics* (4th Edition). New York: Que Publishing.

DCIT 102 Computer Hardware and Circuits

It provides comprehensive understanding of the essential components associated with computers with a focus on PCs. Topics include: The microprocessor, motherboard, memory, graphics and sound adapters, I/O devices storage and circuit theory. An overview of operating systems and other software, as well as the various methods used to connect computers to each other and the Internet, are presented. The course also addresses recent advances in computer architectures and computer hardware and how they affect computer performance. Presentations of actual hardware are included so that students can gain experience in identifying the various internal and external components of a PC.

Reading List:

Dandamudi, S. P. (2013). *Fundamentals of Computer Organization and Design* (3rd Edition). New York: Springer.

Norton, P., & Clark, S. H. (2012). *Inside the PC* (2nd Edition). Indianapolis, IN: Sams Publishing.

Parker, C. S., & Morley, D. (2014). *Understanding Computers: Today and Tomorrow, Introductory* (13th Edition). Cambridge, MA: Course Technology.

Patterson, D. A., & Hennessy, J. L. (2012). *Computer Organization and Design: The Hardware/Software Interface (The Morgan Kaufmann Series in Computer Architecture and Design).* Amsterdam: Morgan Kaufmann.

White, R., & Downs, T. E. (2013). *How Computers Work* (9th Edition). Indianapolis, IN: Que Pub.

DCIT103 Office Productivity Tools

This course teaches use of office productivity tools. Microsoft Office 2016 software products Word, Excel, Outlook, and PowerPoint will be taught in depth. Topics include: Word– creating documents text editing, formatting, saving, and printing, creating table of contents; commenting tools, proofing, tracking; Excel- creating spreadsheets, data entry, formatting, formulas, functions, tables and performing calculations on data, charts and graphics, dynamic

worksheets using pivot tables, macros; Outlook- setting up Outlook server, managing email messages, contacts, appointments and tasks, and efficiency and customization; PowerPoint-creating slide presentations using design templates, formatting, graphics, animations, presentation, add sounds and graphics, visual elements, and tables.

Reading List

Curtis, F. (2015). *Microsoft Excel 2016 Step by Step* (1st Edition).

Joan, L. (2016). *Microsoft Outlook 2016 Step by Step*, (1st Edition). Microsoft Press.

Margo, C. A., Lisa, H., Catherine, H., & Stephanie M-W. (2016). *Skills for Success with Microsoft Office 2016 Volume 1 (Skills for Success for Office 2016 Series)* (1st Edition).

Steven, M. F., Joy, L. S., & Eric, S.(2016). *Cashman Series Microsoft Office 365 & Excel 2016: Comprehensive*, (1st Edition). CENGAGE Learning.

Randy, N. (2016). *Microsoft Office 2016: In Practice*, (1st Edition).

DCIT 104 Programming Fundamentals

Problem Solving and Programming are essential skills for IT students and IT professionals. Learning how to solve a problem using a structured programming language provides a strong foundation for a successful career. Designing of solutions to problems using procedural techniques and deciding on an appropriate repetition and/or selection structures for given problems will be covered. Topics Include: The importance of algorithms in the problem-solving process; Properties of good algorithms, Algorithms for solving simple problems; the use of a programming language to implement, test, and debug algorithms for solving simple problems, data definition, control structures, functions, arrays, pointers and strings.

Reading List:

Dean, J., & Dean, R. (2012). *Introduction to Programming with Java: A Problem Solving Approach* (4th Edition). Dubuque, IA: McGraw-Hill.

Felleisen, M., Findler, R. B., Flatt, M., & Krishnamurthi, S. (2011). *How to Design Programs: An Introduction to Programming and Computing,* Cambridge, MA: MIT Press.

Liang, D. Y. (2014). *Intro to Java Programming, Comprehensive Version (10th Edition)*. Pearson.

Robertson, L. A. (2010). *Simple Program Design, A Step-by-Step Approach,* (5th Edition). Cambridge, MA: Course Technology.

Savitch, W. (2013). *Java: An Introduction to Problem Solving and Programming* (6th Edition). Harlow: Addison Wesley.

CSIT 104: Mathematics for IT Professionals

This course will cover some particularly important concepts used in computer science. Graph theory concepts are used in networks, operating systems, and compilers. Set theory concepts are used in software engineering and in databases. Topics to be covered include Sets Venn diagrams, Cartesian product, Power sets, Cardinality of finite sets; Relations, Reflexivity, symmetry, partial orders; Functions, Surjections, injections, bijections, Inverses,

Composition; Trees, Properties, Traversal strategies, Undirected graphs, Directed graphs, Weighted graphs, Spanning trees/forests, Graph isomorphism; Counting arguments, Set cardinality and counting, Sum and product rule, Inclusion-exclusion principle, Arithmetic and geometric progressions, The pigeonhole principle, Permutations and combinations, Pascal's identity.

Reading Lists:

Barnett, R. A. (1999). *Applied Calculus with Linear Programming for Business, Economics, Life Sciences and Social Sciences* (5th Edition). Boston, MA: Prentice Hall.

Busbee, K. L. (2009). *Programming Fundamentals: A Modular Structured Approach Using C++*. Orange Grove Texts Plus.

Larson, R., Edwards, B. H., & Falvo, D. C. (1999). *Brief Calculus: An Applied Approach,* (5th Edition). Boston, MA: Houghton Mifflin College Div.

Lex, H., & Toon, K. (2007). *Applied Mathematics for Database Professionals*. New York, Apress.

Steele, J. M. (2010*). Stochastic Calculus and Financial Application (Stochastic Modelling and Applied Probability)*. Berlin: Springer.

MATH 121: Algebra and Trigonometry

This course is a precalculus course which aims to develop the students' ability to think logically, use sound mathematical reasoning and understand the geometry in algebra. It includes advanced levels of topics addressed in high school such as arrangements, selections and the binomial theorem. Sequences and series. Logic and Proof. Set theory. Indices, logarithms and the algebra of surds. Concept of a function. Trigonometric functions, their inverses, their graphs, circular measure and trigonometric identities.

Reading List:

Backhouse, J.K., Houldsworth, S.P.T., & Cooper B.E.D. (2010). *Pure Mathematics 2,* Longman.

Bittinger, M. L. et al (2012) *Algebra and Trigonometry* (5th edition). Pearson

Bostock, L., Chandler, S., & Thorpes, S. (2014). *Mathematics; the core course for A-level.* Oxford University Press.

Bostock, L., Chandler. S., & Thorpes, S. (2014) *Further Pure Mathematics*, Oxford University Press.

Spiegel, M.R., & Moyer, R.E. (2014). *Schaum's Outline of College Algebra* (4th Edition). McGraw-Hill Education

MATH 123 Vectors and Geometry

Vectors may be used very neatly to prove several theorems of geometry. This course is about applying vector operations and the method of mathematical proof (of MATH 121) to geometric problems. The areas of study include: vector operations with geometric examples;

components of a vector and the scalar product of vectors. Coordinate geometry in the plane including normal vector to a line, angle between intersecting lines, reflection in a line, angle bisectors and the equation of a circle, the tangent and the normal at a point.

Reading List:

Akyeampong, D.A., (2006). *Vectors and Geometry*. Departmental Lecture notes.

Backhouse, J.K., Houldsworth, S.P.T., & Horril, P.J.F. (2010). *Pure Mathematics*. Longman

Bostock, L., Chandler. S., & Thorpes, S. (2014). *Further Pure Mathematics*. Oxford University Press.

Robinson, G. B. (2011). *Vector geometry*. Dover.

Schuster, S. (2008). *Elementary Vector Geometry.* Dover.

MATH 122: Calculus I

Elementary idea of limit, continuity and derivative of a function. Rules of differentiation. Applications of differentiation. Derivative of the elementary and transcendental functions. Methods of integration. Improper integrals. Applications of integration. Formation of differential equations and solution of first order differential equations both separable variable type and using an integrating factor.

Reading List:

Hughes-Hallett, D., Gleason A.M., et al (1994). *Calculus*. A. J. Wiley.

Kline, M. (1998). *Calculus: An Intuitive and Physical Approach* (2nd Edition). Dover.

Lang, S. (1998). *A First Course in Calculus* (Undergraduate texts). Springer.

Stewart, J. (1995). *Calculus, concepts and context*. Brooks/Cole

Thomas, G.B., & Finney, R.L. (1995). *Calculus and Analytic Geometry*. Addison Wesley Publishing Company

MATH 126 Algebra and Geometry

This is a course which highlights the interplay of algebra and geometry. It includes topics such as: polar coordinates; conic sections. Complex numbers, Argand diagram, DeMoivre's theorem, roots of unity. Algebra of matrices and determinants, linear transformations. Transformations of the complex plane. Sketching polar curves and some coordinate geometry in 3 dimensions. Vector product and triple products.

Reading List:

Beacher, J., Penna, J. A., & Bittinger, M. L. (2005). *College Algebra (*2nd Edition). Addison Wesley

Copeland, A. H. (1962). *Geometry, algebra and trigonometry by vector methods.* Mac-Millan

Safler, F. (2012). *Schaum's Outline of Precalculus* (3rd Edition). McGraw-Hill Education

Spiegel, M.R., & Moyer, R.E. (2014). *Schaum's Outline of College Algebra (4th Edition).* McGraw-Hill Education

Sullivan, M. (2005). *College Algebra.* Prentice Hall.

MATH 101 General Mathematics I (Non-Mathematics students)
The aim of this course is to equip students with sufficient elementary algebra and calculus to allow them to solve elementary problems in the biological and physical world. Topics from high school are revised and in some cases extended. The main focus is to provide sufficient precalculus and trigonometry to allow students to apply calculus to problem solving.

Reading List:
Aufman, R.N., Barker, V.C., & Nation, R. D. (2008). *College Algebra.* Houghton, Mifflin Boston

Backhouse, J.K., & Houldsworth, S.P.T (2010). *Pure Mathematics 1.* Longman.

Greenwell, R. N., Ritchey, N.P., & Lial, M. L. (2002). C*alculus with applications to the life sciences.* Pearson

Lial, M. L., & Miller, C.D. (1975). *Essential calculus with applications in Business, Biology and the Behavioural Sciences.* Pearson Scott Foresman

Mannal, G., & Kenwood, M. (1994). *Pure mathematics 2.* Heinemann Publishers Oxford

STAT 111: Introduction to Statistics and Probability I
This course introduces students to basic principles in Statistics and Probability. The definition, reduction and interpretation of data. Introduction to basic concepts of Probability; Random Events and Random Variables, and Bayes Theorem. Students will be given overview of computational statistics and an introduction to the computing environment. The statistical software (R, Minitab and Stata) will be used to execute concepts learned in class. Methods of data description and analysis using R, Minitab and Stata: emphasis on learning statistical methods and concepts through hands-on experience with real data. One-hour Lab session a week will be organized for students.

Reading List
Anderson, A. J. (1989). *Interpreting data: a first course in statistics* (Vol. 8). CRC

Clarke, G. M., & Cooke, D. (1979). *Basic course in statistics* [A]. Press.

Rizzo, M.L. (2007). *Statistical Computing with R*.

Schinazi, R. B. (2011). *Probability with statistical applications*. Springer Science & Business Media.

Sheldon, R. (2002). *A first course in probability*. Pearson Education India.

STAT 112: Introduction to Statistics and Probability II
This course is aimed at enhancing students understanding of basic principles in Statistics and Probability. Relative frequency function, Introduction to probability distributions, some univariate probability distributions; Bernoulli, Binomial, Poisson, Uniform distributions. Simulation of random variables from probability distributions; Bernoulli, Binomial, Uniform distributions using R, Minitab and Stata: mean, variance, mode of probability distribution. Writing simple codes to generate discrete random values of the Bernoulli, Binomial and Poisson distributed random variables. One-hour Lab session a week will be organized for students.

Reading List
Chung, K.L. (2012). *Elementary probability theory with stochastic processes*. Springer Science & Business Media.

Feller, W. (1968). *An Introduction to probability theory and its applications*. Vol. I. London-New York-Sydney-Toronto: John Wiley & Sons.

Rizzo, M.L. (2007). *Statistical computing with R.*

Schinazi, R.B. (2011). *Probability with statistical applications*. Springer Science & Business Media.

Sheldon, R. (2002). *A first course in probability*. Pearson Education India.

LEVEL 200 - 400
TYPE OF DEGREE PROGRAMMES
The SPMS will continue to run three types of programmes:
1. Single-Subject Major
2. Major – Minor
3. Combined –Major

Single-Major Programmes
1. Actuarial Science
2. Applied Geology
3. Applied Geophysics
4. Biomathematics
5. Chemistry
6. Computer Science
7. Geology
8. Geophysics
9. Information Technology
10. Mathematics
11. Physics
12. Statistics

Combined-Major Programmes
1. Chemistry and a Biological Science programme
2. Chemistry and Physics
3. Computer Science and Mathematics

4. Computer Science and Statistics
5. Computer Science and Physics
6. Mathematics and Statistics
7. Physics and Mathematics
8. Physics and Statistics

Major-Minor

1. Computer Science with Mathematics
2. Computer Science with Physics
3. Computer Science with Statistics
4. Geology with Physics
5. Geology with Mathematics
6. Mathematics with Computer Science
7. Mathematics with Physics
8. Mathematics with Statistics
9. Mathematics with Geology
10. Physics with Computer Science
11. Physics with Geology
12. Physics with Mathematics
13. Statistics with Computer Science
14. Statistics with Mathematics
15. Physics with Statistics

BACHELOR OF SCIENCE PROGRAMMES
DEPARTMENT OF CHEMISTRY

The Department of Chemistry runs two types of undergraduate degrees: Single Major and Combined-Major degrees. For the Combined Major programme students combine Chemistry with other subjects such as Biochemistry, Physics, Geology, Animal Biology, Botany, Psychology and Nutrition and Food Science. Entry requirement is passes in the following Level 100 courses: CHEM 113, CHEM 114, CHEM 120 and CHEM 122.

SINGLE MAJOR IN CHEMISTRY

LEVEL 200

FIRST SEMESTER

Code	Title	Credits	Pre-requisite
Core			
CHEM 217	Physical Chemistry I	2	CHEM 113
CHEM 233	Organic Chemistry I	2	CHEM 114
CHEM 271	Foundation Chemistry III	2	CHEM 113
CHEM 215	Structure and Bonding	2	

CHEM 203	Analytical Chemistry Laboratory I	1	CHEM 120
UGRC		3	
Total		**12**	
Electives: Select 3 to 6 credits from other departments			

SECOND SEMESTER

Code	**Title**	**Credits**	**Pre-requisite**
Core			
CHEM 234	Organic Chemistry II	2	CHEM 114, CHEM 233
CHEM 252	Inorganic Chemistry I	2	
CHEM 272	Analytical Chemistry I	2	CHEM 113, CHEM 271
CHEM 216	Chemistry of Materials	2	CHEM 215
CHEM 204	Organic Chemistry Laboratory I	1	
UGRC		3	
Total		**12**	
Electives: Select 3 to 6 credits from other departments			

LEVEL 300
FIRST SEMESTER

Code	**Title**	**Credits**	**Pre-requisite**
Core			
CHEM 301	Mathematics for Chemists	2	
CHEM 341	Spectroscopy and Structure Elucidation	3	
CHEM 343	Chemistry of Aromatic Compounds	3	CHEM 233, CHEM 234
CHEM 355	Inorganic Chemistry II	3	CHEM 252
CHEM 311	Physical Chemistry Laboratory	2	
CHEM 351	Inorganic Chemistry Laboratory	2	CHEM 252
Total		**15**	
Electives: Select up to 3 credits from other departments			

SECOND SEMESTER

Code	**Title**	**Credits**	**Pre-requisite**
Core			
CHEM 312	Thermodynamics I	2	CHEM 217
CHEM 344	Carbanions and their Reactions	2	CHEM 233, CHEM 234
CHEM 346	Molecular Rearrangement Reactions	2	CHEM 233, CHEM 234
CHEM 352	Coordination Chemistry	2	CHEM 252, CHEM 355
CHEM 374	Analytical Chemistry II	3	CHEM 272
CHEM 332	Organic Chemistry Laboratory II	2	
CHEM 372	Analytical Chemistry Laboratory II	2	
Total		**15**	
Electives: Select up to 3 credits from other departments			

LEVEL 400

FIRST SEMESTER

Code	Title	Credits	Pre-requisite
Core			
CHEM 400	Project	3	
CHEM 401	Thermodynamics II	2	CHEM 312
CHEM 403	Symmetry, Group Theory and Application	2	CHEM 217, CHEM 215
CHEM 405	Reaction Kinetics	2	
CHEM 441	Chemistry of Natural Products	3	CHEM 217
Total		**12**	
Electives: Select minimum of 2 credits from <u>each</u> Group			
Group A			
CHEM 439	Organometallic Chemistry	2	CHEM 252, CHEM 355, CHEM 352
CHEM 437	Medicinal Chemistry	2	
CHEM 423	Polymer Chemistry and Technology	2	CHEM 233, CHEM 234
CHEM 471	Nuclear Chemistry	2	
CHEM 473	X-ray Crystallography	2	
Group B			
CHEM 491	Petroleum Chemistry and Technology	2	
CHEM 493	Mineral Processing	2	
CHEM 495	Pulp and Paper Chemistry and Technology	2	

SECOND SEMESTER

Code	Title	Credits	Pre-requisite
Core			
CHEM 400	Project	3	
CHEM 402	Quantum Chemistry	2	CHEM 301
CHEM 412	Surface Chemistry and Colloids	2	
CHEM 454	Transition Metal Chemistry	3	CHEM 252, CHEM 355, CHEM 352
CHEM 472	Instrumental Methods of Chemical Analys	3	
Total		**13**	
Electives: Select minimum of 2 credits from <u>each</u> Group			
Group A			
CHEM 414	Molecular Structure	2	
CHEM 452	Solid State Chemistry	2	CHEM 403
CHEM 492	Industrial Chemistry	2	
CHEM 494	Textile Chemistry and Technology	2	
Group B			

CHEM 474	Elements of Forensic Chemistry	2	CHEM 113, CHEM 271
CHEM 496	Environmental Chemistry	2	CHEM 271

COMBINED MAJOR IN CHEMISTRY

LEVEL 200

FIRST SEMESTER

Code	Title	Credits	Pre-requisite
Core			
CHEM 233	Organic Chemistry I	2	CHEM 114
CHEM 271	Foundation Chemistry III	2	
CHEM 215	Structure and Bonding	2	
CHEM 203	Analytical Chemistry Laboratory I	1	
CHEM 217	Physical Chemistry I	2	
Total		**9**	

SECOND SEMESTER

Code	Title	Credits	Pre-requisite
Core			
CHEM 234	Organic Chemistry II	2	CHEM 114
CHEM 252	Inorganic Chemistry I	2	
CHEM 272	Analytical Chemistry I	2	
CHEM 204	Organic Chemistry Laboratory I	1	
CHEM 216	Chemistry of Materials	2	
Total		**9**	

LEVEL 300

FIRST SEMESTER

Code	Title	Credits	Pre-requisite
Core			
CHEM 343	Chemistry of Aromatic Compounds	3	CHEM 233, CHEM 234
CHEM 355	Inorganic Chemistry II	3	CHEM 252
Electives: Select 2 credits			
CHEM 311	Physical Chemistry Laboratory	2	
CHEM 351	Inorganic Chemistry Laboratory	2	

SECOND SEMESTER

Code	Title	Credits	Pre-requisite
Core			
CHEM 312	Thermodynamics I	2	
CHEM 374	Analytical Chemistry II	3	

Electives: Select a minimum of 2 credits from each Group			
Group A			
CHEM 344	Carbanions and their Reactions	2	CHEM 114, CHEM 233, CHEM 234
CHEM 346	Molecular Rearrangement Reactions	2	
CHEM 352	Coordination Chemistry	2	
Group B			
CHEM 332	Organic Chemistry Laboratory II	2	
CHEM 372	Analytical Chemistry Laboratory II	2	

LEVEL 400

FIRST SEMESTER

Code	Title	Credits	Pre-requisite
Group A: Select a minimum of 5 credits			
CHEM 401	Thermodynamics II	2	CHEM 312
CHEM 423	Polymer Chemistry and Technology	2	CHEM 233, CHEM 234
CHEM 405	Reaction Kinetics	2	
CHEM 441	Chemistry of Natural Products	3	
Group B: Select a minimum of 2 credits			
CHEM 403	Symmetry, Group Theory and Applicati	2	
CHEM 437	Medicinal Chemistry	2	
CHEM 439	Organometallic Chemistry	2	
CHEM 471	Nuclear Chemistry	2	
CHEM 473	X-ray Crystallography	2	
Group C: Select a minimum of 2 credits			
CHEM 491	Petroleum Chemistry and Technology	2	
CHEM 493	Mineral Processing	2	
CHEM 495	Pulp and Paper Chemistry and Technolo	2	

SECOND SEMESTER

Code	Title	Credits	Pre-requisite
Group A: Select minimum 2 credits			
CHEM 402	Quantum Chemistry	2	CHEM 301
CHEM 412	Surface Chemistry and Colloids	2	
Group B: Select minimum 3 credits			
CHEM 454	Transition Metal Chemistry	3	
CHEM 472	Instrumental Methods of Chemical Analysis	3	
Group C: Select minimum 2 credits			
CHEM 414	Molecular Structure	2	
CHEM 492	Industrial Chemistry	2	
CHEM 494	Textile Chemistry and Technology	2	
CHEM 452	Solid State Chemistry	2	
Group D: Select minimum 2 credits			
CHEM 474	Elements of Forensic Chemistry	2	CHEM 113, CHEM 271

CHEM 496	Environmental Chemistry	2	CHEM 271

COURSE DESCRIPTIONS

CHEM 203: Analytical Chemistry Laboratory I
This laboratory-based course is designed to complement theoretical lectures in quantitative analytical chemistry. This component provides students with experience in the analysis of environmental samples. Students are introduced to safety in the analytical laboratory, titration of acid-base mixtures, total alkalinity, hydrolysis of salts, pH of buffer solutions and solubility products; rates of chemical reactions, iodometric titrations, determination of hardness in varied water samples, analysis of commercial bleaching products and silver in alloys (Volhard's method). Additionally, solution preparation, basic skills in titrimetry, pH measurements, etc are surveyed at the beginning of the course.

Reading List
Fifield, F. W., & Kealey (2000). *Principles and Practice of Analytical Chemistry.* Wiley & Sons.

Gary, C. (2004). *Analytical Chemistry* (6th Edition). John Wiley & Sons, New York.

Jeffery, G.H., Basset, J., & Denney, R. C., (2008). *Vogel's Quantitative Practical Chemical Analysis* (5th Edition). John Wiley & Sons, INC., New York.

Kenkel, J., (2003). *Analytical Chemistry for Technicians*. CRC Press Boca Raton, Florida, USA.

Svehla, G.C., (2006). *Vogel's Textbook of macro and semi qualitative inorganic analysis* (5th Edition). John Wiley & Sons, INC., New York.

CHEM 204: Organic Chemistry Laboratory I
This laboratory-based course seeks to complement theoretical lectures in basic organic chemistry. Here students are taught skills such as synthesis of organic compounds (e.g. esters, acids, ketones) requiring basic heating under reflux, distillation, crystallization, extraction, filtration, melting point determination and spectroscopic (UV) analysis. Additionally, students are made to engage in the qualitative analysis of alcohols, carboxylic acids, aldehydes, ketones, amines and phenols.

Reading List
Fessenden, R., & Fessenden, J. S., (2013). *Organic Laboratory Techniques* (3rd Edition).

Furniss, B.S., Hannaford, A.J., Smith, P.W.G., & Tatchell, A.R., (1989). *Vogel's Practical Organic Chemistry* (5th Edition). John Wiley & Sons, INC., New York.

Isaac-Garcia, J., Dobado, A. J., Calvo-Flores, G.F., & Martinez-Garcia, H., (2015). *Experimental Organic Chemistry.* Elsevier Science & Technology.

Nichols, L., (2016). *Organic Laboratory Techniques*. Independent.

Wade Jr, L.G., (2013). *Organic Chemistry*. Pearson Education Inc. New York.

Zubrick, J. W., (1998). *The Organic Chem Lab Survival Manual: A Student's Guide to Techniques.* John Wiley and Sons, New York.

CHEM 216: Chemistry of Materials

As a follow-up to structure and bonding, this course looks at the binding forces in various solid materials including metals, alloys, molecules, covalent and ionic crystals and their related properties and internal structures. The geometric and energetic factors affecting ionic crystals are discussed, together with the effects of polarization, and the changes that result on introduction of complex ions - the later illustrated with silicates. Structure and properties of glasses, polymers, and composites, as well as new materials such as nanomaterials are also discussed.

Reading List

Allcock, H. R. (2008). *Introduction to Materials Chemistry.* John Wiley and Sons Inc, NJ USA.

Fahlman, B. D. (2011). *Materials Chemistry.* Springer Publishers.

Gersten, J. I., & Smith, F. W. (2001). *The physics and chemistry of materials*. Wiley Interscience.

Robert, J., & Naumann, R. J. (2008). *Introduction to the Physics and Chemistry of Materials.* CRC Press, Boca Raton, FL.

Paul J., & van der Put. (1998). *The Inorganic Chemistry of Materials: How to make things out of elements.* Plenum Press, NY.

CHEM 217: Physical Chemistry I

This course is designed to introduce students to some fundamental concepts in physical chemistry with a focus on chemical equilibrium and kinetics of reactions. Topics to be considered under Chemical Reactions and equilibrium will include: Enthalpy of reactions; heat capacities; Born-Haber cycle (Hess' law); Bond energies, standard enthalpies of formation; Entropy; Gibbs free energy and spontaneity; relationship between free energy, enthalpy and entropy. Under kinetics, topics to be considered will be: differential rate law, rate constants, order of reactions, effects of concentration, temperature (Arrhenius equation); mechanical slope method (No integrated rate laws); and the concept of reaction mechanism.

Reading List

Alberty, R. A., & Silbey, R. J. (1997). *Physical chemistry.* Wiley publishers.

Ball, D. W., (2015). *Physical chemistry* (2nd Edition). Cengage Learning, CT, USA.

Hans Kuhn, H., Forsterling, H-D., & Waldeck, D. H., (2009). *Principles of Physical Chemistry* (2nd Edition). John Wiley and Sons Inc, NJ, USA.

Mortimer, R. G., (2008). *Physical Chemistry*. Elsevier Academic Press, London, UK.

Atkins, P., & De Paula, J. (2006). *Physical Chemistry for the Life Sciences.* Freeman Publishers.

CHEM 215: Structure and Bonding

This course seeks to provide students with fundamental knowledge in atomic structure and bonding in elements and molecules. A qualitative treatment of the Quantum Mechanical Model of the atom is introduced and discussed. Other topics will include: quantum numbers; shape of orbitals; electronic configuration of atoms; chemical periodicity; and models of chemical bonding. Valence Bond concepts such as orbital overlaps; electron-pair sharing; sigma- and pi-bonds; hybridization (as mathematical combination of atomic orbitals LCAO); Valence bond description of simple molecules; VSEPR; as well and qualitative Molecular Orbital model are discussed.

Reading List

Barrett, J., (2002). *Atomic Structure and Periodicity*. The Royal Society of Chemistry, Cambridge, UK

Dekock, R. L., & Gray, H. B. (1989). *Chemical Structure and Bonding* (2nd edition). University Science Books, USA.

Hill, J. W., & Petrucci, R. H. (2002). *General Chemistry: An Integrated Approach*. Prentice Hall Publishers.

Kotz, J. C., & Paul-Treichel, P. Jr., (1999). *Chemistry and Chemical Reactivity* (4th edition). Saunders College Publishing, New York, USA.

Meek, T. L., (1998). *An Introduction to Spectroscopy, Atomic Structure and Chemical Bonding.* Canoe Press, University of the West Indies.

CHEM 233: Organic Chemistry I

This course builds on the knowledge gained in CHEM 114 by providing students with a sound understanding of some important concepts in Organic Chemistry. The phenomenon of Stereochemistry which plays a very vital role in Organic Chemistry is extensively treated. The treatment includes an in-depth review of Stereochemistry both configurational and conformational. In addition, compounds with more than one chiral center, pairs of Enantiomers, diastereomers, Meso compounds, Racemic mixtures and Stereoisomerism of disubstituted cycloalkanes are considered. Some important classes of Organic Compounds such as alkenes, alcohols and ethers are discussed with special emphasis on their nomenclature, properties, preparations and reactions.

Reading List

Bailey, P. S. Jr., Bailey, C. A., (1995). *Organic Chemistry; A brief Survey of Concepts and Applications* (5th Edition). Prentice-Hall International (UK) Limited, London.

Graham, S. T.W., Fryhle, C.B., & Synder, S. C., (2011). *Organic Chemistry*. John Wiley and Sons.

Loudon G. M., (2009). *Chemistry of Organic Compounds* (3rd Edition). Roberts and Company Publishers.

Vollhardt, K. P. C., Schore N. E., (2007). *Organic Chemistry, Structure and Function* (5th Edition). W. H. Freeman & Co., New York.

Wade, Jr. L.G., (2013). *Organic Chemistry* (9th Edition). Pearson, Boston.

CHEM 234: Organic Chemistry II

This course introduces the student to the carbonyl and amine functional groups in Organic Chemistry. It involves treatment of the structures and naming systems of these functional groups. The course also treats the properties of these compounds, their preparations, reactions including mechanisms and some applications. Simple identification tests for these functional groups are also considered. The similarities and differences between the aldehydes and ketones on one hand and the carboxylic acids and their derivatives on the other are extensively looked at.

Reading List

Loudon, G. M., (2009). *Chemistry of Organic Compounds* (3rd Edition). Roberts and Company Publishers.

Schmid, G. H., (1996). *Organic Chemistry*. Mosby Publishers. St. Louis, Missouri.

Solomons, G.T.W., Fryhle, C.B., & Synder, S. C., (2011). *Organic Chemistry*. John Wiley and Sons.

Vollhardt, K. P. C., & Schore, N. E., (2007). *Organic Chemistry, Structure and Function* (5th Edition). W. H. Freeman & Co., New York.

Wade, Jr. L.G., (2013). *Organic Chemistry* (9th Edition). Pearson, Boston.

CHEM 252: Inorganic Chemistry I

This course deals with the systematic chemistry of the s-block elements namely the main group elements. Group 1A (the alkali metals, Group IIA (the alkaline Earth Metals) and Group IIB (Zinc, Cadmium and Mercury) including their organometallic compounds will be covered. Physical and chemical periodic trends including atomic and ionic size, ionization energies, electronegativity and metallic character will be discussed. Anomalous position of Hydrogen on the periodic table and properties of its isotopes will be covered. Properties of compounds of these elements including, oxides, hydroxides, halides, carbonates, carbides will also be highlighted.

Reading List

Cotton, F. A., Wilkinson, G., Murilo, C.A., & Bochman, M., (1998). *Advanced Inorganic Chemistry (*6th Edition). New York, Wiley.

Greenwood, N. N., & Earnshaw A., (1997). *Chemistry of the Elements* (2nd Edition). Butterworth-Heinemann

Huheey, J. H., (1972). *Inorganic Chemistry - Principles, structure and reactivity*. New York. (NY) Harper and Row.

Lee, J.D., (1998). *Concise Inorganic Chemistry* (5th Edition). Wiley-Blackwell.

Meisler, G.L., Fischer, P.J., & Tarr, D., (2014). *Inorganic Chemistry* (5th Edition) Pearson.

CHEM 271: Foundation Chemistry III

This course builds on the knowledge gained in CHEM 111 and involves the quantitative treatment of ampholytes, (salts and amino acids), Buffer solutions, and very dilute solutions ($\leq 10^{-6}$M) of Bronsted-Lowry acids and bases. The Method of Successive Approximations; Electrochemistry-Electrode and galvanic cells; Nernst Equation; Concentration cells; applications of emf measurements in the determination of e.g. standard potentials, solubility and Ksp, dissociation constants; Potentiometric titrations; Conductance and applications of conductivity measurements are discussed.

Reading List

Hill, J. W., & Petrucci, R. H., (2002). *General Chemistry: An Integrated Approach*. Prentice Hall, Upper Saddle River, New Jersey, USA.

Khopkar, S. M., (1998). *Basic Concepts of Analytical Chemistry*. New Age International Publishers, New Delhi.

Gary, C. D., (2003). *Analytical Chemistry* (6th Edition). John Wiley and Sons.

Mermet, J-M., Otto, M. & Kellner, R., (2004). *Analytical chemistry: a modern approach to analytical science.* Wiley-VCH.

Skoog, D. A., West, D. M., Holler, F. J., & Crouch, R. S., (2014). *Fundamentals of Analytical Chemistry* (9th Edition). Sanders College Publishing, San Francisco, USA.

CHEM 272: Analytical Chemistry I

This course introduces students to some fundamental principles of analytical chemistry. The course begins with an introduction to analytical chemistry, the analytical process, units, concentration and stoichiometry. Calibration curves and their use in estimating concentrations, experimental errors and statistical analysis for evaluating the data are explored. Finally sampling techniques, quality assurance and quality control, as well as gravimetric analysis and applications are discussed.

Reading List

Gary, C. D., (2003). *Analytical Chemistry* (6th Edition). John Wiley and Sons.

Khopkar, S. M., (1998). *Basic Concepts of Analytical Chemistry*. New Age International Publishers, New Delhi.

Kateman, G., & Buydens, L. (1993). *Quality Control in Analytical Chemistry* (2nd Edition). John Wiley and Sons Inc, NY, USA

Mermet, J-M., Otto, M. & Kellner, R. (2004). *Analytical chemistry: a modern approach to analytical science.* Wiley-VCH.

Skooge, D. A., West, D., Holler, F. J. & Crouch, S. (2004). *Fundamentals of Analytical Chemistry.* Thomson Learning Inc,

CHEM 301: Mathematics for Chemists

This course is tailored to suit chemistry majors and intends to give basic mathematical skills to the chemist especially those in physical chemistry. Calculus of functions of several variables; partial differentiation; total differentials; Euler's theorem on homogeneous

functions; Differentiation and Integration skills; Solution of ordinary and partial differential equations; Matrices and determinants; Fourier analysis and transformation applied to spectroscopy and transport processes; Regression analysis and some numerical techniques e.g. Newton-Raphson method are taught.

Reading List

Hecht, H.G., (1990). *Mathematics in Chemistry : An Introduction to Modern Methods*. New Jersey, Prentice-Hall.

Himones, A., & Howard, A., (2003). *Calculus – Ideas and Applications*. New York, John Wiley and Sons Inc.

Hoffmann, L., Bradly, G., & Rosen, K. (2005). *Applied Calculus* (8th Edition). New York, McGraw Hill Inc.

Larson, R., & Edwards, B. (2012). *Calculus* (9th Edition). Brooks/Cole Cengage Learning.

Larson, R., Hostetler, R., & Edwards, B., (2002). *Calculus with Precalculus.* New York, Houghton Mifflin Company.

Stroud, K.A., (2001). *Engineering Mathematics* (5th Edition). Palgrave Publishers Ltd.

CHEM 311: Physical Chemistry Practical

This laboratory course is designed to impart basic techniques in physical chemistry to students. The course requires students to undertake experiments involving refractometry, potentiometry, conductimetry, spectrophotometry, and polarimetry. The use of adsorption isotherms, partitioning, and kinetic studies will be used to further illustrate physical chemistry phenomenon already taught in theory.

Reading List

Atkins, P., & De Paula, J. (2001). Physical Chemistry. 8th ed. New York, NY: W.H. Freeman and Company.

Errington, R. J. (1997). *Advanced Practical Inorganic and Metalorganic Chemistry*. CRC Press, Taylor & Francis Group, ISBN 9780751402254.

Girolami, G., Rauchfuss, T., & Angelici, R. (1999). *Synthesis and Technique in Inorganic Chemistry: A Laboratory Manual* (3rd Edition). University Science Books

Hargis L. G., (2014). *Analytical Chemistry - Principles and Techniques*.

Harris, D. C., (2002). *Quantitative Chemical Analysis* (7th Edition). New York, Freeman.

CHEM 312: Thermodynamics I

This course is focused on the fundamentals of thermodynamics and will include the Grammar and Vocabulary of thermodynamics; Discussion of State variables and equations of state, the Zeroth and First laws of thermodynamics, and thermochemistry. Other topics will include; the Second law of Thermodynamics, The Carnot cycle, spontaneity and equilibrium. Finally, an

introduction to the third law of thermodynamics, Phase Equilibrium (One Component). And chemical equilibrium will be discussed.

Reading List

Atkins, P., & De Paula, J. (2001). *Physical Chemistry* (8th Edition). New York, NY: W.H. Freeman and Company.

Castellan, G., (1983). *Physical Chemistry* (3rd Edition). Reading, MA: Addison-Wesley,

Laidler, K. J., Meiser, J. H., & Sanctuary B. C., (2003). *Physical Chemistry* (4th Edition). Houghton Mifflin Company, Boston.

Levine, I. N., (2009). *Physical Chemistry* (6th Edition). McGraw-Hill, NewYork.

Mortimer, R. G., (2008). *Physical Chemistry* (3rd Edition). Elsevier Burlington.

Silbey, R., Alberty, R., & Bawendi. M., (2004). *Physical Chemistry* (4th Edition). New York, NY: John Wiley & Sons.

CHEM 332: Organic Practical

This course will be laboratory-based and will focus on the synthesis of organic compounds using basic skills such as heating under reflux, distillation, crystallization, solvent extraction, solvent partitioning, filtration, thin layer or gravity column chromatography and melting point determination. Other important activities will include the use of infrared, ultraviolet and ^{1}H NMR spectroscopy to confirm the structures of synthesized materials; Methods in multi-step synthesis of compounds such as dibenzalacetone, 1-bromo-3-chloro-5-iodobenzene, benzocaine, sulfanilamide, ferrocene and 2,4-dinitroaniline; and Tests for functional groups.

Reading List

Carey, F. A., (2000). *Organic Chemistry* (4th Edition). New York.

Fabirkiewicz, A. M, & Stowell, J. C., (2015). *Intermediate Organic Chemistry* (3rd Edition). Wiley.

Leonard, J., Lygo, B., & Procter, G., (2013). *Advanced Practical Organic Chemistry* (3rd Edition). CRC press.

Mendlam, J., Denny, R. C., Barnes, J. D., & Thomas, M. J. K., (2000). *Vogel's Quantitative Chemical Analysis* (6th Edition). Prentice Hall.

Wade. L.G., (2013), *Organic Chemistry* (8th Edition). Pearson.

CHEM 341: Spectroscopy and Structure Elucidation

This course will cover the determination of organic structures using infrared (IR) spectroscopy, ultraviolet-visible (UV) spectroscopy, mass spectrometry (MS) and nuclear magnetic resonance (NMR) spectroscopy (1H and 13C); the principles in each method are outlined and the structural features which may be deduced from spectra are discussed. Structure elucidation problems involving the joint application of IR, UV, MS, 1H- NMR and 13C- NMR; structure elucidation of small molecules using real or computer simulated spectra and aided by Tables of data (IR, UV, and NMR) which are provided as part of the course material.

Reading List

Abraham, R. J., Fisher, J., & Loftus, P. (1989). *Introduction to NMR spectroscopy*. Wiley.

Banwell, C. N., & McCash, E. M., (1994). *Fundamentals of molecular spectroscopy*. McGraw-Hill College.

Bovey, F. A., Mirau, P. A., & Gutowsky, H. S. (1988). *Nuclear magnetic resonance spectroscopy*. Elsevier.

Crews, P., Rodriquez, J., Jaspars, M., & Crews, R. J. (2009). *Organic structure analysis* (2nd Edition). Oxford University Press.

Williams, D. H., & Fleming, I. (2011). *Spectroscopic methods in Organic Chemistry* (6th Edition). McGraw-Hill.

CHEM 343: Chemistry of Aromatic Compounds

This course focusses on aromatic compounds and their reactions and will begin with evidence of aromaticity from physical and chemical properties of benzene. Other important considerations will include: The use of Huckel's rule and chemical/physical properties to determine aromaticity; Structure and nomenclature of arenes; reactions - hydrogenation, oxidation, and side chain halogenation. Electrophilic aromatic substitution and their use in synthesis; addition-elimination reactions and the benzyne mechanism. The course will conclude with Applications, classification, nomenclature and chemistry of aromatic amines and diazonium salts as well as their importance especially in synthesis and coupling.

Reading List

Carey, F.A. (2000). *Organic Chemistry* (4th Edition). Boston: Mc-Graw Hill.

Graham, S. T.W., & Fryhle, C.B. (2011). *Organic Chemistry* (9th Edition). New York: Wiley.

McMurry, J. E. (2012). *Organic Chemistry* (9th Edition). Boston: Cengage,

Oppong, I.V., Addae-Mensah, I. & Asunka, S. A. (2008). *Organic Chemistry – A Systematic Functional Group Approach (*1st Edition). Accra: First Generation Publishers,

Sykes, P. (1986). *A Guidebook to Mechanism in Organic Chemistry* (6th Edition). London: Longman.

Wade, Jr. L.G. (2013). *Organic Chemistry (*9th Edition). *Boston: Pearson.*

CHEM 344: Carbanions and their Reactions

The course involves the general principles underlying carbanion chemistry. Definition of carbanions; comparison of carbanions to other reactive intermediates; hybridization of carbon in different carbanion structures; hemolytic and heterolytic cleavage; different substrates as sources of carbanions; Factors affecting the stability of carbanions; Mechanisms, stereochemistry, and synthetic applications of reactions involving carbanions or potential carbanions with a variety of carbonyl compounds; Carbanion reactions in biosynthesis of bioactive natural products; Anionic polymerization reactions involving carbanions.

Reading List

Carey, F.A. (2000). *Organic Chemistry* (4th Edition). Boston: Mc-Graw Hill.

McMurry, J. E. (2012), *Organic Chemistry* (9th Edition). Boston: Cengage,

Oppong, I.V., Addae-Mensah, I. & Asunka, S. A. (2008). *Organic Chemistry – A Systematic Functional Group Approach* (1st Edition). Accra: First Generation Publishers.

Solomons, G.T.W., & Fryhle, C.B. (2011). *Organic Chemistry* (9th Edition), New York: Wiley

Sykes, P., (1986). *A Guidebook to Mechanism in Organic Chemistry* (6th Edition). London: Longman.

Wade, Jr. L.G., (2013). *Organic Chemistry* (9th Edition). Boston: Pearson.

CHEM 346: Molecular Rearrangement Reactions

The course will teach the key fundamentals of molecular rearrangement reactions. Classification of rearrangement reactions on the basis of the nature of the migrating group/atom; Nucleophilic/aniotropic (intermolecular and intramolecular), electrophilic or cationotropic, free radical. The five (5) types of skeletal rearrangements- Electron deficient skeletal rearrangement (Wagner- Meerwin Rearrangement, Pinacol-Pinacolone Rearrangement, Semipinacol Rearrangement, Tiffeneau-Demjanov Rearrangement), Electron rich skeletal rearrangement (Benzilic acid Rearrangement, Wittig Rearrangement, Sommelet-Hauser Rearrangement, Radical rearrangement, Rearrangements on an aromatic ring (Fries Rearrangement, Claisen Rearrangement, Rearrangements of Derivative of aniline, Sigmatropic rearrangement (Stevens Rearrangement, Ene Reaction, Cope Rearrangement).

Reading List

Clayden, J., Greeves, N., Warren, S., & Wothers, P. (2012). *Organic Chemistry* (2nd Edition). Oxford University Press Canada.

McMurry, J. E., (2011). *Organic Chemistry* (8th Edition). Brooks Cole.

Morrison, R. T., Boyd, R. N., & Rajora, S. (2018). *Organic Chemistry* (6th Edition). Pearson Education India.

Solomons, T. G., & Fryhle, C. B., (2011). *Organic chemistry* (10th Edition). John Wiley & Sons.

Vollhardt, K. P. C., & Schore, N. E., (2014). *Organic chemistry: structure and function* (7th Edition), Macmillan.

CHEM 351: Inorganic Chemistry Laboratory

This laboratory-based course is designed to impart basic techniques in inorganic synthesis to students. The course also requires students to separate, purify and dry their products for analysis using standard spectroscopic techniques. Selected experiments include: Qualitative inorganic analysis, Simple complexation reaction; Chelation reactions; preparation of double salts; stabilization of "unstable" species through complexation; determination of dissolved oxygen in water; interpretation of infra-red spectra of samples obtained by students.

Reading List

Errington, R. J., (1997). *Advanced Practical Inorganic and Metalorganic Chemistry.* CRC Press, Taylor & Francis Group.

Fackler; J. P., (1966). *Metal β-Ketoenolate Complexes Prog. Inorg. Chem*. (Ed. S.J. Lippard). **7**, 361.

Girolami, G., Rauchfuss, T., Angelici, R., (1999). *Synthesis and Technique in Inorganic Chemistry: A Laboratory Manual* (3rd Edition). University Science Books.

Komiya, S., (1997). *Synthesis of Organometallic Compounds: A Practical Guide (*1st edition). A Willey series.

Szafran, Z., Pike, R., Singh, M., (1991). *Microscale Inorganic Chemistry: A Comprehensive Laboratory Experience* (1st Edition). Wiley.

Thompson, D.W., (1971). *Inorganic derivatives of acetylacetone.* J. Chem. Ed. 48, 79.

CHEM 352: Coordination Chemistry

This is an introductory course to Transition Metal Ions and their complexes. The d-orbital occupation and electronic configuration of M2+ ions, common oxidation numbers and their colours. General properties of TM Elements. Useful Definitions - ligand, chelate, coordination number. Common Stereochemistries (CN = 2-12) will be reviewed. Crystal Field Theory. Shapes of d-orbitals, the energy of the d-orbitals with respect to the effect of octahedral, tetrahedral and square planar crystal fields. High-spin, Low-spin complexes and the spectrochemical series. Stability of Metal Complexes. Systematic approach to naming and complexes. Magnetic Moments of octahedral, tetrahedral and square planar complexes. Isomerism. Stereoisomerism and Structural isomerism.

Reading List

Butler, I. S., & Harrod, J. F., (1989). *Inorganic Chemistry Principles and Applications.* Benjamin-Cummings Pub. Co.

Cotton, F. A, Wilkinson, G., Murillo, C. A., & Bochmann, M., (1999). *Advanced Inorganic Chemistry* (6th Edition). John Wiley & Sons Inc.

Douglas, B. E., McDaniel, D., & Alexander, J., (1994). *Concepts and Models of Inorganic Chemistry* (3rd edition). Wiley.

Greenwood, N. N & Earnshaw, A., (1997). *The Chemistry of the Elements* (2nd Edition). Oxford: Butterworth-Heinmann, eBook

Holleman, A. F., & Wiberg, E., (2001). *Inorganic Chemistry* (1st edition). Academic Press.

CHEM 355: Inorganic Chemistry (p-block Elements)

This course involves the systematic study of the p-block elements groups 3A to 8A as well as the chemistry of the non-metals. Trends within and between groups; reasons for and causes of trends in ionization energy, electron affinity, electronegativity, oxidation states, inert pair effect, role of valence shell d-orbitals, electrode potential and conductivity. The general

increase in metallic character of the p-elements (as evidenced by both physical and chemical properties) as one goes down the group.

Reading List

Greenwood, N. N., & Earnshaw, A., (1997). *Chemistry of the Elements* (2nd Edition). Elsevier.

Greenwood, N. N., & Earnshaw, A., (1985). *Chemistry of the Elements.* Journal of Chemical Education.

Cotton, F. A., & Wilkinson, G., (2017). *Inorganic Chemistry* (6th Edition). Wiley and Sons.

Cotton, F. A, Wilkinson, G., Murillo, C. A., & Bochmann, M., (1999). *Advanced Inorganic Chemistry.*

Shriver, & Atkins, P., (2010). *Inorganic Chemistry.* Published by Oxford University Press,

CHEM 372: Analytical Chemistry Laboratory II

This Laboratory-based course is designed to give students the opportunity to acquire hands on experience in basic chemical techniques and methods. The course is made up of selected experiments which are complete in themselves, students may be required to perform their own sampling, preparation of reagents and standards, etc. Some of the experiments are argentometric determination of halides, complexometric (EDTA) analysis of real samples, ion exchange chromatography, Spectrophotometric determinations involving use of calibration curves and standard chelating agents; soil analysis for pH, phosphate, nitrogen; gravimetric analysis.

Reading List

Dean, J. A., Merritt, L. L., Settle, F. A., & Willard, H. H., (2015). *Instrumental methods of analysis.*

Hargis, L. G., (2014). *Analytical Chemistry - Principles and Techniques*.

Harris, D. C., (2002). *Quantitative Chemical Analysis* (7th Edition). New York, Freeman.

Manahan, E. S., (2012). *Environmental Chemistry*. Boca Raton, Fl., USA. Lewis Publishers, CRC Press.

Spiro, T. G., & Stigliani, W. M., (1996). *Chemistry of the Environment.* Prentice-Hall. Inc. New Jersey.

CHEM 374: Analytical Chemistry II

This course is focused on the fundamentals of spectroscopy and its applications. Topics will include; spectrometers – interferometry, UV-VIS spectrophotometry: Beer-Lambert's Law, atomic spectrometry: atomic absorption spectroscopy (AAS), atomic emission spectroscopy-ICP, optimization of signal-to-noise ratio, detection limit, analytical sensitivity, background correction: definition, D2-lamp, (zeeman effect, smith-hieftje) interferences, application; flame photometry; analytical separations, solvent extraction, partition coefficient, chelation–extraction of inorganic species.

Reading List

Harvey, D., (2000). *Modern Analytical Chemistry.* New York, McGraw Hill

Harris, D. C., (2002). *Quantitative Chemical Analysis* (7th Edition). New York, Freeman

Jeffery, G. H., Bassett, J., Mendham, J. & Denney, R. C., (1989). *Vogels Textbook of Quantitative Chemical Analysis* (5th Edition). London, Longmans.

Skoog, D. A., Holler, J. E., & Nieman, A. T. (1998). *Principles of Instrumental analysis* (5th. Edition). New York, Sounders College Publishing.

Skoog, D. A, West D. M, & Holler. J. E. (2004). *Fundamentals of Analytical Chemistry* (8th Edition). New York, Sounders College Publishing.

CHEM 401: Thermodynamics II

This course builds on the introduction to thermodynamics and focusses on its applications. Some of the topics to be covered include: Chemical potential and phase equilibria; solutions and colligative properties; electrolytes and the Debye-Hückel theory; electrochemical cells as a source for thermodynamic data, The Nernst equation. Concentration cells Applications of emf measurements: Electrode processes: over-potential, current density, fuel cells, storage cells, photovoltaic cells; electrolysis.

Reading List

Atkins, P. & De Paula, J. (2001). *Physical Chemistry* (8th Edition). New York, NY: W.H. Freeman and Company.

Castellan, G. (1983). *Physical Chemistry* (3rd Edition). Reading, MA: Addison-Wesley.

Engel, T., Reid, P. (2009). *Thermodynamics, Statistical Thermodynamics, & Kinetics* (2nd Edition). New Jersey Upper Saddle River, Prentice Hall.

Levine,I.N., (2009). *Physical Chemistry* (6th Edition). McGraw-Hill, New York.

Mortimer, G. R., (2008). *Physical Chemistry* (3rd Edition). Elsevier Burlington.

Silbey, R., Alberty, R. & Bawendi, M. (2004). Physical Chemistry (4th Edition). New York, NY: John Wiley & Sons.

CHEM 402: Quantum Chemistry

The course will introduce students to the mathematical and physical principles of quantum chemistry, including operators, and operator algebra, eigenvalue problems; Postulates of quantum mechanics; the Schrodinger equation-Hydrogen atom, Simple Harmonic Oscillator and diatomic molecules; the Rigid Rotator and angular momentum. Approximation methods including; Variation method, Perturbation method; Multielectron atoms, Hartree-Fock Self-Consistent Field Method; Born-Oppenheimer approximation; Huckel Molecular Orbital Theory, Slater determinants, conjugated pi-electron systems; Ab-initio methods will be discussed.

Reading List

Atkins, P.W., (1994). *Physical Chemistry* (5th Edition). Oxford University Press.

Denaro, A.R., (1975). *A Foundation for Quantum Chemistry.* London, Butterworth & Co.

Hanna, M.W. (1969). *Quantum Mechanics in Chemistry* (2nd Edition). New York, W.A. Benjamin Inc.

Levine, I. (1995). *Physical Chemistry* (4th Edition). New York, McGraw Hill Inc.

Roberts, J.D. (1962). *Notes on Molecular Orbital Calculations*. New York, W. A. Benjamin Inc.

CHEM 403: Symmetry, Group Theory, and Applications

This course seeks to introduce students to the principles of symmetry and group theory. Topics will include; Symmetry elements and operations, arrangement of symmetry operations into classes; Group theory- Point groups, and assignment of point groups to molecules using flow charts; Non-degenerate representations, Reducible representations and reduction to irreducible representations; Degenerate representations. Application of symmetry and group theory - The symmetry properties of molecules and their use to predict chemical bonding, vibrational spectra, hybridization, optical activity, etc will be discussed.

Reading List

Ladd, M. (1998). *Symmetry and Group Theory in Chemistry*. Elsevier.

Lesk, A. M. (2004). *Introduction to Symmetry and Group Theory for Chemists*. Kluwer Academic Publishers, New York.

Ohrn, Y. (2000). *Elements of Molecular Symmetry.* Wiley New York.

Vincent, A. (2010). *Molecular Symmetry and Group Theory: A Programmed Introduction to Chemical Applications* (2nd Edition). Wiley New York.

Willock, D. J. (2009). *Molecular Symmetry* (2nd Edition). Wiley New York.

CHEM 405: Reaction Kinetics

This course seeks to aid students to develop both a conceptual and a quantitative understanding of rates of chemical reactions. Quantitative description of reaction rates and mechanisms will also be explored. Some topics to be treated will include: Experimental techniques in chemical kinetics, Elementary kinetics, Theories of reaction rates, Reactions in Solution, Homogeneous and heterogeneous catalysis Enzyme kinetics, and reaction dynamics. Photochemical sources of energy for kinetic reactions.

Reading List

Atkins, P., & De Paula, J. (2001). *Physical Chemistry* (8th Edition). New York, NY: W.H. Freeman and Company.

Castellan, G. (1983). *Physical Chemistry* (3rd Edition). Reading, MA: Addison-Wesley.

Engel, T., Reid, P., (2009). *Thermodynamics, Statistical Thermodynamics, & Kinetics* (2nd Edition). New Jersey Upper Saddle River, Prentice Hall.

Hammes, G., (1978). *Principles of Chemical Kinetics* (1st Edition). Academic Press.

Houston, P. (2006). *Chemical Kinetics and Reaction Dynamics*. Dover Books.

CHEM 412: Surface Chemistry and Colloids

The course is focused on the principles and chemistry of Surfaces and the application of Thermodynamics to Interface Phenomena. Topics will include: the concept of Interfacial Tension/Free Energy and Work associated with interface formation, Physical phenomena related to surface tension and Capillarity, Vapor pressure of curved surfaces, Surface tension and temperature, spreading of liquids, Gibbs equation, Surfactants and Detergency, Insoluble surface films, Double layer Potential, Adsorption/Isotherms, Applications of adsorption, Surface catalysis, Surface area of adsorbents, Adsorption of solutes by solids, Colloids and other dispersions, Effects of Surface forces on colloids, Preparation and properties of Colloids will be discussed.

Reading List

Adamson, A. W., & Gast, A. P. (1997). *Physical Chemistry of Surfaces* (6th Edition). Wiley New York.

Birdi, K. S. (2014). *Surface Chemistry Essentials.* CRC Press London.

Cosgrove, T. (2005). *Colloid Science Principles; Methods and Applications*. Blackwell, Oxford.

Hienenz, P. C., & Rajagopalan, R. (1997). *Principles of Colloid and Surface Chemistry* (3rd Edition). Marcel Decker. New York.

Shaw, D. J. (2003). *Introduction to Colloid and Surface Chemistry* (4th Edition). Butterworth-Heinemann.

CHEM 414: Molecular Structure

The course examines electrical and magnetic properties of molecules in relation to molecular structure and spectra at the basic level. Relationship between molecular shape and symmetry is examined. Molecular electronic structure parameters like Bond radii, Bond energy, bond moments, Electronegativity and Born-Oppenheimer Approximation. The study would also introduce to students basic Computational Concepts. Applications of theories to Molecular modeling, Computer aided Drug design (CAMD. Quantum Mechanical Methods, Ab initio Calculations and Semi-empirical Methods. Molecular Modelling of simple organic molecules and use of Density Functional Methods would be used to solve problems on chemical structures.

Reading list:

Atkins, P. W. (2006). *Physical Chemistry*. Oxford University Press (8th Edition).

David, Y. D. (2001). *Computational Chemistry: A Practical Guide for Applying Techniques to Real World Problems*. Wiley.

Kuhn, H., Försterling, Horst-Dieter & Waldeck, D. H. (2009). *Principles of Physical Chemistry.* John Wiley & Sons.

Leach, A. R. (2001). *Molecular Modelling: Principles and Applications*. Prentice Hall.

Leszczynski, J. (2017). *Challenges and Advances in Computational Chemistry and Physics Series.* Springer.

CHEM 423: Polymer Chemistry and Technology

The course is intended to develop fundamental understanding for polymers and polymerization reactions. Functionality concepts and applications in industrial synthesis of polymers, with reference to rubber, plastics, fibers, coatings and adhesives industries will be covered. Mechanisms and kinetics of polymerization will be dealt with. Common concepts within polymer classes and the recognition of the potential value of polymeric materials and their areas of application will be highlighted. The student will be made to become familiar with current topics in polymer science and recognize sustainability issues in polymer chemistry

Reading List

Carraher, Jr., & Charles, E. (2012). *Introduction to Polymer Chemistry* (3rd Edition). publisher CRC Press.

Painter, P.C., & Coleman, M. M. (2009). *Essentials of Polymer Science and Engineering*. Destech Publications.

Ravve, A. (2000). *Principles of Polymer Chemistry* (2nd Edition). Springer US.

Ravve, A. (2012). *Principles of Polymer Chemistry* (3rd Edition). New York: Springer-Verlag.

Young, R. J., & Lovell, P. A. (1991). *Introduction to Polymers* (2nd Edition). Chapman & Hall.

CHEM 437: Medicinal Chemistry

This course will introduce students to some fundamental concepts in medicinal chemistry. Topics may include; Classification of Drugs, Principles of drug action, Pharmacodynamics, pharmacokinetics and pharmacogenetics; the Receptor Theory, Drug absorption, distribution, metabolims and excretion (ADME); Structure-Activity Relationships (excluding quantitative SAR). Specific Drug Types - their chemistry and pharmacology. Pesticides - Pyrethroids, DDT and related compounds, organophosphates, naturally occurring pesticides; Drug Development, including development from natural sources. Quality Assurance and good manufacturing practices.

Reading List

Graham, L. P., (1995). *Introduction to Medicinal Chemistry*. Oxford University Press.

Patrick, G., (2001). *Instant notes Medicinal Chemistry*. Bios Scientific Oxford.

Thomas, G., (2000). *Medicinal Chemistry; an introduction.*

Silverman, R. B., (2004). *The Organic Chemistry of Drug Design and Action* (2nd Edition). Academic Press San Diego

Watson, D. G., (2005). *Pharmaceutical Analysis* (2nd Edition). Elsevier Churchill

Livingstone.

CHEM 439: Organometallic Chemistry

The course introduces students to organometallic compounds, their chemistry and reactions. Topics will include; Preparation and reactions of the organometallic compounds of the Main Group elements, and of the d-block Transition elements; Organometallics as useful synthetic intermediates. Structure and bonding. Ligands. Reactivity. Catalysis. Applications of organometallic complexes in organic synthesis and industrial catalysis. Recent developments in organic synthesis, organometallics, heterocyclics, phase transfer catalysis, and physical organic chemistry will be discussed.

Reading List

Bochmann, M. (2015). *Organometallic Chemistry and Catalysis*. Oxford University Press.

Crabtree, H. R., (2014). *The Organometallic Chemistry of Transition Metals* (6th Edition), New York: John Wiley & Sons Inc.

Elschenbroich, C., & Salzer, A. (2006). Organometallics (3rd Edition). Weinheim, Germany: Wiley-VCH Verlag GmbH.

Housecroft, & Sharpe, (2012). *Inorganic Chemistry* (4th Edition). Pearson Prentice Hall,

Pregosin, P. S. (2012). *NMR in Organometallic Chemistry* (1st Edition). John Wiley and Sons Ltd.

CHEM 441: Chemistry of Natural Products

This course introduces students to some important compounds and groups of compounds from natural sources. Topics will include: monosaccharides, Disaccharides, Synthesis of alpha-amino acids; determination of primary and secondary structures of peptides; synthesis of peptides; brief description of the structures of Coenzyme A, ATP and ADP, NAD and NADH, DNA and RNA; Anthocyanins and flavonoid compounds; Structure elucidation of some specific examples. Methods of extraction, isoprene rule and Biosynthesis; Terpenes, Carotenoids - their chemistry and structural elucidation; Types - sterols, bile acids, sex hormones, adrenal cortex hormones - structures of above and biological functions; Introduction to conformational analysis.

Reading List

Finar, I. L., (1982). *Organic Chemistry* (5th & 6th Edition) Harlow, Essex, UK: Longman Group Limited, Vol 1.

Loudon, G. M., (2002). *Organic Chemistry* (4th Edition). New York: Oxford University Press Inc.

Mann, J., Davidson, R. S., Hobbs, J. B., Banthorpe, D. V., & Harborne, J. B., (1994). Natural Products, Their Chemistry and Biological Significance. (1st Edition) Harlow, Essex: Longman Group UK Limited.

McMurry, J. (2000). *Organic Chemistry* (5th Edition). Pacific Grove, CA: Brooks/Cole, Thompson Learning.

Schmid, G. H., (1996). *Organic Chemistry*. St Louis, Missouri: Mosby Year Book Inc.,

Solomons, G. T. W., (1992). *Organic Chemistry* (5th Edition). New York: John Wiley & Sons Inc.

Vollhardt, K. P. C., & Shore, N. E., (1994). *Organic Chemistry* (2nd Edition). New York: W. H. Freeman and Company.

CHEM 452: Solid State Chemistry

This is an introductory course that begins with an exploration of the fundamental relationship between electronic structure, chemical bonding, and atomic order, then proceed to the chemical properties of "aggregates of molecules," including crystals, metals, glasses, semiconductors, solutions and acid-base equilibria, polymers, and biomaterials. Real-world examples are drawn from industrial practice (e.g. semiconductor manufacturing), energy generation and storage (e.g. automobile engines, lithium batteries), emerging technologies (e.g. photonic and biomedical devices), and the environmental impact of chemical processing (e.g. recycling glass, metal, and plastic).

Reading List

Atkins, P. W. (1990). *Physical Chemistry* (4th Edition). Oxford University Press.

Bard, A. J. (2001). *Electrochemical Methods, Fundamentals and Applications* (2nd Edition). John Wiley and Sons, Inc.

Chang, R. (2008). *General Chemistry* (5th Edition). The McGraw-Hill Companies Inc. New York.

Fahlman, B. (2011). *Materials Chemistry* (2nd Edition). Springer Science + Business Media B. V.

Laidler, K. J. (1999). *Physical Chemistry* (3rd Edition). Houghton Mifflin Company,

Maron, S. H. (1965). *Principles of Physical Chemistry* (4th Edition). New York, The Macmillan Company.

Wiley-VCH, (2015). *Ullmann's Energy: Resources, Processes, Products.* Wiley-VCH Verlag GmbH & Co. KGaA, Boschstr. 12, 69469 Weinheim, Germany, Vol 3.

CHEM 454: Transition Metal Chemistry

This course introduces students to some general characteristics of d and f block elements. Topics will include: coordination chemistry: structure and isomerism, stability, theories of metal- ligand bonding (CFT and LFT), mechanisms of substitution and electron transfer reactions of coordination complexes. Electronic spectra and magnetic properties of transition metal complexes, lanthanides and actinides. Metal carbonyls, metal- metal bonds and metal atom clusters, metallocenes; transition metal complexes with bonds to hydrogen, alkyls,

alkenes and arenes; metal carbenes; use of organometallic compounds as catalysts in organic synthesis; Bioinorganic chemistry of Na, K. Mg, Ca, Fe, Co, Zn, Cu and Mo.

Reading List

Bochmann, M. (2015). *Organometallic Chemistry and Catalysis*. Oxford University Press.

Crabtree, H. R., (2014). *The Organometallic Chemistry of Transition Metals* (6th Edition). New York: John Wiley & Sons Inc.

Elschenbroich, C., & Salzer, A. (2006). *Organometallics* (3rd Edition). Weinheim, Germany: Wiley-VCH Verlag GmbH.

Fenton, D. E., (1996). *Biocordination Chemistry* (1st Edition). Oxford UK: Oxford University Press.

Housecroft, & Sharpe, (2012). *Inorganic Chemistry* (4th Edition). Pearson Prentice Hall,

Pregosin, P. S. (2012). *NMR in Organometallic Chemistry* (1st Edition). John Wiley and Sons Ltd.

CHEM 471: Nuclear & Radiochemistry

The course seeks to introduce some basic principles of nuclear and radiochemistry and their application. Topics will include; Radioactive Decay and Nuclear Stability; types of radioactive decay, the Kinetics of radioactive decay; radioisotope dating; the interconversion of matter and energy; The mass defect, nuclear binding energy, natural radioactivity; nuclear transmission: particle accelerators and the transuranium elements; the effect of nuclear radiation on matter: excitation and ionization emissions; application of radioisopes: application of ionizing and non-ionizing radiation; Nuclear fission and fusion and their applications.

Reading List

Choppin, G., Liljenzin, J., Rydberg, J., Ekberg, C., (2013). Radiochemistry and Nuclear Chemistry (4th Edition). Academic press.

Konya, J., & Nagy, N. (2012). *Nuclear and Radiochemistry* (1st Edition). Elsevier

Kratz, J-V., & Lieser, K. H. (2013). Nuclear and Radiochemistry: Fundamentals and Applications (3rd Edition). Vol 1. Wiley-VCH

Loveland, W. D., Morrissey, D. J., Seaborg, G. T., (2017). *Modern Nuclear Chemistry* (2nd Edition). John Wiley & Sons, Inc.

McPherson, P. A. C., (2017). *Principles of Nuclear Chemistry*. World Scientific publishing Europe Ltd.

CHEM 472: Instrumental Methods of Chemical Analysis

This course is focused on the principles and application of analytical instrumentation. Topics will include; resolution, sensitivity, selectivity; and sample pre-treatment techniques. A detailed consideration and applications of some selected methods including: basic principles

of chromatography, gas chromatography, liquid chromatography (Normal and reversed phase), HPLC, GC-MS, etc. x-ray fluorescence spectrophotometry (XRF), x-ray diffraction techniques such as powder and single crystal (XRD), neutron activation analysis (NAA), voltammetric stripping analysis, nuclear magnetic resonance spectroscopy will be performed,

Reading List

Dean, J. A., Merritt, L. L., Settle, F. A., & Willard, H. H. (2015). *Instrumental methods of analysis.*

Hargis, L. G. (2014). *Analytical Chemistry - Principles and Techniques.*

Harris, D. C., (2002). *Quantitative Chemical Analysis* (7th Edition). New York, Freeman.

Skoog, D. A., (2016). *Instrumental Methods of analysis.*

Skoog, D. A., Holler, F. J., & Crouch, S. R. (2016). *Principles of Instrumental analysis.*

CHEM 473: X-ray Crystallography

This course is intended to give students a basic understanding of X-ray crystallography. Principles and Techniques governing Powder and Single Crystal X-ray crystallography would be taught. Differences and similarities between the powder and single crystal techniques would be taught. X-ray generation, interaction of X-ray with matter and Scattering patterns and crystal growth experiments as part of single crystal diffraction studies. Relate Bragg reflections and diffractions to x-ray diffraction patterns in both powder and single crystal diffractions. The concept of small building blocks, unit cell, cell lattice constants, Symmetry, Crystal systems theory and experiments are covered.

Reading List

Clegg, W. (1998). Crystal Structure Determination. Oxford Univ. Press.

Clegg, W. (2001). *Crystal Structure Analysis: Principles and Practice* (3rd Edition). Oxford Univ. Press.

Clegg, W. (2015). *X-ray Crystallography*. Oxford University Press.

Glusker, J.P., Lewis, M., & Rossi, M. (1994). *Crystal structure Analysis for Chemists and Biologists*. Oxford University Press.

Glusker, J. P. & Trueblood, K. N. (2010). Crystal Structure Analysis: A Primer: Oxford Univ. Press (3rd Edition).

Massa, W. (2004). *Crystal Structure Determination, 3. Auflage 2002, Teubner*. (2nd Edition). Springer,

CHEM 474: Elements of Forensic Chemistry

This course introduces students to the techniques of forensic chemistry as they relate to crime scene investigation and on-going analysis of evidence obtained after a crime is committed. The course involves the basic chemistry concepts, origins of foreign science, evidence

collection and preservation, documentation, fingerprint development, toxicology and drug testing, foreign techniques and instrumentation, explosives and arson investigation.

Reading List

Hall, B. A., (2017). *Forensic Science Handbook*. CRC Press, Boca Raton, Florida.

Johll, M. E., (2007). *Investigating Chemistry: A Forensic Science Perspective*. W.H. Freeman and Company: New York.

Khan, J. I., Kennedy, T. J., & Christian, D. R. (2012). *Basic Principles of Forensic Chemistry*. Humana Press, New York.

Newton, D. E., (2008). *Forensic Chemistry*. Checkmark Books, New York.

Saferstein, R., (2011). *Criminalistics: An Introduction to Forensic Science*. Prentice Hall,

CHEM 491: Petroleum Chemistry and Technology

The purpose of this course is to provide the student with an understanding of petroleum chemistry. It addresses the processes involved in the formation, and the chemical composition and properties, of petroleum (oil and gas). The course provides knowledge of the processes of petroleum refining and of petroleum products as well as alternative fuels and reviews the chemical basis for most of the important production processes. The topics of petrochemicals will be discussed. The course also takes a look at the petroleum fractions and the methods for analyzing them.

Reading List

Gary, J. H, Handwerk, G. E. & Kaiser, M. J. (2007). *Petroleum Refining: Technology and Economics* (5th Edition). CRC Press.

Killops, S., & Killops, V. (2009). *Introduction to Organic Geochemistry* (2nd Edition).

Blackwell Publishing.

Schobert, H. H. (1990). *The Chemistry of Hydrocarbon Fuels*. Butterworths.

Speight, J. G. (2015). *Handbook of Petroleum Product Analysis* (2nd Edition). Wiley

Tissot, B. P., & Welte, D. H. (1984). *Petroleum Formation and Occurrence* (2nd Edition). Springer-Verlag.

CHEM 492: Industrial Chemistry

The course introduces some fundamental principles of industrial chemistry. Topics will include: the economic importance of the chemical industry; conversion, efficiency, yield, economic and technical feasibilities of a chemical process; material and energy balance in chemical processes. Major inorganic chemical processes: Gases (N_2, O_2, NH_3 and Cl_2); acids/bases (H_2SO_4, H_2PO_3, NaOH, Na_2CO_3), Major organic chemical processes: fossil fuel and petrochemicals (ethylene, propylene, vinyl chloride); Major commercial products: food additives, anionic, cationic and non-ionic surfactants; pharmaceuticals. Industrial activities and their environmental impact such as; global warming, acid rain, smog, ozone depletion, eutrophication, toxic metals and carcinogens will be discussed.

Reading List

Ali, F.M, (2005). *Handbook of Industrial Chemistry* (1st Edition). McGraw-Hill Education

Chenier, P. J., (2002). *Survey of Industrial Chemistry* (3rd Edition). Kluwer Academic / Plenum Publishers, New York..

Greenwood, N. N., & Earnshaw, A., (2005). *Chemistry of the Elements* (2nd Edition). Elsevier.

Timberlake, K.C., (2014). *An introduction to General, Organic and Biological Chemistry* (12th Edition). Prentice Hall.

Trim, H. H, & Hunter. W., (2011). *Industrial Chemistry*. Apple Academic press.

Tyrell, J. A, (2005). *Fundamentals of Industrial Chemistry: Pharmaceuticals, Polymers, and Business* (1st Edition). Wiley-Blackwell.

CHEM 493: Mineral Processing

The course introduces students to the fundamentals of mineral processing and will involve the following: Characterization of particles; analysis of separation processes; fluid dynamics; mechanisms and processes of particulate separations; Size reduction: mechanisms of fracture; crashing and grinding; Size separations: screening and sieving; classification; gravity and dense medium separations; dewatering; sedimentation; filtration; Concentrate separation: surfaces and interfaces; ore sorting; flotation and other separation methods (magnetic separations, electrostatic separation); and Gold refining technology.

Reading List

Adams, M. D., (2005). *Advances in Gold Ore Processing* (1st Edition). Elsevier, Vol 15.

Jain, S. K., (2012). *Mineral Processing* (2nd Edition). CBS Publisher & Distributors P Ltd.

Lele, A. & Rao, S. P. V. (2017). *Mineral Processing: (Including Mineral Dressing, Experiments and Numerical).* I. K. International Publishing Hse PVT. Ltd.

Maurice, C. & Han, K. N., (2003). *Principles of Mineral Processing*.
Pryor, E. J., (1971). *Mineral Processing* (3rd Edition). Elsevier.

Wills, B. A., & Finch, J. A., (2016). *Wills' Mineral Processing Technology* (8th Edition). Elsevier.Fuerstenau,

CHEM 494: Textile Chemistry and Technology

This course introduces students to the chemical principles and applications underlying the textile industry. Topics will include; Physical and chemical properties of raw materials; natural fibres of animal origin such as wool or of plant origin such cotton are selected for discussions. Structure of the constituent fibers; physical and chemical properties for example; the helical structure of wool or cotton; grading parameters such as length, diameter, crimp, colour as quality indicators of fibres. Physical and chemical changes in these materials during

preparation of yarns for weaving; treatment of fabric after weaving (dyes, dyestuffs, printing etc): treatments of textile industrial waste.

Reading List

Fay, C. R., & MCmurry, J.E., (2011). *Chemistry* (6th Edition). Prentice Hall.

Mather, R. R., (2009). *The Chemistry of Textile Fibres* (2nd Edition). Royal Society of Chemistry.

McGraw, H. (2007). *Chemistry: Matter & Change* (1st Edition). Glencoe/McGraw-Hill,

Timberlake, K. C. (2014). *An introduction to General, Organic and Biological Chemistry* (12th Edition). Prentice Hall

Tro, N. J. (2015). *Principle of Chemistry: A Molecular Approach* (3rd Edition). Prentice Hall,

CHEM 495: Pulp and Paper Chemistry and Technology

This course introduces students to the use of wood, non-woody and agricultural waste as viable industrial raw material in paper making. Students are taught the basic chemistry of wood, separation techniques, chemical and mechanical methods, sources of wood, softwood, hardwood and their global distribution. The main chemical components of wood, cellulose, hemicelluloses and extractives are considered. Students are taken through various chemical reactions of wood technology towards paper making with emphasis on the organic, physical and surface chemistries that are involved. The various uses of paper are discussed at the end of the course.

Reading List

Casey, J. P. (1983). *Pulp and paper chemistry and chemical technology.* Wiley-Interscience.

Hon, D. N. S., & Shiraishi, N., (2000). Woo*d and cellulosic chemistry* (2nd Edition). CRC Press.

Neimo, L., (1999). *Papermaking chemistry (Papermaking science and technology).* Tappi,

Roberts, J. C., (1996). *Paper chemistry, Glasgow*. Blackie Academic & Professional,
Young, R. A., & Akhtar, M. (1997). *Environmentally friendly technologies for the pulp and paper industry.* John Wiley & Sons.

CHEM 496: Environmental Chemistry

This course is an introduction to "Environmental Chemistry" which seeks to bring an understanding in the chemical behavior of important elements and compounds in the environment. The course focuses on the study of sources, reactions, transport, effects, and fates of chemical species in atmosphere, water, soil and biosphere; and the effect of technology thereon.

Reading List

Bard, C., & Cann, M. (2008). *Environmental Chemistry* (4th Edition). W.H .Freeman and Company.

Hities, R. H. (2007). *Elements of Environmental Chemistry*. John Wiley & Sons, INC., New York.

Manahan, E. S. (2012). *Environmental Chemistry*. Boca Raton, Fl., USA. Lewis Publishers, CRC Press.

Spiro, T. G. & Stigliani W. M. (1996). *Chemistry of the Environment*. Prentice-Hall. Inc. New Jersey.

VanLoon, G.W., & Duffy. S. I. (2011). *Environmental Chemistry: A Global Perspective* (3rd Edition) . Oxford University Press, Oxford, UK.

REVISED UNDERGRADUATE PROGRAMS IN THE DEPARTMENT OF COMPUTER SCIENCE
BSc Computer Science and BSc Information Technology

The Department of Computer Science runs two types of programmes: BSc Computer Science which may be taken as a single major or combined with some other subjects and the BSc Information Technology. The programmes have been designed to ensure maximum flexibility allowing students to switch from one programme to the other.

SINGLE MAJOR IN COMPUTER SCIENCE

LEVEL 200
FIRST SEMESTER

Code	Title	Credits	Pre-requisite
Core			
UGRC 210	Academic Writing II	3	
DCIT 201	Programming I	3	
DCIT 203	Digital and Logic Systems Design	3	
DCIT 205	Multi Media and Web Design	3	
DCIT 207	Computer Organization and Architecture	3	
MATH 223	Calculus II	3	
Total		**18**	

SECOND SEMESTER

Code	Title	Credits	Pre-requisite
Core			
UGRC 220	Introduction to African Studies	3	
DCIT202	Mobile Application Development	3	
DCIT204	Data Structures & Algorithm I	3	
DCIT206	Systems Administration	3	
DCIT208	Software Engineering	3	
Total		**15**	
Electives: Select 3-6 credits			
DCIT 200	Internship	1	
DCIT 212	Numerical and Computational Methods	3	
DCIT 214	Information Modeling and Specification	3	

Students who wish to be considered for Computer Science programme should select DCIT 212

LEVEL 300
FIRST SEMESTER

Code	Title	Credits	Pre-requisite
Core			
DCIT 301	Operating Systems	3	
DCIT 303	Computer Networks	3	
DCIT 305	Database Fundamentals	3	
DCIT 313	Introduction to Artificial Intelligence	3	
MATH 359	Discrete Mathematics	3	

Total		**16**	
Electives: Students may select 3 credits			
DCIT 307	Mini-Project	1	
DCIT 309	Embedded Systems and IoT	3	
DCIT 311	Machine Learning	3	

SECOND SEMESTER

Code	**Title**	**Credits**	**Pre-requisite**
Core			
DCIT 302	Human Computer Interaction	3	
DCIT 304	Research Methods	3	
DCIT 308	Data Structures and Algorithms II	3	
DCIT 312	Information Security Management	3	
DCIT 318	Programming II	3	
Total		**15**	
Electives: Select 3-6 credits			
DCIT 306	Cloud Computing	3	
DCIT 316	Computational models for Social Media Mining	3	

LEVEL 400

FIRST SEMESTER

Code	**Title**	**Credits**	**Pre-requisite**
Core			
DCIT 400	Project	3	
DCIT 401	Social, Legal, Ethical and Professional Issues	3	
DCIT 407	Image Processing	3	
Total		**9**	
Electives: Select 6-9 credits			
DCIT 403	Designing Intelligent Agents	3	
DCIT 405	Statistical Models and Methods for Data Science	3	
DCIT 411	Bioinformatics	3	
DCIT 417	Network Performance Analysis and Modeling	3	
DCIT 423	Network Servers and Infrastructure	3	

SECOND SEMESTER

Code	**Title**	**Credits**	**Pre-requisite**
Core			
DCIT 400	Project	3	
DCIT 402	Management Principles in Computing	3	
DCIT 418	Systems and Network Security	3	
DCIT 428	Wireless Systems and Networks	3	

Total		**12**	
Electives: Select 3-9 credits			
DCIT 404	Advanced Databases	3	
DCIT 406	Advanced Computer Networks	3	
DCIT 408	Compilers	3	
DCIT 426	Telecommunication Systems	3	
DCIT 412	Computer Vision	3	
DCIT 414	Data Mining and Warehousing	3	
DCIT 416	Digital Signal Processing	3	
DCIT 422	Information Visualization	3	

COMBINED PROGRAMME IN COMPUTER SCIENCE

Students can major or minor in Computer Science. The Level 400 courses are for students who opt for a major in Computer Science only. Student minoring in Computer Science shall take at least 9 credits of any of the under listed courses per semester at level 200 and 6 credits per semester at level 300. Students who intend to major in Computer Science shall take 9 credits per semester at level 200 and 12 credits per semester at level 300.

LEVEL 200
FIRST SEMESTER

Code	Title	Credits	Pre-requisite
Core			
UGRC 210	Academic Writing II	3	
DCIT 201	Programming I	3	
DCIT 203	Digital and Logic Systems Design	3	
MATH 223	Calculus II	3	
Total		**12**	

SECOND SEMESTER

Code	Title	Credits	Pre-requisite
Core			
UGRC 220	Introduction to African Studies	3	
DCIT202	Mobile Application Development	3	
DCIT204	Data Structures & Algorithm I	3	
DCIT208	Software Engineering	3	
Total		**9**	
	Select 9 credits from above		

LEVEL 300
FIRST SEMESTER

Code	Title	Credits	Pre-requisite
Core			
DCIT 301	Operating Systems	3	
DCIT 303	Computer Networks	3	
DCIT 305	Database Fundamentals	3	

Minor students shall select 6 credits from above Major students shall select all 9 credits. In addition, they shall select 3 credits from the electives below		**6-9**	
Electives: Major students shall select minimum 3 credits from below			
DCIT 309	Embedded Systems and IoT	3	
DCIT 313	Introduction to Artificial Intelligence	3	

SECOND SEMESTER

Code	**Title**	**Credits**	**Pre-requisite**
Core			
DCIT 302	Human Computer Interaction	3	
DCIT 308	Data Structures and Algorithms II	3	
Total	Major and minor students shall select all 6 credits above	**6**	
Electives: Major students shall select all 6 credits			
DCIT 304	Research Methods	3	
DCIT 318	Programming II	3	

LEVEL 400

FIRST SEMESTER

Code	**Title**	**Credits**	**Pre-requisite**
Core			
DCIT 400	Project	3	
DCIT 401	Social, Legal, Ethical and Professional Issues	3	
DCIT 407	Image Processing	3	
Total		**9**	
Electives			
DCIT 403	Designing Intelligent Agents	3	
DCIT 405	Statistical Models and Methods for Data Science	3	
DCIT 411	Bioinformatics	3	
DCIT 417	Network Performance Analysis and Modeling	3	
DCIT 423	Network Servers and Infrastructure	3	

SECOND SEMESTER

Code	**Title**	**Credits**	**Pre-requisite**
Core			
DCIT 400	Project	3	
DCIT 402	Management Principles in Computing	3	
DCIT 418	Systems and Network Security	3	
DCIT 428	Wireless Systems and Networks	3	
Total		**12**	
Electives: Select minimum of 3 credits			

DCIT 404	Advanced Databases	3	
DCIT 406	Advanced Computer Networks	3	
DCIT 408	Compilers	3	
DCIT 426	Telecommunication Systems	3	
DCIT 412	Computer Vision	3	
DCIT 414	Data Mining and Warehousing	3	
DCIT 416	Digital Signal Processing	3	
DCIT 422	Information Visualization	3	

INFORMATION TECHNOLOGY

LEVEL 200

FIRST SEMESTER

Code	Title	Credits	Pre-requisite
Core			
UGRC 210	Academic Writing II	3	
DCIT 201	Programming I	3	
DCIT 203	Digital and Logic Systems Design	3	
DCIT 205	Multi Media and Web Design	3	
DCIT 207	Computer Organization and Architecture	3	
DCIT209	E-Business Architectures	3	
Total		**18**	

SECOND SEMESTER

Code	Title	Credits	Pre-requisite
Core			
UGRC 220	Introduction to African Studies	3	
DCIT202	Mobile Application Development	3	
DCIT204	Data Structures & Algorithm I	3	
DCIT206	Systems Administration	3	
DCIT208	Software Engineering	3	
Total		**15**	
Electives: Select 3-6 credits			
DCIT 200	Internship	1	
DCIT 212	Numerical and Computational Methods	3	
DCIT 214	Information Modeling and Specification	3	

LEVEL 300

FIRST SEMESTER

Code	Title	Credits	Pre-requisite
Core			
DCIT 301	Operating Systems	3	
DCIT 303	Computer Networks	3	
DCIT 305	Database Fundamentals	3	
DCIT 313	Introduction to Artificial Intelligence	3	
DCIT 317	IT Project Management	3	

Total		**15**	
Electives: select 3-6 credits			
DCIT 307	Mini-Project	3	
DCIT 315	Principles of 3D Environment	3	
DCIT 321	Software Evolution	3	

SECOND SEMESTER

Code	Title	Credits	Pre-requisite
Core			
DCIT 302	Human Computer Interaction	3	
DCIT 304	Research Methods	3	
DCIT 308	Data Structures and Algorithms II	3	
DCIT 312	Information Security Management	3	
DCIT 318	Programming II	3	
Total		**15**	
Electives: Select 3-6 credits			
DCIT 314	Game Engine Architecture	3	
DCIT 322	Database Management Administration	3	

LEVEL 400

FIRST SEMESTER

Code	Title	Credits	Pre-requisite
Core			
DCIT 400	Project	3	
DCIT 401	Social, Legal, Ethical and Professional Issues	3	
DCIT 409	Digital Forensics	3	
Total		**9**	
Electives: Select 9-12 credits			
DCIT 413	Play and Games	3	
DCIT 415	Advanced Software Engineering	3	
DCIT 419	Agile Methods	3	
DCIT 421	Persuasive Systems Development	3	

SECOND SEMESTER

Code	Title	Credits	Pre-requisite
Core			
DCIT 400	Project	3	
DCIT 402	Management Principles in Computing	3	
DCIT 418	Systems and Network Security	3	
DCIT 428	Wireless Systems and Networks	3	
Total		**12**	
Electives: Select 3-6 credits			
DCIT 404	Advanced Databases	3	
DCIT 406	Advanced Computer Networks	3	

DCIT 408	Compilers	3	
DCIT 426	Telecommunication Systems	3	
DCIT 412	Computer Vision	3	
DCIT 414	Data Mining and Warehousing	3	
DCIT 416	Digital Signal Processing	3	
DCIT 422	Information Visualization	3	

COURSE DESCRIPTIONS

DCIT 200: Internship
Student in is now being recognized as adding value to student education. This non-scoring course provides students with opportunity to gain practical insight into the working world. Students will be encouraged to seek internship opportunities with companies. The idea is that this will help them come up with practical ideas for their project work.

DCIT 201: Programming I
This course is expected to give students the understanding of object-oriented methodology, the approach to modular and reusable software systems. Object orientation will be discussed from ground up, pointing out and explaining key concepts of object orientation, its justification and how it is applied in Software Engineering. Students will be exposed to at least four language implementation to the covered principles and concepts- Java, C#, Python and PHP. Topics include: Classes and Objects, Object Design and Programming – Encapsulation, Abstraction, Inheritance, Polymorphism, Composition, Aggregation, Method overloading, Interfaces, Exception Handling, Collections, etc. This course will ensure that students have adequate practical exposure.

Reading List
Clarke, D. (2013). *Beginning C# Object-Oriented Programming* (2nd Edition). Apress,

Liang, D. Y. (2014). *Intro to Java Programming, Comprehensive Version* (10th Edition). Pearson.

Lutz, M. (2013). *Learning Python* (5th Edition). Sebastopol, CA 95472: O'Reilly Media, Inc.

Schildt, H. (2014). *Java: The Complete Reference, Ninth Edition* (9th Edition). McGraw- Hill Education.

Schildt, H. (2002). *C++: The Complete Reference, Ninth Edition* (4th Edition). McGraw-Hill Education.

DCIT 202: Mobile Application Development
This course studies the design and implementation of mobile applications for popular platforms including Blackberry, Android and Apple devices. The course will provide an overview of the various mobile platforms but will focus on developing applications for iPhone, iPod Touch and iPad. Programming topics covered will include an introduction to Objective-C, the XCode IDE and will focus on designing, implementing and running applications using the simulator for the various Apple devices. Students will leverage their object oriented programming skills for such things classes, objects, inheritance, exception handling, and graphical user interface design.

Reading List

Adelstein, F., Gupta, S. K.S., Richard III, G., & Shwiebert, L. (2014). *Fundamentals of Mobile and Pervasive Computing.* New York: McGraw-Hill Professional.

B'Far, R., & Fielding, R. T. (2014). *Mobile Computing Principles: Designing and Developing Mobile Applications with UML and XML.* New York: Cambridge University Press.

Kamal, R. (2010). *Mobile Computing*. New Delhi: Oxford University Press.

Poslad, S. (2009). *Ubiquitous Computing: Smart Devices. Environments and Interactions*. Chichester, U.K.: Wiley.

Talukder, A. K., & Yavagal, R. (2009). *Mobile Computing: Technology, Applications, and Service Creation.* New York: McGraw-Hill Professional.

DCIT 203: Digital and Logic Systems Design

This course will provide an overview of principles and Techniques of modern digital systems. This course exposes individuals to a wide array of classic as well as state of the art digital electronics technology. Topics Include: Introduction to numbers systems and codes, logics circuits, combinational and sequential logic, storage elements, digital arithmetic, integrated circuit logic families. An Overview of Technologies and Application of wide array of digital components used within state of the art IT Systems. An understanding of the applications of such digital devices embedded within telecommunications systems, storage systems, computing systems, multimedia systems, and computer networks.

Reading Lists:

Coughlin, T. M. (2010). *Digital Storage in Consumer Electronics: The Essential Guide (Embedded Technology)* (1st Edition). Burlington: Elsevier.

Floyd, T. L. (2013). *Digital Fundamentals (10th Edition)*, Englewood Cliffs, NJ: Prentice Hall.

Kleitz, W. (2011), *Digital Electronics: A Practical Approach (8th Edition)*, Englewood Cliffs, NJ: Prentice Hall.

Patterson, D. A., & Hennessy, J. L. (2012). *Computer Organization and Design: The Hardware/Software Interface (The Morgan Kaufmann Series in Computer Architecture and Design).* Amsterdam: Morgan Kaufmann.

Tocci, R. J., Widmer, N. & Moss, G. (2010). *Digital Systems: Principles and Applications* (11th Edition). Englewood Cliffs, NJ: Prentice Hall.

DCIT 204: Data Structures and Algorithms I

This course focuses on the fundamentals of computer algorithms, emphasizing methods useful in practice. Using the big-O notation, algorithms are classified by their efficiency. We

look into basic algorithm strategies and approaches to problem solving. Some of these approaches include the divide and conquer method, dynamic programming, and greedy programming paradigms. Sorting and searching algorithms are discussed in detail as they form part of a solution to a large number of problems solved using computers. The course also provides an introduction to the graph theory and graph algorithms as they are also used in many computer-based applications today.

Reading List:

Aho, A. V., Hopcroft, J. E., & Ullman, J. D. (2010).*The Design and Analysis of Computer Algorithms.* Reading, Mass.: Addison-Wesley.

Cormen, T. H., Leiserson C. E., Rivest R. L., & Stein, C. (2013*). Introduction to Algorithms. Cambridge, Mass*.: The MIT Press.

Dasgupta, S., Papadimitriou, C. H., & Vazirani, U. (2012). *Algorithms.* Boston: The McGraw-Hill Companies.

Goodman, S. E., & Hedetniemi, S. T. (2012). *Introduction to the Design and Analysis of Algorithms*. New York: Mcgraw-Hill College.

Levitin, A. (2011). *Introduction to the Design and Analysis of Algorithms* (3rd Edition). Harlow: Addison Wesley.

DCIT 205: Multimedia and Web Design

This course delivers sound training in the latest web technologies that are relevant to build modern and feature-rich web applications. It provides insight into state-of-the-art web design practice and introduces emerging topics in web development, such as package management and version control. The course features an introduction to the building blocks of the web – HTML, CSS and JavaScript. Topic include: Introduction to HTML, CSS and JavaScript, understanding frameworks and tools for modern web development, exploring CSS frameworks – bootstrap and foundation, exploring JavaScript frameworks – VueJS, AngularJS, ReactJS, NodeJS, package management with npm and a gentle introduction to version control using github.

Reading List

Crockford, D. (2008). *JavaScript: The Good Parts*, Sebastopol, CA 95472: O'Reilly Media, Inc.

Dayley, B. (2014). *Node.js, MongoDB, and AngularJS Web Development* (1st Edition). One Lake Street, Upper Saddle River, New Jersey 07458: Addison-Wesley.

Deitel, P. J., Dietel, H. M., & Dietel, A. (2013). *Internet and World Wide Web How To Program* (5th Edition.). Englewood Cliffs, N.J: Prentice Hall.

Duckett, J. (2011). *HTML and CSS: Design and Build Websites* (1st Edition). John Wiley & Sons.

Hogan, B. P. (2013*). HTML5 and CSS3: Develop with Tomorrow's Standards Today (Pragmatic Programmers)*. NC: Pragmatic Bookshelf.

DCIT 206: Systems Administration
This course provides students with the skills and concepts that are essential to the administration of operating systems, networks, software, file systems, file servers, web systems, database systems, and system documentation, policies, and procedures. This also includes education and support of the users of these systems. Topics include: Installation Configuration Maintenance (service packs, patches) Server services, Client services Support, Installation Configuration, Server services (database, web, network services, Content management and deployment, Server administration and management, User and group management, Backup management Security management Disaster recovery Resource management Automation management.

Reading List:
Æleen Frisch (2011). *Essential System Administration* (O'Reilly) (3rd Edition).

Thomas, A. L., Christine, H., & Strata, R. C. (2012). *The Practice of System and Network Administration* (2nd Edition). Addison-Wesley

Chuck, E. (2013). *Essential Linux Administration: A Comprehensive Guide for Beginners*, (Cengage Press).

Mark, B. (2003). *Principles of Network and System Administration* (2nd Edition). J. Wiley & Sons.

Thomas, A. L. (2015). *Time Management for System Administrators* (O'Reilly).

DCIT 207 Computer Organization and Architecture
Students will acquire an understanding and appreciation of a computer system's functional components, their characteristics, performance, interactions and in particular, the challenge of harnessing parallelism to sustain performance improvements now and into the future. In selecting a system to use, students should be able to understand the tradeoff among various components, such as CPU clock speed, cycles per instruction, memory size, and average memory access time. Topics include: Basic organization of von Neumann machine, Instruction sets, format and types, Assembly/machine language programming, Addressing modes, Subroutine call and return mechanisms, I/O and interrupts, Shared memory multiprocessors/multicore organization, Memory Organization and Architecture.

Reading List
Hamacher, C., Vranesic, Z., Zaky, S., & Manjikian, N. (2011). *Computer Organization and Embedded Systems*. New York: McGraw-Hill Science.

Hayes, J. P. (2012). *Computer Architecture and Organization*. New York: McGraw-Hill Science.

Null, L. (2013). *The Essentials of Computer Organization and Architecture*. Sudbury, MA: Jones and Bartlett Publishers, Inc.

Patterson, D. A., & Hennessy, J. L. (2012). *Computer Organization and Design: The Hardware/Software Interface (The Morgan Kaufmann Series in Computer Architecture and Design)*. Amsterdam: Morgan Kaufmann.

Stallings, W. (2011). *Computer Organization and Architecture: Designing for Performance* (8th Edition). Englewood Cliffs, N.J: Prentice Hall.

Shiva, S. G. (2011). *Computer Organization, Design, and Architecture* (4th Edition). Boca Raton:

DCIT 208: Software Engineering

The course covers the basics of software engineering. The basic foundation and concepts are to be covered. This course covers the software development process, from software characteristics to programming practices. A variety of concepts, principles, techniques, and tools are presented, encompassing topics are Characteristics of Software, software environments, major players in software engineering, software myths, software realities, product vs processes, Risks, project lifecycles, software processes, project management, people management, software requirements, analysis and specification, design software requirements, system models, architectural and detailed design, user interface design, programming practices.

Reading List

Booch, G., Rumbaugh, J., & Jacobson, I. (2015). *The Unified Modelling Languages Users Guide* (5th Edition). Upper Saddle River, NJ. Addison Wesley Professional.

Braude. E. J., & Bernstein, M. E. (2010). *Software Engineering: Modern Approaches*. New York: Wiley.

Ian, S.,(2011). *Software Engineering* (9th Edition). Addison-Wesley.

Pressman, R. (2010). *Software Engineering* (7th Edition). Boston, Massachusetts: McGraw Hill,

Lecture notes: include presentations that will be made available by the instructors and notes that you will take during lectures

DCIT209: E-Business Architectures

This course will introduce the concepts, vocabulary, and procedures associated with E-Commerce and the Internet. Student shall be introduced to the fundamentals of e-buisness and its relevance to modern business. Topics will include: the evolution of the Internet and E-Commerce, features of Web sites and the tools used to build an E-Commerce web site, marketing issues, payment options, security issues, and customer service. B2B, B2C, E-commerce, supply-chain, emerging business models shall also be discussed.

Reading List

Beynon-Davies, P. (2004). *E-Business*. Palgrave, Basingstoke.

Evi, N., Garth, S., Trent, R., & Hein, B. W. (2010). *UNIX and Linux System Administration Handbook (*4th Edition). Prentice Hall.

Kenneth, C. L., Carol, G. T., Carol, G. T. *E-commerce: Business, Technology, Societ.y* United States.

Lowry, P. B., Cherrington, J. O., Watson, R. J. (2001). *E-Business Handbook*. Boca Raton, FL: CRC Press.

Pettit, R. (2012). *Learning from Winners: How the ARF Ogilvy Award Winners Use Market Research to Create Advertising Success.* Taylor & Francis.

DCIT 212: Numerical and Computational Methods

This course will study iterative methods for solving nonlinear equations; direct and iterative methods for solving linear systems; approximations of functions, derivatives, and integrals; error analysis. The course will take students through Solving Numerical Algebraic and Transcendental Equations, Bisection Methods, False Position Method, Newton Raphson Method, Successive Approximation Method, Simultaneous Linear Algebraic Equations, Gauss Elimination Method, Jacobi Method. There will also be a significant programming component in the course. Students will be expected to implement a range of numerical methods in homework assignments to get hands-on experience with modern scientific computing. In-class demos will be performed with Matlab and/or Python.

Reading List

Cheney, W., Kincaid, D. (2004). *Numerical Mathematics & Computing* (5th Edition). Brooks/Cole.

Greenbaum, & Chartier, T. P. (2012). *Numerical Methods: Design, Analysis and Computer Implementation of Algorithms.* Princeton University Press.

Moler, (2004). Numerical Computing with MATLAB. SIAM.

Michael, T. H., McGraw-Hill, E. (2001). *Scientific Computing: An Introductory Survey* (2nd Edition).

Richard, L. B., & Faires, J. D. *Numerical Analysis* (8th Edition). Student Edition:

DCIT 214: Information Modeling and Specification

The course introduces the area of database systems. The course will tackle modeling issues and the translation of models into relational tables. We will introduce the basics of querying databases and, in particular we will see the syntax and composition of SQL queries. At the end of this course students should understand the role of analysis and design in the software engineering lifecycle, develop object-oriented designs by applying established design principles, develop use-case and scenario descriptions of the requirements, develop descriptions of design models using UML diagrams, understand the role and influence of design patterns and frameworks in software design.

Reading List

Blaha, M., & Rumbaugh, J. (2005). *Object-Oriented Modeling and Design with UML* (2nd Edition). Prentice-Hall.

Fowler, M. (2004). *UML Distilled: A Brief Guide to the Standard Object Modeling Language* (3rd Edition). Pearson Education Inc.

Gamma, E., Helm, R., Johnson, R., & Vlissides, J. *Design Patterns: Elements of Reusable Object-Oriented Software.* Addison-Wesley.

Halpin, T. & Morgan, T. (Mar 2008). *Information Modeling and Relational Databases* (2nd Edition). Elsevier Inc.

Ramakrishnana, R., & Gehrk, J. (2002). *Database Management Systems* (2nd Edition). McGraw Hill.

DCIT 301: Operating Systems

This course will study basic principles of operating systems: addressing modes, indexing, relative addressing, indirect addressing, stack maintenance; implementation of multitask systems; control and coordination of tasks, deadlocks, synchronization, mutual exclusion; storage management, segmentation, paging, virtual memory; protection, sharing, access control; file systems; resource management; evaluation and prediction of performance. Introduction to operating systems. Topics Include: Threads and Processes; Interprocess Communication, Synchronization; CPU Scheduling; Memory Management; File and I/0 Systems; Protection and Security; Distributed System Structures; Distributed Coordination; Fault Tolerance, Real-time Computing.

Reading List

Coulouris, G., Dollimore, J. & Kindberg, T. (2015). *Distributed Systems: Concepts and Design*. Harlow, England: Addison-Wesley.

Flynn, I. M., & McHoes, A. (2013). *Understanding Operating Systems*. Cambridge, Mass: Course Technology.

Silberschatz, A., Galvin, P. B., & Gagne, G. (2012). *Operating System Concepts*. Hoboken, N.J.: John Wiley & Sons.

Stallings, W. (2011). *Operating Systems: Internals and Design Principles* (7th Edition). Boston, MA: Pearson Custom Publishing.

Tanenbaum, A. S. (2014). *Modern Operating Systems*. Upper Saddle River, N.J.: Pearson Prentice Hall.

DCIT 302: Human-Computer Interaction (HCI)

Human-Computer Interaction (HCI) is concerned with designing interactions between human activities and the computational systems that support them, and with constructing interfaces to afford those interactions. This course illustrates the principles of user interface design, development, and programming. Topics Include: User psychology and cognitive science, menu system design, command language design, icon and window design, graphical user interfaces, web-based user interfaces. Principles of user interface design. Concepts for objectively and quantitatively assessing the usability of software user interfaces, designing Interaction, Programming Interactive Systems, User-Centered Design and Testing, New Interactive Technologies, emerging technologies are discussed.

Reading List:

Dix, A., Finlay, J. E., Abowd, G. D. & Beale, R. (2013). *Human-Computer Interaction* (3rd Edition). Upper Saddle River, NJ: Pearson.

Jacko, J. A. (2012). *Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications (Human Factors and Ergonomics)*. Boca Raton: CRC Press.

Johnson, J. (2010). *Designing with the Mind in Mind: Simple Guide to Understanding User Interface Design Rules* (1st Edition). Amsterdam: Morgan Kaufmann Publishers/Elsevier,

Preece, J., Rogers, Y., Sharp, H., Benyon, D., Holland, S., & Carey, T. (1994). *Human Computer Interaction: Concepts and Design (Ics S.).* Wokingham: Addison Wesley.

Shneiderman, B., Plaisant, C., Cohen, M. & Jacobs, S. (2012), *Designing the User Interface: Strategies for Effective Human-Computer Interaction (5th Edition)*, Boston, MA: Addison Wesley.

DCIT 303: Computer Networks

This course covers both the Introduction to Networks and Routing and Switching Essentials in CCNA. The principles of IP addressing and fundamentals of Ethernet concepts, media, and operations are introduced to provide a foundation for the curriculum. At the end of the course students will be able to build simple LANs, perform basic configurations for routers and switches, and implement IP addressing schemes, configure and troubleshoot routers and switches and resolve common issues with RIPv1, RIPv2, single-area and multi-area OSPF, virtual LANs, and inter-VLAN routing in both IPv4 and IPv6 networks.

Reading List:

Cisco Networking Academy Program, *CCNA 1 and 2 Companion Guide,* Revised 3rd Edition). Cisco Systems.

Cisco Networking Academy Program, *CCNA 1 and 2 Lab Companion*, Revised (3rd Edition). Cisco Systems.

Cisco Systems Inc. Cisco Networking Academy Program, *CCNA 1 and 2 Engineering Journal and Workbook*, Revised (3rd Edition).

McDonald, R. & Odom, W. Cisco Networking Academy*, Routers and Routing Basics CCN A 2 Companion Guide.* Cisco System.

Odom, W. & Knott, T. Cisco Networking Academy*, Networking Basics CCNA 1 Companion Guide,* Cisco System.

DCIT 304: Research Methods

This course examines different methods of acquiring knowledge, role of economic research, identification of a research problem and stating of research questions and hypotheses. Also review of literature, meaning, purpose and principles of research designs and the measurement design will be examined. The course further acquaints students with the method of data collection and analysis; descriptive and inferential statistics; interpretation of data and proposal and research writing.

Reading List

Cairns, P., & Cox, A. L. (2012). Research *Methods for Human-Computer Interaction*. Cambridge: Cambridge University Press.

Lazar, J., Feng, J. H., & Hochheiser, H. (2010). *Research Methods in Human-Computer Interaction*. West Sussex: Wiley.

Lewis, R. J., & Sauro, J. (2012). *Quantifying the User Experience: Practical Statistics for User Research*. San Diego: Morgan Kaufmann.

Unger, R, & Warfel, T. Z. (2012). *Guerrilla UX Research Methods: Thrifty, Fast, and Effective User Experience Research Techniques*. San Diego: Morgan Kaufmann.

Vaishnavi, V. K., & Kuechler, W. (2011*). Design Science Research Methods and Patterns: Innovating Information and Communication Technology*. Boca Raton: Auerbach Publications.

DCIT 305: Database Fundamentals

In this course, students will be introduced to relational database concepts, E/R diagrams, normalization, structured query language (SQL). Students will write and execute queries and sub-queries, create database objects (tables. views, indices, sequences, functions, triggers, stored procedures), and manipulate data in tables. Topics covered in this course will include: Database Concepts and Architecture, Database Modelling and Design, Entity-Relationship Model, Normalization, Data Manipulation Language (DML), Data Definition Language (DDL), Data Control Language (DCL), Sub-queries, Multiple Tables, Database Views, Database Triggers, Stored Procedures, Decision and Control Structures, PL/SQL, and Transaction Processing.

Reading List

Gillenson, M. L. (2011). *Fundamentals of Database Management Systems*. New York: Wiley.

Kroenke, D. M. (2013). *Database concepts*. Upper Saddle River, NJ: Prentice Hall.

Post, G. V. (2015*). Database Management Systems*. Boston, Mass.: Richard D Irwin, Inc.

Pratt, P. J., & Adamski, J. J. (2011). *Concepts of Database Management.* Cambridge, Mass: Course Technology.

Teorey, T. J., Lightstone, S. S., Nadeau, T., & Jagadish, H. V. (2011).*Database Modeling and Design* (5th Edition). San Diego: Morgan Kaufmann.

DCIT 306: Cloud Computing

This course provides a hands-on comprehensive study of Cloud concepts and capabilities across the various Cloud service models IaaS, PaaS, SaaS, and Business Process as a Service (BPaaS). IaaS topics start with a detailed study the evolution of infrastructure migration approaches from VMWare/Xen/KVM virtualization, to adaptive virtualization, and Cloud Computing/on-demand resources provisioning. Mainstream Cloud infrastructure services and related vendor solutions are also covered in detail. PaaS topics cover a broad range of Cloud

vendor platforms including AWS, Google App Engine, Microsoft Azure, Eucalyptus, OpenStack as well as storage services that leverage Google Storage, Amazon S3, Amazon Dynamo.

Reading List

Bhowmik, S. (2017). *Cloud Computing* (1st Edition). Cambridge University Press.

Bahga, A. & Madisetti, V. (2014). *Cloud Computing: A Hands-On Approach.*

Erl, T., Puttini, R., & Mahmood, Z. (2013). *Cloud Computing: Concepts, Technology & Architecture* (1st Edition). Arcitura Education Inc.

Goyal, A. (2017). *Cloud Computing: A step-by-step approach while learning Cloud Computing concepts.: SaaS, PaaS, IaaS, Virtualization, Business Models, Mobile, Security and More.*

Rafaels, J. R. (2015). *Cloud Computing: From Beginning to End, Paperback.*

DCIT 307: Mini-Project

Students use information technology as a tool to redesign business processes so the enterprise can achieve its objectives. Student teams analyze the business processes of real organizations, quantify the negative impact caused by current process challenges, then develop and present a compelling Business Case for Change. Students develop skills critical for preparing and delivering effective verbal briefings and presentations.

Reading List

Hallows, J. (2015), *Information Systems Project Management: How to Deliver Function and Value in Information Technology Projects* (2nd Edition). New York: AMACOM.

Marchewka, J. T. (2013), *Information Technology Project Management* (3rd Edition). New York: Wiley.

Phillips, J. (February 25, 2010), *IT Project Management: On Track from Start to Finish (3rd Edition)*, McGraw-Hill Osborne Media.

Schwalbe, K. (2010*). Information Technology Project Management, Revised* (6th Edition). Cambridge, MA: Course Technology.

DCIT 308: Data Structures and Algorithms II

This course covers further topics in data structures and the algorithms required for their implementation. Data structures include heaps and search, splay, and spanning trees. Analysis techniques include asymptotic worst case, expected time, amortized analysis, and reductions between problems. Include Generic types, Linked lists, Stacks and queues, Binary trees, Balanced binary trees, Multi-way trees, B-trees and B+-trees, File organization, Searching and sorting, Hashing. Running time analysis of algorithms and their implementations, one-dimensional data structures, trees, heaps, additional sorting algorithms, binary search trees, hash tables, graphs, directed graphs, weighted graph algorithms.

Reading List

Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C. (2009*). Introduction to Algorithms. Cambridge, Mass*. The MIT Press.

Deitel, H. M. & Deitel, P. J. (2014). *Java: How to Programme: Late Objects Version* (8th Edition). Upper Saddle River, NJ: Pearson Prentice Hall,

Kruse, R. L. & Ryba, A. (2012). *Data Structures and Program Design in C++* (1st Edition). Upper Saddle River, NJ: Prentice Hall.

Lewis, J., DePasquale, P. & Chase, J. (2010), *Java Foundations: Introduction to Program Design and Data Structures* (2nd Edition). Harlow: Addison Wesley,

Malik, D. S. (2012). *C++ Programming: Program Design Including Data Structures* (6th Edition). Cambridge, MA: Course Technology.

DCIT 309: Embedded Systems and Internet of Things

This course aims at teaching students the fundamental principles underpinning the design and construction of devices through the theory and practice of embedded systems. Topics Include: Embedded Systems Architecture and design; Middleware and Application Software; Embedded software; Embedded hardware; Embedded Processor, Board Memory, Board Buses, Board Input/Output. Students will learn about sensor operation, signal acquisition, the role of measurement uncertainty and noise, common sensor communication interfaces and how they interact with modern embedded microcontrollers Other topics in this course are components of IoT devices, IoT design considerations and constraints, design trade-offs between hardware and software, IoT device and the Internet.

Reading List

Berger, A. & Berger, A. S. (2010). *Embedded Systems Design: An Introduction to Processes, Tools and Techniques*. Oxford, England: Newnes.

Catsoulis, J. (2015). *Designing Embedded Hardware*. Beijing: O'Reilly Media.

Charalampos, D. (2012). *Building Internet of Things with the Arduino* (1st Edition). CreateSpace Independent Publishing Platform.

Noergaard, T. (2013). *Embedded Systems Architecture: A Comprehensive Guide for Engineers and Programmer*s. Amsterdam: Newnes.

Peckol, J. K. (2012). *Embedded Systems: A Contemporary Design Tool*. Hoboken, NJ: Wiley.

DCIT 311: Machine Learning

In this introductory course covers the basic theory and algorithms that form the core of machine learning. Machine Learning draws on concepts and results from many fields and forms a key technology in Big Data, and in many financial, medical, commercial, and scientific applications. Topics covered in this course are The Learning Problem, The Linear Model I, Error and Noise, Training versus Testing, Theory of Generalization, The VC Dimension, Bias-Variance Tradeoff, Neural Networks, Overfitting, Regularization, Validation, Support Vector Machines, decision trees, Kernel Methods, Radial Basis Functions, Learning Principles, Deep Learning, Epilogue.

Reading List

Andreas, C. M., Sarah, G. (2016), *Introduction to Machine Learning with Python: A Guide for Data Scientists* (1st Edition). Publisher: O'Reilly Media.

Aurélien, G. (2017), *Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems,* (1st Edition). Publisher: O'Reilly Media, Paperback.

Ian, G., Yoshua, B., Aaron, C. (2016), *Deep Learning (Adaptive Computation and Machine Learning series)*, (1st Edition). MIT Press Publishing.

John, D. K., Brian, M.N., Aoife, D. (2015), *Fundamentals of Machine Learning for Predictive Data Analytics: Algorithms, Worked Examples, and Case Studies (MIT Press)*, (1st Edition). MIT Press.

Yaser, S. A. M., Malik, M. I., Hsuan-Tien, L. (2012), *Learning From Data Hardcover* (1st Edition). Publisher: AMLBook, pages.

DCIT 312: Information Security Management

This course covers the range of concepts, approaches and techniques that are applicable in Information Security Management Principles. Students are required to demonstrate their knowledge and understanding of these aspects in Information Security Management Principles. It provides the opportunity for those already within these roles to enhance or refresh their knowledge. Key areas are: Knowledge of the concepts relating to information security management, Understanding of current national legislation and regulations which impact upon information security management, Awareness of current national and international standards, frameworks and organizations which facilitate the management of information security.

Reading List

Alexander, D., Finch, A., Sutton, D., & Taylor A. (2013). *Information Security Management Principles* (2nd Edition). BSC Learning and Development Limited.

Hanley, R. O., & Tiller, J. S. (2013). *Information Security Management Handbook* (7th Edition). Auerbach Publications.

Krause, M., & Tipton, F. H. (2007). *Information Security Management Handbook* (6th Edition). Taylor & Francis Group.

Serwin, A. B., McLaughlin, P., & Tomaszewski, (2014). *Privacy, Security and Information Management: An Overview.*

Whitman, M. E., & MattordH, J. (2016). *Management of Information Security* (5th Edition). Cengage Learning.

DCIT 313: Introduction to Artificial Intelligence

This course will cover the theory and practice of developing systems that exhibit the characteristics we associate with intelligence in human behavior such as reasoning, planning and problem solving, learning and adaptation, natural language processing, and perception.

Basic problem-solving strategies, heuristic search, problem reduction and AND/OR graphs, knowledge representation, uncertainty reasoning, game playing, planning, machine learning, computer vision, and programming systems such as Lisp or Prolog. Topics include state space search, logic, and resolution theorem proving. Application areas may include expert systems, natural language understanding, planning, machine learning, or machine perception.

Reading List

Brighton, H., & Selina, H. (2013). *Introducing Artificial Intelligence*. Toronto: Totem Books.

Carter, M. (2012). *Minds and Computers: An Introduction to the Philosophy of Artificial Intelligence*. Edinburgh: Edinburgh University Press.

Ertel, W., & Black, N. T. (2011). *Introduction to Artificial Intelligence*. Berlin: Springer.

Jackson, P. C. (2014). *Introduction to Artificial Intelligence* (2nd Edition). New York: Dover Publications.

Russell, S., & Norvig, P. (2009). *Artificial Intelligence: A Modern Approach* (3rd Edition). Upper Saddle River, N.J: Prentice Hall.

DCIT 314: Game Engine Architecture

This course provides students with an introduction to the theory and practice of video game programming. Students will participate in individual hands-on lab exercises, and also work together like a real game development team to design and build their own functional game using an existing game engine (e.g. XNA) and also by designing and implementing engine subsystems and integrating 3rd party components. Topics would include real-time programming and the game loop, human interface devices, 3D rendering, collision detection, skeletal animation, rigid body dynamics, game object models, event-driven programming, game scripting languages.

Reading List:

Adams, E., & Joris, D. (2012). *Game Mechanics Advanced Game Design*. Berkeley, Calif: New Riders,

Jason, G., *Game Engine Architecture.* AK Peters.

Mike, M., *Game Coding Complete* (3rd Edition). Cengage Learning, 2012, ISBN:

Robert, N. (2014). *Game Programming Patterns*. Genever Benning,

Sanjay, M. (2013). *Game Programming Algorithms and Techniques: A Platform-agnostic Approach,* Addison-Wesley.

DCIT 315: Principles of 3D Environment

This an introductory course focusing on 3D concepts for game play, modeling, and programming with a view on current and future technologies for electronic game design. Topics include graphics, game scripting, game engines, motion control, narrative in games, game interfaces, artificial intelligence, music and sound, "Serious Games" and social and interface issues of game development. The course explores game engine software framework

to design and implement games, animation techniques, physics simulation, user controls, graphical methods, and intelligent behaviors. Students will finally be introduced to Game Studio for control of objects and interactions in 2D and 3D game worlds.

Reading List

Andy, B. (2012). *3D Animation Essentials* (1st Edition). Sybex publishing.

Brian, M., Mike, B., Sean, D., Eric, V. K., & Anthony, U. (2016). *Unity Games by Tutorials: Make 4 Complete Unity Games from Scratch Using C#.* Razeware LLC Publishing.

Frank, L. (2012). *Introduction to 3D Game Programming with DirectX*. Mercury Learning & Information publishing.

Jeremy, G. B. (2017*). Introduction to Game Design, Prototyping, and Development: From Concept to Playable Game with Unity and C#.* (2nd Edition). Addison-Wesley Professional publishing.

John M. B. (2016). *The Complete Guide to Blender Graphics: Computer Modeling & Animation, (3rd Edition).* A K Peters/CRC Press.

DCIT 316: Computational models for Social Media Mining

This course will introduce students to computational methods for extracting social and interactional meaning from large volumes of text and speech (both traditional media and social media). The use of computational techniques to model social phenomena and the use of data analytics to learn models of (and to predict) social phenomena using real data will be taught. Topics will include: Sentiment Analysis, Emotion and Mood Analysis, Belief Analysis and Hedging, Deception Detection, Argumentation Mining and Social Power analysis.

Reading List:

Easley, D., & Kleinberg, J. *Networks, Crowds, and Markets: Reasoning About a Highly Connected World.* Cambridge University Press.

Kleinberg, J. C., (2007). *Behavior in Networks: Algorithmic and Economic Issues. In Algorithmic Game Theory* (N. Nisan, T. Roughgarden, E. Tardos, V. Vazirani, Editions.), Cambridge University Press.

Leskovec, J., Huttenlocher, D., & Kleinberg, J. (2010). *Signed Networks in Social Media.* Proc. 28th ACM SIGCHI Conf. on Human Factors in Computing Systems (CHI).

Leskovec, J., Backstrom, L. & Kleinberg, J. (2009) Meme-tracking and the dynamics of the news cycle. Proc. 15th ACM SIGKDD Intl. Conf. on Knowledge Discovery and Data Mining.

Philipp, K. J. (2010). Data Analysis with Open Source Tools. O'Reilly Media.

DCIT 317: IT Project Management

This course is mainly designed to prepare IT project managers, novice or experienced, with project management skills needed to better manage IT projects. Built along the IT project management lifecycle, this course covers detailed topics of the basic concepts of IT project management, including initiating, planning, controlling, executing, and closing projects. The course also shows how IT projects should be managed, from inception to post implementation review. The audience who take this course will likely improve their management skills and abilities to define the project scope, create a workable project plan, and manage within the budget and schedule.

Reading List

Kerzner, H. (2013). *Project Management: A Systems Approach to Planning, Scheduling, and Controlling* (11th Edition). Wiley.

Lientz, B. P. (2011). *Information Technology Project Management.* Palgrave Macmillan.

Marchewka, J. T. (2016). *Information Technology Project Management* (5th Edition). Wiley.

Schwalbe, K. (2014). *Information Technology Project Management (*7th Edition). Cengage Learning.

Wideman, R. M. (2006). *A Management Framework for Project, Program and Portfolio Integration.*

DCIT 318: Programming II

The course introduces students to advanced application software development using Microsoft application development platform. It teaches students how to design desktop and web based application software using the design tools available in Microsoft Visual Studio. Topics to covered in this course are introduction to C# Syntax, Methods, Classes and Inheritance, Exceptions handling and Monitoring, UI design using windows forms, controls, menus, and toolbar, Reading and writing files on to local disk and Accessing a Database using ADO.Net, LINQ and Entity Data Models, Accessing Remote Data using the types in the System.Net namespace, and WCF Data Services, UI design using XAML.

Reading List

Adam, F. (2013). *Pro ASP.NET MVC 5 (Expert's Voice in ASP.Net)* (5th ed). Apress Publisher.

Ben, A. (2017). *C# 7.0 in a Nutshell: The Definitive Reference* (1st Edition). O'Reilly Media Publishers.

Jesse, L., Jon, G. & Philip, J. (2014). *Pro Windows 8.1 Development with XAML and C#* (1st Edition). Apress publishing.

Jon, G., Brad, W. & Scott, K. A., & David. (2014). *Professional ASP.NET MVC 5* (1st ed.). Wrox publishing.

Sergii, B. (2016). *Developing Windows 10 Applications with C# Paperback, CreateSpace.* Independent Publishing Platform.

DCIT 319: Discrete Structures

The goal of this course is to introduce students to ideas and techniques from discrete mathematics that are widely used in science and engineering. Students will learn logic and proof, sets, functions, as well as algorithms and mathematical reasoning. Key topics to be covered include Propositional Logic, Predicate Logic and Quantification, Methods of Proof, Sets and Functions, Arithmetic Algorithms, Growth of Functions, Computational Complexity of Algorithms, Integer properties and Matrices, Mathematical Induction, Recursion, Sequences and Summations, Program Correctness, Graphs and its Applications, Trees and its Applications, Languages and Grammars, Finite-State Machines, Automata and Language Recognition and Turing Machines.

Reading List

Bernard, K., Robert, B. & Sharon, C. R. (2017). *Discrete Mathematical Structures* (6th Edition). Pearson publishing.

Harriet, F., & Javed, A. A. (2016). *Discrete Structures* (1st Edition). Cognella Academic Publishing.

Judith, L. G. (2014). *Mathematical Structures for Computer Science.* (7th Edition). W. H. Freeman publishing.

Kenneth, H.R. (2011). Discrete Mathematics and Its Applications (7th Edition). McGraw-Hill Higher Education

Vatsa, B.S., & Suchi, V. *Discrete Structures.* (4th Edition). New Academic Science Ltd publishing.

DCIT 321: Software Evolution

Software evolution plays a key role in software development. In most case programmers do not build software from scratch as rather they modify existing software to provide new features to customers and fix defects in existing software. Evolving software systems is often a time-consuming and error-prone process. This course will focus on the fundamentals of state-of-the art methods, tools, and techniques for evolving software based on the current software engineering research literature. Students will be expected to read current literature on software evolution since the course will be discussion based.

Reading List

Mens, D. (2008). *Software Evolution* Springer.

Mens, T. (2008). *Introduction and Roadmap: History and Challenges of Software Evolution*. In: Software Evolution. Springer, Berlin, Heidelberg

Lehman, M. M. (1980).*"Programs, life cycles, and laws of software evolution," in Proceedings of the IEEE*, vol. 68, no. 9.

Lehman, M. M., Ramil, J. F., Wernick, P. D., Perry, D. E., & Turski, W. M. (1997).*"Metrics and laws of software evolution-the nineties view."* Proceedings Fourth International Software Metrics Symposium, Albuquerque, NM,

Pressman, R. (2010). *Software Engineering* (7th Edition). Boston, Massachusetts: McGraw Hall.

DCIT 322: Database Management Administration

This course will study overview of database systems, Introduction to Database Design; The Relational Model Relational Algebra SQL Database Application Development; Storage and Indexing; Tree-Structured Indexing; Hash-Based Indexing; Schema Refinement and Normalisation object oriented database languages; the relational database model with introductions to SQL and DBMS; hierarchical models and network models with introductions to HDDL, HDML, and DBTG Codasyl; data mining; data warehousing; database connectivity; distributed databases; the client/server paradigm; middleware, including ODBC, JDBC, CORBA, and MOM.

Reading List

Coronel, C., Morris, S., & Rob, P. (2009). *Database Systems: Design, Implementation and Management*. Australia: Course Technology.

Gillenson, M. L. (2011). *Fundamentals of Database Management Systems*. New York: Wiley.

Kroenke, D. M. (2013). *Database concepts*. Upper Saddle River, NJ: Prentice Hall.

Post, G. V. (2015*). Database Management Systems*. Boston, Mass.: Richard D Irwin, Inc.

Teorey, T. J., Lightstone, S. S., Nadeau, T., & Jagadish, H. V. (2011). *Database Modeling and Design* (5th Edition). San Diego: Morgan Kaufmann.

DCIT 400: Project

The project work provides students with experience in carrying out a significant computer science project from conception to completion with minimal supervision and assistance. It comprises of the design, implementation and documentation of a significant software or hardware system, but theoretical investigations are equally valid. Other project ideas which do not fall into any of these categories are also possible. A faculty member and the student will agree on a topic and appropriate scope of work before the project begins. All project work must be done independently by individual students.

Reading List

Berndtsson, M., Hansson, J., Olsson, B., & Lundell, B. (2013). *Thesis Projects: A Guide for Students in Computer Science and Information Systems*. Berlin: Springer.

Dennis, A., Wixom, B. H., & Tegarden, D. (2012). *Systems Analysis and Design with UML*. New York: Wiley.

Fincher, S., Petre, M., & Clark, M. (2011). *Computer Science Project Work: Principles and Pragmatics*. Berlin: Springer.

Pilone, D., & Miles, R. (2014). *Head First Software Development*. Sebastopol, CA: O'Reilly Media.

Wiegers, K. (2010). *Software Requirements 2*. Redmond, Wash: Microsoft Press.

DCIT 401: Social, Legal, Ethical and Professional Issues
This course will study legal, social, and ethical issues surrounding software development and computer use. It will give an overview of the subject aimed at raising students' awareness about ethics in Information Technology and in research. Professional conduct, social responsibility and rigorous standards for software testing and reliability will be stressed. Issues such as Cyberspace Privacy Laws and Issues, Cyberspace Free Speech Laws and Issues, liability, intellectual property laws and issues, security and crime will be examined in the context of computer use, Professionalism and Work Place issues in the IT field, Contracts and Leadership

Reading List
Baase, S. (2015). *A Gift of Fire: Social, Legal, and Ethical Issues for Computing and the Internet* (3rd Edition). Upper Saddle River, NJ: Prentice Hall.

Floridi, L. (2010). *The Cambridge Handbook of Information and Computer Ethics*. Cambridge, UK: Cambridge University Press.

Johnson, D.G. (2009). *Computer Ethics* (4th Edition). Upper Saddle River, N.J.: Prentice Hall.

Plotkin, R. (2011). *Computer Ethics (Computers, Internet, and Society).* New York: Facts on File, Inc.

Quinn, M. J. (2010). *Ethics for the Information Age* (4th Edition). Harlow: Addison Wesley.

DCIT 402: Management Principles in Computing
This course presents the basics of the theory and science of management. Students will understand the fact that managing is a part of a larger system interacting with a manager's total environment – economic, technological, social, political and ethnical. The functions of management – planning, organizing, staffing and leading, and controlling will provide the conceptual framework for students to increase their understanding of Ghanaian and global management challenges, ethical decision-making, technology management and emerging workplace issues. This course lays the foundation for an understanding of the nature and importance of managing and of management as a developed and important science.

Reading List
Benowitz, E. A. (2011). *Principles of Management (Cliffs Quick Review).* Lincoln, Neb: Cliffs Notes.

Carpenter, M., Bauer, T., & Erdogan, B. (2010). *Principles of Management (Version 1.1.)* Irvington, New York: Flat World Knowledge, Inc.

Griffin, R. W. (2010). *Students Achievement Series: Principles of Management.* Boston, Mass: Houghton Mifflin Company.

Hill, C. W. L., & McShane, S. (2010). *Principles of Management.* Boston: McGraw Hill/Irwin.

Rue, L. & Byars, L. (2008). *Management: Skills and Application*. Boston, Mass: McGraw Hill/Irwin.

DCIT 403: Designing Intelligent Agents

This course provides an overview of robot mechanisms, dynamics, and intelligent controls. It will cover: basic components of robotic systems; selection of coordinate frames; homogeneous transformations; solutions to kinematic equations; velocity and force/torque relations; manipulator dynamics in Lagrange's formulation; digital simulation of manipulator motion; motion planning; obstacle avoidance; controller design using the computed torque method; and classical controllers for manipulators of mobile robots, multi-rigid-body dynamics, 3D graphic simulation; control design, actuators, and sensors; wireless networking, task modeling, human-machine interface, and embedded software. Students will design and fabricate working robotic systems in a group-based term project.

Reading List

Craig, J. J. (2014). *Introduction to Robotics: Mechanics and Control*. Upper Saddle River, N.J.: Prentice Hall. ISBN-10: 0201543613, ISBN-13: 978-0201543612

Jazar, R. N. (2010). *Theory of Applied Robotics: Kinematics, Dynamics, and Control* (2nd ed.). Berlin: Springer. ISBN-10: 1441917497, ISBN-13: 978-1441917492

Niku, S. B. (2013). *Introduction to Robotics: Analysis, Control, Applications*. Hoboken, NJ: Wiley. ISBN-10: 0470604468, ISBN-13: 978-0470604465

Simpson, C. D., Santers, R., & Nikipierowicz, S. (2008). *Introduction to Robotics*. Panford: Logic Design Publishing. ISBN-10: 0968686028, ISBN-13: 978-0968686027

Spong, M. W., Hutchinson, S., & Vidyasagar, M. (2010). *Robot Modeling and Control*. Hoboken, NJ: Wiley. ISBN-10: 0471649902, ISBN-13: 978-0471649908

DCIT 404: Advanced Databases

This course introduces students to the skills necessary to become a Database administrator. Students will learn how to create an operational database and manage the structures in an effective and efficient manner, including performance monitoring, database security, user management, performance tuning, and backup/recovery techniques. Oracle Database management system will be used. Topics covered in this course will include: Database Architecture, installation configuration of the Oracle Network Environment, Managing Database Storage Structures, Administering User and Database Security, Oracle object management, Managing Concurrency & Locks, Undo Data, Network environment: oracle shared servers, performance monitoring & management, etc.

Reading List

Craig, S. M. (2013). *Database Administration: The Complete Guide to DBA Practices and Procedures* (2nd Edition).

Coronel, C., Morris, S., & Rob, P. (2010).*Database Systems: Design, Implementation and Management*. Australia: Course Technology.

Ignatius, F. (2015). *Beginning Oracle Database 12c Administration: From Novice to Professional* (2nd Edition). Apress.

John, W. (2014). *OCA Oracle Database 12c Installation and Administration Exam Guide (Exam 1Z0-062) (Oracle Press)* (2nd Edition). Oracle Press.

Michael, M. (2014). Database Design, Application Development, and Administration, (6th Edition).

DCIT 405: Statistical Models and Methods for Data Science
The course shall cover intermediate topics in probability and statistics required for data scientists to analyze and interpret data. Topics to be covered include : The probability theory and statistical inference used in data science; Probabilistic models, random variables, useful distributions, expectations, law of large numbers, central limit theorem; Statistical inference; point and confidence interval estimation, hypothesis tests, linear regression. Students shall use statistical tools such as XLMiner, SPSS, Ms Excel during lab sections.

Reading List
Chung, K.L. (2012). *Elementary probability theory with stochastic processes*. Springer Science & Business Media.

Jay, L. D. *Probability and Statistics for Engineering and the Sciences* (9th Edition).

Larry, W. *"All of Statistics: A Concise Course in Statistical Inference Harchol-Balter "Performance Modeling and Design of Computer Systems: Queueing Theory in Action*".

DeGroot M. H. & Schervish, M. J. (2012). Probability and Statistics (4th Edition). Publisher: Pearson.

DCIT 406: Advanced Computer Networks
This course covers Scaling Networks and Connecting Networks in CCNA. Scaling Networks describes the architecture, components, and operations of routers and switches in a large and complex network. Connecting Network discusses the WAN technologies and network services required by converged applications in a complex network. The course enables you to understand the selection criteria of network devices and WAN technologies to meet network requirements. Students will learn to configure routers and switches for advanced functionality, configure and troubleshoot network devices and resolve common issues with data link protocols how to implement IPSec and virtual private network operations in complex networks.

Reading List:
Cisco Networking Academy Program*, CCNA 3 and 4 Companion Guide* (3rd Edition).

Cisco Networking Academy Program*, CCNA 3 and 4 Lab Companion* (3rd Edition).

Cisco Networking Academy (2014). *Scaling Networks Companion Guide*. Cisco Press.

Heap, G. & Maynes L. *CCNA Practical Studies,* (2002), Cisco Press.

Johnson, A. & Cisco Networking Academy. (2017). *Connecting Networks v6 Labs & Study Guide.* Cisco Press.

DCIT 407: Image Processing
The course will cover techniques and tools for digital image processing, and finally also introduce image analysis techniques in the form of image segmentation. The course is

primarily meant to develop on-hand experience in applying these tools to process these images. Hence the programming assignments form a key component of this course. The topics to be covered are: Digital image fundamentals: representation, sampling and quantization, image acquisition, basic relationships between pixels, imaging geometry; Image transforms: discrete Fourier transform, discrete cosine transform, Walsh and Hadamard transforms, Hotelling transform; Image enhancement: in spatial domain and in frequency domain, image smoothing and sharpening.

Reading List

Scott, E. U. (2011). *Digital Image Processing and Analysis* (2nd Edition). The CRC Press, Boca Raton, FL.

Scott, E. U. (2015). *Computer Imaging: Digital Image Analysis and Processing* . The CRC Press, Boca Raton, FL, January

Solomon, C.J., & Breckon, T.P. (2010). *Fundamentals of Digital Image Processing: A Practical Approach with Examples in Matlab*. Wiley-Blackwell.

Umbaugh, S. E. (1012). *Computer Vision and Image Processing: A Practical Approach Using CVIPtools*. Prentice Hall PTR, Upper Saddle, NJ.

Wilhelm, B. & Mark, J. B. (2007). *Digital Image Processing: An Algorithmic Approach Using Java*. Springer.

DCIT 408: Compilers

This course will provide introduction to the field of compilers, which translate programs written in high-level languages to a form that can be executed. Students will learn the core ideas behind compilation and how to use software tools such as lex/flex, yacc/bison to build a compiler for a non-trivial programming language. The theory and practice of programming language translation, compilation, and run-time systems, organized around a significant programming project to build compiler for simple but nontrivial programming language. Modules, interfaces, tools. Topics Include: Compiler Design; Lexical Analysis; Syntax Analysis- grammars, LL(1) parsers, LR(1) parsers; Semantic Processing; Code generation and optimization.

Reading List

Aho, A. V., Sethi, R., Lam, M.S., & Ullman, J. D. (2013). *Compilers: Principles, Techniques and Tools* (2nd ed.). Boston: Prentice Hall.

Allen, R., & Kennedy, K. (2012). *Optimizing Compilers for Modern Architectures: A Dependence-based Approach*. San Francisco, Calif.: Morgan Kaufmann.

Louden, K. C. (2010). *Compiler Construction: Principles and Practice*. Boston: PWS Pub Co.

Mak, R. (2009). *Writing Compilers and Interpreters: A Software Engineering Approach*. New York: Wiley.

Mozgovoy, M. (2009). *Algorithms, Languages, Automata, & Compilers: A Practical Approach.* Sudbury, MA: Jones and Bartlett Publishers, Inc.;

DCIT 409: Digital Forensics
This course covers computer crime, relevant laws, agencies, and standards. It presents auditing, logging, forensics, and related software. It also explores legal principles such as chain of evidence, electronic document discovery, eavesdropping, and entrapment. Students get hands-on experience with forensics tools. Topics Include: The legal and technical aspects of computer forensics. Applicable laws and the roles of legal authorities. How to obtain and handle digital evidence and will have been exposed to a range of freeware forensic tools.

Reading List:
Arnes, A. (2017). *Digital Forensics,* Wiley.

EC-Council (2013), *Computer Forensics: Investigation Procedures and Response (1st Edition),* Cambridge, MA: Course Technology.

EC-Council, (2009), *Computer Forensics: Hard Disk and Operating Systems EC-Council (1st Edition),* Cambridge, MA: Course Technology.

Sammons, J, (2015). *The Basics of Digital Forenics,*2nd Edition. Elsevier Inc. ISBN: 978-0-12-801635-0

Wells, J. T. (January 9, 2009), *Computer Fraud Casebook: The Bytes that Bite (1st Edition)*, New York: Wiley, ISBN-10: 0470278145, ISBN-13: 978-0470278147

DCIT 411: BioInformatics
The aim of this course is to introduce students to the computational techniques used in the field of bioinformatics. To reinforce the theory underlying the concepts and techniques of sequence analysis and post-genomic bioinformatics. The course introduces basic concepts of molecule biology, sequence analysis and genomic era biology. It introduces a number of many different tools and their usage, as well as the analysis algorithms behind some of them. Topics include: Basic concepts of molecular biology: genomes, transcripomes, proteomes. Sequence analysis: genome annotation, sequence alignment, multiple sequence alignment, Phylogenetic analysis, Protein families, Database searching tools.

Reading List
Jiang, T., Xu, Y. & Zhang, M.Q. (Eds), (2013). *Current Topics in Computational Biology.* MIT Press.

Lesk, A.M. (2008). *Introduction to bioinformatics*, Oxford: Oxford *University Press, (3rd Edition)*

Waterman, M.S., Deonier, R.C. & Tavaré, S. (2014), *Computational Genome Analysis: An Introduction*, Springer.

Waterman, M. (2010*). Introduction to Computational Biology.* Chapman & Hall/CRC Press.

Wunschiers, R. (2009). *Computational Biology: Unix/Linux, Data Processing and Programming*. New York. Springer-Verlag.

DCIT 412: Computer Vision
This course will cover essentials of computer vision. Students will learn basic principles of image formation, image processing algorithms and different algorithms for 3D reconstruction and recognition from single or multiple images (video). Applications to 3D modelling, video analysis, video surveillance, object recognition and vision based control will be discussed.

Reading List
Ballard, D. H, & Brown, C. M. (2012). *Computer Vision*. Englewood Cliffs, NJ: Prentice Hall.

Davies, E. R. (2009). *Machine Vision (3rd Edition). Theory, Algorithms, Practicalities.* Amsterdam: Morgan Kaufmann.

Ponce, J., & Forsyth, D. A. (2011). *Computer Vision: A Modern Approach* (2nd Edition). Englewood Cliffs, N.J: Prentice Hall.

Verri, A. (2011). *Introductory Techniques for 3-D Computer Vision*. Upper Saddle River, NJ: Prentice Hall.

Shapiro, L. G., & Stockman, G. C. (2013*). Computer Vision*. Upper Saddle River, N.J.: Prentice Hall.

DCIT 413: Play and Games
This course shall introduce students to the underlining principles of video games. It will examine the concept of "play" using methods from literary criticism, cultural anthropology, poststructuralism, and cinema studies. The philosophy of action, ludology, and theories of machinic and gamic visuality shall be discussed. Themes will include simulation, social realism, and war games. Topics will include: what is “Play”?, formal criticism, Poststructuralism: Narrative, Authorship and Play, Counter-Gaming: The Politics of Play and artist game mods, Ideology and War, and Gamic Vision.

Reading List
Bertolt, B., *Alienation Effects in Chinese Acting*. Brecht on Theater, Augusto Boal, Theater of the Oppressed.

Sutton-Smith, B. *Play and Ambiguity*. The Ambiguity of Play, pp. 1-17.

Carol, C. *The Eye of Horror, Viewing Positions: Ways of Seeing Film* (Williams Edition).

Shaviro, S. *Regimes of Vision: Kathryn Bigelow, Strange Days*. Polygraph 13.

Huizinga, J. *Nature and Significance of Play as a Cultural Phenomenon," Homo Ludens*.

Caillois, R. *The Definition of Play" and "The Classification of Games," Man, Play, and Games.*

Geertz, C. *Deep Play: Notes on the Balinese Cockfight, The Interpretation of Cultures.*

Stallabrass, J. *Just Gaming: Allegory and Economy in Computer Games*.

DCIT 414: Data Mining and Warehousing
This course is an introduction to data mining and motivating challenges, types of data, measures of similarity and distance, data exploration and warehousing, supervised learning, bias and variance. Classification techniques and their evaluation. Clustering, Association and sequence rule mining. The course aims to provide students with viable alternatives for managers rather than replacing judgment with an optimized solution. It also aims to enable students to acquire an understanding of the basic concepts and skills associated with decision-making and the modelling of business decisions using data.

Reading
Bharati, P., & Chaudhury, A. (2004). *An empirical investigation of decision-making satisfaction in web-based decision support systems*. Decision support systems.

Shmueli, G., Patel, N. & Bruc, P. (2005). *Data Mining for Business Intelligence.*

Hammergren, T. C. (2009). *Data Warehousing For Dummies.* Hoboken, NJ: For Dummies.

Kimball, R., Ross, M., Thornthwaite, W., Mundy, J., & Becker, B. (2008). *The Data Warehouse Lifecycle Toolkit* (2nd Edition).

Sauter, V. L. (2011). *Decision Support Systems for Business Intelligence.* (2nd Edition) Wiley-Blackwell, Chichester.

DCIT 415: Advanced Software Engineering
The course aims to develop the broad understanding of the discipline of software engineering (gained in the earlier Software Engineering course). Additional topics that will be covered include verification and validation, Testing and inspection, Reliability, software evolution, advanced design topics such as system architecture design, object oriented design and functional-oriented design, and finally, Business aspect of software engineering. Although the emphasis will be on modern approaches some more traditional software engineering techniques will also be discussed. The course will also provide an on-going project clinic to directly support a group project work.

Reading List:
Booch, G., Rumbaugh, J. & Jacobson, I. (2015). *The Unified Modelling Languages Users Guide* (5th Edition). Upper Saddle River, NJ. Addison Wesley Professional.

Braude. E. J., & Bernstein, M. E. (2010). *Software Engineering: Modern Approaches.* New York: Wiley.

Gomaa, H. (2011). *Software Modeling and Design: UML, Use Cases, Patterns, and Software Architectures*. Cambridge, UK: Cambridge University Press.

Sommerville, I. (2011). *Software Engineering* (9th Edition). Addison-Wesley.

Pressman, R, (2010). *Software Engineering* (7th Edition). Boston, Massachusetts: McGraw Hill.

DCIT 416: Digital Signal Processing
This course provides an introduction to digital signal processing for both undergraduate. In this course, a detailed examination of basic digital signal processing operations including sampling/reconstruction of continuous time signals, Fourier and Z-transforms will be given. The Fourier and Z-transforms will be used to analyze the stability of systems, and to find the system transfer function. The discrete Fourier transform (DFT) and fast Fourier transform (FFT) will be studied, etc. Further, computer simulation exercises are intended to familiarize the student with implementation aspects and the application of theoretical knowledge to practical problems.

Reading List:
Mitra, S. K., & McGraw-Hill, (2006). *Digital Signal Processing: A Computer-Based Approach* (3rd Edition).

Proakis, J. G., & Dimitris G. Manolakis, D. G. (2007). *Digital Signal Processing Principles, Algorithms, and Applications* (4th Edition). Prentice- Hall.

Ingle and Proakis, (2006). *Digital Signal Processing using Matlab* (2nd Edition). Thomson-Engineering.

Richard G. Lyons, R. G. (1996). *Understanding Digital Signal Processing.* Prentice Hall,

Smith, S. W. (1997). *The Scientist and Engineer's and Guide to Digital Signal Processing, California.* Technical Publishing.

DCIT 417: Network Performance Analysis and Modeling
This course aims to develop an understanding of the tools and technologies for understanding and improving the performance of communication networks such as the Internet. It will introduce students to quantitative methods for loss and delay analysis in packet networks, using techniques from stochastic traffic modelling, Markov chains, and queueing theory. It will expose students to frameworks for optimization and orchestration of network performance, including emerging paradigms such as SDN. The quantitative methods studied in this course will be applied to practical examples from network architecture and design, in different network domains.

Reading List
Chapman, C. (2016). *Network performance and security: testing and analyzing using open source and low-cost tools*. Publisher: Elsevier Ltd, Syngress.

Kakadia, D. (2017). *Network performance and fault analytics for wireless service providers.* Publisher: springer, India, private,

German R. (2000). *Performance Analysis of Communication Systems: Modeling with Non-Markovian Stochastic Petri Nets* (1st Edition). Wiley Publishing.

Stênio, F. (2017). *Performance Evaluation for Network Services, Systems and Protocols* (1st Edition). Springer International Publishing.

Yang, Y., Jing, X., Guang, S. & Cheng-Xiang W. (2017). *5G Wireless Systems: Simulation and Evaluation Techniques (Wireless Networks)* (1st Edition). Springer publishing.

DCIT 418: Systems and Network Security

This course provides a comprehensive study of security principles and practices in computer and network systems. Topics include computer security concepts, attack techniques, security policies, basic cryptographic tools, authentication, access control, network intrusion detection, software security, operating system security, network security, legal and ethical issues in computer security. Combined with the experiences that they obtain from the course projects, students would improve their skills of developing secured network applications and systems that detect and defend against malicious attacks. Students will be prepared to evaluate the security of real network systems, and to develop strategies to detect and defend against attacks.

Reading List:

Charles, P., & Shari, L. P. (2003). *Security in Computing* (3rd Edition). Prentice Hall,

Bishop, M. (2003). *Computer Security: Art and Science.* Addison-Wesley

Easttom, C. (2011). *Computer Security Fundamentals* (2nd Edition). Indianapolis: Que.

Kaufman, C., Perlman, R., & Speciner, M. (2014). *Network Security, Private Communication in a Public World* (2nd Edition). Englewood Cliffs, N.J.: Prentice Hall.

Stewart, J. M. (2011). *CompTIA Security+ Review Guide* (2nd Edition). Wiley Publishing.

DCIT 419: Agile Methods

This course will address what agile methods are, how they are implemented and their impact on software engineering. A variety of agile methods will be described, but the focus will be on Scrum and Extreme Programming. Issues associated with planning and controlling agile projects, along with the implications of empowered teams on the customer-supplier dynamic, will give a fuller picture of how the agile practices are realized. Assignments and projects are designed to help students apply agile principles and practices in their own professional context. Additional subthemes include enterprise agility, team dynamics, collaboration, software quality, and metrics for reporting progress.

Reading List:

Larman, C. (2004). *Agile and Iterative Development: A Manager's Guide.*

Schwaber, K. (2004). *Agile Project Management using Scrum.* Microsoft Press.

Schwaber, K. & Beedle, M. (2002). *Agile Software Development with Scrum.*

Poppendieck, M., & Poppendieck, T. (2003). *Lean Software Development: An Agile Toolkit.* Addison Wesley

Sahota, M. (2012). *An Agile Adoption and Transformation Survival Guide.* InfoQ

DCIT 421: Persuasive Systems and Design

In this course students will be introduced to the philosophy underpinning human computer persuasion. They will explore latest research results, best practices and guidelines for the use of persuasive applications. Student teams will work on real-world projects in which they will design and implement persuasive technology applications. In addition, the course will host several expert guest speakers from industry and higher education institutions who will share their latest findings. Topics include, persuasive technologies, modeling human attitude behavior change, persuasive system features, technology, design perspectives, methods for designing persuasive systems, ethical issues and unexpected effects of persuasive technologies and disruptive technologies.

Reading List

Fogg, B.J. (2002). *Persuasive Technology: Using Computers to Change What We Think and Do* (Interactive Technologies).

Booch, G., Rumbaugh, J. & Jacobson, I. (2005). *The Unified Modeling Language Users Guide* (2nd Edition). Upper Saddle River, NJ: Addison-Wesley Professional.

Oinas-Kukkonen, H., & Harjumaa, M. (2009). *Persuasive systems design: Key issues, process model and system features in Communications of the Association for Information System.s* 24 (1)

Orji, R., Vassileva, J., & Mandryk, R. L. *Modeling the efficacy of persuasive strategies for different gamer types in serious games for health in User Modeling and User-Adapted Interaction.* 24 (5)

Wiafe, I., Nakata, K., & Gulliver, S. (2014). *Categorizing users in behavior change support systems based on cognitive dissonance, in Personal and Ubiquitous Computing.* vol: 18 (7)

DCIT 422: Information Visualization

This course will study the principles of computer graphics and interactive graphical methods for problem solving. Emphasis placed on both development and use of graphical tools for various display devices. Several classes of graphics hardware considered in detail. Topics include pen plotting, storage tubes, refresh, dynamic techniques, three dimensions, color, modeling of geometry, and hidden surface removal. Part of the laboratory involves use of an interactive minicomputer graphics system. Introduces the fundamentals of three-dimensional computer graphics: rendering, modeling, and animation. Students learn how to represent three-dimensional objects (modeling) and the movement of those objects over time (animation).

Reading List

Bouweraerts, D. (2004). *Introduction to Computer Graphics - Design Professional*. Boston, Mass.: Course Technology.

Bungartz, H., Griebel, M., & Zenger, C. (2004). *Introduction To Computer Graphics*. London: Charles River Media.

Foley, J. D., Dam, A. V., Feiner, S. K., Hughhes, J. F., & Phillips, R. L. (2011). *Introduction to Computer Graphics*. Reading, Mass.: Addison-Wesley Professional.

Shirley, P., Ashikhmin, M., & Marshner, S. (2009*). Fundamentals of Computer Graphics*. Wellesley, Mass.: A K Peters.

Vince, J. A. (2010). *Introduction to the Mathematics for Computer Graphics*. Berlin: Springer.

DCIT 423: Network Servers and Infrastructure

Covers IP networking concepts and practices for using DHCP, DNS, secure communication, routing, remote address services, web servers, and network connectivity between operating systems. Students learn TCP/IP, routing architecture, and understand application-level services used in Internet. Through networking lab sessions, students focus on using switches and routers connected in LANs and WANs.

Reading List

Burgess, M. (2014). *Principles of Network and System Administration* (2nd Edition). New York: Wiley.

Hunt, C. (2002). *TCP/IP Network Administration* (3rd Edition; O'Reilly Networking). Sebastopol, CA: O'Reilly & Associates,

Iniewski, K., McCrosky, C. & Minoli, D. (2008). *Network Infrastructure and Architecture: Designing High-Availability Networks* (1st Edition). Hoboken, NJ: Wiley-Interscience.

Kurose, J. F. & Ross, K. W. (2009). *Computer Networking: A Top-Down Approach* (5th Edition). Boston, MA: Addison-Wesley,

Limoncelli, T. A., Hogan, C. J. & Chalup, S. R. (2007*). The Practice of System and Network Administration (2nd Edition)*, Upper Saddle River, NJ: Addison-Wesley.

DCIT 424: Entertainment Software Development

Education is experiencing innovation with various new technologies incorporated into classrooms. Technology incorporated edutainment plays as a motivator or facilitator in learning. In this course students will be introduced to how educational content can be deliberately incorporated into digital entertainment such as digital games, cartoons, etc. The course will provide an overview of the new generation's traits, locating and searching for instructional elements in cartoons, TV programs, movies, and digital games. New emerging forms of edutainment for on mobile devices shall also be discussed. Student shall be given projects to develop applications that combines learning and fun.

Reading List

Booch, G., Rumbaugh, J. & Jacobson, I. (2005). *The Unified Modeling Language Users Guide* (2nd Edition). Upper Saddle River, NJ: Addison-Wesley Professional.

Charsky, D. *From Edutainment to Serious Games: A Change in the Use of Game Characteristics in Games and Culture* Vol 5.

Calvo-Ferrer, J. R. (2017). *Educational games as stand-alone learning tools and their motivational effect on L2 vocabulary acquisition and perceived learning gains,* British Journal of Educational Technology.

Minhua, Ma. & Oikonomou, A. (2011). *Serious Games and Edutainment Applications.*

Egenfeldt-Nielsen, S. (2011). *Beyond Edutainment: Exploring the Educational Potential of Computer Games.*

DCIT 426: Telecommunication Systems

This course focuses on Third generation mobile systems: WCDMA concepts, Multi-User Detection, Antenna Array techniques, MIMO, high speed packet access, long term evolution, radio resource management, packet scheduling, core network evolution. Multimedia: Image and video representation and transmission. Competing technologies: WiFi, WiMAX, FttX. Emerging techniques: may include MANET, cognitive radio. At the end of this course, students will be able to: Demonstrate a broad understanding of Third generation mobile systems, Multimedia representation and the interaction with telecommunications protocols, Other contemporary and emerging wide area data technologies, Emerging research areas in telecommunications, and the interaction between commercial interests and technology standards.

Reading List

Dover, T. (2014). *Introduction to Telecommunications: Analog Voice and Data System.* DTS Inc.

Freeman, R. (2014)**.** *Telecommunication System Engineering (4th Edition).* Wiley.

Freeman, R. (2007). *Radio System Design for Telecommunication* (3rd Edition).

Lathi, B. P. (2004). *Linear Systems and Signals* (2nd Edition).

Lindsey, W. C., & Simon, M. K. (2011). *Telecommunication System Engineering*.

DCIT 428: Wireless Systems & Networks

This course covers fundamental principles underlying wireless data communications. Topics include wireless transmission basics, radio propagation issues, antennas, digital modulation, spread spectrum techniques and their applications, and popular standards: WiFi, WiMAX and Bluetooth. Also presents practical knowledge to enable the design, testing, deployment, debugging and commissioning of WiFi, WiMAX networks and point-to-point microwave systems. Discussions on cellular network technologies are also included.

Reading List

Freeman, R. (2014)**.** *Telecommunication System Engineering* (4th Edition). Wiley.

Gast, M. (2015). *802.11 Wireless Networks: The Definitive Guide* (2nd Edition). Beijing: O'Reilly Media.

Rappaport, T. S. (2012). *Wireless Communications: Principles and Practice* (2nd Edition). Upper Saddle River, NJ: Prentice Hall.

Stallings, W. (2014). *Wireless Communications & Networks* (2nd Edition). Upper Saddle River, NJ: Prentice Hall.

Unger, J. (2013). *Deploying License-Free Wireless Wide-Area Networks* (1st Edition). Indianapolis, IN: Cisco Press.

DEPARTMENT OF EARTH SCIENCE

REVIEW OF UNDERGRADUATE PROGRAMME

HIGHLIGHTS OF CHANGES IN THE UNDERGRADUATE PROGRAMME

Level 100

The course EASC 102: Geological Map Work has been moved to Level 200 and combined with the course on Geological Structures. The reason for the move is that most textbooks on geological structures treat these together, where the geological structures treated are related to their manifestation on geological maps. In its place, a new course, Geological Field Excursions, is introduced to present a practical way for first year students to learn about geology.

Level 200

The programme has been structured to allow Earth Science students take core courses in the Earth Sciences (mainly Geology) and electives from the basic sciences. The reason for this is that basic sciences, specifically Physics, Chemistry and Mathematics, form the foundation of any Earth Science programme.

The 3-credit course Geological Field Methods I has been renamed Geological Field Exercises I and credits reduced to 2.

A course in Quantitative Geology (EASC 225) has been introduced as an elective course to introduce students to quantitative problem solving techniques in the geological sciences at the basic level. They will build on this course in the upper undergraduate levels and at the graduate level.

Level 300

At this level students take core courses mainly in Geology and take electives from applied fields such as geophysics, hydrogeology, engineering geology, petroleum geology and environmental geology.

Level 400

On the basis of elective courses selected at Level 300, students select a specialisation in one of these fields in the final year: Geology, Applied Geophysics, and Applied Geology. Upon successful completion of the programme students will be awarded a BSc degree in the following, depending on option selected at Level 400:

- Geology
- Applied Geophysics
- Applied Geology

PROGRAMME STRUCTURE

SINGLE MAJOR EARTH SCIENCE DEGREE PROGRAMME

Students will be awarded a BSc degree in the following, depending on option selected at Level 400:

- Geology
- Applied Geophysics
- Applied Geology

LEVEL 200

FIRST SEMESTER

Code	**Title**	**Credits**	**Pre-requisite**
Core			
EASC 219	Practical Crystallography	1	EASC 101
EASC 227	Geological Structures and Maps	2	EASC 101
EASC 229	Introduction to Stratigraphy and Sedimentation	2	EASC 101, EASC 104
EASC 217	Optical Mineralogy	2	EASC 101
EASC 220	Geological Field Exercises I	2	EASC 101, EASC 104
UGRC 210	Academic Writing II	3	
TOTAL		**12**	
Electives: Select 3 – 6 credits			
EASC 225	Quantitative Geology	2	
MATH 223	Calculus II	3	MATH 122
STAT 223	Elementary Statistical Methods	3	
CHEM 213	Physical Chemistry I	2	
CHEM 233	Organic Chemistry I	2	
CHEM 271	Analytical Chemistry I	2	
PHYS 241	Atomic Physics and Quantum Phenomena	2	
PHYS 245	Electromagnetism I	3	

SECOND SEMESTER

Code	**Title**	**Credits**	**Pre-requisite**
Core			
EASC 222	Petrography	3	EASC 101
EASC 214	Principles of Geochemistry	2	
EASC 216	Fundamentals of Geophysics	2	
EASC 218	Introduction to Paleontology	2	EASC 104
UGRC 220-238	Introduction to African Studies	3	
TOTAL		12	
Electives: Select 3 – 6 credits			
EASC 280	Internship in Earth Science I	1	
MATH 224	Introductory Abstract Algebra	3	MATH 126
MATH 220	Introductory Computational	3	MATH 122

	Mathematics		
CHEM 234	Organic Chemistry II	2	
CHEM 252	Inorganic Chemistry I	2	
PHYS 242	Oscillations and Waves	2	
PHYS 244	Mathematical Methods I	3	
PHYS 256	Computational Methods in Physics I	2	

LEVEL 300

FIRST SEMESTER

Code	**Title**	**Credits**	**Pre-requisite**
Core			
EASC 320	Geological Field Exercises II	2	EASC 220
EASC 321	Introduction to Igneous and Metamorphic Petrology	3	EASC 224
EASC 341	Structural Geology	3	EASC 227
EASC 343	Sedimentology	2	EASC 229
TOTAL		**10**	
Electives: Select 5 – 8 credits			
EASC 323	Soil Mechanics	3	
EASC 325	Fundamentals of Hydrogeology and Hydrology	2	
EASC 333	Environmental Impact Assessment	2	
EASC 339	Principles of Applied Geophysics	3	EASC 216
EASC 380	Internship in Earth Science II	1	
PHYS 345	Electromagnetism II	3	
PHYS 347	Electronics I	3	
EASC 317	Environmental Geochemistry	2	
MATH 357	Computational Mathematics I	3	MATH 220

SECONDSEMESTER

Code	**Title**	**Credits**	**Pre-requisite**
Core			
EASC 342	Geology of Ghana	3	EASC 320
EASC 326	Aerial Photo Interpretation	2	
EASC 354	Geological Resources	3	
EASC 352	Geological Field Methods	2	EASC 320
TOTAL		**10**	
Electives: Select 5 – 8 credits			
EASC 332	Introduction to Petroleum Geology	2	
EASC 336	Mineral Economics	2	
EASC 338	Earthquake Seismology and Disaster Risk Reduction	3	
EASC 322	Environmental Pollution	2	
EASC 334	Organic Geochemistry	2	
MATH 358	Computational Mathematics II	3	

CHEM 312	Thermodynamics I	2	
PHYS 356	Computational Methods in Physics II	3	

LEVEL 400

OPTIONS (select one option)
OPTION 1: GEOLOGY

FIRST SEMESTER

Code	**Title**	**Credits**	**Pre-requisite**
Core			
EASC 420	Project	3	
EASC 471	Remote Sensing and Geographic Information Systems	3	
EASC 450	Geological Field Mapping	3	EASC 352
EASC 419	Igneous and Metamorphic Petrology	3	EASC 321
TOTAL		**12**	
Electives: Select 3 – 6 credits			
EASC 417	Mineralogy	3	EASC 217
EASC 437	Geochemistry and Cosmochemistry	2	
EASC 465	Micropaleontology	3	EASC 218
EASC 461	Basin Analysis	3	EASC 343
EASC 449	Mineral Exploration Methods, Planning and Management	3	

SECOND SEMESTER

Code	**Title**	**Credits**	**Pre-requisite**
Core			
EASC 420	Project	3	
EASC 404	Statistical Methods in Earth Science	2	
EASC 480	Field Studies in Earth Science	1	EASC 220, EASC 320
EASC 470	Communication and Entrepreneurship in the Earth Sciences	2	
EASC 446	Sedimentary Petrology	3	EASC 224
TOTAL		**11**	
Electives: Select 4 – 7 credits			
EASC 448	Geology of Africa	3	EASC 342
EASC 454	Geochronology	2	
EASC 476	Geotectonics	2	EASC 341
EASC 478	Stratigraphy	2	EASC 229
EASC 482	Geology of Mineral Deposits	3	

OPTION 2: APPLIED GEOPHYSICS

Students who opt for Applied Geophysics must have taken and passed at least 9 credits of elective courses in Physics and/or Mathematics at Level 200.

FIRST SEMESTER

Code	Title	Credits	Pre-requisite
Core			
GPHY 400	Project	3	
EASC 471	Remote Sensing and Geographic Information Systems	3	
GPHY 403	Geophysical Instrumentation and Techniques	3	
EASC 470	Communication and Entrepreneurship in the Earth Sciences	2	
TOTAL		**11**	
Electives: Select 4 – 7 credits			
EASC 467	Rock Mechanics	3	
EASC 405	Hydrogeology	3	EASC 325
EASC 449	Exploration Methods, Planning and Management	3	
EASC 457	Geology of Civil Engineering Projects	3	
PHYS 455	Energy Systems	2	
PHYS 461	Principles of Radioactive Dating	2	
PHYS 447	Electronics II	2	

SECOND SEMESTER

Code	Title	Credits	Pre-requisite
Core			
GPHY 400	Project	3	
EASC 458	Exploration Geophysics	3	EASC 339
EASC 466	Petroleum Reservoir Geophysics	3	EASC 339
EASC 480	Field Studies in Earth Science	1	
TOTAL		**10**	
Electives: Select 5 – 8 credits			
EASC 468	Reservoir Engineering	2	
EASC 472	Site Investigations	3	EASC 339
OCNO 422	Marine Geophysics	2	
EASC 454	Geochronology	2	
EASC 476	Geotectonics	2	EASC 341

OPTION 3: APPLIED GEOLOGY (Hydrogeology, Engineering Geology, Mineral Exploration, Petroleum Geoscience)

FIRST SEMESTER

Code	Title	Credits	Pre-requisite
Core			
EASC 420	Project	3	

EASC 471	Remote Sensing and Geographic Information Systems	3	
EASC 480	Field Studies in Earth Science	1	
TOTAL		**7**	
Electives: Select 8 – 11 credits			
EASC 401	Hydrology	3	EASC 325
EASC 405	Hydrogeology	3	EASC 325
EASC 407	Integrated Water Resources Management	2	EASC 325
EASC 449	Mineral Exploration Methods, Planning and Management	3	
EASC 447	Mineral Projects Feasibility Studies	2	
EASC 439	Geostatistical Ore Reserve Estimation	2	
EASC 457	Rock Mechanics	3	
EASC 459	Bearing Capacity and Slope Stability Analysis	3	
EASC 467	Geology of Civil Engineering Projects	3	
EASC 461	Basin Analysis	3	EASC 343

SECOND SEMESTER

Code	**Title**	**Credits**	**Pre-requisite**
Core			
EASC 420	Project	3	
EASC 404	Statistical Methods in Earth Science	2	
EASC 470	Communication and Entrepreneurship in the Earth Sciences	2	
TOTAL		**7**	
Electives: Select 8 – 11 credits			
EASC 426	Rural Water Supply	2	EASC 325
EASC 438	Water Quality and Hydrochemistry	2	EASC 325
EASC 458	Exploration Geophysics	3	EASC 339
EASC 462	Exploration Geochemistry	3	
EASC 466	Petroleum Reservoir Geophysics	3	EASC 339
EASC 468	Reservoir Engineering	2	
EASC 472	Site Investigations	3	EASC 339
EASC 474	Rocks as Construction Materials	2	

MAJOR - MINOR GEOLOGY DEGREE PROGRAMME

Students can major in Geology and minor in either Physics or Mathematics. After successful completion such students will be awarded BSc degree in any one of the following categories depending on second subject:

- Geology with Physics
- Geology with Mathematics
- Geology with Chemistry

Students can also minor in Geology and major in either Physics, Mathematics or Chemistry. After successful completion such students will be awarded BSc degree in any one of the following categories depending on second subject:

- Physics with Geology
- Mathematics with Geology
- Chemistry with Geology

LEVEL 200

FIRST SEMESTER

Code	Title	Credits	Pre-requisite
Core			
EASC 219	Practical Crystallography	1	EASC 101
EASC 227	Geological Structures and Maps	2	EASC 101
EASC 229	Introduction to Stratigraphy and Sedimentation	2	EASC 101, EASC 104
EASC 217	Optical Mineralogy	2	EASC 101
EASC 220	Geological Field Exercises I	2	EASC 101, EASC 104
UGRC 210	Academic Writing II	3	
TOTAL		**12**	

SECOND SEMESTER

Code	Title	Credits	Pre-requisite
Core			
EASC 224	Petrography	3	EASC 101
EASC 214	Principles of Geochemistry	2	
EASC 216	Fundamentals of Geophysics	2	
EASC 218	Introduction to Paleontology	2	
UGRC 220-238	Introduction to African Studies	3	
TOTAL		**12**	

LEVEL 300

Students shall take 18 – 21 credits per Semester (12 to 15 credits per Semester in major subject and 6 to 9 credits per Semester from the minor subject)

FIRST SEMESTER

Code	Title	Credits	Pre-Requisite
Core			
*EASC 320	Geological Field Exercises II	2	EASC 220
EASC 321	Introduction to Igneous and Metamorphic Petrology	3	EASC 224
*EASC 341	Structural Geology	3	EASC 227
EASC 343	Sedimentology	2	EASC 229
TOTAL		**10**	
Electives			
EASC 323	Soil Mechanics	3	
EASC 325	Fundamentals of Hydrogeology and Hydrology	2	
EASC 333	Environmental Impact Assessment	2	

EASC 339	Principles of Applied Geophysics	3	EASC 216
EASC 380	Internship in Earth Science II	1	

*Core for students majoring in Geology

SECONDSEMESTER

Code	**Title**	**Credits**	**Pre-Requisite**
Core			
*EASC 342	Geology of Ghana	3	EASC 320
*EASC 326	Aerial Photo Interpretation	2	
EASC 354	Earth Resources	3	
EASC 352	Geological Field Methods	2	EASC 320
TOTAL		**10**	
Electives			
EASC 332	Introduction to Petroleum Geology	2	
EASC 336	Mineral Economics	2	
EASC 338	Earthquake Seismology and Disaster Risk Reduction	3	
EASC 322	Environmental Pollution	2	
EASC 334	Organic Geochemistry	2	

*Core for students majoring in Geology

LEVEL 400

The Level 400 courses are for students who opt for major in Geology. Students will take 15 – 18 credits per Semester. Students are advised to select at least 3 credits per Semester from the minor subject. Student minoring in Geology shall take at least 3 credits of any of the under listed courses per Semester.

FIRST SEMESTER

Code	**Title**	**Credits**	**Pre-Requisite**
Core			
EASC 420	Project	3	
EASC 471	Remote Sensing and Geographic Information Systems	3	
EASC 450	Geological Field Mapping	3	EASC 352
EASC 419	Igneous and Metamorphic Petrology	3	EASC 321
TOTAL		**12**	
Electives: Select 3 – 6 credits			
EASC 417	Mineralogy	3	EASC 217
EASC 437	Geochemistry and Cosmochemistry	2	
EASC 465	Micropaleontology	3	EASC 218
EASC 461	Basin Analysis	3	EASC 343

SECOND SEMESTER

Code	**Title**	**Credits**	**Pre-Requisite**
Core			
EASC 420	Project	3	
EASC 404	Statistical Methods in Earth Science	2	
EASC 480	Field Studies in Earth Science	1	

EASC 470	Communication and Entrepreneurship in the Earth Sciences	2	
EASC 446	Sedimentary Petrology	3	EASC 224
TOTAL		**11**	
Electives: Select 4 – 7 credits			
EASC 448	Geology of Africa	3	
EASC 454	Geochronology	2	
EASC 476	Geotectonics	2	EASC 341
EASC 478	Stratigraphy	2	EASC 229
EASC 482	Geology of Mineral Deposits	3	

COURSE DESCRIPTIONS

LEVEL 200

EASC 227: Geological Structures and Maps
The course discusses, from first principles, the morphology of the common types of geological structures, and relates them to their manifestation on the ground and geological maps. It covers the recognition and interpretation of geological structures from maps. The types of geological structures taught in class include: rock bodies, horizontal and dipping strata, folds, faults, joints, fractures, faulted folds, folds with cleavages, unconformities, and mapping of rocks and structures. Students shall learn how maps show the distribution of rocks and structures and how these can be interpreted to give information on the geological history, relative ages of rocks and events.

Reading lists:
Bennison, G.M. (1990). *An introduction to geological structures and maps.* New York, NY: Chapman and Hall

Borradaile, G. (2014). *Understanding geology through maps*. Amsterdam: Elsevier.

Lisle, R.J. (2004). *Geological structures and maps: a practical guide*. Amsterdam: Elsevier

McClay, K.R. (1987). *The mapping of geological structures*. Hoboken, NJ: John Wiley & Sons Inc.

Roberts, J.L. (1982). *Introduction to geological maps and structures*. New York, NY: Pergamon Press Inc.

EASC 229: Introduction to Stratigraphy and Sedimentation
This course provides an overview of sedimentary processes and products, and the basic principles of stratigraphic analysis and correlation. Topics covered in class include weathering, erosion, transport, deposition; sediments; lithification, diagenesis; sedimentary rocks; common sedimentary structures, depositional environments; stratigraphic nomenclature and the stratigraphic column; basic principles of stratigraphy. Lab work involving application and interpretation of the sedimentary and stratigraphic principles to historical geology.

Reading List:

Boggs, S. Jr; (2006). *Principles of sedimentology and Stratigraphy* (4th Edition). Pearson, Prentice Hall, New Jersey.

Davis, R. (1983). *Depositional Systems.* Prentice Hall INC, New Jersey.

Poort, J. M., & Carlson, R.J. (1992). *Historical Geology. Interpretation and Applications* (4th Edition). Prentice Hall INC, New Jersey.

Krumbein, W. C., & Sloss, L. L. (1959). *Stratigraphy and Sedimentation*. W. H. Freeman and Company, San Francisco.

Laporte, L.F. (1979). *Ancient Environments* (2nd Edition). Prentice Hall, New Jersey.

Mathews, R. K. (1974). *Dynamic Stratigraphy.* Prentice Hall INC, New Jersey.

EASC 217: Optical Mineralogy

This course is designed to prepare students for the study of rocks in thin section (i.e. petrography). Topics to be covered include the elementary principles of crystal optics, familiarization with and use of the microscope, the immersion method, isotropic, uniaxial, and biaxial optics, and the detailed study of rock-forming minerals in thin section. By the end of the course students should be able to identify the major rock-forming minerals in thin section. In order to accomplish this objective students will learn about the underlying concepts related to mineral behaviour in transmitted/polarized light and the use of the petrographic microscope.

Reading lists:

Edward, M. (2013). *The Practical Methods of Identifying Minerals in Thin Section with microscope and the principle*. Read Books Limited, India.

Gribble, C.D., & Hall, A.J. (1992). *Optical Mineralogy; Principles and Practice.* Chapman & Hall, New York.

Mita, S. (1996). *Fundamentals of Optical, Spectroscopic and X-ray Mineralogy*. New York.

Perkins, D., & Henke, K.R. (2004). *Minerals in Thin Section*. Prentice Hall, New York.

Stoiber, R.E., & Morse, S.A. (1994). *Crystal identification with the polarizing microscope*. Springer-Verlag, Berlin.

William, D, & Nesse, (2016). *Introduction to Mineralogy*. Oxford University Press, London.

EASC 219: Practical Crystallography

This is a practical course involving the essentials of geometrical crystallography and internal order of crystals. The detail syllabus is as follows: *Essentials of geometrical crystallography*: Crystal description, symmetry elements, crystal symmetry, crystallographic axes. Parameters, indices, crystallographic notation, principal laws of geometric crystallography. Faces, forms,

zones, crystal habit, measurement of crystal angles. Law of rational indices, classification of crystals, crystal systems, thirty-two crystal classes, spherical projection, stereographic projection, intergrowth of crystals. *Essentials of Internal Order of crystals*: Symmetry elements, space lattice, unit cell, space groups.

Reading List

Clegg, W. (1998). *Crystal Structure Determination* (2nd Edition). Oxford University Press,

Muller, P., Herbst-Irmer, R., Spek, A., Schneider, T., & Sawaya, M. (2006). *Crystal Structure Refinement: A Crystallographer's Guide to SHELXL (International Union of Crystallography Texts on Crystallography).* Oxford University Press.

Phillips, F.C. (1971). *Introduction to Crystallography*. John Wiley & Sons Canada Limited,

Sands, D.E. (2010). *Introduction to Crystallography*. Dover Publications.

Stout, G.H. (1989). *X-Ray Structure Determination: A Practical Guide* (2nd Edition). X Wiley-Interscience.

EASC 220: Geological Field Exercises I

A practical field-based course consisting of two parts. Part I covers the most commonly used field equipment and outlines field safety procedures. It explores the general objectives of fieldwork, the use of a field notebook, and the necessary skills for the collection of paleontological and sedimentological data. Part II involves about six days 'live-in' field exercises in a sedimentary terrain (e.g., the Sekondian Group in the Sekondi/Takoradi area), providing 'hands-on' instructions on the recognition, identification, description and interpretations of geological features.

Reading lists:

Assaad, A.F., LaMoreaux, E.P., & Hughes, T.H. (2004). *Field methods for Geologists and Hydrogeologists*. Springer.

Coe, L.A., Argles, T.W., Rothery, D.A., & Spicer, R.A. (2010). *Geological field mapping techniques.* Blackwell Publishing Limited.

Lisle, J.R., Brabham, P., & Barnes, J. (2011). *Basic Geological mapping. The geological field guide series* (5th Edition). John Wiley.

EASC 214: Principles of Geochemistry

This course is intended to familiarize students with the tools of geochemistry. These include the tools of thermodynamics, kinetics, aquatic chemistry, and trace element geochemistry. The course is divided into two parts. Part I covers the theory and application of thermodynamics and kinetics to processes controlling the composition of natural waters, and basic mineral-water-atmospheric gas interactions. Part II covers trace elements in igneous processes, including Goldschmidt's classification of the elements and the geochemical periodic table, element partitioning between coexisting minerals, and trace element distribution during partial melting and crystallization.

Reading lists:

Faure, G. (1998). *Principles and Applications of Geochemistry* (2nd Edition). Prentice Hall

Holland, H., & Turekian, K. (2011). *Geochemistry of earth surface systems*. Academic Press, Elsevier

McSween, H.Y. Jr., Richardson, S.M. & Uhle, M.E. (2003). *Geochemistry: Pathways and Processes.* New York, NY: Columbia University Press.

Shaw, D.M. (2006). *Trace Elements in Magmas*. New York, NY: Cambridge University Press.

White, W.M. (2013). *Geochemistry.* Wiley-Blackwell

EASC 216: Fundamentals of Geophysics

Introduction to basic principles of geophysics as applicable to the solid earth. Topics covered include general earth properties (size, mass, and moment of inertia), seismology (wave equation, P, S, and surface waves, seismic reflection and refraction), gravity (gravity anomalies, rheology, flexure, geodesy, and geoid), magnetics (dipole field, paleomagnetics, and seafloor spreading), the electrical methods, radioactivity and geochronology, and heat flow.

Reading List:

Cara, M., & Babuska, V. (1991). *Modern Approaches in Geophysics: Seismic Anisotropy in Earth 10.* Springer.

Lowrie, W. (2007). *Fundamentals of Geophysics* (2nd Edition). Cambridge University Press.

McDowell, P.W. (2002). *Geophysics in Engineering Investigations*. Construction Industry Research & Information Association.

Parasnis, D.S. (1996). *Principles of Applied Geophysics*. Springer.

Reynolds, J.M. (2011). *An Introduction to Applied and Environmental Geophysics*. Wiley & Sons Incorporated.

EASC 218: Introduction to Palaeontology

This course aims to provide a practical introduction to palaeontology - the study of ancient life forms preserved as fossils. It examines how fossils are preserved, the identification of fossils and explains how fossils are used in establishing geologic age of rocks, correlating strata, and reconstructing paleoenvironments. The contents are as follows: Study of Phyla: porifera, cnidarian, hemichordata,mollusca, brachiopoda; nature of the organism and geologic importance; important index fossils; environmental stratigraphy and environmental reconstruction. Identification and sketching of some specimens of the phyla of organisms indicated above.

Reading List

Brouwer, A. (1967). *General Palaeontology*. Oliver and Boyd Ltd, London.

Clarkson, E. N. K. (1996). Invertebrate Palaeotology and Evolution (3rd Edition). Chapman and Hall, London, New York.

Jackson, P. N. *Introducing Palaeontology, A guide to ancient life*. Dunedin.

Laporte, L. F. (1979). *Ancient Environments* (2nd Edition). Prentice -Hall Inc. New Jersey.

Raup, M. P., & Stanley, S. M. (1978). *Principles of Palaeontology* (2nd Edition). W. H. Freeman and Company, San Francisco.

Shrock, R. R. & Twenhofel, W.H. (1953). *Principles of Invertebrate Palaeontology* (2nd Edition). McGraw-Hill Book Company, Inc. New York.

EASC 222: Petrography

This course has both lecture and practical components. The lecture component covers petrographic work on the origin, mode of formation, compositions, textures, fabric and classification of igneous, sedimentary and metamorphic rocks. The practical component covers the study of igneous, sedimentary and metamorphic rocks in hand specimen and in thin sections. Concepts are illustrated by rock suites from Ghana and elsewhere.

Reading lists:

Best, M.G. (1982). Igneous and metamorphic petrology. Freeman.

Ehlers, G.E. & Blatt, H. (1997). *Petrology, Igneous, sedimentary and metamorphic*. CBS publishers and distribution.4596/1-A new delhi-11000, India.

Loren, A. R. (1995). *Petrology: The study of igneous, sedimentary and metamorphic rocks.* WCB, McGraw-Hill.

Nesse, & William, D. (2000). Introduction to Mineralogy. New York, Oxford University Press.

Deer, W.A., Howie, R.A., & Zussman, J. (2013). An Introduction to the Rock-forming Minerals. London: Mineralogical Society.

Winter, D.J. (2001). *An Introduction to Igneous and Metamorphic Petrology.* Prentice hall

EASC 280: Internship in Earth Science I

Long vacation industrial attachment to a governmental or private sector geoscience or related institution/ company. Credit is contingent on submission of a final report by students and an assessment report by industry. This course offers an opportunity for students with little or no experience to come into a professional working environment and work hands-on in their chosen field.

EASC 225: Quantitative Geology
This course is designed to improve students' quantitative and problem solving skills applied to geological problems. Student will learn and practice various types of mathematical approaches used to quantify processes across a broad range of geoscience disciplines, including mineralogy, petrology, structural geology, hydrogeology, and geophysics. Topics to be covered include: mathematics as a tool for solving geological problems; common relationships between geological variables; equations and how to manipulate them; trigonometry; graphs; statistics; differential and integral calculus. Students will be given projects to design and solve mathematically relevant problems in geology using any of the mathematical techniques discussed in class.

Reading list:
Davis, J.C. (2003). *Statistics and data analysis in geology*. Wiley

Ferguson, J. (1994). *Introduction to linear algebra in geology.* Chapman and Hall

Fowler, C.M.R. (2004). *The solid earth: an introduction to global geophysics*. Cambridge University Press.

Koch, G.S., & Link, R.G. (1970). *Statistical analysis of geological data*. Dover Publications.

Turcotte & Schubert (1982). *Geodynamics*. Wiley

Waltham, D. (2000). *Mathematics: a simple tool for geologists*. Oxford: Blackwell Science Ltd.

EASC 317: Environmental Geochemistry
The course will offer students the opportunity to learn how the principles of Geochemistry are applied to the understanding of specific types of contaminants and contaminated environments: heavy metal contamination; landfills; pollutant transport in groundwater, environmental geochemistry of mineral deposits; acid rock and acid mine drainage processes; geochemistry of radioactive waste disposal; and geochemistry of organic compound contamination.

Reading List:
Langmuir, D. (1996). *Aqueous Environmental Geochemistry*. Prentice Hall,

Nelson, G. (2003). *Principles of Environmental Geochemistry*. Brooks/Cole.

Nicholson, K. (2005). *Environmental Geochemistry: Principles and Applications*. Wiley & Sons,

Nordstrom, K., & Drever, J. (1998). *Environmental Geochemistry*. Wiley & Sons.

Siegel, F.R. (2001). *Environmental Geochemistry of Potentially Toxic Metals*. Springer,

EASC 321: Introduction to Igneous and Metamorphic Petrology
The introduction to the origin and evolution of magmatic systems, and metamorphic systems and processes. It gives students good preparation in the techniques of modern petrology; a

clear and organized review of the classifications, textures, petrofabric and approach to petrologic study; and then applies these concepts to the real occurrences of the rocks themselves. Concepts are illustrated by rock suites from Ghana and elsewhere.

Reading List

Best, M.G. (2003). *Igneous and Metamorphic Petrology*. Wiley & Sons.

Frost, B.R., & Frost, C.D. (2013). *Essentials of Igneous and Metamorphic Petrology.* Cambridge University Press.

Higgins, M.D. (2010). *Quantitative Textural Measurements in Igneous and Metamorphic Petrology.* Cambridge University Press.

Philpotts, A.R., Philpotts, A., Ague, J.J., & Ague, J. (2009). *Principles of Igneous and Metamorphic Petrology.* Cambridge University Press.

Winter, J.D. (2009). *Principles of Igneous and Metamorphic Petrology*. Prentice Hall.

EASC 323: Soil Mechanics

This is an introductory course in soil properties and testing techniques. Topics covered include: soil classification; practical importance of index properties; principal types of soils; size and shape of soil particles; properties of very fine soil fractions; mechanical analysis of soils; clay-silt-sand-gravel-loess- peat-fills-soil admixtures; total and effective stresses; shear strength tests; residual strength. Emphasis is placed on practical field applications. Laboratory exercises are included to compliment lecture topics.

Reading List

Budhu, M. (2010). *Soil Mechanics and Foundations*. Wiley & Sons.

Budhu M., (2006). *Soil Mechanics and Foundations*. Wiley & Sons.

Helmany, S. (2007). *Applied Soil Mechanics with ABAQUS Applications.* Wiley & Sons,

McCarthy, D.F. (2006). *Essentials of Soil Mechanics and Foundations: Basic Geotectonics*. Prentice Hall.

Terzaghi, K., Mesri, G., & Peck, R.B. (1996). Soil Mechanics in Engineering Practice. Wiley & Sons.

EASC 325: Fundamentals of Hydrogeology and Hydrology

This course provides an overview of water on the planet and its interaction with geologic materials. The first part of the course describes surface water processes, including precipitation, evaporation, snow hydrology, and runoff processes. The second part of the course follows water as it moves to the subsurface as soil water and ground water. Lecture topics include properties of aquifers, principals of groundwater flow, regional groundwater flow, wells, basin development, and water quality management.

Reading List

Domenico, P. A., & Schwartz, F. W. (1998). *Physical and Chemical Hydrogeology* (2nd Edition). Wiley and Sons, New York.

Driscoll, F. G. (1986). *Groundwater and Wells* (2nd Edition). Johnson Filtration Systems, Inc., Saint Paul, Minn.

Fitts, C.R. (2002). *Groundwater Science*. *Academic Press.*

Fetter, C. W. (2001). *Applied Hydrogeology* (4th Edition). Prentice–Hall, Upper Saddle River, N.J.

Freeze, R. A., & Cherry, J. A. (1979). *Groundwater*. Prentice Hall, Englewood Cliffs, N.J.

EASC 333: Environmental Impact Assessment

This course provides knowledge on environmental impact assessment (EIA) as a vital tool for sound environmental management and decision-making. Topics covered in class include: evolution of EIA processes, the concept of sustainable development, national legislation on the environment and the EIA process; identification and assessment of environmental impacts of development and their implication on overall decision-making process; tools of impact assessment and mitigation; environmental management systems; land disturbance and reclamation; project decommissioning. The course mainly draws on case studies from Ghana, but also includes other EIA systems of other countries.

Reading List

Barrow, C.J. (1997). *Environmental and Social Impact Assessment*: An Introduction. Routledge,

Canter, L.W. (1995). *Environmental Impact Assessment*. McGraw Hill Higher Education,

Marriott, B.B., (1997). *Environmental Impact Assessment: A Practical Guide*. McGraw Hill Professional Publishing.

Noble, B.F. (2005). *Introduction to Environmental Impact Assessment: A Guide to Principles and Practice*. Oxford University Press.

Ortolano, L. (1997). *Environmental Regulation and Impact Assessment*. Wiley & Sons Incorporated.

EASC 339: Principles of Applied Geophysics

This course is a study of geophysical techniques applied to solving geoscience problems in resource exploration and development, natural hazards, and pollution control. It provides a comprehensive introduction to the methods of applied geophysics including seismic, gravity, magnetic, electrical methods and electromagnetics. The course covers the basic theories, field procedures, data acquisition, processing and interpretation of the above methods. The emphasis of the course is on basic principles (i.e., the physics and mathematics behind the methods) rather than on applications.

Reading List

Cara, M., & Babuska, V. (1991). *Modern Approaches in Geophysics: Seismic Anisotropy in Earth 10.* Springer.

Lowrie, W. (2007). *Fundamentals of Geophysics* (2nd Edition). Cambridge University Press,

McDowell, P.W. (2002). *Geophysics in Engineering Investigations*. Construction Industry Research & Information Association

Parasnis, D.S. (1996). *Principles of Applied Geophysics*. Springer.

Reynolds, J.M. (2011). *An Introduction to Applied and Environmental Geophysics.* Wiley & Sons Incorporated.

EASC 341: Structural Geology

Structural geology is the study of processes and products of rock formation and deformation. This course introduces the discipline and techniques of structural geology through a study of the mechanics of rock deformation and related structures, identification and interpretation of structures from the microscopic scale to the scale of mountain belts, a study of the features and geometries of rock bodies, faults and folds, and techniques of strain analysis. Class lectures are supplemented by lab exercises as well as field trips to local outcrops. The practical aspect enables a student to work to unravel the deformational history of the rocks.

Reading list:

Ghosh, S.K. (2013). *Structural Geology: Fundamentals and modern developments*. Elsevier Science.

Davis, G.H., & Reynolds, S.J. (1996). *Structural geology and rocks of regions*. John Wiley,

Groshong, Jr., R.H. (1999). 3-D *Structural Geology. A practical guide to surface and subsurface Map Interpretation*. Springer

Passchier, W.C., & Trouw, J.A.R. (2005). *Microtectonics.* Springer.

Pric, N. J. (1966). *Fault and Joint Development in Brittle and Semi-Brittle Rock*. Pergamon Press, New York, 176pp.

Ragan, D.M. (2009). *Structural Geology: An introduction to geometrical techniques*. Cambridge university press

Rowland, S. M., & Duebendorfer E. M. (1994) Structural Analysis and Synthesis: A Laboratory Course in Structural Geology (2nd Edition). Blackwell Scientific Publ.

EASC 343: Sedimentology

In this course, students will study the formation, accumulation, alteration, and preservation of sediments in the geological record. It focuses on the reconstruction and interpretation of ancient carbonate and siliciclastic paleoenvironments based on the analysis of lithology, geometry, sedimentary structures, modern depositional environments, stratigraphic successions, and fossils. The course will include a laboratory component and may include a

field trip allowing for first-hand experience with describing and interpreting sedimentological units.

Reading List

Boggs, S. (2011). *Principles of Sedimentology and Stratigraphy*. Prentice Hall.

Leeder, M.R. (1991). *Sedimentology: Process and products*. Chapman & Hall, London

Lindholm, R. (1987). *A Practical Approach to Sedimentology*. Springer.

Nichols, G. (2009). *Sedimentology and Stratigraphy*. Wiley & Sons Incorporated.

Selley, R.C. (2000). *Applied Sedimentology*. Elsevier Science & Technology.

EASC 320: Geological Field Exercises II

This is a practical field-based course consisting of: (i) Lecture/practical sessions on the study of igneous and metamorphic rocks in the field, and construction and interpretation of geological maps and cross-sections, and (ii) About one week 'live-in' geological field mapping, with supervision, in an igneous/metamorphic terrain (e.g., the Dahomeyan/Togo/Buem Structural Units in the Volta Region of Ghana.

Reading list:

Coe, A. L. (2011). *Geological Field Techniques* (1st Edition). Wiley-Blackwell

Compton, R. R. (l985). *Geology in the Field:* John Wiley & Sons, NY.

Lisle, R. J., Brabham, P., & Barnes J. W. (2011). *Basic Geological Mapping (Geological Field Guide)* (5th & Kindle Edition). John Wiley & Sons.

Moseley, F. (1981). *Methods in Field Geology*. W. H. Freeman & Co. Oxford.

Tucker, M. E. (1982). Field Description of Sedimentary Rocks (Geological Society of London handbook series) (1st Edition). John Wiley & Sons.

EASC 322: Environmental Pollution

The purpose of this course is to give students an overview of the environmental pollution associated with air, water and solid waste, and methods for prevention, control and management of the pollution. Major categories and sources of air and water pollution; dangers of some air and water pollutants; detecting pollution; control and monitoring of pollution; acid rain and deposition; measurement of air and water pollution; air and water pollutant standards index from EPA and WHO; status of air and water quality in developed and developing countries; groundwater protection; human waste disposal will be discussed.

Reading List

Barrat, R., & Feates, F.S. (1995). *Integrated Pollution Management: Improving Environmental Performance.* McGraw Hill Companies.

Eckenfelder, W.W. (1988). *McGraw-Hill Series in Water Resources and Environmental Engineering: Industrial Water Pollution Control*. McGraw-Hill Higher Education,

Farmer, A. (1998). *Routledge Environmental Management: Managing Environmental Pollution.* Routledge

Friedman, F. (2006). *Practical Guide to Environmental Management* (10th Edition). Environmental Law.

Nathanson, J.A., & Schneider, R.A. (2014). *Basic Environmental Technology: Water Supply, Waste Management and Pollution Control.* Pearson Education

EASC 326: Aerial Photo Interpretation

This course introduces students to the principles of visual interpretation, measurement taking, and mapping from aerial photographs and remotely sensed imagery for geological and environmental applications. The course is a mix of lecture and hands-on exercises. Topics covered include stereoscopic vision, scale, stereogram construction, optical distortions and the techniques of stereo viewing, how to identify features on vertical air photos, and the application of aerial photo interpretation in geological mapping, mineral exploration, petroleum geology, engineering geology, hydrogeological, and environmental studies. The applications are illustrated by detailed case studies and numerous photographic examples.

Reading List

Bhatta, B. (2011). *Remote Sensing and GIS*. Oxford University Press Incorporated.

Campbell, J.B, (2008). *Introduction to Remote Sensing* (4th Edition). Guilford Publications,

Chipman, J.W., Lillesand, T.M., & Kiefer, R.W. (2003). *Remote Sensing and Image Interpretation.* Wiley & Sons Incorporated.

Jensen, J.R. (2006). *Remote Sensing of the Environment: An Earth Resource Perspective.* Prentice Hall

Lillesand, T., Kiefer, R.W., & Chipman, J. (2015). Remote Sensing and Image Interpretation. Wiley & Sons Incorporated,

EASC 332: Introduction to Petroleum Geology

This course provides an overview of how petroleum is generated and how it is found and how wells are drilled to produce it, the conditions in nature required for petroleum formation and trapping, and the role that geologists and geophysicists have in petroleum exploration and production. Areas of emphasis include concepts, terms, and history of petroleum and energy use in Ghana and the world; reservoir rocks and their fluids; drilling and logging of a well; the subsurface environment of sedimentary basins; generation and migration of petroleum; traps and seals; unconventional oil (oil sands, oil shales etc) and gas (shale gas).

Reading List:

Baker Hughes INTEQ (1999). *Petroleum Geology*. Rev A

Halliburton (2001). *Basic Petroleum Geology and Log Analysis.*

Maverick Energy Inc. (1999). *Fundamentals of Finding Oil & Gas*.

Hyne, N. (2012). *Nontechnical Guide to Petroleum Geology, Exploration, Drilling and Production* (3rd Edition). PennWell Corporation, USA.

Selly, R. (1985). Elements of Petroleum Geology (2nd Edition) by. W. H. Freeman and Company, New York.

EASC 334: Organic Geochemistry

This course focuses on organic carbon geochemistry and its use to solve problems of geological and environmental relevance. The subjects treated include organic carbon in space, the global carbon cycle, chemical composition of biogenic matter, sedimentology of organic matter, organic matter diagenesis, molecular fossils, geopolymers, generation and composition of fossil fuels, environmental organic geochemistry, and carbon stable isotope geochemistry.

Reading List

Killops, S.D., & Killops, V. (2005). *An Introduction to Organic Geochemistry*. Wiley & Sons Incorporated.

Lillis, P.G., & Dolan, M.P., (2013). *Organic Geochemistry of Oils from Oil Spring and Florence Oil Field near Canon City, Colorado*. Usgs Open-File Report 98-617. BiblioBazaar.

Pratt, L.M., Brasse, S.C., & Comer, J.B. (1992). *Geochemistry of Organic Matter in Sediments and Sedimentary Rocks.* Society of Sedimentary Petrology,

Romankevich, E.A. (2012). *Geochemistry of Organic Matter in the Oceans*. Springer.

Schenck, P.A., Leeuw, J.W., & Lijmbach, G.W. (1985). *Organic Geochemistry: Advances in Organic Geochemistry* (Vol. 6). Elsevier Science & Technology Books,

EASC 336: Mineral Economics

This course provides an understanding of the broad aspects of minerals as resources, the mineral industry, ore reserve classification and estimation, and project evaluation criteria. The course covers the following: uniqueness of the mining sector investment, mine taxation, ore reserve estimation, valuation, mineral projects evaluation and selection criteria, introduction to Ghana's mineral policy, and environmental considerations in mining sector management.

Reading list:

King, F. H., McMahon D. W., & Bujtor, G. J. (1982). *A Guide to the Understanding of Ore Reserve Estimation.* Australasian Institute of Mining and Metallurgy.

Moran, K. (1995). *Investment Appraisal for Non-Financial Managers*. Pitman Publishing, London.

Ruuge, I. C. (2003). *Mineral Economics and Strategy*. Society for Mining, Metallurgy and Exploration; Englewood, Colorado, USA.

Sabhash, C. R., & Indra N. S. (2016). *Mine and mineral economics*. Prentice Hall, India.

Wellmer, F.-W. (1986). *Economic Evaluations in Exploration*. Springer-verlag, Berlin.

EASC 338: Earthquake Seismology and Disaster Risk Reduction

This course covers the physics of earthquakes and seismic energy propagation, and seismic methods to determine Earth structure. Lectures cover the following: earthquake seismology; earthquake mechanics; earth structure; instrumentation; interpretation of seismograms; focal mechanisms; faults; paleoseismology; seismotectonics; earthquake locations and magnitudes; earthquake hazard assessment. Laboratory work will focus on the interpretation and analyses of digital earthquake data using digital and analog seismograms, analyses of local earthquake data on a workstation, plotting and interpretation of earthquake record sections, interpretation of paper record seismograms, and spectral analyses of strong ground motion records and probabilistic risk assessment.

Reading List

Dahlen, F.A., & Tromp, J. (1998). *Theoretical Global Seismology*. Princeton University Press.

Doyle, H.A. (1996). *Seismology*. Wiley & Sons Incorporated.

Geldart, L.P., & Sheriff, R.E. (1995). *Exploration Seismology*. Cambridge University Press,

Shearer, P.M. (1999). *Introduction to Seismology*. Cambridge University Press.

Udias, A. (2000). *Principles of Seismology*. Cambridge University Press.

EASC 342: Geology of Ghana

This course gives a general overview of the geology of Ghana. It covers the following topics: Introduction to the geology of the various geological units of Ghana: i.e., Birimian Supergroup, Tarkwaian Group, Voltaian Supergroup, coastal sedimentary basins (i.e., Sekondian Group, Tano Basin, Keta Basin), Togo, Buem, and the Dahomeyide Structural Units; Lithotectonic evolution of the geological units of Ghana; Metallogenesis; Theories on the evolution of the geology of Ghana.

Reading List

Hirdes, W., & Leube, A. (1989). *On gold mineralisation of the Proterozoic Birimian Supergroup in Ghana, West Africa.* Ghanaian-German Mineral Prospecting Project, Technical Cooperation Project No. 80, 2046.6

Kesse, G.O. (1985). *The Mineral and Rocks Resources of Ghana*. A.A. Balkema Publishers. Netherlands-Rotterdam.

Kesse, G.O. (1978). *The Search for Oil in Ghana*. Geological Survey Report No.78/1, Accra.

Leube, A., Hirdes, W., Mauer, R., & Kesse, G.O. (1990). *The early Proterozoic Birimian Supergroup of Ghana and some aspects of its associated gold mineralisation*. Precambrian Research.

Nude, P.M., Shervais, J.W., Attoh, K., Vetter, S.K., & Barton, C. (2009). *Petrology and geochemistry of nepheline syenite and related carbonate-rich rocks in the Pan-African Dahomeyide orogen, southeastern Ghana.* West Africa. Journal of African Earth Sciences.

EASC 352: Geological Field Methods
This course provides a comprehensive introduction to geological mapping in the field, and application of appropriate field techniques to support the generation of a geological map. Students will be taught how to collect, process and interpret field data and solve geological relationships at a variety of scales. Thus, the course will draw upon the principles of structural geology and combine them with an understanding of sedimentary, igneous and metamorphic rock systems. Students will also be taught how to write a field-based geological report. The course may include several one-day long trips to the field to practice concepts learned in class.

Reading list:
Assaad, A.F., LaMoreaux, E.P., & Hughes, T.H. (2004). *Field methods for Geologists and Hydrogeologists.* Springer.

Coe, L.A., Argles, T.W., Rothery, D.A., & Spicer, R.A. (2010). *Geological field mapping techniques*. Blackwell Publishing Limited.

Compton, R. R. (l985). *Geology in the Field.* John Wiley & Sons, NY.

Lisle, J.R., Brabham, P., & Barnes, J. (2011). *Basic Geological mapping* (5th Edition). The geological field guide series. John Wiley.

Moseley, F. (1981). *Methods in Field Geology*. W. H. Freeman & Co. Oxford.

EASC 354: Earth Resources
Everyday life and the fabric of modern civilization depend on using the Earth's physical resources: water to drink; fuel to burn; rocks and minerals to build roads and houses; metals for machinery, electronics, and communications. This course focuses on the occurrence, availability, exploration, exploitation and sustainability of these essential resources. It also considers their origins, how to find and extract them, and the environmental consequences of their exploitation. The course may include several one-day long trips to the field to reinforce geological and environmental concepts studied in class.

Reading list:
Barnes, H.L. (1979). *Geochemistry of Hydrothermal Ore deposits*. John Wiley and Sons, New York.

Edwards, R. & Atkinson, K. (1986). *Ore Deposit Geology and its influence on Mineral Exploration*. Chapman & Hall, London.

Guilbert, J.M. & Park, Jr. C.F. (1986). *The Geology of ore deposits.* W.H. Freman and Co, New York.

Jensen, M. L., & Bateman, A. M. (2013). *Economic Mineral Deposits.* Book Section Centre, India.

Prasad, U. (2010). *Economic Geology: Economic Mineral Deposits*. CBS, India.

EASC 380: Internship in Earth Science II
Long vacation industrial attachment to a governmental or private sector geoscience or related institution/ company. Credit is contingent on submission of a final report by student and an assessment report by industry. The course offers an opportunity to students to with little or no experience come into a professional working environment and work hands-on in their chosen field.

EASC 401: Hydrology
This course covers the following: the hydrological cycle, hydrometeorology and climate, hydrometric networks and catchment morphometry, precipitation measurements and analysis, evaporation measurements and analysis, soil moisture, river flow measurements and analysis, rainfall-runoff analysis, hydrographs. Hydrological instruments are introduced; students employ the instruments to make field measurements and perform a range of data analysis and exercises.

Reading List
Brutsaert, W. (2005). *Hydrology: An Introduction*. Cambridge University Press,

Gunston, H. (1998). *Field Hydrology in Tropical Countries: A Practical Introduction.* Practical Action Publishing.

Keen, J.D. (1995). *Practical Hydrology*. Land Surveyor's Workshop.

Lewis, G.L., Viessman, W., & Viessman W. Jr. (2002). *Introduction to Hydrology.* Prentice Hall,

Manning, J.C. (1996). *Applied Principles of Hydrology*. Prentice Hall,

EASC 404: Statistical Methods in Earth Science
This course covers the techniques of probability and data analysis as applied to problems in the earth and environmental sciences. Areas to be covered include probability, data description, hypothesis testing, time series analysis, correlation and regression analyses, and multivariate methods. Laboratory work focuses on the use of statistical software packages for data analysis.

References
Cloutier, V., Lefebvre, R., Therrien, R., & Savard, M.M. (2008). *Multivariate Statistical Analysis of the hydrochemical evolution of groundwater in a sedimentary rock aquifer.* Journal of Hydrology.

Davis, J.C., (1986). *Statistics and Data Analysis in Geology*. John Wiley & Sons Inc., New York.

Devore, J., & Farnum, N. (1999). *Applied Statistics for Engineers and Scientists*, Duxbury Press, New York

Johnson, A. R., & Wichern, D.W. (1998). *Applied Multivariate Statistical Analysis* (4th Edition). Prentice Hall, New Jersey.

Yidana, S.M. (2010). *Groundwater classification using multivariate statistical methods: Southern Ghana.* Journal of African Earth Sciences.

EASC 405: Hydrogeology

This course examines the exploration for groundwater resources (e.g., using geophysical methods), the development and evaluation of groundwater resources (well construction and hydraulic testing) in a variety of hydrogeological systems, and groundwater management approaches (sustainability, vulnerability). Course topics include groundwater and the hydrologic cycle, groundwater resource evaluation, well drilling methods, well screens and methods of sediment size analysis, water well design, installation and removal of screens, water well development, and well and pump maintenance and rehabilitation.

Reading List

Domenico, P. A., & Schwartz, F. W. (1998). *Physical and Chemical Hydrogeology* (2nd Edition, Wiley and Sons, New York.

Driscoll, F. G. (1986). *Groundwater and Wells* (2nd Edition). Johnson Filtration Systems, Inc., Saint Paul, Minn.

Fitts, C.R. (2002). *Groundwater Science*. Academic Press.

Fetter, C. W. (2001). *Applied Hydrogeology* (4th Edition). Prentice–Hall, Upper Saddle River, N.J.

Freeze, R. A., & Cherry, J. A. (1979). *Groundwater*. Prentice Hall, Englewood Cliffs, N.J.

EASC 407: Integrated Water Resources Management

This course develops knowledge in climate dynamics, hydrology and surface water resources which actually links hydro-meteorological and hydrological processes together with the relationship between rainfall and hydrological measurements, the important of groundwater resources in water resources management. Integrated water resources management designed to provide basic understanding of the principles, paradigms and methodologies in IWRM shall be treated along with water management and the environment and water quality management and the impacts of human activities on the ecosystem. Case studies involving the major river catchments shall be carried out.

Reading List

Biswas, A.K. (1997). *Water Resources: Environmental Planning, Management, and Development.* McGraw Hill Professional Publishing.

Cech, C.T.V. (2009). *Principles of Water Resources: History, Development, Management and Policy*. Wiley & Sons.

Grigg, N.S. (1996). *Water Resources Management: Principles, Regulations, and Cases.* McGraw Hill Professional Publishing.

Tarlock, A.D. (2002). *University Casebook: Water Resources Management*. West Academic.

Vaidyanathan, A. (1999). *Water Resources Management: Institutions and Irrigation Development in India*. Oxford University Press.

EASC 417: Mineralogy

The course is divided into two parts. Part 1 comprises crystal chemistry, crystal growth, relationship between crystal structure and temperature, pressure, and composition (phase equilibria), x-ray crystallography and chemical analysis of minerals. Part 2 concerns detailed study of selected phase systems, systematic and determinative mineralogy and analysis of some selected minerals.

Reading List

Cox, K. G., Price, N. B., & Harte, B. (1988). *An Introduction to the Practical Study of Crystals, Minerals, and Rocks.* McGraw-Hill Professional Publishing, 1988, 245p.

Hammond, C. (2009).*The Basics of Crystallography and Diffraction* (3rd Edition). Oxford University Press

Hibbard, M.J. (2001). *Mineralogy: A Geologist's Point of View*. McGraw-Hill Higher Education.

Nesse, W.D. (2003). *Introduction to Optical Mineralogy*. Oxford University Press.

Phillips, F.C. (1971). *Introduction to Crystallography*. John Wiley & Sons Canada Limited.

EASC 421: Igneous and Metamorphic Petrology

This course covers advanced concepts in the origin and evolution of magmatic and metamorphic systems. It builds on material taught in the course EASC 321: Introduction to Igneous and Metamorphic Petrology. The course presents a broad review of igneous and metamorphic rocks, emphasizing their tectonic associations, interrelationships and petrogenesis. Concepts are illustrated by rocks from Ghana and elsewhere.

Reading List

Best, M.G. (2003). *Igneous and Metamorphic Petrology*. Wiley & Sons.

Frost, B.R., & Frost, C.D. (2013). *Essentials of Igneous and Metamorphic Petrology.* Cambridge University Press.

Higgins, M.D. (2010). *Quantitative Textural Measurements in Igneous and Metamorphic Petrology.* Cambridge University Press.

Philpotts, A.R., Philpotts, A., Ague, J.J., & Ague, J. (2009). *Principles of Igneous and Metamorphic Petrology.* Cambridge University Press.

Winter, J.D. (2009). *Principles of Igneous and Metamorphic Petrology*. Prentice Hall.

EASC 437: Geochemistry and Cosmochemistry
This course discusses the Earth from geochemical perspective using the fundamental geochemical tools studied in EASC 214. It covers the following: Cosmochemistry: nucleosynthesis, meteorites, formation of the solar system and the planets; The Mantle and Core of the Earth: composition of the earth's mantle and core, the "primitive mantle", magma ocean and mantle differentiation, mantle geochemical reservoirs; The crust of the Earth: oceanic crust; crust-mantle interaction, continental crust, growth of the continental crust; Reactions at the earth's surface: weathering, soils, and stream chemistry; The oceans as a chemical system.

Reading list:
Faure, G. (1998). *Principles and Applications of Geochemistry* (2nd Edition). Prentice Hall.

Holland, H., & Turekian, K. (2011). *Geochemistry of earth surface systems*. Academic Press, Elsevier.

McSween, H.Y. Jr., Richardson, S.M. & Uhle, M.E. (2003*). Geochemistry: Pathways and Processes.* New York, NY: Columbia University Press.

Rollinson, H.R. (1993). *Using Geochemical Data: Evaluation, Presentation, Interpretation. Harlow, Essex, England.* Longman Group.

Shaw, D.M. (2006). *Trace Elements in Magmas*. New York, NY: Cambridge University Press

White, W.M. (2013). *Geochemistry.* Wiley-Blackwell

EASC 449: Mineral Exploration Methods, Planning and Management
The course introduces mineral exploration and mining methods. It focuses on the exploration of mineral deposits from desk studies up to harnessing of the mineral deposit. The various methods of exploration are treated in detail. Project evaluation is also discussed. The course covers the following topics: exploration programme design, reconnaissance exploration, detailed or follow-up exploration, sampling and assaying techniques, drilling techniques, project evaluation.

Reading list:
Camus, J. P. (2002). *Management of Mineral Resources*. Creating Value in the mining Business by Society for Mining, Metallurgy and Exploration; Englewood, Colorado, USA.

Gentry, D. W. and O'Neil, T. J. (1984): *Mine Investment Analysis*. Society of Mining Engineers of American Institute of Mining, Metallurgical and Petroleum Engineers, New York.

Haldar, S.K. (2012). *Mineral Exploration, Principles and Applications*. Elsevier.

Eggert, R. G. (2010): *Mineral Exploration and development: Risk and Reward*. Paper presented at International Conference on Mining, Phnom Penh, Cambodia.

Skelly, & Loy (1977). *Recommendations to improve pre-mining investigations in metal and non-metal mining.* USA Bureau of Mines open File Report.

EASC 447: Mineral Projects Feasibility Studies

A mining feasibility study is an evaluation of a proposed mining project to determine whether the mineral resource can be mined economically. This course deals with the basic concepts of feasibility studies, including important aspects and stages. *Course content*: The role of the feasibility study in the mine development decision process, organization of the preliminary feasibility study, presentation of project material, mining methods, geological data, mineral processing, surface facilities/ infrastructure/environmental requirements, capital and operating cost, revenue estimation, mineral taxation and financial evaluation, sensitivity and risk analysis.

Reading list:

Gentry, D. W., & O'Neil, T. J. (1984): *Mine Investment Analysis*. Society of Mining Engineers of American Institute of Mining, Metallurgical and Petroleum Engineers, New York.

Haldar, S.K. (2012). *Mineral Exploration, Principles and Applications*. Elsevier.

Marjoribanks, R. (2010). *Geological Methods in mineral Exploration and Mining.* Springer Verlag, Heidelberg.

Torries, T. F. (1998). *Evaluating Mineral Projects; Applications and Misconceptions*. Society for Mining, Metallurgy and Exploration, Englewood, Colorado, USA.

Ward, M.-C. (1997). *Technical Report Writing and Common Terminology*. Exploration and Mining Fundamentals – A Short course for representatives from Developing countries; given by prospectors and Developers Association of Canada., Toronto, Canada.

EASC 439: Geostatistical Ore Reserve Estimation

This course will present basic concepts of geostatistics and ore reserve estimation. It will treat the data requirements for optimal geospatial modelling, data distributions, and the univariate statistical tools that are applicable to the preliminary assessment of data prior to geospatial modelling. The traditional estimation methods will be treated. The course will discuss the relevance of spatial continuity modelling, the types of theoretical variogram models commonly used, and the concept of structural analysis. Ordinary kriging will be treated, along with the concepts of geological modelling, and resource estimation. Students will be introduced to multivariate kriging, and non-linear estimation techniques.

Reading list:

David, M. (1977). *Geostatistical Ore Reserve Estimation*. Elsevier, Amsterdam

Hohn, M.E. (1999). *Geostatistics and Petroleum Geology* (2nd Edition). Kluwer Academic Publishers, Boston, Massachusetts, USA.

Isaaks, E.H., & Srivastava, R.M. (1989). *Applied Geostatistics*. Oxford University Press, Oxford, UK.

Journel, A. G., & Huijbregt, C. J. (1978). *Mining Geostatistics*. Academic Press, London.

Webster, R., & Oliver, M.A. (2007). *Geostatistics for Environmental Scientists* (2nd Edition). John Wiley & Sons, England, UK

EASC 457: Rock Mechanics

Index properties of rocks; engineering characteristics of rocks. Shear strength of planar discontinuities; Shearing on an inclined plane; Surface roughness; Shear testing on discontinuities in rocks; Estimating joint compressive strength and friction angle; Shear strength of filled discontinuities and closely jointed rock masses; Residual Strength; Schmidt Hammer Test. Rock Mass Classification and their importance in engineering works; Rock Quality Designation; Influence of clay seams and fault gouge; CSIR classification of jointed rock masses; NGI Tunneling Quality Index. Types of earth-moving equipment; Borrow materials; Cuts in rocks and soils; Foundations; Free-draining materials; Roads and Highways; Earth dams; Canal works. Laboratory work.

Reading List

Cook, N.G., & Jaeger, J.C. (1979). *Fundamentals of Rock Mechanics*. Chapman and Hall,

Goodman, R.E. (1989). *Introduction to Rock Mechanics*. Wiley & Sons Incorporated.

Harrison, J,P., & Hudson, J.A. (1997). *Engineering Rock Mechanics: An Introduction to the Principles.* Elsevier Science & Technology Books.

Hudson, J.A. (1989). *Rock Mechanics Principles in Engineering Practice*. Elsevier Science & Technology Books.

Jumikis, A.R. (1983). *Rock Mechanics*. CRC Press.

EASC 459: Bearing Capacity and Slope Stability Analysis

Theory of bearing capacity cohesive and cohesionless soils and clays; Bearing capacity estimation from in situ tests; Estimation of bearing pressures by empirical methods, Foundation Types; Protection of foundations against attack by soils and groundwater. Slope failure types in soils, General methods of analysis in cohesive and cohesionless soils, End-of-construction and long-term stability. Plane failures; Wedge failure; Circular failure; Toppling failure; Application of Hemispherical Projections to Determine Failure Modes; Influence of a slope curvature upon stability; Surface protection of slopes; Control of rock falls; Monitoring and interpretation of slope displacements. The course will also include a three day field visit.

Reading List

Correia, A.G., & Staff, G.C. (2002). *Bearing Capacity of Roads, Railways and Airfields*. CRC Press.

Das, B.M. (2009). *Shallow Foundations: Bearing Capacity and Settlement* (2nd Edition). CRC Press.

Guyer, J. (2013). *An Introduction to Bearing Capacity Analysis*. Create Space Independent Publishing Platform.

Straus, S., & Das, B.M. (1999). *Shallow Foundations: Bearing Capacity and Sediments*. CRC Press.

United States Corps of Engineers, (2004). *Bearing Capacity of Soils*. University Press of the Pacific.

EASC 461: Basin Analysis

This course focuses on the different kinds of sedimentary basins, the processes that form these basins, the processes that bring about filling of basins, and the nature of the fills. The methods used to carry out basin analysis and the applications of basin analysis are also discussed. Topics to be discussed include physical state of lithosphere, mechanisms of sedimentary basin formation by stretching, strike-slip, flexure and compression, effects of mantle dynamics, basin infill mechanisms and depositional systems, subsidence and thermal history, basin mapping methods, and application to the petroleum system, leading towards the play concept.

Reading List

Allen, J.R., & Allen, P.A. (2005). *Basin Analysis: Principles and Applications*. Wiley & Sons Incorporated.

Miall, A.D. (2006). *Geology of Fluvial Deposits: Sedimentary Facies, Basin Analysis and Petroleum Geology.* Springer.

Miall, A.D. (1997). *Principles of Sedimentary Basin Analysis*. Springer.

Makhous, M., & Gallushkin, Y. (2004). *Basin Analysis and Modelling of the Burial, Thermal and Maturation Histories in Sedimentary Basins*. Editions Technip.

Wangen, M. (2010). *Physical Principles of Sedimentary Basin Analysis*. Cambridge University Press.

EASC 465: Micropalaeontology

This course will touch on Foraminifera; Ostracods;Conodonts; Diatoms; Introduction to Palynologyand palynofacies analysis {(pollen & spore, dinoflagellates, acritarchs, chitinozoans, sedimentary organic matter (SOM)}Application of micropaleontology in the oil industry. Practicals: Method of preparation and identification of microfossil.

Reading List

Boardman, R.S, Cheetham, A.H., & Rowell, A.J. (1987). *Fossil Invertebrates*. Blackwell Scientific Publication. 728 pp.

Haq, B. U., & Boersma, A. (1981). *Introduction to Micropalaeontology*. Elsevier Science Publishers B.V.

Lipps, J. H. (1993). *Fossil Prokaryotes and Protists.* Blackwell Scientific Publ.

Loeblich, C., & Tappan, A.R. (1964).*Treatise on invertebrate paleontology*. University of Kansas Press.

Shrock, R. R., & Twenhofel, W. H. (1953). *Principles of Invertebrate Palaeontology* (2nd Edition). McGraw-Hill Series in the Geological Science.

Woods, H. (1950). *Palaeontology of Invetebrate* (8th Edition). Cambridge Biological Series.

EASC 467: Geology of Civil Engineering Projects

The course will cover urban geology, engineering geology of dams and tunnels, building cracks evaluation, and ground treatment. It will also consider the role of engineering geologist during construction of roads, houses, dams, tunnels, etc. Indepth study using case studies of major civil engineering projects such as tunnels, motorways, dams, etc., will also be covered. The course may include visits to mine sites.

Reading List

Goodman, R.E. (1989). *Introduction to Rock Mechanics*. Wiley & Sons Incorporated,

Goss, C.M. (2008). *Geo-Velopment: The Role of Geological and Geotechnical Engineering in New and Redevelopment Projects*. American Society of Civil Engineers,

Harrison, J,P., & Hudson, J.A. (1997). *Engineering Rock Mechanics: An Introduction to the Principles.* Elsevier Science & Technology Books.

Straus, S., & Das, B.M. (1999). *Shallow Foundations: Bearing Capacity and Sediments*. CRC Press.

United States Army Corps of Engineers (1986). *Construction Materials for Civil Engineering Projects*. American Society of Civil Engineers.

EASC 471: Remote Sensing and Geographic Information Systems

This course is of two parts. Part I introduces the principles and concepts of Remote Sensing (RS). In this part, students are introduced to environmental issues of the Earth, principles of RS, satellites and sensors, RS imagery, data acquisition systems, digital image processing for RS imagery, and applications. Part II introduces the principles, concepts and applications of Geographic Information Systems (GIS). Database development, manipulation and spatial analysis techniques for information generation will be taught. Application of GIS in natural resource management, environment, civil engineering, etc, will be discussed through mini project and laboratory exercises.

Reading List

Bhatta, B. (2011). *Remote Sensing and GIS*. Oxford University Press Incorporated.

Campbell, J.B, (2008). *Introduction to Remote Sensing* (4th Edition). Guilford Publications.

Chipman, J.W., Lillesand, T.M., & Kiefer, R.W. (2003). Remote Sensing and Image Interpretation. Wiley & Sons Incorporated.

Jensen, J.R. (2006). *Remote Sensing of the Environment: An Earth Resource Perspective*. Prentice Hall.

Lillesand, T., Kiefer, R.W., & Chipman, J. (2015). Remote Sensing and Image Interpretation. Wiley & Sons Incorporated.

EASC 420: Project
Students undertake an independent research work which is the culmination of the BSc degree programme. This provides students with the opportunity to consolidate their specialist knowledge in a particular area. The dissertation is undertaken under the supervision of faculty. The Project may commonly include a fieldwork component or may entirely consist of the analysis of raw data. The project will normally begin in the first semester. Students will present their project report at the end of the academic year.

EASC 426: Rural Water Supply
The course is designed to incorporate various areas in water resources management including water as a resource, water resources of Ghana, Ghana's water policy, water supply options in Ghana; management, planning and implementation of rural water schemes. Basic principles and concepts in rural water supply, community interactions, developing a project strategy; Community Water supply policy of Ghana will also be taught. Topics such as finding, design, constructing and assessing groundwater, water quality aspects of rural water supply; rural water infrastructure, capacity building, community water supply options and innovations will also be taught. Case histories will be discussed.

Reading List
Greenwell, A. (2009). *Rural Water Supply: A Practical Handbook on the Supply of Water and Construction of Waterworks*. BiblioBazaar,

Greenwell, A. (2012). *Rural Water Supply; a Practical Handbook on Supply of Water and Construction of Waterworks for Small Country Districts*. General Books,

Greenwell, A., Curry, W.T. (2010). *Rural Water Supply: A Practical Handbook on the Supply of Water and Construction of Waterworks for Small Country Districts*. Kessinger Publishing.

Harvey, P., & Reed, B. (2004). *Rural Water Supply in Africa: Building Blocks for Handpump and Sustainability*. Water, Engineering & Development Centre.

Lockwood, H., & Smits, S. (2011). *Supporting Rural Water Supply: Moving Towards a Service Delivery Approach.* Practical Action Publishing.

EASC 438: Water Quality and Hydrochemistry
This course deals with water quality studies and sources, behavior and transport of contaminants. There is particular focus on interactions between water and minerals and their significance for groundwater composition. Course content include: water quality standards; hydrochemical behaviour of contaminants; measurement of parameters; hydrochemical sequences; graphical methods and hydrochemical facies; sources of contaminants; contaminant transport; hydrochemical behaviour of contaminants.

Reading List
Appelo, C.A.J., & Postma, D. (2005). *Geochemistry, Groundwater, and Pollution* (2nd Edition). CRC Press.

Drever, J.I. (1997). *The Geochemistry of Natural Waters: Surface and Groundwater Environments.* Prentice Hall.

Erikson, E. (2011). *Principle and Applications of Hydrochemistry*. Springer.

Fetter, C.W. (2008). *Contaminant Hydrogeology*. Waveland Press.

Yidana, S.M., Ophori, D., & Banoeng-Yakubo, B. (2008). *A multivariate Statistical Analysis of Surface Water Chemistry: The Ankobra Basin, Ghana.* Journal of Environmental Management.

EASC 446: Sedimentary Petrology

This course gives a broad understanding of the petrology of sedimentary rocks. The course consists of two parts. Part I deals with siliciclastic sedimentary rocks by examining the characteristics features of sandstones, conglomerates, shales and mudrocks. The important topic of sediment provenance is discussed followed by discussion of diagenesis of siliciclastic sedimentary rocks. Part II deals with chemical/biochemical sedimentary rocks. It describes limestones, discusses dolomites and examines the diagenesis of these carbonate rocks. It then describes the characteristics of evaporites, cherts, phosphorites, and iron-rich sedimentary rocks and discusses some of the controversial aspects of their origin.

Reading List

Adams, A.E., Mackenzie, W.S., & Guilford, C. (1988). *Atlas of Sedimentary Rocks under the Microscope.* Longman Scientific & Technical, England.

Boggs, S. (2009). *Petrology of Sedimentary Rocks.* Cambridge University Press, New York.

Greensmith, J.T. (1989). *Petrology of the Sedimentary Rocks*. Unwin Hyman Ltd, London.

Mackenzie, F.T. (2005). *Sediment, Diagenesis, and Sedimentary Rocks*. Treatise on Geochemistry, Vol. 7. Elsevier B.V., The Netherlands

Morton, A.C., Todd, S.P., & Houghton, P.D.W. (1991). *Developments in Sedimentary Provenance Studies.* The Geological Society, London.

EASC 448: Geology of Africa

This course is designed to introduce the student to the regional geology of Africa, the major geological events that have shaped the continent, mineral resources of Africa as well as the evolutional history of Africa. The main focus of the course is a discussion on the major tectonic events that consolidated the continent and the timelines, the resulting mineralisation and the compositions of the different cratons in Africa.The course covers the following topics: Precambrian Geology of Africa, Proterozoic cratonic basins and mobile belts, Palaeozoic sedimentary basins in Africa, Mesozoic – Cenozoic basins in Africa, the Atlas Belt.

Reading list:

Goodwin, A. (1996). *Principles of Precambrian Geology*. Academic Press.

Leube, A., Hirdes, W., Mauer, R., & Kesse, G.O., (1990). *The early Proterozoic Birimian Supergroup of Ghana and some aspects of its associated gold mineralisation*. Precambrian Research.

Nude, P.M., Shervais, J.W., Attoh, K., Vetter, S.K., & Barton, C. (2009). *Petrology and geochemistry of nepheline syenite and related carbonate-rich rocks in the Pan-African Dahomeyide orogen, southeastern Ghana.* West Africa. Journal of African Earth Sciences.

Petters, W. (1991). *Regional Geology of Africa*. Springer.

Wright, J.B., Hastings, D.A., Jones, W.B., & Williams, A.R. (1985). *Geology and mineral Resources of Africa.* George Allen and Unwin.

EASC 450: Geological Field Mapping

This course is designed to train students in field mapping techniques and related skills. Skills developed during field camp typically include: field surveying, collection of geological data, construction of measured sections, interpretation of geological structures and how to take data, samples, and notes in the field. Students spend 3-4 weeks in the field during the long vacation, to collect geological data, analyze and interpret the data, and prepare geological maps and cross sections. Students work in groups in the field but work independently on the data gathered. At the end of the course, students present a report on the geology of the studied area.

Reading list:

Coe, A. L. (2011). *Geological Field Techniques* (1st Edition). Wiley-Blackwell

Compton, R. R. (l985). *Geology in the Field*. John Wiley & Sons, NY.

Lisle, R. J., Brabham, P., & Barnes, J. W. (2011). Basic Geological Mapping (Geological Field Guide) (5th Edition). John Wiley & Sons.

Moseley, F. (1981). *Methods in Field Geology*. W. H. Freeman & Co. Oxford.

Tucker, M. E. (1982). *Field Description of Sedimentary Rocks (Geological Society of London handbook series)* (1st Edition). John Wiley & Sons.

EASC 454: Geochronology

The primary objective of this course is to provide a practical overview of principles and techniques used in geochronology. The theory, methodology and interpretation of the following dating techniques will be discussed: U-Th-Pb, Rb-Sr, Sm-Nd, Pb-Pb, K-Ar, Ar-Ar, and Fission track dating. Cosmogenic and fossil isotopes. The dating of Ghanaian rocks will also be discussed.

Reading list:

Dickin, A. P. (1995). *Radiogenic Isotope Geology***.** Cambridge, Cambridge University Press. Encyclopedia of Scientific Dating Methods. Springer Netherlands.

Faure, G. (1986). *Principles of Isotope Geology*. Cambridge, Cambridge University Press.

Faure, G., & Mensing, D. (2005). *Isotopes - Principles and applications* (3rd Edition). J. Wiley & Sons.

McDougall, I & Harrison, T.M., (1999). *Geochronology and Thermochronology.* 40Ar/39Ar Method. Oxford University Press.

Noller, J. S., Sowers, J.M, & Lettis, W. R. (2000). *Quaternary geochronology: methods and applications.* American Geophysical Union.

EASC 458: Exploration Geophysics

This course builds on EASC 335 and deals with geophysical techniques applied to solving geoscience problems with focus on techniques relevant to the exploration for groundwater and mineral resources: seismic, electrical (resistivity, S.P. & I.P.), electromagnetic, gravity, and magnetic methods. The course is intended to be practical, hands-on, and field-oriented so applications are emphasized and theory is kept to the minimum. Case studies are included to illustrate applications. Hands-on experience at working with data is provided through laboratory exercises and take-home assignments.

Reading List

Cara, M., & Babuska, V. (1991). *Modern Approaches in Geophysics: Seismic Anisotropy in Earth* 10. Springer.

Lowrie, W. (2007). *Fundamentals of Geophysics* (2nd Edition). Cambridge University Press,

McDowell, P.W. (2002). *Geophysics in Engineering Investigations*. Construction Industry Research & Information Association.

Parasnis, D.S. (1996). *Principles of Applied Geophysics*. Springer.

Reynolds, J.M. (2011). *An Introduction to Applied and Environmental Geophysics*. Wiley & Sons Incorporated.

EASC 480: Field Studies in Earth Science

The course includes several one-day long and one week long field trips to hydrogeological, engineering, geoenvironmental and mine sites. It introduces practical skills appropriate to the study of earth and environmental science. The course concentrates on interactions and feedbacks in the environment, including studies of geology, landforms, soil types and water quality.

Reading list:

Coe, A. L. (2011). *Geological Field Techniques* (1st Edition). Wiley-Blackwell

Compton, R. R. (l985). *Geology in the Field*. John Wiley & Sons, NY.

Lisle, R. J., Brabham, P. & Barnes, J. W. (2011). Basic Geological Mapping (Geological Field Guide) (5th Edition). John Wiley & Sons.

Moseley, F. (1981). *Methods in Field Geology*. W. H. Freeman & Co. Oxford.

Tucker, M. E. (1982). *Field Description of Sedimentary Rocks (Geological Society of*

London).

EASC 462: Exploration Geochemistry
The course focuses on the application of geochemistry to mineral exploration. Topics discussed include the following: geochemistry of the supergene environment; supergene mineralization; regolith geochemistry; geochemical survey methods (lithogeochemical, stream sediments, soil, hydrogeochemical, geobotanical, biogeochemical); statistical treatment of geochemical data; analytical methods. Modern developments in understanding geochemical and isotopic systems and techniques applied to mineral exploration will also be discussed.

Reading list:
Levinson, A. A., (1980). *Introduction to exploration geochemistry*. Applied Science Publishers Ltd, Essex England.

Levinson, A.A., Thomson, I., & Bradshaw, P.M. (1987). *Practical Problems in Exploration Geochemistry.* Applied Publishing Limited.

Randive, K. R. (2012). *Elements of Geochemistry, Geochemical Exploration and Medical Geology.* Research publishing.

Reedman, J. H., (1979). *Techniques in Mineral Exploration*. Applied Science Publishers Ltd, Essex England.

Rose, A.W. (1980). *Geochemistry in Mineral Exploration*. Elsevier Science & Technology,

EASC 466: Petroleum Reservoir Geophysics
The applications of geophysics in 2D and 3D mapping of geological structures. Reflection seismic acquisition. Seismic processing fundamentals and digital filtering. Interpretation of 2D and 3D seismic reflection data, including horizontal and vertical slices, presentation parameters, horizon autotracking, fault mapping, stratigraphic and structural interpretation, and reservoir evaluation. Reservoir aspects of seismic interpretation. Seismic stratigraphy.

Reading List:
Abriel, W.L. (2008). *Reservoir Geophysics: Applications*. Society of Exploration Geophysicists.

Datta-Gupta, A., & Vasco, D.W. (2016). *Subsurface Fluid Flow and Imaging: With Applications for Hydrology, Reservoir Engineering, and Geophysics*. Cambridge University Press.

Gadallah, M.R. (1994). *PennWell Nontechnical: Reservoir Seismology: Geophysics in Nontechnical Language*. PennWell Corporation.

Johnston, D.H., & Cooper, M.R. (2010). *Methods and Applications in Reservoir Geophysics*. Society of Exploration Geophysicists.

Mari, A-L., & Chapellier, D. (1999). *Reservoir and Civil Engineering Geophysics*. Editions Technip,

EASC 468: Reservoir Engineering

The course covers basic petrophysical properties of reservoir rocks including porosity, permeability, fluid saturation, electrical conductivity, capillary pressure, and relative permeability; classification of oil and natural gas reservoirs; introduction to reserve estimation principles. Laboratory measurement of the reservoir rock characteristics mentioned above. Derivation of the general material balance equation. Application of the general material balance equation for determining initial oil in place and gas cap size and water influx constant under different drive mechanisms. Application of the general material balance equation for determining the initial gas in place for conventional gas reservoir.

Reading List

Ahmed, T., & McKinney, P.D. (2004). Advanced Reservoir Engineering. Elsevier Science & Technology.

Amyx, J.W. (1960). *Petroleum Reservoir Engineering Physical Properties*. McGraw-Hill Higher Education.

Dake, L.P. (1983). *Developments in Petroleum Science: Fundamentals of Reservoir Engineering.* Elsevier Science & Technology.

Hawkins, M.F., & Craft, B.C. (1959). Applied Petroleum Reservoir Engineering. Prentice Hall.

Lee, L. (1996). *Gas Reservoir Engineering*. Society of Petroleum Engineers, SPE Textbook.

EASC 470: Communication and Entrepreneurship in the Earth Sciences

The course is divided into two parts. The purpose of Part I is to help students to communicate ideas better and to learn the skills of communicating geoscience. Topics include discussion and review of different kinds of geological publications. Also included are oral presentation delivery, proposal development, and content organization. Part II teaches students the foundational skills needed to start their own business in the geoscience industries. Using the fundamentals of economics, marketing, accounting and business organizations, students will develop comprehensive business plans that include sales, financial, and legal considerations for starting and operating small or medium scale businesses.

Reading List

Desai, V., & Rai, U. (2016). *Entrepreneurship Development and Business Communication.* Ebsco Publishing.

Rai, U. (2008). *Entrepreneurship Development and Business Communication*. Global Media Publications.

Ireland, R.D., & Barringer, B.R. (2015). *Entrepreneurship: Successfully Launching New Ventures.* Prentice Hall.

Mariotti, S., & Glackin, C. (2011). *Entrepreneurship: Starting and Operating a Small Business.* Prentice Hall.

Mayo, T. (1997). *The Joy of Self Employment: Entrepreneurship and Education in a Changing World.* Capital Communications Incorporated.

EASC 472: Site Investigations

Covers site mapping,test pit excavations and logs,drilling methods and equipment, disturbed and undisturbed sampling, water sampling, in-situ tests, exploratory drifts and tunnels,and installation of piezometers. It also covers the application of geophysical surveys in site investigations, and the interpretation of geophysical survey results and implications on engineering geological problems. Students are also taught how to prepare site investigation reports. Case studies are discussed in class. The course may include field visits.

Reading List

Cara, M., & Babuska, V. (1991). *Modern Approaches in Geophysics: Seismic Anisotropy in Earth* 10. Springer.

Carter, M., & Symons, M.V. (1989). *Site Investigations Explained*. American Society of Civil Engineers.

McDowell, P.W. (2002). *Geophysics in Engineering Investigations*. Construction Industry Research & Information Association.

Parasnis, D.S. (1996). *Principles of Applied Geophysics*. Springer.

Reynolds, J.M. (2011). *An Introduction to Applied and Environmental Geophysics*. Wiley & Sons Incorporated.

EASC 474: Rock as Construction Materials

The course deals with explorations for quarries and rock aggregates for concrete, roads and highways, runways and railways. It also considers explosives and blasting, physical properties and chemical reaction on aggregates in concrete mixes, sulphides and organic substances in concrete, and pozzolanic materials. The techniques in sampling and laboratory analyses of samples are also considered. The course includes field visits to quarries and construction sites.

Reading List

Allen, E., & Iano, J. (2003). *Building Construction: Materials and Methods*. Wiley & Sons Incorporated.

Allen, E., & Iano, J. (2013). *Fundamentals of Building Construction: Materials and Methods*. Wiley & Sons Incorporated.

Scarborough, W., Armpriest, D., & Mehta, M. (2011). *Building Construction: Principles, Materials, and Systems.* Prentice Hall.

Spence, W.P. (1997). *Construction Materials, Methods and Techniques*. Delmar Cengage Learning.

Zaniewski, J.P., & Mamlouk, M.S. (2016). *Materials for Civil and Construction Engineers*. Pearson Education.

EASC 476: Geotectonics

Covers the origin and history of major tectonic forms and features of the earth, and their interaction and evolution through time. It examines modern tectonic principles and fundamental tectonic forms and textures of the earth's lithosphere and crust - orogenic belts, cratons, island arcs, rift zones, continental margins, etc, and discusses geotectonic models emphasizing on modern plate tectonic concepts. A knowledge of structural geology is required.

Reading list:

Beloussov, V.V. (2012). *Geotectonics*. Springer.

Dubey, A.K. (2014). Understanding orogenic belts: Structural Evolution of the Himalaya. Springer.

Lomnitz, C. (2013). *Developments in Geotectonics: Global Tectonics and Earthquake Risk*. Elsevier Science & Technology.

Sawkins, F.J. (1989). *Minerals and Rocks: Metal Deposits in Relation to Plate Tectonics*. Springer.

Yeda, S., Toksoz, N., & Franchesteau, J. (1980). *Developments in Geotectonics: Oceanic Ridges and Arcs*. Elsevier.

EASC 478: Stratigraphy

This course involves the large scale vertical and lateral relationships between units of sedimentary rock that are defined on the basis of lithologic properties, paleontological characteristics, geophysical properties, age relationships, and geographic position and distribution. The course is divided into three parts. Part I deals with lithostratigaphy and considers vertical and lateral successions of strata and correlation of lithostatigraphic units. Part II deals with fundamental principles, and methods and applications of sequence stratigraphy. Part III deals with biostratigraphy, the characterization and correlation of rock units on the basis of their fossil contents.

Reading List

Boggs, S. (2000). *Principles of Sedimentology and Stratigraphy*. Prentice Hall.

Davis, R. (1983). *Depositional Systems*. Prentice Hall INC, New Jersey.

Krumbein, W. C. & Sloss, L. L. (1959). *Stratigraphy and Sedimentation*. W. H. Freeman and Company, San Francisco

Mathews, R. K. (1974). *Dynamic Stratigraphy*. Prentice Hall INC, New Jersey.

Miall, A.D. (1996). *The Geology of Sequence Stratigraphy*. Springer,

Prothero, D.R., & Schwab, F. (2003). *Sedimentary Geology: An Introduction to Sedimentary Rocks and Stratigraphy.* Freeman & Company.

EASC 482: Geology of Mineral Deposits

The course gives an overview of the main types of metallic and non-metallic mineral deposits, their geological environments, geochemistry, mineralogy, structural geology and genetic constraints. It also considers the chemical, petrological, structural, and sedimentological processes that contribute to ore formation. Contents include: Distribution of economic mineral deposits with respect to their plate tectonic setting, lithological-stratigraphical environments, mineralogy, geochemistry, morphology and structural features. Description of classic deposits representing individual deposit types. Review of exploration strategies. Laboratory classes consists of hand specimen study of host rock-ore mineral suites and reflected light microscopy.

Reading List

Bateman, A.M., & Jensen, M.L. (1981). Economic Mineral Deposits. Wiley & Sons Incorporated.

Jensen, J. (1979). *Economic Mineral Deposits*. Wiley & Sons Incorporated.

Misra, K.C. (1999). *Understanding Mineral Deposits*. Springer.

Pirajno, F. (2012). *Hydrothermal Mineral Deposits: Principles and Fundamental Concepts for Exploration Geologist*. Springer.

Sawkins, F.J. (1989). *Minerals and Rocks: Metal Deposits in Relation to Plate Tectonics.* Springer.

DEPARTMENT OF MATHEMATICS

Undergraduate programmes

LEVEL 100

FIRST SEMESTER

Core

Code	Title	Credits
UGRC 150	Critical Thinking and Practical Reasoning	3
MATH 121	Algebra and Trigonometry	3
MATH 123	Vectors and Geometry	3
STAT 111	Introduction to Statistics and Probability I	3
Total		**12**
Electives (Select 3-4 credits)		
PHYS 105	Practical Physics I	1
PHYS 143	Mechanics and Thermal Physics	3
ABCS 101	Introductory Animal Biology	3
DCIT 101	Introduction to Computer Science I	3
ECON 101	Introduction to Economics I	3

SECOND SEMESTER

Core

Code	Title	Credits
URGC 110	Academic Writing I	3
UGRC 130	Understanding Human Society	3
MATH 122	Calculus I	3
MATH 126	Algebra and geometry	3
STAT 112	Introduction to Statistics and Probability II	3
Total		**15**
Electives (Select 3-4 credits)		
PHYS 106	Practical Physics II	1
PHYS 144	Electricity and Magnetism	3
BOTN 104	Growth of Flowering Plants	3
DCIT 104	Programming Fundamentals	3
ECON 102	Introduction to Economics II	3

SINGLE MAJOR IN MATHEMATICS

LEVEL 200

FIRST SEMESTER

Core

Code	Title	Prerequisite- Pass in	Credits
UGRC 210	Academic Writing II		3
MATH 223	Calculus II	MATH 122	3
MATH 225	Vectors and Mechanics	MATH 122	3
STAT 221	Introductory Probability I		3
	3-6 credits from one other department from		3-6

	100 level		
Total			**15-18**

SECOND SEMESTER

Core

Code	**Title**	**Prerequisite- Pass in**	**Credits**
UGRC 220	Liberal and African Studies		3
MATH 222	Vector Mechanics	MATH 225	3
MATH 224	Introductory Abstract Algebra	MATH 126	3
MATH 220	Introductory Computational Mathematics	MATH 122	3
STAT 224	Introductory Probability II		3
Total			**15**
Electives			
	3 credits from one other department from 100 level		
			15-18

LEVEL 300

FIRST SEMESTER

Core

Code	**Title**	**Prerequisite- Pass in**	**Credits**
MATH 351	Linear Algebra	MATH 224	3
MATH 353	Analysis I	MATH 223	3
MATH 355	Calculus of Several Variables	MATH 223	3
[i]MATH 350*	Differential Equations I	MATH 223	3
Total			**9-12**
Electives (Select 6-9 credits)			
MATH 359	Discrete Mathematics	MATH 224	3
MATH 361	Classical Mechanics	MATH 222	3
MATH 363	Introductory concepts of financial mathematics	MATH 223/STAT 221	3
STAT 331	Probability distributions		3

SECOND SEMESTER

Core

Code	**Title**	**Prerequisite- Pass in**	**Credits**
MATH 354	Abstract Algebra I	MATH 224	3
MATH 356	Analysis II	MATH 223	3
MATH 372	Topology	MATH 353	3
[i]MATH 350*	Differential Equations I	MATH 223	3

Total			**9-12**
Electives (Select 6-9 credits)			
MATH 366	Electromagnetic Theory I	MATH 222	3
MATH 362	Analytical Mechanics	MATH 222	3
MATH 358	Computational Mathematics I	MATH 220	3
MATH 368	Introductory number theory	MATH 224	3
STAT 332	Multivariate distributions		3

*Please note MATH 350 may be taken in either First or the Second Semester

LEVEL 400

FIRST SEMESTER

Core

Code	Title	Prerequisite- Pass in	Credits
[i]MATH 400	Project		3
MATH 441	Advanced Calculus	MATH 353 or MATH 351	3
MATH 440*	Abstract Algebra II	MATH 354	3
MATH 447	Complex Analysis	MATH 223	3
Total			**9-12**
Select at least 6 credits			
MATH 443	Differential Geometry	MATH 355	3
MATH 445	Introductory Functional Analysis	MATH 356	3
MATH 449	Electromagnetic Theory II	MATH 366	3
MATH 451	Introduction to Algebraic Field Theory	MATH 354	3
MATH 453	Introduction to Quantum Mechanics	MATH 362	3
MATH 455	Computational Mathematics II	MATH 358	3
MATH 457	Mathematical Biology I		3

Project may be replaced by two elective courses in mathematics

MATH 440 may be taken in either semester

SECOND SEMESTER

Core

Code	Title	Prerequisite- Pass in	Credits
MATH 400	Project		3
MATH 442	Integration Theory and Measure	MATH 356	3
MATH 440*	Abstract Algebra II	MATH 354	3
Total			**6-9**
Electives (Select a minimum of 9 credits)			
MATH 444	Calculus on Manifolds	MATH 441	3
MATH 446	Module Theory	MATH 440	3
MATH 448	Special Relativity	MATH 362	3
MATH 452	Introduction to Lie Groups and Lie Algebra	MATH 354	3
MATH 450	Differential Equations II	MATH 350	3
MATH 458	Mathematical Biology II	MATH 457	3
MATH 460	Fourier series and Fourier transforms	MATH 356	3

MAJOR – MINOR IN MATHEMATICS

LEVEL 200

FIRST SEMESTER

Core

Code	**Title**	**Prerequisite- Pass in**	**Credits**
UGRC 210	Academic Writing II		3
MATH 225	Vectors and Mechanics	MATH 122	3
MATH 223	Calculus II	MATH 122	3
Total			**9**
Electives (Select a minimum of 3 credits)			
MATH 220*	Introductory Computational Mathematics	MATH 122	3
STAT 221	Introductory Probability I		3

SECOND SEMESTER

Core

Code	**Title**		**Credits**
UGRC 220	Liberal and African Studies		3
MATH 224	Introductory Abstract Algebra	MATH 126	3
Total			**6**
Electives (Select a minimum of 3 credits)			
MATH 222	Vector Mechanics	MATH 225	3
MATH 220*	Introductory Computational Mathematics	MATH 122	3
STAT 224	Introductory Probability II		3

Students take 6 credits each semester from their minor department

MATH 220 may be taken in either semester

LEVEL 300

FIRST SEMESTER

Core

Code	**Title**	**Prerequisite- Pass in**	**Credits**
MATH 351	Linear Algebra	MATH 224	3
MATH 353	Analysis I	MATH 223	3
MATH 355	Calculus of Several Variables	MATH 223	3
Total			**9**

SECOND SEMESTER

Core

Code	**Title**	**Prerequisite- Pass in**	**Credits**
MATH 354	Abstract Algebra I	MATH 224	3
MATH 356	Analysis II	MATH 223	3
MATH 350	Differential Equations I	MATH 223	3
MATH 372	Topology	MATH 353	3
Total			**9-12**

Students take 6 credits each semester from their minor department. Students may choose to add an elective from the single subject elective list. MATH 372 Topology may be done in level 400.
Minor students choose any two courses each semester.

LEVEL 400
FIRST SEMESTER
Core

Code	**Title**	**Prerequisite- Pass in**	**Credits**
[i]MATH 400	Project		3
MATH 441	Advanced Calculus	MATH 351 or MATH 353	3
MATH 447	Complex Analysis	MATH 223	3
Total			**9**
Electives (Select 6-9 credits)			
MATH 440	Abstract Algebra II	MATH 354	3
MATH 443	Differential Geometry	MATH 355	3
MATH 451	Introduction to Algebraic Field Theory	MATH 354	3
MATH 453	Introduction to Quantum Mechanics	MATH 362	3
MATH 455	Computational Mathematics II	MATH 358	3
MATH 445	Introductory Functional Analysis	MATH 353	3
MATH 457	Mathematical Biology I		3
MATH 449	Electromagnetic theory II	MATH 366	3

SECOND SEMESTER
Core

Code	**Title**	**Prerequisite- Pass in**	**Credits**
[i]MATH 400	Project		3
MATH 442	Integration Theory and Measure	MATH 356	3
Total			**3**
Electives (Select 12 credits)			
MATH 444	Calculus on Manifolds	MATH 441	3
MATH 446	Module Theory	MATH 440	3
MATH 448	Special Relativity	MATH 362	3
MATH 452	Introduction to Lie Groups and Lie Algebra	MATH 354	3
MATH 450	Differential Equations II	MATH 350	3
MATH 458	Mathematical Biology II	MATH 457	3
MATH 460	Fourier series and Fourier transforms	MATH 356	3

*Project may be replaced by two elective courses in mathematics

COMBINED MAJOR

LEVEL 200

FIRST SEMESTER
Core

Code	**Title**	**Prerequisite- Pass in**	**Credits**
UGRC 210	Academic Writing II		3

MATH 225	Vectors and Mechanics	MATH 122	3
MATH 223	Calculus II	MATH 122	3
Total			**9**

SECOND SEMESTER

Core

Code	**Title**	**Prerequisite- Pass in**	**Credits**
UGRC 220	Liberal and African Studies		3
MATH 224	Introductory Abstract Algebra	MATH 126	3
Total			**6**
Electives (Select a minimum of 3 credits)			
MATH 222	Vector Mechanics	MATH 225	3
MATH 220	Introductory Computational Mathematics	MATH 122	3

Students take 6-9 credits each semester from their other department

LEVEL 300

FIRST SEMESTER

Core

Code	**Title**	**Prerequisite- Pass in**	**Credits**
MATH 351	Linear Algebra	MATH 224	3
MATH 353	Analysis I	MATH 223	3
MATH 355	Calculus of Several Variables	MATH 223	3
Total			**9**

SECOND SEMESTER

Core

Code	**Title**	**Prerequisite- Pass in**	**Credits**
MATH 354	Abstract Algebra I	MATH 224	3
MATH 356	Analysis II	MATH 223	3
MATH 350	Differential Equations I	MATH 223	3
Total			**9**

Students take 9 credits each semester from their other department.

LEVEL 400

FIRST SEMESTER

Core

Code	**Title**	**Prerequisite- Pass in**	**Credits**
MATH 441	Advanced Calculus	MATH 351 or MATH 353	3
MATH 447	Complex Analysis	MATH 223	3
Total			**6**
Electives (Select 3-6 credits)			
MATH 440	Abstract Algebra II	MATH 354	3
MATH 443	Differential Geometry	MATH 355	3
MATH 445	Introductory Functional Analysis	MATH 353	3
MATH 449	Electromagnetic theory II	MATH 366	3

MATH 451	Introduction to Algebraic Field Theory	MATH 354	3
MATH 453	Introduction to Quantum Mechanics	MATH 362	3
MATH 455	Computational Mathematics II	MATH 358	3
MATH 457	Mathematical Biology I		3

SECOND SEMESTER

Core

Code	**Title**	**Prerequisite- Pass in**	**Credits**
MATH 442	Integration Theory and Measure	MATH 356	3
Electives (Select 6 credits)			
MATH 372	Topology	MATH 353	3
MATH 444	Calculus on Manifolds	MATH 441	3
MATH 446	Module Theory	MATH 440	3
MATH 448	Special Relativity	MATH 362	3
MATH 450	Differential Equations II	MATH 350	3
MATH 452	Introduction to Lie Groups and Lie Algebra	MATH 354	3
MATH 458	Mathematical Biology II	MATH 457	3
MATH 460	Fourier series and Fourier transforms	MATH 356	3

Students take 9 credits each semester from their other department.

COURSE DESCRIPTIONS AND PREREQUISITES

Prerequisite for 100 LEVEL: SHS (or equivalent) pass in elective mathematics.

LEVEL 200

MATH 223 Calculus II-Prerequisite pass in MATH 122

The first and the second derivatives of functions of a single variable and their applications. Integration as a sum; definite and indefinite integrals; improper integrals. The logarithmic and exponential functions, the hyperbolic functions and their inverses. Techniques of integration including integration by parts, recurrence relations among integrals, applications of integral calculus to curves: arc length, area of surface of revolution. Ordinary differential equations: first order and second order linear equations with constants coefficients. Applications of first order differentials equations.

Reading List:

Ayres, F. Jr. & Mendelson, E. (2009). *Schaum's Outline Series Theory and Problems Differential and Integral Calculus.* McGraw-Hill Book Company, New York.

Backhouse, J.K., Houldsworth S.P.T., & Cooper, B.E.D. (2012). *Pure Mathematics, A Second Course SI Edition*, Oxford.

Edwards, C.H.Jr. & Penney, D.E. (2012). *Calculus and Analytic Geometry* (6th Edition).Pearson.

Larson, R.E., Edwards, B. H. & Hostetler, R.P. (2014). *Calculus of a Single Variable,Early transcendental functions*(6th Edition)*. Cengage Learning.*

Stewart, J. (2016). *Calculus* (8th Edition). Cengage Learning.

Tranter, C.J., & Lambe, C.G. (2012). *Advanced Level Mathematics (Pure and Applied),* (4th Edition). Hodder Arnold H&S.

MATH 225 Vectors and Mechanics

This is a first course in the applications of differentiation and integration of vector functions of a scalar variable. Kinematics of a single particle in motion, displacement, velocity acceleration. Relative motion. Concept of a force, line of action of a force, Newtons laws of motion. Motion in a straight line, motion in a plane, projectiles, circular motion. Work, energy, power. Impulse and linear momentum. Moment of a force, couple, conditions for equilibrium of rigid bodies.

Reading List:

Bostock, L. & Chandler, S. (2012). *Mathematics Mechanics and Probability*. Stanley Thornes (Publishers) Ltd, Wellington Street, England.

Hebborn, J. & Littlewood, J. (2014). *Heinemann Modular Mathematics for London AS and A-level Mechanics 2.* Heinemann Educational Publishers, Halley Court, Jordan Hill, Oxford.

Jefferson, B. & Beadsworth, T. (2012). *Introducing Mechanics*. Oxford University Press.

Solomon, R.C. (1997). *A Level Mechanics* (4th Edition). Hillman Printers (Frome) Ltd, Great Britain.

Tranter, C. J. and Lambe, C. G. (2014) *Advanced Level Mathematics (Pure and Applied), (4th Edition).* Hodder Headline PLC, London Sydney Auckland.

MATH 222 Vector Mechanics

Vector functions of a scalar variable; further differentiation and integration; Serret-Frenet formulae; differential equations of a vector function. Motion of a particle; Kinematics, Newton's laws; concept of a force; work, energy and power; impulse and momentum, conservation laws of energy and linear momentum. Rectilinear motion, motion in a plane. Two-body problem, variable mass.

Reading List:

Bostock, L. & Chandler, S. (2012). *Further Mechanics and Probability*. Stanley Thomas Ltd, Wellington Street, England.

Bostock, L. & Chandler, S. (2014). *Modular Mechanics, Module F, Mechanics 2*. Stanley Thornes (Publishers) Ltd, Wellington Street, England.

Bostock, L. & Chandler, S. (1989). *Mathematics Mechanics and Probability*. Stanley Thornes (Publishers) Ltd, Wellington Street, England.

Spiegel, M. R. (2015). *Schaum's Outline of Theory and Problems of Theoretical Mechanics.* SI (Metric) Edition, McGraw-Hill Book Company, Singapore.

Tranter, C. J. & Lambe, C. G. (2010). *Advanced Level Mathematics (Pure and Applied),* (4th Edition). Hodder Headline PLC, London Sydney Auckland, Toronto.

MATH 224 Introductory Abstract Algebra Prerequisite- pass in MATH 126
This is the first course in abstract algebra and as such it will be the students' first approach to an axiomatic presentation of Mathematics. Among the topics to be discussed are notions of relations on sets, equivalence relations and equivalence classes as well as the concept of partial ordering. The system of real numbers and their properties will be discussed. The principle of induction will be reviewed. An introduction to number theory will be given as numbers are the most familiar mathematical objects. The course seeks also to introduce axiomatically defined systems like groups, rings and fields, and vector spaces.

Reading List:

Fraleign, J. B (2013). *A First Course in Abstract Algebra* (8th Edition). Addison Wesley.

Friedberg, S.H., Insel, A.J., & Spence, L.E (2012). *Linear Algebra* (2nd Edition). Prentice- Hall.

Goodaire, E.G. & Parmenter, M.M. (2006). *Discrete Mathematics with Graph Theory* (3rd Edition). Pearson Prentice Hall.

Herstein, I.N. (2012). *Abstract Algebra,* 2nd edition, Macmillan.

Rotman, J.J. (2006). *A First Course in Abstract Algebra with Applications* (3rd Edition). Pearson Prentice Hall.

MATH 220 Introductory Programming for Computational Mathematics-
This course is in two parts. The first part is an introduction to programming using the python programming language. This part of the course begins with the basics of python. Vectorization, and visualization in python are also treated. The second part is an introduction to solving mathematical problems numerically. These problems include
finding the roots of nonlinear equations, solving large systems of linear equations and fitting polynomials to data. By the end of this course, students will be able to use python to solve basic mathematical problems.

Reading List:

Burden, R.L. & Faires, J. D. (2008). *Numerical analysis* (9th Edition). Cengage Learning.

Chapra, S. (2008). *Applied numerical methods with Matlab for engineers and scientists* (3rd Edition). McGraw Hill.

Langtangen, H.P. (2016). *A primer on scientific programming with python* (2nd Edition) Springer.

Lott, S.F. (2015). *BuildingSkills in Python,* Release 2.6
{\url{http://buildingskills.itmaybeahack.com/book/python2.6/latex/BuildingSkillsinPython.pdf}},

Varoquaux, G., Gouillart, E. & Olaf, V. (2015). *Scipy lecture notes,* \url{www.scipy-lectures.org}

Wiki (2015). *Non-Programmer's Tutorial for Python 2.6,* \url{https://upload.wikimedia.org/wikipedia/commons/6/69/Non-Programmer%27s_Tutorial_for_Python_2.6.pdf}

LEVEL 300

MATH 350 Differential Equations I-prerequisite MATH 223
Differential equations can be studied analytically, numerically and qualitatively. The focus of this course is to find solutions to differential equations using analytic techniques. Differential forms of 2 and 3 variables. Exactness and integrability conditions. Existence and uniqueness of solution. Second order differential equations with variable coefficients. Reduction of order, variation of parameters. Series solution. Ordinary and regular singular points. Orthogonal sets of functions. Partial differential equations.

Reading List:
Agarwal, R. P., & O'Regan, D. (2009). *Ordinary and Partial Differential Equations*. Springer, New York.

Collatz, L. (2013). *Differential Equations : An Introduction and Applications*. John Wiley and Sons Ltd.

Edwards, C. H., & Penny, D. E. (2015). *Elementary Differential Equations*, (7th Edition). Pearson Education Ltd.

Goodwine, B. (2011). *Engineering Differential Equations - Theory and Applications*. Springer, New York.

Zill, D. G. (2014). *A first course in Differential Equations with Modelling Applications* (7th Edition). Brooks/Cole.

MATH 351 Linear Algebra-prerequisite MATH 224
We will develop a core of material called linear algebra by introducing
definitions and procedures for determining properties and proving theorems about matrices and linear transformations, with applications. Topics to be discussed include: spanning sets; subspaces, solution spaces. Bases. Linear maps and their matrices. Inverse maps. Range space, rank and kernel. Eigenvalues and eigenvectors. Diagonalization of a linear operator. Change of basis. Diagonalizing matrices. Diagonalization theorem. Bases of eigenvectors. Symmetric maps, matrices and quadratic forms.

Reading List:
Hefferon, J. (2014). *Linear Algebra* http://joshua.smcvt.edu/linearalgebra

Kolman, B. (2003.) *Linear Algebra* (8th Edition).

Lang, S. (2014). *Linear Algebra.* Undergraduate Texts in Mathematics, Springer.

Lipshultz, S. (2008). *Schaum's outline of Linear Algebra.*

Robinson, D.J.S. (2012). *A course in linear algebra with applications.* World Scientific Publishing Co. Pty Ltd.

MATH 353 Analysis I-prerequisite MATH 223
This is the first rigorous analysis course. Topics to be discussed include: normed vector spaces, limits and continuity of maps between normed vector spaces. Students will be expected to produce

proofs to justify their claims.
We study the algebra of continuous functions. Bounded sets of real numbers. Limit of a sequence. Subsequences. Series with positive terms.Convergence tests. Absolute convergence. Alternating series. Cauchy sequences and complete spaces.

Reading List:
Davidson, K. R. & Donsig, A. P. (2010). *Real Analyis and its Applications.* Springer.

Lang, S. (2015). *Undergraduate Analysis.* Springer.

McIntyre, M (2016). *Analysis notes.* Departmental Lecture Notes.

Royden, H Fitzpatrick, P, (2016) *Real Analysis*, (4th edition).
http://math.harvard.edu/~ctm/home/text/books/royden-fitzpatrick/royden- fitzpatrick.pdf

Rudin, W. (1976). *Principles of Mathematical Analysis.* McGraw-Hill Higher Education.

MATH 354 Abstract Algebra I-prerequisite MATH 224
The primary aim of Math 354 is to study groups and their properties. We shall develop the foundations of group theory and study some notable groups like cyclic groups, permutation groups, finite Abelian groups and their characterization. Other ideas include: subgroups, cyclic groups.The Stabilizer-Orbit theorem.Lagrange's theorem. Classifying groups. Structural properties of a group. Cayley's theorem. Generating sets. Direct products. Finite abelian groups. Cosets and the proof of Lagrange's theorem. Proof of the Stabilizer-Orbit theorem.

Reading List:
Dummit, D. S. & Foote, R. M. (2003). *Abstract Algebra* (3rd Edition). Wiley

Fraleign, J. B. (2013). *A First Course in Abstract Algebra* (8th Edition). Addison Wesley.

Gallian, J. A. (2013). *Contemporary Abstract Algebra* (8th Edition). Brooks/Cole.

Judson, T. (2015). *Abstract Algebra: Theory and Applications.* Open Source available at http://abstract.ups.edu/index.html

Pinter, C. C. (2010). *A Book of Abstract Algebra* (2nd Edition). (Dover Books on Mathematics).

MATH 355 Calculus of Several Variables-prerequisite MATH 223
The major goal for this course is to understand and apply the concepts of differentiation and integration to functions of several variables. Functions of several variables, partial derivative. Directional derivative, gradient. Local extema, constrained extrema. Lagrange multipliers. The gradient, divergence and curl operators. Line, surface and volume integrals. Green's theorem, divergence theorem, Stokes' theorem.

Reading List
Lang, S. (2016). *Calculus of Several Variables.* Undergraduate Texts in Mathematics, Springer.

Marsden, J. & Tromba, A. (2003). *Vector Calculus.* W H Freeman.

Stewart, J. (2014). *Multivariable Calculus* (6th edition). Brooks/Cole

Strang, G. (2012). *Calculus* (http://ocw.mit.edu/resources/res-18-001-calculus-online- *textbook-spring-2005/textbook/).*

Thomas, G. & Weir, M. (2013). *Calculus: Early Transcendentals* (13th Edition). Pearson

MATH 356 Analysis II-prerequisite MATH 223
This is a continuation of MATH 353. We now consider vector spaces of functions and discuss convergence of sequences of functions; pointwise and uniform convergence. Other topics discussed include; power series, the contraction mapping theorem and applications. We examine the definition of the Riemann integral and conditions for integrability. We give a proof of the fundamental theorem of calculus and major
basic results involved in its proof . We finish with some point set topology in R.

Reading List:
Davidson, K. R. & Donsig, A. P. (2010). *Real Analyis and its Applications.* Springer

Lang, S. (2015). *Undergraduate Analysis.* Springer

McIntyre, M. (2016). *Analysis notes.* Departmental Lecture Notes.

Royden, H. & Fitzpatrick, P. (2010). *Real Analysis* (4th Edition).
http://math.harvard.edu/~ctm/home/text/books/royden-fitzpatrick/royden-fitzpatrick.pdf

Rudin, W. (1976). *Principles of Mathematical Analysis.* McGraw-Hill Higher Education.

MATH 358 Computational Mathematics I-prerequisite MATH 220
This course is a sequel to Math220. In this course, we continue the solution of linear systems by treating matrices with special structures. We also continue with data fitting using polynomials. Several high order methods for discretizing the derivative and definite integral are also treated. The course ends with approximations of eigenvalues for large matrices. We explain the concept of the dominant eigenvalue and its eigenvector. We also look at simultaneous approximation of eigenvalues.

Reading List:
Burden, R. L. & Faires, J. D. (2008). *Numerical analysis*. Cengage Learning, (9th Edition).

Chapra, S. (2008). *Applied numerical methods with Matlab for engineers and scientists* (3rd Edition). McGraw Hill.

Epperson, J. F. (2013). *An introduction to numerical methods and analysis* (2nd Edition).Wiley.

Matthews, J.H. & Fink, K.D. (2014). *Numerical methods using Matlab*. Pearson (5th Edition).

Sauer, T. (2006). *Numerical Analysis*. Pearson.

MATH 359 Discrete Mathematics-prerequisite MATH 224
This course is a study of discrete rather than continuous mathematical structures. Topics include: asymptotic analysis and analysis of algorithms, recurrence relations and equations, Counting techniques (examples include: Inclusion-exclusion and pigeon-hole
principles and applications, Multinomial Theorem, generating functions),
Elementary Number Theory and Cryptography, Graph Theory, Discrete probability
theory. Planarity, Euler circuits, shortest-path algorithm. Network flows. Modelling computation: languages and grammars, models, finite state machines, Turing machines

Reading List:
Gossett, E. (2008). *Discrete Mathematics with Proof.* Wiley.

Levin, O. (2013). *Discrete Mathematics.* http://discretetext.oscarlevin.com/home.php

Lipschultz, S. (2007). *Schaum's outline of discrete mathematics.* Schaums Outlines.

Rajagopalan, S. P. & Sattanathan, R. (2015). *Discrete mathematics.* Margham Publications.

Rosen, K. H. (2012). *Discrete mathematics and its applications.* McGraw-Hill

MATH 361 Classical Mechanics -prerequisite MATH 222
The methods of classical mechanics have evolved into a broad theory of dynamical systems and therefore there are many applications outside of Physics; for example to biological systems. Topics to be discusses will include1-dimensional dynamics: damped and forced oscillations. Motion in a plane: projectiles, circular motion, use of polar coordinates and intrinsic coordinates. Two-body problems, variable mass. Motion under a central, non-inertial frame. Dynamics of a system of particles.

Reading List:
Corben, H. & Stehle, P. (1994). *Classical Mechanics* (2nd edition). Dover

Kibble, T. W. B. & Berkshire, F. H. (2011). *Classical mechanics* (5th Edition). Imperial College Press.

Marsden, J. & Abraham, R. (2012). *Foundations of mechanics.* Westview Press.

Morin, D. (2008). *Introduction to Classical Mechanics*. Cambridge University Press.

Susskind, L. (2014). *Classical mechanics.* Penguin Books Ltd

MATH 362 Analytical Mechanics- prerequisite MATH 222
In this course the student is introduced to a collection of closely related alternative formulations of classical mechanics. It provides a detailed introduction to the key analytical techniques of classical mechanics. Topics discussed include
rigid body motion, rotation about a fixed axis. General motion in a plane, rigid bodies in contact, impulse. General motion of a rigid body. Euler-Lagrange equations of motion.

Reading List:
Finch, J. D. & Hand, L.N. (1998). *Analytical mechanics.* Cambridge University Press

Fowles, G. R. & Cassiday, G. L. (2004). *Analytical Mechanics* (7th Edition). Brooks/Cole

Lanczos, C. (2011). *The variational principles of mechanics.* Dover

Merches, I. & Radu, D. (2014). *Analytical Mechanics: Solutions to problems in Classical Physics.* CRC press.

Helrich, C. (2017). *Analytical Mechanics*. Springer

MATH 363 Introductory concepts in Financial Mathematics-prerequisite MATH 223, STAT 221

This course introduces the basic methods applied in financial mathematics. We will discuss probability functions, stochastic processes, random walks and martingales; Ito's lemma and stochastic calculus. Students will understand the stochastic differential equations for a geometric Brownian motion process. We will study mean reverting models such as the Ornstein- Uhlembeck process, as well as stochastic volatility models such as the Heston Model. Stochastic models for stock pricing are also discussed; we study a binomial option pricing model, the Black-Scholes model and the capital asset pricing model.

Reading List:

Bass, R. (2003). *The basics of financial mathematics.* Springer.

Doob, J. L. (2014). *Stochastic processes.* Wiley Interscience.

Wilmott, P. & Howison, S. (1995). *The Mathematics of Financial Derivatives: A Student Introduction*. Cambridge University Press.

Oksendal, B. (2010). *Stochastic Differential Equations* (5th Edition). Universitext

Parzen, E. (2010). *Modern probability theory and applications.* John Wiley, Canada.

MATH 366 Electromagnetic Theory I-prerequisite MATH 222

This course develops the mathematical foundations for the application of the electromagnetic model to various problems. Mathematics discussed includes scalar and vector fields, grad, div and curl operators. Orthogonal curvilinear coordinates. Electrostatics: charge, Coulomb's law, the electric field and electrostatic potential, Gauss's law, Laplace's and Poisson's equations. Conductors in the electrostatic field. Potential theory.

Reading List:

Chirgwin, B.H., Plumpton, C., & Kilmister, C.W. (1972). *Elementary Electromagnetic Theory. Vols. II. and III.* Pergamon Press.

Friedriches, K. O. (2014). *Mathematical Methods of Electromagnetic Theory.* AMS

Griffiths, D. J. (2014). *Introduction to Electrodynamics.* Pearson Educational.

Jackson, J. D. (1962). *Classical Electrodynamics.* Wiley and Sons

Reitz, J. R., Milford. F. J., & Christy, R.W. (1979). *Foundations of Electromagnetic Theory, (*3rd

Edition). Narosa Pub. House.

MATH 368 Introductory number theory-prerequisite MATH 224
This course builds on the elementary number theory introduced in MATH 224 Topics include: the Fundamental theorem of Arithmetic, Proof and Application: GCD,
LCM. Asymptotic notations,Congruences: Introduction to Congruences, Residue systems and Euler Phi-function, Linear Congruence, Chinese Remainder theorem, Theorems of Euler, Fermat and Wilson Arithmetic functions and Dirichlet Multiplication: Mobius, Euler Phi, Mangoldt, Sum of divisors etc functions, Dirichlet's product and Mobius inversion formula, averages of arithmetical functions Quadratic Residues and Quadratic Reciprocity Law: Quadratic Residues, Legendre's symbol and its properties, The quadratic reciprocity law and applications, the Jacobi symbol. Prime Number distribution.

Reading List:
Apostol, T. M. (1998). *Introduction to Analytical number theory*. Springer

Chandrasekharan, K. (2012). *Introduction to Analytical number theory.* Springer

Tenenbaum, G. (2015). *Introduction to Analytical and Probabalistic number theory*. Springer.

Jones, G., & Jones, J. (1998). *Elementary Number Theory*. Springer

Ireland, K., & Rosen, M. (1998). *A Classical Introduction to Modern Number Theory* (2nd Edition). Springer.

MATH 372 Topology –prerequisite MATH 353
This is a first course in point set topology. Students will be introduced to **t**opological spaces and be able to identify open and closed sets with respect to the given topology. Other aspects to be discussed are basis for a topological space. Separation and countability properties. Limit points. Connectedness. Subspace topology. Homeomorphism.Continuity. Metrizability. Continuity via convergent sequences. Compactness.

Reading List:
Davis, S. W. (2004). *Topology.* McGraw-Hill Higher Education.

Lipschultz, S. (1965). *Schaum's outline of theory and problems of general topology.* Schaums Outlines.

McIntyre, M. (2009). *Topology.* Departmental Lecture Notes

Chirgwin, B.H, Plumpton, C., & Kilmister, C.W. (1972). *Elementary Electromagnetic Theory. Vols. II. and III.* Pergamon Press.

Griffiths, D.J. (2014). *Introduction to Electrodynamics.* Pearson Educational

Jackson, J. D. (1962). *Classical Electrodynamics.* Wiley and Sons.

Reitz, J.R., Milford. F. J., & Christy, R.W. (1979). *Foundations of Electromagnetic Theory (*3rd Edition). Narosa Pub. House.

Morris, S. (2011). *Topology. without tears* ebook.

LEVEL 400

MATH 440 Abstract Algebra II-prerequisite MATH 354
This is a second course in group theory Topics covered will include: finite groups, Sylow theorems and simple groups. Composition series. We state and prove the Zassenhaus Lemma, the Schreier theorem and the Jordan-Hölder theorem. Direct and semi-direct products. Abelian groups, torsion, torsion-free and mixed abelian groups. Finitely generated group and subgroups. P-groups, nilpotent groups and solvable groups.

Reading List:
Dummit, D. S. & Foote, R. M. (2003). *Abstract Algebra* (3rd Edition). Wiley

Fraleign, J. B. (2013). *A First Course in Abstract Algebra* (8th Edition). Addison Wesley.

Gallian, J. A. (2013). *Contemporary Abstract Algebra* (8th Edition). Brooks/Cole

Judson, T. (2015). *Abstract Algebra: Theory and Applications.* Open Source available http://abstract.ups.edu/index.html

Pinter, C. C. (2010). *A Book of Abstract Algebra* (2nd Edition). (Dover Books on Mathematics)

MATH 441 Advanced Calculus-prerequisite MATH 351 or MATH 353
Here we think of differentiation as a process of approximating the function f near a, by a linear map. This linear map is called the Fr´echet derivative of f at a. The main aim of this course is to understand two of the most important theorems for modern analysis: the
Inverse Map Theorem and the Implicit Function Theorem. Other ideas include:
linear and affine maps between normed vector spaces. Limits, continuity, tangency of maps and the derivative as a linear map. Component-wise differentiation, partial derivatives, the Jacobian as the matrix of the linear map. Generalized mean value theorem.

Reading List:
Loomis, L., & Sternberg. S. (1990). *Advanced calculus.* Jones and Bartlett [also at http://www.math.harvard.edu/~shlomo/docs/Advanced_Calculus.pdf]

McIntyre, M. (2011). *Advanced calculus.* Departmental lecture notes

Rudin, W. (2009). *Principles of Mathematical Analysis* available https://notendur.hi.is/vae11/%C3%9Eekking/principles_of_mathematical_analysis_walter_rudin.pdf

Spivak, M. (2008). *Calculus* (4th Edition). Publish or Perish

Taylor, A. E. & Mann, W. R. (2013). *Advanced Calculus.* Wiley

MATH 442 Integration theory and Measure –prerequisite MATH 356
Algebra of sets, measurable sets and functions, measures and their construction (in particular Lebesgue measure), measure spaces. Integration, convergence theorems (Fatou's Lemma, Monotone Convergence Theorem, Lebesgue Dominated Convergence Theorem). Lebesgue spaces, elementary

inequalities, modes of convergence. Product measures and Fubini's theorem. Generalisation of the Riemann (R) integral (eg Kurzweil-Henstock (KH) integral). Lebesgue (L) integral. Relationship between the KH-integrable, L-integrable and R-integrable functions.

Reading List:

Bass, R. *Real Analysis for Graduate Students*, (3rd Edition).

Cannarsa, P. & D'Aprile, T. D. (2007). *Lecture notes on measure and functional analysis.* https://www.mat.uniroma2.it/~cannarsa/cam_0607.pdf

Rudin, W. (1966). *Real and ComplexAnalysis* available at http://ruangbacafmipa.staff.ub.ac.id/files/2012/02/Real-and-Complex-Analysis-by-Walter Rudin.pdf

Stein, E., & Shakarchi, R. (2005). *Real analysis:measure theory, integration and Hilbert spaces* Princeton Lectures in Analysis.

Yee, L. P. & Vyborny, R. (2000). *The integral: an easy approach after Kurzweil and Henstock.* Aust Math Soc Lecture series 14. Cambridge University Press

MATH 443 Differential Geometry-prerequisite MATH 355

The modern approach to differential geometry uses the language of manifolds. This provides a theory and a variable free notation which frees us from always having to consider the coordinate system. We want to be able to deal with the elements of calculus both invariantly (i.e. independently of the local coordinates) and intrinsically (i.e. independently of the way a geometric object is embedded in Euclidean space). But to appreciate the great contribution to differential geometry made by the theory of manifolds, we will first study classical differential geometry and then a little of the modern approach.

Reading List:

Carmo, M. (2016). *Differential Geometry of Curves and Surfaces* (2nd Edition). Dover.

Kuhnel, W. (2006). *Differential Geometry -Curves SurfacesManifolds.* AMS.

Millman, R. S., & Parker, G. D. (2007). *Elements of Differential Geometry.* Pearson

O'Neill, B. (2012). *Elementary Differential Geometry.* Academic Press

Willmore, T. J. (2007). *Introduction to Differential Geometry.* Oxford University Press

MATH 444 Calculus on Manifolds-prerequisite MATH 355

This course aims to provide an introduction to Differentiable Manifolds and
the tools for performing calculus on these objects; tangent vectors and differential forms. We will see how concepts like the derivative in R^n is extended to a smooth *n*-dimensional manifold. Topics include: manifold, submanifold, differentiability of maps between manifolds, the tangent space, the tangent bundle and the tangent functor. Vector bundle. The exterior algebra, the notion of a differentiable form on a manifold, singular n-chains and integration of a form over a chain. Partition of unity. Application to Stokes' theorem.

Reading List:
Jones, A., Gray, A., & Hutton, R. (1987). *Manifolds and Mechanics* Aust. Math Soc. Lecture series (2), Cambridge University Press.

Lee, J. M. (2012). *Introdution to Smooth Manifolds*. Springer GTM

Spivak, M. (2015). *Calculus on Manifolds.* Addison-Wesley

Spivak, M. (1999). *A Comprehensive Introduction to Differential Geometry* (3rd Edition). Vol 1, , Publish or Perish

Tu, L.W. (2011). *An Introduction to Manifolds.* Universitext

MATH 445 Introductory Functional Analysis-prerequisite MATH 356
This course aims to use the methods of mathematical analysis and apply them to a special kind of vector space – Function spaces. The course begins with finite dimensional normed vector spaces and treats the following topics: Equivalent norms. Banach spaces. Infinite-dimensional normed vector spaces--Hamel and Schauder bases;
separability. Compact linear operators on a Banach space. Complementary subspaces and the open-mapping theorem. Closed Graph theorem. Hilbert spaces. Special subspaces of and and the dual space. The completion of a normed vector space. Reflexive Banach spaces

Reading List.
Eidelman, Y., Milman, V., & Tsolomitis, A. (2004). *Functional Analysis: An Introduction*. AMS

Kreyszig, E. (2013). *Introductory Functional Analysis.* Wiley and Sons

Lax, P. (2004). *Functional Analysis*. Wiley-Interscience.

Rudin, W. (1966). *Real and ComplexAnalysis* available at http://ruangbacafmipa.staff.ub.ac.id/files/2012/02/Real-and-Complex-Analysis-by-Walter Rudin.pdf

Royden, H. (1988). *Real analysis.* Prentice Hall

MATH 446 Module Theory-prerequisite MATH 354
In this course we shall study the mathematical objects called modules. The use of modules was pioneered by one of the most prominent mathematicians, Emmy Noether (a German), who led the way in demonstrating the power and elegant of this structure. Topics include: modules, submodules, homomorphism of modules. Quotient modules, free (finitely generated) modules. Exact sequences of modules. Direct sum and product of modules.Chain conditions, Noetherian and Artinian modules. Projective and injective modules. Tensor product, categories and functors. Hom and duality of modules.

Reading List:
Blyth, T. S. (2015). *Module theory; an approach to linear algebra.* Oxford University Press

Dummit, D. S., & Foote, R. M. (2003). *Abstract Algebra* (3rd Edition). Wiley.

Lam, T.Y. (1998). *Lectures on Modules and Rings.* Springer GTM.

Rotman, J. (2008). *An Introdution to Homological Algebra* (2nd Edition). Springer Universitext

Wisbauer, R. (2011). *Foundations of Module and Ring Theory.* Available at http://reh.math.uni-duesseldorf.de/~wisbauer/book.pdf

MATH 447 Complex Analysis-prerequisite MATH 223
The objective of this course is to introduce students to complex numbers and functions of a complex variable. We introduce the notions of differentiability (and analyticity) and integrability for a function defined on the complex plane. We also look at ways in which one can integrate complex-valued functions. Elementary topology of the complex plane. Complex functions and mappings. The derivative. Differentiability and analyticity. Harmonic functions. Integrals. Maximum modulus, Cauchy-Gorsat, Cauchy theorems. Applications. Taylor and Laurent series, zeros and poles of a complex function. Residue theorem and consequences. Conformal mapping, analytic continuation.

Reading List:
Alfors, L.V. (1979). *Complex Analysis.* McGraw-Hill.

Saff, E. B. & Snider, A. B. (2013). *Fundamentals of Complex Analysis.* Pearson Educational

Stewart, I. N., & Tall, D.O. (2011). *Complex Analysis.* Cambridge University Press.

Wunsch, A.D. (2005). *Complex Variables with Applications.* Pearson Educational

Zill, D. G., & Shanaban, (2003). *A First Course in Complex Analysis.* Jones and Bartlett

MATH 448 Special Relativity
By employing the mathematics of sets, mappings and relations, we aim to develop an ability to think relativistically, exploring the relationship between space and time. Topics include: Galilean relativity, postulates of special relativity; Lorentz transformations. Lorentz-Fitzgerald contraction, time dilation. 4-vectors, relativistic mechanics, kinematics and force, conservation laws; decay of particles; collision problems, covariant formulation of electrodynamics.

Reading List:
Dray, T. (2012). *The geometry of special relativity.* CRC Press

Frankel, T. (2013). *The Geometry of Physics* (3rd Edition). Cambridge

Matsko, V. J., & Noll, W. (1993). *Mathematical Structures of Special Relativity.* available at http://repository.cmu.edu/cgi/viewcontent.cgi Article=1014&content=math

Susskind, L., & Friedman, A. (2017). *Special Relativity and Classical Field Theory: The Theoretical Minimum.* Basic Books.

Woodhouse, N. M. J. (2003). *Special Relativity.* Springer Undergraduate Mathematics Series

MATH 449 Electromagnetic theory II-prerequisite MATH 366
This is a second course in the development of the mathematical foundations for the application of the electromagnetic model to various problems. Magnetostatics: steady currents, heating affect and magnetic field, magnetic vector potential, magnetic properties of matter, dipoles, induced

magnetism, permanent magnetism. Time-varying fields: electromagnetic induction. Differential form of Faraday's law, energy in electromagnetic fields. Maxwell's equations and their consequences Poynting vector; electromagnetic potentials formation of electrodynamics.

Reading List:

Chirgwin, B. H., Plumpton, C., & Kilmister, C.W. (1972). *Elementary Electromagnetic Theory. Vols. II. and III.* Pergamon Press.

Fleisch, D. (2008). *A Student's guide to Electromagnetic Theory*. Cambridge.

Griffiths, D.J. (2014). *Introduction to Electrodynamics.* Pearson Educational

Jackson, J.D. (1962). *Classical Electrodynamics.* Wiley and Sons

Reitz, J. R., Milford. F. J., & Christy, R.W. (1979). *Foundations of Electromagnetic Theory (*3rd Edition). Narosa Pub. House

MATH 450 Differential equations II-prerequisite MATH 350

This course introduces undergraduate students to the qualitative theory of Ordinary Differential Equations. We will use the Picard-Lindelöf Theorem to analyze whether an ODE or a system of ODEs has a solution and the behavior of the solution as the parameter is varied (bifurcation). We will especially consider autonomous linear and nonlinear systems and investigate the stability of the solutions that result. We will also introduce the concept of a Lyapunov function. Other topics might include partial differential equations, the method of characteristics and classification.

Reading List:

Argawal, R., & O'Regan, D. (2008). *An Introduction to Ordinary Differential Equations.* Universitext.

Hirsch, S., & Devaney, (2004). *Differential Equations, Dynamical Systems and An Introduction to Chaos*. Elsevier.

Kelley, W., & Peterson, A. (2014). *The theory of differential equations: classical and qualitative.* Pearson New Jersey

O'Neil, P. V. (2008). *Beginning partial differential equations.* Wiley New York.

Schroers, B. (2011). *Ordinary Differential Equations.* AIMS Library Series, Cambridge University Press.

MATH 451 Introduction to Algebraic Field Theory-prerequisite MATH 354

The famous problems of squaring the circle, doubling the cube and trisecting an angle captured the imagination of both professional and amateur mathematicians for over two thousand years. Despite the enormous effort and ingenious attempts by these men and women, the problems would not yield to purely geometrical methods. It was only the development of abstract algebra in the nineteenth century which enabled mathematicians to arrive at the surprising conclusion that these problems are impossible.

This course aims to introduce students to the idea of a field in algebra, and investigates properties of algebraic fields, of finite and zero characteristic.

Reading List:

Eisenbud, D. (1999). *Commutative Algebra with a view towards Algebraic Geometry*. Springer GTM.

Fraleigh, J. B. (2013). *A First Course in Abstract Algebra* (8th Edition). Addison Wesley.

Gallian, J. A. (2013). *Contemporary Abstract Algebra* (8th Edition). Brooks/Cole

Jones, A., Morris, S., & Pearson, K.R. (1991). *Abstract algebra and famous impossibilities.* Universitext, Springer.

Rotman, J. (2006). *A First Course in Abstract Algebra with Applications* (3rd Edition). Pearson

MATH 452 Introduction to Lie Groups and Lie Algebras

This course will cover the basic theory of Lie groups and Lie algebras. Topics may include: topological groups and Haar measure, vector fields and groups of linear transformations. The exponential map. Linear groups and their Lie algebras. Structure of semi-simple Lie algebras, Cartan and Iwasawa decompositions. Connectedness. Closed subgroups. The classical groups. Manifolds, homogeneous spaces and Lie groups. Integration and representations.

Reading List:

Carter, R., Segal, G., & Macdonald, I. (1995). Lectures on Lie Groups and Lie Algebras. Cambridge

Hall, B. (2009). *Lie groups, Lie algebras and Representations-an elementary introduction.* Springer

Krillov, A. (2006). *An introduction to Lie groups and Lie algebras* Cambridge. University Press

Sagel, A. A., & Walde, R. E. (2013). *An introduction to Lie groups and Lie algebras.* Academic Press Inc.

Serre, J. P. (2005). *Lie Algebras and Lie Groups: 1964 Lectures given at Harvard University*. Springer

MATH 453 Introduction to Quantum Mechanics-prerequisite MATH 362

This course introduces students to the equations govening extremely small particles and their interactions. It introduces new mathematics to model the behavior of such objects. Topics include: The principle of least action, Hamilton's equation, Poisson brackets. Liouville's equation. Canonical transformations. Symmetry and conservation laws.
Postulates of quantum mechanics, the wave formalism. Dynamical variables. The Schrodinger equation in one-dimension; free particles in a box, single step and square well potentials. Orbital angular momentum. The 3-dimensional Schrodinger equation; motion in a central force field, the 3-d square well potential, the hydrogenic atom. Heisenberg's equation of motion, harmonic oscillator and angular momentum.

Reading List:

Jackson, J. D., (2006). *Mathematics for quantum mechanics*- Dover Publications

von Neumann, (1955), *The Mathematical Foundations of Quantum Mechanics*. Princeton Landmarks in Mathematics.

Shankar, R., (2011). *Principles of quantum mechanics.* Plenum Press

Susskind, L., & Friedman, A. (2012). *Quantum Mechanics- the theoretical minimum.* Basic Books.

Woit, P. (2016). *Quantum Theory, Groups and Representations: An Introduction* available at http://www.math.columbia.edu/~woit/QM/qmbook.pdf

MATH 455 Computational Mathematics II-prerequisite MATH 358
This course looks at methods of discretizing and solving differential equations. It begins with the solution of initial value problems for ordinary differential equations. We start with the Euler methods and systematically develop high order solutions for solving problems. The course then develops the concept of finite differences to solve boundary value problems. In addition, we look at the problem of discretizing partial differential equations in space and time both implicitly and explicitly.

Reading List:
Burden, R. L., & Faires, J. D. (2008). *Numerical analysis*. Cengage Learning (9th Edition).

Chapra, S. (2008). *Applied numerical methods with Matlab for engineers and scientists* (3rd Edition). McGraw Hill.

Epperson, J. F. (2013). *An introduction to numerical methods and analysis* (2nd Edition). Wiley.

Gautschi, W. (2012). *Numerical Analysis* (2nd Edition). Birkhauser.

Matthews, J.H., & Fink, K.D. (2014). *Numerical methods using Matlab* (5th Edition). Pearson.

Sauer, T. (2006). *Numerical Analysis*. Pearson.

MATH 457 Mathematical Biology I
In this course we focus on 3 types of biological phenomena to be modelled, namely single species population dynamics, interacting species and molecular dynamics. In single species population dynamics we will use difference equations: graphical analysis, fixed points and linear stability analysis. First order systems of ordinary differential equations: logistic equation, steady states, linearisation, and stability. And we will examine applications to
harvesting and fisheries. For interacting species we examine systems of difference equations (host-parasitoid systems)and systems of ordinary differential equation (predator-prey and competition models) Finally, we will consider biochemical kinetics: Michaelis-Menten kinetics and metabolic pathways: activation and inhibition.

Reading List:
Britton, N. F. (2003). *Essential Mathematical Biology*. Springer.

De Vries, G., Hillen, T., Lewis, M., Muller, J., & Schonfisch, B. (2006) *A Course in Mathematical Biology. Quantitative Modeling* SIAM.

Edelstein-Keshet, L. (1987). *Mathematical Models in Biology*. Birkhauser.

Murray, J. D. (2007). *Mathematical Biology I*, *An Introduction*. Springer.

Segel, L.A., & Edelstein-Keshet, (2013). *A primer on mathematical models in biology.* SIAM.

MATH 458 Mathematical Biology II

The detail of this course may be informed by the student choice(s) of project topic and could include: (i) modelling of biological systems using partial differential equations. Derivation of conservation equations. Different models for movement. Connection between diffusion and probability.
(ii) Linear reaction-diffusion equations and fundamental solutions
Speed of a wave of invasion. Non-linear reaction-diffusion equations. Travelling wave solutions for monostable equations and bistable equations.
(iii) Systems of reaction-diffusion equations and travelling wave solutions. Pattern formations. Pattern formations in chemotaxis equations. (iv) Mathematical modelling of infectious diseases
Derivation of a simple SIR model and travelling wave solutions.

Reading List:

Britton, N. F. (2003). *Essential Mathematical Biology*. Springer.

De Vries, G., Hillen, T., Lewis, M., Muller, J., & Schonfisch, B. (2006). *A Course in Mathematical Biology. Quantitative Modeling* SIAM.

Edelstein-Keshet, L. (1987). *Mathematical Biology I*, *An introduction.* Springer.

Segel, L.A., & Edelstein-Keshet, (2013). *A primer on mathematical models in biology.* SIAM.

Murray, J.D. (2007). *Mathematical Biology I*, *An introduction.* Springer.

MATH 460 Fourier Series and Fourier Transforms

The objective of this course is to introduce the theory of Fourier series and Fourier transforms on the real line. Topics include: convolutions, summability kernels, convergence of Cesaro means. Mean-square convergence, pointwise convergence.
Fourier transform on the real line, inversion formula, Plancherel formula, Weierstrass approximation theorem. Applications to partial differential equations, Poisson summation formula. The Heisenberg uncertainty principle.

Reading List:

Katznelson, Y. (2002). *An introduction to harmonic analysis,* available at www.mat.uniroma2.it/~picard/SMC/..../Katznelson/Katznelson.pdf

Pinkus, A. & Zafrany, S. (1997). *Fourier Series and Integral Transforms*. Cambridge.

Sneddon I. N. (2010). *Fourier Transforms.* Dover Books on Mathematics

Stein, E.M., & Shakarchi, R. (2013). *Fourier analysis, an introduction.* Princeton.

Weaver, H. J. (1989). *Theory of discrete and continuous Fourier analysis.* JohnWiley and Sons, NewYork.

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STAT 339 Methods of Linear Algebra (Non-mathematics students)- Prerequisite MATH 126 Algebra and Geometry

The emphasis is on the geometric and computational foundations of Linear Algebra with abstraction (and proof) kept to a minimum. We would examine matrices, linear systems of equations and their solutions. Basic properties of determinants, vectors in R^n and a simple introduction to the idea of an arbitrary vector space. The pinnacle of the course is to be able to find eigenvalues and their corresponding eigenvectors for a given matrix and indeed for a linear map. We would carefully develop the diagonalisation of symmetric matrices. For those who did the MATH 220 there would be applications using Python.

Reading List:

Kolman, B., & Hill, D. R. (2005). *Introductory Linear Algebra, an applied firstcourse* (8th Edition). Addison Wesley

Hefferon, J. (2014). *Linear Algebra.* http://joshua.smcvt.edu/linearalgebra

Kolman, B. (2003). *Linear Algebra* (8th Edition).

Lipshultz, S. (2008). Schaum's *outline of Linear Algebra.*

Robinson, D. J. S. (2012). *A course in linear algebra with applications.* World Scientific Publishing Co. Pty Ltd.

DEPARTMENT OF PHYSICS

INTRODUCTION

Degree programmes leading to a BSc Major in Physics, a BSc in Geophysics, a BSc Major in Physics and a Minor in another subject, a BSc Minor in Physics and a Major in another subject, and a Combined Major in Physics and another subject are available.

The BSc Major in Physics programme is designed to provide a comprehensive foundation in physics and preparation for advanced studies in physics and related fields. The programme provides a variety of electives, representing various specialized areas of physics.

The BSc Major and Minor programmes are designed to provide students with the flexibility of pursuing their interests in other subjects while still acquiring a foundation in physics. Two options are available: BSc Major in Physics with a Minor in another subject and BSc Minor in Physics with a Major in another subject.

The BSc Combined Major programme is designed to provide students the opportunity to pursue their interests in physics and another subject.

The Geophysics programme prepares students for careers in geophysics and also provides the foundation for advanced study in geophysics and related fields.

PROGRAMMME STRUCTURE

SINGLE MAJOR IN PHYSICS

The Single Major Physics programme is available to students admitted into the Physical Science programme or students who, at Level 100, selected PHYS 143: PHYS 144: PHYS 105: Practical Physics I and PHYS 106: Practical Physics II as elective courses.

LEVEL 200
FIRST SEMESTER
Core

Course Code	**Course Title**	**Credits**	**Pre-requisites**
UGRC 210	Academic Writing II	3	
MATH 223	Calculus II	3	
PHYS 205	Practical Physics III	1	
PHYS 241	Atomic Physics and Quantum Phenomena	2	
PHYS 245	Electromagnetism I	3	
Select one course			
STAT 223	Elementary Statistical Methods	3	
MATH 225	Vectors and Mechanics	3	
Total		**15**	

SECOND SEMESTER
Core

Course Code	**Course Title**	**Credits**	**Pre-requisites**
UGRC 220-238	Introduction to African Studies	3	
PHYS 206	Practical Physics IV	1	
PHYS 242	Oscillations and Waves	2	
PHYS 244	Mathematical Methods I	3	
PHYS 246	Nuclear Physics I	2	
PHYS 248	Introduction to Physics of Materials	2	
PHYS 256	Computational Methods in Physics I	2	
Total		**15**	

LEVEL 300
FIRST SEMESTER
Core

Course Code	Course Title	Credits	Pre-requisites
PHYS 305	Practical Physics V	1	
PHYS 343	Thermodynamics	2	
PHYS 345	Electromagnetism II	3	
PHYS 359	Solid State Physics I	2	
PHYS 351	Optics	3	
Total		**11**	
Electives (Select a minimum of 4 credits)			
PHYS 361	Physics of the Atmosphere	2	
PHYS 347	Electronics I	3	
PHYS 365	Physics of the Ocean	2	
EASC 339	Principles of Applied Geophysics	3	
Total		**15**	

SECOND SEMESTER
Core

Course Code	Course Title	Credits	Pre-requisites
PHYS 306	Practical Physics VI	1	
PHYS 342	Classical Mechanics	3	
PHYS 344	Mathematical Methods II	3	
PHYS 352	Quantum Mechanics I	3	
PHYS 354	Special Relativity	2	
PHYS 356	Computational Methods in Physics II	3	
Total		**15**	
Electives (Select up to 3 credits)			
PHYS 364	Principles and Applications of Neutron Activation Analysis	2	
STAT 336	Design of Experiments	3	
Total		**17**	

LEVEL 400
FIRST SEMESTER
Core

Course Code	Course Title	Credits	Pre-requisites
PHYS 410	Project	3	
PHYS 401	Seminar I	1	
PHYS 443	Statistical Mechanics	3	
PHYS 459	Solid State Physics II	2	
Total		**9**	
Electives (Select minimum of 6 credits)			
PHYS 447	Electronics II	2	
PHYS 455	Energy Systems	2	
PHYS 461	Principles of Radioactive Dating	2	
PHYS 465	Physics of Telecommunications	2	

Total		**15**	

SECOND SEMESTER
Core

Course Code	Course Title	Credits	Pre-requisites
PHYS 410	Project	3	
PHYS 402	Seminar II	1	
PHYS 446	Nuclear Physics II	2	
PHYS 448	Particle Physics	2	
PHYS 452	Quantum Mechanics II	3	
PHYS 454	Contemporary Physics	2	
PHYS 468	Introduction to Cosmology and Astrophysics	2	
Total		**15**	
Electives (Select a minimum of 2 credits)			
PHYS 462	Basic Meteorology	2	
PHYS 466	Physics at the Nanoscale	2	
Total		**17**	

MAJOR – MINOR IN PHYSICS

The Major – Minor in Physics programme is available to students admitted into the Physical Science programme or students who, at Level 100, selected PHYS 143: PHYS 144: PHYS 105: Practical Physics I and PHYS 106: Practical Physics II as elective courses.

LEVEL 200
FIRST SEMESTER
Core

Course Code	Course Title	Credits	Pre-requisites
UGRC 210	Academic Writing II	3	
PHYS 205	Practical Physics III	1	
PHYS 241	Atomic Physics and Quantum Phenomena	2	
PHYS 245	Electromagnetism I	3	
*MATH 223	Calculus II	3	
Total		**12**	

SECOND SEMESTER
Core

Course Code	Course Title	Credits	Pre-requisites
UGRC 220-238	Introduction to African Studies	3	
PHYS 206	Practical Physics IV	1	
PHYS 242	Oscillations and Waves	2	
PHYS 244	Mathematical Methods I	3	
*PHYS 246	Nuclear Physics I	2	
Total		**11**	

LEVEL 300
FIRST SEMESTER
Core

Course Code	Course Title	Credits	Pre-requisites
PHYS 305	Practical Physics V	1	
PHYS 343	Thermodynamics	2	
PHYS 345	Electromagnetism II	3	
PHYS 351	Optics	3	
*PHYS 347	Electronics I	3	
Total		**12**	

SECOND SEMESTER

Core

Course Code	Course Title	Credits	Pre-requisites
PHYS 306	Practical Physics VI	1	
PHYS 342	Classical Mechanics	3	
PHYS 352	Quantum Mechanics I	3	
PHYS 354	Special Relativity	2	
*PHYS 344	Mathematical Methods II	3	
Total		**12**	

*** Students majoring in Physics are required to take these courses.**

LEVEL 400

For only students majoring in Physics.

FIRST SEMESTER

Core

Course Code	Course Title	Credits	Pre-requisites
PHYS 410	Project	3	
PHYS 401	Seminar I	1	
PHYS 443	Statistical Mechanics	3	
PHYS 449	Physics of Solids	3	
Total		**10**	
Electives (Select minimum of 6 credits)			
PHYS 447	Electronics II	2	
PHYS 455	Energy Systems	2	
PHYS 461	Principles of Radioactive Dating	2	
PHYS 465	Physics of Telecommunications	2	
Total		**16**	

SECOND SEMESTER

Core

Course Code	Course Title	Credits	Pre-requisites
PHYS 410	Project	3	
PHYS 402	Seminar II	1	
PHYS 446	Nuclear Physics II	2	
PHYS 448	Particle Physics	2	
PHYS 452	Quantum Mechanics II	3	
PHYS 454	Contemporary Physics	2	
Total		**13**	
Electives (Select a minimum of 2 credits)			
PHYS 462	Basic Meteorology	2	
PHYS 466	Physics at the Nanoscale	2	
PHYS 468	Introduction to Cosmology and	2	

	Astrophysics		
Total		**15**	

COMBINED MAJOR IN PHYSICS

The Combined Major Physics programme is available to students admitted into the Physical Science programme or students who, at Level 100, selected PHYS 143: PHYS 144: PHYS 105: Practical Physics I and PHYS 106: Practical Physics II as elective courses.

LEVEL 200
FIRST SEMESTER
Core

Course Code	Course Title	Credits	Pre-requisites
UGRC 210	Writing Academic II	3	
PHYS 205	Practical Physics III	1	
PHYS 241	Atomic Physics and Quantum Phenomena	2	
PHYS 245	Electromagnetism I	3	
MATH 223	Calculus II	3	
Total		**12**	

SECOND SEMESTER
Core

Course Code	Course Title	Credits	Pre-requisites
UGRC 220-238	Introduction to African Studies	3	
PHYS 206	Practical Physics IV	1	
PHYS 242	Oscillations and Waves	2	
PHYS 244	Mathematical Methods I	3	
Total		**9**	

LEVEL 300
FIRST SEMESTER
Core

Course Code	Course Title	Credits	Pre-requisites
PHYS 305	Practical Physics V	1	
PHYS 343	Thermodynamics	2	
PHYS 345	Electromagnetism II	3	
PHYS 351	Optics	3	
Total		**9**	

SECOND SEMESTER
Core

Course Code	Course Title	Credits	Pre-requisites
PHYS 306	Practical Physics VI	1	
PHYS 342	Classical Mechanics	3	
PHYS 352	Quantum Mechanics I	3	
PHYS 354	Special Relativity	2	

Total		**9**	

LEVEL 400
FIRST SEMESTER
Core

Course Code	Course Title	Credits	Pre-requisites
PHYS 443	Statistical Mechanics	3	
PHYS 449	Physics of Solids	3	
Total		**6**	
Electives (Select a minimum of 3 credits)			
PHYS 410	Project	3	
PHYS 401	Seminar I	1	
PHYS 447	Electronics II	2	
PHYS 455	Energy Systems	2	
PHYS 461	Principles of Radioactive Dating	2	
PHYS 465	Physics of Telecommunications	2	
Total		**9**	

SECOND SEMESTER
Core

Course Code	Course Title	Credits	Pre-requisites
PHYS 402	Seminar II	1	
PHYS 452	Quantum Mechanics II	3	
PHYS 454	Contemporary Physics	2	
Total		**6**	
Electives (Select a minimum of 3 credits)			
PHYS 410	Project	3	
PHYS 446	Nuclear Physics II	2	
PHYS 448	Particle Physics	2	
PHYS 462	Basic Meteorology	2	
PHYS 466	Physics at the Nanoscale	2	
PHYS 468	Introduction to Cosmology and Astrophysics	2	
Total		**9**	

GEOPHYSICS

To qualify for the Geophysics programme at Level 200 students should have taken the following elective courses at Level 100

Course Code	Course Title	Credits	Pre-requisites
EASC 101	Physical Geology	3	
EASC 104	Historical Geology	2	
EASC 106	Geological Field Excursions	1	

LEVEL 200

FIRST SEMESTER

Course Code	Course Title	Credits	Pre-requisites
Core			
UGRC 210	Writing Academic II	3	
PHYS 205	Practical Physics III	1	
PHYS 245	Electromagnetism I	3	
MATH 223	Calculus II	3	
PHYS 241	Atomic Physics and Quantum Phenomena	2	
EASC 227	Geological Structures and Maps	2	EASC 101, EASC 104
EASC 220	Geological Field Exercises I	2	EASC 101, EASC 104
Electives: Select up to 3 credits			
EASC 225	Quantitative Geology	2	
MATH 225	Vectors and Mechanics	3	
STAT 223	Elementary Statistical Methods	3	

SECOND SEMESTER

Course Code	Course Title	Credits	Pre-requisites
UGRC 220-238	Introduction to African Studies	3	
PHYS 206	Practical Physics IV	1	
PHYS 242	Oscillations and Waves	2	
PHYS 244	Mathematical Methods I	3	
PHYS 246	Nuclear Physics I	2	
PHYS 248	Introduction to Physics of Materials	2	
PHYS 256	Computational Methods in Physics I	2	
EASC 216	Fundamentals of Geophysics	2	
TOTAL		**17**	

LEVEL 300

FIRST SEMESTER

Course Code	Course Title	Credits	Pre-requisites
Core			
EASC 303	Soil Mechanics	3	
EASC 305	Fundamentals of Hydrogeology and Hydrology	2	
EASC 339	Principles of Applied Geophysics	3	
TOTAL		8	
Electives (select 7 to 10 credits)			
PHYS 345	Electromagnetism II	3	
PHYS 347	Electronics I	3	
PHYS 343	Thermodynamics	2	
PHYS 351	Optics	3	
EASC 341	Structural Geology	3	EASC 227
MATH 357	Computational Mathematics I	3	

SECOND SEMESTER

Course Code	Course Title	Credits	Pre-requisites
Core			
EASC 302	Geology of Ghana	3	
EASC 318	Earthquake Seismology and Disaster Risk Reduction	3	EASC 216
EASC 312	Introduction to Petroleum Geology	2	
GPHYS 301	Mathematical Methods for Geophysicists	2	
TOTAL		10	
Electives (select 5 to 8 credits)			
EASC 306	Aerial Photo Interpretation	2	
EASC 354	Geologic Resources	3	
PHYS 356	Computational Methods in Physics II	3	
PHYS 342	Classical Mechanics	3	
PHYS 364	Principles and Applications of Neutron Activation Analysis	2	
PHYS 352	Quantum Mechanics I	3	

LEVEL 400
FIRST SEMESTER

Course Code	Course Title	Credits	Pre-requisites
Core			
GPHY 400	Project	6	
EASC 401	Remote Sensing and Geographic Information Systems	3	
GPHY 403	Geophysical Instrumentation and Techniques	3	
PHYS 401	Seminar I	1	
TOTAL		10	
Electives (select 5 to 8 credits)			
EASC 451	Rock Mechanics	3	
EASC 423	Hydrogeology	3	EASC 325
PHYS 447	Electronics II	2	
PHYS 443	Statistical Mechanics	3	
PHYS 449	Physics of Solids	3	
PHYS 455	Energy systems	2	
PHYS 461	Principles of Radioactive Dating	2	

SECOND SEMESTER

Course Code	Course Title	Credits	Pre-requisites
Core			
EASC 428	Exploration Geophysics	3	EASC 339
EASC 442	Petroleum Reservoir Geophysics	3	EASC 339
EASC 452	Site Investigations	3	
PHYS 402	Seminar II	1	
TOTAL		10	
Electives (select 2 to 5 credits)			
EASC 404	Statistical Methods in Earth Science	2	
PHYS 446	Nuclear Physics II	2	
PHYS 448	Particle Physics	2	
PHYS 452	Quantum Mechanics II	3	

PHYS 462	Basic Meteorology	2	
PHYS 466	Physics of the Nanoscale	2	
PHYS 468	Introduction to Cosmology and Astrophysics	2	

COURSE DESCRIPTIONS

PHYS 205: Practical Physics III

This is the third course in practical physics and follows from PHYS 105 and PHYS 106, which exposed students to handling various measuring instruments. PHYS 205 introduces students to data and error analysis in addition to work on laboratory. Students will conduct experiments illustrating modern experimental techniques and error analysis in several topical areas in physics.

Reading List

Baird, D. C. (1995). *Experimentation: An introduction to measurement theory and experiment design* (3rd Edition). Englewood Cliffs, NJ: Prentice-Hall.

Bennington, P. R., & Robinson, D. K. (2003). *Data reduction and error analysis for the physical sciences*. New York, NY: McGraw-Hill.

Melissinos, A. C. & Napolitano, J. (2003). *Experiments in modern physics* (2nd Edition). San Diego, CA: Academic Press.

Morris, A.S. (2001). *Measurement and instrumentation principles*. Oxford: Butterworth-Heinemann.

Squires, G. L. (2001). *Practical physics* (4th Edition). Cambridge, UK: Cambridge University Press.

Taylor, J. R. (1982). *An introduction to error analysis.* Mill Valley, CA: University Science Books.

PHYS 206: Practical Physics IV

This course continues from PHYS 205. Experiments will be carried out to illustrate modern experimental techniques and error analysis in several topical areas in physics, including but not limited to: filters; electromagnetic induction; properties of matter; thermodynamics; microwave radiation; electronics. Students are also exposed to application of computers in data acquisition and data analysis as well as report preparation.

Reading List

Baird, D. C. (1995). *Experimentation: An introduction to measurement theory and experiment design* (3rd Edition). Englewood Cliffs, NJ: Prentice-Hall.

Bennington, P. R., & Robinson, D. K. (2003). *Data reduction and error analysis for the physical sciences.* New York, NY: McGraw-Hill.

Melissinos, A. C. & Napolitano, J. (2003). *Experiments in modern physics* (2nd Edition). San Diego, CA: Academic Press.

Morris, A.S. (2001). *Measurement and instrumentation principles*. Oxford: Butterworth-

Heinemann.

Squires, G. L. (2001). *Practical physics* (4th Edition). Cambridge, UK: Cambridge University Press.

Taylor, J. R. (1982). *An introduction to error analysis.* Mill Valley, CA: University Science Books.

PHYS 241: Atomic Physics and Quantum Phenomena

This course presents a concise introduction to the main tenets of modern physics. It is structured to provide the foundation for the study of more advanced concepts in physics. Areas to be covered are: Blackbody radiation and Planck's hypothesis, photons and electromagnetic waves, photo-electric effect, Compton Effect, double-slit experiment, wave properties of particles, uncertainty principle, the Schrödinger equation and simple solutions of same, atomic structure, the Bohr atom, line spectra and energy levels, angular momentum (orbital angular momentum, spin angular momentum, multiplets), spectroscopic terms; fine structure, hyperfine structure, Stark and Zeeman effects, and x-ray production and scattering.

Reading List

Bransden, B. H., & Joachain, C. J. (1990). *The physics of atoms and molecules*. Essex, England: Longman.

Brooks, R. L. (2013). *The fundamentals of atomic and molecular physics*. New York, NY: Springer.

Demtröder, W. (2010). *Atoms, molecules and photons: An introduction to atomic-,molecular and quantum physics* (2nd Edition). New York, NY: Springer.

Eisberg, R. & Resnick, R. (1985). *Quantum physics of atoms, molecules, solids, nuclei, and particles* (2nd Edition). New York, NY: Wiley.

Griffiths, D. J. (2005). *Introduction to quantum mechanics* (2nd Edition). Upper Saddle River, NJ: Pearson.

Krane, K. S. (2012). *Modern physics* (3rd Edition). New York, NY: Wiley.

PHYS 242: Oscillations and Waves

This course deals with the phenomena of oscillations, vibrations, and waves. Topics to be covered are: simple, damped and forced oscillations; decay of oscillations, resonance; general properties of waves; waves in one dimension; superposition of waves; dispersion and group velocity; Doppler Effect; waves in physical media; waves in two and three dimensions, circular and spherical wave fronts.

Reading List

French, A. P. (1971). *Vibrations and waves*. New York, NY: W. W. Norton & Company.

King, G. C. (2009). *Vibrations and waves.* West Sussex, England: Wiley.

Main, I. G. (1993). *Vibrations and waves in physics*. Cambridge, UK: Cambridge University Press.

Pain, H. J. & Rankin, P. (2015). *Introduction to vibrations and waves*. West Sussex, England: Wiley.

Samiullah, M. (2015). *A first course in vibrations and waves.* Oxford, UK: Oxford University Press.

PHYS 244: Mathematical Methods I

This course introduces students to the elementary mathematics used in undergraduate physics courses. Topics covered in the course include the following: Calculus of functions of several variables, partial differentiation, total differential, Euler's theorem on homogeneous functions; Constrained and unconstrained extrema, multiple integrals; Jacobian; Scalar and vector fields; Line, surface and volume integrals; Vector operators, grad, div and curl; Gauss, Stokes and Green's theorems; Ordinary differential equations with variable coefficients, series solutions.

Reading List

Boas, M. L. (2006). *Mathematical methods for the physical sciences* (3rd Edition). Hoboken, NJ: John Wiley.

Larson, R. & Edwards, B. (2018). *Calculus* (11th Edition). Boston, MA: Cengage Learning.

Riley, K. F., Hobson, M. P. & Bence, S. J. (2006). *Mathematical methods for physics and engineering* (3rd Edition). Cambridge, UK: Cambridge University Press.

Verma, P.D.S (1999). *Mathematical physics*. Vikas Pub. House (New Delhi).

Weber, H. J. & Arfken, G. B. (2003). *Essential mathematical methods for physicists*. San Diego, CA: Academic Press.

PHYS 245: Electromagnetism I

This is the first of a two-sequence course on the fundamentals of electromagnetism. Topics treated include: Electric field and potential gradient; Gauss's law and it's applications; electric field around conductors; Dielectric medium: polar and non-polar molecules, electric polarization and bound charges; Displacement vector; Gauss's Law in dielectrics; Potential energy of a charge distribution in the presence of dielectrics; Boundary conditions on **E** and **D**; Magnetic fields, magnetic force law and concept of magnetic induction **B**: Biot-Savart law, Lorentz force; Electromagnetic induction.

Reading List

Garg, A. (2012). *Classical electromagnetism in a nutshell.* Princeton, NJ: Princeton University Press.

Griffiths, D. J. (1999). *Introduction to electrodynamics* (4th Edition). Upper Saddle River, NJ: Pearson Prentice Hall.

Lorrain, P. & Corson, D. R. (1979). *Electromagnetism: Principles and applications*. San Francisco, CA: W. H. Freeman & Co.

Purcell, E. M. & Morin, D. J. (2013). *Electricity and magnetism* (3rd Edition). Cambridge, UK: Cambridge University Press.

Wangsness, R. K. (1979). *Electromagnetic fields* (2nd Edition). New York, NY: Wiley.

PHYS 246: Nuclear Physics I

This course introduces the properties of atomic nuclei. Topics covered include the following: Review of J. J. Thomson's atomic model; Review of alpha scattering experiments; Size and charge of nuclei; Energies of nucleons in the nucleus; Analysis of the nucleus as a quantum system; Nuclear forces and nuclear binding energy (mass defect and mass excess computations); Radioactive decay and decay processes; Nuclear radiation and its detection; Fission and fusion; Applications of radioactivity – dating, radiology, radiotherapy.

Reading List

Enge, H. A. (1969). *Introduction to nuclear physics*. Reading, MA: Addison-Wesley.

Evans, R. D. (1982). *The atomic nucleus*. Malabar, FL: Krieger Publishing Co.

Kaplan, I. (1969). *Nuclear physics*. Reading, MA: Addison-Wesley.

Krane, K. S. (1988). *Introductory nuclear physics* (3rd Edition). New York, NY: Wiley.

Reid, J. M. (1972). *The atomic nucleus*. London, England: Penguin.

PHYS 248: Introduction to Physics of Materials

This course introduces the structure and properties of materials from both a microscopic and a macroscopic point of view. Topics covered include the following: Forces between atoms and molecules and their consequences; Elastic modulae – Young's, Shear, Bulk; Poisson ratio, non-elastic behaviour; Flow properties of fluids; Continuity equation, hydrostatic equation, Euler's and Bernoulli's equations, Kelvin's circulation theorem, Reynold's number.

Reading List

Fredriksson, H. & Åkerlind, U. (2008). *Physics of functional materials.* New York, NY: John Wiley & Sons.

Gersten, J. I. & Smith, F. W. (2001). *The physics and chemistry of materials.* New York, NY: John Wiley & Sons.

Gerhart, P. M., Gerhart, A. L. & Hochstein, J. I. (2015). *Munson, Young and Okiishi's Fundamentals of fluid mechanics* (8th Edition). New York, NY: John Wiley.

Hughes, W. & Brighton, J. (1999). *Schaum's outline of fluid dynamics* (3rd Edition). New York, NY: McGraw-Hill.

Naumann, R. J. (2008). *Introduction to the physics and chemistry of materials*. Boca Raton, FL: CRC Press.

PHYS 256: Computational Methods in Physics I

Computational physics deals with basic computational problems in physics.
The purpose of this course is to teach students to develop the skills in numerical solutions to physics problems and solve the problems using computer programs. Topics to be discussed include introduction to basic computational tools and routines, projectile motion, Limits of computation; Introduction to numerical methods—Functions and roots, Approximation,

Interpolation, Systems of linear equations, Least squares, Numerical differentiation and integration, Finite differences; Oscillatory motion and chaos; Solar system; Potentials and fields of charges and currents; Waves.

Reading List

De Vries, P. L. (1994). *A first course in computational physics.* New York, NY: John Wiley.

Garcia, A. L. (2000). *Numerical methods for physics* (2nd Edition). Upper Saddle River, NJ: Prentice-Hall.

Klein, A. & Godunov, A. (2006), *Introductory Computational Physics.* Cambridge, UK: Cambridge University Press.

Landau, R. H., Paez, M. J., & Bordeianu, C.C. (2008). *A survey of computational physics.* Princeton, NJ: Princeton University press.

Thijssen, J. M. (2007). *Computational physics*. Cambridge, UK: Cambridge University Press.

PHYS 305: Practical Physics V

This the first of a two-part course in which laboratory experiments including those fundamental to modern physics and those illustrating modern experimental techniques are conducted. Students are introduced to scientific writing. Experiments include x-ray diffraction and crystal structure, x-ray absorption, x-ray fluorescence, Fermi energy, Wiedemann-Franz law, image charges in electrostatics, Rutherford scattering, fine structure, electronics, Boltzmann constant, diffraction, wave propagation, and β spectroscopy.

Reading List

Baird, D. C. (1995). *Experimentation: An introduction to measurement theory and experiment design* (3rd Edition). Englewood Cliffs, NJ: Prentice-Hall.

Bennington, P. R., & Robinson, D. K. (2003). *Data reduction and error analysis for the physical sciences.* New York, NY: McGraw-Hill.

Melissinos, A. C. & Napolitano, J. (2003). *Experiments in modern physics* (2nd Edition). San Diego, CA: Academic Press.

Morris, A.S. (2001). *Measurement and instrumentation principles*. Oxford: Butterworth-Heinemann.

Squires, G. L. (2001). *Practical physics* (4th Edition). Cambridge, UK: Cambridge University Press.

Taylor, J. R. (1982). *An introduction to error analysis.* Mill Valley, CA: University Science Books.

PHYS 306: Practical Physics VI

This the second of a two-part course in which laboratory experiments including those fundamental to modern physics and those illustrating modern experimental techniques are conducted. Students are introduced to scientific writing. Experiments include x-ray

diffraction and crystal structure, x-ray absorption, x-ray fluorescence, Fermi energy, Wiedemann-Franz law, image charges in electrostatics, Rutherford scattering, fine structure, electronics, Boltzmann constant, diffraction, wave propagation, and β spectroscopy.

Reading List

Baird, D. C. (1995). *Experimentation: An introduction to measurement theory and experiment design* (3rd Edition). Englewood Cliffs, NJ: Prentice-Hall.

Bennington, P. R., & Robinson, D. K. (2003). *Data reduction and error analysis for the physical sciences.* New York, NY: McGraw-Hill.

Melissinos, A. C. & Napolitano, J. (2003). *Experiments in modern physics* (2nd Edition). San Diego, CA: Academic Press.

Morris, A.S. (2001). *Measurement and instrumentation principles*. Oxford: Butterworth-Heinemann.

Squires, G. L. (2001). *Practical physics* (4th Edition). Cambridge, UK: Cambridge University Press.

Taylor, J. R. (1982). *An introduction to error analysis.* Mill Valley, CA: University Science Books.

PHYS 342: Classical Mechanics

This course aims to introduce students to the fundamentals of classical mechanics. Topics covered include the following: Force Fields, conservative and non-conservative forces; Gravitation; Equipotential surfaces; Gradient of a potential; Gauss's law and applications; Central forces and applications to two-particle systems; Orbits; Escape velocity; Drag; Motion with variable mass; Statics of rigid bodies; Moment of inertia; Angular momentum; Motion of a top; Centrifuges; Gyroscopic motion; Lagrange's and Hamilton's equations.

Reading List

French, A. P. (1971). *Newtonian mechanics.* New York, NY: W. W. Norton.

Kibble, T. W. B., & Berkshire, F. H. (2004). *Classical mechanics* (5th Edition). London, UK: Imperial College Press.

McCall, M. W. (2001). *Classical mechanics*. Chichester, UK: John Wiley.

Symon, K. R. (1971). *Mechanics* (3rd Edition). Reading, MA: Addison-Wesley.

Thornton, S. T., & Marion, J. B. (2004). *Classical dynamics of particles and systems* (5th Edition). Belmont, CA: Brooks/Cole.

PHYS 343: Thermodynamics

This course aims to introduce students to the fundamentals of thermodynamics: Topics covered include the following. Concept of Systems; Classification of thermodynamic systems; Laws of thermodynamics – their implications and applications; Heat transfer mechanisms; Thermodynamic properties, macroscopic variables and equations of state; Phase

change; Work and Energy; Thermodynamic machines – heat engines, refrigerators and heat pumps; Efficiency and coefficient of performance of thermodynamic machines; Entropy, thermal pollution and global warming; Unavailability of energy; Heat death; Control Volume Analysis; Thermodynamic potentials – Gibbs functions, Helmholtz functions and Free energy functions; Generalized thermodynamic relations – multivariate calculus foundations, Gibbsian equations and Maxwell's relations.

Reading List

Adkins, C. J. (1983). *Equilibrium thermodynamics*. Cambridge University Press.

Callen, H. B. (1985). *Thermodynamics and an introduction to thermostatistics* (2nd Edition). Hoboken, NJ: John Wiley.

Kittel, C., & Kroemer, H. (1980). *Thermal physics*. New York, NY: W. H. Freeman.

Reif, F. (1965). *Fundamentals of statistical and thermal physics*. McGraw-Hill.

Schroeder, D. V. (1999). *An introduction to thermal physics.* Upper Saddle River, NJ: Pearson.

PHYS 344: Mathematical Methods II

This course introduces students to the elementary mathematics used in undergraduate physics courses. Topics covered in the course include the following: Vector and Tensor Analysis; Determinants, Matrices and Group Theory; Infinite Series; First Order Differential Equations; Functions of Complex Variables; Second Order Differential Equations; Power Series Solution of Differential Equations; Special Functions - Bessel Functions, Gamma Functions, Beta Functions, Legendre Functions; Fourier Series; Partial Differential Equations; Integral Functions - Fourier Transform, Laplace Transform.

Reading List

Arkfen, G. B., Weber, H. J., & Harris, F. E. (2013). *Mathematical methods for physicists: A comprehensive guide* (7th Edition). Waltham, MA: Academic Press.

Boas, M. L. (2006). *Mathematical methods for the physical sciences* (3rd Edition). Hoboken, NJ: John Wiley.

Chow, T. (2003). *Mathematical methods for physicists: A concise introduction*. Cambridge, UK: Cambridge University Press.

Kusse, B., & Westwig, E. (2006). *Mathematical physics: Applied mathematics for scientists and engineers* (2nd Edition). Weinheim, Germany: Wiley-VCH.

Tang, K. T. (2007). *Mathematical methods for engineers and scientists*. New York, NY: Springer.

PHYS 345: Electromagnetism II

This course is the second in a sequence of two courses on the fundamentals of electromagnetism. This course extends the topics treated in PHYS 245 to include additional techniques for calculating electromagnetic fields and a discussion electromagnetic waves. Topics include: Electromagnetic potentials: scalar and vector potentials; Poisson and Laplace

equations; General methods of solving electrostatic problems; Electrostatic boundary value problems; Method of images; Magnetic materials, magnetization, magnetic field intensity **H**, magnetic susceptibility, relative permeability, hysteresis; Multipole fields; Maxwell's equations; derivation of the electromagnetic wave equation, its solutions, and some applications; Electromagnetic waves in dielectric and conducting media; skin effect.

Reading List

Garg, A. (2012). *Classical electromagnetism in a nutshell.* Princeton, NJ: Princeton University Press.

Griffiths, D. J. (1999). *Introduction to electrodynamics* (4th Edition). Upper Saddle River, NJ: Pearson Prentice Hall.

Lorrain, P., & Corson, D. R. (1979). *Electromagnetism: Principles and applications*. San Francisco, CA: W. H. Freeman & Co.

Purcell, E. M., & Morin, D. J. (2013). *Electricity and magnetism* (3rd Edition). Cambridge, UK: Cambridge University Press.

Wangsness, R. K. (1979). *Electromagnetic fields* (2nd Edition). New York, NY: Wiley.

PHYS 347: Electronics I

This course covers elementary analogue and digital electronics. Topics treated include the following: Voltage, current and resistance; Voltage dividers; Circuit analysis: Thévenin equivalent circuits, Norton equivalent circuits; Diodes and diode circuits; design of regulated power supply, basic transistor circuits (Bipolar-Junction Transistors and Field-Effect Transistors); Operational amplifiers (linear applications only); Introduction to digital electronics (Number systems, Boolean algebra, logic gates, combinational logic circuits, Karnaugh maps).

Reading List

Ahmed, H., & Spreadbury, P. J. (1984). *Analogue and digital electronics for engineers: An Introduction.* Cambridge, UK: Cambridge University Press.

Floyd, T. L., & Buchla, D. L. (2014). *Electronics fundamentals: Circuits, devices and applications* (8th Edition). Essex, England: Pearson.

Horowitz, P., & Hill, W. (2008). *The art of electronics.* Cambridge, UK: Cambridge University Press.

Maini, A. K. (2007). *Digital electronics principles, devices and applications*. West Sussex, England: John Wiley & Sons Ltd.

Malvino, A. P. (1999). *Electronic principles*. New York, NY: Glencoe McGraw-Hill Education.

PHYS 351: Optics

This course covers both classical and modern optics. Topics include the following: Nature and propagation of light: refractive index and optical path, Huygen's principle, Fermat's principle. Advanced geometrical optics. Physical Optics: interference, Young's double slit

experiment, other optical devices for the division of wave fronts, multiple-beam interference, and Michelson's interferometer. Diffraction: Fraunhofer diffraction, Fresnel diffraction. Polarization. Holography. Fiber optics.

Reading List

Fowles, G. R. (1989). *Introduction to modern optics* (2nd Edition). Mineola, NY: Dover.

Hecht. E. (2017). *Optics* (5th Edition). Essex, England: Pearson.

Jenkins, F. A., & White, H. E. (2001). *Fundamentals of optics* (4th Edition). McGraw-Hill.

Lipson, A., Lipson, S. G., & Lipson, H. (2011). *Optical physics*. Cambridge, UK: Cambridge University Press.

Longhurst, R. S. (1974). *Geometrical and physical optics* (3rd Edition). Harlow, UK: Longman.

PHYS 352: Quantum Mechanics I

This course is the first in a two-course sequence on elementary quantum mechanics. Topics include: Principles of quantum mechanics; Time-independent Schrödinger equation; Interpretation of wave properties as probability amplitudes; Superposed energy states; Uncertainty principle; Lifetimes; Moving wave packets; One dimensional scattering; Potential wells and barriers, tunnelling; probability currents; Harmonic oscillator; Formalism of quantum mechanics.

Reading List

Griffiths, D. J. (2005). *Introduction to quantum mechanics.* Upper Saddle River, NJ: Pearson Prentice Hall.

Liboff, R. L. (2002). *Introductory quantum mechanics.* Reading, MA: Addison-Wesley.

Goswami, A. (2003). *Quantum mechanics.* Long Grove, IL: Waveland Press.

McIntyre, D. H. (2012). *Quantum mechanics: A paradigms approach.* San Francisco, CA: Pearson.

Mezbacher, E. (1998). *Quantum mechanics.* New York, NY: Wiley.

PHYS 354: Special Relativity

This course aims to introduce students to the Special Theory of Relativity. Topics covered include: Newtonian Mechanics and Relativity: failure of classical relativity, inertial frames, Galilean transformation, Michelson-Morley experiment. Einstein's basic ideas: invariance of physical laws; Einstein's postulates, relativity and simultaneity. Consequences of Einstein's postulates. Doppler Effect for electromagnetic waves: classical Doppler shift, relativistic Doppler shift. Relativistic Dynamics: mass, momentum, work, energy. Experimental Tests of Special Relativity.

Reading List

Bergmann, P. G. (1942). *Introduction to the theory of relativity.* Englewood Cliffs, NJ: Prentice-Hall.

French, A. P. (1968). *Special relativity.* New York, NY: W. W. Norton.

Resnick, R. (1972). *Basic concepts in relativity and early quantum theory.* New York, NY: Wiley.

Rindler, W. (1982). *Introduction to special relativity*. Oxford, UK: Clarendon.

Taylor, E. F. & Wheeler, J. A. (1966). *Spacetime physics.* San Francisco, CA: Freeman.

PHYS 356: Computational Methods in Physics II

This course extends the techniques developed in PHYS 256 to more complex systems. Topics covered include the following: Random systems; Monte Carlo methods; Random walks, diffusion, and the Ising model; Phase transitions; Molecular dynamics; Variational and Spectral methods; Hartree-Fock method: helium atom, hydrogen ion; Periodic potentials and band structures; Self-organized criticality; Fractals; Protein folding; Neural networks.

Reading List

De Vries, P. L. (1994). *A first course in computational physics.* New York, NY: John Wiley.

Garcia, A. L. (2000). *Numerical methods for physics* (2nd Edition). Upper Saddle River, NJ: Prentice-Hall.

Klein, A., & Godunov, A. (2006). *Introductory Computational Physics.* Cambridge, UK: Cambridge University Press

Landau, R. H., Paez, M. J., & Bordeianu, C.C. (2008). *A survey of computational physics.* Princeton, NJ: Princeton University press.

Thijssen, J. M. (2007). *Computational physics*. Cambridge, UK: Cambridge University Press.

PHYS 359: Solid State Physics I

This course is the first of a two-part course which introduces the concepts and theory of the physics of materials in the solid state. Topics covered in this part include: Lattice translation vectors, symmetry operations; types of lattices; simple crystal structures; effect of deformation on crystals and their properties; crystal diffraction and the reciprocal lattice; Bragg's Law; experimental diffraction methods; reciprocal lattice vectors; Brillouin zones; structure and atomic form factors; Lattice vibrations; Lattice heat capacity; thermal conductivity.

Reading List

Ashcroft, N. W., & Mermin, N. D. (1976). *Solid state physics.* Orlando. FL: Harcourt.

Blakemore, J. S. (1985). *Solid state physics* (2nd Edition). Cambridge University Press.

Hook, J. R., & Hall, H. E. (2001). *Solid state physics* (2nd Edition). New York, NY: Wiley.

Kittel, C. (2005). *Solid state physics* (8th Edition). New York, NY: Wiley.

Rosenberg, H.M. (1988). *Solid state*: *An introduction to the physics of crystals for students of physics, materials science and engineering* (3rd Edition). Oxford, UK: Oxford University Press.

PHYS 361: Physics of the Atmosphere

This course is an introduction to the physics of the processes that occur in the at atmosphere. Topics covered include the following: Origin and composition of the atmosphere; Distribution of constituents; Charged particles; Temperature distribution. Thermodynamics of water vapour and moist air: Thermodynamics of dry and moist air, stability; changes of phase and latent heat; Adiabatic processes, moisture variables; Thermodynamic diagrams; Radiation: Fundamental physics of atmospheric electricity, radiation laws; Solar and terrestrial radiation, applications, ozone hole, atmospheric energy transport; Global energy balance.

Reading List

Andrews, D. G. (2010). *An introduction to atmospheric physics* (2nd Edition). Cambridge, UK: Cambridge University Press.

Iribarne, J. V., & Cho, H. R. (1980). *Atmospheric physics*. Dordrecht, Holland: D. Reidel Publishing Company.

Liou, K. N. (2002). *An introduction to atmospheric radiation*. San Diego, CA: Academic Press.

Salby, M. L. (1996). *Fundamentals of atmospheric physics.* San Diego, CA: Academic Press.

Wallace, J. M., & Hobbs, P. V. (2006). *Atmospheric science: An introductory survey* (2nd Edition). Burlington, MA: Elsevier.

PHYS 364: Principles and Applications of Neutron Activation Analysis

This course shows how stable materials (matter/samples) can be made radioactive by irradiation with neutrons, and then analyzed through the emanating gamma radiation from the resulting radionuclide. Topics covered include Irradiation facilities: Neutron Sources; Nuclear Reactors Source; Isotopic Neutron Sources; Neutron Generator (Accelerator) Sources: Kinetics of activation: Irradiation Scheme (Conditions); Gamma Ray Spectrometry (Measurement of Gamma Rays). Absolute Method; Relative (Comparative) Method; K_0 Method Measurement and evaluation: Qualitative Analysis; Quantitative Analysis; Applications of neutron activation analysis: Environmental Studies - Pollution Studies; Forensic Investigations; Archaeological Studies, Biochemistry; Semiconductor Materials Studies; Geological Science; Soil Science; Epidemiology Studies.

Reading List

Alfassi, Z. B., & Chung, C. (1995). *Prompt gamma neutron activation analysis.* Boca Raton, FL: CRC Press.

De Soete, D., Gijbels. R., & Hoste, J. (1991). *Neutron activation analysis*. New York, NY: Wiley Inter Science.

Ehmann, W. D., & Vance, D. E. (1993). *Radiochemistry and nuclear methods of analysis*. New York, NY: Wiley Inter science.

International Atomic Energy Agency (1990). *Practical aspect of operating a neutron activation analysis laboratory, IAEA- TECDOC – 564*. Vienna, Austria: IAEA.

Molnar, G. (2004). *Handbook of prompt gamma activation analysis: with neutron beams*(ed.). Dordrecht, The Netherlands: Kluwer.

PHYS 365: Physics of the Ocean

In this course, students are introduced to the physical processes that occur in the oceans. Topics covered in this course include: Physical properties of the ocean and seawater, sound and light; T-S forcing and conservation laws, Global T-S distribution; Equations of continuity and motion; Balance of forces; the effect of Earth's rotation; Ocean currents; Deep currents and general ocean circulation; Surface waves; Tides and long-period waves; Oceanographic instrumentation; El Nino.

Reading List

Kantha, L. H., & Clayson, C. A. (2000). *Numerical models of oceans and oceanic processes*. San Diego, CA: Academic Press.

McLellan, H. J. (1965). *Elements of physical oceanography.* New York, NY: Pergamon Press.

Pond, S., & Pickard G. L. (1983). *Introductory dynamical oceanography* (2nd ed.). Oxford, UK: Butterworth-Heinemann.

Talley, L. D., Pickard, G. L., Emery, W. J., & Swift, J. H. (2011). *Descriptive physical oceanography: An introduction*. San Diego, CA: Academic Press.

Thurman. H.V. (2001). *Introductory oceanography* (9th Edition). Charles E. Merill Pub. Co.

GPHYS 301: Mathematical Methods for Geophysicists

This course takes the mathematics and related courses in Levels 100 and 200 and applies it to the study of the Earth, extending mathematical skills and exploring the insights that can be developed through quantitative modelling of geological processes. It covers the following topics: Vectors and their use in describing positions and directions on the Earth's surface; Spherical geometry and plate tectonics; Potential fields and the gradient and divergence operators applied to gravity and heat flow; Ordinary differential equations applied to heat flow in the Earth; The diffusion equation applied to time-dependent heat flow into the Earth.

Reading List

Fowler, C.M.R. (2004). *The solid earth*: *An introduction to global geophysics*. Cambridge University Press.

Menke, W., & Abbott, D. (1990). *Geophysical theory*. New York, NY: Columbia University Press.

Middleton, G.V., & Wilcock, P. R. (1994). *Mechanics in the earth and environmental sciences*. Cambridge University Press.

Snieder, S., & van Wijk, K. (2015). *A guided tour of mathematical methods for the physical sciences*. New York, NY: Cambridge University Press.

Turcotte, D. L., & Schubert, G. (1982). *Geodynamics*. Wiley

GPHY 400: Project

This course provides students the opportunity to pursue a limited research activity in various subfields of geophysics using modern geophysical research tools. Students undertake a research project under the supervision of a Senior Member over the course of two semesters. A final report is required. Students are expected to report on their findings at a seminar.

Reading List

Anderson, N.A. (1997). *Instrumentation for process measurement and control*. Boca Raton, FL: CRC Press.

Goldbort, R. (2006). *Writing for science.* New Haven, CT: Yale University Press.

Milsom, J. J., & Eriksen, A. (2011). *Field geophysics (geological field guide)* (4the Edition). Sussex, UK: Wiley.

Morris, A.S. (2001). *Measurement and instrumentation principles*. Oxford: Butterworth-Heinemann.

Taylor, J. R. (1982). *An introduction to error analysis.* Mill Valley, CA: University Science Books.

GPHYS 403: Geophysical Instrumentation and Techniques

In this course students understand key concepts of geophysical instrumentation and their application to field surveys. Students learn the underlying physical principles of how geophysical instruments work, what they measure and how they work as instruments (e.g, electronic components). They would learn how to use geophysical field equipment and conduct geophysical surveys, and how to do electronic instrumentation and build basic circuits. Course content include: basic electronics for geophysical instrumentation; underlying physical principles of geophysical measurements and relation to rock physical properties; basic concepts for conducting geophysical surveys in the field including analysis of geophysical data; geophysical software applications.

Reading List

Anderson, N.A. (1997). *Instrumentation for process measurement and control*. Boca Raton, FL: CRC Press.

Buforn, E., Pro, C., & Udías, A. (2012). *Solved problems in geophysics*. Cambridge: Cambridge University Press.

Milsom, J. J., & Eriksen, A. (2011). *Field geophysics (geological field guide)* (4th Edition). Sussex, UK: Wiley.

Morris, A.S. (2001). *Measurement and instrumentation principles*. Oxford: Butterworth-Heinemann.

Phillips, J. D. (2013). *Potential-field geophysical software for the PC.* Open-File Report. BiblioGov.

Reford, S. W. (1986). *Development of computer software for geophysical interpretation: Exploration Technology Development Fund, grant no. 011*. Ministry of Northern Development and Mines, Ontario Geological Survey.

PHYS 410: Project Work

In this two-semester course, students pursue a project on topics drawn from experimental and/or theoretical physics under the supervision of a Senior Member. Students meet weekly to discuss their projects and research experiences and findings. A final report is required. Students are expected to report on their findings at a seminar.

Reading List

Anderson, N.A. (1997). *Instrumentation for process measurement and control*. Boca Raton, FL: CRC Press.

Bennington, P. R., & Robinson, D. K. (2003). *Data reduction and error analysis for the physical sciences*. New York, NY: McGraw-Hill.

Goldbort, R. (2006). *Writing for science.* New Haven, CT: Yale University Press.

Morris, A.S. (2001). *Measurement and instrumentation principles*. Oxford: Butterworth-Heinemann.

Taylor, J. R. (1982). *An introduction to error analysis.* Mill Valley, CA: University Science Books.

PHYS 401: Seminar I

This is the first of a two-part seminar course sequence designed to give students the opportunity to hone their scientific communication skills. Students attend weekly seminars and present proposals for their final year research project. Topics vary from semester to semester according to interest of the students. This course provides an introduction to the preparation, organization and delivery of a scientific presentation. It provides a guide on research proposal and thesis writing.

Reading List

Albuquerque, U. P. (2015). *Speaking in public about science: A quick guide for the preparation of good lectures, seminars, and scientific presentations.* Cham, Switzerland: Springer.

Barrass, R. (2002). *Scientist must write: a guide to better writing for scientists, engineers and students*. New York, NY: Routledge.

Hofmann, A. (2016). *Scientific writing and communication: Papers, proposals, and presentations* (3rd Edition). Oxford, UK: Oxford University Press.

Morgan, & Whitener, (2006). Speaking about Science: a manual for creating clear presentations, Cambridge University Press.

Walters, D. E., & Walters, G. C. (2011). *Scientists must speak: Bringing presentations to life* (2nd Edition). Boca Raton, FL: CRC Press.

PHYS 402: Seminar II

This is the first of a two-part seminar course sequence designed to give students the opportunity to hone their scientific communication skills. Students attend weekly seminars and report on their research findings. Topics vary from semester to semester according to interest of the students. This course provides an introduction to the preparation, organization and delivery of a scientific presentation. It provides a guide on research proposal and thesis writing.

Reading List

Albuquerque, U. P. (2015). *Speaking in public about science: A quick guide for the preparation of good lectures, seminars, and scientific presentations.* Cham, Switzerland: Springer.

Barrass, R. (2002). *Scientist must write: a guide to better writing for scientists, engineers and students*. New York, NY: Routledge.

Hofmann, A. (2016). *Scientific writing and communication: Papers, proposals, and presentations* (3rd Edition). Oxford, UK: Oxford University Press.

Morgan, & Whitener, (2006). Speaking about Science: a manual for creating clear presentations, Cambridge University Press.

Walters, D. E., & Walters, G. C. (2011). *Scientists must speak: Bringing presentations to life* (2nd Edition). Boca Raton, FL: CRC Press.

PHYS 443: Statistical Mechanics

This course introduces the fundamentals of Statistical Mechanics. Topics covered in the course include the following. Probability distribution functions; velocity distributions; distributions in phase space; transport phenomena; fluctuation; ensembles and distribution functions; entropy and ensembles; the micro-canonical ensemble; the canonical ensemble; Bose-Einstein statistics (black body radiation); Fermi-Dirac statistics (free-electron gas).

Reading List

Chandler, D. (1987). *Introduction to modern statistical mechanics*. Oxford, UK: Oxford University Press.

Kittel, C., & Kroemer, H. (1980). *Thermal physics*. New York, NY: W. H. Freeman.

Mandl, F. (1971). *Statistical physics*. New York, NY: Wiley.

Reif, F. (1965). *Fundamentals of statistical and thermal physics*. McGraw-Hill.

Schroeder, D. V. (1999). *An introduction to thermal physics.* Upper Saddle River, NJ: Pearson.

PHYS 446: Nuclear Physics II

This course aims to introduce students to models of atomic nuclei as well as nuclear phenomena and their applications. Topics covered in the course include the following: Nuclear properties: constituents, nuclear sizes, masses, densities and abundance; Mass leading to definition of binding energy; Empirical mass formula; Nuclear Models: liquid drop and shell models, unified (collective) model and how they explain properties of nucleus; Nuclear reactions: representation, conservation laws, radioactivity, decay of parent and daughter, equilibrium; Nuclear fission and fusion: types of fission, release of energy, fusion in stars and the sun; Nuclear reactors: constituents of a reactor, Types of reactors, generation of electricity, Advantages and disadvantages.

Reading List

Enge, H. A. (1969). *Introduction to nuclear physics*. Reading, MA: Addison-Wesley.

Evans, R. D. (1982). *The atomic nucleus*. Malabar, FL: Krieger Publishing Co.

Kaplan, I. (1969). *Nuclear physics*. Reading, MA: Addison-Wesley.

Krane, K. S. (1988). *Introductory nuclear physics* (3rd Edition). New York, NY: Wiley.

Reid, J. M. (1972). *The atomic nucleus*. London, England: Penguin.

PHYS 447: Electronics II

This course is designed to teach students the basics of digital electronic devices and techniques used in digital circuit design. It also provides an in-depth study of the principles and applications of digital systems. Topics to be discussed include Boolean algebra, basic logic circuits, logic families, combinational logic, arithmetic circuits, multivibrators, flip-flops and timing circuits, counters, registers, semiconductor memories, introduction to microprocessors and microcontrollers.

Reading List

Ahmed, H., & Spreadbury, P. J. (1984). *Analogue and digital electronics for engineers: An introduction.* Cambridge, UK: Cambridge University Press.

Floyd, T. L., & Buchla, D. L. (2014). *Electronics fundamentals: Circuits, devices and applications* (8th Edition). Essex, England: Pearson.

Horowitz, P., & Hill, W. (2008). *The art of electronics.* Cambridge, UK: Cambridge University Press.

Maini, A. K. (2007). *Digital electronics principles, devices and applications*. West Sussex, England: John Wiley & Sons Ltd.

Malvino, A. P. (1999). *Electronic principles*. New York, NY: Glencoe McGraw-Hill Education.

PHYS 448: Particle Physics

This course exposes students to the study of the basic nature of matter, and their interacting forces at the level of fundamental particles and at very high energies. It also shows the link between theoretical physics predictions on fundamental particles and verification through experimentation. It covers the standard model: elementary particles quarks, leptons, and bosons; Feynman diagrams and conservation laws; electro-weak theory, and grand unification theory; acceleration and collision of elementary particles (the large hadron collider LHC); particle detectors and applications of particle physics research results.

Reading List

Bransden, B. H., Evans, D., &Major, J. V. (1973). *The fundamental particles.* London, England: Van Nostrand Reinhold.

Coughlan, G. D., Dodd, J. E., & Gripaios, B. (2006). *The ideas of particle physics*: *An introduction for scientists*. Cambridge University press.

Gibson, W. M., & Pollard. B. R. (1976). *Symmetry principles in elementary particle physics*. Cambridge University Press.

Griffiths, D. (2008). *Introduction to elementary particles* (2nd Edition). Weinheim, Germany: Wiley-VCH.

Halzen, F., & Martin, A. D. (1984). *Quarks and leptons: An introductory course in modern particle physics.* New York, NY: John Wiley.

PHYS 449: Physics of Solids

This course introduces the concepts and theory of the physics of materials in the solid state. Topics covered include: Lattice translation vectors, symmetry operations; types of lattices; simple crystal structures; crystal diffraction and the reciprocal lattice; Bragg's Law; reciprocal lattice vectors; Brillouin zones; Lattice vibrations; Lattice heat capacity; thermal conductivity. Free electron Fermi gas; Fermi distribution, heat capacity of an electron gas; electrical conductivity; Wiedemann – Franz law; metals; insulators.

Reading List

Ashcroft, N. W., & Mermin, N. D. (1976). *Solid state physics.* Belmont, CA: Brooks/Cole.

Blakemore, J. S. (1985). *Solid state physics* (2nd Edition). Cambridge University Press.

Hook, J. R., & Hall, H. E. (2001). *Solid state physics* (corrected 2nd ed.). New York, NY: Wiley.

Kittel, C. (2005). *Solid state physics* (8th Edition). New York, NY: Wiley.

Rosenberg, H.M. (1988). *Solid state*: *An introduction to the physics of crystals for students of physics, materials science and engineering* (3rd Edition.). Oxford, UK: Oxford University Press.

PHYS 452: Quantum Mechanics II

The course introduces the basic theory of quantum mechanics, and how it explains some of the behaviour of the physical universe from a fundamental point of view. Topics to be discussed include Schrödinger equation in three dimensions; the stationary states of the hydrogen atom; general properties of angular momentum in quantum mechanics; electron spin; system of identical particles; time-independent perturbation theory; variational principles; the Wentzel-Kramers-Brillouin (WKB) approximation; Scattering.

Reading List

Goswami, A. (2003). *Quantum mechanics.* Long Grove, IL: Waveland Press.

Griffiths, D. J. (2005). *Introduction to quantum mechanics.* Upper Saddle River, NJ: Pearson Prentice Hall.

Liboff, R. L. (2002). *Introductory quantum mechanics.* Reading, MA: Addison-Wesley.

McIntyre, D. H. (2012). *Quantum mechanics: A paradigms approach.* San Francisco, CA: Pearson.

Mezbacher, E. (1998). *Quantum mechanics.* New York, NY: Wiley.

PHYS 454: Contemporary Physics

This course is at an introductory level, dealing with selected topics taken from current trends in Physics. It is aimed at motivating students in the subject and ensuring a general literacy in the frontiers of Physics. Areas covered include recent advances in fields such as Unification, General Relativity and Black Holes.

Reading List

New Journal of Physics. Bristol, UK: IOP Publishing.

Journal of physics conference series. Bristol, UK: IOP Publishing.

Physics today. Washington, DC: American Institute of Physics.

Physical review series. Washington, DC: American Physical Society.

Physics world. Bristol, UK: IOP Publishing

PHYS 455: Energy Systems
This course introduces contemporary topics in energy systems. Topics covered include the following. Review of energy sources; conventional and non-conventional, renewable and non-renewable. Nuclear energy – fission, fusion, breeder reactors; solar energy – physical problems connected with conversion; technological problems and applications. Fossil fuels, hydro-power, wind power, tidal power; bio-chemical energy, Conservation and storage.

Reading List
Markvart, T. (1994). *Solar electricity*. New York, NY: Wiley.

Meyer, R. A. (1983). *Handbook of energy technology and economics.* New York, NY: John Wiley.

Quaschning, V. (2005). *Understanding renewable energy systems.* London, UK: Earthscan.

Sioshansi, F. P. (2012). *Smart grid: Integrating renewable, distributed and efficient energy.* Waltham, MA: Academic Press.

Sørensen, B. E. (2017). *Renewable energy: Physics, engineering, environmental impacts, economics and planning* (5th Edition). London, UK: Academic Press.

PHYS 459: Solid State Physics II
This course is the second of a two-part course which introduces the concepts and theory of the physics of materials in the solid state. Topics covered in this part include: Free electron Fermi gas; Fermi distribution, heat capacity of an electron gas; electrical conductivity; motion in magnetic fields; Wiedemann-Franz law; Energy Bands; Bloch functions; weakly perturbing lattice potential; holes; effective mass; metals; insulators; semiconductors; semiconductor crystals; intrinsic carrier concentration; thermo-electric effects in semiconductors; semi metals; p-n junctions; solar cells and photovoltaic detectors.

Reading List
Ashcroft, N. W., & Mermin, N. D. (1976). *Solid state physics.* Belmont, CA: Brooks/Cole.

Blakemore, J. S. (1985). *Solid state physics* (2nd Edition). Cambridge University Press.

Hook, J. R., & Hall, H. E. (2001). *Solid state physics* (2nd Edition). New York, NY: Wiley.

Kittel, C. (2005). *Solid state physics* (8th Edition). New York, NY: Wiley.

Rosenberg, H.M. (1988). *Solid state*: *An introduction to the physics of crystals for students of physics, materials science and engineering* (3rd Edition). Oxford, UK: Oxford University Press.

PHYS 461: Principles of Radioactive Dating
Topics covered in this course include the following. Radioactive decay, Types of radioactive clocks: decay clock accumulation clock. Fundamental requirements of radiometric dating, Useful radioactive decay schemes. Analytical techniques – fundamental mass spectrometry, Isotope dilution, analytical errors. Typical radiometric dating methods – K-Ar, Ar40/Ar39, Rb-Sr, U-Pb, Sm-Nd. Fission Track method of dating.

Reading List

Aitken, M. J. (1974). *Physics and archaeology*. Oxford, UK: Oxford University Press.

Criss, R. E. (1999). *Principles of stable isotope distribution.* New York, NY: Oxford University Press.

Faure, G., & Mensing, T. M. (2005). *Isotopes: Principles and applications* (3rd Edition). Hoboken, NJ: John Wiley.

Geyh, M. A., & Schleicher, H. (1990). *Absolute age determination: Physical and chemical dating methods and their application*. Berlin, Germany: Springer-Verlag.

Gopalan, K. (2017). *Principles of radiometric dating.* Cambridge, UK: Cambridge University Press.

PHYS 462: Basic Meteorology

This course introduces students to the physical description of weather and climate. Topics include the following: Structure of the atmosphere; weather processes and weather systems, including climatic process. Data analysis, instruments, and weather system models, Global distribution of principal climatic elements with emphasis on physical causes. Physics of moist air; physics of aerosols; condensation of water vapour on aerosols; cloud physics. 1D and 3D climate models, applications, global warming.

Reading List

Iribarne, J. V., & Cho, H. R. (1980). *Atmospheric physics*. Dordrecht, Holland: D. Reidel Publishing Company.

Hess, E. S. L. (1959). *Introduction to theoretical meteorology*. Malabar, FL: Krieger Publishing Co.

Holton, J. R., & Hakim, G. J. (2013). *An introduction to dynamic meteorology* (5th Edition). altham, MA: Academic Press Inc.

Oke, T. R. (1992). *Boundary layer climates* (2nd Edition). London, UK: Routledge.

Stull, R. B. (1988). *An introduction to boundary Layer meteorology*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

PHYS 465: Physics of Telecommunications

This course introduces students to the physical principles that govern telecommunication devices and networks. Topics treated include the following: Network theorems, Circuit theory, Transmission lines, Attenuators and filters, Low and high frequencies amplifiers, Oscillator circuits; Modulation, demodulation, and detection circuits, Noise, Transmission of information, Microphones and sound reproducers, Telephony, High frequency transmission lines and waveguides, Ultra-high frequency devices, Wave propagation and aerials, Radio transmission systems, Microwaves and laser, Fiber optics

Reading List

Beasley, J. S., Hymer, J. D., & Miller, G. M. (2013). *Electronic communications: A systems approach.* Essex, UK: Pearson.

Frenzel, L. E. (2016). *Principles of electronic communication systems* (4th Edition). New York, NY: McGraw-Hill.

Kennedy, G. (1977). *Electronic communication systems*. New York, NY: McGraw-Hill.

Roddy, D., & Coolen, J. (1995). *Electronic communication* (4th Edition). Englewood Cliffs, NJ: Prentice-Hall.

Tomasi, W. (2014). *Advanced electronic communications systems.* Essex, UK: Pearson.

PHYS 466: Physics at the Nanoscale

This course introduces the concept of nanophysics by focusing on phenomena which change as the dimension of length scales from the macroscopic to the nanoscale. The course covers the synthesis and characterization of carbon-based nanomaterials, semiconductor nanocrystals and metallic nanocrystals. Unique phenomena arising from quantum confinement will be discussed. The course will also present basic computer modeling methods for the study of nano-structured materials. Current and potential applications of nanotechnology will be discussed.

Reading List

Dupas, C., Houdy, P., & Lahmani, M. (2004). *Nanoscience: Nanotechnologies and nanophysics.* Berlin, Germany: Springer-Verlag.

Shaito, R., Dresselhaus, G., & Dresselhaus, M. S. (1998). *Physical properties of carbon Nanotubes*. London, UK: Imperial College Press.

Verma, V. K. (2012). *Nanophysics.* New Delhi, India: Pearl Books.

Wilson, M., Kannangara, K., Smith, G., Simmons, M., & Raguse, B. (2002).*Nanotechnology: Basic science and merging technologies.* Boca Raton, FL: CRC Press.

Wolf, E. L. (2004). *Nanophysics and nanotechnology*: *An introduction to modern concepts in nanoscienc*e. Weinheim, Germany: Wiley-VCH.

PHYS 468: Introduction to Cosmology and Astrophysics

This course is designed to provide an introduction to modern concepts in astrophysics. It includes a preliminary section on astronomy with a focus on observational techniques. The historical development of astronomy and astrophysics will be presented, with a discussion of landmark discoveries. The main content of the course involves a study of stars and their evolution and will cover basic stellar models and the Lane-Emden model. End-of-life scenarios will be discussed, with focus on white dwarfs, neutron stars and black holes. Other topics to be covered are galaxies and basic cosmology.

Reading List

Caroll, B. W., & Ostlie, D. A. (2017). *An introduction to modern astrophysics* (2nd Edition). Cambridge, UK: Cambridge University Press.

Choudhuri, A. R. (2010). *Astrophysics for physicists*. Cambridge, UK: Cambridge University Press.

Harwit, M. (2006). *Astrophysical concepts* (4th Edition). New York, NY: Springer.

Kippenhahn, R., & Wiegert, A. (2012). *Stellar structure and evolution*. Berlin, Germany: Springer.

Moaz, D. (2007). *Astrophysics in a nutshell.* Princeton, NJ: Princeton University Press.

DEPARTMENT OF STATISTICS & ACTUARIAL SCIENCE

INTRODUCTION

The Department at a meeting held on 25th February, 2016 proposed the following programmes structure to replace the existing ones. These modifications to the programmes is informed by current demand by industry for well-trained graduates with various level of computational skills for employment.

BSc/BA STATISTICS

LEVEL 100 COURSES

FIRST SEMESTER		
Course Code	***Course Title***	***Credits***
DCIT 101	Introduction to Computer	3
STAT 111	Introduction to Statistics and Probability I	3
MATH 121	Algebra and Trigonometry	3
*UGRC 130	Science and Technology in our Lives	3
*UGRC 150	Critical Thinking and Practical Reasoning	3
*UGRC 160	Introduction to Literature	3
SECOND SEMESTER		
Course Code	***Course Title***	***Credits***
DCIT 102	Programming Fundamentals	3
STAT 112	Introduction to Statistics and Probability II	3
MATH 122	Calculus I	3
MATH 126	Algebra and Geometry	3
*UGRC 110	Academic Writing I	3
*UGRC 130	Science and Technology in our Lives	3
*UGRC 150	Critical Thinking and Practical Reasoning	3
*UGRC 160	Introduction to Literature	3

*NOTE: Students to choose any 2 courses (6 credits) of the UGRC in First Semester and any course (3 credits) of the UGRC in Second Semester.
MINIMUM CREDITS REQUIRED IS 15 CREDITS

SINGLE MAJOR IN STATISTICS

ENTRY REQUIREMENT: *STAT 111, STAT 112, MATH 121MATH 122, MATH 126*

LEVEL 200

FIRST SEMESTER			
Course Code	***Course Title***	***Credits***	***Pre-requisite(s)***
UGRC210/ UGRC 220	Academic Writing II/ Introduction to African Studies	3	
STAT 221	Introductory Probability I	3	MATH121,122, 126
STAT 223	Elementary Statistical Methods	3	
MATH 223	Calculus II	3	MATH 122
*STAT 240	Introduction to Statistical Computing	3	
Total		**15**	
Electives (3-6 Credits)			
ACTU 203	Introduction to Financial Mathematics I	3	
*STAT 220	Introduction to Actuarial Science	1	
*STAT 230	Data Mining	3	
SECOND SEMESTER			
Course Code	***Course Title***	***Credits***	***Pre-requisite(s)***
UGRC 210/ UGRC 220	Academic Writing II/ Introduction to African Studies	3	
STAT 222	Introduction to Regression and Time Series Analysis	2	
STAT 224	Introductory Probability II	3	STAT 221
STAT 226	Official Statistics	2	
Electives (3-6 Credits)			
ACTU 204	Introduction to Financial Mathematics II	3	ACTU 203
*STAT 220	Introduction to Actuarial Sciences	1	
MATH 224	Introduction to Abstract Algebra	3	**MATH 126**
STAT 228	Introduction to Non-Parametric Statistics	**3**	**STAT 223**
*STAT 230	Data Mining	3	**STAT 121, 122**

*STAT 220, STAT 230 and STAT 240 could be taken in the first semester or the second semester.

LEVEL 300

FIRST SEMESTER			
Course Code	***Course Title***	***Credits***	***Pre-requisite(s)***
STAT 331	Probability Distributions	3	STAT 221, 224
STAT 333	Statistical Inference I	3	STAT 224
STAT 335	Sampling Survey Methods	3	
MATH351/STAT	Linear Algebra/Methods of Linear	3	MATH 126

339	Algebra		
Total		**12**	
Electives(Select 3-6 Credits)			
ACTU 301	Life Contingency I	3	**ACTU 204**
STAT 337	Introduction to Operations Research	3	
MATH 353	Analysis I	3	**MATH 223**
MATH 355	Calculus of Several Variables	3	
MATH 359	Discrete Mathematics	3	**MATH 224**
SECOND SEMESTER			
Course Code	***Course Title***	***Credits***	***Pre-requisite(s)***
STAT 332	Multivariate Distributions	3	STAT 331
STAT 334	Statistical Inference II	3	STAT 333
STAT 336	Design of Experiments	3	STAT 223
MATH 350	Differential Equations I	3	MATH 122, 223
Total		**12**	
Electives (Select 3-6 Credits)			
DCIT 308	Data Structures and Algorithms	3	
ACTU 332	Life Contingency II	3	**ACTU 301**
STAT 338	Decision Theory	3	
MATH 356	Analysis II	3	**MATH 223**

LEVEL 400

FIRST SEMESTER			
Course Code	***Course Title***	***Credits***	***Pre-requisite(s)***
STAT 443	Theory of Sampling	3	STAT 335
STAT 445	Advanced Regression Analysis	3	STAT 334
STAT 450	Project	3	
STAT 461	Bayesian Statistics	3	STAT 224
Total		**12**	
Electives (Select 3-6 Credits)			
STAT 440	Business Statistics	3	STAT 222,203
STAT 447	Non –Parametric Statistics	3	STAT 228
STAT 451	Random Processes	3	STAT 331
STAT 453	Population Statistics	3	
STAT 459	Statistical Quality Control	3	
STAT 455	Actuarial Statistics I	3	STAT 331
STAT 457	Economic and Social Statistics I	3	STAT 226
MATH 441	Advanced Calculus	3	MATH 353
MATH 445	Introductory Functional Analysis	3	MATH 356
SECOND SEMESTER			
Course Code	***Course Title***	***Credits***	***Pre-requisite(s)***
STAT 444	Survey Organisation and Management	3	STAT 335

STAT 466	Discrete Data Analysis	3	
STAT 450	Project	3	
Total		**9**	
Electives(Select 3-6 Credits)			
STAT 442	Applied Times Series Analysis	3	
MATH 422	Integration Theory and Measure	3	MATH 356
STAT 446	Multivariate Methods	3	STAT 332
STAT 448	Analysis of Experimental Design	3	STAT 335
MATH 450	Differential Equation II	3	**MATH 350**
STAT 464	Statistical Computing with R	3	STAT 240
STAT 454	Biometrics	3	STAT 331
STAT 456	Actuarial Statistics II	3	STAT 455, 453
STAT 458	Economic and Social Statistics II	3	STAT 457
STAT 462	Biostatistics	3	

MAJOR- MINOR IN STATISTICS
LEVEL 200

FIRST SEMESTER			
Course Code	***Course Title***	***Credits***	***Pre-requisite(s)***
*UGRC 210	Academic Writing II	3	
*UGRC 220	Introduction to African Studies	3	
STAT 221	Introductory Probability I	3	MATH 121, STAT 122
STAT 223	Elementary Statistical Methods	3	
STAT 230	Data Mining	3	STAT 121, 122
Total		**12**	
SECOND SEMESTER			
Course Code	***Course Title***	***Credits***	***Pre-requisite(s)***
UGRC210/ UGRC 220	Academic Writing II/ Introduction to African Studies	3	
STAT 222	Introduction to Regression and Time Series Analysis	2	
STAT 224	Introductory Probability II	3	STAT 221
STAT 226	Official Statistics	2	
Total		**10**	
Electives(0-4 Credits)			
STAT 220	Introduction to Actuarial Science	1	
STAT 228	Introduction to Non-Parametric Statistics	3	STAT 223
STAT 240	Statistical Computing	3	

*STAT 220, STAT 230 and STAT 240 could be taken in the first semester or the second semester.

LEVEL 300

FIRST SEMESTER			
Course Code	***Course Title***	***Credits***	***Pre-requisite(s)***
STAT 331	Probability Distributions	3	STAT 221, 224
STAT 333	Statistical Inference I	3	STAT 224
STAT 335	Sample Survey Methods	3	
MATH351/ STAT339	Linear Algebra/Methods of Linear Algebra	3	**MATH 224**
Total		**12**	
SECOND SEMESTER			
Course Code	***Course Title***	***Credits***	***Pre-requisite(s)***
STAT 332	Multivariate Distributions	3	STAT 331
STAT 334	Statistical Inference II	3	STAT 333
STAT 336	Design of Experiments	3	STAT 223
Total		**9**	
	Elective(0-3Credits)		
ACTU 302	Introduction to Actuarial Computing	3	

LEVEL 400

FIRST SEMESTER			
Course Code	***Course Title***	***Credits***	***Pre-requisite(s)***
STAT 443	Theory of Sampling	3	**STAT 335**
STAT 461	Bayesian Statistics Methods	3	**STAT 224**
STAT 445	Advanced Regression Analysis	3	**STAT 334**
STAT 450	Project	3	
Total		**12**	
Electives(Select 3-6 Credits)			
STAT 440	Business Statistics	3	STAT 222,203
STAT 447	Non –Parametric Statistics	3	
STAT 451	Random Processes	3	STAT 331
STAT 453	Population Statistics	3	STAT 453
STAT 455	Actuarial Statistics I	3	STAT 331
STAT 457	Economic and Social Statistics I	3	STAT 226
STAT 459	Statistical Quality Control	3	
SECOND SEMESTER			
Course Code	***Course Title***	***Credits***	***Pre-requisite(s)***
STAT 444	Survey Organization and Management	3	
STAT 466	Discrete Data Analysis	3	
STAT 450	Project	3	
Total		**9**	
	Electives (Select 6 Credits)		
STAT 442	Applied Time Series Analysis	3	
MATH 422	Integration Theory and Measure	3	MATH 356
STAT 446	Multivariate Methods	3	STAT 332
MATH 450	Differential Equation II	3	

STAT 454	Biometrics	3	STAT 331
STAT 456	Actuarial Statistics II	3	STAT 455, 453
STAT 458	Economic and Social Statistics II	3	STAT 447
STAT 462	Biostatistics	3	
STAT 464	Statistical Computing with R	3	STAT 240

COMBINED MAJOR IN STATISTICS
LEVEL 200

FIRST SEMESTER			
Course Code	***Course Title***	***Credits***	***Pre-requisite(s)***
UGRC210/ UGRC 220	Academic Writing II/ Introduction to African Studies	3	
STAT 221	Introductory Probability I	3	MATH 121, 122
STAT 223	Elementary Statistical Methods	3	
STAT 230	Data Mining	3	STAT 121, STAT122
Total		**12**	
SECOND SEMESTER			
Course Code	***Course Title***	***Credits***	***Pre-requisite(s)***
UGRC210/ UGRC 220	Academic Writing II/ Introduction to African Studies	3	
STAT 222	Introduction to Regression and Time series	2	
STAT 224	Introductory Probability II	3	STAT 221
STAT 226	Official Statistics	2	
Total		**10**	

LEVEL 300

FIRST SEMESTER			
Course Code	***Course Title***	***Credits***	***Pre-requisite(s)***
STAT 331	Probability Distributions	3	STAT 221, 204
STAT 333	Statistical Inference I	3	STAT 224
STAT 335	Sample Survey Methods	3	
MATH351/STAT339	Linear Algebra/Methods of Linear Algebra	3	
Total		**12**	
SECOND SEMESTER			
Course Code	***Course Title***	***Credits***	***Pre-requisite(s)***
STAT 332	Multivariate Distributions	3	STAT 331
STAT 334	Statistical Inference II	3	STAT 333
STAT 336	Design of Experiments	3	STAT 223
Total		**9**	
Elective(0-3 Credit)			
ACTU 302	Introduction to Actuarial Computing	3	

LEVEL 400

FIRST SEMESTER			
Core Courses			
Course Code	***Course Title***	***Credits***	***Pre-requisite(s)***
STAT 443	Theory of Sampling	3	STAT 335
STAT 445	Advanced Regression Analysis	3	STAT 334
Total		**6**	
Electives(Select 3-6 Credits)			
STAT 440	Business Statistics	3	STAT 222,203
STAT 447	Non-Parametric Statistics	3	STAT 333, 304
STAT 450	Project	3	
STAT 451	Random Processes	3	STAT 331
STAT 453	Population Statistics	3	
STAT 455	Actuarial Statistics I	3	STAT 331
STAT 457	Economic and Social Statistics I	3	STAT 226
STAT 459	Statistical Quality Control	3	STAT 459
STAT 461	Bayesian Statistics Methods	3	STAT 224
SECOND SEMESTER			
Course Code	***Course Title***	***Credits***	***Pre-requisite(s)***
STAT 444	Survey Organization and Management	3	STAT 335
Total		**3**	
Electives(Select 3 Credits)			
STAT 446	Multivariate Methods	3	STAT 332
STAT 448	Analysis of Experimental design	3	STAT336
STAT 450	Project	3	
STAT 454	Biometrics	3	**STAT 331**
STAT 456	Actuarial Statistics II	3	STAT 455, 453
STAT 458	Economic and Social Statistics II	3	STAT 447
STAT 464	Statistical Computing with R	3	STAT 222, 233
STAT 466	Discrete Data Analysis	3	

MINOR IN STATISTICS
LEVEL 200

FIRST SEMESTER			
Course Code	***Course Title***	***Credits***	***Pre-requisite(s)***
*UGRC 210	Academic Writing II	3	
*UGRC 220	Introduction to African Studies	3	
STAT 221	Introductory Probability I	3	MATH 121, 122
STAT 223	Elementary Statistical Methods	3	
Total		**12**	
SECOND SEMESTER			
Course Code	***Course Title***	***Credits***	***Pre-requisite(s)***
*UGRC 210	Academic Writing II	3	

*UGRC 220	Introduction to African Studies	3	
STAT 222	Introduction to Regression and Time Series Analysis	2	
STAT 224	Introductory Probability II	3	**STAT 221**
STAT 226	Official Statistics	2	
Total		**13**	

LEVEL 300

FIRST SEMESTER			
Course Code	***Course Title***	***Credits***	***Pre-requisite(s)***
STAT 333	Statistical Inference I	3	**STAT 224**
STAT 335	Sample Survey Methods	3	
Total		**6**	
Electives(0-3 Credits)			
STAT 337	Introduction to Operation Research	3	
SECOND SEMESTER			
Course Code	***Course Title***	***Credits***	***Pre-requisite(s)***
STAT 334	Statistical Inference II	3	**STAT 333**
STAT 336	Design of Experiments	3	**STAT 223**
Elective(0-3 Credits)			
ACTU 302	Introduction to Actuarial Computing	3	
Total		**6**	

STAT 220: Introduction to Actuarial Science (Continuously assessed)
Topics to cover the first foundations of actuarial practice module, role of the actuary etc. what an actuary is and does, external forces that influence actuarial work, and framework and processes actuaries use to perform actuarial work using Microsoft excel. One hour a week seminar by Members of Actuarial Society of Ghana. Students would be divided into working groups and each group would be assessed at the end of the Lecture series

STAT 221: Introductory Probability I (Pre-Req. MATH 121, 122**)**
The course builds on concepts introduced in STAT 112. Topics to be covered includes: Further concepts of Probability, Random Events and Random Variables. The Probability Calculus, Univariate Probability Distributions. Univariate Moment Generating Functions; their properties and uses. Introduction to Bivariate Discrete Distributions; conditional discrete distribution, expectation. Introduction to conditional expectation. Some Probability Modelling based on discrete distributions.

Reading List
Chung, K. L. (2012). *Elementary Probability Theory with Stochastic Processes Springer Science & Business Media.*

Doku-Amponsah, K. (2016). *Probability Distributions* (Unpublished Manuscript).

Mosteller, F., Rourke, R. E., & Thomas, G. B. (1961). *Probability with Statistical Applications.* Addison Wesley.

Schinazi, R. B. (2011). *Probability with Statistical Applications*. Springer Science & Business Media

Sheldon, R. (2002). *A First Course in Probability*. Pearson Education India.

STAT 222: Introduction to Regression and Time Series Analysis

The course is to provide the student with a basic knowledge of Regression and Time Series. Topics include Regression analysis; Simple linear regression: The model and its assumption; Least Square Estimation. Analysis of variance; sums of squares and their interpretation. Coefficient of determination and the correlation coefficient .Examining the Model Assumptions: Graphical Examination of residual. Test of Randomness of residuals, for constancy of variance, for normality. Forecasting; Time Series methods and Models; some financial/actuarial application of time series. Use of statistical computing packages in forecasting.

Reading List

Bhattacharyya, G. K. J., & Arnold, R. (1977). *Statistical Concepts and Methods.* (No. HA29. B4).

Draper, N. R., & Smith, H. (2014). *Applied Regression Analysis*. John Wiley & Sons.

Dunn, O. J., & Clark, V. A. (1986). *Applied Statistics: Analysis Of Variance And Regression*.

Edwards, A. L. (1985). *Multiple Regression and the Analysis Of Variance and Covariance.* WH Freeman/Times Books/Henry Holt & Co.

Kutner, M. H., Nachtsheim, C. J., Neter, J., & Li, W. (2005). Applied Linear Statistical Models.

STAT 223: Elementary Statistical Methods

This course introduces students to some basic concepts of statistical methods. Topics to be covered are Bivariate Data analysis, Elements of Statistical inference. Hypothesis testing – One-sample case (test for mean, proportion, power, sample size, test for variance, Confidence intervals) Hypothesis testing – Two-sample case (two-sample test for paired and unpaired means and proportions, power, sample size, equality of variance test, CI).
ANOVA (one- and two-way), Simple Linear Regression and Correlation Analysis.

Reading List

Anderson, A. J. (1989). *Interpreting Data: A First Course in Statistics* (Vol. 8). CRC Press.

Clarke, G. M., & Cooke, D. (1979). *Basic Course in Statistics* [A].

Hoel, P. G. (1971). *Elementary Statistics* (No. QA276. 12. H63 1966.). New York: Wiley

Spiegel, M. R., & Stephens, L. J. (1998). *Schaum's Outline of Statistics.*

Rees, D. G. (1987). *Foundations of Statistics* (Vol. 214). CRC Press.

Wetherill, G. (2012). *Elementary Statistical Methods* (Vol. 179). Springer Science & Business

Media.

STAT 224: Introductory Probability II (Pre-Req. STAT 221**)**
This course aims at introducing students to the concepts of multivariate distributions. Topics to be discussed include the following: Bivariate Distributions, Bivariate Moment Generating Functions; their properties and uses. Sampling distributions. Distribution associated with samples from a normal population. The laws of Large Numbers, and the Central Limit Theorem and its Applications. Statistical Inequalities. Some Statistical Applications of Probability; likelihood functions and estimation. Some financial and Actuarial Applications of Probability.

Reading Text
Chung, K. L. (2012). *Elementary Probability Theory with Stochastic Processes*. Springer Science & Business Media.

Doku-Amponsah, K. (2016). *Probability Distributions* (Unpublished Manuscript).

Mosteller, F., Rourke, R. E., & Thomas, G. B. (1961). *Probability with Statistical Applications* Addison. Wesley.

Schinazi, R. B. (2011). *Probability with Statistical Applications*. Springer.

Sheldon, R. (2002). *A First Course in Probability*. Pearson Education India.

STAT 226: Official Statistics
In this course students are introduced to economic, social and demographic statistics. Purposes and scope of the course includes, the structure and work of the National Statistical System; Ghana Statistical Service. Organizational, Methods and Practices of Data Collection and Dissemination. Population Census Methods, Health Information Systems. Environmental Statistics and Introduction to Categorical Data Analysis.

Reading Text
Danso–Manu, M. E. (1999).*Official Statistics in Ghana: Coverage Sources and Methods.* Publications of the Ghana Statistical Service.

United Nations **(**1958). *Handbook of Population Census Methods.* General Aspects of a Population Census. Studies in Methods. Series F. No.5. Vol. 1. New York.

United Nations **(**1968**).** *International Recommendations for Industrial Statistics*. Statistical Papers Series M. No. 43. New York.

United Nations (1973). *Principles and Recommendations for a Vital Statistics System Statistical Papers Series M*. No. 19. Rev. 1. New York.

United Nations (1980). *Handbook of Statistical Organisation*. Volume 1: A Study on the Organisation of National Statistical Services and Related Management Issues. Studies in Methods – Series F. No. 28, New York.

STAT 230: Data Mining
The course will introduce students to introductory data mining. Topics to be covered include: data warehousing, data mining process (data preparation/cleansing, task identification), Association rules (mining and different algorithm types), Classification/Prediction, Classification (tree-based approaches, Neural Networks, etc), Clustering (statistical vs neural-net and other approaches), Model evaluation and visualization techniques. The course will help students make better sense of large chunks of data which will be incredibly useful in understanding big data.

Reading List
Aggarwal, C. (2015). *Data Mining: The Textbook*. Springer.

Han, J., Kamber, M. & Pei, J. (2012). *Data Mining: Concepts and Techniques*. Elsevier

Shmueli, G. (2016). *Data Mining For Business Intelligence: Concepts, Techniques and Applications In Microsoft Office Excel With XL miner.*

Tan, P., Steinbach, M. & Kumar, V. (2006) *Introduction to Data Mining.* Addison Wesley.

Zaki, M.J. & Meira, Jr., W. (2014). *Data Mining and Analysis: Fundamental Concepts and Algorithms.* Cambridge University Press.

STAT 240: Introduction to Statistical Computing
The course aims to build on the skills of computing students acquired in the course STAT 111 and STAT 112. Topics to be covers include: Reviews of some basic concepts in probability and classical statistical inference; triangular distribution, sampling distribution, point estimation, interval estimation, and hypothesis testing. Writing simple codes in R to perform inferences, simulation of random variables from probability distributions; geometric, negative binomial, hyper-geometric, exponential, normal distributions, the visualization of bivariate data.

Reading List
Crawley, M. J. (2002). *Statistical Computing: An Introduction to Data Analysis Using S-Plus.* Wiley.

Crawley, M. J. (2014). *Statistics: An Introduction Using R* (2nd Edition). Wiley

James, G., Witten, D. & Hastie, T. (2015). *An Introduction to Statistical Learning: With Applications in R* (5th Edition). Springer.

Rizzo, M.L. (2007). *Statistical Computing With R*.

Schinazi, R. B. (2011). *Probability with Statistical Applications*. Springer Science & Business Media.

STAT 228: Introduction to Non-Parametric Statistics
In this course students are introduced to the basic concepts of non-parametric statistics. Topics to be discussed include: Single Sample problems; the problem of location, the Sign Test, Wilcoxon Sign Rank Test. Introduction to Chi-square tests for Homogeneity, Chi-square tests for Independence, The Median Test, Mann-Whitney-Wilcoxon Tests all

under two-sample tests. Some applications to data in the field of medicine and biological sciences will be discussed in class.

Reading List

Bhattacharyya, G. K. J., & Arnold, R. (1977). *Statistical Concepts and Methods* (No.HA29. B4).
Conover, W. J. (1980). *Practical Nonparametric Statistics*.

Fotopoulous, S.B. (2012). *Introduction to Modern Non-Parametric Statistics*. Taylor & Francis

Gibbons, J. D. & Subhabrata, C. S. (2010).*Nonparametric Statistical Inference* (5th Edition) CRC Press

Higgins, J.J (2011). *Introduction to Modern Non-Parametric Statistics.* Duxbury

STAT 331: Probability Distributions (Pre-Req. STAT 221, 204**)**

This course is aimed at introducing students to Elementary Distribution Theory. Topics to be covered includes: Generating Functions and Applications; moment generating functions, probability generating function, factorial moment generating function and characteristic function, moments and limiting distributions. Sequences of random variables; modes of convergences, the Central Limit Theorem and its Applications. Concentration inequalities. Introduction to large deviation theory; large deviation probabilities, method of types.

Reading List

Hoel, P. G. (1971). *Elementary Statistics* (No. QA276. 12. H63 1966.). New York:Wiley.

Hogg, R. V., & Craig, A. T. (1967). *Introduction to Mathematical Statistics* (2nd Edition). Macmillan.

Hogg, R. V., & Tanis, E. A. (1977). *Probability and Statistical Inference*.

Larson, H. (1982). *Introduction to Probability Theory and Statistical Inference*.

Sheldon, R. (2002). *A First Course in Probability*. Pearson Education India.

STAT 332: Multivariate Distributions (Pre-Req. STAT 331**)**

This course is aimed at introducing students to multivariate distribution theory. Topics to be covered include: Introduction to Vector Random Variables; vector of means, dispersion matrix, matrix of co-variances. Distribution Concepts for several random variables; exponential-type distribution, multivariate moment generating function. Transformation of Random Vectors; gamma distribution, beta distribution, chi-square distribution t-distribution, f-distribution. Order Statistics; joint distribution of order statistics. Multivariate Normal Distributions.

Reading List

Doku-Amponsah, K. (2015). *Multivariate Distributions.* Unpublished Manuscript.

Hoel, P. G. (1971). *Elementary Statistics* (No. Qa276. 12. H63 1966.). New York: Wiley.

Hogg, R. V., & Craig, A. T. (1967). *Introduction to Mathematical Statistics* (2nd Edition). Macmillan.

Morrison, D. F. (1967). *Multivariate Statistical Methods*. In *Multivariate Statistical Methods* Mcgraw-Hill Book.

Odoom, S. I.K. (1997). *Multivariate Distributions.* Unpublished Manuscript.

STAT 333: Statistical Inference I (Pre-Req. STAT 204**)**
The first part of the two-semester course provides a systematic development of the principles and methods of statistical inference, on a largely intuitive basis with a minimum of mathematical theory. This part deals with the general nature of Statistical Problems, Statistical Models and Problems of Estimation. Introduction to Bayesian Statistics. Introduction to statistical modelling with R. Some applications to data in the field of Pharmacy, Biology, Economics, Agriculture, Biology, Pharmacy, Medicine and Finance.

Reading List
Alexander, M., Graybill, F. A., & Duane, C. (1974). *Introduction to the Theory of Statistics.* Mcgraw-Hill.

Barnett, V. (1999). *Comparative Statistical Inference* (Vol. 522). John Wiley & Sons.

Hoel, P. G., Port, S. C., & Stone, C. J. (1972). *Introduction to Statistical Theory*.

Lindgren, B. (1993). *Statistical Theory* (Vol. 22). CRC Press.

Rao, C. R. (2009). *Linear Statistical Inference and Its Applications* (Vol. 22). John Wiley & Sons.

STAT 334: Statistical Inference II (Pre-Req. STAT 333**)**
This course is a sequel to STAT 333. It is aimed at building on the concepts of mathematical statistics acquired in STAT 333. Topics to be covered include: General principles and Procedures of Hypotheses Testing. Parametric and Non- Parametric Test. Simple Linear Regression and Correlation Analysis. The Analysis of Frequency Data. Introduction to Categorical Analysis. Statistical modelling with R. Some applications to real-life data in the fields of Pharmacy, Biology, Economics, Agriculture, Biology, Pharmacy, Medicine and Finance.

Reading List
Alexander, M., Graybill, F. A., & Duane, C. (1974). *Introduction to the Theory of Statistics.* Mcgraw-Hill.

Barnett, V. (1999). *Comparative Statistical Inference* (Vol. 522). John Wiley & Sons.

Hoel, P. G., Port, S. C., & Stone, C. J. (1972). *Introduction to Statistical Theory*.

Lindgren, B. (1993). *Statistical Theory* (Vol. 22). CRC Press.

Rao, C. R. (2009). *Linear Statistical Inference and Its Applications* (Vol. 22). John Wiley & Sons.

ACTU 301: Life Contingency I
This course introduces students to mathematics of life contingencies. Being probabilistic in nature, the course seeks to develop theoretical basis for modelling future lifetime status with emphasis on insurance. Topics to be covered include brief review of probability theory, international actuarial notations, actuarial survival models, life table format, life statuses, survival distributions, concept of dependence (common shock models, copulas etc), multiple lives and multiple decrement theory and multiple-state models. The course is designed to set the pace towards ensuring the student's adequate preparation for the MLC/3L exam of the Society of Actuaries or Canadian Institute of Actuaries respectively.

Reading List
Bowers, N.L., Gerber, H.U., & Hickman, J.C. *et al*. (1997). *Actuarial Mathematics* (2nd Edition).

Jordan, C.W. (2003). *Life Contingencies*. New York, NY: John Wiley and Sons.

Olivieri, A., & Pitacco, E. (2015). *Introduction to insurance mathematics: technical and financial features of risk transfers*. Springer.

Parmenter, M.M. (2010). *Theory of Interest & Life Contingencies with Pension Applications.* Winsted: Avctex Publications.

Pitacco, E. (2014). *Health insurance: Basic actuarial models*. Springer.

STAT 339: Methods of Linear Algebra (Non-Mathematics Students Only)- (Pre-requisite MATH 126)
The emphasis is on the geometric and computational foundations of Linear Algebra with abstraction (and proof) kept to a minimum. We would examine matrices, linear systems of equations and their solutions. Basic properties of determinants, vectors in R^n and a simple introduction to the idea of an arbitrary vector space. The pinnacle of the course is to be able to find eigenvalues and their corresponding eigenvectors for a given matrix and indeed for a linear map. We would carefully develop the diagonalization of symmetric matrices. For those who did the MATH 220 there would be applications using Python.

Reading List
Artin, M. (2010*). Algebra* (2nd Edition). Pearson Higher Ed USA.

Kolman, B., & Hill, D.R. (2005). *Introductory Linear Algebra, an Applied First Course* (8th Edition). Addison Wesley.

Roman, S. (2007). *Advanced Linear Algebra* (3rd Edition). Springer.

Sheldon, A. (2010). *Linear Algebra Done Right.* Springer.

Strang, G. (2006). *Introduction to Linear Algebra.* Wellesley-Cambridge Press.

ACTU 302: Introduction to Actuarial Computing
This course provides a basic foundation of knowledge concerning fundamental building blocks of actuarial practice. This is to present the student with a transition from understanding

the mathematical underpinnings of actuarial science to putting them into practice. The course focuses on two areas of actuarial practice: investment management and life insurance. All mathematical computations will be computer program assisted. Students will be able to construct and use life tables in simulation studies, portfolio management theory and design basic individual life. Concepts will apply the concepts within an actuarial problem statement. Recommended software include excel, R and MATLAB.

Reading List

Beckley, J. A., Scahill, P. L., Varitek, M. C., & White, T. A., (2012). *Understanding Actuarial Practice* (1st Edition). Society of Actuaries. United States

Borowiak, D.S. Arnold, F. & Shapiro, A.F. (2014). *Financial and Actuarial Statistics: An Introduction* (2nd Edition). CRC Press.

Chambers, J. M., (2008). *Software for Data Analysis, Programming with R*. Springer.

Charpentier, A. (2014).*Computational Actuarial Science with R.* CRC Press.

Jong, P. D. & Heller, G. Z. (2008). *Generalized Linear Models for Insurance Data* (International Series on Actuarial Science). Cambridge University Press.

ACTU 304: Life Contingency II (Pre-requisites: ACTU 301)

This course builds on Life contingency 1. It is designed to develop theoretical basis for pricing and supporting life-contingency products. Topics treated includes economics of insurance, general insurances, annuities, premiums (level and non-level benefits and premiums) and expense (incorporating expenses in insurance models) analysis, analysis of reserves, Hattendorf theorem, probability models: Poisson Processes. The course is designed to set the pace towards ensuring the student's adequate preparation for the MLC/3L exam of the Society of Actuaries or Canadian Institute of Actuaries respectively.

Reading List

Antonio, K., & Valdez, E. A. (2012). *Statistical Concepts of a Priori and a Posteriori Risk Classification In Insurance*. Advances in Statistical Analysis.

Jordan, C.W (2003). *Life Contingencies.* New York, NY: John Wiley and Sons.

Parmenter, M. M. (2010). *Theory of Interest & Life Contingencies with Pension Applications.* Winsted: Avctex Publications.

Pitacco, E. (2014). *Health Insurance: Basic Actuarial Models.* Springer.

Wetherill, M. (2001). *Life Contingencies* London. Addison Wesley.

STAT 335: Sample Survey Methods

This course is aimed at introducing students to the Theory of Sampling. Topics to be covered include: Basic Sample Survey Procedures and Sample Designs. Estimation of population of parameters. Sampling and Non Sampling Errors, Sampling experiments, Estimation of population proportions and percentages. Proportion of simple sample

estimation. Some applications to real-life data from the fields of Agriculture, Biology, Finance etc.

Reading List

Barnett , V. (2002). *Sample Survey Principles and Methods* (3rd Edition). John Wiley& Sons.

Czaja, R. (2005). *Designing Surveys*. Pine Forge Press.

Hanson, M. (1993). *Sample Survey Methods & Theory*. John Wiley & Sons, New York.

Howard, G. (2006). *Sample Survey*. London: Chapman & Sons.

Pfeffermann, C. R. (2009) *Sample Surveys: Design, Methods and Applications (Handbook of Statistics, 29A)*. Elsevier.

STAT 336: Design of Experiments (Pre-Req. STAT 223**)**

This course introduces students to the concept of Analysis of Experimental Design. Topics include: Single and multifactor experiments; analysis of variance; multiple comparisons; contrasts; diagnostics, fixed, random, and mixed effects models; designs with blocking and/or nesting; two-level factorials and fractions thereof; use of statistical computing packages. Some applications to data from the field of Agriculture, Biology, Pharmacy and Medicine.

Reading List

Cochran, W. G., & Cox, G. M. (1950). *Experimental Designs*.Wiley Publications in Statistic

Finney, D. J. (1963). *An Introduction to the Theory of Experimental Design*. University Of Chicago Press.

Hicks, C. R. (1964). *Fundamental Concepts in the Design of Experiments*. Holt, Reinhart & Winston.

Kempthorne, O. (1952). *The Design and Analysis of Experiments*. John Wiley Publications.

Li, C. C. (1964). *Introduction to Experimental Statistics*. Mcgraw Hill.

STAT 337: Introduction to Operations Research

The course will introduce students to the use of mathematical and statistical techniques to solve a wide variety of organizational problems. Topics include linear programming, network analysis, queuing theory, decision analysis. Transport problem, dynamic programming, game theory, scheduling problem, Markov chains, decision trees, Optimization and inventory control and Introduction to Supply Chain Management.

Reading List

Cooper, D. & Schindler, (2013). *Business Research Methods* (12th Edition). McGraw-Hill/Irwin.

Hillier, F. S. & Lieberman, G. J. (2001*). Introduction to Operations Research* (7th Edition) McGraw Hill.

Jensen, P.A. & Bard, J.F. (2002). *Operations Research Models and Methods.* Wiley.

Rader, D. J (2010). *Deterministic Operations Research: Models and Methods in Linear Optimization.* Wiley.

Taha, H.A. (2017) *Operations Research: An Introduction* (10th Edition). Pearson.

STAT 338: Decision Theory

The course introduces the main concepts and tools of game theory with the aim to enable students to read original game-theory literature and to prepare them to do research in the field. They will learn how to represent an economic situation as a game and how to analyze it using different equilibrium concepts proposed in the literature, the prominent one being the Nash equilibrium. Concentration will be on strategic interaction under incomplete information and modify the Nash equilibrium concept to include the uncertainty of the players about some of the parameters of the game.

Reading List

Baron, E.N. (2008). *Game Theory: An Introduction.* John Wiley & Sons.

Deng-Feng, L. (2014). *Decision and Game Theory in Management with Intuitionistic Fuzzy Sets.* Springer

Gibbons, R. (1992). *Game theory for Applied Economist.* Princeton.

Tadelis, S. (2015). *Game Theory: An Application.* Princeton University Press

Watson, J. (2013).*Strategy: An Introduction to Game theory* (3rd Edition). W.W. Norton & Company.

STAT 440: Business Statistics

This course is designed to introduce students to the application of in statistics business. Topics to be discussed include: Customer analytics, operation analytics, people analytic, accounting analytic and bus analytic capstone. Descriptive analytics; use to understand past and present data , predictive analytic; past performance, prescriptive analytic; uses of optimization techniques. Some applications to real-life data from the field of business.

Reading List

Evans, J.R. (2012). *Business Analytics*. Pearson Publishers.

Francis, A. (2007). *Business Mathematics and Statistics* (6th Edition). Thomson.

Hanke, J. E & Wichern, D.(2009). *Business Forecasting (*9th Edition). Pearson Publishers

Liebowitz, J. (2013). *Business Analytics: An Introduction*. CRC Press. Auerbach Publications.

Shmueli, G., Bruce, P.C. & Patel, N. R.(2016). *Data Mining for Business Analytics (3rd Edition).* Wiley.

STAT442: Applied Time Series Analysis
The course is aimed at providing students with the working knowledge of Time Series. Topics include: General stationary, nonstationary models, auto-covariance autocorrelation functions; stationary, nonstationary autoregressive integrated moving average models; identification, estimation, forecasting in linear models; financial times series models, use of statistical computer packages. Some applications to financial and actuarial data will be discussed in class.

Reading List
Cryer,J. D. & Chen, K-S.(2010). *Time Series Analysis: With Applications in R*. (2nd Edition). Springer.

Enders, W. (2014). *Applied Econometric Times Series*. (4th Edition).

Findley, F.F.(1978). Applied Time Series. Elsevier.

Schumwau, R.H. & Stoffer, D. S. (2010).*Time Series Analysis and Its Application: with R*

Woodward, W.A., Gray, H.,L., & Elliott, A.C. (2011) *Applied Time Series*. CRC Press.

STAT 443: Theory of Sampling
This course is a sequel to STAT 335: Sample Survey Methods. It is aimed exposing students to the theory of sampling. Topics to be covered include the following: Analysis and comparison of various sampling schemes, Estimates of population means, totals, proportions, and their variances, Multi-stage and Multi-phase Designs, Ratio and Regression Estimation.

Reading List
Cochran, W. G. (2007). *Sampling Techniques*. John Wiley & Sons.

Hanson, M. (1993). *Sample Survey Methods & Theory*. John Wiley & Sons, New York.

Kish, L. (1965). *Survey Sampling. In Survey Sampling*. John Wiley & Sons.

Pfeffermann, C. & Rao, E., (2009). *Sample Surveys: Design, Methods and Applications (Handbook of Statistics, 29A)*. Elsevier Publications.

Raj, D. (1968). *Sampling Theory.* McGraw Hill

STAT 444: Survey Organization and Management (Pre-Req. STAT 334**)**
This course will expose students to Multi-subject and specialized Socio-Economic surveys household surveys, Types of Surveys: by subject coverage, unit of enquiry, and mode of enquiry. Longitudinal and cross-sectional Studies. Other topics to be covered include: Single-purpose and Integrated surveys, Planning, Design and Organization. Error Control, Problems relating to Concepts, Definitions, Classification and Measurement.

Reading List

Church, A. H., J., & Kraut, A.I. (2001). *Designing and Using Organizational Surveys: A Seven-Step Process (1st Edition)*. Jossey-Bass.

Fowler, F. J. (2013). *Survey Research Methods (Applied Social Research Methods)* (5th Edition). SAGE Publications.

Jessen, R. J. (1978). *Statistical Survey Techniques*. New York: Wiley.

Raj, D. (1972). *The Design of Sample Surveys*. Mcgraw Hill.

UNITED NATIONS (2005). *Handbook on Household Surveys*. United Nations.

STAT 445: Advanced Regression Analysis (Pre-Req. STAT 334)

The course aims to build on introductory regression knowledge gained in previous years. Advanced Regression analysis focuses on applications of basic statistical techniques; model formulation, checking/diagnostics, selection; interpretation and presentation of analysis results; simple and multiple linear regressions; logistic regression; ANOVA; hands-on data analysis with R computer software. Some applications to data from the field of Agriculture , Biology , Economics, Finance etc.

Reading List

Bhattacharyya, G. K. J., & Arnold, R.(1977). *Statistical Concepts and Methods*, Wiley Series.

Draper, N. R., & Smith, H. (2014). *Applied Regression Analysis*. John Wiley & Sons.

Dunn, O. J., & Clark, V. A. (1986). *Applied Statistics: Analysis Of Variance and Regression.*

Edwards, A. L. (1985). *Multiple Regression and the Analysis Of Variance and Covariance*. WH Freeman/Times Books/Henry Holt & Co

Kutner, M. H., Nachtsheim, C. J., Neter, J., & Li, W. (2005). *Applied Linear Statistical Models.*

STAT 446: Multivariate Methods (Pre-Req. STAT 332**)**

This course is aimed at equipping students with solid linear algebra background with further Statistical Inference Methods. Topics include: Introduction to theory and methods of Multivariate Data Analysis; Estimation and Tests of Hypotheses, Profile Analysis, Multivariate Structure, Discriminant Analysis. Use of statistical computer packages. Some applications to hand-on data will be discussed in class.

Reading List

Doku-Amponsah, K. (2016). Multivariate Distributions. (Unpublished Manuscript)

Kendall, M., & Stuart, A. (1977). *The Advanced Theory of Statistics*, *Distribution Theory* (4th Edition). London: Griffin.

Mardia, K. V., Kent, J. T., & Bibby, J. M. (1979). *Multivariate Analysis*. *Probability And Mathematical Statistics.* London: Academic Press.

Morrison, D. F. (1967). *Multivariate Statistical Methods*. Mcgraw-Hill Book.

Rao, C. R. (2009). *Linear Statistical Inference and Its Applications* (Vol. 22). John Wiley & Sons.

STAT 447: Non-Parametric Statistics (Pre-Req. STAT 333, 304**)**

The course aimed at building on the basic concepts of non-parametric statistics acquired in the course STAT 228. Topics to be covered include; Chi-square tests for Homogeneity, Chi-square tests for Independence, The Median Test, and Mann-Whitney-Wilcoxon Tests all under two-sample tests. Uses of Order Statistics Distribution under alternative Hypotheses. Introduction to nonparametric regression smoothing; basic ideal of smoothing, kernel smoothing, k-nearest neighbour estimates, orthogonal series estimators, spline smoothing. Use of statistical computer packages.

Reading List

Bhattacharyya, G. K. J., & Arnold, R. (1977). *Statistical Concepts and Methods*.

Conover, W. J. (1980). *Practical Nonparametric Statistics*.

Hardle, W.(1989). *Applied Non-Parametric Regression*. Cambridge University Press.

Macfarland, T. W & Yates, J. M.(2016*). Introduction to Nonparametric Statistics For The Biological Sciences Using R.* Springer.

Wasserman, L.(2006). *All of Nonparametric Statistics*. Springer

STAT 448: Analysis of Experimental Design

This course is a sequel to STAT 336: Design of Experiments. Topics to be covered include; Single-factor and multi-factor experiments, Analysis of Variance (ANOVA), Multiple Comparisons, Contrasts, Diagnostics, Fixed, Random and Mixed Effects models, Design with blocking and/or nesting, two level factorials and fractions thereof, Some Medical and Agricultural Applications. Use of Statistical Computing Packages.

Reading List

Cochran, W. G., & Cox, G. M. (1950). *Experimental Designs*. Wiley Publications in Statistics

Finney, D. J. (1963). *An Introduction to the Theory of Experimental Design*. University of Chicago Press.

Hicks, C. R. (1964). *Fundamental Concepts in the Design of Experiments*. Holt, Reinhart &Winston.

Kempthorne, O. (1952). *The Design and Analysis of Experiments*. John Wiley Publications.

Li, C. C. (1964). *Introduction to Experimental Statistics*. McGraw Hill.

STAT 450: Project
The project work is aimed at developing students problem solving and written skills. It has one year duration. Students present a project on a relevant and topical issues pertaining to Statistics while applying appropriate Statistical techniques and tools to problems or data emanating from Insurance, business, financial and banking sector, communication sector, agricultural sector, mining sector, construction sector etc.

STAT 451: Random Processes (Pre-Req. STAT 331**)**
This course is to introduce students to stochastic models in the fields of natural and social sciences. Topics to be covered include: Some discrete and continuous time processes; Markov Chains, Random Walks, Birth and Death Process, Random Trees; Galton-Watson Processes, Introduction to Brownian Process, Basic Theory and Applications in Demography/Population study, Insurance, Finance and Risk Management.

Reading List
Bartholomew, D. J., (1967). *Stochastic Models for Social Processes*. London: Wiley

Bhat, U. N., & Miller, G. K. (1972). *Elements of Applied Stochastic Processes*. John Wiley.

Chiang, C. L. (1980). *Introduction to Stochastic Process and Their Applications*. John Wiley

Cox, D. R., & Miller, H. D. (1977). *The Theory of Stochastic Processes* (Vol. 134). CRC Press.

Karlin, S., & Taylor, H. M. (1975). *A first Course in Stochastic Processes*. Academic, San Diego. Sons. N. York.

STAT 453: Population Statistics
The course is designed to broaden and deepen students understanding of Demography and Population issues. Topics to be studied includes; Demographic Concepts and Measures. Collection and analysis of Demographic data. The Dynamics of population change. Mortality; Measures of Mortality, Construction of Mortality Tables, Construction of Mortality Tables from graduated data, Rate and Force of Mortality. Introduction to Survival Models and Reliability Models.

Reading List
Coale, A. J. & Brass, W. (1981). *Collecting Data for the Estimation of Fertility and Mortality.*

Committee on Population and Demography. Report No. 6. National Academy Press, Washington DC.

Eubank, D.C (1981). *Age Misreporting and Age–Selective Under enumeration: Sources, Patterns, and Consequences for Demographic Analysis Committee on Population and Demography. Report No. 4*. National Academy Press, Washington D.C.

Kpedekpo, G.M.K .*Essentials of Demographic Analysis for Africa*. Heinemann.

Shryock, H.S., Siegel, J.S. & Associates, (1992). *The Methods and Materials of Demography*. (Condensed Edition). Academic Press.

Spiegelman, M. (1980). *Introduction to Demography*. Harvard University Press,

STAT 454: Biometrics (Pre-Req. STAT 331)
The course is aimed at introducing students to application of experimental design and analysis in Biology and Agriculture. Topics to be discussed in class includes; Biological Assay, Analysis of Quantile responses. Agricultural and clinical trials. Sampling and Estimation of Biological Populations. Some applications to hand-on data using R computer package.

Reading List
Cochran, W. G., & Cox, D. R. (1957) *Experimental designs* (2nd Edition). John Wiley and Sons, Inc., New York.

Hocking R.R. (1976). *The Analysis and Selection of Variables in Linear Regression in Biometrics.* Biometrics, Vol 32, No.1

Jain, A.K., Bolle, R. & Pankanti S. (2006). *Biometrics-Personal Identification in Networked Society.* Springer Publications.

Jain, A.K., Flynn, P., Ross, A.A. (2007). *Handbook of Biometrics.* Springer Publications.

Lentner, M. & Bishop, T. (1993) *Experimental design and analysis* (2nd Edition), Valley Book Company, Blacksburg, Virginia.

STAT 455: Actuarial Statistics I (Pre-Req. STAT 331)
The course is aimed at introducing students to basic concepts of financial statistics. Topics to be discussed includes the following: Principles of time value of money. Concepts of compound Interest and Discounting. Interest or Discounting Rates. Compound Interest Functions. Investment Project appraisals. Stochastic Interest Rate Models. Dynamic portfolio management, introductory applications to insurance liabilities.

Reading List
Benjamin, B., & Pollard, J. H. (1970). *The Analysis of Mortality and Other Actuarial Statistics*.

Bowers, N. L., Gerber, H. U., Hickman, J. C., Jones, D. A., & Nesbitt, C. J. (1997). *Actuarial Mathematics*. Schaumburg, IL. Society of Actuaries.

Jordan, C.W. (2003). *Life Contingencies*. New York, NY: John Wiley and Sons.

Parmenter, M.M. (2010). *Theory of Interest & Life Contingencies with Pension Applications.*

Pitacco, E. (2014). *Health Insurance: Basic Actuarial Models*. Springer. Winsted: Actex Publications.

STAT 456: Actuarial Statistics II (Pre-Req. STAT 453, 455)
This course introduces students to basic concepts of mathematics of life contingencies. Principles of simple life insurance and annuity contracts. Means and variances of payment under these contracts. Determination of expected present value and variances of benefits. Determination of net premiums and policy values. Survival Models and Reliability Models. to stochastic optimal control.

Reading List
Benjamin, B., & Pollard, J. H. (1970). *The Analysis of Mortality and Other Actuarial Statistics*.

Bowers, N. L., Gerber, H. U., Hickman, J. C., Jones, D. A., & Nesbitt, C. J. (1997). *Actuarial Mathematics*. Schaumburg, IL. Society of Actuaries.

Butcher, M. V., & Nesbitt, C. J. (1971). *Mathematics of Compound Interest*. Ulrich's Books.

Ingersoll, J. E. (1987). *Theory of Financial Decision Making* (Vol. 3). Rowman & Littlefield.

Jordan, C.W. (2003). *Life Contingencies*. New York, NY: John Wiley and Sons.

STAT 457: Economic and Social Statistics I (Pre-Req. STAT 226)
STAT 457 is designed to broaden and deepen student knowledge of the Applied Statistics that concerns the collection, processing, compilation, dissemination, and analysis of social and economic data. Topics to be covered include: Statistics on Economic and Social Activities and Trends and their uses. Methods and sources of data collection. Indices and indicators of Economic Activity. Indicators of Social Development and Living Standard.

Reading List
Thirlwall, A. (1994). *Growth and Development with Special Reference to Development Economies*. Macmillan Press Ltd.

UN Statistical Papers, Series M, New York, 1990.

UNDP: Human Development Reports.

Various Publications of Ghana Statistical Service.

World Bank 1995: Social Indicators of Development.

STAT 458: Economic and Social Statistics II (Pre-Req. STAT 447**)**
This course is aimed at building on the knowledge acquired by students in STAT 457. Topics to be discussed includes: review of statistical analysis of topics and problems in microeconomics, macroeconomics, business, finance, forecasting, data quality, and policy evaluation. Introduction to the System of National Accounts (SNA). The system, its Accounts and their corresponding economic activities. Input-Output Tables. Social Accounting.

Reading List

Beckerman, W. (1976). *An Introduction to National Income Analysis*. Weidenfied and Nicholson.

Singal, M. S. & Nartey, J.D.H. (1971).*Sources and Methods of Estimation of National Income at Current Prices in Ghana.* Central Bureau of Statistics.

Singal, M.S. (1973). *Input–Out Table of Ghana, 1968*. Central Bureau of Statistics.

Thirlwall, A. (1994). *Growth and Development with Special Reference to Development Economies*. Macmillan Press Ltd.

Van Arkadie, B. & Charles, R. F. Jnr. *Economic Accounting and Development Planning.* Oxford Press.

STAT 459: Statistical Quality Control

This course provides in-depth definition of statistical quality control. Source of variations: common and assignable causes. Descriptive statistics. Development of control charts; control chart for variables, control chart for attributes. Acceptance sampling and process capability indices, reliability modelling, regression models for reliability data. Single and double acceptance sampling plans for attributes and variables.

Reading List

Montgomery, D.C. (1985). *Introduction to Statistical Quality Control (*6th Edition). Wiley

Montgomery, D.C. (2002). *Introduction to Statistical Quality Control, Student Resource Manual*. Wiley Publications.

Montgomery, D. C. (2012). *Statistical Quality Control* (7th Edition). Wiley.

Wetherill, G.B & Brown, D.W. (1990). *Statistical Process Control - Theory and Practices.* London, Chapman and Hill.

Wheeler, D.J. (2010). *Understanding Statistical Process Control* (3rd Edition). SPC Press.

STAT 461: Bayesian Statistics Methods

This course is intended to equip students with concepts of Bayesian Statistical Analysis, with focus on applications; Bayesian and frequentist methods compared; Bayesian model specification, choice of priors, computational methods; hands-on Bayesian data analysis using appropriate software; interpretation and presentation of analysis results. Use of statistical computer packages. Some applications to data in the field of Pharmacy, Biology, Economics, Agriculture, Biology, Pharmacy, Medicine and Finance.

Reading List

Albert**, J. (**2009). Bayesian Computation with R. Springer.

Bolstad, W. M. (2007). *Introduction to Bayesian Statistics* (2nd Edition). John Wiley & Sons.

Harney**,** H. L. (2016**).** *Bayesian Inference Parameter Estimation and Decisions*. Springer

Hoff**, P.** D. (2009). *A First Course in Bayesian Statistical Methods.* Springer.

Pole, A. & West, M., & Harrison, J. (1994). *Applied Bayesian Forecasting and Time Series.* CRC Press.

STAT462: Biostatistics

This course introduces concepts in design and analysis of medical studies, with emphasis on randomized controlled clinical trials. Primarily use data arising from biomedical and health sciences literature and analyzed using standard statistical computer packages.
Design of clinical trials: bias elimination, treatment assignment, randomization and matching, precision, replication, repeated measures design, Prevalence and Incidence, Sensitivity and Specificity, ROC curves, Relative Risk, R x C tables, Cochran-Mantel-Haenszel test, Kappa statistics. Introduction to Survival data: Parametric and nonparametric methods, Kaplan-Meier survival curve estimator, Cox proportional hazards model.

Reading List

Agresti, A. (2013). *Categorical data analysis* (3rd Edition). Wiley.

Glover, T., & Nitchell, K. (2013). *An introduction to Biostatistics* (3rd Edition). Waveland Press Inc.
Sharma, A.K. (2005). *Text Book of Biostatistics I.* Discovery Publishing House.

Triola, M., & Triola, M. (2013). *Biostatistics for the Biological and Health Sciences with Statdisk.* Pearson New International Edition.

Zar, J. (2013). *Biostatistical Analysis* (5th Edition). Pearson.

STAT 464: Statistical Computing with R

This course is aimed at developing students programming and computational skills in the R package. Topics to be considered include: Simulation of random variables from probability distributions, the visualization of multivariate data, Monte Carlo integration and variance reduction methods, Monte Carlo methods in inference, bootstrap and jack-knife, permutation tests, Markov chain Monte Carlo (MCMC) methods, and density estimation. Selection of examples that illustrate the application of numerical methods using R functions.

Reading List

Albert, J**. (**2009). *Bayesian Computation with R*. Springer.
Carlberg, C. (2017*).R for Microsoft® Excel Users: Making the Transition for Statistical Analysis.* Que Publishing.

Charpentier, A. (2014). *Computational Actuarial Science with R.* Chapman and Hall/CRC.

Chung, K. L. (2012). *Elementary probability theory with stochastic processes*. Springer Science & Business Media.

Rizzo, M.L. (2007). *Statistical Computing with R*.

Schinazi, R. B. (2011). *Probability with Statistical Applications*. Springer Science & Business Media.

Witten, D., G., Hastie, T., & Tibshirani, R. (2013). *An Introduction to Statistical Learning: with Applications in R* (6th Edition). Springer.

STAT 466: Discrete Data Analysis
This course will focus on modelling categorical data. The basic aim of the course is to equip students with the basic skills in the analysis of discrete data. Contents include: contingency tables, general tests, binomial data, measures of association, logistic regression, logit models for multinomial responses (nominal and ordinal), log-linear models for contingency tables, Poisson model, model building/selection, and diagnostics.

Reading List
Agresti, A. (2013). *Categorical data analysis* (3rd Edition). Wiley.

Bishop, Y. M., Fienberg, S. E., & Holland, P.W. (2007). *Discrete Multivariate Analysis: Theory and Practice.* Springer.

Friendly, M., & Meyer, D. (2015). *Discrete Data Analysis with R: Visualization and Modeling Techniques for Categorical and Count Data*. Chapman and Hall/CRC.

Santner, T. J., & Duffy**,** D. E. (1989). *The Statistical Analysis of Discrete Data.* Springer.

Ton, J., Cleophas**, T.J., &** Zwinderman, A.H. (2016). *Discrete Data Analysis, Failure Time Data Analysis: Better Assessments of Biological and Pharmaceutical Agents.* Springer International Publishing.

BSC. IN ACTUARIAL SCIENCE

MAJOR IN ACTUARIAL SCIENCE
Level 100
First Semester

Course Code	Course Title	Credits
Core		
*UGRC 131/133/135/136		3
*UGRC 150/110	Critical Thinking and Practical Reasoning/Academic Writing I	3
ECON 101	Introduction to Economics I	3
DCIT 101	Introduction to Computer Science	3
STAT 111	Introduction to Statistics and Probability I	3
MATH 121	Algebra and Trigonometry	3
Total		18

*Students offering BSc Major in Actuarial Science should choose one of UGRC150/UGRC110 and one of UGRC 131/UGRC 133/UGRC 135.

Second Semester

Course Code	Course Title	Credits
Core		
*UGRC 150/110	Critical Thinking and Practical Reasoning/Academic Writing I	3
MATH 126	Algebra and Geometry	3
MATH 122	Calculus I	3
STAT 112	Introduction to Statistics and Probability II	3
ECON 102	Introduction to Economics II	3
DCIT 102	Programming Fundamentals	3
Total	**Minimum Credit Required**	18

*Students offering BSc Major in Actuarial Science should choose one of UGRC150/UGRC110.

LEVEL 200 (ENTRY REQUIREMENT*: MATH 121, MATH 126, STAT 111, STAT 112 and MATH 122*)

First Semester

Course Code	*Course Title*	*Credits*	*Pre-requisite(s)*
Core			
UGRC 210	Academic Writing II	3	
STAT 201	Introductory Probability I	3	MATH 121, STAT 122
ACTU 203	Introduction to Financial Mathematics I	3	
MATH 223	Calculus II	3	
STAT 223	Elementary Statistical Methods	3	
Total		15	
Electives (Select 3 – 6 Credits)			
*STAT 240	Introduction Statistical Computing	3	
ECON 201	Elements of Economics I	3	
STAT 220	Introduction to Actuarial Sciences	1	

Second Semester

Course Code	*Course Title*	*Credits*	*Pre-requisite(s)*
Core			
UGRC 220-238	Introduction to African Studies	3	
ACTU 204	Introduction to Financial Mathematics II	3	
STAT 224	Introductory Probability II	3	STAT 221
MATH 224	Introductory Abstract Algebra	3	
MATH 220	Introductory Computational Mathematics	3	MATH 122
Total		15	
Electives (Select 3 – 6 Credits)			
ECON 202	Elements of Economics II	3	
DCIT 204	Database Fundamentals	3	
MATH 225	Vector Mechanics	3	MATH 122
STAT 230	Data Mining	3	

LEVEL 300

First Semester

Course Code	*Course Title*	*Credits*	*Pre-requisite(s)*
Core			
STAT 331	Probability Distributions	3	STAT 224
MATH 351/STAT 339	Linear Algebra/Methods of Linear Algebra	3	MATH 224
ACTU 301	Life Contingencies I	3	ACTU 204
FINC 301	Introduction to Business Finance	3	
MATH 355	Calculus of Several Variables	3	MATH 223
Total		15	
Electives (Select 3-4 Credits)			
STAT 333	Statistical Inference I	3	
MATH 359	Discrete Mathematics	3	
STAT 335	Sample Survey Methods	3	
MATH 353	Analysis I	3	MATH 223
MATH 358	Computational Mathematics I	3	MATH 220
ACTU 320	Internship in Actuarial Science (either 1st or 2nd Semester) **	1	
ACTU 335	Microeconomic Theory for Actuaries I	3	
ACTU 359	Risk Management and Insurance	3	

**** To be taken during vacation**

Second Semester

Course Code	*Course Title*	*Credits*	*Pre-requisite(s)*
Core			
STAT 332	Multivariate Distributions	3	STAT 331, MATH 331
ACTU 304	Life Contingencies II	3	
MATH 350	Differential Equations I*	3	MATH 223
ACTU 302	Introduction to Actuarial Computing	3	
MATH 356	Analysis II	3	MATH 223
Electives (Select 3 – 6 Credit)			
CSCD 314	Operations Research	3	
MATH 354	Abstract Algebra I**	3	MATH 224
STAT 334	Statistical Inference II	3	
ACTU 334	Microeconomic Theory for Actuaries II	3	
FINC 352	Principle and Practice of Insurance	3	
STAT 338	Decision Theory	3	
STAT 356	Life Insurance and Retirement Security	3	

***Please note MATH 350 is offered either in first or second semester by the Dept. of Mathematics. BSC Actuarial Science Major students will take the course in the second semester.**

**** Not to be taken by Mathematics Students**

LEVEL 400

First Semester

Course Code	*Course Title*	*Credits*	*Pre-requisite(s)*
Core			
ACTU 410	Project	3	
ACTU 405	Fundamentals of Financial Accounting I	3	
ACTU 409	Loss Distributions & Actuarial Risk Measures	3	
ACTU 453	Introduction to Non-Life Insurance Mathematics I	3	
ACTU 407	Financial Economics I	3	
Total		**15**	
Electives (Select 3 – 6 credits)			
STAT 457	Economic and Social Statistics II	3	
STAT 445	Advanced Regression Analysis	3	STAT 334,MATH 335
ACTU 445	Macroeconomic Theory for Actuaries I	3	
STAT 443	Population Statistics	3	
STAT 451	Random Processes	3	STAT 331
MATH 441	Advanced Calculus	3	MATH 351 or MATH 353
MATH 445	Introductory Functional Analysis	3	MATH 356
ACTU 441	Econometrics for Actuaries I	3	
MATH 447	Complex Analysis	3	MATH 223
STAT 459	Statistical Quality Control	3	
STAT 440	Business Statistics	3	

Second Semester

Course Code	*Course Title*	*Credits*	*Pre-requisite(s)*
Core			
ACTU 410	Project	3	
ACTU 412	Fundamental Financial Accounting II	3	
ACTU 454	Introduction to Non-life Insurance Mathematics II	3	
ACTU 408	Financial Economics II	3	ACTU204,STAT 331,STAT332
ACTU 404	Pensions and Social Security	3	
Total		**15**	
Electives (Select 3 – 6 Credits)			
MATH 442	Differential Equation II	3	
ACTU 448	Macroeconomic Theory for Actuaries II	3	
FINC 458	Health Insurance	3	
STAT 458	Economic and Social Statistics II	3	
ACTU 442	Econometrics for Actuaries II	3	
FINC 452	Property and Pecuniary Insurance	3	

COMBINED MAJOR IN ACTUARIAL SCIENCE

BSc/BA. ACTUARIAL SCIENCE AND MATHEMATICS
LEVEL 200(ENTRY REQUIREMENT*: MATH 121, MATH 126, STAT 111, STAT 112, MATH 12*2)

First Semester

Course Code	*Course Title*	*Credits*	*Pre-requisite(s)*
Core			
UGRC 210	Academic Writing II	3	
STAT 201	Introductory Probability I	3	MATH
ACTU 203	Introduction to Financial Mathematics I	3	
MATH 223	Calculus II	3	
Total		12	
Electives (Select 3 – 6 Credits)			
STAT 223	Elementary Statistical Methods	3	
STAT 227	Introduction Statistical Computing	3	
ECON 201	Elements of Economics I	3	

Second Semester

Course Code	*Course Title*	*Credits*	*Pre-requisite(s)*
Core			
UGRC 220-238	Introduction to African Studies	3	
ACTU 204	Introduction to Financial Mathematics II	3	ACTU 203
STAT 224	Introductory Probability II	3	STAT 221
MATH 224	Introductory Abstract Algebra	3	
MATH 220	Introductory Computational Mathematics	3	MATH 122
Total		**15**	
Electives (Select 3 – 6 Credits)			
ECON 202	Elements of Economics II	3	
DCIT 204	Database Fundamentals	3	
STAT 222	Introduction to Regression and Time Series	3	
STAT 230	Data Mining	3	

LEVEL 300
First Semester

Course Code	*Course Title*	*Credits*	*Pre-requisite(s)*
Core			
STAT 331	Probability Distributions	3	STAT 221, 224
MATH 351	Linear Algebra	3	MATH 224
ACTU 301	Life Contingencies I	3	ACTU 204
FINC 301	Introduction to Business Finance	3	
MATH 355	Calculus of Several Variables	3	MATH 223
Total		**15**	
Electives (Select 1-3 Credits)			
STAT 333	Statistical Inference I	3	STAT 223
MATH 359	Discrete Mathematics	3	

STAT 335	Sample Survey Methods	3	
ACTU 320	Internship in Actuarial Science (either 1st or 2nd Semester) **	1	
ACTU 335	Microeconomic Theory for Actuaries I	3	
ACTU 359	Risk Management and Insurance	3	

**** To be taken during vacation**

Second Semester

Course Code	*Course Title*	*Credits*	*Pre-requisite(s)*
Core			
STAT 332	Multivariate Distributions	3	STAT 331, MATH 331
ACTU 304	Life Contingencies II	3	
MATH 350	Differential Equations I*	3	MATH 223
ACTU 302	Introduction to Actuarial Computing	3	
MATH 356	Analysis II	3	MATH 223
Total		**15**	
Electives (Select 0 – 3 Credit)			
DCIT 314	Operations Research	3	
STAT 334	Statistical Inference II	3	
ACTU 334	Microeconomic Theory for Actuaries II	3	
FINC 352	Principle and Practice of Insurance	3	
STAT 338	Decision Theory	3	
STAT 356	Life Insurance and Retirement Security	3	
MATH 358	Computational Mathematics I	3	MATH 220

***Please note MATH 350 is offered either in first or second semester by the Dept. of Mathematics. BSC Actuarial Science Major students will take the course in the second semester. ** Not to be taken by Mathematics Students**

LEVEL 400

First Semester

Course Code	*Course Title*	*Credits*	*Pre-requisite(s)*
Core			
ACTU 403	Introduction to Non-Life Insurance Mathematics I	3	
ACTU 405	Fundamentals of Financial Accounting I	3	
ACTU 407	Financial Economics I	3	
ACTU 409	Loss Distributions & Actuarial Risk Measures	3	
MATH 441	Advanced Calculus	3	
Total		15	
Electives (Select 3 – 6 credits)			
MATH 445	Introductory Functional Analysis	3	
STAT 440	Business Statistics	3	
STAT 451	Random Processes	3	STAT 331
ACTU 443	Econometrics for Actuaries I	3	
STAT 443	Population Statistics	3	
STAT 445	Advanced Regression Analysis	3	STAT 334,MATH 335

ACTU 445	Macroeconomic Theory for Actuaries I	3	
MATH 447	Complex Analysis	3	
STAT 457	Economic and Social Statistics I	3	
STAT 459	Statistical Quality Control	3	

Second Semester

Course Code	*Course Title*	*Credits*	*Pre-requisite(s)*
Core			
ACTU 404	Pensions and Social Security	3	
ACTU 412	Fundamental Financial Accounting II	3	
MATH 442	Integration and Measure Theory	3	MATH 356
ACTU 444	Introduction Non-life Insurance Mathematics II	3	ACTU 443
Total		12	
Electives (Select 0 – 3 Credits)			
ACTU 408	Financial Economics II	3	ACTU204,STAT 331,STAT332
ACTU 442	Econometrics for Actuaries II	3	
ACTU 448	Macroeconomic Theory for Actuaries II	3	
MATH 450	Differential Equation II	3	MATH 350
FINC 452	Property and Pecuniary Insurance	3	
FINC 458	Health Insurance	3	
STAT 458	Economic and Social Statistics II	3	STAT 457

COURSE DESCRIPTION

ACTU 203: Introduction to Financial Mathematics I

This course is aim at introducing students to some basic concepts of mathematical finance. Course content includes foundational concepts of financial mathematics, with applications in calculating present and accumulated values for varied streams of cash flows as a basis for future use in actuarial reserving, valuation, pricing, duration calculation, asset/liability management, investment income, capital budgeting and valuation of contingent cash flows. Basic asset pricing theory, Introduction to optimal portfolio theory; mean–variance approach, markovitz solution for two assets. Introduction to option pricing; definition and types of options. One period binomial and trinomial models for option pricing. A basic knowledge of calculus and an introductory knowledge of probability is assumed for students taking this course.

Reading List

Broverman, S. A. (2015). *Mathematics of Investment and Credit* (6th Edition). ACTEX Publications.

Daniel, J.W., & Vaaler, L.J.F. (2009). *Mathematical Interest Theory* (2nd Edition). The Mathematical Association of America.

Kellison, S.G., (2009). *The Theory of Interest* (3rd Edition). Irwin/McGraw-Hill.

McDonald, R.L. (2013). *Derivatives Markets*. (3rd Edition). Pearson.

Ruckman, C., & Francis, J. (2005). *Financial Mathematics: A Practical Guide for Actuaries and Other Business Professionals*. BPP Professional Education.

ACTU 204: Introduction to Financial Mathematics II

This course is aim at building on the foundation of mathematical finance that has been laid in the course ACTU 203. Topics to be cover include: Introduction to option pricing; definition and types of options. One period binomial and trinomial models for option pricing. Conditional expectation, utility functions, examples of stochastic process. Introduction to interest theory; coupon rate, swap rate, forward rate, simple rate, LIBOR rate. Financial market; some complete market models, some incomplete market models, arbitrage opportunities.

Reading List

Broverman, S. A. (2015). *Mathematics of Investment and Credit* (6th Edition). ACTEX Publications.

Daniel, J.W., & Vaaler, L.J.F. (2009). *Mathematical Interest Theory* (2nd Edition). The Mathematical Association of America.

Kellison, S.G., (2009). *The Theory of Interest* (3rd Edition). Irwin/McGraw-Hill.

McDonald, R.L. (2013). *Derivatives Markets*. (3rd Edition). Pearson.

Ruckman, C., & Francis, J. (2005). *Financial Mathematics: A Practical Guide for Actuaries and Other Business Professionals*. BPP Professional Education.

STAT 221: Introductory Probability I (Pre-Req. MATH 121, 122 **)**

The course builds on concepts introduced in STAT 112. Topics to be considered include: Further concepts of Probability, Random Events and Random Variables. The Probability Calculus, Univariate Probability Distributions. Univariate Moment Generating Functions; their properties and uses. Introduction to Bivariate Discrete Distributions; conditional discrete distribution, expectation. Some Probability Modelling based on discrete distributions.

Reading List

Chung, K. L. (2012). *Elementary Probability Theory with Stochastic Processes*. Springer Science & Business Media.

Mosteller, F., Rourke, R. E., & Thomas, G. B. (1961). *Probability with Statistical Applications*, Addison Wesley.

Rizzo, M.L. (2007). *Statistical Computing with R*.

Schinazi, R. B. (2011). *Probability with Statistical Applications*. Springer Science & Business Media.

Sheldon, R. (2002). *A First Course in Probability*. Pearson Education India.

STAT 223: Elementary Statistical Methods
This course introduces students to some basic concepts of statistical methods. Topics to be covered are Bivariate Data analysis, Elements of Statistical inference. Hypothesis testing – One-sample case (test for mean, proportion, power, sample size, test for variance, Confidence intervals) Hypothesis testing – Two-sample case (two-sample test for paired and unpaired means and proportions, power, sample size, equality of variance test, CI). ANOVA (one- and two-way), Simple Linear Regression and Correlation Analysis.

Reading List
Anderson, A. J. (1989). *Interpreting Data: A First Course in Statistics* (Vol. 8). CRC Press.

Clarke, G. M., & Cooke, D. (1979). *Basic Course in Statistics*.

Freund, J.E. (1987). *Mathematical Statistics* (5th Edition). Reston, Preston-Hall.

Hoel, P. G. (1971). *Elementary Statistics*. New York: Wiley.

Wetherill, G. (2012). *Elementary Statistical Methods* (Vol. 179). Springer Science & Business Media.

STAT 224: Introductory Probability II (Pre-Req. STAT 221**)**
This course is aimed at broaden and deepen the knowledge of students theory probability. Topics to be considered include the following: Bivariate Distributions, Bivariate Moment Generating Functions; their properties and uses. Sampling distributions. Distribution associated with samples from a normal population. The Laws of Large Numbers, and the Central Limit Theorem and its Applications. Statistical Inequalities. Some Statistical Applications of Probability; likelihood functions and estimation. Financial and Actuarial Applications of Probability.

Reading List
Chung, K. L. (2012). *Elementary Probability Theory with Stochastic Processes*. Springer Science & Business Media.

Doku-Amponsah, K. (2016). *Probability Distributions*. (Unpublished Manuscript)

Mosteller, F., Rourke, R. E., & Thomas, G. B. (1961). *Probability with Statistical Applications*. Addison Wesley.

Schinazi, R. B. (2011). *Probability with Statistical Applications*. Springer.

Sheldon, R. (2002). *A First Course in Probability*. Pearson Education India.

STAT 230: Data Mining
The course will introduce students to introductory data mining. Topics to be covered include: data warehousing, data mining process (data preparation/cleansing, task identification), Association rules (mining and different algorithm types), Classification/Prediction, Classification (tree-based approaches, Neural Networks, etc), Clustering (statistical vs neural-net and other approaches), Model evaluation and visualization techniques. The course will

help students make better sense of large chunks of data which will be incredibly useful in understanding big data.

Reading List

Aggarwal, C. (2015). *Data Mining: The Textbook*. Springer Publications.

Han, J., Kamber, M. & Pei, J. (2012). *Data Mining : Concepts and Techniques.* Elsevier Publishers.

Shmueli, G. (2016). *Data Mining for Business Intelligence: Concepts, Techniques and Applications In Microsoft Office Excel With XL Miner*.

Tan, P., Steinbach, M. & Kumar, V. (2006). *Introduction to Data Mining*. Addison Wesley.

Zaki, M. J., & Meira, Jr. W. (2014). *Data Mining and Analysis: Fundamental Concepts and Algorithms.* Cambridge University Press.

ACTU 301: Life Contingency I

This course introduces students to mathematics of life contingencies. Being probabilistic in nature, the course seeks to develop theoretical basis for modelling future lifetime status with emphasis on insurance. Topics to be covered include brief review of probability theory, international actuarial notations, actuarial survival models, life table format, life statuses, survival distributions, concept of dependence (common shock models, copulas etc), multiple lives and multiple decrement theory and multiple-state models. The course is designed to set the pace towards ensuring the student's adequate preparation for the MLC/3L exam of the Society of Actuaries or Canadian Institute of Actuaries respectively.

Reading List

Antonio, K., & Valdez, E. A. (2012). *Statistical Concepts of a Priori and a Posteriori Risk Classification in Insurance*. Advances in Statistical Analysis.

Bowers, N.L., Gerber, H.U. & Hickman, J.C. (1997). *Actuarial Mathematics* (2nd Edition), Schaumburg, IL; Society of Actuaries.

Broverman, S.A. (2008). *Mathematics of Investment and Credit* (4th Edition). ACTEX Publications.

Dickson, D. C., Hardy, M., Hardy, M. R., & Waters, H. R. (2013). *Actuarial Mathematics for Life Contingent Risks*. Cambridge University Press.

Olivieri, A., & Pitacco, E. (2015). *Introduction to Insurance Mathematics: Technical and Financial Features of Risk Transfers*. Springer.

ACTU 302: Introduction to Actuarial Computing

This course provides basic foundation of knowledge concerning fundamental building blocks of actuarial practice. It is meant to present students with a transition from understanding the mathematical underpinnings of actuarial science to putting them into practice. The course

focuses on two areas of actuarial practice: investment management and life insurance. All mathematical computations will be computer program assisted. Students will be able to construct and use life tables in simulation studies, portfolio management theory and design basic individual life. Concepts will apply the concepts within an actuarial problem statement. Recommended software include excel, R and MATLAB.

Reading List

Beckley J. A., Scahill P. L., Varitek M. C., White T. A., (2012) *Understanding Actuarial Practice*. (1st Edition). Society of Actuaries. United States

Borowiak, D.S. & Arnold F. Shapiro, A.F. (2014). *Financial and Actuarial Statistics: An Introduction* (2nd Edition). CRC Press.

Chambers, J. M., (2008). *Software for Data Analysis, Programming with R*. Springer.

Charpentier, A. (2014).*Computational Actuarial Science with R.* CRC Press.

Jong, P. D. & Heller, G. Z. (2008). *Generalized Linear Models for Insurance Data* (International Series on Actuarial Science). Cambridge University Press.

ACTU 304: Life Contingency II (Pre-requisites: ACTU 301)

This course builds on Life contingency I. It is designed to develop theoretical basis for pricing and supporting life-contingency products. Topics treated includes economics of insurance, general insurances, annuities, premiums (level and non-level benefits and premiums) and expense (incorporating expenses in insurance models) analysis, analysis of reserves, Hattendorf theorem, probability models: Poisson Processes. The course is designed to set the pace towards ensuring the student's adequate preparation for the MLC/3L exam of the Society of Actuaries or Canadian Institute of Actuaries respectively.

Reading List

Antonio, K., & Valdez, E. A. (2012). *Statistical Concepts of a Priori and a Posteriori Risk Classification in Insurance*. Asta Advances in Statistical Analysis.

Jordan, C.W. (2003). *Life Contingencies*. New York, NY: John Wiley and Sons.

Parmenter, M.M. (2010). *Theory Of Interest & Life Contingencies With Pension Applications*. Winsted: Actex Publications.

Pitacco, E. (2014). *Health Insurance: Basic Actuarial Models*. Springer.

Wetherill, M. (2001). *Life Contingencies*. London: Addison Wesley.

STAT 331: Probability Distributions (Pre-Req. STAT 221, 204**)**

This course is aimed at introducing students to Elementary Distribution Theory. Topics to be covered include Generating Functions and Applications; moment generating functions, probability generating function, factorial moment generating function and characteristic

function, moments and limiting distributions. Sequences of random variables; modes of convergences, the Central Limit Theorem and its Applications. Concentration inequalities. Introduction to large deviation theory; large deviation probabilities, method of types.

Reading List

Doku-Amponsah, K. (2015). *Probability Distributions*. Unpublished Manuscript.

Hoel, P. G. (1971). *Elementary Statistics* (No. QA276. 12. H63 1966.). New York: Wiley.

Hogg, R. V., & Craig, A. T. (1967). *Introduction to Mathematical Statistics (2nd Edition)*. Macmillan Publications.

Hogg, R. V., & Tanis, E. A. (1977). *Probability and Statistical Inference*.

Larson, H. (1982). *Introduction to Probability Theory and Statistical Inference*.

Sheldon, R. (2002). *A First Course in Probability*. Pearson Education India.

ACTU 333: Microeconomics for Actuaries I

The course is designed to introduce actuarial science students to a thorough understanding of the fundamentals of economic analysis of individual, business and industry choices in market economies as it applies to actuarial practice. Topics to be covered include basic economic concepts, nature and function of product markets, price mechanism, supply and demand, optimizing economic behaviour, cost and revenue, market structures, factor markets, income distribution, market failure and government intervention. Introduction to Economic model-building, comparative static and dynamic models.

Reading List

Gould, P. & Edwards, P. (2008). *Microeconomic Theory* (6th Edition). USA: Richard D Irvin Inc.

Kountsoyiannnis, A. (2003). *Modern Microeconomic Theory* (2nd Edition). New York: Macmillan Publishing Company.

Mankiw, G.N. (2016). *Principle of Microeconomics*. Cengage Learning.

McConell, C., Brue, S., & Flynn, S. (2014). *Microeconomics: Principles, Problems and Policies,* McGraw-Hill Publishing Company.

Pindyck, S. (2002). *Microeconomic Theory* (2nd Edition). New York. NY: Macmillan Publishing Company.

ACTU 334: Microeconomics for Actuaries II

Introduction to Economic model-building, comparative static and dynamic models. Consumer Behaviour and Demand theory, law of diminishing marginal utility, ordinary utility approach, Demand function, income elasticity of demand, short-run cost; fixed, variable, total , average and marginal cost, production function, perfect competition; the firm, market, product homogeneity, perfect knowledge, profit maximization, free entry, short-run equilibrium of firm and industry, constant and increasing cost.

Reading List

Gould, P. & Edwards, P. (2008). *Microeconomic Theory* (6th Edition). USA: Richard D Irvin Inc.

Kountsoyiannnis, A. (2003). *Modern Microeconomic Theory* (2nd Edition). New York: Macmillan Publishing Company.

Mankiw, G.N. (2016). *Principle of Microeconomics*. Cengage Learning.

McConell, C., Brue, S., & Flynn, S. (2014). *Microeconomics: Principles, Problems and Policies,* McGraw-Hill Publishing Company.

Pindyck, S. (2002). *Microeconomic Theory* (2nd Edition). New York. NY: Macmillan Publishing Company.

STAT 332: Multivariate Distributions (Pre-Req. STAT 331**)**

This course is aimed at introducing students to multivariate distribution theory. Topics to be covered include: Introduction to Vector Random Variables; vector of means, dispersion matrix, matrix of co-variances. Distribution Concepts for several random variables; exponential-type distribution, multivariate moment generating function. Transformation of Random Vectors; gamma distribution, beta distribution, chi-square distribution t-distribution, f-distribution. Order Statistics; joint distribution of order statistics. Multivariate Normal Distributions.

Reading List

Doku-Amponsah, K. (2015). *Multivariate Distributions.* Unpublished Manuscript.

Hoel, P. G. (1971). *Elementary Statistics* (No. QA276. 12. H63 1966.). New York: Wiley.

Hogg, R. V., & Craig, A. T. (1967). *Introduction to Mathematical Statistics:* In *Multivariate statistical methods* (2nd Edition). Macmillan.

Morrison, D. F. (1967). *Multivariate statistical methods*. McGraw-Hill Book.

Odoom, S. I.K. (1997). *Multivariate Distributions.* Unpublished Manuscript.

STAT 333: Statistical Inference I (Pre-Req. STAT 204**)**

The first part of the two-semester course provides a systematic development of the principles and methods of statistical inference, on a largely intuitive basis with a minimum of mathematical theory. This part deals with the general nature of Statistical Problems, Statistical Models and Problems of Estimation. Introduction to Bayesian Statistics. Introduction to statistical modelling with R. Some applications to data in the field of Pharmacy, Biology, Economics, Agriculture, Biology, Pharmacy, Medicine and Finance.

Reading List

Alexander, M., Graybill, F. A., & Duane, C. (1974). *Introduction to the Theory of Statistics*. McGraw-Hill.

Barnett, V. (1999). *Comparative statistical inference*. John Wiley & Sons.

Hoel, P. G., Port, S. C., & Stone, C. J. (1972). *Introduction to statistical theory.*

Lindgren, B. (1993). *Statistical theory*. CRC Press.

Rao, C. R. (2009). *Linear statistical inference and its applications* (Vol. 22). John Wiley & Sons.

STAT 334: Statistical Inference II (Pre-Req. STAT 333**)**

This course is a follow up to STAT 333. It is aimed at building on the concepts of mathematical statistics acquired in STAT 333. Topics to be covered include: General principles and Procedures of Hypotheses Testing. Parametric and Non- Parametric Test. Simple Linear Regression and Correlation Analysis. The Analysis of Frequency Data. Introduction to Categorical Analysis. Statistical modelling with R. Some applications to real-life data in the fields of Pharmacy, Biology, Economics, Agriculture, Biology, Pharmacy, Medicine and Finance.

Reading List

Alexander, M., Graybill, F. A., & Duane, C. (1974). *Introduction to the Theory of Statistics*. McGraw-Hill.

Barnett, V. (1999). *Comparative statistical inference* (Vol. 522). John Wiley & Sons.

Barnett, V. (1999). *Comparative statistical inference* (Vol. 522). John Wiley & Sons.

Hoel, P. G., Port, S. C., & Stone, C. J. (1972). Introduction to statistical theory.

Hogg, R. V., & Craig, A. T. (1967). *Introduction to Mathematical Statistics* (2nd Edition). Macmillan.

Larson, H. (1982). *Introduction to probability theory and statistical inference*.

Lindgren, B. (1993). *Statistical theory* (Vol. 22). CRC Press.

STAT 338: Decision Theory

The course introduces the main concepts and tools of game theory. The main aim of the course is to enable students to read original game-theory literature and to prepare them to do research in the field. They will learn how to represent an economic situation as a game and how to analyze it using different equilibrium concepts proposed in the literature, the prominent one being the Nash equilibrium. Concentration will be on strategic interaction under incomplete information and modify the Nash equilibrium concept to include the uncertainty of the players about some of the parameters of the game.

Reading List

Baron, E.N. (2008). *Game Theory: An Introduction.* John Wiley & Sons.

Deng-Feng, L. (2014). *Decision and Game Theory in Management with Intuitionistic Fuzzy Sets.* Springer

Gibbons, R.(1992). *Game Theory for Applied Economist.* Princeton.

Tadelis. S. (2015). *Game Theory: An Application*.

Watson, J. (2013).*Strategy: An Introduction to Game Theory.* (3rd Edition). W.W. Norton & Company.

STAT 339: Methods of Linear Algebra (Non-mathematics students)- (Pre-requisite MATH 126)

The emphasis is on the geometric and computational foundations of Linear Algebra with abstraction (and proof) kept to a minimum. We would examine matrices, linear systems of equations and their solutions. Basic properties of determinants, vectors in R^n and a simple introduction to the idea of an arbitrary vector space. The pinnacle of the course is to be able to find eigenvalues and their corresponding eigenvectors for a given matrix and indeed for a linear map. We would carefully develop the diagonalization of symmetric matrices. For those who did the MATH 220 there would be applications using Python.

Reading List

Artin, M. (2010*). Algebra (2nd Edition).* Pearson Higher Edition USA.

Kolman, B., & Hill, D. R. (2005) *Introductory Linear Algebra, An Applied First Course* (8th Edition). Addison Wesley

Roman, S. (2007). *Advanced Linear Algebra* (3rd Edition). Springer.

Sheldon, A. (2010). *Linear Algebra Done Right.* Springer.

Strang, G. (2006). *Introduction to Linear Algebra.* Wellesley-Cambridge Press.

ACTU 359: Risk Management and Insurance

This course focuses on the core principles of risk management and insurance in actuarial science. Topics covered include types of risk identification and analysis, risk modelling concepts, risk quantification, approaches for managing risks (how business entities makes decisions about risk management techniques). The further sections of the course will delve into the concept of economic capital, risk measures in capital assessment and techniques to allocate cost of risk within business units. Topics also cover life and health insurance, property and liability insurance, value-based enterprise risk management for corporations, pensions and employee benefits and risk aggregation techniques.

Reading List

Baranoff, E. Z., & Baranoff, E. Z. (2004). *Risk Management and Insurance*. Danvers. Wiley.

Harrington, S. E., Niehaus, G. R., & Harrington, N. (1999). *Risk Management and Insurance.*

Rejda, G. E., (2005). *Risk Management and Insurance.* Pearson Education Inc.

Segal, S. (2011). *Corporate Value of Enterprise Risk Management: The Next Step in Business Management* (Vol. 3). John Wiley & Sons.

Williams, C. A., & Heins, R. M. (1985). *Risk Management and Insurance*. Mcgraw- Hill Companies.

ACTU 453: Introduction to Non-Life Insurance Mathematics I

This course aim at introducing students to the concept of non-life computations and analysis. Basic models and concepts; reserve process, risk process, Cramer-Lundberg model, homogeneous poisson process, compound Poisson model, Erlang's model. Common distributions for number of claims; Binomial distribution, negative binomial distribution, poisson distribution. Common distributions for claims size; Gamma distribution, lognormal distribution, some extreme risk distributions. Distribution of sum of claims; convolution theorem, generating functions, moments estimates.

Reading List

Dickson, C.M.D., Hardy, M.R. & Waters, H.R. (2009). *Actuarial Mathematics for life Contingent Risk.* Cambridge University Press.

Embrechts, P., Kluppelberg, C., & Mikosch, T. (2011). *Modelling Extremal Events for Insurance and Finance*. Springer

Klugman, S.A., Panjer, H.H., & Wilmot, G.F.(2008). *Loss Models*. John Wiley and sons.

Johnson, N.L. (2011). *Non-Life Insurance Models*. London Heinemann.

Mikosch, T. (2009). *Non-Life Insurance Mathematics: An Introduction with the Poisson Process* (2nd Edition). Springer Berlin Heidelberg.

ACTU 454: Introduction to Non-life Insurance Mathematics II

This course is a sequel to ACTU 453. Topics include: Premium; calculation and principles, notion of utility function; linear utility, exponential utility, properties of premium calculation principles. Introduction to experience rating; under writer A, B and C, bayesian approach. Introduction to extreme value theory; limit behaviour of maximum.

Reading List

Dickson, C.M.D., Hardy, M.R. & Waters, H.R. (2009). *Actuarial Mathematics for life Contingent Risk.* Cambridge University Press.

Embrechts, P., Kluppelberg, C., & Mikosch, T. (2011). *Modelling Extremal Events for Insurance and Finance*. Springer

Klugman, S.A., Panjer, H.H., & Wilmot, G.F.(2008). *Loss Models*. John Wiley and sons.

Johnson, N.L. (2011). *Non-Life Insurance Models*. London Heinemann.

Mikosch, T. (2009). *Non-Life Insurance Mathematics: An Introduction with the Poisson Process* (2nd Edition). Springer Berlin Heidelberg.

ACTU 404: Pensions and Social Security

The theory and practice of social security and state, occupational and personal pension plan funding. Features of the main employee benefit schemes, principles of financing,

including asset and liability relationships. Legislative frame work on retirement and various benefit schemes. Tax management, economic and demographic factors, accounting for pension costs, valuation data collection, analysing experience, valuing liabilities and assets, calculating contribution rates; choice and management.

Reading List

Aitken, W. H. (1996). *A Problem-Solving approach to pension funding and valuation* (2nd Edition). Winsted, CT; Actex.

Allen, E.T., Melone, J.J., & Rosenbloom, J.S. (2003). *Pension Planning: Pension Profit sharing and other deferred compensation plans* (9th Edition). Boston, MA: McGraw-Hill.

Berin, B.N. (1989). *The fundamentals of Pension Mathematics*. Schaumburg, IL Society of Actuaries.

Booth, P.M., Chadburn, R.G., & Cooper, D.R. (1999). *Modern Actuarial Theory and Practice*. Boca Raton, FL; Chapman & Hall.

Matthews, J.L. (2013). *Social Security, Medicare & Government. (18th Edition).* Nolo.

ACTU 405: Fundamentals of Financial Accounting I

The course is aimed at equipping students with some concepts of financial accounting. Topics include the following: principles of finance, structure of a joint stock company, and the different methods by which it may be financed, financial instruments used by companies and the way they may be issued, capital structure and dividend policy, a company's cost of capital interacts with the nature of the investment, major types of financial institutions operating in the financial markets.

Reading List

Chiappetta, L. W. (2001). *Fundamental Accounting Principles*. McGraw-Hill.

McLaney, E.J. & Atrill, P.(2014).*Accounting and Finance: An Introduction.* Pearson.

Schaums, W. (1998). Schaums *Outlines : Principles of Accounting*. McGraw-Hill.

Weil, R. L, Schipper, K., & Francis, J. (2012). *Financial Accounting: An Introduction to Concepts, Methods and Uses.* (14th Edition). South-Western College Pub.

Wood, F. & Sangster, A. (2005). *Business Accounting I*. (10th Edition). Prentice Hill.

ACTU 407: Financial Economics I

This course is designed to introduce students to the theoretical knowledge and application of financial models as they are applied to insurance and financial risk management. Topics to be covered include interest rate models, introduction to derivatives, insurance, hedging and simple strategies (introduction to forwards and options, insurance, collars and other strategies etc), Forwards, Futures and Swaps, Options I (Parity and Other Option Relationships, Binomial Option Pricing: Basic Concepts, Binomial Option Pricing: Selected Topics).

Reading List

Baxter, M., & Rennie, A., (1996). *Financial Calculus: An Introduction to Derivative Pricing.* Cambridge University Press, Cambridge, England.

Benzoni, L., (2001). *Pricing Options under Stochastic Volatility: An Empirical Investigation* (unpublished). University of Minnesota.

Bharath, S. T. and Shumway, T., (2004). *Forecasting Default with the KMV-Merton Model* (Working Paper). University of Michigan

Korn, R. & Korn, E.(1999). *Option Pricing and Portfolio Optimization: Modern Methods of Financial Mathematics.* American Mathematical Society.

McDonald, R.L., (2013). *Derivatives Markets* (3rd Edition). Pearson Education.

ACTU 408: Financial Economics II

This course builds on Financial Economics I. Topics to be covered include Options (Black-Scholes Formula, Market-Making and Delta-Hedging, Exotic Options), Financial Engineering and Applications (Financial engineering and security design, corporate applications, real options), Advanced Pricing Theory (The lognormal distribution, Monte Carlo Valuation, Brownian Motion and ItÔ's Lemma, The Black-Scholes-Merton Equation), Risk-Neutral and Martingale Pricing, Volatility, Interest Rate and Bond Derivatives, Value-at-Risk and Credit Risk Modelling.

Reading List

Baxter, M., & Rennie, A., (1996). *Financial Calculus: An Introduction to Derivative Pricing.* Cambridge University Press, Cambridge, England.

Benzoni, L., (2001). *Pricing Options under Stochastic Volatility: An Empirical Investigation* (unpublished). University of Minnesota.

Bharath, S. T. and Shumway, T., (2004). *Forecasting Default with the KMV-Merton Model* (Working Paper). University of Michigan

Korn, R. & Korn, E.(1999). *Option Pricing and Portfolio Optimization: Modern Methods of Financial Mathematics.* American Mathematical Society.

McDonald, R.L., (2013). *Derivatives Markets* (3rd Edition). Pearson Education.

ACTU 409: Loss Distributions and Actuarial Risk Measures

This course is designed to introduce the student to steps involved in actuarial modelling process in solving business problems. Topics relate to severity models (Calculation/interpretation of basic distributional quantities, sensitivity analysis and extreme value distributions), frequency models (Sensitivity analysis of discrete distributions and their mixtures thereof, choosing appropriate discrete distributions for available data etc) and aggregate models (collective risk models estimation, compound models for aggregate claims etc). Types and properties of actuarial risk measures (VaR and TVaR and their limitations).

Construction of empirical models in actuarial business context. A knowledge of calculus and probability is assumed.

Reading List

Denuit, M., Dhaene, J., Goovaerts, M., & Kaas, R. (2006). *Actuarial Theory for Dependent Risks: Measures, Orders and Models*. John Wiley & Sons.

Dowd, K., & Blake, B. (2006). *After Var: The Theory, Estimation, and Insurance Application of Quantile-Based Risk Measure.* The Journal of Risk and Insurance.

Hogg, R. V., & Klugman, S. A. (2009). *Loss Distributions* (Vol. 249). John Wiley & Sons.

Kaas, R., Goovaerts, M., Dhaene, J., & Denuit, M. (2008). *Modern Actuarial Risk Theory:Using R.* Vol. 128. Springer Science & Business Media.

Klugman, S.A, Panjer, H.H. & Willmot, G. E. (2013).*Loss Models: Further Topics (1*st Edition). Wiley Publications.

ACTU 410: Project

The project work is aimed at developing students problem solving and written skills. It has one year duration. Students present a project on a relevant and topical issues pertaining to Actuarial Science while applying appropriate Statistical/Mathematical techniques and tools to problems or data emanating from Insurance, business, financial and banking sector, communication sector, agricultural sector, mining sector, construction sector etc.

ACTU 412: Fundamentals of Financial Accounting II

This course is a sequel to ACTU 405. Topics include: Basic construction of financial statements and the role and principal features of the financial statements of a company, accounts of a company or a group of companies; interpretation and limitations, structure and content of insurance company accounts, basic principles of personal and corporate taxation.

Reading List

Beaver, W. H. (1981). *Financial Reporting: An Accounting Revolution*. Prentice Hall.

Deegan, C. (2013). *Financial Accounting Theory*. Mcgraw-Hill Education Australia.

Elliott, B., & Elliott, J. (1993). *Financial Accounting and Reporting.* Pearson Education Limited.

Henderson, S., Pearson, G., Herbohn, K., Artiach, T., & Howieson, B. (2013). *Issues in Financial Accounting*. Pearson Higher Education AU.

Scott, W. R. (2014). *Financial Accounting Theory*. Pearson Education Canada.

ACTU 443: Econometrics for Actuaries I

The course is designed to introduce the student to the definition, scope, and branches of econometrics as they apply to actuarial science. Topics covered include methodology of econometrics research; partial correlation, limitations of the correlation theory. The

simple linear regression model; ordinary least squares method (OLS), estimation of elasticity's from an estimated regression line. Statistical tests of the significance of the estimates, properties of the OLS estimates, extension of the linear regression model to nonlinear relationships, regression and analysis of variance. Introduction to Panel-data econometric models.

Reading List

Campbell, J. Y., Lo, A. W. C., & MacKinlay, A. C. (1997). *The Econometrics of Financial Markets.* Princeton, NJ: Princeton University press.

Judge, G. G., Hill, R. C., Griffiths, W., Lutkepohl, H., & Lee, T. C. (1988). *Introduction to the Theory and Practice of Econometrics.*

Kmenta, J. (1986). *Elements of Econometrics*.

Stock, J. H., & Watson, M.W.(2002). *Introduction to Econometrics. 3rd Edition*. Addison-Wesley.

Zarembka, P. (1990). *Transformation of Variables in Econometrics*. Palgrave Macmillan UK.

ACTU 444: Econometrics for Actuaries II (Pre-requisites: ACTU 443)

This course is designed to build on Econometrics I. Topics covered include: Test of assumptions of linear regression model; randomness, zero mean, constant variance and normality of the disturbance variable . Autocorrelation, multicollinearity, errors in variables, time as dummy variables, grouped data. Lagged variables and distributed-lag models, models of simultaneous relationships; simultaneous-equation models, identification, simultaneous-equation methods, the method of principal components, maximum likelihood methods, three-stage least squares, testing the forecasting power of an estimated model. Simulation models (Monte-Carlo etc.), Generalized linear models (GLM), and Generalized Estimating Equations (GEE). Recommended texts are left to the discretion of the course instructor

Reading List

Campbell, J. Y., Lo, A. W. C., & MacKinlay, A. C. (1997). *The Econometrics of Financial Markets.* Princeton, NJ: Princeton University press.

Gujarati , D.N. (1992). *Essentials of Econometrics*. McGraw-Hill Education.

Judge, G. G., Hill, R. C., Griffiths, W., Lutkepohl, H., & Lee, T. C. (1988). *Introduction to the Theory and Practice of Econometrics.*

Kmenta, J. (1986). *Elements of Econometrics*.

Zarembka, P. (1990). *Transformation of Variables in Econometrics*. Palgrave Macmillan UK.

ACTU 445: Macroeconomic Theory for Actuaries I (Prerequisites: ACTU 335, ACTU 334)
Building on the core economic principles of ECON 201 and ECON 202, this course is designed to introduce the actuarial student to behaviour of the economy from an aggregate perspective. Core topics include national income calculation, measuring gross domestic product (GDP), unemployment, monetary policy and banking; inflation, interest rates, stagflation and deflation. Fiscal Policy; exchange rate and balance of payment (BOP). Business cycle and exchange rate policy. Interest rate parity. A knowledge of calculus and ECON 201 and ECON 202 is assumed.

Reading List
Blanchard, Olivier, & David, R. J. (2012). *Macroeconomics* (6th Edition). Pearson.

Branson, W. H. (1972). *Macroeconomic theory and policy*.

Mankiw, G.N. (2016). *Principle of Macroeconomics*. Cengage Learning.

Sargent, T. J. (1987). *Macroeconomic theory*. New York: Academic Press.

Sargent, T. J. (2009). *Dynamic macroeconomic theory*. Harvard University Press.

Taylor, L. (1991). *Income distribution, inflation, and growth: Lectures on Structuralist Macroeconomic Theory.* MIT Press.

ACTU 448: Macroeconomic Theory for Actuaries II (Prerequisites: ACTU 445)
This is a sequel to ACTU 448. Topics covered include: Consumption demand, Absolute income, Life Cycle, permanent income and relative income hypothesis. The Keynesian Theory of Investment i.e. marginal efficiency of capital (MEC) and marginal efficiency of investment (MEI). Advanced topics in demand and supply of money. Modern Theory of Interest (The Hicks-Hansen analysis and synthesis).

Reading List
Branson, W. H. (1972). *Macroeconomic theory and policy.*

Korn, R. & Korn, E. (1999). *Option Pricing and Portfolio Optimization: Modern Methods of Financial Mathematics.* American Mathematical Society

Mankiw, G.N. (2016). *Principle of Macroeconomics*. Cengage Learning.

Sargent, T. J. (1987). *Macroeconomic theory*. New York: Academic Press.

Sargent, T. J. (2009). *Dynamic macroeconomic theory*. Harvard University Press.

Taylor, L. (1991). *Income distribution, inflation, and growth: Lectures on Structuralist Macroeconomic Theory.* MIT Press.

STAT 440: Business Statistics
This course is designed to introduce students to the application of in statistics business. Topics to be discussed include: Customer analytics, operation analytics, people analytic, accounting analytic and bus analytic capstone. Descriptive analytics; use to understand

past and present data , predictive analytic; past performance, prescriptive analytic; uses of optimization techniques. Some applications to real-life data from the field of business.

Reading List

Evans, J.R. (2012). *Business Analytics*.

Francis, A. (2007).*Business Mathematics and Statistics* (6th Edition). Thomson.

Hanke, J.E., & Wichern, D.(2009). *Business Forecasting* (9th Edition). Pearson

Liebowitz, J.(2013). *Business Analytics: An Introduction*. CRC Press. Auerbach Publications.

Shmueli, G., Bruce, P.C., & Patel, N. R. (2016). *Data Mining for Business Analytics* (3rd Edition). Wiley Publications.

STAT 451: Random Processes (Pre-Req. STAT 331**)**

This course is to introduce students to stochastic models in the fields of natural and social sciences. Topics to be covered include: Some discrete and continuous time processes; Markov Chains, Random Walks, Birth and Death Process, Random Trees; Galton-Watson Processes, Introduction to Brownian Process, Basic Theory and Applications in Demography/Population study, Insurance, Finance and Risk Management.

Reading List

Bartholomew, D. J., (1967). *Stochastic models for social processes*. London: Wiley & Sons. N. York.

Bhat, U. N., & Miller, G. K. (1972). *Elements of applied stochastic processes*. John Wiley.

Chiang, C. L. (1980). *Introduction to Stochastic Process and Their Applications*. John Wiley

Karlin, S., & Taylor, H. M. (1975). *A first course in stochastic processes*. Academic Press, San Diego.

Parzen, E. (1962). *Stochastic processes*. San Francisco: Holden-Day.

STAT 453: Population Statistics

The course is designed to broaden and deepen students understanding of Demography and Population issues. Topics to be studied include; Demographic Concepts and Measures. Collection and analysis of Demographic data. The Dynamics of population change. Mortality; Measures of Mortality, Measures of Fertility. Rates of incidence and rates of change. Crude and Specific rates. Life expectancy.

Reading List

Coale, A. J., & Brass, W. (1981). *Collecting Data for the Estimation of Fertility and Mortality*. *Committee on Population and Demography*. Report No. 6. National Academy Press, Washington DC.

Eubank, D.C (1981). *Age Misreporting and Age–Selective Under enumeration: Sources, Patterns, and Consequences for Demographic Analysis Committee on Population and Demography. Report No. 4*. National Academy Press, Washington D.C.

Kpedekpo, G. M. K. *Essentials of Demographic Analysis for Africa*. Heinemann.

Shryock, H. S., Siegel, J. S., & Associates (1992). *The Methods and Materials of Demography*. Condensed Edition. Academic Press.

Spiegelman, M. (1980). *Introduction to Demography*. Harvard University Press

STAT 445: Advanced Regression Analysis (Pre-Req. STAT 334**)**
The course aims to build on introductory regression knowledge gained in previous years. Advanced Regression analysis focuses on applications of basic statistical techniques; model formulation, checking/diagnostics, selection; interpretation and presentation of analysis results; simple and multiple linear regressions; logistic regression; ANOVA; hands-on data analysis with R computer software. Some applications to data from the field of Agriculture , Biology , Economics, Finance etc.

Reading List
Bhattacharyya, G. K. J., & Arnold, R. (1977). *Statistical concepts and methods*.

Dunn, O. J., & Clark, V. A. (1986). *Applied statistics: analysis of variance and regression.*

Draper, N. R., & Smith, H. (2014). *Applied regression analysis*. John Wiley & Sons.

Edwards, A. L. (1985). *Multiple regression and the analysis of variance and covariance*. WH Freeman/Times Books/Henry Holt & Co.

Kutner, M. H., Nachtsheim, C. J., Neter, J., & Li, W. (2005). *Applied linear statistical models.*

STAT 457: Economic and Social Statistics I (Pre-Req. STAT 226**)**
STAT 457 is designed to broaden and deepen student knowledge of the Applied Statistics that concerns the collection, processing, compilation, dissemination, and analysis of social and economic data. Topics to be covered include: Statistics on Economic and Social Activities and Trends and their uses. Methods and sources of data collection. Indices and indicators of Economic Activity. Indicators of Social Development and Living Standard.

Reading List
Thirlwall, A. (1994). *Growth and Development with Special Reference to Development Economies*. Macmillan Press Ltd.

UN Statistical Papers, Series M. New York, 1990.

UNDP: *Human Development Reports.*

Various Publications of Ghana Statistical Service.

World Bank 1995: Social Indicators of Development.

STAT 458: Economic and Social Statistics II (Pre-Req. STAT 457**)**
This course is aimed at building on the knowledge acquired by students in STAT 457. Topics to be discussed include: review of statistical analysis of topics and problems in microeconomics, macroeconomics, business, finance,-forecasting, data quality, and policy evaluation. Introduction to the System of National Accounts (SNA). The system, its Accounts and their corresponding economic activities. Input-Output Tables. Social Accounting.

Reading List
Beckerman, W. (1976). *An Introduction to National Income Analysis*. Weidenfied and Nicholson.

Singal, M.S. & Nartey, J.D.H. (1971). *Sources and Methods of Estimation of National Income at Current Prices in Ghana.* Central Bureau of Statistics.

Singal, M.S. (1973). *Input–Out Table of Ghana, 1968*. Central Bureau of Statistics.

Thirlwall, A. (1994). *Growth and Development with Special Reference to Development.* Oxford Press.
Van Arkadie, B. & Charles, R. F. Jnr. *Economic Accounting and Development Planning. Economies*. Macmillan Press Ltd.

STAT 459: Statistical Quality Control
This course introduces students to techniques of statistical quality control. Topics to be discussed include: Development of control charts, acceptance sampling and process capability indices, reliability modelling, regression models for reliability data. Single and double acceptance sampling plans for attributes and variables. Some applications to real-life data will be discussed in class.

Reading List
Montgomery, D.C. (1985). *Introduction to Statistical Quality Control* (6th Edition). Wiley

Montgomery, D.C. (2012). *Statistical Quality Control* (7th Edition). Wiley.

Montgomery, D.C. (2002). *Introduction to Statistical Quality Control, Student Resource Manual*. Wiley.

Wheeler, D.J. (2010). *Understanding Statistical Process Control* (3rd Edition). SPC Press.

Wetherill, G. B & Brown, D.W. (1990). *Statistical Process Control, Theory and Practices.* London, Chapman and Hill.

STAT 464: Statistical Computing with R

This course is aimed at developing students programming and computational skills in the R package. Topics to be considered include: Simulation of random variables from probability distributions, the visualization of multivariate data, Monte Carlo integration and variance reduction methods, Monte Carlo methods in inference, bootstrap and jack-knife, permutation tests, Markov chain Monte Carlo (MCMC) methods, and density estimation. Selection of examples that illustrate the application of numerical methods using R functions.

Reading List

Albert**,** J**. (**2009). *Bayesian Computation with R.* Springer.

Carlberg, C. (2017*). R for Microsoft® Excel Users: Making the Transition for Statistical Analysis*. Que Publishing.

Charpentier, A. (2014).*Computational Actuarial Science with R.* Chapman and Hall/CRC.

Chung, K. L. (2012). *Elementary probability theory with stochastic processes*. Springer Science & Business Media.

Rizzo, M. L. (2007). *Statistical Computing with R*.

Schinazi, R. B. (2011). *Probability with statistical applications*. Springer Science & Business Media.

Witten, D., G., Hastie, T. & Tibshirani, R. (2013). *An Introduction to Statistical Learning: with Applications in R* (6th Edition). Springer.