**Haramaya University**

**VICE-PRESIDENT FOR ACADEMIC AFFAIRS**

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**Syllabi for Masters programs**

**Compiled By THE OFFICE OF ACADEMIC ProgramS Directorate**

**May 2020**

**Haramaya University**

**College of Natural and Computational Siences**

**Department of Biology**

**Program Name: MSc in Botany**

1. **Course Breakdown by Semester**

**Year I, Semester I**

|  |  |  |  |
| --- | --- | --- | --- |
| No. | Course Title | Course Code | Credit Hrs |
| 1 | Biochemistry | BioB 501 | 3 |
| 2 | Molecular Genetics | BioB 521 | 3 |
| 3 | Plant Pathology | BioB 513 | 2 |
| 4 | Soil Microbiology | BioB 503 | 2 |
| 5 | Plant Ecology and Species Chemical Interactions | BioB 511 | 3 |
| 6 | Advanced Plant Systematics | BioB 515 | 2 |
|  | Total Credit Hours |  | 15 |

# Year I, Semester II

|  |  |  |  |
| --- | --- | --- | --- |
| No. | Course Title | Course Code | Credit Hrs |
| 1 | Plant Breeding and Biotechnology | BioB 522 | 3 |
| 2 | Climate Change and Biodiversity Conservation | BioB 518 | 2 |
| 3 | Advanced Plant Physiology | BioB 514 | 3 |
| 4 | Ethnobotany | BioB 516 | 2 |
| 5 | Soil and Plant Nutrition | BioB 510 | 2 |
| 6 | Research Methodology | BioB 504 | 2 |
| 7 | Current Topics in Botanical Sciences | BioB 601 | 1 |
|  | Total Credit Hours |  | 15 |

# Year II, Semester 1 and 2

|  |  |  |  |
| --- | --- | --- | --- |
| No. | Course Title | Course Code | Credit Hrs |
| 2 | Thesis Research (Literature Review, Proposal Development and Approval) | BioB 612 | 6 |
|  | Total Credit Hours |  | 6 |

**b) Course Description**

**Course Name: Biochemistry: BioB 501 (3 credit Hrs)**

**Introduction;** **Amino acids;** **Proteins**: structure, function and metabolism; **Carbohydrates:** structure**,** classification, metabolism; **Lipids:** structure, classification, metabolism; Membrane structure and mechanism of membrane transport; **Nucleic acids: p**yrimidine and purine synthesis, Nucleotide structure, DNA and RNA structures and functions; **Photosynthesis-photophase vs. scotophase reactions;** C3, C4 and CAM metabolisms; **Phytohormones: chemistry, functions, and mechanisms of action; Secondary compounds (Overview)**

**Learning outcome**

After completing this course, students should be able to:

* Explain the structure and synthesis of the different biomolecules
* Discuss the metabolisms of the different biomolecules
* Describe the metabolic pathways of the different biomolecules in energy production and other metabolite synthesis
* Discuss the of membrane transport mechanisms
* Characterize enzymes and their catalytic activities

**Mode of course delivery**

This course will be offered through:

* Classroom teching via traditional lecturing by the help of LCD projector
* Group discussion in classroom
* Lab activities to complement classroom lecture

**Mode of assessment**

Continuous assessment will be made through:

* Assignments (10%)
* Term paper writing and presentation (20%)
* Written exams (70%)

**Course Name: Molecular Genetics: BioB 521 (3 credit Hrs)**

DNA Structure and Manipulation: Separation and identification of genomic DNA fragments; Amplification of genomic DNA fragments; DNA markers found in genomic DNA. Molecular Biology of DNA Replication and Recombination: Initiation by a primosome complex; Chain elongation and proofreading; Sequencing of genomic DNA; Molecular mechanisms of recombination. Molecular Biology of Gene Expression: Colinearity between coding sequences and polypeptides; Transcription; RNA processing in eukaryotes; Translation; The standard genetic code. Molecular Mechanisms of Gene regulation: Transcriptional regulation in prokaryotes; Regulation in bacteriophage lambda; Transcriptional regulation in eukaryotes; translational control by DNA rearrangements. Genetic Linkage and Chromosome Mapping: Linkage and recombination of genes in a chromosome; Genetic mapping in a three point testcross; Mapping by tetrad analysis.

**Learning outcome**

After completing this course, students should be able to:

* Explain gene mutations and DNA damage, and mechanisms of repair
* Discuss and differentiate para-sexual mechanisms in bacteria
* Describe the essential principles of gene expression and its regulation
* Be familiar with extrachromosomal heredity, types, structure and applications of plasmids
* Describe various concepts in eukaryotic genetics with emphasis on linkage, chromosome mapping and crossing over

**Mode of course delivery**

This course will be offered through:

* Classroom teaching via traditional lecturing by the help of LCD projector
* Group discussion in classroom
* Lab activities to complement classroom lecture

**Mode of assessment**

Continuous assessment will be made through:

* Assignments (10%)
* Term paper writing and presentation (20%)
* Written exams (70%)

**Course Name: Plant Pathology: BioB 513 (2 credit Hrs)**

Major group of plant pathogens: fungi, bacteria, viruses, plant parasitic nematodes, parasitic higher plants; identification and biology of plant pathogens; pathogen transmission, penetration and invasion; plant disease symptoms; plant pathogenic disease prevention and control.

**Learning outcome**

After completing this course, students should be able to:

* List major groups of plant pathogens
* Identify major groups of plant pathogens
* Explain the mechanism of plant pathogen transmission
* Diagnose plant diseases caused by pathogens
* Discuss plant pathogenic disease prevention and control mechanisms

**Mode of course delivery**

This course will be offered through:

* Classroom teaching via traditional lecturing by the help of LCD projector
* Group discussion in classroom
* Field visit to assess plant pathogenic diseases and collect diseased plants to isolate pathogens in the lab
* Lab activities to identify the major plant pathogenes and pathogenic disease symptoms

**Mode of assessment**

Continuous assessment will be made through:

* Assignments (10%)
* Term paper writing and presentation (20%)
* Field and lab reports (10%)
* Written exams (60%)

**Course Name: Soil Microbiology: BioB 503 (2 credit Hrs)**

Soil microbes important to plants: Types, Role of soil microbes in rhizosphere (harmful/beneficial); Soil microbes-root associations: Rhizobia (mechanisms of association, types, uses etc.), mycorrhizas: Types (endo and ecto-mycorrhiza), mechanisms of associations and benefits; Isolation and identification of soil microorganisms: rhizobia, mycorrhizas (endo and ecto-mycorrhiza); Techniques in mycorrhizas study: spore counting and quantification of mycorrhizal root; Role of soil microbes in nutrient availability and cycling in rhizosphere.

**Learning outcome**

After completing this course, students should be able to:

* Explain the role of soil microbes in plants’ life
* Discuss the mechanisms of association of plants’ root and soil microbes
* Isolate and identify the different soil microbes
* Explain the role of soil microbes in nutrient cycling

**Mode of course delivery**

This course will be offered through:

* Classroom teaching via traditional lecturing by the help of LCD projector
* Group discussion in classroom
* Lab activities to identify the different soil microbes

**Mode of assessment**

Continuous assessment will be made through:

* Assignments (10%)
* Term paper writing and presentation (20%)
* Field and lab reports (10%)
* Written exams (60%)

### Course Name: Plant Ecology & Species Chemical Interactions: BioB 511 (3 credit Hrs)

Introduction to various approaches of studying ecology; Plant community: concepts and methods of study; Major terrestrial plant communities, their distribution, limiting factors and adaptations; Ecological Succession; Ecological energetics, nutrient cycling,; Chemical basis of species interactions; Ecological role of Secondary compounds: allelochemicals in species interactions (Plant-plant communication, plant-insect interaction, plant-microbial interaction); Defensive role of secondary compounds against biotic (herbivory and microbial pathogens) and abiotic stresses.

**Learning outcome**

After completing this course, students should be able to:

* List different approaches of studying ecology
* Describe the major terrestrial plant community types
* Explain the mechanisms of ecological successions
* Discuss mechanisms of energy and nutrient flow in an ecosystem
* Explain the role of secondary metabolites on plant-plant, plant-animal interactions through chemicals (secondary compounds)
* Discuss the defensive role of secondary compounds against biotic and abiotic stresses

**Mode of course delivery**

This course will be offered through:

* Classroom teaching via traditional lecturing by the help of LCD projector
* Group discussion in classroom
* Field visit to observe the different terrestrial ecosystems and plant species composition
* Lab activities to observe plant-plant/plnt-insect interactions

**Mode of assessment**

Continuous assessment will be made through:

* Assignments (10%)
* Term paper writing and presentation (20%)
* Field and lab reports (10%)
* Written exams (60%)

**Course Name: Advanced Plant Systematics: BioB 515 (2 credit Hrs)**

Definitions and importance of taxonomy; Pre-Darwinian and post-Darwinian theories of biological classification: Essentialism, Nominalism, and Empiricism, evolutionary systematics and phylogenic systematics; Study of the systems of classification by Linnaeus; Bentham and Hooker’s system of classification; Comparative study of the systems of classification by Engler and Bessey including a critical evaluation of their basic tenets; Hutchinson and Takhtajan.; Plant Nomenclature: principles, author citation – Type Method and different types –Publication of names, Rules of Priority, definitions of nomenclatural terms; Construction of taxonomic keys and their utilization; Modern concepts and trends in Plant taxonomy: Cytotaxonomy, Chemotaxonomy, Numerical Taxonomy, Molecular Taxonomy, Cladistics; Study of important Ethiopian plant families based on morphological peculiarities, economic importance, etc.

**Learning outcome**

After completing this course, students should be able to:

* Explain the different approaches of biological classification
* Compare and contrast systems of classification by different taxonomist
* Explain the essential principles of plant nomenclature
* Construct the different taxonomic keys
* Compare and contrast between the different modern taxonomic approaches
* Practice herbarium techniques

**Mode of course delivery**

This course will be offered through:

* Classroom teaching via traditional lecturing by the help of LCD projector
* Group discussion in classroom
* Field visit to collect plant specimen for herbarium activity

**Mode of assessment**

Continuous assessment will be made through:

* Assignments (10%)
* Field and herbarium reports (20%)
* Written exams (70%)

**Plant Breeding and Biotechnology: BioB 522 (3 credit Hrs)**

Plant breeding - History; Genetic resources - centers of diversity and origin of crop plants, Law of homologous variation, genetic resources, Plant breeding-Mode of reproduction and breeding strategies, Plant diseases and pests and defensive mechanisms, Breeding of self and cross pollinated and vegetatively propagated crop plants, Heterosis breeding, Polyploidy and haploids in breeding, Wide hybridization, Mutation breeding, Breeding crops to contain useful and adaptive traits; seed production and variety development and its conservation; Marker assisted breeding using molecular probes (RAPDs, RFLPs and AFLPs); Plant tissue culture and somatic cell genetics – role of growth regulators, Micropropagation, Artificial seeds, Germplasm storage *In vitro*; Embryo rescue, Haploids and triploids, Secondary products, Protoplast culture and fusion, Hybrids, Somaclonal variation, Mutant selection *In vitro* and by transposon tagging, Plant genetic engineering using recombinant DNA techniques, T-DNA and viral genome-derived plant vectors, Transformation using plant protoplasts, Particle gun-mediated transformation, Organelle transformation, Engineering of crops for useful agronomic traits and metabolic pathways, Transgene silencing, Strategies used to avoid gene silencing and improve gene expression in transgenic plants, Description and uses of antisence RNA, ribozymes in plants; Ethics and plant genetic engineering.

**Learning outcome**

After completing this course, students should be able to:

* Describe the history of plant breeding and various breeding strategies
* Apply different approaches in the conventional breeding
* Explain modern breeding techniques using RAPD, RFLP and AFLP
* Become proficecient in the use plant tissue culture tecchniques
* Develop an appreciation of plant genetic engineering in plants through gene manipulation
* Discuss ethical issues associated with plant genetic engineering

**Mode of course delivery**

This course will be offered through:

* Classroom teaching via traditional lecturing by the help of LCD projector
* Group discussion in classroom
* Lab activities through tissue culture techniques, DNA isolation

**Mode of assessment**

Continuous assessment will be made through:

* Assignments (15%)
* Term paper writing and presentation (15%)
* Written exams (70%)

### Course Name: Climate Change and Biodiversity Conservation: BioB 518 (2 credit Hrs)

This course deals with changing climate from Paleo context to current; Drivers of climate change-greenhouse gases (CO2, CH4, O3, NOx,); Biodiversity concept; Levels of Biodiversity-genetic diversity, species diversity, ecosystem diversity, measures of biodiversity; global geographic patterns of biodiversity; climate change and biodiversity; Ecological impacts of climate change: ecosystem shift; habitat loss/reduction, invasion by new species, species extinction and biodiversity loss in general. Species extinction, vulnerability to extinction and biodiversity hot spots; conservation biology-origin and philosophies of conservation-preservationist vs. Conservationist philosophy, why conserve biodiversity, economic evaluation of biodiversity (direct & indirect values) the basic rule of conservation genetics and its methods: in situ/ex situ conservation; Biopiracy.

**Learning outcome**

After completing this course, students should be able to:

* Explain trends of climate change from paleoenvironment to present
* List drivers of climate change
* Define and discuss the concept, levels and measures biodiversity
* Discuss global geographic patterns of biodiversity
* Explain impact of climate change on biodiversity
* Discuss various factors involved in the biodiversity loss
* Describe the mechanism of biodiversity conservation

**Mode of course delivery**

This course will be offered through:

* Classroom teaching via traditional lecturing by the help of LCD projector
* Group discussion in classroom
* Independent learning to prepare term paper
* Field visit

**Mode of assessment**

Continuous assessment will be made through:

* Assignments (10%)
* Term paper writing and presentation (20%)
* Written exams (70%)

**Course Name: Advanced Plant Physiology: BioB 514 (3 credit Hrs)**

Plant growth and development; Seed and seed physiology; Plant hormones and growth regulators: role in plant growth and development, mode of action and bioassays; Plant-water-relations: soil-plant-atmosphere continuum; Plant nutrition-dynamics: nutrient uptake, metabolism and assimilation; Photosynthesis (C3, C4 & CAM); Translocation of photoassimilates; Photorespiration; respiration, etc., Photomorphogenesis; Impact of abiotic stress factors on plant physiology.

**Learning outcome**

After completing this course, students should be able to:

* Explain cellular activities that govern plant growth and development
* Describe structure of seeds
* Discuss seed physiology and germination processes
* List plant growth hormones and explain their role in plant growth and development
* Explain mechanism of water and uptake and their movement in plants
* Discuss photosynthesis
* Explain plants’ responses to various abiotic stresses

**Mode of course delivery**

This course will be offered through:

* Classroom teaching via traditional lecturing by the help of LCD projector
* Group discussion in classroom
* Independent learning to prepare term paper
* Lab activities
* Mini-project

**Mode of assessment**

Continuous assessment will be made through:

* Assignments (10%)
* Lab reports (10%)
* Term paper writing and presentation (20%)
* Written exams (60%)

**Course Name: Ethnobotany: BioB 516 (2 credit Hrs)**

Introduction to ethnobotany; Ethnoecology; Origin of agriculture- traditional, crop domestication, conservation of genetic resources; Classification of ethnobiology. Quantitative ethnobotany; Field techniques in ethnobotanical survey. Traditional uses of plants in medicine, food and other purposes. Role of indigenous knowledge in the conservation in the conservation of PGR. Traditional knowledge and Intellectual property rights (IPR).

**Learning outcome**

After completing this course, students should be able to:

* Explain the concepts of ethnoecology and traditional agricultural practices
* Discuss the important principles of quantitative ethnobotany
* Well aware of ethnomedicinal, ethnofood and other traditional plants
* Discuss the essential principles of IPR with regard to traditional knowledge

**Mode of course delivery**

This course will be offered through:

* Classroom teaching via traditional lecturing by the help of LCD projector
* Group discussion in classroom
* Independent learning to prepare term paper
* Field expeditions

**Mode of assessment**

Continuous assessment will be made through:

* Assignments (10%)
* Field reports (10%)
* Term paper writing and presentation (20%)
* Written exams (60%)

### Course Name: Soil and Plant nutrition BioB 510 (2 credit Hrs)

An overview of soil taxonomy with special emphasis on Ethiopian soils; Soil composition and type; Plant nutrients: macro and micro-nutrients, their uptake by plants and use, symptoms of deficiency and overabundance of plant essential nutrients; Soil fertility management; Characterization of the physical and chemical properties of soils under lab conditions.

**Learning outcome**

After completing this course, students should be able to:

* Describe features of the different soil types
* Explain the roles of plant essential nutrients
* Discuss dynamics of plant nutrient uptake
* Explain symptoms of the different plant essential nutrients

**Mode of course delivery**

This course will be offered through:

* Classroom teaching via traditional lecturing by the help of LCD projector
* Group discussion in classroom
* Independent learning to prepare term paper
* Lab activities

**Mode of assessment**

Continuous assessment will be made through:

* Assignments (10%)
* Lab reports (10%)
* Term paper writing and presentation (20%)
* Written exams (60%)

**Course Name: Research Methodology: BioB 504 (2 credit Hrs)**

Research-definition, types (e.g., descriptive vs. experimental); Research methodology vs. methods/techniques; Research design- problem identification, formulation of hypothesis, sampling techniques; Experimental design: basic principles (randomization, replication, principle of local control), Formal experimental designs- Completely randomized design (C.R. Design), Randomized block design (R.B. Design), Latin square design (L.S. Design), Factorial designs; Data analysis: statistical approaches, parametric vs. non-parametric analysis; selection and use of appropriate statistical analysis; Writing research reports; Reviewing and oral presentation of published research articles.

**Learning outcome**

After completing this course, students should be able to:

* Explain the nature of the different research approaches
* Explain steps in scientific research
* Design experiments
* Practice the use of appropriate statistical software to analyze hypothetical data
* Review and present research papers

**Mode of course delivery**

This course will be offered through:

* Classroom teaching via traditional lecturing by the help of LCD projector
* Group discussion in classroom
* Independent learning to review and make oral presentations on research articles

**Mode of assessment**

Continuous assessment will be made through:

* Assignments (15%)
* Group/individual presentations (20%)
* Written exams (65%)

**Course Name: Current Topics in Botanical Science: BioB 601 (1 credit Hr)**

An in-depth study of the current literature on a topic or topics selected by the instructor. Students will prepare a review article and present it to their peers and other interested audiences.

**Learning outcome**

After completing this course, students should be able to:

* Write standard scientific papers
* Make scientific oral presentaions

**Mode of course delivery**

This course will be offered through:

* Independent learning to review and make oral presentations on research articles

**Mode of assessment**

Continuous assessment will be made through:

* Oral presentaations presentations (50%)
* Submission of reviw papers (50%)

**Course Name: Thesis Research: BioB 612 (6 credit Hrs)**

The research emphasizes on basic or applied aspects of Botanical Sciences, Ethnobotany and Plant Ecology dealing with problems related to agriculture, industry, environment and health etc. Such work can be undertaken with department academic staff members (advisor(s), in collaboration with industry and research organizations. It may begin during Year I, Semester II and proceed through both semesters (I and II) of year II. The work includes proposal preparation and defense, progress reports and the final thesis open defense examination.

**Program Name: Master of Science in Biotechnology**

1. **Course break down by semester:**

**Year I, Semester I**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No** | **Course Code** | **Course Title** | **Credit Hours** |
| **1** | **BIOT 522** | **Biochemistry** | **3** |
| **2** | **BIOT 511** | **Molecular Genetics** | **3** |
| **3** | **BIOT 531** | **Immunotechonolgy** | **2** |
| **4** | **BIOT 522** | **Biophysics and Development Biology** | **2** |
| **5** | **BIOT 552** | **Enzymology and Enzyme technology** | **3** |
|  | | **Total credit .hr** | **13** |

# Year I, Semester II

|  |  |  |  |
| --- | --- | --- | --- |
| **S. No** | **Course Code** | **Course Title** | **Credit Hours** |
| **1** | **BIOT 512** | **Microbial Biotechnology** | **3** |
| **2** | **BIOT 523** | **Biology of cloning Vectors** | **2** |
| **3** | **BIOT 541** | **Bioinformatics** | **2** |
| **4** | **BIOT 521** | **Plant Molecular Biology and Intellectual property rights** | **3** |
| **5** | **BIOT 532** | **Recombinant DNA Technology** | **2** |
| **6** | **BiAp 551** | **Research Methodology** | **2** |
|  | | **Total credit hr** | **14** |

**Year II, Semester 1**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No** | **Course Code** | **Course Title** | **Credit Hours** |
| **1** | **BIOT 514** | **Current Topics In Biotechnology** | **1** |
| **2** | **BIOT 550** | **Animal Biotechnology** | **2** |
| **3** | **BIOT 515** | **Thesis Research Work\*** |  |
|  |  | **Total Credits Hrs** | **3** |

\* This course starts at year II Semester I to be completed at Year II Semester II

**Year II, Semester II**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No** | **Course Code** | **Course Title** | **Credit Hours** |
| **1** | **BIOT 515** | **Thesis Research Work** | **6** |

**b) Course Descriptions**

**Course Name: BIOT 522: Biochemistry (3 Credit Hrs)**

Principles of Bioenergetics; Glycolysis and the catabolism of hexoses, Citric acid cycle, Oxidative phosphorylation; Oxidation of fatty acids and amino acids; Photophosphorylation; Biosynthesis of carbohydrates, lipids, amino acids, nucleotides and related molecules. Integration and hormonal regulation of mammalian metabolism. Biological membranes and mechanisms of transport in cells. Prostaglandins, leukotrienes, thrombaxanes. Interferons and interleukins; Antibiotics; Alkaloids; Animal pigments. Cytoskeletal organization; chemical synthesis of peptides and oligosaccharides

**Course Name: BIOT 511:**  **Molecular genetics (3 Credit Hrs)**

Gene as the unit of mutation and recombination. Identification of DNA as the genetic material. Mutations; molecular nature; mutagenesis by nitrous acid, hydroxyl amine, alkylating agents, intercalaters and UV; origin of spontaneous mutations and control. Para-sexual processes in bacteria: transformation, transduction and gene transfer through conjugation - the phenomena, mechanisms and applications. Fine structure genetic analysis with examples. Recombination control; models and mechanisms. Gene as the unit of expression; Co-linearity of gene and polypeptide; Elucidation of the genetic code; Wobble base pairing. Suppression of non-sense, mis-sense and frame shift mutations; Regulation of gene expression, the operon concept – positive and negative control, attenuation control. Control sequences; promotor, operator, terminator and attenuator. DNA damage and repair: DNA damage by UV, alkylating agents, cross-linkers. Mechanisms of repair: photoreactivation, excision repair, recombinational repair. The SOS and adaptive responses and their regulation. Heat shock response; Extrachormosomal heredity: biology of plasmids- discovery, types and structure of F-RTF, COI-factors and Ti-replication and partitioning. Incompatibility and copy number control. Natural and artificial plasmid transfer and their applications. Genetics of eukaryotes; gene linkage and chromosome mapping, crossing-over: three point cross, tetrad analysis. Complementation; Organization of chromosomes: specialized chromosomes, chromosome abnormalities; quantitative inheritance and population genetics. Developmental genetics using *Drosophila* as a model system; .Somatic cell genetics.

**Course Name: BIOT 531: Biophysics and structural biology (2 Credit Hrs)**

Physics and biology: scope and methods of biophysics. Levels of molecular organization; Understanding structures of proteins at different levels- primary, secondary, tertiary and quaternary structures; conformational analysis and forces. Understanding structures of nucleic acids at different levels (primary, secondary, tertiary and quaternary); analysis of interactions; protein-nucleic acid interactions. Polysaccharides; Association of macromolecules: lipids in biological membranes, protein in biological membranes. Molecular mechanics and dynamics. Structural biology: role and importance. Techniques; CD/ORD, Fluorescence spectroscopy, Raman Spectroscopy, Electron Microscopy, NMR, X-ray crystallography, applications; understanding regulation and kinetics of biological activity with specific examples.

Theory and applications of colorimeter, spectrophotometer, pH meter & buffers; Methods of protein estimation (Lowry and Bradford). Thin layer chromatography. Screening and identification of industrially important microorganisms. Production of an extracellular enzyme from bacteria/fungus and downstream processing –a) Ultrafiltration, b) Ammonium sulphate precipitation, c) Dialysis, d) Ion exchange chromatography d) Gel permeation chromatography etc. Electrophoresis: Polyacrylamide gel Electrophoresis; Radioactive labeling and measurement of radioactivity; Demonstration of GLC and HPLC.

**Course Name: BIOT 552: ENZYMOLOGY AND ENZYME TECHNOLOGY ( 2 Credit Hrs)**

Enzyme classification and nomenclature, General properties of enzymes, factors affecting enzyme activities (pH, temperature, ions etc.). Steady state kinetics: Michaelis – Menten, Lineweaver-Burke, Eadie-hofstee and Hanes-Woolf equations and Km value; Enzyme inhibitors. Pre-steady state kinetics, Fast kinetics to elucidate the intermediates and rate limiting steps (Flow and Relaxation methods). Enzyme specificity. Evidences for enzyme substrate complex. Nucleophilic attack. Role of metal ions in enzyme catalysis. Mechanism of enzyme action e.g. Lysozyme, chymotrypsin, DNA polymerases, RNAase, etc. Zymogens and enzyme activation. Allosteric interactions and product inhibition; Complex kinetics and analyses; Enzyme extraction methods: Assay and purification of enzymes including membrane bound enzymes; Lipid-protein interaction and effect of fluidity on enzyme activity; Coenzymes. Clinical and Industrial applications of enzymes; Immobilization of enzymes and their applications; Ribozymes and their applications; Enzyme engineering.

**Course Name: BIOT 523: BIOLOGY OF CLONING VECTORS ( 2 Credits Hrs)**

DNA transactions: replication, repair, recombination, and restriction. Plasmid biology - plasmids of gram negative bacteria: ColE1, R1, pT181, psc101, Plasmids of gram positive bacteria, P1J101. SLP and SCP plasmids of streptomyces. Plasmid vectors of various types. Biology of lambda bacteriphage: Lambda phage as natural *in vivo* vector, *in vitro* construction of a lambda vector, classes of lambda vectors; Cosmid vectors and their use; M13 vectors and their use; streptomyces phage vectors. How to choose the right type of vector. Specialized vectors: expression vectors, orf vectors, gene fusion vectors etc. Animal viruses and gene cloning; Agrobacterial plasmid biology and their use in plant genetic engineering; Vectors for yeast.

**Course Name: BIOT 541: BIOINFORMATICS ( 2 Credits Hrs)**

Information theory and biology; Entropy, Shannon’s formula, divergences from equiprobability and independence; Markov chains, ergodic processes, redundancy, application to DNA and protein sequences.

Use of databases in biology: Sequence databases, structural databases, sequence analysis in proteins and nucleic acids, structural comparisons, genome projects.

**Course Name: BIOT 521: PLANT MOLECULAR BIOLOGY (3 Credits Hrs)**

Plant genome organization, structural features of a representative plant gene, gene families in plants. Organization of chloroplast genome, nucleus-encoded and chloroplast-encoded genes for chloroplast proteins, targeting of proteins to chloroplast. Organization of mitochondrial genome, nuclear and mitochondria encoded genes for mitochondrial proteins. RNA editing in plant mitochondria, mitochondrial genome and cytoplasmic male sterility. Seed storage proteins, Maize transposable elements, organization and function, transposable elements in transgenic plants. Regulation of gene expression in plant development. Plant hormones and phytochrome.

Symbiotic nitrogen fixation in legumes by Rhizobia – biochemistry and molecular biology, *Agrobacterium* and crown gall tumors. Mechanism of T-DNA transfer to plants, Ti plasmid vectors for plant transformation, Agroinfection. Classification and molecular biology of plant viruses. Molecular biology of plant stress responses.

Genetic engineering in plants, selectable markers, reporter genes and promoters used in plant vectors. Direct transformation of plants by physical methods. Genetic engineering of plants for virus resistance, post resistance, herbicide tolerance, cytoplasmic male-sterility, delay of fruit ripening, resistance to fungi and bacteria. Production of antibodies, viral antigens and peptide hormones in plants, pagene silencin gin transgenic plants, DNA markers in marker-assisted selection and plant breeding. Management aspects of plant genetic engineering. Tagging, mapping and cloning of plant genes. Molecular biology of plant pathogen interactions.Intellectual property rights: Principles and importance.

**Course Name: BIOT 532: RECOMBINANT DNA TECHNOLOGY ( 2 Credits Hrs)**

Core techniques in gene manipulation; Cutting and Joining DNA; Introduction of DNA into Cells. Cloning strategies, construction of genomic libraries and cDNA libraries, .Probe construction, recombinant selection and screening. Analysis of expression, analysis of recombinant DNA, sequencing, mutagenesis, altered expression and engineering genes, .DNA amplification using polymerase chain reaction, .key concepts. Analysis of amplified products, .Applications of PCR; Ligase chain reaction, .Expression systems and their applications; .*E.coli*., *Streptomyces*, Yeast, baculovirus and animal cells as cloning hosts.

**Course Name: BIOT 531: IMMUNOTECHNOLOGY (2 credits Hrs)**

Hybridoma techniques and monoclonal antibody production. Myeloma cell lines, Fusion of myeloma cells with antibody producing B-cells, Fusion methods. Selection and screening methods for positive hybrids. Cloning methods. Production, Purification and characterization of monoclonal antibodies. Application of monoclonals in biomedical research, in clinical diagnosis and treatment. Production of human monoclonal antibodies and their applications.

T-cell cloning; Mechanism of antigen recognition by T- and B-lymphocytes. Structure, function and synthesis of lymphokines. Importance of antigen presentation and MHC class II molecules in T-cell cloning. Antigen specific and alloreactive T-cell cloning. Use of T-cell cloning in understanding the immunologically relevant antigens and T-cell epitopes. Application of T-cell cloning in vaccine development.

Immunity to viruses, bacteria and parasites. Genetic control of immune response. MHC associated predisposition to diseases; Infectious diseases: Leprosy, Tuberculosis, Malaria, Filariasis, Amoebiasis, Rabis, Typhoid, Hepatitis, AIDS. Principles and strategy for developing vaccines. New methods of vaccine preparation. Immunodiagnosis of infectious diseases.

**Course Name: BIOT 512: MICROBIAL BIOTECHNOLOGY (3 credits Hrs)**

Intrachromosomal gene cloning in organisms other than *E.coli*. Degradation of toxic chemicals by pseudomonads. Protein secretion in bacteria. Biological insect control. Microbes as food and feed for animals. Microbial mining and ore-leaching. Pollution and waste control. Environmental release and monitoring of genetically modified/engineered organisms.

**Course Name: BIOT 550: ANIMAL BIOTECHNOLOGY (2 Credits Hrs)**

Genetic Engineering in animals. Transformation of animal cells. Cloning vectors and expression vectors; animal viral vectors and yeast vectors. Genetic engineering as applied to specific areas – regulatory proteins, blood products, vaccines and hormones.

Production of useful proteins in transgenic animals. AIDS. Oncogenes and anti-oncogenes – phase display technology. Signal transduction.

Baculoviruses in biocontrol and foreign gene expression. Biotechnology of aquaculture. Transgenic animals - *In vitro* fertilization and embryo transfer.

Use of nucleic acid probes and antibodies in clinical diagnosis and tissue typing. Mapping of human genome. RFLP and applications. Gene therapy. Ethical issues in animal biotechnology. Management aspects of biotechnology and genetic engineering.

**Course Name: BIOT 514: Current Topics in Biotechnology (1 Credit hour )**

An in-depth study of the current literature on a topic or topics selected by the instructor

**Course Name: BiAp 551:**  **Research Methodology (2 Credit hours)**

Research methods; historical development; descriptive and experimental methods; characteristics of a good research tool, writing research report; sampling techniques, normal curve, testing hypothesis about mean and other statistics, significance of differences between means, t test, f-test and chi-square test; simple analysis of variance; analysis of qualitative data; correlation and prediction; product moment and rank difference correlation; correlation coefficients, linear regression; partial and multiple correlation, elements of multiple regression analysis

**Course Name: BIOT** **515:** **Thesis Research Work (6 Credit hours)**

The research emphasizes on applied aspects of Biotechnology dealing with problems related to industry, environment and health. Such work is ordinarily undertaken in collaboration with industry, research organizations and department academic staff members. It may begin during Year I, Semester II and proceed through both semesters (I and II) of year II. The work includes proposal preparation and defense, progress reports and the final thesis open defense examination.

**Program Name: Master of Science in Genetics**

1. **Course Breakdown by Semester**

**Year I, Semester I**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No** | **Course Code** | **Course Title** | **Credit Hours** |
| **1** | **BIOG 511** | Concepts of Genetics | **3** |
| **2** | **BIOG 512** | **Population genetics** | **2** |
| **3** | **BIOG 521** | **Concepts of Biochemistry** | **3** |
| **4** | **BIOG 522** | **Cytogenetics and Genome Organization** | **3** |
| **5** | **BIOG 513** | **Gene function** | **2** |
|  | | **Total credit .hr** | **13** |

# Year I, Semester II

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No** | **Course Code** | **Course Title** | **Credit Hours** |
| **1** | **BIOG 552** | **Regulation of Gene Expression** | **3** |
| **2** | **BIOG 553** | **Advanced Microbial Genetics** | **3** |
| **3** | **BIOG 542** | **Human Genetics** | **2** |
| **4** | **BIOG 541** | **Plant Breeding and biotechnology** | **3** |
| **5** | **BiAp 551** | **Research Methodology** | **2** |
|  |  |  |  |
|  | | **Total credit.hr** | **13** |

**Year II, Semester 1**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No** | **Course Code** | **Course Title** | **Credit Hours** |
| **1** | **BIOT 531** | **Recombinant DNA Technology** | **2** |
| **2** | **BIOT 514** | **Current topics in Genetics** | **1** |
| **3** | **BIOT 515** | **Thesis Research Work\*** |  |
|  | **BIOT** | **Total Credits Hrs** | **3** |

\* This course starts at year II Semester I to be completed at Year II Semester II

**Year II, Semester II**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No** | **Course Code** | **Course Title** | **Credit Hours** |
| **1** | **BIOT 515** | **Thesis Research Work** | **6** |

1. **Course Descriptions**

**Course Name: BIOG 511: Concepts of Genetics (3 Cr. hr)**

History and scope of Genetics; Role of Breeding systems; Life cycles of some genetically useful organisms such as viruses, bacteria, *Neurospora*, *Drosophila*, maize and *Homo sapiens*; Mendelian genetics-Mendel’s laws of inheritance; Expression and interaction of genes, allelic and nonallelic interaction; Multiple alleles, pseudo-alleles, complex loci, complementation; Linkage, crossing–over and chromosome mapping. Microbes as model systems in genetic analysis; Principles, basic procedures and terminologies of microbial genetics; Gene mapping in bacteria and viruses, fine-structure mapping. Genetic analysis in fungi, tetrad analysis, gene conversion. Mechanism of recombination, mitotic mapping. Penetration and expressivity, heritability; Qualitative and quantitative traits, polygenic inheritance; Sex-linked inheritance; Interaction of genes and environment; Extranuclear genetics - Role of organellar genome, maternal inheritance and maternal effect. Genetic variation – History, Categories of mutations: Genome, chromosome and gene mutations; Somatic mutations, Extrachromosomal mutations, Origin and frequency of spontaneous mutations, Mutator genes, Mobile genetic elements, Chromosomal alterations and evolution, Induced mutations, Physical and chemical mutagenes; Methods of mutation induction; Screening and selection of mutations, Molecular basis of spontaneous and induced mutations, DNA repair mechanisms, Reversion, Transposon mutagenesis, *In vitro* mutagenesis, Site-specific mutagenesis, Environmental mutagenesis, Genetic hazards of radiation, Radiation damage to proteins, Radiation safety, Genotoxicity test systems.

**Course Name: BIOG 512: Population genetics (2 Credit Hrs)**

History, Genetics of polymorphism, Panmictic & Mendelian population, Hardy-Weinberg genetic equilibrium, Causes of changes in gene frequency (migration, selection, genetic drift, inbreeding and mutations), Natural and artificial selection, Heritability, Genetic load, Fisher’s fundamental theorem, Co-adapted gene complex, Super genes, Linkage disequilibrium, Genetic distance, Molecular genetic analysis of populations, Mechanisms of evolution and speciation.

**Course Name: BIOG** **521:** **Concepts of Biochemistry (3 Credit Hrs)**

The living versus non-living state: Lehninger’s thesis of “molecular logic” of life; biomolecules: building blocks, macromolecules; informational macromolecules. Proteins as informational macromolecules; chemistry of aminoacids; the primary, secondary and tertiary structure of polypeptides; peptides; peptide subunits and quaternary structure; metabolism of proteins and aminoacids. Enzymes as biocatalysts; specificity of enzyme kinetics; inhibition of enzyme action; assay of enzymes; mechanism of enzyme action: regulation of enzyme activity *In vitro*; enzyme classification. Cellular metabolism: energy-yielding and energy-requiring processes; metabolic pathways; thermodynamics of cellular reactions; energy-rich compounds; biological oxidation and its coupling to ATP synthesis. Laws of Thermodynamics: Energy production and transduction in autotrophs; photosynthesis; mitrochondrial oxidative phosphorylation - the chemiosmotic theory; organizational and chemistry of energy transducing machinery of the eukaryotic cells; redox potential. Metabolic cycles and energy production: the Embeden-Meyerhof Parnas pathway; the hexose-monophosphate shunt; oxidation of fatty acids; significance of the TCA cycle. Gluco-and glycogenolysis; regulation of carbohydrate metabolism. Integration and regulation of metabolic pathways; hormones as regulators of metabolism and development; chemistry and mechanisms of action of hormones. Fatty acid breakdown and synthesis; chemistry of lipids - their biosynthesis and breakdown; regulation of lipid metabolism; interrelationship between carbohydrates and lipid metabolism. Organization of biological membranes: the fluid-mosaic model and its implication for membrane-mediated cellular events. Techniques in biochemistry; Adsorption and Fluorescence; pH, pK and Buffers used in biology; Hydrodynamic methods; Chromatographic techniques: TLC, GLC, HPLC, FPLC, Gel filtration, ion exchange and affinity chromatography; X-ray diffraction and crystallography and its application in protein structure determination; Microscopy: Bright field, Fluorescence, phase contrast, video and electron microscopy; Radioisotopes and their use in biology - Autoradiography, radioactive labeling of biological macromolecules; Ligand binding, membrane filtration and equilibrium dialysis.

**Course Name: BIOG 522: Cytogenetics and Genome Organization (3 Credit Hrs)**

Chromosome structure & organization: Chromatin structure, nucleosomal and higher order structures, morphology and basic functions; Techniques in the study of chromosomes and applications. Mitotic and meiotic chromosomes, banding, karyotyping, chromosome labeling and cell cycle analysis, *In situ* hybridization, chromosome painting, gene mapping, somatic cell hybrids, premature chromosome condensation; Special types of chromosomes: sex chromosomes, sex chromatin, B-chromosome, polytene and lambrush chromosomes; Numerical and structural changes in the chromosome. Mechanisms of sex determination in plants and animals. Dosage compensation; Genome organization in viruses, prokaryotes and eukaryotes (animals and plants); Organization of nuclear and organellar genomes; c-value paradox; Techniques in genome analysis, genome mapping and functional genomics; Repetitive DNA-satellite, DNAs and interspersed repeated DNAs, Transposable Elements, LINES, SINES, Alu family, mechanisms of DNA amplification, genome evolution; Fine structure of gene, split genes, pseudogenes, overlapping genes and multigene families. DNA and RNA as genetic material; Chemistry and structure of DNA.

**Course Name: BIOG** **513:** **Gene function (2 Credit Hrs)**

DNA replication in prokaryotes and eukaryotes; Importance of RNA in information transfer, Types of RNA and their structure; Transcription: General principles, assembly of the basic transcription apparatus, types of RNA polymerases, control at initiation, elongation and termination; RNA processing: processing of mRNA, tRNA and rRNA, capping and polyadenylation, RNA editing, mRNA stability; Genetic code, Deciphering the code, Codon usage; Protein synthesis: structure of ribosome, role of tRNA and rRNA, translation and its control, translational introns and protein splicing; Concepts of protein folding and transport, Chaperons, signal peptide hypothesis, transport of proteins to organelles; DNA binding proteins: structure and function, methods of isolating DNA binding proteins and analyzing DNA-Protein interactions. Ribozymes, Antisense RNA.

**Course Name: BIOG 552: Regulation of Gene Expression (3 Credit Hrs )**

Gene regulation in prokaryotes: Operon model of regulation (with examples of lac, trp and ara); Lytic and lysogenic switch in lambda. Gene regulation in eukaryotes: overview of gene regulation in animals and plants using examples of galactose-utilization in yeast; heat shock gene expression; regulation of SV40 and CaMV 35S viral promoters; hormonal control of gene regulation in animals and plants. Regulation of Cell cycle & signal transduction. Global influences on gene expression: chromatin conformation and methylation; Molecular genetics of development: Introduction to developmental biology - Zygote development and differentiation in animals and plants; Model systems to study pattern formation -*Dictyostelium*: Life cycle, aggregation and slug formation, mechanism of cell differentiation in the slug and final body formation; *Caenorhabditis elegans*: cell lineage and mosaic development; vulval cell formation. *Drosophila*: Polarity

determination of embryo by maternal genes, segmentation genes and formation of body segments; Homeotic genes specifying segment identity; Vertebrate limb: specification of axis and limb field, zone of polarizing activity and digit formation, hox genes and limb pattern, regeneration; *Arabidopsis*: Life cycle, embryogenesis and seed development, genes involved in flower development.

**Course Name: BIOG** **553:** **Advanced Microbial Genetics (3 Credit Hrs)**

Methods of genetic analysis; Genetic analysis of mutants: recombination and genetic mapping. Test of allelism, Methods of gene transfer in bacteria -Conjugation: Discovery, nature of donor strains and compatibility, interrupted mating and temporal mapping, Hfr, F', heteroduplex analysis, mechanism of chromosome transfer, molecular pathway of recombination. Chromosome transfer in other bacteria; Transformation: natural transformation systems, Biology of transformation, transformation and gene mapping, Chemical-mediated and electrotransformation; Transduction: discovery, generalized and specialized or restricted transduction, Phage P1 and P22-mediated transduction, mechanism of generalized transduction, abortive transduction, Temperate phage lambda and mechanism of specialized transduction, gene mapping, fine-structure mapping; Techniques for studying bacteriophages - Virulent phage (T4) and Temperate phage (phage lambda), Important aspects of relationship, impunity and repression. Site specific recombination (lambda and P1), transposable phage (phage Mu), genetic organization, and transposition, Plasmids: Types, detection, replication, partitioning, copy-number control and transfer. Properties of some known plasmids; Genetic rearrangements and their evolutionary significance: Phase variation in Salmonella and others; Aspects of fungal Genetics: Meiotic and mitotic mapping, gene conversion, mitotic segregation and recombination, heterothallism and mating type switches. Parasexual analysis - protoplast fusion, transformation, gene disruption, plasmids, retroposon and retrotransposon. Microbial strain improvement: genetic resources and genetics of economically useful and adaptive traits, methods of strain improvement, Prospects of microbial technology and genetic engineering, synthesis of microbial and recombinant products: Fermentation Technology - basic principles and techniques used, applications of fermentation, optimization and scaling-up; Immobilization techniques.

**Course Name: BIOG** **542:** **Human Genetics (2 Credit Hr)**

History and development of human genetics; Organization of the human genome; Genes and chromosome - structure, function and inheritance; Repetitive DNA in human genome – Alu and SINE repeats; Methods for Genetic study in man - Pedigree analysis, Chromosomal analysis, Biochemical analysis, Somatic cell genetics (somatic cell hybrids, monochromosome hybrid panels, gene mapping, hybridoma technology, polyclonal and monoclonal antibodies), Molecular genetic analysis; Mammalian tissue culture techniques; congenital abnormalities; Clinical aspects of autosomal and sex chromosomal disorders, Inborn errors of metabolism; Haemoglobinopathies; Human genome mapping -Physical, Genetic and Microsatellite mapping; Human genome project; inherited human diseases - single gene diseases, Polygenic/multifactorial disease, identification and isolation of disease genes - positional cloning and functional cloning; Cancer genetics; Immunogenetics, Diagnostic genetics (Cytogenetics, Biochemical, Molecular); DNA fingerprinting; Gene manipulation; Gene therapy; Genetic counseling

**Course Name: BIOG** **541:** **Plant Breeding and Biotechnology (3 Credit Hr)**

Plant breeding - History; Genetic resources - centers of diversity and origin of crop plants, Law of homologous variation, genetic resources, Plant breeding-Mode of reproduction and breeding strategies, Plant diseases and pests and defensive mechanisms, Breeding of self and cross pollinated and vegetatively propagated crop plants, Heterosis breeding, Polyploidy and haploids in breeding, Wide hybridization, Mutation breeding, Breeding crops to contain useful and adaptive traits; seed production and variety development and its conservation; Marker assisted breeding using molecular probes (RAPDs, RFLPs and AFLPs); Plant tissue culture and somatic cell genetics – role of growth regulators, Micropropagation, Artificial seeds, Germplasm storage *In vitro*; Embryo rescue, Haploids and triploids, Secondary products, Protoplast culture and fusion, Hybrids, Somaclonal variation, Mutant selection *In vitro* and by transposon tagging, Plant genetic engineering using recombinant DNA techniques, T-DNA and viral genome-derived plant vectors, Transformation using plant protoplasts, Particle gun-mediated transformation, Organelle transformation, Engineering of crops for useful agronomic traits and metabolic pathways, Transgene silencing, Strategies used to avoid gene silencing and improve gene expression in transgenic plants, Description and uses of antisence RNA, ribozymes in plants; Ethics and plant genetic engineering.

**Course Name: BIOG 531:** **Recombinant DNA Technology (2 Credit Hrs)**

Historical emergence of recombinant DNA technology; basic principles and methods; Properties, mode of action and uses of restriction endonucleases and other enzymes; electrophoretic techniques; Cloning - Phage and plasmid vectors, cosmids, shuttle vectors, yeast vectors, artificial chromosomes, chromosome walking, chimeric gene construction; Genomic and cDNA libraries; colony hybridization; Southern blot, northern blot and western blot; Dot and slot blots; Methods of preparing probes; Transformation, selection and expression of cloned DNA; Sequencing of DNA and proteins; Synthesis of oligonucleotides; Site-directed mutagenesis; Protein engineering; Gene isolation and synthesis; Polymerase chain reaction; DNA footprinting; RAPD, RFLP and AFLP; Restriction mapping; Containment (Physical and biological); Application of r-DNA technology in agriculture, health, medicine and industry; Bioethics and geneticengineering.

**Course Name: BIOG** **514:** **Current topics in Genetics (1 Credit Hrs)**

An in-depth study of the current literature on a topic or topics selected by the instructor

**Course Name: BiAp 551:** **Research Methodology (2 Credit hours)**

Research methods; historical development; descriptive and experimental methods; characteristics of a good research tool, writing research report; sampling techniques, normal curve, testing hypothesis about mean and other statistics, significance of differences between means, t-test, f-test and chi-square test; simple analysis of variance; analysis of qualitative data; correlation and prediction; product moment and rank difference correlation; correlation coefficients, linear regression; partial and multiple correlation elements of multiple regression analysis

**Course Name: BIOG** **515:** **Thesis Research Work (6 Credit hours)**

The research emphasizes on applied aspects of Genetics dealing with problems related to industry, environment and health. Such work is ordinarily undertaken in collaboration with industry, research organizations and department academic staff members. It may begin during Year I, Semester II and proceed through both semesters (I and II) of year II. The work includes proposal preparation and defense, progress reports and the final thesis open defense examination.

**Program Name: Master of Science in Microbiology**

1. **Course Breakdown by Semester**

**Year I, Semester I**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No** | **Course Code** | **Course Title** | **Credit Hours** |
| **1** | **BIOM 511** | **Environmental Microbiology** | **3** |
| **2** | **BIOM 521** | **Microbial Physiology and Biochemistry** | **3** |
| **3** | **BIOM 531** | **Virology** | **3** |
| **4** | **BIOM 541** | **Pathogenic Microorganisms** | **3** |
| **5** | **BIOM 551** | **Immunology** | **3** |
| **Total Credit Hr** | | | **15** |

# Year I, Semester II

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No** | **Course Code** | **Course Title** | **Credit Hours** |
| **1** | **BIOM 512** | **Microbial and Molecular Genetics** | **3** |
| **2** | **BIOM 522** | **Industrial Microbiology** | **3** |
| **3** | **BIOM 532** | **Food Microbiology** | **3** |
| **4** | **BIOM 542** | **Advanced Parasitology** | **3** |
| **Total credit. Hr** | | | **12** |

**Year II, Semester 1**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No** | **Course Code** | **Course Title** | **Credit Hours** |
| **2** | **BiAp 551** | **Research Methodology** | **2** |
| **4** | **BIOM 514** | **Current topics in Microbiology** | **1** |
| **5** | **BIOM 515** | **Thesis Research work** | **NG\*** |
| **Total** | | | **3** |

**Year II, Semester II**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No** | **Course Code** | **Course Title** | **Credit Hours** |
| **1** | **BIOM 515** | **Thesis Research work** | **6** |

1. **Course Descriptions**

**Course Name: BIOM 511: Environmental Microbiology** **(3 Credit hours)**

Microorganisms in the natural environments, Microbes in terrestrial, aquatic, atmospheric and biological environments; environmental selecting factors (physical, chemical and biological); microbes in the extreme environments and their adaptations; dispersal of microorganisms; methods for the determination of microbial numbers, biomass and activities. Significance of microbial activities in the environment, role of microorganisms in the cycling of bioelements (carbon, nitrogen, phosphorus, sulphur, iron, manganese, silicon etc.); microbial degradation of pesticides and other recalcitrant chemicals (Xenobiotics); microorganisms used in mineral recovery; microbial degradation of petroleum and hydrocarbons; biodeteriroration and control methods; microbial inoculants in agriculture; biological control. Microorganisms and pollution; Microbial aspects of air and water pollution; microbial toxins in the environments; disposal/treatment of organic solid wastes, sewage, industrial effluents and air pollutants. Pathogenic microorganisms in the environment. Air and water-borne diseases; sources of environmental pathogens, mode of transmission and disinfections.

**Course Name: BIOM 512: Microbial Physiology and Biochemistry (3 Credit hours)**

Growth physiology and kinetics, Transport mechanisms in microbes, Oxygenic and anoxygenic photosynthesis, Heterotrophic CO2 assimilation: Acetogenesis, methanogenesis, and hydrogen production; Nitrogen metabolism: Ammonification, nitrification, and denitrification; nitrogen fixation - symbiotic and asymbiotic, nitrogenases and the present status of advances in nitrogen fixation. Physiology of motility and bioluminescence, Carbohydrate metabolism: various pathways underlying the utilization of different sugars. Biosynthesis and metabolism of other intracellular storage products in different groups of microbes. Electron transport systems and ATP generation. Biosynthesis and catabolism of amino acids; protein chemistry, purification and sequencing. Metabolism of lipids. Enzymes: Nomenclature and classification, nature of enzymes and their active sites; mechanism of action, kinetics, allosteric enzymes, muti-enzyme complexes and isozymes; ribozymes and abzymes. Biosynthesis of secondary metabolites viz. antibiotics (penicillin, streptomycin), alkaloids (Ergot toxins); Chemistry and biosynthesis of nucleic acids.

**Course Name: BIOM 521: VIROLOGY** **(3 Credit hours)**

General account: Detailed discussion of icosahedral and helical symmetries of viruses and arrangement of capsomers. Chemical composition of viruses. Cell structure, cultivation, purification, characterization and assay of viruses. Effect of physical and chemical agents on viruses. Classification and general properties of major families of viruses including detailed account of their modes of replication. The effect of virus multiplication on the host macromolecular synthesis. Cell transformation by tumor viruses; Oncogenes. Immune mechanisms in viral infections; Interleukins and interferons; Epidemiology of virus infection. Principles of diagnostic virology, statistical methods in virology. Viroids and Prions. Human and animal viruses: Detailed study of the pathology, pathogenesis, symptomatology, epidemiology, transmission, diagnosis, prevention and control of important genera of viruses causing diseases in man and animals among the following families: Poxviridae, Picornaviridae, Paramyxoviridae. DNA tumor viruses, RNA tumor viruses; HIV and AIDS. Plant Viruses: Plant tissue culture; Mechanism of virus entry into plant cells. Methods of assay of plant viruses. Biochemical changes induced by virus in plant cells. Biology and mode of transmission of plant viruses. Discussion on some of the important plant diseases caused by viruses and their control. Bacteriophages: General principles of phage-bacterium interaction and growth cycle studies of RNA and DNA phages. The biochemistry of a phage-infected bacterium; Phage genetics. Introduction to viruses that are pathogenic for insects, algae (including cyanophages) and fungi.

**Course Name: BIOM 522: Pathogenic Microorganisms (3 Credit hours)**

Introduction to pathogens, symptoms, pathogenesis, host-pathogen interactions and host defense mechanisms, i.e. determinants of microbial pathogenicity and antimicrobial defenses of the host; infectious diseases, prevention of epidemics and disease control methods. Detailed study of the following genera of pathogenic bacteria: Corynebacterium, Staphylococcus, Streptococcus, Neisseria, Escherichia Klebriella, Proteus, Salmonella, Shigella, Virbrio, Camphylobacter, Pseudomonas, Acinetobacter, Yersinia, Francisella, Pasteurella, Haemophilus, Bordetella, Bacillus, Clostridium, Mycobacterium, Actinomyces, Nocardia, Bacteroides, Fusobacterium, Listeria, Legionella. General description, biological properties and diseases caused by the following

groups of pathogens : Mycoplasma , L-phase variants, Rickettsiae, Chlamydiae,

Spirochetes. General account of the diseases caused by pathogenic fungi: Trichophyton, Microsporum, Epidermophyton, General descriptions of mycoses: Sporotrichosis, Rhinosporidiosis, Mycetoma, Coccidioidomycosis, Histoplasmosis, Cryptococcosis, Candidiasis, Aspergillosis and pneumonia caused by Pneumocystis. Fungous allergies, Immunology of fungal infection. Preliminary account of the biology and infectious potential of protozoans: Cryptoporidium and Toxoplasma. Antimicrobial spectrum and mode of action of common antibacterial (Penicillins, Cephalosporins, Chloramphenicol, Streptomycin, Rifampicin, Tetracycline, Erythromycin, Polymyxins, Vancomycin, Nalidixic acid, Ethambutol and Novobiocin) and antifungal (Amphoteriin B, Nystatin, Griseofulvin, Flucytosine, Ketoconazole) agents. Mechanisms of drug resistance in bacteria.

**Course Name: BIOM 532: Immunology** **(3 Credit hours)**

General account of cells and organs of the immune system. Fundamental concepts in Immunology: antibody specificity, diversity, memory and self & non-self discrimination. Theories of antibody production; Immunogens, Immunoglobulins - fine structure and classification; function, synthesis and evolutionary aspects. Membrane bound forms of immunoglobulins; Genetic basis of antibody diversity; Hybridoma production. Monoclonal antibodies: general properties and applications. Antigen-antibody reactions; Complement system. Basic biology of B cells and T cells: their ontogeny, subsets and functions. Phagocytosis; Triggering of immune response; both humoral and cell-mediated; Antibody formation. Mechanism of cell mediated immunity (CMI); Mitogens, and Adjuvants. Immune tolerance: development and mechanism. Immunosuppression; Immunological hazards of transfusion. Immunological methods: immunofluorescence, immunoelectrophoresis, counter current immunoeletrophoresis, RIA, ELISA and immunoblotting. Germ free animals: general considerations. Immunogentics: Structure, distribution and function of histocompatibility antigens. Major Histocompatibility gene complex (MHC), HLA and H-2 systems. MHC restriction. Immune response (IR) genes; HLA and disease. Immunogenetics of tissueTransplantation, HLA-typing. Mechanism of graft rejection with particular reference to Kidney and bone marrow transplantations. Avoidance of transplant reactions. Immunopathology: Classification of immunopathological disorders. General account of immune deficiency disorders: both primary and secondary type. Acquired immune deficiency syndrome (AIDS), Phagocytic cell disorders;Gammopathies; Complement deficiencies. Atopy, allergy and hypersensitivity (Type I, II, III, IV) reactions. Auto-immunity and Mechanisms of development of autoimmune diseases; Immunological aspects of ageing. Tumor Immunology: Host-tumor interactions, Classification of tumor specific transplantation antigens (TSTA), Host immune response to tumors, antibody dependent cell cytotoxicity (ADCC), Natural Killer (NK) Cells, Immune surveillance. Tumor escape mechanisms, blocking antibodies, Immunotherapy of cancer; Immunotoxins.

**Course Name: BIOM 552: Microbial and Molecular Genetics (3 Credit hours)**

Principles of microbial genetics: basic procedures and terminologies, establishment of crosses, selection and classification of variations, and cis—trans complementation. Genome organization in bacteria, viruses and eukaryotic microorganisms, and nucleic acid replication. Genetic analysis of bacteria (including Cyanobacteria and actinomycetes): gene transfer—transformation, conjugation, transduction, and methods of gene mapping. Extra-chromosomal genetic elements and their inheritance, Genetic analysis of bacteriophages including cyanophages. Genetic mechanisms in algae, yeast and moulds. Origin and mechanism of variations in microbes. Gene-protein relationship: transcription, translation, genetic code, and regulatrion of gene expression. Genetic engineering, recombinant DNA, restriction endonucleases, vectors, principles of gene cloning, shot-gun genomic and cDNA cloning, criteria for the expression of recombinant DNA, characterization of recombinant DNA (Genetic, immunochemical and nucleic acid hybridization methods). Sequencing of nucleic acids (Sanger’s and Maxam and Gilbert’s methods), and applications of genetic engineering in medicine, agriculture and industry.

**Course Name: BIOM 523: Industrial Microbiology (3 Credit hours)**

Introduction to industrial microbials covering suitability of microbes in industrial processes and their source; types of fermentations and bioreactors; substrates for industrial fermentations; growth kinetics in batch and continuous fermentation processes; strain improvement and recent developments in industrial microbiology. Design of a fermentor; instrumentation and control. Methods for the recovery and purification of fermentation products (downstream -processing). Economic aspects of fermentation processes; Production aspects (microbial strains, substrate, flow diagrams, product optimization, and applications) of the following: Industrial alcohol and alcoholic beverages and glycerol; organic acids (citric, lactic, acetic, propionic, gluconic, itaconic, gibberellic acids; aminoacids (glutamic, lysine, tryptophan and asparatame); enzymes (Extracellular amylases, proteases, pectinases, lipases, cellulases, xylanases, and intracellular-glucose isomerase, invertase, asparaginase, penicillin acylase, lactase), and immobilized enzymes; Vitamins (Vit. B12 and riboflavin); antibiotics-β-lactam (Penicillin and cephalosporin), aminoacids (D-cycloserine) and peptide (bacitracin), tetracycline, polyenes (nystatin), aromatic (grieseofulvin); microbial transformations of steriods and sterols, non-steriod compounds and antibiotics; single-cell protein; polysaccharides; recombinant DNA products: insulin, somatostatin, interferon; and microbial insecticides.

**Course Name: BIOM 531: FOOD MICROBIOLOGY** **(3 Credit hours)**

Brief history of microorganisms in foodstuffs; sources, types and roles of microorganisms in foods; intrinsic and extrinsic parameters of foods which affect

microbial growth; methods for studying microbes and their products in food stuffs;

spoilage of fruits and vegetables, fresh and processed meats and poultry, and

miscellaneous foods such as eggs, bakery products, dairy products, beer and wines, fermented foods, and canned foods; food preservation with chemicals, irradiation, drying, low and high temperatures; manufacture of fermented foods: dairy products (acidophilus milk, cheese, yoghurt), meat and fishery products (dry sausages and fish sauces), plant products (cocoa beans, coffee beans, olives, pickles, sauerkraut, soy sauce, tempeh , breads, beverages including cider, sake, vinegar, & palm wines; food-borne diseases and food poisoning.

**Course Name: BIOM 541 Advanced Parasitology ( 3 Credit hours)**

Detailed study of the morphology, biochemistry, physiology and evolution of protozoan and metazoan parasites; the biological associations between parasites and their hosts with particular emphasis on mechanisms of pathogenicity of parasites and the host defense system; current research interest in parasitology.

**Course Name: BIOM 514: Current topics in Microbiology (2 Credit hours)**

An in-depth study of the current literature on a topic or topics selected by the instructor

**Course Name: BiAp 551:** **Research Methodology (2 Credit hours)**

Research methods; historical development; descriptive and experimental methods; characteristics of a good research tool, writing research report; sampling techniques, normal curve, testing hypothesis about mean and other statistics, significance of differences between means, t-test, f-test and chi-square test; simple analysis of variance; analysis of qualitative data; correlation and prediction; product moment and rank difference correlation; correlation coefficients, linear regression; partial and multiple correlation elements of multiple regression analysis

**Course Name: BIOM** **515:** **Thesis Research Work (6 Credit hours)**

The research emphasizes on applied aspects of Biology dealing with problems related to industry, environment and health. Such work is ordinarily undertaken in collaboration with industry, research organizations and department academic staff members. It may begin during Year I, Semester II and proceed through both semesters (I and II) of year II. The work includes proposal preparation and defense, progress reports and final thesis open defense examination.

**Program Name: Master of Education in Biology**

1. **Course breakdown by semester: Year I, Semester I**

|  |  |  |
| --- | --- | --- |
| Course code | Course title | Credit hours |
| Biol 511 | Animal Physiology | 3 |
| Biol 521 | Applied Genetics | 2 |
| Educ 531 | Science Education: Theory and Practice | 2 |
| Educ 541 | Research Methods in Science Education | 3 |
| Educ 551 | Instructional Design in Biology Education | 2 |
|  | Semester total | 12 |

**Year I, Semester II**

|  |  |  |
| --- | --- | --- |
| Course code | Course title | Credit hours |
| Biol 512 | Plant Physiology | 3 |
| Biol 522 | Applied Microbiology | 2 |
| Biol 532 | Ecology: Terrestrial and Aquatic Ecosystems | 3 |
| Educ 532 | Active Learning Approach: Principles and Methods | 3 |
|  | Semester total | 11 |

**Year II, Semester I**

|  |  |  |
| --- | --- | --- |
| Course code | Course Title | Credit hours |
| Biol 611 | Current Topics in Biology | 1 |
| Educ 621 | Selected Topics in Education | 1 |
| Educ 631 | Thesis Research Work | NG\* |
|  | Semester total | 2 |

\* This course starts at year II, Semester I to be completed at Year II Semester II.

**Year II, Semester II**

|  |  |  |
| --- | --- | --- |
| Course code | Course Title | Credit Hours |
| Educ 631 | Thesis Research Work | 6 |

1. **Course descriptions**

**Course Name: Educ 531(2)**: **Science Education: Theory and Practice**

How students learn science: the behavioral and cognitive-developmental learning theories; the positivist and constructivist epistemologies; learning styles in the science classrooms; multiple intelligences and science education; Problem-based learning and constructivism in the science classrooms; Research on science laboratory instruction; Trends in science curricula; Designing constructivist lessons for science classrooms; Observing and assessing science lessons; Constructivist classroom management.

**Course Name: Educ 532(3)**: **Active Learning Approach: Principles and Methods**

The Traditional Approach (Principles and Methods), active learning approach (principles and methods), increasing instructional productivity, developing of skills of the professional teacher in managing the curriculum changes, linkage with schools and communities, continuous development as a professional teacher:

**Course Name: Educ 541(3)**: **Research Methods in Science Education**

Meaning, characteristics and purposes of educational research; Scientific method and theory; development, fundamental, applied, and active research problems; Hypothesis, preparing research proposal; Research Methods: historical, descriptive and experimental methods; Characteristics of a good research tool, questionnaire, interview, observing, rating scales, tests of aptitudes and abilities, projective and sociometric techniques; Writing research report; Sampling techniques, normal curve, testing hypothesis about mean and other statistics, significance of differences between means, t-test, f-test and chi square, simple analysis of variance; analysis of qualitative data; Correlation and prediction; product moment and rank difference correlation; Coefficients, linear regressions; partial and multiple correlation elements of multiple regression analysis.

**Course Name: Educ 551(2)**: **Instructional Design in Biology Education**

Foundations of instructional design; Analyzing the learning context, learners and the learning task in biology or chemistry; Traditional and modern instructional strategies in biology or chemistry; Designing delivery and management strategies (selection of appropriate media); Producing instruction in biology / chemistry; formative and summative evaluation of the developed instruction in biology / chemistry.

**Course Name: Educ 611(1)**: **Current Topics in Education**

Topics for this course would vary depending on the current theories and research in chemistry education. However, the following could be some major points to be included: Students` misconceptions in chemistry-types, causes and possible intervention strategies; Teaching different chemical contents: facts, concepts, laws/principles and problems; Teaching and assessing chemical process skills; Higher order cognitive skills (HOCS) in chemistry; Analysis of and reflection on the Ethiopian secondary school chemistry/biology syllabuses and textbooks; The design and implementation of low-cost teaching materials for chemistry/biology; Everyday life chemistry; Selected chemistry experiments for secondary schools; Students will search for information sources, invite expert specialists to speak, prepare oral and written reports.

**Course Name: Educ 631(6)**: **Thesis Research Work (Research in Biology Education)**

The facilities for education research in problems related to chemistry (biology) teaching are available at all times to graduate students pursuing original investigations toward MEd degree at the University. Such work is ordinarily in collaboration with a member of the chemistry (biology) department academic staff member or methodology specialist teaching in the graduate program or in any other similar institution. Program may begin during Year I, Semester II and proceeds through both Semesters I and II of Year II for the investigation of educational problems of research interest related to chemistry (biology) teaching and curriculum issues. The work includes proposal preparation and defense, progress reports (at least two) and the final thesis defense.

**Course Name: Biol 511(3)**: **Animal Physiology**

Understanding of animals as integrated systems at every level of organization and principles of physiological processes and systems, i.e., principles of physiology: Contemporary experimental methods for exploring physiology, molecules, energy, and biosynthesis; Physiological processes: neurophysiology, cardiovascular, respiratory, renal acid-base, endocrine physiology and integration of physiological systems. Circulation, gas exchange, ionic and osmotic balance, acquiring energy, energy expenditure, energetic costs of meeting environmental challenges.

**Course Name: Biol 512(3)**: **Plant Physiology**

Plant growth and development, plant hormones and growth regulators and their chemistry, biosynthesis, bioassay and mode of action; plant-water-relations, soil-plant-atmosphere continuum; plant nutrition-dynamics of nutrient uptake and assimilation, nitrogen metabolism; Sulphur metabolism; important metabolic pathways; photosynthesis (C3, C4 CAM), translocation of photoassimilates, photorespiration, respiration, etc., photomorphogenesis and stress physiology.

**Course Name: Biol 521(2) Applied Genetics**

Nature and expression of genes, experimental verification of Mendelian genetics, exercising genetics in daily life. Implications of modern genetics to mankind and cognition of candidates on the principles of genetic engineering through paper write up and impact of genetic manipulation in underdeveloped countries.

**Course Name: Biol. 522(2)**: **Applied Microbiology**

Classification and identification of bacteria, energy and metabolism, physiology of bacterial growth, bacterial genetics, anti-microbial agents, application of microbiological principles in sewage treatment (environment), industrial use, nutrient re-cycling, food processing, biotechnology, disease control and soil fertility. Fungi-morphology and metabolism, mycotoxins, fungal associations to plants and animals, parasitism. Virology-virus morphology, physiology and reproduction, practical and fundamental aspects of virology.

**Course Name: Biol 532(3): Ecology: Terrestrial and Aquatic Ecosystems**

Abundance and dynamics of species population; Community structure, composition and change in space and time; Process of community analysis and description; ecological energetics and cycling of nutrients in ecosystem; ecological modeling and resource management. Water resources: hydrologic cycle, types of water and their quality; life in Water: microscopic to mammals, interactions in water (living, non-living), pollution, conservation in all cases with reference to Ethiopian condition.

**Course Name: Biol 611(1)**: **Current Topics in Biology**

Independent work by students on select-topics on recent advances in the area of biology by reviewing the literature with clear indications in conclusion formulation and indications of future directions. Evaluation by compilation of desktop reports and seminar presentations.

**Department of Chemistry**

**Program Name: Master of Science in Chemistry (Organic, Inorganic, Analytical, or Physical)’**

**a) List of Chemistry Courses for the THESIS-BASED (OPTION-1)**

**M.Sc. in ANALYTICAL CHEMISTRY**

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Course Title** | **Course Code** | **Cr.hrs.** |
| **1.** | **Advanced Analytical Chemistry** | **Chem. 511** | **3** |
| **2.** | **Advanced Inorganic Chemistry** | **Chem. 521** | **3** |
| **3.** | **Advanced Organic Chemistry** | **Chem. 531** | **3** |
| **4.** | **Advanced Physical Chemistry** | **Chem. 541** | **3** |
| **5.** | **Chemical Instrumentation** | **Chem. 512** | **2** |
| **6.** | **Advanced Chromatographic Techniques** | **Chem. 514** | **3 (2+1)** |
| **7.** | **Practical Instrumental Analysis** | **Chem. 516** | **2** |
| **8.** | **Chemical Kinetics** | **Chem. 543** | **2** |
| **9.** | **Electroanalytical Chemistry** | **Chem. 518** | **3 (2+1)** |
| **10.** | **Chemometrics** | **Chem. 611** | **2** |
| **11.** | **Scientific Communications** | **Chem. 602** | **2** |
| **12.** | **Special Topics in Analytical Chemistry I** | **Chem. 613** | **1** |
| **13.** | **Graduate Seminar** | **Chem. 651** | **1** |
| **14.** | **Thesis Research** | **Chem. 670** | **6** |
|  | **TOTAL** |  | **36** |

**Table 2 List of Chemistry Courses for the THESIS-BASED (OPTION-1) M.Sc. in**

**INORGANIC CHEMISTRY**



|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Course Title** | **Course Code** | **Cr.hrs.** |
| **1.** | **Advanced Analytical Chemistry** | **Chem. 511** | **3** |
| **2.** | **Advanced Inorganic Chemistry** | **Chem. 521** | **3** |
| **3.** | **Advanced Organic Chemistry** | **Chem. 531** | **3** |
| **4.** | **Advanced Physical Chemistry** | **Chem. 541** | **3** |
| **5.** | **Physical Methods in Inorganic Chemistry** | **Chem. 522** | **2** |
| **6.** | **Organo-Transition Metal & Bio-Inorganic Chemistry** | **Chem. 524** | **3** |
| **7.** | **Materials Inorganic Chemistry** | **Chem. 527** | **2** |
| **8.** | **Inorganic Synthesis & Characterization** | **Chem. 528** | **2** |
| **9.** | **Practical Instrumental Analysis** | **Chem. 516** | **2** |
| **10.** | **Chemical Kinetics** | **Chem. 543** | **2** |
| **11.** | **Scientific Communications** | **Chem. 602** | **2** |
| **12.** | **Special Topics in Inorganic Chemistry I** | **Chem. 623** | **1** |
| **13.** | **Graduate Seminar** | **Chem. 651** | **1** |
| **14.** | **Thesis Research** | **Chem. 670** | **6** |
|  | **TOTAL** |  | **35** |

**Table 3 List of Chemistry Courses for the THESIS-BASED (OPTION-1) M.Sc. in**

**ORGANIC CHEMISTRY**



|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Course Title** | **Course Code** | **Cr.hrs.** |
| **1.** | **Advanced Analytical Chemistry** | **Chem. 511** | **3** |
| **2.** | **Advanced Inorganic Chemistry** | **Chem. 521** | **3** |
| **3.** | **Advanced Organic Chemistry** | **Chem. 531** | **3** |
| **4.** | **Advanced Physical Chemistry** | **Chem. 541** | **3** |
| **5.** | **Mechanistic & Physical Organic Chemistry** | **Chem. 532** | **3** |
| **6.** | **Physical Methods in Organic Chemistry** | **Chem. 534** | **2** |
| **7.** | **Synthetic Organic Chemistry** | **Chem. 631** | **2** |
| **8.** | **Chemical Kinetics** | **Chem. 543** | **2** |
| **9.** | **Organic Synthesis & Characterization** | **Chem. 536** | **2** |
| **10.** | **Practical Instrumental Analysis** | **Chem. 516** | **2** |
| **11.** | **Scientific Communications** | **Chem. 602** | **2** |
| **12.** | **Special Topics in Organic Chemistry I** | **Chem. 633** | **1** |
| **13.** | **Graduate Seminar** | **Chem. 651** | **1** |
| **14.** | **Thesis Research** | **Chem. 670** | **6** |
|  | **TOTAL** |  | **35** |

**Table 4 List of Chemistry Courses for the THESIS-BASED (OPTION-1) M.Sc. in**

**PHYSICAL CHEMISTRY**



|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Course Title** | **Course Code** | **Cr.hrs.** |
| **1.** | **Advanced Analytical Chemistry** | **Chem. 511** | **3** |
| **2.** | **Advanced Inorganic Chemistry** | **Chem. 521** | **3** |
| **3.** | **Advanced Organic Chemistry** | **Chem. 531** | **3** |
| **4.** | **Advanced Physical Chemistry** | **Chem. 541** | **3** |
| **5.** | **Statistical Thermodynamics** | **Chem. 542** | **3** |
| **6.** | **Chemical Kinetics** | **Chem. 543** | **2** |
| **7.** | **Electrochemistry** | **Chem. 546** | **2** |
| **8.** | **Electrochemical Methods** | **Chem. 548** | **2** |
| **9.** | **Computational Chemistry** | **Chem. 643** | **2** |
| **10.** | **Practical Instrumental Analysis** | **Chem. 516** | **2** |
| **11.** | **Scientific Communications** | **Chem. 602** | **2** |
| **12.** | **Special Topics in Physical Chemistry I** | **Chem. 645** | **1** |
| **13.** | **Graduate Seminar** | **Chem. 651** | **1** |
| **14.** | **Thesis Research** | **Chem. 670** | **6** |
|  | **TOTAL** |  | **35** |

**COURSE REQUIREMENTS FOR PROJECT-BASED (OPTION-2) M.Sc.**

**Table 1 List of Chemistry Courses for the PROJECT-BASED (OPTION-2) M.Sc. in ANALYTICAL CHEMISTRY**

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Course Title** | **Course Code** | **Cr.hrs.** |
| **1.** | **Advanced Analytical Chemistry** | **Chem. 511** | **3** |
| **2.** | **Advanced Inorganic Chemistry** | **Chem. 521** | **3** |
| **3.** | **Advanced Organic Chemistry** | **Chem. 531** | **3** |
| **4.** | **Advanced Physical Chemistry** | **Chem. 541** | **3** |
| **5.** | **Chemical Instrumentation** | **Chem. 512** | **2** |
| **6.** | **Advanced Chromatographic Techniques** | **Chem. 514** | **3 (2+1)** |
| **7.** | **Practical Instrumental Analysis** | **Chem. 516** | **2** |
| **8.** | **Electroanalytical Chemistry** | **Chem. 518** | **3 (2+1)** |
| **9.** | **Chemometrics** | **Chem. 611** | **2** |
| **10.** | **Environmental Chemistry** | **Chem. 612** | **3** |
| **11.** | **Non-Aqueous Solution Chemistry** | **Chem. 616** | **2** |
| **12.** | **Chemical Kinetics** | **Chem. 543** | **2** |
| **13.** | **Scientific Communications** | **Chem. 602** | **2** |
| **14.** | **Special Topics in Analytical Chemistry I** | **Chem. 613** | **1** |
| **15.** | **Special Topics in Analytical Chemistry II** | **Chem. 614** | **1** |
| **16.** | **Graduate Seminar** | **Chem. 651** | **1** |
| **17.** | **Graduate Project** | **Chem. 660** | **3** |
|  | **TOTAL** |  | **39** |

**Table.2 List of Chemistry Courses for the PROJECT-BASED (OPTION-2) M.Sc. in**

**INORGANIC CHEMISTRY**



|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Course Title** | **Course Code** | **Cr.hrs.** |
| **1.** | **Advanced Analytical Chemistry** | **Chem. 511** | **3** |
| **2.** | **Advanced Inorganic Chemistry** | **Chem. 521** | **3** |
| **3.** | **Advanced Organic Chemistry** | **Chem. 531** | **3** |
| **4.** | **Advanced Physical Chemistry** | **Chem. 541** | **3** |
| **5.** | **Physical Methods in Inorganic Chemistry** | **Chem. 522** | **2** |
| **6.** | **Organo-Transition Metal & Bio-Inorganic Chemistry** | **Chem. 524** | **3** |
| **7.** | **Materials Inorganic Chemistry** | **Chem. 527** | **2** |
| **8.** | **Inorganic Synthesis & Characterization** | **Chem. 528** | **2** |
| **9.** | **Practical Instrumental Analysis** | **Chem. 516** | **2** |
| **10.** | **Chemical Kinetics** | **Chem. 543** | **2** |
| **11.** | **Environmental Chemistry** | **Chem. 612** | **3** |
| **12.** | **Inorganic Reaction Mechanisms** | **Chem. 626** | **2** |
| **13.** | **Main Group Organometallics** | **Chem. 628** | **2** |
| **14.** | **Scientific Communications** | **Chem. 602** | **2** |
| **15.** | **Special Topics in Inorganic Chemistry I** | **Chem. 623** | **1** |
| **16.** | **Special Topics in Inorganic Chemistry II** | **Chem. 624** | **1** |
| **17.** | **Graduate Seminar** | **Chem. 651** | **1** |
| **18.** | **Graduate Project** | **Chem. 660** | **3** |
|  | **TOTAL** |  | **39** |

**Table 3 List of Chemistry Courses for the PROJECT-BASED/OPTION-2/ M.Sc. in ORGANIC CHEMISTRY**



|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Course Title** | **Course Code** | **Cr.hrs.** |
| **1.** | **Advanced Analytical Chemistry** | **Chem. 511** | **3** |
| **2.** | **Advanced Inorganic Chemistry** | **Chem. 521** | **3** |
| **3.** | **Advanced Organic Chemistry** | **Chem. 531** | **3** |
| **4.** | **Advanced Physical Chemistry** | **Chem. 541** | **3** |
| **5.** | **Mechanistic & Physical Organic Chemistry** | **Chem. 532** | **3** |
| **6.** | **Physical Methods in Organic Chemistry** | **Chem. 534** | **2** |
| **7.** | **Synthetic Organic Chemistry** | **Chem. 631** | **2** |
| **8.** | **Natural Product Chemistry** | **Chem. 632** | **2** |
| **9.** | **Environmental Chemistry** | **Chem. 612** | **3** |
| **10.** | **Chemical Kinetics** | **Chem. 543** | **2** |
| **11.** | **Organic Synthesis & Characterization** | **Chem. 536** | **2** |
| **12.** | **Organometals in Organic Synthesis** | **Chem. 636** | **2** |
| **13.** | **Practical Instrumental Analysis** | **Chem. 516** | **2** |
| **14.** | **Scientific Communications** | **Chem. 602** | **2** |
| **15.** | **Special Topics in Organic Chemistry I** | **Chem. 633** | **1** |
| **16.** | **Special Topics in Organic Chemistry II** | **Chem. 634** | **1** |
| **16.** | **Graduate Seminar** | **Chem. 651** | **1** |
| **17.** | **Graduate Project** | **Chem. 660** | **3** |
|  | **TOTAL** |  | **40** |

**Table 4 List of Chemistry Courses for the PROJECT-BASED/OPTION-2/ M.Sc. in**

**PHYSICAL CHEMISTRY**

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Course Title** | **Course Code** | **Cr.hrs.** |
| **1.** | **Advanced Analytical Chemistry** | **Chem. 511** | **3** |
| **2.** | **Advanced Inorganic Chemistry** | **Chem. 521** | **3** |
| **3.** | **Advanced Organic Chemistry** | **Chem. 531** | **3** |
| **4.** | **Advanced Physical Chemistry** | **Chem. 541** | **3** |
| **5.** | **Statistical Thermodynamics** | **Chem. 542** | **3** |
| **6.** | **Chemical Kinetics** | **Chem. 543** | **2** |
| **7.** | **Electrochemistry** | **Chem. 546** | **2** |
| **8** | **Environmental Chemistry** | **Chem. 612** | **3** |
| **9.** | **Electrochemical Methods** | **Chem. 548** | **2** |
| **10.** | **Computational Chemistry** | **Chem. 643** | **2** |
| **11.** | **Chemistry of Solids & Liquids** | **Chem. 642** | **2** |
| **12.** | **Surface Chemistry** | **Chem. 648** | **2** |
| **13.** | **Practical Instrumental Analysis** | **Chem. 516** | **2** |
| **14.** | **Scientific Communications** | **Chem. 602** | **2** |
| **15.** | **Special Topics in Physical Chemistry I** | **Chem. 645** | **1** |
| **16.** | **Special Topics in Physical Chemistry II** | **Chem. 646** | **1** |
| **17.** | **Graduate Seminar** | **Chem. 651** | **1** |
| **18.** | **Graduate Project** | **Chem. 660** | **3** |
|  | **TOTAL** |  | **42** |

**DESCRIPTION OF ALL PG CHEMISTRY COURSES**

**Analytical Chemistry Stream**

**Course Name: Advanced Analytical Chemistry Chem. 511 3 Cr.hr**

Spectroscopic Methods. IR, UV-Vis, Mass spectrometry, AAS, NMR (1D & 2D), Raman spectroscopy, Brief introduction to all chromatographic and electroanalytical techniques.

**Course Name: Chemical Instrumentation Chem. 512 2 Cr.hr**

Electronic and optical aspects of chemical instrumentation test and measuring instruments. Radiation sources, optical devices, filters, monochromators, and detectors. Analog instrumentation: semiconductor devices; feedback, operational amplifiers and their application in chemistry. Digital instrumentation: digital circuits, Analog to digital conversion and digital to analog conversion. Applications of computers in chemistry.

**Course Name: Advanced Chromatographic Techniques Chem. 514 3(2+1) Cr.hr**

Theory and practice of separation methods. Topics to be discussed include size exclusion chromatography, affinity chromatography, TLC, Gas-Liquid chromatography, Gas-Solid chromatography, HPLC and its type, Supercritical fluid chromatography, electrophoresis, electrochromatography and other hyphenated techniques (LC-MS, GC-MS etc).

**Course Name: Practical Instrumental Analysis Chem. 516 2 Cr.hr**

Selected lab experiments from spectroscopic techniques will be provided.

**Course Name: Electroanalytical Chemistry Chem. 518 3(2+1) Cr.hr**

Modern electroanalytical methods. Transport number Theory and applications to chemical and biological problems: conductometry Coulometry, voltametry, electrometric titrations, ion-selective potentiometry in macro, micro and trace analysis, flow techniques, electrochemical sensors etc.

**Course Name: Chemometrics Chem. 611 2 Cr.hr**

Errors in classical analysis, selected tests of significance; quality control: sampling applied to quality control; collaborative trials & control charts. Errors in instrumental analysis (regression & correlation). The correlation coefficients, limits of detection, regression lines & curve fitting. Non-parametric and Robust methods. Experimental design, optimization and pattern recognition.

**Course Name: Environmental Chemistry Chem. 612 3 Cr.hr**

An overview of chemistry of water, atmosphere and soil; environmental pollutants, environmental sample quality assurance and quality control in environmental sampling. Methodologies of treatments of results of water, air, soil, food and biological samples will be examined; The design and development of environmentally benign chemical pathways challenges & opportunities. High yield and zero-waste chemical processes. Representation industrial processes.

**Course Name: Non-aqueous Solution Chemistry Chem. 616 2 Cr.hr**

Introduction, solvent-solute interactions (Intermolecular forces, the nature of salvation). General features and characteristics of non-aqueous solvents (Classification of solvents, physicochemical properties of typical solvents), correlation properties in different solvents (Thermodynamic Transfer Functions, transfer functions for single ions & their applications), advanced treatment of Acid-Base chemistry.

**Course Name: Special Topics in Analytical Chemistry I Chem. 613 1 Cr.hr**

Complex formation equilibria, stability constant of the complex, conditional stability constants of complexes, extraction equilibria, extraction of chelates, extraction of ion association complexes extraction techniques: solid-phase extraction, supported liquid membrane extraction and supercritical fluid extraction.

**Course Name: Special Topics in Analytical Chemistry II Chem. 614 1 Cr.hr**

Flow techniques, sensors and biosensors. Role of analytical chemistry in nanotechnology, biotechnology, food science, environmental and material sciences, speciation.

**Inorganic Chemistry Stream**

**Course Name: Advanced Inorganic Chemistry I Chem. 521 3 Cr.hr**

Chemical Application of Group Theory; advanced coordination chemistry: structure and bonding (Interdependence of chemical bonding, spectroscopic characteristics, and reactivity properties of coordination compounds are described and formalized using the fundamental concepts of symmetry as applied to inorganic coordination complexes). Introduction to organometallic & bioinorganic chemistry.

**Course Name: Physical Methods in Inorganic Chemistry Chem. 522 2Cr.hr**

A survey course of physical techniques used in modern inorganic chemistry. Topics covered include x-ray diffraction, matrix isolation, GC and LC- mass spectrometry, magnetism, electrochemistry, various spectroscopies (IR, Roman, UV-Vis, NMR, EPR, XPS, EXAFS & Mossbauer), Thermal methods: melting point, DTA, DSC, TGA.

**Course Name: Materials Inorganic Chemistry Chem. 527 2 Cr.hr**

Solid state structure; overview of diffraction methods; bonding & band theory of solids; electronic properties, magnetic properties, defects & non-stoichiometry, phase diagrams & transitions, synthetic methods, low dimensional materials & nanostructures; special topics such as solar cells & photovoltoics, gasoline refining, fuel cells; ceramics, layered compounds etc.

**Course Name: Organotransition Metal & Bioinorganic Chemistry Chem. 524 3 Cr.hr**

General properties of organometallic compounds, metal sigma bonded ligand complexes, carbonyls & phosphine complexes, complexes of pi-bound ligands, organometallic reaction mechanisms, catalysis, characterization, clusters, bioorganometallic chemistry; coordination equilibria, stability constants, HSAB, methods of determination of stability constants, structure-function relationships of key metalloenzymes etc.

**Course Name: Inorganic Synthesis and Characterization Chem. 528 2 Cr.hr**

This course is a practical inorganic chemistry course which emphasis on synthesis of inorganic and organometallic compounds and characterization using analytical, spectral, conductance, thermal, magnetic etc studies.

**Course Name: Special Topics in Inorganic Chemistry I Chem. 621 1 Cr.hr**

Selected topics from the following will be treated: Coordination chemistry, organometallic chemistry and catalysis, solid state chemistry, bio-inorganic chemistry, surface chemistry, nanotechnology, Chemical crystallography,etc.

**Course Name: Inorganic Reaction Mechanisms Chem. 626 2 Cr.hr**

The classic literature covering octahedral and square planar substitution reactions, electron transfer, bioinorganic mechanisms; Modern approaches to kinetic analysis and mechanistic interpretation

**Course Name: Main Group Organometallics Chem. 628 2 Cr.hr**

General properties of inorganic and organometallic compounds of main group elements; hydrogen, carbon, silicon, germanium, tin and lead; nitrogen, phosphorus, arsenic, antimony, and bismuth; the chaleogenes; halogens and noble gases; boron, aluminum, gallium, indium, and thallium, the alkali and alkaline earth metals.

**Course Name: Special Topic in Inorganic Chemistry II Chem. 624 1 Cr.hr**

Selected topics from the following will be treated. Electronic liquids, coordination and supramolecular chemistry, metal clusters and nonoparticle chemistry, molecular and biomolecular electronics, recent developments in catalysis, biomimetric chemistry, metallodrugs and metal ion complexes used as imaging agents in medicine etc.

**Organic Chemistry Stream**

**Course Name: Advanced Organic Chemistry Chem. 531 3 Cr.hr**

A comprehensive survey of organic chemistry with emphasis on important synthetic reactions and stereochemistry conformational analysis, configurations and chirality, symmetry elements, determination of absolute and relative configurations, stereochemistry of enzyme processes, reaction mechanisms, synthetically useful reactions.

**Course Name: Mechanistic and Physical Organic Chemistry Chem. 532 3 Cr.hr**

Mechanism of acid & base catalyzed reactions, nucleophilic and electrophilic substitutions, additions and eliminations reactions, condensation reactions. The transition state theory of chemical kinetics, applications to reaction mechanisms, kinetic isotope effects, linear free energy relationships reaction intermediates, stable intermediates species, trapping of intermediates, methods of establishing reaction mechanisms.

**Course Name: Physical Methods in Organic Chemistry Chem. 534 2 Cr.hr**

Principles and applications of important physical and spectroscopic methods in organic structure determination IR, UV, NMR, MS, ESR, ORD, and CD etc.

**Course Name: Organic Synthesis and Characterization Chem. 536 2 Cr.hr**

This course is a practical organic chemistry course which emphasis on multi step syntheses of organic compounds, their isolation, purification and characterization using modern spectroscopic and chromatographic techniques.

**Course Name: Natural Product Chemistry Chem. 632 2 Cr.hr**

Classification of natural products, biogenesis and biosynthesis of natural products: alkaloids, terpenes, steroids, prostaglandins, cumarins & chromans etc.

**Course Name: Special Topics in Organic Chemistry I Chem. 633 1 Cr.hr**

Topics of current interest in organic chemistry such as spectroscopy, physical organic chemistry, photochemistry, organometallic chemistry, mechanisms of oxidations & reductions, modern organic synthesis, reactive intermediates bioorganic chemistry & polymers . . . (variable)

**Course Name: Special Topics in Organic Chemistry II Chem. 634 1 Cr.hr**

Topics of current interest in organic chemistry including photochemistry, fluorine chemistry, heterocyclic chemistry, pharmaceutical chemistry, opto-electronic chemistry, biocatalysis, asymmetric synthesis, carbohydrate based organic synthesis, mechanistic & structural studies on enzyme synthesis, new ynthetic methodology etc (variable)

**Course Name: Organometallics in Organic Synthesis Chem. 636 2 Cr.hr**

The course covers important transition metal mediated reactions with relevance to organic synthesis, emphasizing recent developments: Topics covered include palladium catalyzed coupling, carbonylation and insertion reactions, ion and cobalt metal carbonyl anions, thermal and photochemical reactions of chromium carbones, catalytic metathesis reactions, electrophilic alkene complexes, cobalt alkyne complex, allyl complexes of various metals, diene and dienyl complexes of iron and arene complexes of chromium.

**Course Name: Synthetic Organic Chemistry Chem. 631 2 Cr.hr**

The application of organic reactions to the synthesis of complex molecules, including natural products will be studied. In addition to synthetic strategies, detailed reaction mechanisms, reaction scopes and issues in catalysis will be covered.

**Physical Chemistry Stream**

**Course Name: Advanced Physical Chemistry Chem. 541 3 Cr.hr**

Schrodinger Equation and Exact Solution, square wells and barriers; harmonic oscillator; the hydrogen atom; atomic orbitals; operators including angular momenta; time-independent and time-dependent perturbation theory; Schrodinger and Heisenberg representations; unitary operators; interaction picture, density matrix; variational method, many electron atoms; addition of angular momentum, self-consistent field method for open and closed shells, LCAO, origin of chemical bonding, many electron diatomic and polyatomic molecules, treatments of electron correlation, approximation methods, Spectroscopy

**Course Name: Statistical Thermodynamics Chem. 542 3 Cr.hr**

Introduction. Assembly by localized system. Assembly of independent non-localized systems. Classical statistical mechanics. Ideal gases. Mixed gases, law of mass action. Chemical equilibrium and calculation of equilibrium constant. Phase equilibrium for one and two-component systems: a crystal in equilibrium with its own vapor; adsorption of gases on a surface; derivation of Langmuir adsorption isotherm; derivation of Raoult’s law. The canonical Ensemble. The Grand canonical ensemble. Imperfect gases. Introduction to theory of liquids. Monte Carlo and molecular dynamics methods. Transition state theory.

**Course Name: Chemical Kinetics**   **Chem. 543 2 Cr.hr**

Brief review of reactions with simple kinetics forms; deduction of reaction mechanisms; reaction rate theories; collision theory and transition state theory; unimolecular gaseous reactions; reactions in solutions; homogeneous and enzyme catalysis; kinetics of surface reactions and heterogeneous catalysis; complex reactions; chain reactions and oscillating chemical reactions; atmospheric kinetics; photochemical kinetics kinetic modeling.

**Course Name: Electrochemistry Chem. 546 2 Cr.hr**

The electric double layer. Electrode kinetics, electrocatalysis, electron transfer theory corrosion. Electrochemical energy conversion: Electrode kinetic aspects, batteries, fuels, cells, photoelectrochemical solar energy conversion. Industrial electrochemistry. Inorganic electrolytic processes, Organic electrosynthesis; other industrial electrochemical processes (electroplating, electroforming, electrowinning, electrochemical machining). Introduction to bioelectrochemistry.

**Course Name: Practical**

This course is accompanied by selected experiments related to the theoretical principles presented in the class room. Examples will be taken from the Journal of chemical education and from Internet source.

**Course Name: Electrochemical Methods Chem. 548 2 Cr.hr**

Thermodynamics and potential, change transfer kinetics of mass transfer. Potential step and potential sweep methods including hydrodynamic methods. Bulk electrolysis methods. Electrode reactions coupled with homogeneous chemical reactions. Double layer structure and adsorbed intermediates in electrode processes. Digital simulation of electrochemical processes. Scanning probe techniques and spectroelectrochemistry.

**Course Name: Computational Chemistry Chem. 643 2 Cr.hr**

Introduction, Molecular Mechanics and Force Fields, Quantum Mechanics; Hartree-Fock Theory and Basis sets, Semiempirical Methods, Electron Correlations (CI, MP2, MCSCF, CB), Density Functional Theory, Molecular Simulations; Monte-Carlo Simulations, Molecular Dynamics Simulations, Combined QM/MM Methods, Applications: Free energy perturbation liquids.

**Course Name: Special Topics in Physical Chemistry I Chem. 645 1 Cr.hr**

Topics of current interest in physical chemistry such as structure at interfaces, theories & computational chemistry, spectroscopy & molecular structure, photochemistry and reaction dynamics. Electrochemistry and electroanalysis, biophysical chemistry. biophotonics, polymer etc. will be treated in this course.

**Course Name: Special Topics in Physical Chemistry II Chem. 646 1 Cr.hr**

Topics of current interest in physical chemistry such as structure at interfaces, theories & computational chemistry, spectroscopy & molecular structure, photochemistry and reaction dynamics. Electrochemistry and electroanalysis, biophysical chemistry. Biophotonics etc. will be treated in this course**.**

**Course Name: Surface Chemistry Chem. 648 2 Cr.hr**

Capillarity; surface tension curved surfaces, babbles, cavities and droplets Interfacial thermodynamics, Electrokinetics aspects of surface chemistry, adsorbed layers. The surface excess concentration study of surface films colloidal system stability of colloids, micelle formation electrical double layer,DLVO theory, schulze hardy rule, physisorption, chemisorption, adsorption isotherms, Langmuir, Freurskch, BET isotherm

**Course Name: Chemistry of Solids & Liquids Chem. 642 2 Cr.hr**

Introduction to simple crystal structure. X-ray diffraction; powder and single crystal x-ray diffraction. Defects and non-stoichiometry; defects and their concentration; ionic conductivity in solids. Solid electrolytes. Non-stoichiometric compounds (Electronic, optical and magnetic properties. Introduction to liquids: Bulk properties of liquids(viscosity , surface tension and etc); intermolecular forces. The structure of liquids, liquid models. Properties of liquids; atomic liquids; molecular liquids; ionic liquids. Introduction to liquid crystals: Types; classifications. Polymorphism in thermochromic liquid crystals. Molecular structure of thermotropic mesogens. Properties of ordered fluid mesophases.

**Course Name: Scientific Communications Chem. 602 2 Cr.hr**

Scientific writing;; How to write a proposal, Thesis, Conference reports, scientific articles (Title, Abstract Introduction, Review Literature, materials and Methods including research designs, Results, Discussions, Acknowledgement, reference, Summary, conclusions and recommendations), Review papers; Oral Presentation; The course will culminate by seminar presentation

**Course Name: Graduate Seminar Chem. 651 1 Cr.hr**

A lecture to be prepared presented and defended by graduate students on current topics of their field of specialization.

**Course Name: Graduate Project Chem. 660 3 Cr.hr**

Independent study of specific problems under the supervision of an advisor approved by the department.

**Course Name: Thesis (Independent Research Work) Chem. 670 6 Cr.hr**

Independent research work on specific problem under the supervision of an advisor (s) approved by the department and SGS. Students registering for this course will be required to produce original research work.

**Program Name: Master of Sciences in Material Chemistry**

1. **Course Breakdown**

|  |  |  |
| --- | --- | --- |
| **Course Title** | **Course Code** | **Cr. hr** |
| Advanced Analytical Chemistry | Chem. 511 | 3 |
| Advanced Inorganic Chemistry | Chem. 521 | 3 |
| Advanced Organic Chemistry | Chem. 531 | 3 |
| Advanced Physical Chemistry | Chem. 541 | 3 |
| Scientific Communications | Chem. 602 | 2 |
|  | **Total** | **14** |

**YEAR I SEMESTER II**

|  |  |  |
| --- | --- | --- |
| **Course Title** | **Course Code** | **Cr. hr** |
| Materials Chemistry | Chem. XXX | 3 |
| Physical Methods in Materials Chemistry | Chem. XXX | 2+1 |
| Nanochemistry | Chem. XXX | 2 |
| Surface Chemistry and catalysis | Chem. XXX | 2 |
| Elective I | Chem. XXX | 2 |
| Elective II | Chem. XXX | 2 |
|  | **Total** | **14** |

**Year II SEMESTER I**

|  |  |  |
| --- | --- | --- |
| **Course Title** | **Course Code** | **Cr. hr** |
| Seminar on Advanced Materials | Chem XXX | 1 |
| MSc Thesis | Chem XXX | 6 |
|  | **TOTAL** | **7** |

**Year II SEMESTER II**

|  |  |  |
| --- | --- | --- |
| **Course Title** | **Course Code** | **Cr. hr** |
| MSc Thesis | Chem XXX | 6 |
|  | **TOTAL** | **6** |

#### 

#### Course Descriptions

**Course Name: Advanced Analytical Chemistry (Chem. 511) 3 Cr.hr**

**Pre-requisite:**

Spectroscopic Methods: IR, UV-Vis, Mass spectrometry, AAS, NMR (1D & 2D), Raman spectroscopy, Brief introduction to all chromatographic and electroanalytical techniques.

**Mode of Delivery**: Lecture, Laboratory Demonstration, Independent Reading, Hands-on computer training using current online literature resources and recent discipline-specific computer programs.

**Evaluation**: Presentations (15%), Mid-exams (30%), Final Exams (40%), Practical Exam (15%)

**References:**

Principles of Instrumental Analysis, 6th edition by Skoog, Holler, Crouch (copyright 2007)

**Course Name: Advanced Inorganic Chemistry (Chem. 521) 3 Cr.hr**

**Pre-reqisite:**

Chemical Application of Group Theory; advanced coordination chemistry: structure and bonding (Interdependence of chemical bonding, spectroscopic characteristics, and reactivity properties of coordination compounds are described and formalized using the fundamental concepts of symmetry as applied to inorganic coordination complexes). Introduction to organometallic & bioinorganic chemistry.

**Mode of Delivery:** Lecture, Teaching Aids (Models), Independent Reading, Hands-on softwares on symmetry from websites.

**Evaluation :** Assignment/Quiz, 20% (Two Assignments)Exam, 30% (TBA)Final exam 50% (TBA)

**Texts**

# A. Vincent (2001) Molecular Symmetry and group theory. 2nd edition.

* J.E. Huheey, E.A. Keiter & R.L. Keiter (1993) Inorganic Chemistry: Principles of Structure and Reactivity. 4th edition.

**References**

* F.A. Cotton (1990) Chemical applications of group theory, 3rd edition.
* R.L. Carter (1996) Molecular Symmetry and Group Theory, 2nd Edition
* J.D. Lee (1996) Concise inorganic chemistry, 5th edition.
* F.A. Cotton, G. Willinkson, C.A. Murilo & M. Bochman (2004) Advanced inorganic chemistry, 6th edition.
* D.F. Shriver, P.W. Atkins & C.H. Langford (1996) Inorganic chemistry, 2nd edition.
* S.F.A. Kettel (2007) Symmetry and Structure: Readable group Theory for Chemists.
* P. Powel (1998) Principles of organometallic Chemistry, 2nd edition.
* R.H. Carbtree (1994). The organometallic chemistry of transition metals, 2nd edition.
* G.L. Mieseler (2000?). Inorganic chemistry, 3rd edition.
* I Hargittai and M. Hargittai (1995) Symmetry through the eyes of the chemist 2nd edition. Plenum press, NY.

**Course Name: Advanced Organic Chemistry (Chem. 531) 3 Cr.hr**

**Pre-requisite:**

A comprehensive survey of organic chemistry with emphasis on important synthetic reactions and stereochemistry conformational analysis, configurations and chirality, symmetry elements, determination of absolute and relative configurations, stereochemistry of enzyme processes, reaction mechanisms, synthetically useful reactions.

**Mode of Delivery**: Lecture, Models, Independent Reading/Presentation

**Evaluation:** Assignments, Mid-exams, Final exams

**References**:

* Carey, F. A., and R. J. Sundberg. Advanced Organic Chemistry, Part A: Structure and Mechanisms. 4th ed. New York, NY: Springer, 2000. ISBN: 9780306462429.
* Joule, J. A., and K. Mills. Heterocyclic Chemistry. 4th ed. Malden, MA: Blackwell Science, 2000. ISBN: 9780632054534.

**Course Name: Advanced Physical Chemistry (Chem. 541) 3 Cr. hr**

Schrodinger Equation and Exact Solution, square wells and barriers; harmonic oscillator; the hydrogen atom; atomic orbitals; operators including angular momenta; time-independent and time-dependent perturbation theory; Schrodinger and Heisenberg representations; unitary operators; interaction picture, density matrix; variational method, many electron atoms; addition of angular momentum, self-consistent field method for open and closed shells, LCAO, origin of chemical bonding, many electron diatomic and polyatomic molecules, treatments of electron correlation, approximation methods, Spectroscopy

**Mode of Delivery:** Lecture, Independent Reading,

**Evaluation:** Assignments, Exercises, Mid exams, Final exams

**References:**

* Levine, I. N. Quantum Chemistry, 7th(or older)Ed.; Prentice Hall, 2008
* Donald A. McQuarrie, Quantum Chemistry, 1983, University Science Books.

**Course Name: Scientific Communications (Chem. 602) 2 Cr. hr**

Scientific writing; How to write a proposal, Thesis, Conference reports, scientific articles (Title, Abstract, Introduction, Review Literature, Materials and Methods including research designs, Results, Discussions, Acknowledgement, Reference, Summary, conclusions and recommendations), Review papers; Oral Presentation; The course will culminate by seminar presentation

**Mode of Delivery**: Lecture, Independent reading, Presentation by students, Critics of journal articles

**Evaluation**: Assignments 40% (Four assignments); Seminar presentation 50% (Oral 25% and Manuscript 25%)

**References**

* Marin S.R., & L. S. Fredricka, Mrs. Costanza – Rdinon & K. J. James (2008). **Write Like a Chemist**, Oxford University Press
* Robert, A.D., B.Gastel (2011) **How to write and publish a scientific paper** 7th Edition
* Robert, A.D. (1998) **How to write and publish a scientific paper** 5th Edition
* Malnfors, B., B. Garnswarthy, & M. Grossman (2004) **Writing and presenting scientific papers** 2nd Edition Nottingham University Press.
* Staplton, P. (1984) **Writing research papers: an easy guide for non-native English speakers.**
* Stock, M. (1985) **A practical guide to graduate research**. McGraw-Hill Book Company
* Heether, S. R. (2002). **Writing for science and Engineering**, Butter Worth – Hnemoun.
* Smith, R.V. (1998) **Graduate Research**: A Guide for students in the sciences. University of Washington press

**Evaluation:** Assignments 40% (Four assignments); Seminar presentation 50% (Oral 25% and Manuscript 25%)

**Course Name: Nanochemistry (Chem. 553) 2 Cr. hr**

**Prerequisite:**

Basic principles and fundamental properties (size and confinement effects, structure and phase transitions, thermodynamics of solid-liquid transition); Physical and chemical properties (Magnetic, electronic, optical and mechanical properties); Synthesis of nanomaterials (various synthesis techniques such as hydrothermal, sol-gel, precipitation, thermal decomposition, supercritical fluids approach, microwave, sonochemical etc.; Fabrication of nanostructured and bulk materials; Application of nanomaterials

**Mode of Delivery**: Lecture, Independent Reading,

**Evaluation:** Assignments, Exercises, Mid exams, Final exams

**References:**

* C. Br´echignac P. Houdy M. Lahmani, Nanomaterials andNanochemistry Springer-Verlag Berlin Heidelberg 2007
* Jean-Michel Lourtioz • Marcel Lahmani Claire Dupas-Haeberlin • Patrice Hesto, Nanosciences and Nanotechnology Evolution or Revolution? © Springer International Publishing Switzerland 2016

**Course Name: Surface Chemistry and Catalysis (Chem. 554) 2 Cr. hr**

**Prerequisite:**

Surface phenomena: Structure of clean surfaces; Notation of surface structure;  Structure of adsorbate layers; Stepped surfaces; Surface relaxation and reconstruction; Dynamics and energetics of surfaces; Heterogeneous Catalysis: Adsorption isotherms, surface area, pore size and acid strength measurements; Porous solids; Catalysis by metals, semiconductors and solid acids; Supported metal catalysts; Catalyst preparation, deactivation and regeneration. Model catalysts: Ammonia synthesis; Hydrogenation of carbon monoxide; Hydrocarbon conversion; Instrumental methods of catalyst characterization: Diffraction and thermal methods; spectroscopic and microscopic techniques

**Mode of Delivery:** Lecture, Independent Learning

**Evaluation**: Assignments, Exercises, Mid exams, Final exams

**References**:

* Albert F. Carley Philip R. Davies Graham J. Hutchings Michael S. Spencer 2002 Springer Science+Business Media New York Originally published by Kluwer Academic/Plenum Publishers, New York in 2002
* K. Christmann, Introduction to Surface Physical Chemistry, 1991 by Springer-Verlag Berlin Heidelberg

**Course Name: Materials Chemistry (Chem. 551) 2 Cr. hr**

**Prerequisite:**

This course will explain the application of materials chemistry through the materials properties and characterization, detailing how the crystalline and molecular structure of materials can be related to electronic, optical, thermal, and mechanical properties

**Mode of Delivery**: Lecture, Independent Reading,

**Evaluation**: Assignments, Exercises, Mid exams, Final exams

**References:**

* Bradley D. Fahlman, Materials Chemistry, Second Edition, Springer Science+Business Media B.V. 2011
* U. Schubert, N. Husing, R.M. Laine, Materials Syntheses, A Practical Guide, 2008 by Springer-Verlag Berlin Heidelberg

**Course Name Physical Methods in Materials Chemistry (Chem. 552) 2 Cr. hr**

**Prerequisite:**

This course deals with the state-of-the-art instruments employed in characterizing materials in terms of composition, structure and reactivity. **Composition**: TGA, Mass Spectrometry analysis (SIMS,RRS), Elemental Analysis, Atomic and Molecular spectroscopy, X-ray elemental analysis, Synchroton X-ray methods; **Structure:**  X-ay diffraction, synchroton and electron based methods for surfaces (VTR, LEEDS), SEM, TEM; Methods of thin film (Ellipsometry, Profilometry); **Reactivity:** Scanned Probe Tecniques such as STM, AFM, NSDM;Reactivity in vacuum: TPD, Dynamic methods for structure and composition; Electrochemical techniques such as CV, adsorption and electrocatalysis, EQCM, Scanned probe electrochemistry and impedance; Gas sorption in porous materials

**Mode of Delivery**: Lecture, Problem based Approach, Laboratory Demonstration, Independent Learning, Hands-on computer training using current online literature resources and recent discipline-specific computer programs, Laboratory Experiments (to be designed by the Instructor).

**Evaluation:** Assignments, Exercises, Mid exams, Final exams, Practical Exams

**References:**

* Leng, Yang. Materials Characterization: Introduction to Microscopic and Spectroscopic Methods. 2nd ed. Wiley.
* Elaine M. McCash. Surface Chemistry. Oxford University Press, 2001.
* Als-Nielsen, Jens and McMorrow, Des. Elements of Modern X-ray physics, 2nd edition, Wiley 2011. (Available on Reserve)
* Skoog, Douglas; Holler, James, F; Crouch, Stanley R . Principles of Instrumental Analysis. Brooks/Cole, 6th ed. 2007.
* Watts, John and Wostenholme, John. Surface Analysis by XPS and AES, Wiley, 2003.
* Goodhew, Peter; Humphreys, John; Beanland, Richard. Electron Microscopy and Analysis. 3rd edition, Taylor and Francis, 2001.
* Recent reviews and journal publications related to the course

**Course Name: Contemporary Materials Chemistry (Chem. 651) 1 Cr. hr**

**Prerequisite:**

This course is designed to provide the recent updates in materials chemistry. The topics include but not limited to **Energy Materials**: Encompassing all aspects of Materials Chemistry related to energy conversion, storage and fuel generation; **Nanomaterials Chemistry**: Encompassing synthesis, characterization and application of materials whose functionality depends on their nanoscale dimensions; **Porous Materials**: This will encompass the chemistry and properties of porous materials for sorption, storage and separation; **Soft Matter**: Including wide and varied aspects of soft matter materials showing the power of the interplay between a priori design and physical function; **Biomaterials**: Encompassing biomaterials for tissue engineering, biomaterials for healthcare, green biomaterials and advanced synthesis methods of biomaterials.

**Mode of Delivery:** Team Teaching (Lecture, PBL, Practicals as required), Independent Learning

**Evaluation:** Assignments, Presentations, Mid exams, Final exams

**References:** There is no single reference material for this course. Recent books pertaining to the topics and Journal articles/reviews are considered valuable resources

**Course Name: Seminar on Advanced Materials (Chem. 659) 1 Cr. hr**

This is an independent study on topics of current/recent interest in advanced materials. The topics include but not limited to the following: Molecular and nanoelectronics; Computational approach to materials design and property prediction; New techniques in molecular or atomic imaging; Application of nanomatrials to energy, sensor, environment, drug delivery and agriculture

**Mode of Delivery**: Independent learning

**Evaluation**: Preparation of review paper (50%), Oral Presentation (50%)

**Course Name: Chemical Instrumentation (Chem. 512) 2 Cr. hr**

**Prerequisite:**

Electronic and optical aspects of chemical instrumentation test and measuring instruments. Radiation sources, optical devices, filters, monochromators, and detectors. Analog instrumentation: semiconductor devices; feedback, operational amplifiers and their application in chemistry. Digital instrumentation: digital circuits, Analog to digital conversion and digital to analog conversion. Applications of computers in chemistry.

**Mode of Delivery**: Lecture, Demonstration in the laboratory, Independent Learning

**Evaluation**: Assignments, Practical Exams, Final Exams

**References:**

* H.A. Strobel and W.R. Heineman 1989 Chemical Instrumentation: A Systematic Approach, 3rd Edition
* [Richard P. Wayne](https://www.amazon.com/Richard-P.-Wayne/e/B004VTCYBE/ref=dp_byline_cont_book_1) Chemical Instrumentation (Oxford Chemistry Primers) 1st Edition, 1994
* [Francis Rouessac](https://www.amazon.com/Francis-Rouessac/e/B001H9MI1C/ref=dp_byline_cont_book_1) (Author), [Annick Rouessac](https://www.amazon.com/s/ref=dp_byline_sr_book_2?ie=UTF8&text=Annick+Rouessac&search-alias=books&field-author=Annick+Rouessac&sort=relevancerank) (Author) Chemical Analysis: Modern Instrumentation Methods and Techniques 2nd Edition , 2013
* [Jack Cazes](https://www.amazon.com/s/ref=dp_byline_sr_book_1?ie=UTF8&text=Jack+Cazes&search-alias=books&field-author=Jack+Cazes&sort=relevancerank) Ewings Analytical Instrumentation Handbook, 3rd Edition Editor, 2004

**Course Name: Electrochemical Methods (Chem. 548) 2 Cr. hr**

**Prerequisite:**

Thermodynamics and potential, electrode kinetics. Potential step and potential sweep methods including hydrodynamic methods. Bulk electrolysis methods. Electrode reactions coupled with homogeneous chemical reactions. Double layer structure and adsorbed intermediates in electrode processes. Digital simulation of electrochemical processes. Scanning probe techniques and spectroelectrochemistry.

**Mode of Delivery**: Lecture, Practical demonstration, Laboratory Experiments

**Evaluation:** Assignment, Practical Exams, Theoretical Exams

**References**

* [Allen J. Bard](https://www.amazon.com/s/ref=dp_byline_sr_book_1?ie=UTF8&text=Allen+J.+Bard&search-alias=books&field-author=Allen+J.+Bard&sort=relevancerank) and [Larry R. Faulkner](https://www.amazon.com/s/ref=dp_byline_sr_book_2?ie=UTF8&text=Larry+R.+Faulkner&search-alias=books&field-author=Larry+R.+Faulkner&sort=relevancerank) Electrochemical Methods: Fundamentals and Applications 2nd Edition , 2000
* [Allen J. And Larry R. Faulkner Bard](https://www.amazon.com/s/ref=dp_byline_sr_book_1?ie=UTF8&text=Allen+J.+And+Larry+R.+Faulkner+Bard&search-alias=books&field-author=Allen+J.+And+Larry+R.+Faulkner+Bard&sort=relevancerank) Electrochemical Methods & Applications Paperback – 2002

**Course Name: Solid State Chemistry (Chem. 652) 2 Cr. hr**

**Prerequisite:**

Basic principles of chemistry are applied to the description of structure-property relationships in the solid state. Connections among electronic structure, chemical bonding, and crystal structure of a variety of materials are developed. Attention is given to characterization of local and extended arrangements in crystalline and amorphous solids, including metals, ceramics, and semiconductors. Contents include: Local structure and optical properties – group theory, phosphors, laser materials, quantum dots; Materials Synthesis – solid-state reactions, phase diagrams, crystal growth, thin-film deposition, solution processing; Electro-optic properties – semiquantitive band structures, electroluminescence, solar cell materials, semiconductor diode materials; Close packing – various types, radius ratio rule; Common crystal structure types – important structures; Defects – point and extended; ionic transport; Mixed valency - unstable s, disproportionation, charge-ordering; Electrical properties - insulators, metals, semiconductors, superconductors, thermopower; Dielectric Properties – Polarization mechanisms, Shannon’s dielectric polarizability; Magnetic Properties – para, Pauli, anti, ferro, ferri, canted; magnetic superexchange rules; magnetodielectrics; Thermal properties-conductivity, expansion; Thermoelectrics

**Mode of Delivery**: Lecture, Models, Independent Learning

**Evaluation**: Assignments, Mid Exam, Final Exam

**References:**

* [Anthony R. West](https://www.amazon.com/Anthony-R.-West/e/B001ITVRJU/ref=dp_byline_cont_book_1) Solid State Chemistry and its Applications 2nd Edition, 2014.
* [Mark Ladd](https://www.amazon.com/s/ref=dp_byline_sr_book_1?ie=UTF8&text=Mark+Ladd&search-alias=books&field-author=Mark+Ladd&sort=relevancerank) Bonding, Structure and Solid-State Chemistry 1st Edition , 2016
* [Lesley E. Smart](https://www.amazon.com/s/ref=dp_byline_sr_book_1?ie=UTF8&text=Lesley+E.+Smart&search-alias=books&field-author=Lesley+E.+Smart&sort=relevancerank) , [Elaine A. Moore](https://www.amazon.com/s/ref=dp_byline_sr_book_2?ie=UTF8&text=Elaine+A.+Moore&search-alias=books&field-author=Elaine+A.+Moore&sort=relevancerank) Solid State Chemistry: An Introduction, Fourth Edition 4th Edition 2012
* [Lesley E. Smart](https://www.amazon.com/s/ref=dp_byline_sr_book_1?ie=UTF8&text=Lesley+E.+Smart&search-alias=books&field-author=Lesley+E.+Smart&sort=relevancerank) , [Elaine A. Moore](https://www.amazon.com/s/ref=dp_byline_sr_book_2?ie=UTF8&text=Elaine+A.+Moore&search-alias=books&field-author=Elaine+A.+Moore&sort=relevancerank) Solid State Chemistry: An Introduction, Third Edition 3rd Edition , 2005

**Course Name: Photocatalysis (Chem. 653) 2 Cr. hr**

**Prerequisite:**

Principles of heterogeneous photocatalysis; Kinetic concepts of heterogeneous catalysis; Mechanistic principles of photocatalytic reactions; Origin of the activity of semiconductor photocatalysis, Perspectives and advances in photocatalysis; photosynthetic routes to organic reactions

**Mode of Delivery**: Lecture, Independent learning, Problem based Approach

**Evaluation:** Assignmnet, Mid exam, Presentation, Final Exam

**References**

1. Jenny Schneider, Detlef Bahnemann, Jinhua Ye National, Gianluca Li Puma, Dionysios D. Dionysiou, Phtocatalysis: Fundamentals and Perspectives, © The Royal Society of Chemistry 2016

**Course Name: Phytochemicals and Biopesticides (Chem. 654) 2 Cr. hr**

**Prerequisite:**

Phytochemical pesticides and their synthetic analogues; Ethnobotanicals of pesticidal importance in Ethiopia; Other bioactive natural products chemicals; Chemistry of insect repellents, attractants, antecedents and hormones herbicide chemistry.

**Mode of Delivery**: Lecture, Independent learning

**Evaluation**: Assignment, Mid exam, Presentation, Final Exam

**References**

1. [Opender Koul](https://www.amazon.com/s/ref=dp_byline_sr_book_1?ie=UTF8&text=Opender+Koul&search-alias=books&field-author=Opender+Koul&sort=relevancerank) , [G. S. Dhaliwal](https://www.amazon.com/s/ref=dp_byline_sr_book_2?ie=UTF8&text=G.+S.+Dhaliwal&search-alias=books&field-author=G.+S.+Dhaliwal&sort=relevancerank) Phytochemical Biopesticides (Advances in Biopesticide Research,), 2000
2. [Dwijendra Singh](https://www.amazon.com/s/ref=dp_byline_sr_book_1?ie=UTF8&text=Dwijendra+Singh&search-alias=books&field-author=Dwijendra+Singh&sort=relevancerank) Advances in Plant Biopesticides 2014th Edition
3. [John T. Arnason](https://www.amazon.com/s/ref=dp_byline_sr_book_1?ie=UTF8&text=John+T.+Arnason&search-alias=books&field-author=John+T.+Arnason&sort=relevancerank) , [Rachel Mata](https://www.amazon.com/s/ref=dp_byline_sr_book_2?ie=UTF8&text=Rachel+Mata&search-alias=books&field-author=Rachel+Mata&sort=relevancerank) , [John T. Romeo](https://www.amazon.com/s/ref=dp_byline_sr_book_3?ie=UTF8&text=John+T.+Romeo&search-alias=books&field-author=John+T.+Romeo&sort=relevancerank) Phytochemistry of Medicinal Plants (Recent Advances in Phytochemistry), 1st ed. 1995 Edition
4. K. Sahayaraj, Basic and Applied Aspects of Biopesticides, Springer India 2014

**Course Name: Agrochemical Technology (Chem. 656) 2 Cr. hr**

**Prerequisite:**

Survey of (minor and major) plant nutrients in soil; soil fertility evaluation History of soil fertilization; Nature, purpose and function of fertilizers; Fertilizer-soil-plant relationship; Nitrogen fertilizers, nitrates, cyanamide, ammonia and its synthesis, ammonium based fertilizers; Urea; Phosphorus fertilizers; minor sources; phosphate rock; mining and processing for fertilizer production; single superphosphate fertilizers; phosphoric acid manufacture; Ammonium phosphate; Nitrogen phosphorus compound fertilizers; Potassium fertilizers; mining and proceeding of potash; trace elements in fertilizers; compound fertilizers and granulation including methods of manufacturing dry mixture of compounds (NPK): Liquid fertilizers; Organic fertilizers; slow release fertilizers; composting and compost utilization; pesticide (insecticides, herbicides, fungicides, nematicides, etc) formulation; controlled released formulations and methods; application equipment and methods; the Agrochemical R and D process (targeting, synthesis, screening, evaluation, development, post-sales technical support); Product Safety.

**Mode of Delivery**: Lecture, Independent learning

**Evaluation**: Assignment, Mid exam, Presentation, Final Exam

**References:**

[A. Knowles](https://www.amazon.com/s/ref=dp_byline_sr_book_1?ie=UTF8&text=A.+Knowles&search-alias=books&field-author=A.+Knowles&sort=relevancerank) Chemistry and Technology of Agrochemical Formulations 1998th Edition

**Course Name: Solid State Electronics (PHYS XXX) 2 Cr. hr**

**Prerequisite:**

Band-structure and doping of semiconductors. Drift-Diffusion Equations; Density of states; Fermi function; Law of Mass Action. PN Junctions: Derivation of I-V characteristics. PN Junctions: Capacitance; Breakdown; Non-idealities. Bipolar Junction Transistor (BJT): Operation principles. BJT: Derivation of I-V characteristics. BJT: Ebers-Moll model; Non-idealities. MOSFET: Derivation of I-V characteristics. MOSFET: Structure; Threshold Voltage; Enhancement- & Depletion-mode. Microwave devices. Transistors for Digital Logic: TTL, ECL, CMOS. Optoelectronic & Photonic Devices: Direct Vs Indirect Band-gap devices. LEDs; Semiconductor Lasers; Photovoltaic Cells. Principles and key technologies involved in microfabrication of integrated circuits. Microfabrication of: MOSFETs; CMOS; BJTs.

**Mode of Delivery**: Lecture, Independent learning

**Evaluation:** Assignment, Mid-exam, Presentation, Final Exam

**References**

* [George B Rutkowski](https://www.amazon.com/George-B-Rutkowski/e/B001HPQ7EK/ref=dp_byline_cont_book_1) , [Jerome E Oleksy](https://www.amazon.com/s/ref=dp_byline_sr_book_2?ie=UTF8&text=Jerome+E+Oleksy&search-alias=books&field-author=Jerome+E+Oleksy&sort=relevancerank) Solid-State Electronics 4th Edition, 1992
* [Banerjee Streetman](https://www.amazon.com/s/ref=dp_byline_sr_book_1?ie=UTF8&text=Banerjee+Streetman&search-alias=books&field-author=Banerjee+Streetman&sort=relevancerank) Solid State Electronic Devices 2015

**Course Name: Biotechnology (BIOL XXX) 2 Cr hr**

**Prerequisite:**

The goal is to cover fundamental concepts, principles, and technologies central to the modern biotechnology industry. Topics range from, but are not limited to, recombinant DNA technologies; genomics, proteomics, and epigenetics; viruses, vaccines, and gene therapy; stem cell biology; genetically modified organisms (GMOs); synthetic biology; drug discovery and development; and regulatory issues in the biotechnology and biopharmaceutical industries. The course also introduces students to the fundamentals of tissue engineering (TE) and the biomaterials, cells and growth factors used in TE through consideration of cell and tissue biology, biomaterials, drug delivery, engineering methods and design, and clinical implementation. Topics include: Tissue engineering, Biomaterials, Stem cells, Drug delivery

**Mode of Delivery**: Lecture, Independent learning

**Evaluation**: Assignment, Mid-exam, Presentation, Final Exam

**References:**

1. Indu Ravi, Mamta Baunthiyal, Jyoti Saxena Advances in Biotechnology, 2014
2. R.K. Salar, S.K. Gahlawat, P. Siwach, J.S. Duhan Biotechnology: Prospects and Applications, 2013

**Department of Physics**

Program Name: Master of Sciences in Physics

1. **Course Schedule**

**First Year – Semester I**

|  |  |  |
| --- | --- | --- |
| Course Code | Course Title | Credit Hours |
| Phys. 523 | Statistical Mechanics | 3 |
| Phys. 501  Phys. 511 | Computational Physics  or  Advanced Physics Laboratory | 3  3 |
| Phys. 553 | Electronics | 3 |
| Phys. 503 | Mathematical Physics | 3 |

**Total**  **12**

**First Year-Semester II**

|  |  |  |  |
| --- | --- | --- | --- |
| Course Code | Course Title | | Credit Hours |
| Phys. 532 | Classical Mechanics | | 3 |
| Phys. 544 | Quantum mechanics I | | 3 |
| Phys. 592 | | Research Methodology | 1 |
| Specialization course I | |  | 3 |
| Specialization course II | |  | 3 |

**Total 13**

**Second Year-Semester I (MSc with thesis)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Course Code | | Course Title | | Credit Hours |
| Phys. 695 | | MSc Thesis | | 6 |
| Phys. 693 | Seminar in Physics | | 1 | |

**Total 7**

**Second Year- Semester II (MSc with thesis)**

|  |  |  |
| --- | --- | --- |
| Course Code | Course Title | Credit Hours |
| Phys. 695 | MSc Thesis | 6 |

**Total 6**

**Second Year-Semester I (MSc Non \_ thesis)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Course Code | | Course Title | Credit Hours | |
| Elective Course I | |  | 3 | |
| Elective course II | |  | 3 | |
| Elective Course III | |  | 3 | |
| Phys. 693 | Seminar in Physics | | | 1 |

**Total 10**

**Second Year –Semester II (MSc Non\_ thesis)**

|  |  |  |
| --- | --- | --- |
| Course Code | Course Title | Credit Hours |
| Phys. 694 | Graduate Project | 3 |

**Total 3**

**Course breakdown for the Summer M.Sc program**

**Summer I**

|  |  |  |
| --- | --- | --- |
| Course Code | Course Title | Credit Hours |
| Phys. 503 | Mathematical Physics | 3 |
| Phys. 532 | Classical Mechanics | 3 |
| Phys. 553 | Electronics | 3 |

**Total**  **9**

**Summer II**

|  |  |  |
| --- | --- | --- |
| Course Code | Course Title | Credit Hours |
| Phys. 523 | Statistical Mechanics | 3 |
| Phys. 501  Phys. 511 | Computational Physics  or  Advanced Physics Laboratory | 3  3 |
| Phys. 544 | Quantum Mechanics I | 3 |

**Total 9**

**Summer III (MSc with thesis)**

|  |  |  |
| --- | --- | --- |
| Course Code | Course Title | Credit Hours |
| Specialization course I |  | 3 |
| Specialization course II |  | 3 |
| Phys. 592 | Research Methodology | 1 |
| Phys. 695 | MSc Thesis | NG |

**Total 7**

**Summer IV (MSc with thesis)**

|  |  |  |
| --- | --- | --- |
| Course Code | Course Title | Credit Hours |
| Phys. 695 | MSc Thesis | 6 |

**7**

**Summer III (MSc Non \_ thesis)**

|  |  |  |
| --- | --- | --- |
| Course Code | Course Title | Credit Hours |
| Specialization course I |  | 3 |
| Specialization course II |  | 3 |
| Elective course I |  | 3 |
| Elective course II |  | 3 |
| Phys. 592 | Research Methodology | 1 |
| Phys. 694 | M.Sc Graduate Project | NG |

**Total 13**

**Summer IV (MSc Non \_ thesis)**

|  |  |  |
| --- | --- | --- |
| Course Code | Course Title | Credit Hours |
| Elective course III |  | 3 |
| Phys. 693 | Seminar in Physics | 1 |
| Phys. 694 | M.Sc Graduate Project | 3 |

1. **Courses Syllabus**

**Course Title: Research Methodology**

**Course code: (Phys. 592),**

**Credit hours: 1cr.hr**

**Course Outline**

**1**) **NATURE AND CHARACTERISTICS OF RESEARCH** (2 hrs)

* Meaning of Research
* Qualities and Characteristic of a Good Researcher
* Values of Research to Man
* Types and Classification of Research
* Meaning and Types of Variable
* Components of the Research Process

**2**) **RESEARCH PROBLEMS AND OBJECTIVES** (2 hrs)

* The Research Problem
* The Research Objectives
* Statement of Research Problem/Objectives
* The Hypothesis and Assumption
* Theoretical and Conceptual Framework
* Significance of Study
* Scope and Limitations of the Study
* Definition of Terms

**3**) **REVIEW OF RELATED LITERATURE** (1 hrs)

* Related Readings
* Related Literature
* Related Studies
* Justification of the Present Study

**4**) **RESEARCH DESIGN** ( 1 hrs)

* Descriptive Design (Types of Descriptive Design)
* Experimental Design (Types of Experimental Design)

**5**) **QUALITIES OF A GOOD RESEARCH INSTRUMENT** (1 hrs)

* Validity
* Reliability
* Usability

**6**) **SAMPLING DESIGNS** (2 hrs)

* Advantages of Sampling
* Limitations of Sampling
* Planning a Sampling Survey
* Determination of Sample Size
* Scientific Sampling

**7**) **DATA PROCESSING AND STATISTICAL TREATMENT** (2 hrs)

* Data Processing
* Categorization of Data
* Coding of Data
* Tabulation of Data
* Data Matrix
* Statistical Treatment
* Statistical Tools for - Research , Descriptive and Experimental Designs

**8**) **DATA ANALYSIS AND INTERPRETATION** (2 hrs)

* Univariate, Bivariate, Multivariate Analysis
* Normative Analysis
* Status Analysis
* Descriptive Analysis
* Classification Analysis
* Evaluative Analysis
* Comparative Analysis
* Cost-Effective Analysis

**9**) **FORM AND STYLE IN WRITING A RESEARCH (THESIS AND PROPOSAL)** (2 hrs)

* The Preliminaries of a Research
* The Text of a Research Paper
* Chapter Headings
* Documentation in Research Paper
* Notes, Bibliography, References and Literature Cited
* Style in Writing

**10**) **Project Work**

The course methodology includes lecture that provides condensed explanations, discussion that encourages a flexible exchange of information, and practical work which requires students to practice the techniques they are learning. The focus of the course will be the paradigm shift from instructor-centered to student-centered curricula wherein teaching strategies that promote active learning will be applied such as case studies, cooperative learning, concept tests and problem based learning. Students will have independent project work and submit to the course instructor.

**Assessment**

\_ Class participation, and group oral reporting 15%

\_ Individual written output from each chapter: 25%

\_ One exam (25%), .

\_ project work (35%)

**Recommended References**

* Paler-Calmorin, Laurentina. Methods of Research and Thesis Writing, 2006. .Rex Bookstore, Inc. Manila, Philippines Temechegn Engida. Educational ResearchMethods (Module), 2008.
* Louis Cohen, Lawrence Manion and Keith Morrison. Research Methods in Education 5th ed.,. Routledge Falmer, London, 2000.
* Judith Bell. Doing Your Research Project (3rd Edition). Open University Press, United Kingdom, 1999.
* Joseph Gibaldi. MLA Handbook for Writers of Research Paper 6th ed.,. First East-West Press Edition, New Delhi, 2004

**Course Title: Electrodynamics**

**Course code: Phys. 673**

**Credit hours: 3**

**Course objectives**: the course is designed to give the students some advanced knowledge of classical electrodynamics. After the completion of the course, students will have an idea of the implications of Maxwell’s equations, various conservation laws, Lorentz transformation of electromagnetic fields and formulation of electrodynamics in four – dimensional space.

**Course description**:

Maxwell’s equations of electrodynamics; displacement current; continuity equation, conservation laws; Poynting’s theorem; coulomb’s gauge and Lorentz gauge ; retarded potentials; relativistic electrodynamics; Lorentz-Wichart transformation of field; covariant formulation of Maxwell’s equations

**Course outline**

* 1. **Maxwell’s equations**
* Electrodynamics before Maxwell
* Displacement current; Ampere’s and Maxwell’s laws
* Maxwell’s equations
* Magnetic charge
* Maxwell’s equations in matter
* Continuity equation
* Poynting’s theorem; Poyntings vector
  1. **Electromagnetic waves**
* Wave equation
* Electromagnetic waves in vacuum; wave equations for E and B
* Monochromatic plane waves; transverse nature of electromagnetic waves
* Energy and momentum in electromagnetic waves
* Electromagnetic waves in matter; propagation in linear media
* Reflection and transmission at normal and oblique incidence
* Electromagnetic waves in conductors
  1. **Potentials and Fields**
* Scalar and vector potentials
* Gauge transformation
* Coulomb gauge and Lorentz gauge
* Retarded potentials; Lienard – Wiechert potentials
  1. **Electrodynamics and Relativity**
* Lorentz transformation
* Magnetism as a relativistic phenomenon
* Lorentz transformation of electric and magnetic fields
* The electromagnetic field tensor
* Fields of moving charges
* Electrodynamics in covariant form
* Relativistic potentials

**Mode of instruction**: There will be pre-planned class- room lectures, question and answer sessions will be there. Application of the theoretical principles to the solution of problems will be encouraged.

**Assessment**: Regular homework and group discussions. Two written examinations; one mid and the other at the end of the semester.

**Text and Reference Books**:

* Introduction to electrodynamics : David J. Griffiths
* Basic electromagnetism – E.R. Dobbs
* Electromagnetism – M.H. Choudhury
* Classical Electrodynamics – J.D. Jackson

**Course Title: Mathematical physics**

**Course code: Phys. 503**

**Credit Hours: 3**

**Course objectives**: the course has been designed to acquaint the students with those essential aspects of mathematics, which would help them in understanding some of the basic and difficult theories of physics. They will also learn the techniques of solving theoretical problems in physics.

**Course description**: Vectors in a general space; vector operations like products, differentiation and integration, tensors and their use in physics, Euclidean and Riemannian space, matrices and their mathematical operations, eigenvalues and eigenvectors of matrices, beta and gamma functions, **complex variables, special functions**.

**Course outline**

1. **Vectors**

* Introduction
* Vectors in a general space; linear independence and orthonormality of vectors.
* Schwarz inequality
* Vector operations in three dimensions; products; differentiation; integration
* Simple applications of vectors to mechanics
* Gradient of a scalar; divergence and curl of a vector
* Orthogonal curvilinear co- ordinates, unit vectors and their relationships in different orthogonal curvilinear co- ordinates; gradient, divergence and curl in orthogonal curvilinear co- ordinates
* Line integral ; surface integral, volume integral
* Gauss’s divergence theorem; Green’s theorem; Stoke’s theorem

1. **Tensors**

* Introduction
* Notation and conventions; tensors as classification of transformation laws; contravariant and covariant tensors
* Addition and subtraction of tensors; outer product and inner product of tensors
* Symmetric and antisymmetric tensors
* The fundamental of metric tensors
* Concept of Euclidean space and Riemannian space

1. **Matrices**

* Definitions and notations
* Addition and multiplication of matrices
* Special matrices with their properties
* Trace and determinants of matrices; eigenvalues and eigenvectors of matrices.
* Diagonalization of a matrix

1. **Special functions**
2. Definitions
3. Fundamental property of gamma functions
4. Transformation of gamma function; the value of gamma half
5. Different forms or beta functions
6. Relation between beta and gamma functions
7. **Dirac delta function**; its properties and application in physics

**Mode of instruction**:

All the relevant mathematical principles with detailed calculations will be through pre- planned lectures. There will be active sessions in the classroom, where solutions of real physical problems using the mathematical ideas developed will be discussed.

**Mode of assessment**: Continuous assessment through assignments and discussions; two written examinations, one at the mid- term, and other at end of the semester.

**Text and References Books**

* Mathematical Methods of physics by G.B. Arfken and H.J. weber
* Mathematical physics – B.D. Gupta
* Matrices and tensors in physics by A.W. Joshi
* 4. Methods of theoretical physics by P. Morse and H. Feshback

**Course Title: Computational Physics**

**Course code: Phys. 501**

**Credit hours: 3**

**Course Objectives**

This course will be offered after” Mathematical Physics” where the students learn how to solve problems analytically. It is designed to expose students to computer and teach them to solve physical problems numerically using software package . therefore, at the end of the course the student.

Windows applications

Understands Numerical Methods

Use these techniques physical problems

Develops a skill of computer programming using MATLAB

**Course Description**

1. Introduction to windows applications and MATLAB programming
2. Sources of errors in numerical calculations
3. Interpolation and Extrapolation
4. Numerical differentiation and integration
5. Non linear equation and root finding
6. Numerical solutions of Ordinary and partial Differential equations
7. Numerical solution of initial value problems
8. Numerical solution of boundary value problems
9. Solution of systems of linear algebraic equations
10. Data modeling and least square fitting
11. Monte Carlo Calculation
12. Fourier transformation and wavelet analysis

**Course Outline**

Text Book and Referneces

* Numerical Recipes, the art of scientific Computing. W. Press, S. Teukolsky, W. Vetterling and B. Flannery, third edition (2007), cambridge university Press ( ISBN – 10: 0521880688, or ISBN – 13: 978 -0521880688)
* An introduction to computational physics. Tao Pang Cambridge University Press ( ISBN 0-521 -48592-4)
* Applied Numerical Mehods Using MATLAB Won Y.Yang, Wenwn Cao, Tae – Sang chung ( ISBN 9780471698333) Jhon wiley and Sons, Inc.
* Applied Numerical Methods with MATLAB for engineers & scientists,. Steve C. Chapra, Tufts University

**Course Title: Electronics**

**Course code: Phys. 553**

**Credit hours: 3**

**Course Objectives**

**Course Descriptions**

**Course Outline**

1. Combinational logic circuits

* introduction to digital logic
* Boolean algebra
* De Morgans theorem
* Karnaugh maps

2. Tranistors as amplifiers

* one and two stage amplifiers
* negative and positive feedback
* Amplifiers as oscillators
* conditions for satisfied oscillation
* RC phase shift oscillator

3. Communication systems

* Radio wave propagation in space
* Tropospheric and Inospheric propagation
* model of a communication system
* classification of signals
* Representation of signals
* Amplitude modulation
* phase and frequency modulation
* pulse amplitude modulation
  1. Microprocessors
* Introduction to micro computers
* Memory input – output
* Interfacing devices
* 8085/8086 CPU architecture
* Bus timings
* Instruction set
* Addressing modes
* Assembly language programmes counting and indexing
* Counting and indexing
* Counters and time delays

Text books

* Introduction to microprocessors for engineers and physicists P.k. ghosh and P.R. Sridhar; Printice hall of india
* Electronic principles, A.P Malvino; tata mc Grew Hill
* Painciples of communication systems H. taub and D.L. schilling
* Integrated electronics: analog and digital circuit systems J. Milliman and c. halkics; mc Graw Hill

**Course Title: Nuclear Physics**

**Course Code: Phys. 685**

**Credit Hours: 3**

**Course objectives**: The course has been designed to give introductory ideas about the nucleus and its fundamental properties. After the completion of this course, students will be in a position to go for higher studies in nuclear physics, both theoretical and experimental.

**Course Description**: the course focuses on the nucleus, its constituents and properties; nature of nuclear forces; meson theory of nuclear forces; the deuteron problem; liquid drop model; shell model; predictions and success of the models.

**Course outline:**

1. **Nucleus and its constituents**

* Introduction
* Rutherford scattering and estimation of the nuclear size
* Measurement of nuclear radius
* Constituents of the nucleus and their properties
* Nuclear spin, moments and statistics

1. **Nuclear force**

* Introduction
* Saturation of nuclear force; charge symmetry and charge independence of nuclear forces.
* Central and non- central forces; the tensor force as an example
* Exchange forces; meson theory of nuclear force

1. **The deuteron problem**

* Introduction
* The ground state of the deuteron
* Magnetic dipole and electric quadruple moments of the deuteron
* Square well solution for the deuteron.

1. **The liquid drop model of a nucleus**

* Introduction
* Binding energies of nuclei
* Weizsacher’s semi- empirical mass formula
* Mass parabolas, stability against beta decay
* Nuclear fission; stability limits; energy released in fission process

**V The shell model of a nucleus**

* introduction
* evidence leading to the shell model.
* Single particle shell model; the parabolic potential
* Predications of the shell model

**Mode of instruction:** instruction will be mainly through planned lecturers in the class room. Illustration of the ideas by solving of problems will be there. Discussion through questions and answers will be encouraged.

**Method of assessment**: there will be continuous assessment through home assignments and group discussion. There will be two written examinations, one at the mid- term and the other at the end of the semester.

**Text and Reference books**

* Concepts of Nuclear physics : B.l. cohen
* Nuclear physics: S.B. Patel
* The atomic nucleus : R. Evans
* Atomic and nuclear Physics ( vol.1&2) : S.N. Ghosal
* Introductory Nuclear theory: L.R.B Elton

**Course Title: Classical Mechanics**

**Course Code: Phys. 532**

**Credit hours: 3**

**Course objectives:** The course has been designed to acquaint the students with the Lagrangian and Hamiltonian methods of classical mechanics. They will learn to apply these methods to actual physical problems where the conventional Newtonian mechanics may not be easy to use. The student will also learn in details the physics behind the planetary motion.

**Course description** : variational principle and lagrangian formulation; lagrange’s equations of motion and their applications; Hamilton’s equations of motion and their applications; canonical transformations; Poisson brackets; Hamilton- Jacobi theory; motion under central force; Kepler’s problem; Rutherford scattering **rigid body motion, theory of oscillation.**

**Course outline:**

1. **Variational Principle and lagrangian formulation**

* Introduction to calculus of variations
* Variational technique for many independent variables; Euler lagarange differential equation
* Hamilton’s variational principle; deduction of Lagranges equations of motion
* D’alembert’s principle; deducation of Lagrange’s equations of motion; conservative system; non- conservative system
* Lagrangian for a charged particle in an electromagnetic field
* A few applications of lagrange’s equations of motion
* Conservation theorems

1. **Hamiltonian formulation of mechanics**

* Introduction
* Phase space; the Hamiltonian of a system
* Hamiltons canonical equations of motion
* Some applications of hamiltons equations of motion
* Canonical transformations with examples
* Hamilton – Jacobi method
* Poisson brackets; definition and properties; equatiosn of motion in terms of poission brackets.

1. **Motion under central force**

* Introduction
* Two- body problem; reduction to equivalent one body problem
* General features of central force motion
* Motion under inverse square force; kepler’s problem
* Ruther ford scattering

**Mode of instruction**: instruction will be through class-room lectures. Time will be allotted to question- answer sessions. Students will be motivated to apply the basic principles to the solution of real physical problems.

**Method of Assessment**: There will be regular home assignments and group discussions. Two written examinations will be held- one at the mid and the other at the end of the semester.

**Text and reference books:**

* Classical Mechanics – H. Goldstein
* Classical Dynamics – J.B. Marion
* Introduction to classical mechanics – Atam p. Arya
* Classical Mechanics – Gupta, Kumar, and Sharma
* Classical mechanics – Tai L. chow
* Mechanics – W. Arthur, s.k. fenster

**Course Title: Atomic and molecular physics**

**Course code: Phys. 681**

**Credit hours: 3**

**Course objectives**: This course is designed to give the students a deep understanding of the fundamental properties of atoms and molecules. They would also learn the application value of atomic and molecular spectroscopy.

**Course description** : Quantum theory of atomic structure; fine structure of spectral lines; Lamb shift; Zeeman effect; Paschan- Back effect; Helium atom; Thomas – Fermi model; Hartree- Fock approximation; Rotational and vibration spectra of molecules; electronic bands; Raman effect and its theory; application of raman effect; Heitler- London theory of hydrogen molecule.

**Course outline**:

1. **Quantum theory of Atomic structure**

* Introduction
* Fine structure of hydrogen like atoms
* Fine structure of hydrogen spectral terms.
* Lamb and Rutherford’s experiments
* Theory of Zeeman effect
* Strong field case: Paschen back effect
* Two- electron atoms; term scheme for the helium atom
* Calculation of the ground state energy of the helium atom
* The nature of the central field; Thomas- Fermi model of the atom
* Hartree Fock method of self consistent field
* Application of Hartree Fock method to many – electron atoms

1. **Molecular spectra**

* Introduction
* Origin of band spectra
* Pure rotational spectra of a diatomic molecule
* Rotation – vibration spectra of diatomic molecules
* Electronic bands and their vibrational structure
* Frank- Condon principle
* Rotational structure of electronic bands
* Roman effect; classical theory of Raman effect
* Quantum theory of roman effect
* Applications of Raman effect
* Hydrogen molecule ; Heitler- London theory ; molecular orbital theory

**Mode of instruction:** Through intensive class- room lectures, students will be encouraged to think and analyze problems related to atomic and molecular properties.

**Method of assessment**: there will be assignments and question- hour session in the class- room. Written examinations will be held at mid- term and at the end of the session.

**Text and Reference Books**

* Atomic spectra and atomic structure - G. Hertzberg
* Introduction to atomic spectra -H. white
* Atomic and nuclear physics ( vol I) - S.N. Ghoshal
* Physics of atoms and molecules \_ B.H Bransden and c.J. Jachain
* Quantum theory of atomic structure (vol II) - J.c. Slater

**Course Title: Statistical Mechanics**

**Course Code: Phys. 523**

**Credit hours: 3**

**Course objectives**: The course has been designed to give the students the basic knowledge about the physical and mathematical concepts of statistical physics. The students will learn to apply these concepts to real physical problems taken from molecular physics, magnetism, solid state physics, and so on.

**Course description**: Review of laws of thermodynamics, relation of entropy with multiplicity; concept of ensembles and related probability distribution functions; partition functions of monatomic and diatomic molecules; non- ideal gases; Van del Waals equation; classical and quantum statistics, and application to various physical systems and theory of phase transition .

**Course Outline**

1. **Thermodynamics**

* Introduction
* First, second and third laws of thermodynamics
* The basic thermodynamic functions
* Entropy and multiplicity of a thermodynamic system.
* Concept of chemical potential, and its expressions as derivatives of various thermodynamic functions
* Concept of phase space

1. **Ensembles**

* Introduction
* Microcanonical ensemble
* Canonical ensemble and the corresponding probability distribution function .
* Grand canonical ensemble and the corresponding probability distribution function
* Physical meaning of the alpha and beta parameters appearing in the probability expressions
* Maxwell- Boltzmann distribution law from the canonical probability distribution function

1. **Partition function**

* Definition
* Evaluation of partition function of a monatomic gas
* Partition function of a diatomic gas; translational, rotational, vibrational and electronic partition functions.
* Statistical averages of basic thermodynamic variables like, work, energy, pressure and entropy
* Entropy in terms of probability; additive property of entropy;
* Entropy of an ideal gas; equation of state for an ideal gas

1. **Non- ideal gas**

* Introduction
* Deviation of gases from the ideal state
* Expansion in powers of density of particles
* Van der waals equation of state for non- ideal gases.

**V Quantum statistics of ideal gases**

* Introduction
* Symmetry of wave function
* Base- Einstein distribution function
* Fermi- dirac distribution function
* The classical limit of quantum distribution functions
* Photon gas; Planck’s law
* Specific heat of solids; Einstein and Debye theories

**Mode of Instruction:**

Instruction will be by pre- planned lectures. There will be question- answer sessions after the lecture hours. Application of the ideas developed, to specific problems will be encouraged.

**Method of assessment**:

Continuous assessment through home assignments and group discussions. There will be two written examinations: at the mid and end of the semester.

**Text and Reference Books**

* Fundamentals of statistical and thermal physics – F. Reif
* Statistical thermodynamics – M.C. Gupta
* Fundamentals of statistical Mechanics - B.B Laud
* Statistical Mechanics – R.K. Parthia
* Statistical Mechanics – K. Huang

**Course Title: Quantum Mechanics I**

**Course Code: Phys. 544**

**Credit hours: 3**

**Course objectives**: This course has been designed to give the students an in- depth knowledge about the fundamental principles of quantum mechanics. The students will learn the techniques of various approximation methods. These will enable them to solve varieties of problems in physics.

**Course Description** : Review of the Schrödinger equation; operators in quantum mechanics; types, properties, and algebra of operators; general uncertainty principle; motion in a central field; angular momentum and its eigenvalues; hydrogen atom; various approximation methods like perturbation method and variational method.

**Course outline:**

1. **Review of the Schrödinger equation**

* Introduction
* Properties and physical criteria of the wave function
* Equation of continuity and probability current density; their significance.

1. **Operator formalism in quantum mechanics**

* Introduction
* Dynamical variables as operators
* Operator algebra; linear; hermitian operators; unitary operators
* Eigenvalues and eigenfunctions of operators, completeness and orthonormality of eigenfunctions; expansion postulate.
* Commuativity of operators and simultaneous measurements; General Heisenberg’s uncertainty relation for non- commuting operators.

1. **Motion in a central field**

* The Schrödinger equation in spherical polar co-ordinates
* Constants of motion of a particle moving in central field
* Orbital angular momentum operators and determination of their eigen values using the method of raising and lowering operators.
* The hydrogen atom and its energy eigenvalues; degeneracy of energy levels.

1. **Approximation Methods in quantum mechanics**

* Introduction
* Time- independent perturbation theory for a non- degenerate level
* Time- independent perturbation theory for a degenerate level.
* Application to Zeeman effect and Stark effect
* Time – dependent perturbation theory in first- order; Fermi’s golden rule; constant perturbation.
* Variational method and its application to hydrogen and helium atoms.

**Mode of instruction**: Mainly by intensive class- room lectures. Students will be encouraged to solve important problems using the basic principles of quantum mechanics.

**Method of assessment**: there will be periodic assignments and question hour sessions in the class- room. Two written examinations will be there – one at the mid- term and one at the end of the semester.

**Text and Reference Books :**

* Quantum Mechancis -L. I. Schiff
* A text book of quantum mechanics -Mathews and venkatesan
* Quantum Mechanics – A.S. Davydov
* Quatnum Mechanics – Thankappan
* Principles of quantum mechanics - P.A.M. Dirac
* Quantum Mechanics – B.H. Bransden and C.J. Joachin

**Course Title: Quantum mechanics II**

**Course code: Phys. 546**

**Credit hours: 3**

**Course objectives**: This course introduces the students to the matrix mechanics as developed by Heisenberg, and which is another equivalent form of quantum mechanics. The students will get to learn the connection between symmetry and conservation laws and also how the special theory of relativity can be integrated with quantum mechanics.

**Course Description**: matrix mechanics; Heisenberg’s equation of motion; Pauli’s theory of electron spin; the spin matrices; identical particles, symmetry and conservation laws; quantum theory of scattering; Born approximation; relativitistic quantum mechanics; Klein- Gordon equation; Dirac equation.

**Course Outline**

**1. Matrix mechanics**

* Introduction
* Heisenberg’s equation of motion in matrix mechanics
* Application to linear harmonic oscillator; creation and annihilation operators
* Pauli’s theory of electron spin; Pauli spin matrices; spin eigenvectors
* Identical particles in quantum mechanics; symmetry of wave function; the Pauli exclusion principle

**2. Invariance, symmetry and conservation laws**

* Introduction
* Symmetry under space translation and conservation of linear momentum
* Symmetry under time translation and conservation of energy
* Symmetry under rotation in space and conservation of angular momentum
* Space inversion or parity; time reversal or time reflection.

1. **Quantum theory of scattering**

* Introduction
* Formal theory of potential scattering using the method of Green function
* Born approximation
* Scattering by screened coulomb potential

1. **Relativistic quantum Mechanics**

* Introduction
* Klein- Gordon equation; probability density and probability current density; the difficulties involved
* Dirac equation for a free particle; the alpha and beta matrices; probability density and probability current density; removal of difficulties present in the Klein Gordon equation
* Dirac Hamiltonian in a central field ; existence of spin angular momentum and anomalous magnetic moment.
* Dirac equation in covariant form; the gamma matrices
* Solution of Dirac equation for a free particle; interpretation of negative energy solutions; theory of position or antielectron.

**Mode of instruction**: There will be intensive class room lectures followed by question – hour sessions. Students will be provided with problems to be solved using the principles developed.

**Method of assessment**:-

There will be continuous assessment through assignments. Two written examinations will be there – one at the mid- term and one at the end of the semester.

**Text and Reference Books**

* Quantum Mechanics - L.I.Schiff
* A text book of quantum mechanics - Mathews and venkatesan
* Quantum mechanics – A.S. Davydov
* Quantum Mechanics – Thankappan
* Principles of quantum mechanics - P. A.M. Dirac

**Course Title: Solid state physics**

**Course Code: Phys. 552**

**Credit hours: 3**

**Course objectives**: The course has been designed to give the students knowledge about the basic properties of matter in the solid state. They will learn why solids get classified into conductors, insulators and semiconductors, and also the exciting thermal and magnetic properties of super conductors.

**Course Description**: crystalline solids; unit cell; Bravais lattice in two and three dimensions; different crystal structures; x- ray diffraction by crystals; Lattice vibrations, lattice specific heat; electrons in a periodic potential; Block theorem; kronig-Penny model; super conductivity; London’s theory; cooper pairs; BCs theory.

**Course Outline**:

1. **crystalline solids**

* Translational symmetry in crystals
* Lattice vector; unit cell; two and three dimensional Bravais lattice
* Crystal planes; Miller indices; spacing in crystal planes
* Different crystal structures; simple cubic, b.c.c, f.c.c and h.c.p crystals

1. **Diffraction of x- rays by crystals**

* Determination fo crystal structure
* Bragg’s law in one- and three dimensions; characteristic features of Bragg’s law
* Experimental methods in x- ray diffraction.
* Concept of reciprocal lattice; reciprocal lattice of b.c.c and f.c.c lattice.

1. **Lattice Vibrations**

* Elastic vibration of continuous media
* Vibration of one- dimensional monatomic lattice; frequency spectra
* Vibration of one- dimensional diatomic lattice; frequency spectra; acoustic and optical branches.
* Concept of phonons
* Lattice specific heat of solids; Einstein’s theory; Debye’s theory

1. **Band theory of solids**

* Introduction
* Electrons in a periodic potential; Bloch theorem
* Kronig- Penny model; origin of bands and band gaps
* Concept of Brillouin zone, effective mass of electron
* Classification of solids into conductors, insulators and semiconductors.

**5. Super conductivity**

* Introduction
* Zero electrical resistance and persistent currents; Meissner effect
* London’s semi- empirical theory of superconductivity
* Flux quantization
* Concept of cooper pairs; ideas of BCS quantum theory of super conductivity

**Mode of instruction**: Teaching will be mainly through pre- planned lectures. There will be question- answer sessions. Students will be encouraged to solve problems related to simple physical systems.

**Method of assessment**: continuous assessment through home assignments and group discussions. There will be two written examinations- one at the mid- term and the other at the end of the semester.

**Text and Reference Books**

* Solid state physics – N. Aschroft and Mermin
* Solid state physics – A.J. Dekkar
* Solid state physics – C. Kittel
* Solid state physics – S.O.Pillai

**Course Title: Physics of Semiconductors and Devices**

**Course code: Phys. 655**

**Credit Hour: 3**

**Course description**

Crystal structure, Energy band, Impurities, Carrier statistics, Optical property,   
Nonequilibrium phenomena, Basic equations for semiconductor, p-n junction, Bipolar transistor, Metal-Semiconductor contacts, Field effect transistor, Photonic Devices: LED and Semiconductor laser, Photo detectors, Solar cells

**Course Outline**

**Text & References**

**Course Title: Advanced Physics Laboratory**

**Course Code: Phys. 621**

**Credit Hour: 3**

**Course description**

Photoelectric effect, Photovoltaic energy conversion, Fraunhofer diffraction phenomena in monochromatic light, Interferometry, X-ray diffraction, Electron diffraction, Holography, The Franck-Hertz experiment, Hall effect in p-germanium, e/m determination by Millikan’s oil drop method, Determination of Earth’s magnetic field.

**Course Outline**

**Text & References**

**Course Title: M.Sc Graduate Project**

**Course Code: Phys. 694**

**Credit Hour: 3**

**This is a project work which mainly involves literature review of a certain topic in theoretical physics or some experimental work. It is a compulsory course for students registered for M.Sc without thesis.**

**Course Title: Atmospheric Physics**

**Course code: Phys. 661**

**Credit Hour: 3**

**Course description**

Atmosphere of other planets and their Equilibrium temperatures; Hydrostatic Equation; Atmospheric thermodynamics: Atmospheric dynamics: Numerical Modeling of Atmospheric State; and Introduction to remote Sounding of Atmosphere

**Course Title:** Seminar in Physics

**Course Code: Phys. 693**

**Credit Hour: 1**

**Course description:**

A student is expected to review scientific journals on current topics and organize a seminar

**Course Title: Research Project (M.Sc Thesis)**

**Course code: Phys. 695**

**Credit Hour: 6**

**Course description**

A research project to be carried out in theoretical or experimental physics, with an objective of assisting students to plan and execute research projects independently.

**ELECTIVE SPECIALITY COURSES**

**FIELDS OF SPECIALIZATION**

The following fields of specialization will be offered to the students: A student has the option to choose any one of the fields of specialization mentioned below:

* + Environmental Physics
  + Medical Physics
  + Quantum Physics
  + Meteorological Physics
  + Radiation Physics
  + Reactor Physics
  + Methods of Theoretical Physics
  + Geophysics
  + Computational Physics
  + Nanoscale Physics
  + Electronics
  + Condensed Matter Physics
  + High Energy Physics
  + Alternative Energy Sources

Each field of specialization consists of two specialization courses.

**I-SPECIALITY IN MEDICAL PHYSICS**

**Course Title: Radiological Physics I**

**Course Code: Phys.584**

**3 credit hours**

**PART 1 RADIOGRAPHY AND MATHEMATICS**

**PART CONSTRUCTION AND OPERATION OF X-RAY TUBES**

* Units Of Measurements
* Heat In X-Ray Tube
* Ac And The X-Ray Tube
* The Ac Transformer In X-Ray Tube
* X-Ray Tubes And Rectifiers
* Diagnostic X-Ray Tubes
* Monitoring And Protection Of X-Ray Tubes

Part 2 Atomic Physics

* Laws Of Modern Physics
* Electromagnetic Radiations
* Elementary Structure Of The Atom
* Radioactivity

Part 3 X-Rays And Matter

* The Production Of X-Rays
* Factors Affecting X-Ray Beam Quality And Quantity
* Interaction Of X-Rays With Matter
* The Radiographic Image
* Geometric Radiography
* Experimental Error
* The Inverse Square Law

Course Title- **Radiological Quality Assurance (Radiological Physics II)**

Course No. Phys.588

Credit Hour—3 Lecture 2 Credit Hrs 1 credit Hrs Practicum

**Description**: this course focuses on the overall activities performed in the production of a qualitative radiograph. The students should be able to recognize the parameters that influence the standard of a radiograph and apply when necessary.

**Course objective**

**At the end of the course the students will be able to:**

* to Set and Check Standards of Good Practice
* assess radiation detriment so that radiological techniques can be justified
* to establish the approximate risk from a particular examination
* to assess risk to individual patient and minimize it
* to compare with Diagnostic Reference Levels (DRLs) agreed nationally and internationally
* to monitor collective dose to population
* to asses equipment performance as part of QA programme

**Description**: this course focuses on the overall activities performed in the production of a qualitative radiograph. The students should be able to recognize the parameters that influence the standard of a radiograph and apply when necessary.

**Curse out line:**

Chapter 1 **Experimental error**

* Aim
* Introduction
* Experimental errors
  + How exact is accurate?
  + Random and systematic errors
  + Fractional and percentage errors
  + Combining errors
    - * Errors in a product
      * Errors in a quotient
      * Errors in a sum
    - Examples of errors in practical radiography and radiotherapy

**Chapter 2**

* **Aim**
* Effective (apparent) and real focal spot sizes
* Field size and FFD
* Image magnification
* Geometric unsharpness (penumbra)

**Chapter 3 .The inverse square law**

* Aim
* Intensity of radiation
* Statement of inverse square law
* Mathematical proofs of inverse square law
* The inverse square law and the x-ray beam
* mAs and the inverse square law

**4. Radiation interaction with tissue**

* αParticles until
* β-particle
* γ-photon
* Linear energy transfer (LET)
* Exposure and exposure rate
* Absorbed dose, D
* Absorbed dose, D and KERMA
* Relation between absorbed dose and exposure
* Equivalent dose
* Radiation weighting factor, wR
* Tissue weighting factors, wT
* Effective dose, E
* Introduction: dose to whom?
* How is dose measured?
* Entrance surface dose (ESD)
* Dose area product
* Radiation monitoring

**5. Radiation protection**

* Justification of a practice
* Optimization of protection
* Limitation of doses
* Exposure situations
* 5.4.1 Normal exposure
  + - Occupational exposure
    - Medical exposure
    - Public exposure
* The Internal and External Hazard
* Internal Hazard
* Common methods of internal Entry
* External radiation hazards
* Practical means of Radiation Protection
* 5.6.1. Time
* 5.6.2. Distance
* 5.6.3. Shielding

**6. Biological effects of ionizing radiation**

* Deterministic Effects
* Stochastic Effects
* DNA and RNA
* Radiosensitivity
* Factors affecting the radiosensitivity

**Demonstration**

**1** Test on peak tube voltage; kVp accuracy, kVp reproducecibility; 2. Test on timer accuracy, 3. Checking the radiation out put, 4. Light field, beam alignment test, 5. Half value layer measurements, 6. Influence of on focus sizes, 7. Influence of the mAs, 8. Influence of tube, voltage, 9. Influence of distance, 10. Backscatter, 11. Processor QC (Sensitometry)

**Course Title- Radiological Physics II**

Course No. Phys.688

Credit Hour—3

Placement: Year II Semester II

**Course Description** the student will understand the physics of U/S, CT& MRI

**Course content**

Characteristic of sound, Interaction of ultrasound with matter, Transducers

Beam properties, Image data acquisition, Two dimensional image display and storage, Image quality and artifacts, Doppler Ultrasound: Magnetization properties Generation and detection of the magnetic resonance signal Pulse sequenced Inversion recovery, Gradient recalled Echo Artifacts, Instrumentation, Geometric Tomography, Computed tomography (basic principle), Geometry and Historical development, Detectors and detector arranges, Detection of Acquisition Tomography , Radiation dose and image quality, Artifacts

**Course objectives**

At the end of the course the students will be able to

* explainCharacteristics of Sound, Interactions of Ultrasound with Matter, beam Properties Two-Dimensional image Display and Storage
* Discusses Image Quality and Artifacts
* explain Doppler ultrasound
* Discusses Nuclear Magnetic Resonance imaging
* Explain Basic Principles of CT, Detectors and Detector Arrays, Details of Acquisition of CT, Tompographic Reconstruction, Digital Image Display , Radiation Dose , Image Quality and Artifacts

**Course outline**

Chapter 1: Ultrasound

*Characteristics* of Sound

* Interactions of Ultrasound with Matter
* Transducers
* Beam Properties
* Image Data Acquisition
* Two-Dimensional image Display and Storage
* Miscellaneous Issues
* *I*mage Quality and Artifacts
* Doppler Ultrasound

Chapter 2: Nuclear Magnetic Resonance

* Magnetization properties
* Generation and Detection of the Magnetic Resonance Signal
* Pulse Sequences
* Spine Echo
* Inversion Recovery
* Gradient Recalled Echo
* Signal Form Flow
* Contrast

Chapter 3: Magnetic Resonance Imaging (MRI)

* + Localization of the MR Signal
  + K-space Data Acquisition and Image Reconstruction
  + Image Characteristics
  + Artifacts
  + Instrumentation
  + Safety and Bioeffects

Chapter 4: Computed Tomography

* + Basic Principles
  + Geometry and Historical Development
  + Detectors and Detector Arrays
  + Details of Acquisition
  + Tompographic Reconstruction
  + Digital Image Display
  + Radiation Dose
  + Image Quality
  + Artifacts

References

* Diagnostic Ultrasound, Principles and instrumentation, Fifth edition, By Frederlok W. Kremkau
* The essencial physics of medical imaging, second edition, By Jerrol

**II- SPECIALITY IN METEOROLOGY**

**Course Title: Atmospheric Physics**

**Course code: Phys. 661**

**Credit Hour: 3**

**Course objectives:** This course equips students with the basic knowledge of the atmosphere of the earth and its motion.

**Course description**

Atmosphere of the earth; atmospheric thermodynamics; atmospheric radiation; the dynamics of atmosphere

**Course Outline**:

* 1. **The atmosphere of the earth and its vertical profile**
* Composition of the earth's atmosphere
* Vertical profile of the earth's atmosphere
  1. **Atmospheric thermodynamics**
* The ideal gas law
* Hydrostatic balance
* Entropy and potential temperature
* parcel concept
* The available potential energy
* Moisture in the atmosphere
* The saturated adiabatic lapse rate
* The tephigram
* Cloud formation

1. **Atmospheric radiation**

* Basic physical concepts
  1. The radiative transfer equations
* Transmittance and absorption by the atmosphere
* Heating rates
* The heat budget of the earth and its atmosphere
* Green house effect and climate change
* Atmospheric windows and remote sensing

1. **Basic fluid dynamics**

* Mass conservation
* The material derivatives
* An alternative form of continuity equation
* The equation of state of the atmosphere
* The Navier-Strokes Equation
* Rotating frame of reference
* Equation of motion in coordinate form
* Geostrophic and hydrostatic approximation
* Pressure coordinates and geopotential
* The thermodynamics energy equations

1. **Further atmospheric fluid dynamics**

* Vorticity and potential vorticity
* The Boussinesq approximation
* Quasi-geostrophic motion
* Gravity waves
* Rossby waves
* Boundary layers
* Instability

**Text and Reference Books**

* An Introduction to atmospheric physics-DG. Andrews
* An Introduction to Dynamic meteorology – J. Holton
* Meteorology today – Ahrens, C. Donald

**III SPECIALITY IN GEOPHYSICS**

**Speciality Course 1. Electrical and Electromagnetic Methods**

**Electric Fields**, Generalized Ohm’s law, Electric Potential, Geometric Factor, Apparent resistivity, Conductivity and resistivity in Earth materials, Mechanism of current conduction in solids, Conduction in water bearing rocks, Electric Polarization of rocks, Induced Polarization, Self potential, Layered earth potential, Geoelectric section, Electrical sounding, sounding curves and interpretation, profiling and interpretation, Exploration Survey design and methodologies, complex resistivity, Spectral IP, case histories of exploration and research.

**Electromagnetic Fields,** Fundamental laws, Maxwell’s equations, wave equations, Electromagnetic spectrum, Electromagnetic prospecting, Electromagnetic response of target conductors and host medium, EM systems and Instrumentation, Interpretation, case histories of exploration and research

**Speciality course 2. Potential Field Methods**

2D and 3D gravitational and magnetic potentials, Gauss’s divergence Theorem, La Place’ equations, Poisson’s’ equation, transformation of potential fields, ambiguity.

Measurement of G and gravitational acceleration, Figure of the earth, rock and Mineral densities, Instrumentation and Gravity Field data observation and acquisition reduction of gravity observations, gravity anomalies, isostasy, interpretation of anomalies, case histories

The earth’s internal and external magnetic fields, basic physics, magnetic properties of rocks and minerals, Instrumentation (different types of magnetometers), magnetic fields of simple geometries, Design of ground and airborne magnetic surveys, image processing to magnetic and gravity data, case histories, **Advanced Topics** (Satellite measurement of Geoid and gravity, earth tides, geological significance of Geoid, isostatic compensation models, Aeromagnetic survey design, joint interpretation of gravity and magnetic anomalies).

**Speciality Course 3. Alternative Energy**

**Fossil Fuels** (Petroleum, natural Gas, Coal, Propane, Butane, Methanol etc..), **Bioenergy** (solid Biomass, Biodiesel, Biogas, Ethanol etc.), **Geothermal Energy** (Definition, resource exploration, potential, applications, Power plants), **Hydrogen** (Producing hydrogen, transporting, storing, and future technology), **Nuclear Energy** (Overview, current future technology, benefits and drawbacks, environmental impact, societal impact), **Solar Energy** (Basics, Passive solar design, Photovoltaic cells, solar ponds and solar towers, solar energy potential), **Wind Energy** (How wind energy works, current future technology, benefits and draw backs, wind turbines, Potentials, challenges and obstacles), **Water Energy** (Hydropower, hydroelectricity), **Energy conservation and Efficiency, Possible Future Energy sources.**

**Department of Mathematics**

**Program: Mater of Science in Mathematics**

1. **Course Breakdown:**

#### Year I, Semester I

|  |  |  |  |
| --- | --- | --- | --- |
| **No** | **Title of courses** | **Code** | **Cr.hr** |
| 1 | Algebra I | Math541 | 3 |
| 2 | Real Analysis I | Math561 | 3 |
| 3 | Theory of Ordinary differential Equations | Math581 | 3 |
| Total | | | **9** |

#### Year I, Semester II

|  |  |  |  |
| --- | --- | --- | --- |
| **No** | **Title of courses** | **Code** | **Cr.hr** |
| 1 | Algebra II | Math542 | 3 |
| 2 | Real Analysis II | Math562 | 3 |
| 3 | Special Functions & Partial Differential Equations | Math582 | 3 |
| 4 | Complex Analysis | Math668 | 3 |
|  | Total |  | **12** |

#### Year II Semester I

|  |  |  |  |
| --- | --- | --- | --- |
| **No** | **Title of courses** | **Code** | **Cr.hr** |
| 1 | Real Analysis III | Math663 | 3 |
| 2 | General Topology | Math563 | 3 |
| 3 | Elective I (From Specialization ) | Math\*\*\* | 3 |
|  | Total |  | **9** |

#### Year II, Semester II

|  |  |  |  |
| --- | --- | --- | --- |
| **No** | **Title of courses** | **Code** | **Cr.hr** |
| **1** | Functional Analysis | Math664 | **3** |
| **2** | Elective II | Math\*\*\* | **3** |
| **3** | Seminar in Specialization | Math698 | **2** |
| Total | | | **8** |

**COURSE DESCRIPTIONS:**

**Math 541: Algebra I (3)**

Basic Terminologies on Groups, Permutation Groups, Direct Product/sum, Free Groups, Free products, Generation and Relation, structure of groups, Action of a group on a set, The Sylow Theorem, Decomposable groups, finitely generated abelian groups, solvable and nilpotent groups.

Basic Terminologies on rings, localization and quotient rings, unique factorization domain, Pilland Euclidean domains. Modules over rings, homomorphism and exact sequences, free modules, projective and injective modules.  
Fields and Galois theory: Algebraic and transcendental field extensions, separable and inseparable extension, splitting fields and normal extensions, Fundamental Theorem of Galois Extension, the Galois group of polynomials, Galois fields.

**Math 542 :** **Algebra II (3)**

***Prerequisite: Math 541***

Modules over principal ideal domains, decomposition theorems, applications to finitely generated Abelian groups and linear transformation

Linear Algebra and Representation: Matrices and linear maps; Structure of bilinear forms; Representation of one endomorphism; Multi-linear products.

Structure of rings: simple and primitive rings; The Jacobson radical; Semi-simple rings, prime and semi-prime rings; Algebras; Division Algebras.

**Math 561**: **Real Analysis I (3)**

***Prerequisite: None***

Revision : order sets, Real number system as an order field, Extended real number system,) Metric space, compact sets, perfect sets, connected sets, series and sequences in metric spaces, continuity and compactness discontinuities; Monotonic functions, infinity limits and limits at infinity, Riemann Satieties integral, properties of integral, integration and differentiation. Sequence and series of functions, uniform convergence, uniform continuity, uniform convergence and integration, Differential, Eqicontinuous family of functions

**Math 562**: **Real Analysis II (3)**

The Lebesgue measure of the real, outer measure, measurable sets, measurable functions, the Lebesgue integral, Differentiation Fatuous Lemma, Monotone convergence theorem, Dominated convergence.

**Math 663:** **Real Analysis III (3)**

***Prerequisite: Math 562***

Abstract measure theory, The Lebesgue integral, signed measure, Radn-Nikodyn theorem, L P -spaces, Hilbert spaces, Banach spaces. The open mapping theorem Hahn Banach theorem.

**Math 563:** **General Topology (3)**

***Prerequisite: None***

Open sets, neighborhoods, nets, separation axioms, continuous functions, compactness, product spaces, Tychonoffs theorem and quotient spaces.

**Math 581: Theory of Ordinary Differential Equations(3)**

***Prerequisite: None***

Linear equation with variable coefficients, Existence and uniqueness of solutions of first order equations, Existence and Uniqueness of solutions to system of nth order equation

**Math 582: Special Functions and Partial Differential Equations (3)**

***Prerequisite: Math 581***

Legendre’s equations and its solution-Legendre’s function of the first kind Legendre’s polynomials-Laplace first and second integrals for P-Orthogonal properties of Legendre polynomials-Rodirigue’s formula-Orthogonality and recurrence relations-Legendre polynomials of second kind Bessel’s, equation and its solutions-Bessel’s function of the first kind of order n- Bessel’s function of the second kind-Recurrence relations-Generation function-orthogonality of Bessel functions-Fourier Bessel series. Total Differential equations-Necessary and sufficient condition for inerrability of P dx + Q dy+ R dz =0, Condition for exactness , Method of Solving-Partial Differential Equations of first and second order linear ,PDE with constant coefficients Monge’s method.

**Math 668:** **Complex Analysis (3)**

The Topology of the Complex Plane: Complex Differential Analysis; Infinite Series and Elementary Functions; Complex Integration; Power Series; Cauchy Formula and Basic Theorems: Singularities and Riemann Theory. The Maximum Principle; Mattage-Leffler and Weierstrass Theorems Rung's Theorem. Harmonic Functions: Entire and Meromorphic Functions; Analytic continuation and Remain Surfaces; Conformal Mapping; Riemann Mapping Theorem; Picard's Theorem.

**Math 612: Differential Geometry (3)**

***Prerequisite: Math 665***

Manifolds: differentiable Structures: The Tangent Bundle; Tensors Vector Fields; Integral Manifolds; Differential Forms: Integration Riemann Matrices; line groups.

**Math 621:** **Introduction to Commutative Algebra (3)**

***Prerequisite: Math 542***

Flatness; Localizations: Associated Prime ideals and Primary Decompositions; Graded Rings; Completion; Dimension Theory; Normal Rings and Regular Rings.

**Math 622: Introduction to Homological Algebra(3)**

***Prerequisite: Math 542***

Categories and Functions; Extensions and Resolutions: Derived Factors: The Kunneth Formula; Cohomology of Groups; Spectral Sequences; Satellites.

**Math 623: Group Theory (3)**

***Prerequisite: Math 541***

Sugroups; Permutation Groups; Finite Groups. The Sylow Theorems; Finitely Generated Abelian Groups; Solvable and Nilpoten Groups, Free Groups and Presentations:Representations and Character.

**Math 624: Topics in Algebra (3)**

***Prerequisite: Math 542***

Current as well as relevant topics selected in the field will be discussed.

**Math 633: Numerical Analysis I (3)**

***Prerequisite: Math 562***

Numerical methods in linear; Approximations theory of functions; Study of eigen-value problems through numerical methods including power method and House Holder's methods; Numerical methods for multiple integrals.

**Math 634: Numerical Analysis II(3)**

***Prerequisite: Math633***

Numerical methods for solving ordinary differential equations: Muti-step methods; Finite difference method; Runge-Kutta-Nystorm methods.  
Introduction to partial differential equations: Numerical methods for elliptic partial differential equations ADI methods; Neumann and mixed boundary value problems. Methods for parabolic equations; Crank - Nicholson method; Methods for hyperbolic equations. Finite element method for ordinary differential equations

**Math 635: Geophysical Fluid Dynamics (3)**

***Prerequisite: Math 562***

Lagrangian and Euler frame of reference; Fundamental concepts of dynamics of rotating fluids; Geophysical fluids; Density stratification; Bossuninessq approximation; Non­dimensional numbers; Navier's Stokes equations; Atmospheric dynamics; Basic equations, equations of motions of viscous fluid on rotating earth; Coriolis force, continuity equation, Geostropic approximation, Rossby number and Baratropic and Baroclonic fluid systems.

Atmospheric Waves and instability: Phase and group velocity, Momentum and energy transport by waves in horizontal and vertical Barotropic and Baroclinic instability; Geostropic turbulence.

**Math 636: Magneto Hydrodynamics (3)**

***Prerequisite: Math 562***

Basic equations of Magneto hydrodynamics; continuum hypothesis; Momentum and energy equations for viscous finitely electrical conducting fluids; Magnetic pressure and tension; Non-dimensional numbers; Magnetostatics-classical MHD-Alfen's theorem; Flow problem: Hartman, couette flow in circular pipes; Boundary layers; Waves andmagneto-hydrodynamic stability.

**Math 637: Mathematical Theory of Elasticity (3)**

***Prerequisite: Math 562***

Suffix notation, Cartesian tensor; Continuum deformation, Elastic and thermoplastic materials; Isotropic and constitutive equations in linear isotropic elasticity; Strain energy and strain rate in the theory of linear elasticity; Equations of equilibrium; Stress in rotating shaft; Torsion of a cylinder of arbitrary cross-section elastodynamics.

**Math 651: Optimization Theory of Approximation (3)**

***Prerequisite: Math 5*62, *Math 663***

Basic notions of convex Analysis, general (necessary and sufficient) optimality conditions, Penality Method, Lagrange Method, Kuhn- Tucker Theory, Convex optimization, Duality Theory for nonlinear optimization (Fenchel Duality, Lagrange Duality), Approximation in pre-Hilbert spaces and in Hilbert spaces, existence and uniqueness of best approximation, Fourier series, linear finite codimensional approximation, Chebyshev approximation, Approximation Theorems of Weierstrass, Theorem of Korovokin, Theorem of Stone-Weierstrass.

**Math 652: Mathematical Theory of Optimal Control (3)**

***Prerequisite: Math 651***

Variational calculus, Euler Lagrange differential equation, local minimum and global minimum, costraints variational problems, convex variational problems, necessary and sufficient optimality conditions, applications, optimal processes (optimal control problems), Lagrange approach for solving optimal processes Bolza and Mayer problems, Hamiltonian theory and Maximum principle of Pontrjagin, separated and no separated optimal control problems, quadratic optimal control problems, linear optimal control problems, minimal time problems, applications.

**Math 664: Functional Analysis (3)**

***Prerequisite: Math 5*62, *Math 663***

Linear topological spaces, locally convex spaces, Hann-Banach theorem, weak topologies, weak compactness, Banach spaces, Hiber spaces, Orthogonality, bases. Linear operators banch spaces, closed operations, bounded operators in Banch spaces,polar decomposition spectrum resolution.

**Math 662:Advanced Functional Analysis (3)**

***Prerequisite: Math 664***

Riesz-Schauder-theory, spectral decomposition of self-adjoint compact operators. Integral equations, properties of the spectrum, one parameter semigroups of operators and their generators, Sobolery spaces, linear differential equations, eigenvalues and eigenfucntions.

**Math 665: Algebraic Topology (3)**

***Prerequisite: Math* 562, *Math 542***

Homotopy and the Fundamental Group Covering Spaces; Simplicial Complexes; Homology; Chomolgy.

**Math 666: Topics in Analysis (3)**

***Prerequisite:Math665***  
Current as well as relevant topics selected in the field will be discussed.

**Math 681: Ordinary Differential Equations (3)**

***Prerequisite: Math 562 & Math 582***

Existence and uniqueness of solutions of initial value problems; Linear equations; Non­linear differential equations and stability theory; Sturm-Liouville Theory.

**Math 682: Partial Differential Equations (3)**

***Prerequisite: Math 681***

First order quasi-linear equations; First order systems; Second order semi-linear equations; Distributions and Fourier Transforms

**Math 671: Analytical Number Theory I (3)**

***Prerequisite: Undergraduate Number Theory***

Revision on Divisibility and congruences,Arithmetic Functions μ(n),φ (n),Quadratic Residue, Legendre symbol and Euler’s Criterion, Gauss Lemma and its consequences, Quadradic Reciprocity law and its applications, Primimitive roots, primitive roots modulo on odd prime, Geometric representation of partitions, Generation functions for partions ,Jacobi’s Triple Product Identity

**Math 672: Analytical Number Theory II(3)**

***Prerequisite: Math671***

Averages of Arithmetical Functions, Some elementary Theorems on Distribution of prime numbers, Finite Abelian Groups and Their characters, Theorems on primes in Arithmetic Progression

**Math 622: Graph Theory (3)**

***Prerequisite: Math 621***

Paths and circuits, Trees and Fundamental Circuits, Cut sets and cut-vertices, planar and dual Graphs, Vector spaces of Graphs

**Math 621: Combinatorics (3)**

***Prerequisite: none***

Permutations and Combinations, Application to Probability.2. The Principle of Inclusion and Exclusion, Mobious Inversion. Partially Ordered sets and their mobious functions.3. Generating Functions and Recursions.4. Partitions, Identities and Arithmetic Properties, Guass- Jacobi identity, Jacobi identity, symptotic Properties of P(n).5. Distinct Representatives : The Theorems of P. Hall and D. Konig, Simultaneous presentatives, The Permanent Proof of the Van der Waerden conjucture, Permanents of Integral Matrices with Constant Line Sum.6. Ramsey’s Theorem : Statement of the Theorem. Application of Ramsey’s Theorem. 7. Hadamard Matrices : Paley’s Constructions,Williamson’s method, An infinite class of Williamson’s Matrices. Three Recent Methods.

**Math637: Biomechanics I (3)**

**Prerequisite: Math 581, Math582**

Physical Principles of Circulation :The Conservation Laws- The Forces that Drive or Resist Blood Flow- Newton’s Law of Motion applied to a I lluid – The Importance of Turbulence – Deceleration as a Generator of Pressure Gradlent – Pressure and Flow in in Blood Vessels- Generalled bernoulll’s Equation- analysis of Total peripheral Flow Resistance- The Importance of Blood Rheology – The Mechanics of circulation- A little Bit of History- The energy Balance Equation.

Numerical Methods for ordinary and partial differential equations, and introduction to finite element method

**Math 638: Biomechanics II (3)**

**Prerequisite: Math 637**

Unite – III & IV The Heart: Introduction – The Geometry and Materials of the Heart – The electric System- Mechanical Event: In a Cardiac Cycle – How are the Heart Valves Operated? – Fluid Mechanics of the Heart – The Heart Muscle- Stresses in the Heart Wall – The Need for a New Hypothesis for Residual Stress distribution – The Principle of Optimal Operation- Consequences of our New Hypothesis- Embedding Muscle fibers in a Continuum.

Unit – V & VI :Blood Flow in Arteries : Introduction- Laminar Flow in channel for Tube- Applications of Poiseuille’s Formula: Optimum Design of Blood Vessel Bifurcation- Steady Laminar flow in an elastic tube- Turbulent flow in a Tube Pulsatile Flow- Wave Propagation in Blood vessels- Progressive Waves superposed on a steady Flow- Nonlinear Wave Propagation

Unit – VII & VIII :Reflection and Transmission of waves at Junctions – Effect of Frequency on the Pressure-Flow Relationship at any Point in an Artedal Tree- Pressure and Velocity Waves in Large Arterles – The Effects of Geometric Nonunformity – The Effects of Viscosity of the and Viscoelasticity of the Wall- The Influence of Nonlinearities -Flow Seperation from the Wall.

**Math 635: Fluid Mechanics I (3)**

**Prerequisite: Math 581, Math582**

Kinematics of Fluids in Motion:Real fuids and Ideal fluids- Velocity of a fluid at a point- stream lines and path lines

The velocity potential- the vorticity vector- Local and particle rate of change- The equation of continuity- Acce;eration of a fluid – Conditions at a rigid Boundary General Analysis of fluid motion

Equation of Motion of a Fluid:Pressure at point in a fluid at Rest- Pressure at point in a moving fluid-Conditions at a Boundary of two Inviscid Immiscible fluids-Euler’s Equation of motion-Benoulli’s Equation-discussion of the Case of Steady motion under conservative Body forces

Unit 2 :Some flows involving Axial symmetry- Impulsive Motion-some other Aspects of Vortex Motion , Some three- dimensional Flows:

Numerical Methods for ordinary and partial differential equations, and introduction to finite element method

**Math 636: Fluid Mechanics II (3)**

**Prerequisite: Math 635**

Unit 3 : Some two-dimensional Flows: Meaning of Two- Dimensional Flow – Use of cylindrical Polar coordinates- The Stream function – the complex Potential for Two – dimensional, Irrigational- Incompressible Flow – Complex Velocity potentials for standard two- dimensional flows- Uniform Stream- Line source and Line sinks- Line doublets – Line vortices- The Milne – Thomson circle Theorem- Some Applications of the circle theorem- Extension of the circle theorem- Magus effect- The Theorem of Bastius

Unit 4 Viscous Flow:Stress componenets in a Real fluid- Relation between Cartesian cimponenets of stress – Translational Motion of Fluid element – The rate of strain Quadric and Principal Stresses- Some further properties of the Rate of strain Quadric- Stress analysis in fluid motion- Relation between stress and Rate of Strain- The coefficient of viscosity and Laminar Flow – The Navier – Stokes Equation of Motion of a Viscous Fluid

Unit 5 Steady motion between Parallel Planes- Steady flow through tube of uniform circular cross section –steady flow between concentric roating cylinders- Steady flow in tubes of Unoform Cross section- Uniquencess theorems- Tubes having uniform elliptic cross- section- Tube having equilateral triangular cross section- Steady flow through a channel of Uniform rectangular Cross section – diffusion of Vortieity- Engergy Dissipation due to viscosity- Steady flow past a fixed sphere- Dimensional Analysis- Reynold’s number- Prandtl’s Boundary Layer- Karman’s integral equation.

Numerical Methods for ordinary and partial differential equations, and introduction to finite element method

**Math 621: Mathematical Methods I (3)**

**Prerequisite: Math 581, Math582**

Laplace Transforms : tha Laplace transform, Calculation of the Laplace Trasforms of some elementary functions , Rules of manipulation of the Laplace transform, Laplace transforms of derivatives, Relations involving integrals , The error function, periodic functions, the convolution of two functions , The inversion formula for the Laplace transform,

Initial value problem for a linear equation with constant coefficients, Linear differential equations with variable coefficients, Simultaneous differential equations with constant coefficients, Application to integral equations

Fourier Transform : sine cosine transforms, derivatives convolution integral , the finite fourier transform problems related to Fourier integral, problems related to finite Fourier Transform.

**Math 622: Mathematical Methods II (3)**

**Prerequisite: Math 621**

Calculus of Variations and Applications : the simplest case , illustrative examples ,Natural boundary conditions and transition conditions, the variational notation. Constraints and Lagrange multipliers, Strum Lowville problem, Hamilton’s Principle, Lagrange equation.

Integral Equation : Introduction, Relation between differential and integral equations, The Green’s function, Linear equations in cause and effect, The influence function, Fredholm equations with separable kernels, Illustrative examples

**Math 731: Computational Techniques I (3)**

History of development of computers, computer generations, types of computers, general awareness of computer hardware- CPU, Input, Output and peripherals, software and programming languages, General awareness of Software packages-MSword, Excel and Grapher Programming in FORTRAN 77: Character set, constants, variables, Arithmetic expressions, Library functions, Arithmetic statements, Structure of a FORTRAN Program, FORMAT Specifications, READ and WRITE statements, Simple programs, Control statements: GOTO, IF,IF-THEN-ELSE and ELSE-IF-THEN statements, DO loops: Continue statement, DATA statement, Double precision, Logical data and Complex data, WHILE structure, Arrays and Subscripted variables: implied DO loops, One and two-dimensional Arrays, Sub programs: Function and Subroutine subprograms, Open a file, Read from a file Write in a file. Programming in C: Historical; development of C, Character set, constants, variables, C keywords, Instructions, Hierarchy of operations, Operators, Simple C Programs, Control structures: The if, if-else, nested if-else, unconditional goto, switch structure, Logical and conditional operators, while, do-while and for loops, Break and continue statements, Arrays, Functions, Recursion.

**Math 732: Computational Techniques II (3)**

Solution of non-linear equations: Bisection and Regula-falsi methods-An overview, Secant method, Newton-Raphson Method, Chebyshev Formula of third order, Halley’s Method, Functional iteration Method, Muller’s method, Rate of convergence of these methods, Comparison of these methods, Lin-Bairstow’s Method

Interpolation: Finite Differences, Newton’s formulae for Interpolation, Inverse Interpolation, cubic spline interpolation

Numerical Integration: Trepezoidal rule, Simpson’s 1/3rd rule, Simpson’s 3/8th rule, Boole’s and Weddle’s rule, Errors in integration formula.

Linear and non-linear curve fitting, curve fitting by sum of exponentials, fitting of exponential and trigonometric functions.

Solution of Linear system of equations: Matrix Inversion method, Gauss-Jorden Method and Triangularization method.

Differential equations: Taylor’s series method, Runge-Kutta Method, Predictor-Corrector Methods, Finite Difference Method to solve ODE, Numerical Solutions of PDE-Laplace and Heat equations.

**Computational Techniques (Practical)**

*Practical (2 hours per week):*

Document writing in MS word, Writing programs in FORTRAN and / C for the problems based on the methods studied in theory paper and run them on PC

Practical examination shall be conducted by the Department as per the following distribution of points:

Writing one program of FORTRAN or C and Running it on PC = 15 %

Practical records = 5 %

Viva Voice= 5%

**Math 691: Mathematical Softwares ( Optional Course )**

Note:This paper is divided into two parts viz.Theory and Practicals..

Credit Hours: 2Hrs. Lecture Hours: 3 , Lab Hours : 2

Section – A

THEORY

MatLab: Description, Function list, Support, Documentation, platforms and requirements, feachers. MathCad: Use of Math Cad in solving integration and differentiation.

Section - B

Mathematica: Graphs in 2D, Solving Equations, Differentiation of functions of one variable, integrating functions of one variable, working with sequences and series, solving differential equations, working with vectors and matrices.

Section - C

MathType: Basic concepts of MathType, its toolbar, spacing and alignment, MathType’s system of style, equation numbering. LaTeX: General concept of LaTeX, logic based design of a document, commands and environments, structure of a document, Math Mode Environment and its application to produce Greek letters, Ellipsis, subscripts, superscripts, symbols,

arrays and equations. Spacing in Math Mode, Defining commands and environments for theorems, proposition, axioms and conjectures, Marginal and foot notes.

* Draw graphs of a function in Mathematica.
* Solve an equation in Mathematica.
* Differentiation in Mathematica.
* Integration in Mathematica.
* Differentiation in Math Cad.
* Integration in Math Cad.
* Creating and editing mathematical equations with Math Type and exporting it
* Into MS Word or LaTeX editor.
* Preparing TeX files of Mathematical Documents and converting into PDF format.

**Flen 601: Academic Writing for Graduate Students (Optional Course) (2/3)**

Course Code: FLEn 601

The Academic Writing Course focuses on preparing students for the academic writing and communication required in graduate level courses. The course develops academic writing skills of students by raising their awareness of the conventions of written texts. In addition, the course will help the students become familiar with genres and enhance skills related to critique, argumentation and research-based writing. Students will also acquire an awareness of and ability to use effectively the discourse patterns of academic English typically required for writing and reporting research activities, course assignments, field reports, lab reports, term papers, and book reviews. Students will also learn how to incorporate the work of other authors into their own writing according to existing requirements of academic practice. In addition, they will receive instruction in grammar, rhetorical conventions, and oral communication.

**Math 698: Seminar Course (3)**

*Prerequisite: Pass the Comprehensive Examination*

Current, as well as relevant topics, selected in a specialized area of advanced mathematics, will be discussed. Students will be given the opportunity to carry out independent reading and classroom presentation of their readings. Course evaluation will be based on the reading assignments, quality of presentation and oral and/ or written examinations covering the whole course.

**Program Name: Master of Science Degree in Mathematical Modeling**

**Course breakdown**

**Year I, Semester I**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Course code** | **Course title** | **Credit hours** | **Tutorial** | **Lab.** |
| Math 523 | Computational Programming | **2** | **-** | **2** |
| Math 583 | Selected Topics in Differential Equations | **3** | **2** | **-** |
| Math 585 | Dynamical Systems | **3** | **2** | **-** |
| Math 501 | Mathematical Modeling and Simulation | **3** | **-** | **2** |
| Math 537 | Introduction to Fluid Dynamics | **3** | **2** | **-** |
| Sub-total | | **14** |  |  |

**Year I, Semester II**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Course code** | **Course title** | **Credit hours** | **Tutorial** | **Lab.** |
| Math 554 | Optimization and Optimal control | **3** | **2** | **-** |
| Math 556 | Operations Research | **3** | **2** | **-** |
| Math 524 | Numerical Methods | **3** | **-** | **2** |
| Math 594 | Research Methodology | **2** | **-** | **-** |
| Math 50X | Elective from Specialization | **3** | **-** | **2** |
| Sub-total | | **14** | **6** | **2** |

**Year II Semester I**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Code | **Course title** | **Credit hours** | **Tutorial** | **Lab.** |
| Math695 | Graduate Seminar | **1** | **-** | **-** |
| Math 697-9 | MSc Thesis | **6** | **-** | **-** |
| Sub-total | | **7** |  |  |

**Year II Semester II**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Code | **Course title** | **Credit hours** | **Tutorial** | **Lab.** |
| Math 697 | MSc Thesis | **6** | **-** | **-** |

**12. Course Description**

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| **Haramaya University**  **College of Natural and Computational Sciences**  **Department of Mathematics** | |
| Course Title | Computational Programming |
| Course Code | Math 523 |
| Credit Hours | 2 |
| Tutorial Hours | - |
| Laboratory Hours | 2 |
| Pre-requisite | None |
| Year | I |
| Semester | I |
| Course Objectives | After a successful completion of this course students will be able to:   * understand basic concepts in different mathematical programming languages * write computer codes in different programming languages * learn how to use and apply built-in programs in different mathematical softwares * practice on finding limits of functions, differentiating and integrating functions, solving algebraic, differential and integral equations |
| Course Description | This course introduces students with mathematical softwares like MATLAB, MATHEMATICA and MAPLE.  **MATLAB:** Getting started with MATLAB, Basic syntax and variables, Arrays (vectors and matrices), Graphics, Algebraic equations and calculus, Introduction to programming in MATLAB: script and function m-files, Control flow and operators: Operator precedence, the if statement, if-else structure, the if-else if structure, looping: counted and conditional loops.  **MATHEMATICA:** Getting started with MATHEMATICA, Basic syntax and variables, Notations, Basic symbolic and numeric calculations, Lists and functions, Graphics, Different styles of programming (functional and procedural), Linear algebra, Calculus and differential equations, Probability distributions and simulations, Programming in MATHEMATICA, Solving algebraic and differential equations.  **MAPLE:** Getting started with MAPLE, Variables and names, Calculus on numbers, Computer algebra, Manipulation of polynomials and rational expressions, Functions, Linear algebra, Calculus, Graphics, Programming in MAPLE, Solving algebraic and differential equations. |
| Course Status | Compulsory |
| Teaching and Learning Methods | Lectures, cooperative learning, group discussion |
| Assessment Methods | Assignments (group and individual), continuous assessment, final exam, practical exams |
| Attendance Requirements | Minimum of 80% during lectures and laboratory sessions |
| Text/References | 1. Amos Gilat*, MATLAB: Introduction with Applications*, Fourth Edition, John Wiles & Sons. 2. Paul Wellin, Sam Kamin and Richard Gaylord *An Introduction to Programming with MATHEMATICA* 3. Andre Heck, *Introduction to MAPLE* |

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| **Haramaya University**  **College of Natural and Computational Sciences**  **Department of Mathematics** | |
| Course Title | Selected Topics in Differential Equations |
| Course Code | Math 583 |
| Credit Hours | 3 |
| Tutorial Hours | 2 |
| Laboratory Hours | - |
| Pre-requisite | None |
| Year | I |
| Semester | I |
| Course Objectives | After a successful completion of this course students will be able to:   * state and proof existence and uniqueness of solutions of ordinary differential equations * solve Legendre and Bessel differential equation * develop techniques of solving ordinary and partial differential equations |
| Course Description | Linear differential equations with constant and variable coefficients, Existence and uniqueness of solutions of first order differential equations, Existence and Uniqueness of solutions to system of nth order differential equation, Legendre and Bessel’s equation as examples of second order ordinary differential equations. Basic concepts and Definitions, Classification of Partial Differential Equations, Solutions of PDE of first order, Solution of linear PDE of second order with constant coefficients, Condition for exactness, Method of Solving-Partial Differential Equations of first and second order linear PDE with constant coefficients, Monge’s method. |
| Course Status | Compulsory |
| Teaching and Learning Methods | Lectures, cooperative learning, group discussion |
| Assessment Methods | Assignments (group and individual), continuous assessment, final exam |
| Attendance Requirements | Minimum of 80% during lectures and tutorials |
| Text/References | 1. G. Semon, *Ordinary Differential Equations, Applications and Historical Notes* 2. E. A. Coddington, *Theory of Differential Equations* 3. L. C. Evans, *Partial Differential Equations* 4. S. Salsa, *Partial Differential Equations in Action from Modeling to Theory* |

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| **Haramaya University**  **College of Natural and Computational Sciences**  **Department of Mathematics** | |
| Course Title | Dynamical Systems |
| Course Code | Math 585 |
| Credit Hours | 3 |
| Tutorial Hours | 2 |
| Laboratory Hours | - |
| Pre-requisite | None |
| Year | I |
| Semester | I |
| Course Objectives | After a successful completion of this course students will be able to:   * understand the dynamics of different phenomena * check stability of linear and nonlinear dynamical systems * understand the concept of linearization * check existence and uniqueness of solutions * understand the concept of bifurcation * know how to treat chaos and catastrophes in dynamical systems * perform a perturbation analysis on various systems |
| Course Description | This course introduces n-dimensional dynamics (Population dynamics, mechanical systems, Nullclines, Phase Curves, The Lorenz Model, Quadratic ODEs) , linear systems (stability of linear systems), Nonlinear Systems (linearization of dynamic systems, qualitative solutions) existence and uniqueness of solutions, Gradient Systems, Lagrangean and Hamiltonian Systems, Simplifying Dynamical Systems (Poincare Map, Centre Manifold Theorem, Lyapunov-Schmidt Reduction), Bifurcation theory, Chaos and Catastrophes in Dynamical Systems. Nonlinear Models and Nonlinear Phenomena (pendulum equations, mass spring system, common nonlinearities), Lyapunov Stability (autonomous and non-autonomous systems), Input-output stability, passivity, advanced stability analysis, Perturbation Theory and Averaging, Stability of Perturbed Systems, Singular Perturbations, Feedback Control, Feedback Linearization, Nonlinear Design Tools (backstopping, passivity based control) |
| Course Status | Compulsory |
| Teaching and Learning Methods | Lectures, cooperative learning, group discussion |
| Assessment Methods | Assignments (group and individual), continuous assessment, final exam, practical exams |
| Attendance Requirements | Minimum of 80% during lectures |
| Text/References | 1. Lawrence Perko (2001),  *Differential Equations and Dynamical Systems* 2. Claudia Valls and Luis Barriera (2013),  *Dynamical Systems: An Introduction* |

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| **Haramaya University**  **College of Natural and Computational Sciences**  **Department of Mathematics** | |
| Course Title | Mathematical Modeling and Simulations |
| Course Code | Math 501 |
| Credit Hours | 3 |
| Tutorial Hours | None |
| Laboratory Hours | 2 |
| Pre-requisite | None |
| Year | I |
| Semester | I |
| Course Objectives | After a successful completion of this course students will be able to:   * build models to solve real-world problems. * compute solutions of a model and analyze them * solve numerically using computer * explain dimensional analysis for mathematical modeling |
| Course Description | The course provides a systematic approach to Mathematical modeling and Mathematical analysis of physical processes. For specific applications, relevant differential equations are derived from basic principles such as conservation laws. Dimensional analysis, bifurcation analysis, and scaling are introduced to prepare a model for analysis. A broad range of applications from areas such as physics, engineering, biology, diffusion, heat transfer, and Mathematics will be studied. Computer based projects using MATLAB or Maple or C++ or FORTRAN will be mandatory under each topic. |
| Course Status | Compulsory |
| Teaching and Learning Methods | Lectures, cooperative learning, group discussion |
| Assessment Methods | Assignments (group and individual), continuous assessment, final exam |
| Attendance Requirements | Minimum of 80% during lectures and laboratory sessions |
| Text/References | 1. Kai Velten (2009), *Mathematical Modeling and Simulations: Introduction for Scientists and engineers,* WILEY VCH VerlagGmbH and Co. KGaA 2. P. W. Brigham (1992), *Dimensional Analysis,* Yale University Press 3. R. M. May (1973), *Stability and complexity in model ecosystems*, Princeton Univ. Press. |

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| **Haramaya University**  **College of Natural and Computational Sciences**  **Department of Mathematics** | |
| Course Title | Introduction to Fluid Dynamics |
| Course Code | Math 537 |
| Credit Hours | 3 |
| Tutorial Hours | 2 |
| Laboratory Hours | - |
| Pre-requisite | None |
| Year | I |
| Semester | I |
| Course Objectives | After a successful completion of this course students will be able to:   * identify different type of fluid flows * describe general equation of motion * derive conservation of mass and Navier-Stokes equation * describe stream function |
| Course Description | Lagrangian and Eulerian description, continuity of mass flow, circulation, rotational and irrotational flows, Boundary surface, General equation of motion, Bernoulli’s theorem (Compressible and incompressible flows), Kelvin theorem (constancy of circulation), stream function, complex potential, source sink and doublets, circle theorem, Method of images, Theorem of Blasius, Stokes stream function, Spherical Harmonics and motion sphere, Helmholtz’s Vorticity equation (permanence of vorticity) vortex filaments, Navier-Stokes equation, Dissipation of energy. Diffusion of vorticity, Steady flow between two infinite parallel plates, through a circular pipe (Hagen-poiseulle). |
| Course Status | Compulsory |
| Teaching and Learning Methods | Lectures, cooperative learning, group discussion |
| Assessment Methods | Assignments (group and individual), continuous assessment, final exam |
| Attendance Requirements | Minimum of 80% during lectures and laboratory sessions |
| Text/References | 1. Acheson, D. J. (1990). *Elementary fluid dynamics*. New York, USA: Oxford University Press. 2. Anderson, J. D. (2012). *Computational fluid dynamics: the basics with applications*. New Delhi, India: Tata McGraw-Hill Publishing. |

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| **Haramaya University**  **College of Natural and Computational Sciences**  **Department of Mathematics** | |
| Course Title | Optimization and Optimal Control |
| Course Code | Math 554 |
| Credit Hours | 3 |
| Tutorial Hours | 2 |
| Laboratory Hours | - |
| Pre-requisite | None |
| Year | I |
| Semester | II |
| Course Objectives | After a successful completion of this course students will be able to:   * acquire a working knowledge of optimization and optimal control * know about the major classes of optimization * understand the notion of convex analysis * understand basic solution methods of constrained and unconstrained nonlinear optimization problems * apply the approximation Theorems of Wierestress and the Theorem of Korovkin * understand the basic ideas of variational calculus * understand theory of Optimal Control and its application in linear and quadratic Optimal control problems |
| Course Description | Definition and classes of optimization; Optimality conditions for constrained and unconstrained problems; Notion of convex analysis; Duality theory for nonlinear optimization; Approximation by algebraic and Trigonometric polynomials; Chebychev approximation. Variational problems and admissible trajectories; Gateaux derivatives; Constrained and unconstrained variation problems; Definitions and examples of optimal process; Optimality conditions for optimal controls; Hamiltonian theory and the Pontryagin’s principle; Linear and quadratic optimal control problems. |
| Course Status | Compulsory |
| Teaching and Learning Methods | Lectures, cooperative learning, group discussion |
| Assessment Methods | Assignments (group and individual), continuous assessment, final exam |
| Attendance Requirements | Minimum of 80% during lectures and laboratory sessions |
| Text/References | 1. J. John (1996), *Introduction to Theory of Nonlinear Optimization* 2. L. D. Brkovitz (1974), *Optimal Control Theory*, Springer-Verlag, 3. Richard Weber, *Optimization and Control*, Springer |

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| **Haramaya University**  **College of Natural and Computational Sciences**  **Department of Mathematics** | |
| Course Title | Operations Research |
| Course Code | Math 556 |
| Credit Hours | 3 |
| Tutorial Hours | 2 |
| Laboratory Hours | - |
| Pre-requisite | None |
| Year | I |
| Semester | II |
| Course Objectives | After a successful completion of this course students will be able to:   * formulate and solve linear programming problems using simplex algorithm. * solve transportation, assignment and transshipment problems. * formulate and solve integer linear programming problems using branch-and-bound, implicit enumeration and cutting plane algorithms. * apply game theory to make decisions involving two or more decision makers under conflicting interest. * develop inventory models that can be used to make optimal inventory decisions. * use dynamic programming to solve network, inventory and resource allocation problems. * develop mathematical models for waiting lines (queues). * formulate, solve, analyze and interpret mathematical models using techniques and principles of operations research. |
| Course Description | Introduction to Model Formulation using Operations Research; Linear Programming and its Solution Methods; Transportation, Assignment and Transshipment Models; Integer Linear Programming; Goal Programming; Game Theory; Deterministic and Probabilistic Inventory Models; Introduction to Stochastic Process and Markov Chains; Deterministic and Probabilistic Dynamic Programming; Queuing Theory. |
| Course Status | Compulsory |
| Teaching and Learning Methods | Lectures, cooperative learning, group discussion |
| Assessment Methods | Assignments (group and individual), continuous assessment, final exam |
| Attendance Requirements | Minimum of 80% during lectures and laboratory sessions |
| Text/References | 1. Wayne L. Winston (2004), *Operations Research Applications and Algorithms,* Thomson Books 2. J. K. Sharma (2009), *Operations Research Theory and Applications,* McMillan Publishers Indian Ltd. 3. Hamdy A. Taha (2008), *Operations Research: An Introduction* |

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| **Haramaya University**  **College of Natural and Computational Sciences**  **Department of Mathematics** | |
| Course Title | Numerical Methods |
| Course Code | Math 524 |
| Credit Hours | 3 |
| Tutorial Hours | - |
| Laboratory Hours | 2 |
| Pre-requisite | Math 523 |
| Year | I |
| Semester | II |
| Course Objectives | After a successful completion of this course students will be able to:   * understand the concept of curve fitting and apply it to present and organize data graphically * discretize differential equations using finite difference methods * compute missing data using the concept of interpolation * write MATLAB codes for solving systems of linear and non-linear algebraic equations numerically * write MATLAB codes for solving ordinary and partial differential equations numerically |
| Course Description | Curve fitting and the method of least squares, Essentials of finite difference and interpolation, Numerical solution of systems of linear and non-linear equations, Numerical methods for solving IVPS: single-step numerical methods, systems of first order IVPs, multi-step numerical methods (predictor methods, corrector methods, predictor-corrector methods), Numerical methods for solving BVPs: Shooting and finite difference methods, Numerical methods for solving 1D PDEs, Numerical methods for solving 2D PDEs (Hyperbolic, Parabolic and Elliptic equations): Finite difference, ADI, Crank-Nicholson, Finite element methods for solving differential equations. |
| Course Status | Compulsory |
| Teaching and Learning Methods | Lectures, cooperative learning, group discussion |
| Assessment Methods | Assignments (group and individual), continuous assessment, final exam, practical exams |
| Attendance Requirements | Minimum of 80% during lectures and laboratory sessions |
| Text/References | 1. J. C. Butcher (2016), *Numerical Methods for Ordinary differential Equations,* WILEY 2. SandipMazumder (2016), *Numerical Methods for Partial Differential Equations: Finite Difference and Finite Volume Methods* 3. Claes Johnson, *Numerical Solution of Partial Differential Equations by the Finite element Method* 4. S. S. Sastry (2005), *Introductory Methods of Numerical Analysis* 5. M. K. Jain, S. R. K. Iyengar, and R. K. Jain, *Numerical Methods for Scientific and Engineering* |

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| **Haramaya University**  **College of Natural and Computational Sciences**  **Department of Mathematics** | |
| Course Title | Research Methodology |
| Course Code | Math 594 |
| Credit Hours | 2 |
| Tutorial Hours | - |
| Laboratory Hours | - |
| Pre-requisite | None |
| Year | I |
| Semester | II |
| Course Objectives | After a successful completion of this course students will be able to:   * acquire the knowledge of research methodologies. * select topics for a study, design research method, data collection and analysis, * prepare proposal for scientific study, * make critical reviews of articles, * write appropriate report of a study. |
| Course Description | Meaning of Research and objectives of Research, Types of Research and Research Approaches. Defining a Research Problem. Research Design: Meaning of Research Design, Research Methodologies and Research Design. Measurement and Scaling: Measurement in Research, Measurement Scales and Scaling. Population and Sampling. Methods of Data Collection: Collection of Primary Data, Collection of Secondary Data, Selection of Appropriate Method for Data Collection. Interpretation and analysis of data, Scientific Report Writing: Article, proposal, and thesis. |
| Course Status | Compulsory |
| Teaching and Learning Methods | Lecture, Presentation, Reading assignments, team based learning |
| Assessment Methods | Individual and group assignments, quiz, test, presentation and final exam. |
| Attendance Requirements | A minimum of 80% |
| Text/References | C.R.Kothari (2004),*Research Methodology Methods and Techniques*, New Age International Publishers |

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| **Haramaya University**  **College of Natural and Computational Sciences**  **Department of Mathematics** | |
| Course Title | Mathematical Epidemiology |
| Course Code | Math 502 |
| Credit Hours | 3 |
| Tutorial Hours | - |
| Laboratory Hours | 2 |
| Pre-requisite | Math 501 |
| Year | I |
| Semester | II |
| Course Objectives | After successful completion of the course students will be able to:   * develop compartmental models of different infectious diseases. * compute equilibrium points of the model and their stabilities. * identify sensitivity analysis of basis parameters in the model. * perform numerical simulation. |
| Course Description | Basic mathematical models, physical meaning and analysis in Epidemiology: SI, SIR, SEIR models. Vector transmitted disease models, structured population transmission models, Dynamics of Infectious Diseases. Model formulation, analysis and simulation. |
| Course Status | Elective |
| Teaching and Learning Methods | Lecture, Presentation, Reading assignments, team based learning |
| Assessment Methods | Individual and group assignments, case studies, quizzes, tests, presentation and final exam |
| Attendance Requirements | A minimum of 80% |
| Text/References | 1. Alan Hastings (1996), *Population biology: Concepts and Models*, Springer 2. Alexander Kraner, MrijamKretzschnar and Klaus Krirckeberg (2010),*Modern infectious disease epidemiology; concepts, methods, mathematical models and public health*. Springer |

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| **Haramaya University**  **College of Natural and Computational Sciences**  **Department of Mathematics** | |
| Course Title | Mathematical Biology |
| Course Code | Math504 |
| Credit Hours | 3 |
| Tutorial Hours | - |
| Laboratory Hours | 2 |
| Pre-requisite | Math 501 |
| Year | I |
| Semester | II |
| Course Objectives | After successful completion of the course students will be able to:   * develop biological model and analyze them * analyzed different bifurcations and stabilities which can be experienced by the model * interpret and analyze the developed model to solve societal problems |
| Course Description | This course introduces basic concepts of Mathematical Biology, Stability analysis of Population Dynamics: Continuous Exponential Growth, Continuous Logistic Growth, Further Limited Growth Models: Sigmoid Growth, Allee Effect, Hollying’s functional responses, Interacting population models: Predator-Prey Models, Competition Models, Symbiosis/mutualism models,bifurcation analysis. |
| Course Status | Elective |
| Teaching and Learning Methods | Lecture, Presentation, Reading assignments, team based learning |
| Assessment Methods | Individual and group assignments, case studies, quizzes, tests, presentation and final exam. |
| Attendance Requirements | A minimum of 80% |
| Text/References | Murray, J.D (2002), *Mathematical biology; an introduction*; |

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| **Haramaya University**  **College of Natural and Computational Sciences**  **Department of Mathematics** | |
| Course Title | Advanced Fluid Dynamics |
| Course Code | Math538 |
| Credit Hours | 3 |
| Tutorial Hours | - |
| Laboratory Hours | 2 |
| Pre-requisite | Math 537 |
| Year | I |
| Semester | II |
| Course Objectives | After successful completion of the course students will be able to:   * derive Boundary layer equations of flow and energy transfer * compute dimensional analysis * formulate stability of flow between two infinite parallel plates |
| Course Description | Viscous fluids, similarity principle, Boundary layer equations of flow and energy transfer, Momentum integral, equations and Kraman- Pohlhausen method, flow and heat transfer past a flat plate and coquette flow, finite element equations for steady and unsteady flows, Mathematical formulation of stability problem and stability of flow between two infinite parallel plates, Impulsive flow, Raleigh problems, Compressible boundary layer , theory of turbulence, Turbulent flow through a tube, non-Newtonian  fluids, power law fluids and their flow pasta flat plate through tubes and channels steady flow between concentric rotating cylinders- Steady flow in tubes of uniform Cross section- Uniqueness theorems- Tubes having uniform elliptic cross- section- Tube having equilateral triangular cross section- Steady flow through a channel of Uniform rectangular Cross section – diffusion of Vorticity- Energy Dissipation due to viscosity- Steady flow past a fixed sphere- Dimensional Analysis- Reynold’s number- Prandtl’snumber, Boundary Layer- Karman’s integral equation. |
| Course Status | Elective |
| Teaching and Learning Methods | Lecture, Presentation, Reading assignments, team based learning |
| Assessment Methods | Individual and group assignments, quiz, test, presentation and final exam. |
| Attendance Requirements | A minimum of 80% |
| Text/References | 1. Batchelor, G. K. (1999). *Introduction to fluid dynamics*. New Delhi, India: Cambridge University Press. 532 BAT 002003, 008581, 009557. 2. Cengel, Y. A. (2006). *Fluid mechanics: fundamentals and applications*. New Delhi, India: Tata McGraw-Hill Publishing. 620.106 CEN 003536 & 008902. |

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| **Haramaya University**  **College of Natural and Computational Sciences**  **Department of Mathematics** | |
| Course Title | Mathematical Ecology |
| Course Code | Math508 |
| Credit Hours | 3 |
| Tutorial Hours | - |
| Laboratory Hours | 2 |
| Pre-requisite | Math501 |
| Year | I |
| Semester | II |
| Course Objectives | After successful completion of the course students will be able to:   * develop, analyze and interpret population models for single species, two and many- species interactions. * construct mathematical models that deal with natural (or human) factors that control the abundance and distribution of the various populations of animals and plants that we see in nature. |
| Course Description | Population models for a single species (discrete and continuous-time models), Constant and time-varying environments, Discrete-time population models, logistic map:- Simple age-structured models, Stable age-structure, The Euler-Lotka demographic equation and its analysis using theory of non-negative matrices, Applications to the theory of life-history strategies, Basic phase plane and linear stability analysis, Two-species interactions: Competition, Cooperation and Predator-prey models, Holling’s functional responses, Many-species interactions, General Lotka-Volterra models, Applications of Lyapunov functions, Spatially-structuredpopulation models Patch and metapopulation models,Reaction-diffusion models, Linear models and spatial steady-states, Nonlinear models and spatial steady-states Models of spread Age-structured population models, Lotka integral equation and renewal equation, Leslie matrices and extensions McKendrick- von Foerster equation. |
| Course Status | Elective |
| Teaching and Learning Methods | Lecture, Presentation, Reading assignments, team based learning |
| Assessment Methods | Individual and group assignments, quiz, test, presentation and final exam. |
| Attendance Requirements | A minimum of 80% |
| Text/References | 1. Gerda deVries, Thomas Hillen, et al (2006),*A Course in Mathematical Biology* 2. Gurney, W.S.C and Nisbet, R.M. (1998), *Ecological dynamics*, Oxford Univ.Press. 3. Kot, M. (2001),*Elements of mathematical Ecology*, Cambridge Univ. Press. 4. Murray, J.D. (1989),*Mathematical Biology*, Springer, Berlin |

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| **Haramaya University**  **College of Natural and Computational Sciences**  **Department of Mathematics** | |
| Course Title | Mathematical Modeling in Agriculture and Environmental Sciences |
| Course Code | Math506 |
| Credit Hours | 3 |
| Tutorial Hours | 2 |
| Laboratory Hours | - |
| Pre-requisite | Math 501 |
| Year | I |
| Semester | II |
| Course Objectives | After successful completion of the course students will be able to:   * apply mathematical programming models to solve and analyze real problems in agriculture and environment. * describe, analyze, and predict epidemics of plant disease using mathematical modeling. |
| Course Description | Farm-Level Linear Programming Models (Static Models of a Crop Farm, a Multiple-Year Model, Crop-Livestock Enterprises, Dynamic Models), Transportation and Assignment Models for Food and Agricultural Markets, Natural Resource and Environmental Economics Applications of Linear Programming (Forest Management, Land Use Planning, Efficient Irrigation and Cropping Patterns), Optimizing Agricultural Land Protection & Farmland Conservation as applications to Integer and Binary Programming,Fishery Management Using Nonlinear Programming, Risk Programming Mathematical Models in Agriculture and Climate Change, Price Endogenous Mathematical Programming Models, Optimal Parasite Control & Forest Land Protection as applications to Goal Programming, Mathematical Epidemiology of Plant Diseases. |
| Course Status | Elective |
| Teaching and Learning Methods | Lecture, Presentation, Reading assignments, team based learning |
| Assessment Methods | Individual and group assignments, quiz, test, presentation and final exam. |
| Attendance Requirements | A minimum of 80% |
| Text/References | 1. Harry M. Kaiser and Kent D. Nesser (2011)*Mathematical programming for agricultural, environmental and resource economics*, John Wiley and sons, inc 2. Karel D. Vohnout: (2003) *Mathematical modeling for system analysis in agricultural research*, Elsevier science |

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| **Haramaya University**  **College of Natural and Computational Sciences**  **Department of Mathematics** | |
| Course Title | Graduate Seminar |
| Course Code | Math 695 |
| Credit Hours | 1 |
| Tutorial Hours | - |
| Laboratory Hours | - |
| Pre-requisite | None |
| Year | II |
| Semester | I |
| Course Objectives | After a successful completion of this course students will be able to:   * acquire skills of scientific writing * understand complex ideas |
| Course Description | The purpose is to help students review current topics in mathematical modeling and develop the necessary skills to communicate their knowledge to their colleagues and the public at large. It would entail organizing a content, oral delivery and proper write-up of a particular finding or research results. The skills required to do this will be discussed and practiced. |
| Course Status | Compulsory |
| Teaching and Learning Methods | Presentation and Reading assignments |
| Assessment Methods | Group Assignments and presentation |
| Attendance Requirements | A minimum of 80% |
| Text and References | Recently published articles related to the field of specializations |

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| **Haramaya University**  **College of Natural and Computational Sciences**  **Department of Mathematics** | |
| Course Title | MSc Thesis |
| Course Code | Math697 |
| Credit Hours | 6 |
| Tutorial Hours | - |
| Laboratory Hours | - |
| Pre-requisite | Completion of all courses |
| Year | II |
| Semester | I |
| Course Objectives | After a successful completion of this course students will be able to:   * conduct independent research * understand complex ideas |
| Course Description | Current as well as relevant advanced applied mathematics topics, selected in a specialized area of mathematics, will be studied. Students will be given the opportunity to carry out independent study work in depth on the selected specialized area. The course evaluation will be based on the quality of the thesis and oral examinations. Publishing a paper in a reputed international journal is encouraged but not mandatory. |
| Course Status | Compulsory |
| Teaching and Learning Methods | - |
| Assessment Methods | Open defense |
| Attendance Requirements | - |
| Text and References | - |