I. School of Engineering

Ph.D. Programs

1. Computer Science and Engineering Department

Courses Offered:
a) EED 600: Topics in Mathematics
b) EED 601: Foundations of Signal Processing
c) EED 602: Machine Intelligence
d) CSD 610: Research Methodology
e) CSD 800: Independent Study

2. Electrical Engineering Department

Courses Offered:
 a) EED 600: Topics in Mathematics
 b) EED 603: Semiconductor Devices
c) EED 602: Machine Intelligence
d) EED 610: Research Methodology
e) CSD 800: Independent Study

3. Mechanical Engineering Department

Courses Offered:
 a) EED 600: Topics in Mathematics
 b) EED 602: Machine Intelligence
c) MED 610: Research Methodology
d) MED 800: Independent Study
Graduate Course Details

a) EED 602: Machine Intelligence (3-0-1)

Introduction to m/c intelligence: Supervised learning, unsupervised learning (clustering), evolutionary learning, reinforcement learning; applications to function approximation (regression) and pattern recognition (classification) with examples in robotic control, data mining, speech recognition, and text/image/video data processing.

Learning theory: empirical-risk minimization, bias-variance dilemma, the VC dimension and structural-risk minimization, PAC learning.

Applied m/c learning: evaluation of learning algorithms, cross-validation, ROC graphs.

Linear learning machines: parametric representations (linear/ nonlinear functions), kernel functions, perceptron learning, regression with linear learning machines, linear classification, multi-class discrimination.


Decision-tree learning: ID3 and C4.5 algorithms, fuzzy decision trees

Statistical decision making: the Bayesian learning, k-nearest neighbor learning

Rough sets-based learning, Reinforcement learning and adaptive control.

Prerequisites:
1. Knowledge of computer science principles at a level sufficient to use MATLAB toolboxes
2. Familiarity with basic probability theory
3. Familiarity with basic linear algebra

b) CSD 610, EED 610, MED 610: Research Methodology

1. Quantitative Methods:
   This module will deal with Data handling and Data Analysis, the elements of Quantitative Logic, including Hypothesis testing, Weight of Evidence, and Domain of Applicability estimation.

2. Research Literature:
   This part of the course will be conducted as a Journal Club. Each week one student will be expected to read and summarize a research paper from the recent literature in an area outside their immediate domain of research. The student will familiarize himself/herself with the background necessary to understand the research paper, and will be expected to critically analyze the work and to answer questions from other students and from the faculty moderator(s).

3. Grantsmanship:
   This module will deal with identification of a research problem, formulation of a testable hypothesis and design of experiments to address the question. Strategies for writing a fundable research proposal will be discussed, with particular emphasis on the Specific Aims, and succinctly conveying the significance of the problem to both technical and non-technical readership. Students will refine both writing and presentation skills during this module.

4. Research Seminar:
   In this module, faculty members from the department (and possibly beyond) will present seminars about their areas of interest, the proposed research in their respective groups and the experimental (or computational) techniques used in their field. Students will be expected
to participate actively in these seminars by asking questions. This module will also serve to introduce new students to the possibilities for research, preparatory to selection of their research advisors.

**Masters Programs**


**Core Courses:**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Sl. No.</th>
<th>Course</th>
<th>L:T:P</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EED 601</td>
<td>1.</td>
<td>Foundations of Signal Processing</td>
<td>3:0:1</td>
<td>4</td>
</tr>
<tr>
<td>EED 600</td>
<td>2.</td>
<td>Topics in Mathematics</td>
<td>3:0:1</td>
<td>4</td>
</tr>
<tr>
<td>CSD 600</td>
<td>3.</td>
<td>Advanced Computer Architecture</td>
<td>3:0:1</td>
<td>4</td>
</tr>
<tr>
<td>EED 604</td>
<td>4.</td>
<td>Digital Signal Processing</td>
<td>3:0:1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Total Credits</strong></td>
<td></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>

**Specialization Courses:**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Sl No</th>
<th>Course</th>
<th>L:T:P</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSD 601</td>
<td>1.</td>
<td>Embedded System Design &amp; Programming</td>
<td>3:0:1</td>
<td>4</td>
</tr>
<tr>
<td>CSD 602</td>
<td>2.</td>
<td>Real Time Operating Systems</td>
<td>3:0:1</td>
<td>4</td>
</tr>
<tr>
<td>EED 605</td>
<td>3.</td>
<td>Digital System Design &amp; Verification</td>
<td>3:0:1</td>
<td>4</td>
</tr>
<tr>
<td>CSD 603</td>
<td>4.</td>
<td>Advance Topics in Embedded System</td>
<td>3:0:1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Total Credits</strong></td>
<td></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>

**Notes:**
1. Project/Thesis work will account for 24 credits.
2. Of the total 60 credits, 4 credits can be earned through independent study or a minor software project in relevant area.

**Graduate Course Details**

a) **EED 601: Foundations of Signal Processing (3-0-1)**
Classification and representation of signals and systems, state-space representations, Fourier series and transforms, application to analysis of systems, Laplace transform, its properties, and its application to system analysis, Z transforms its properties and applications, Random variables and random process, characterization of random variables and random process, linear systems and random signals, Applications to signal processing-Filters, Communication systems, Equalizers.

b) **EED 600: Topics in Mathematics (3-0-1)**
Linear Algebra - Linear Equations, Matrix representation and operations, Vector spaces and Subspaces, basis and dimensions, linear transformations, the Algebra of Linear transformation, isomorphism, matrix representation of Linear Transformation, Canonical forms, Eigen value and Eigen Vectors, inner product space and bilinear forms, Aspects of
Matrix Computations. The class room problems will be on the nature of deriving proofs and laboratory exercise will be based on computational algorithms.

Probability and Random Process - Concepts of probability and random variable, function of random variables, random signals, density and distribution functions, statistical averages, transformation, random processes, noise, filtering etc. The class room problem will be mathematical in nature and laboratory exercise will be on simulating and generating different random signals and their transformations. Other topics of interest can be taken based on inputs.

c) CSD 600: Advanced Computer Architecture (3-0-1)
This course involves a detailed study of advanced computer architecture starting with a brief introduction to computer architecture. The included course contents are: A quantitative and qualitative understanding of superscalar, superpipelined, dataflow and VLIW processors; Available parallelism in programs; Out of order instruction execution; Reservation stations; Reorder buffers; Exception handling in out of order processors; Branch prediction techniques; Memory systems for superscalar processors; Trace caches; Memory disambiguation and load/store reordering; Multicore processors. ARM processor will be taken up as case-study.

d) CSD 601: Embedded System Design and Programming (3-0-1)
Embedded systems run the computing devices hidden inside a vast array of everyday products and appliances such as cell phones, MP3 players, handheld PDAs, cameras, and laptops. The course provides an overview of the embedded system, specification and modeling of embedded system, components of embedded system, microcontroller, sensors, actuators, A2D/D2A converters, signal processing, hardware software partitioning, software optimization for embedded system, security in embedded system, fault tolerance for embedded system, control for embedded system. Case studies will be used to demonstrate and explain design and development of embedded systems. Students will get hands on experience on microcontrollers, embedded C programming, assembly language, mixed C and assembly programming, I/O programming, protected mode and real mode (x86), bootloaders and bootsectors, Terminate and Stay Resident (TSR), device drivers and microcontroller based embedded systems.

e) EED 604: Digital Signal Processing (3-0-1)
This course is intended to introduce concepts for analyzing systems that process discrete-time signals and systems with emphasis on realization and implementation. The course will briefly recap Fourier and Z – transforms from the course on Signals and System. Key concepts to be covered include fast Fourier transform (FFT) and fast convolution, flow graphs, quantization effects, Digital Filter design methods, IIR filter design, windowing, frequency sampling, Filter properties in the Z and Fourier transform domains, advanced techniques including linear prediction, adaptive filtering and 2-d signal processing.

f) CSD 602: Real-Time Operating System (3-0-1)
The course will briefly introduce operating system concepts with an emphasis in context of embedded OS covering process management, memory management and I/O management, inter-process communication, threads and kernel. This brief introduction of OS would be followed by Real-Time concepts, difference between general-purpose OS and RTOS; basic architecture of an RTOS, scheduling systems, interrupts and interrupts handling in RTOS.
environment, latency, task management, shared data and synchronization, timers, message passing, tradeoffs between memory space and speed, RTOS comparative study; Real-time Linux as case study. Students will build a simple but relatively complete real-time operating system over the course of the semester.

g) EED 605: Digital System Design and Verification (3-0-1)
Design considerations for combinational and sequential circuits. Iterative networks, Fault diagnostics of logic circuits. State identification and structure realizations of sequential machines, Digital system architecture design: microprogramming and interrupt control. Three critical issues for robust digital systems are design errors, manufacturing faults, and failures during operation. This course covers digital system verification, testing, and reliability for both timing and logic, in order to prepare students to deal with these in real designs. Verification will cover formal verification for logic and timing, and contrast with simulation. FPGA architectures and Verilog will also be covered (if possible).

h) CSD 603: Advanced Topics in Embedded System (3-0-1)
This will cover state-of-art practices and advances in embedded systems. Presentations on current research papers would be a part of the course-curriculum. Topics of the interests include but are not limited to: Single-processor scheduling, multi-processor scheduling, distributed systems, quality of service, resource management, end-to-end processor utilization control, embedded middleware, power-aware computing, energy management, and fault-tolerance.

2. M.Tech. (ECE) with specialization in VLSI System and Technology (VST)

Core Courses:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Sl. No.</th>
<th>Course</th>
<th>L:T:P</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EED 600</td>
<td>1.</td>
<td>Topics in Mathematics</td>
<td>3:0:1</td>
<td>4</td>
</tr>
<tr>
<td>EED 606</td>
<td>2.</td>
<td>Introduction to VLSI</td>
<td>3:0:1</td>
<td>4</td>
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<tr>
<td>EED 607</td>
<td>3.</td>
<td>Analog Circuits and System</td>
<td>3:0:1</td>
<td>4</td>
</tr>
<tr>
<td>EED 604</td>
<td>4.</td>
<td>Digital Signal Processing</td>
<td>3:0:1</td>
<td>4</td>
</tr>
</tbody>
</table>

Total Credits 16

Specialization Courses:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Sl. No.</th>
<th>Course</th>
<th>L:T:P</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EED 603</td>
<td>1.</td>
<td>Semiconductor Devices</td>
<td>3:0:1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>2.</td>
<td><strong>Any 3 of following:</strong></td>
<td>3:0:1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>{IC Technology, Digital System, Mixed Signal Circuit Design, Memory Design and Testing}</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Credits 16

Notes:
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2. Of the total 60 credits, 4 credits can be earned through independent study or a minor software project in relevant area.
Graduate Course Details

a) **EED 600: Topics in Mathematics (3-0-1)**
Linear Algebra - Linear Equations, Matrix representation and operations, Vector spaces and Subspaces, basis and dimensions, linear transformations, the Algebra of Linear transformation, isomorphism, matrix representation of Linear Transformation, Canonical forms, Eigen value and Eigen Vectors, inner product space and bilinear forms, Aspects of Matrix Computations. The class room problems will be on the nature of deriving proofs and laboratory exercise will be based on computational algorithms.
Probability and Random Process - Concepts of probability and random variable, function of random variables, random signals, density and distribution functions, statistical averages, transformation, random processes, noise, filtering etc. The class room problem will be mathematical in nature and laboratory exercise will be on simulating and generating different random signals and their transformations. Other topics of interest can be taken based on inputs.

b) **EED 606: Introduction to VLSI (3-0-1)**
Modeling of MOS Transistor: Introduction, Basic Concepts- LEVEL1-LEVEL2-LEVEL3 modeling technique-various model comparison, MOS scaling theory.
CMOS Technology: Static CMOS inverter, Design of Logic states using stick diagram, layout diagram.
Performance of CMOS inverter: Dynamic Behavior, computing the capacitance-propagation delay sizing inverter for performance optimization. Power consumption in CMOS logic gates: Static Power consumption, Dynamic power consumption, dynamic or glitching transitions, Design techniques to reduce switching activity.
Pass transistor logic: Sizing in pass transistor, Dynamic CMOS design, Domino logic, Optimization of Domino logic, NPCMOS logic, Designing logic for reduced supply voltages.
Design of Latches and flip flops, static memory cell and dynamic memory cell.
This course is accompanied by Lab Exercise (Major lab contents- T-Spice, S-Edit, L-Edit).

c) **EED 607: Analog Circuits and System (3-0-1)**
MOS switch, MOS diode/ active resistor, current sinks and sources, current mirrors, current and voltage references, bandgap reference, simulation of CMOS sub circuits using SPICE.
CMO amplifiers, Common-Source stage (with resistive load, diode connected load, current-source load, triode load, source degeneration), source follower, common-gate stage, cascade stage, simulation of CMOS amplifiers using SPICE.
Frequency response of CS stage, CD stage, CG stage, cascade stage, differential pair, two-stage CMOS op-amp.
Laboratory: In this course, CMOS analog circuits simulation will be carried out using SPICE.

d) **EED 603: Semiconductor Devices (3-0-1)**
This course will cover the fundamentals of semiconductors, carrier transport, excess career, physics of semiconductor junctions, p-n junctions, Zener diodes, Tunnel diodes, metal-
semiconductor junctions, BJT and transistor models, FETs, MOSFETs, MOS capacitors, MOS characteristics, threshold voltage, short channel and narrow width effect, Long and Short Channel Parameters, Statistical Modeling of MOS Transistors, enhancement/depletion type MOSFETs, optoelectronic devices, solar cells, semiconductor power devices (SCR, UJT, Diac, Triac etc.).

e) EED 604: Digital Signal Processing (3-0-1)
The aim of the course is to introduce the theory, algorithms and applications of signal processing. This course starts with a review of discrete time signals and systems. A framework for time domain and transform domain analysis of signals and systems is provided. The Fourier and Z-transform analysis is introduced and important properties of LTI systems are discussed. Structures for discrete time system implementation are provided. Digital FIR and IIR filters and their design procedures. Finite dimensional DFT is introduced and its use in processing signals is emphasized. Fast Algorithms for DFT and other algorithms are also discussed. Some topics on multirate signal processing and adaptive filtering will be also discussed. Issues on implementation of digital filters and noise analysis of digital filters and other applications are explored. The course will have hands on exercises and projects on different aspects of signal processing.

f) EED 701: IC Technology (3-0-1)
This is an advanced course for the design and fabrication of integrated circuits (ICs). The major focus of this course lies in: Process steps for VLSI technology (Clean room concept, growth of single crystal Si, surface contamination, cleaning, oxidation, diffusion, ion implantation, advanced lithography, etching, metallization, vacuum evaporation), Fabrication of monolithic Integrated Circuits (Fabrication of n-channel enhancement and depletion MOSFETS, The CMOS process, Bi CMOS fabrication), scaled down devices, chip assembly and packaging techniques.

g) EED 702: Digital System (3-0-1)
This is a specialized course for digital electronics and systems where all the aspects of digital electronic circuits like combinational and sequential logic circuits, timer circuits, displays, counters and registers, programming technologies, Programmable Logic Element (PLE), Programmable Logic Array (PLA), Programmable Array Logic (PAL), structure of standard PLD’s, complex PLD’s (CPLD) and logic families have been focused. Design of systems using the Algorithmic State Machine (ASM) method.

h) EED 703: Mixed Signal Circuit Design (3-0-1)
This course will discuss the devices and technology issue in system consisting of both digital and analog circuits. As is obvious, this course will discuss the issue inherent when both the digital and analog Basic circuits are part of one subsystem. Specific topics of interests are analog and digital sub-circuits, different current mode circuits, continuous time and sampled data signal processing. Different data converters (ADC and DAC’s) both Nyquist and Over sampled Converters. VLSI Interconnects and timing constraints, scaling of Interconnects. Layout design issues in mixed analog and digital Circuits’ Layout. Statistical Modeling of Devices and Circuits. Issues in analog computer aided design.
EED 704: Memory Design and Testing (3-0-1)

This course is meant to cover the design and testing of semiconductor memories. The topics include: Random Access Memory technology [Static Random Access Memories (SRAMs), Dynamic Random Access Memories (DRAMs)], Read Only Memories (ROMs) [High Density ROMs, Programmable Read-Only Memories (PROMs), Electrically Programmable Read Only Memories EPROMs, Electrically Erasable PROMs (EEPROMs), technology and architecture], Flash Memories, advanced Flash Memory architecture, modeling and testing, IDDQ fault modeling and testing, application specific memory testing, nonvolatile memory reliability, radiation effects, process and design issues, Ferroelectric Random Access Memories (FRAMs), Gallium Arsenide (GaAs), Magnetoresistive Random Access Memories (MRAMs), Memory Cards, High Density Memory Packaging.
## II. School of Natural Sciences

### 1. Department of Mathematics

**Graduate Courses:**

<table>
<thead>
<tr>
<th>Code</th>
<th>Core courses</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT 600</td>
<td>Basic Tools</td>
<td>2</td>
</tr>
<tr>
<td>MAT 601</td>
<td>Mathematical Computing</td>
<td>2</td>
</tr>
<tr>
<td>MAT 620</td>
<td>Measure &amp; Integration</td>
<td>3</td>
</tr>
<tr>
<td>MAT 622</td>
<td>Topology I</td>
<td>3</td>
</tr>
<tr>
<td>MAT 624</td>
<td>Complex Analysis I</td>
<td>3</td>
</tr>
<tr>
<td>MAT 626</td>
<td>Functional Analysis I</td>
<td>3</td>
</tr>
<tr>
<td>MAT 660</td>
<td>Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>MAT 680</td>
<td>Numerical Analysis I</td>
<td>3</td>
</tr>
<tr>
<td>MAT 684</td>
<td>Probability &amp; Statistics I</td>
<td>3</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Code</th>
<th>Elective courses</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>MAT 618</td>
<td>Scientific Computing</td>
<td>3</td>
</tr>
<tr>
<td>MAT 623</td>
<td>Topology II</td>
<td>3</td>
</tr>
<tr>
<td>MAT 625</td>
<td>Complex Analysis II</td>
<td>3</td>
</tr>
<tr>
<td>MAT 627</td>
<td>Functional Analysis II</td>
<td>3</td>
</tr>
<tr>
<td>MAT 628</td>
<td>Abstract Measure Theory</td>
<td>3</td>
</tr>
<tr>
<td>MAT 640</td>
<td>Abstract Algebra</td>
<td>3</td>
</tr>
<tr>
<td>MAT 681</td>
<td>Numerical Analysis II</td>
<td>3</td>
</tr>
<tr>
<td>MAT 682</td>
<td>Optimization</td>
<td>3</td>
</tr>
<tr>
<td>MAT 685</td>
<td>Probability &amp; Statistics II</td>
<td>3</td>
</tr>
<tr>
<td>MAT 686</td>
<td>Ordinary Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>MAT 687</td>
<td>Partial Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>MAT 720</td>
<td>Spectral Theory</td>
<td>3</td>
</tr>
<tr>
<td>MAT 730</td>
<td>Algebraic Topology</td>
<td>3</td>
</tr>
<tr>
<td>MAT 732</td>
<td>Differential Geometry</td>
<td>3</td>
</tr>
<tr>
<td>MAT 740</td>
<td>Galois Theory</td>
<td>3</td>
</tr>
<tr>
<td>MAT 742</td>
<td>Reproducing Kernel Hilbert Space</td>
<td>3</td>
</tr>
<tr>
<td>MAT 744</td>
<td>Frame Theory</td>
<td>3</td>
</tr>
<tr>
<td>MAT 782</td>
<td>Stochastic Processes</td>
<td>3</td>
</tr>
<tr>
<td>MAT 784</td>
<td>Numerical Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>MAT 786</td>
<td>Finite Element Methods</td>
<td>3</td>
</tr>
<tr>
<td>MAT 799</td>
<td>Project</td>
<td>3</td>
</tr>
<tr>
<td>MAT 800</td>
<td>Reading course</td>
<td>3</td>
</tr>
</tbody>
</table>

**Note:**

1. More courses will be added later depending on the availability and the interest of faculty and students.
2. Not all these courses will be offered at a time. It will be a student's responsibility to see which of these courses are being offered and decide according to the choice of core/electives courses to fulfill the requirement, in consultation with the Graduate Student Advisor, Department of Mathematics.

**Graduate Course Details**

### I. Monsoon Semester

1. **MAT 600: Basic Tools** (L:T:L 3:0:0; Credits: 2)
   - Prerequisites: None
   - Course Classification: Mathematics Core
   - Brief Description: Review of linear algebra, probability and statistics, with an emphasis on applications
   - Course Coordinator: Sudeepto Bhattacharya

2. **MAT 601: Mathematical Computing** (L:T:L 1:0:1; Credits: 2)
   - Prerequisites: None
   - Course Classification: Mathematics Core
   - Brief Description: Programming in C++ and Matlab
   - Course Coordinator: Niteesh Sahni & Ziaur Rehman

3. **MAT 620: Measure & Integration** (L:T:L 3:1:0; Credits: 3)
   - Prerequisites: MAT 220, MAT 320 or equivalent
   - Course Classification: Mathematics Core
   - Brief Description: Review of Real numbers and Riemann Integration, Lebesgue Measure and Integral, Differentiation, Classical Banach Spaces, introduction to Abstract Measure and Integration
   - Course Coordinator: Sneh Lata

4. **MAT 622: Topology I** (L:T:L 3:1:0; Credits: 3)
   - Prerequisites: MAT 220 or equivalent
   - Course Classification: Mathematics Core
   - Brief Description: Metric spaces, Topological spaces, Continuous functions, Subspaces, Product and Quotient topologies, Separability Axioms, Connected and Path Connected Spaces, Compact and Locally Compact Spaces, Baire Category Theorem
   - Course Coordinator: Amber Habib

5. **MAT 628: Abstract Measure Theory** (L:T:L 3:1:0; Credits: 3)
   - Prerequisites: MAT 620 or equivalent
   - Course Classification: Mathematics Elective
   - Brief Description: Measure spaces, Integration, General Lp spaces, Borel measures, Hausdorff measures, Invariant measures
   - Course Coordinator: TBA

6. **MAT 660: Linear Algebra** (L:T:L 3:1:0; Credits: 3)
   - Prerequisites: MAT 620 or equivalent
   - Course Classification: Mathematics Core
Brief Description: Familiarity with sets, Vector Spaces, Linear Transformations, System of Linear Equations, Determinants, Diagonalization, Canonical forms.
Course Coordinator: Ved Prakash Gupta

7. MAT 680: Numerical Analysis I (L:T:L 3:1:0; Credits: 3)
Prerequisites: MAT 220, MAT 260 or equivalent
Course Classification: Mathematics Core
Brief Description: Error Analysis, Linear systems, Non-linear equations and systems, Interpolation, Integration, Eigenvalues and Eigenvectors
Course Coordinator: Ajit Kumar

8. MAT 730: Algebraic Topology (L:T:L 3:1:0; Credits: 3)
Prerequisites: MAT622 or equivalent
Course Classification: Mathematics Elective
Brief Description: Fundamental group, Homotopy type, Jordan separation theorem, Invariance of domain, Seifert- van Kampen theorem, Covering spaces, Simplicial Homology.
Course Coordinator: TBA

9. MAT 740: Galois Theory (L:T:L 3:1:0; Credits: 3)
Prerequisites: MAT 640 or equivalent
Course Classification: Mathematics Elective
Brief Description: Field extensions, Irreducibility, Splitting fields, Algebraic closure, Normal extensions, Galois extension, Galois group, Cyclic extensions, Solution by radicals, Transcendental elements and algebraic independence.
Course Coordinator: TBA

10. MAT 799 (Part A): Project (L:T:L 0:0:1; Credits: 0)
Prerequisites: For Final Year students
Course Classification: Mathematics Elective
Brief Description: This will be a hands-on project done over the full academic year. Students shall work in groups on a topic chosen from application of mathematics and computing, like finance, image recognition, encryption, coding theory, etc. The grades will be awarded at the end of the academic year.
Course Coordinator: TBA

II. Spring Semester

1. MAT 624: Complex Analysis I (L:T:L 3:1:0; Credits: 3)
Prerequisites: MAT 622 or equivalent
Course Classification: Mathematics Core
Brief Description: Holomorphic Functions, Power Series, Complex Integration, Cauchy’s Theorem and consequences, Laurent Series, Residues, General Cauchy’s Theorem, applications to Real Integrals.
Course Coordinator: TBA

2. MAT 626: Functional Analysis I (L:T:L 3:1:0; Credits: 3)
Prerequisites: MAT 620, MAT 622, MAT 660 or equivalent
Course Classification: Mathematics Core
Brief Description: Normed spaces, Category theorems, Dual spaces, Hahn-Banach Theorem, Weak topologies, Inner product spaces, Hilbert spaces, Operators on Hilbert spaces, Spectrum of an operator
Course Coordinator: Niteesh Sahni

3. MAT 640: Abstract Algebra (L:T:L 3:1:0; Credits: 3)
Prerequisites: MAT 240 or equivalent
Course Classification: Mathematics Elective
Brief Description: Groups and group actions, Rings, Modules, Applications to canonical forms and finitely generated abelian groups, Fields and extensions, Galois Theory.
Course Coordinator: Neha Gupta

4. MAT 682: Optimization (L:T:L 3:1:0; Credits: 3)
Prerequisites: MAT 220, MAT 260 or equivalent
Course Classification: Mathematics Elective
Brief Description: Multivariable Calculus, Convex sets and functions, Convex optimization; Applications to approximation and fitting, statistical estimation and geometric problems.
Course Coordinator: Ajit Kumar

5. MAT 684: Probability & Statistics (L:T:L 3:1:0; Credits: 3)
Prerequisites: MAT 201 or equivalent
Course Classification: Mathematics Core
Brief Description: Sampling, Point and Interval Estimation, Hypothesis Testing, Linear and Multiple Regression, ANOVA, ANCOVA, Non-parametric tests
Course Coordinator: Charu Sharma

6. MAT 720: Spectral Theory (L:T:L 3:1:0; Credits: 3)
Prerequisites: MAT 626 or equivalent
Course Classification: Mathematics Elective
Brief Description: Banach Algebras, C*-Algebras, Representations of commutative C*-Algebras, Spectral theory for bounded operators, Compact Operators, Fredholm Index, Spectral theory for unbounded operators
Course Coordinator: TBA

7. MAT 732: Differential Geometry (L:T:L 3:1:0; Credits: 3)
Prerequisites: MAT 622 or equivalent
Course Classification: Mathematics Elective
Brief Description: Topological manifolds, Smooth structures, Tangent space, Tangent and Cotangent Bundles, Immersions & Submersions, Curves and Surfaces, Gauss Curvature, Lie Groups and Algebras
Course Coordinator: TBA

8. MAT 799 (Part B): Project (L:T:L 0:0:1; Credits: 3)
Prerequisites: For Final Year students
Course Classification: Mathematics Elective
Brief Description: This is the concluding part of MAT 799.
Course Coordinator: TBA

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2. Department of Chemistry

Graduate Course Details

CHY 501: Medicinal Chemistry (4 credits: 3 Lec + 3-hr.Lab) – Spring
What are the general characteristics of drugs? How can drug potency be optimized? How can side effects and ADMET problems be minimized? Mechanism of drug action at receptors, How is a message received? How does a receptor change shape? Chemical Genetics/Genomics and combinatorial approach for drug discovery process; QSAR and HTS; introduction to Prodrug and drug delivery system; current approaches for drug discovery and their comparative study with traditional approaches; diversity oriented synthesis (DOS) and Fragment based drug design (FBDD); these and other topics will be addressed in this course. Students will be expected to prepare and defend a research proposal in class.
Co-requisite: Informatics & Drug Discovery.

CHY 503: Chemistry of Glycoconjugates

CHY 511: Advanced Quantum Chemistry [+Lab]
This course will cover the principles and methods in time-independent and time-dependent quantum mechanics of many-electron systems; Hartree-Fock theory and density matrices; the topology of molecular electron density distributions; density functional theory, time-dependent density functional theory and ab initio molecular dynamics; many body theory; configuration interaction and coupled cluster techniques.
Prerequisites: Chemical Bonding.

CHY 512: Advanced Molecular Spectroscopy (4 credits: 3 Lec + 2-hr.Lab) – Spring
In this course and the associated lab, students will be exposed to time-dependent quantum mechanics and group theory, as applied to molecular spectroscopy, and will gain experience in several advanced spectroscopic techniques, and learn to analyze and interpret electronic, vibration-rotation, microwave, Mössbauer and nuclear magnetic resonance spectra and X-ray diffraction data in detail.
Prerequisite: Molecular Spectroscopy.

CHY 515: Advanced Statistical Mechanics [+ Lab] (4 credits)
This advanced course aims to construct a bridge between macroscopic thermodynamics and microscopic statistical mechanics. The course will deal with the theory of liquids, the principles of equilibrium and non-equilibrium statistical mechanics and quantum statistical mechanics. Topics covered will include Phase space; Liouville’s theorem; the ergodic hypothesis; the concept of ensembles; classical partition functions, microcanonical, canonical and grand canonical ensembles; Maxwell- Boltzmann distribution; ideal gas in a canonical ensemble; thermodynamic quantities and canonical partition function; fluctuations in energy and magnetization in a canonical ensemble; density and energy fluctuations in the
grand canonical ensemble; density matrices; ideal gases in quantum mechanical ensembles; partition function of non-interacting particles; ideal Bose gas; black body radiation; ideal Fermi gas; the fluctuation dissipation theorem; master equation; Smoluchowski theory of Brownian motion, Langevin theory, Fokker Planck equation. The associated computer lab will cover classical and \textit{ab initio} quantum molecular dynamics and Monte Carlo simulations of liquids and proteins.

\textit{Prerequisites}: Chemical Equilibrium, Chemical Binding, Macromolecules.

**CHY 518: Theoretical Chemistry Seminar** (3 credits) Spring

This advanced course will cover special topics in quantum chemistry and statistical mechanics. Students will examine in-depth selected articles from the current scientific literature, and develop a viable research proposal in the chosen area.

\textit{Prerequisites}: Advanced Quantum Chemistry.

**CHY 522: Informatics and Drug Discovery** (4 credits: 3 Lec + 3-hr.Lab) – Spring

This course and the associated computer lab deal with Bioinformatics and Cheminformatics, applied to the search for new drugs with specific physiological effects (\textit{in silico} Drug Discovery). Students will learn the general principles of structure-activity relationship modeling, docking & scoring, homology modeling, statistical learning methods and advanced data analysis. They will gain familiarity with software for structure-based and ligand-based drug discovery. Some coding and scripting will be required. At the end of the course, students will be expected to present a completed piece of software of significant utility and/or an analysis of experimental data from the published literature. Students will be encouraged to seek avenues for publication of their most significant results.


**CHY 542: Nano and Supramolecular Chemistry**

Introduction to self assembly and supramolecular chemistry; type of self assembly and non covalent interactions, pre-organization, cryptand, metallo-supramolecules, two three and multiple hydrogen bonding system, liquid crystals, Introduction of Nano particles, preparation properties and application in medical science as biomarkers.

**CHY 545: Fundamentals of Crystallography [+Lab]**

1. Fundamentals of crystallography – Symmetry, Point group and space group
2. Different methods of crystallization – practical classes on growing crystals
3. Protein crystallography and the Protein Data Bank
4. Data collection, Strategy, Data processing and analysis – Introduction to different data processing software \textit{e.g.} IMOSFLM, XDS.
5. Introduction to different structure solving package – CCP4, Phenix
6. Hands on classes of structure solving – Molecular replacement, SAD, MAD methods,
7. Structure analysis and model validation
8. Introduction to other methods – Electron microscopy, SAXS etc

**CHY 551: Advanced Chemical Biology** (3 Credits: 2 Lec + 2-hr.Lab) – Spring

mechanism; Chemical glycomics and biophysical techniques. Carbohydrate and protein signaling in living system, mechanism and their application.

Prerequisite: Biochemistry, Macromolecules, Molecular Biology

CHY 552: Polymer Chemistry and its Scope (3 Credits) -- Monsoon
How do changing demands in society lead to polymer invention? How are monomers bonded in nature to form our body’s building blocks? How do scientists mimic nature in labs? How does the several-fold change in molecular weight from monomer to polymer result in different sets of properties? Most of the polymeric materials around us are synthesized in different ways, depending upon end usage. This course will help the students to understand the need and importance of polymers in today’s world. Interesting chemical aspects of synthesis of polymeric architectures from small molecules will be explored.

Prerequisite: Organic Reactions and Mechanisms.

CHY 553: Bio-Inorganic Chemistry (3 Credits: 2 Lec + 2-hr. Lab) – Spring
Metals ions play important role in many biological processes. Their function can range from simple structural roles in which they hold a protein in a specific conformation, to more complex roles in which they are involve in multiple electron transfer processes and in bond cleavage and formation. Understanding of the biological functions of metal ions lies at the heart of bio-inorganic chemistry. This course will focus on the biologically important metal ions and their binding sites, and the techniques used to probe these sites (e.g. IR, UV-VIS, NMR, EPR, Mossbauer and CV). A more in-depth look at several key metalloenzymes and the functional role of the metal ions therein will also be taken.

Prerequisite: Co-ordination Chemistry and Biochemistry.

CHY 554: Green Chemistry and Sustainability (3 Credits) – Spring
Since a decade, scientific community especially in chemistry has been mobilized to develop new chemistries that are less hazardous to human health and the environment. Several steps were taken to protect both the nature and maintain ecological balance. But still such an effort is in nascent stage. Are we really protecting earth? Are we utilizing nature’s sources wisely? What are the hazards associated with one wrong step...and with several such steps? We are surrounded by chemistry since we wake up in morning till we sleep in night such as toothpaste, soap, cloth, perfume, medicine, plastic furniture, shoes etc. For those of us who have been given the capacity to understand chemistry and practice it in our day-to-day life, it is and should be expected that we should use it in a sustainable manner. With knowledge comes the burden of responsibility. We should not enjoy this luxury with ignorance and cannot turn a blind eye to the effects of the science in which we are engaged. We have to work hard and put brain waves together to develop new chemistries that are more benign, and safer to mother earth!!

Prerequisite: Organic Reactions and Mechanisms.

CHY 555: Synthetic Biology (cross-listed with Life Sciences):
• Introduction to Synthetic Biology
• Synthetic Biology for Biosynthetic Chemistry.
• Synthetic Biology work. EgArtemisinin production.
• A practical approach of biological devices.
• Synthetic Biology of stem cells.
• Advanced System and Synthetic Biology.
CHY 583: Topics in the Philosophy of Chemistry (3 credits) -- Spring
Chemical concepts such as atoms, molecular structure, electron density, equilibrium, reaction path, etc. will be discussed from a historical and philosophical context. There will be numerous short papers on topics of student interest, as well as a more comprehensive project in which students will examine the historical and/or philosophical aspects of a chemical concept of their choosing.

CHY 600: Research Methodology
1. Quantitative Methods:
This module will deal with Data handling and Data Analysis, the elements of Quantitative Logic, including Hypothesis testing, Weight of Evidence, and Domain of Applicability estimation.

2. Research Literature:
This part of the course will be conducted as a Journal Club. Each week one student will be expected to read and summarize a research paper from the recent literature in an area outside their immediate domain of research. The student will familiarize himself/herself with the background necessary to understand the research paper, and will be expected to critically analyze the work and to answer questions from other students and from the faculty moderator(s).

3. Grantsmanship:
This module will deal with identification of a research problem, formulation of a testable hypothesis and design of experiments to address the question. Strategies for writing a fundable research proposal will be discussed, with particular emphasis on the Specific Aims, and succinctly conveying the significance of the problem to both technical and non-technical readership. Students will refine both writing and presentation skills during this module.

4. Research Seminar:
In this module, faculty members from the department (and possibly beyond) will present seminars about their areas of interest, the proposed research in their respective groups and the experimental (or computational) techniques used in their field. Students will be expected to participate actively in these seminars by asking questions. This module will also serve to introduce new students to the possibilities for research, preparatory to selection of their research advisors.

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3. Department of Physics

Graduate Coursework: The coursework comprises of core, elective and research exploratory courses. Each scholar is expected to take a minimum of 12 credits per semester and teaching/research assistantship throughout the graduate program. A scholar is expected to complete five core and three elective courses according to his/her research interest during the first two semesters.

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<th>Doctoral Thesis Defense</th>
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<td>Minimum Credit Requirements: Course Work - 24 &amp; Ph.D. Thesis - 48</td>
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*may take non-departmental electives subject to the approval of both graduate student advisor and research advisor.
Graduate Core Courses

**PHY 502: Classical Dynamics** (3 Credits: 3 Lectures/week)
This course reviews classical mechanics and classical electrodynamics by developing Lagrangian and Hamiltonian formalism for particles and fields. The emphasis of the course is in solving various interesting physics problems using these formalisms.
Textbooks:
1. Classical Mechanics, Landau and Lifshitz
2. Classical Theory of Fields, Landau and Lifshitz

**PHY 503: Quantum Mechanics** (3 Credits: 3 Lectures/week)
This course reviews fundamental of quantum mechanics. It includes the study of two state systems, approximate methods, many particle systems, and the interaction of radiation with matter.
Textbooks:
1. Quantum Mechanics, Landau and Lifshitz
2. Lectures on Quantum Mechanics, Baym

**PHY 505: States of Matter** (3 Credits: 3 Lectures/week)
This course reviews the fundamentals of statistical physics and thermodynamics and then applies them to: perfect gas, solid, liquid and interacting gases, and to special states like super fluidity and superconductivity.
Textbooks:
1. States of Matter, Goodstein
2. Statistical Physics, Landau and Lifshitz

**PHY 599: Explorations in Research** (3 Credits)
The aim of this course is to introduce the student to research methodology by exploring a specific research area of his/her interest. A physics faculty member will guide the student.

**DTD 899: Ph.D. Thesis**
This covers the entire Ph.D. research work of a graduate student.

Graduate Elective Courses

**PHY 551: Nanomaterials & Nanophysics** (3 Credits: 3 Lectures/week)
This is an interdisciplinary advanced level Ph.D. course in which various nanomaterials processing techniques, including chemical and physical vapor deposition, lithography, self-assembly, and ion implantation will be introduced. Tools commonly used to characterize nanomaterials will be introduced. The structural, mechanical, optical and electronic properties, which arise due to nano-scale structure, will be discussed from the point of view of nano-scale devices and applications

**PHY 554: Advanced Statistical Physics** (3 Credits: 3 Lectures/week)
This course covers the critical phenomena, Landau-Ginzburg theory of phase transition, renormalization group, time-dependent phenomena in condensed matter, Correlation and response, Langevin theory, Fokker Plank and Smoluchowski equations, broken symmetry,
hydrodynamics of simple fluids, stochastic models and dynamical critical phenomena, nucleation and spinodal decomposition, Topological defects.

**PHY 556: Introduction to Quantum Field Theory** (3 Credits: 3 Lectures/week)
This course introduces the techniques of quantum field theory and its application to condensed matter physics and particle physics.

**PHY 558: Semiconductor Physics & Devices** (3 Credits: 3 Lectures/week)
This course outlines the physics, applications and technology of Semiconductors. The course covers energy band structures in semiconductors, dopants and defects, charge transport, electronic and optical properties, excitons and other quasi-particles, semiconductor heterostructures, diodes, LEDs, photovoltaic, LASERS and field-effect transistors (FETs). The concepts of these conventional devices will be extended to the emerging areas of new generation of flexible electronic and optoelectronics devices based on unconventional materials like metal oxides and organic semiconductors.

**PHY 560: Particle Physics Phenomenology** (3 Credits: 3 Lectures/week)
This course addresses the following topics in Particle Physics Phenomenology: decay rates and cross Sections, the Dirac equation and spin, interaction by particle exchange, electron–positron annihilation, electron–proton scattering, deep inelastic scattering, symmetries and the quark model, QCD and color, V-A and the weak interaction, leptonic weak interactions, the CKM matrix and CP violation, electroweak unification and the W and Z, tests of the standard model, the Higgs Boson and beyond.

**PHY 562: Experimental Techniques in Particle Physics** (3 Credits: 3 Lectures/week)
This course is intended to give an in-depth study of detector, data analysis and other experimental techniques used in particle physics. Modern particle detectors such as micro-pattern gaseous detectors, drift chambers, silicon detectors, calorimeters, Cherenkov detectors and others are discussed along with advanced statistical methods and data analysis techniques to extract results.

**PHY 564: Advanced Simulation Techniques** (3 Credits: 3 Lectures/week)
This course gives an introduction to various simulation techniques such as Monte Carlo, Classical Molecular Dynamics, Quantum Simulations: time-independent Schrödinger equation in one dimension (radial or linear equations); scattering from a spherical potential, Born approximation, bound state solutions; single particle time-dependent Schrödinger equations; Hartree-Fock theory: restricted and unrestricted theory applied to atoms; Schrödinger equation in a basis: matrix operations, variational principle, density functional theory, quantum molecular dynamics.

**PHY 566: Introduction to String Theory** (3 Credits: 3 Lectures/week)
The aim of this course is to introduce the basic concepts of string theory by applying quantum mechanics to a relativistic string. In this manner the student will deepen his or her understanding of quantum mechanics and will also be able to appreciate the diverse areas of physics in which the mathematical description of a string like object is useful.
PHY 568: Multiferroics & Shape Memory Alloys (3 Credits: 2 Lectures + 2 hours lab./week)
The course covers the electric polarization and their types, dipoles, frequency and temperature dependence of polarization, local field and Clausius-Mossotti equation, dielectric constant, loss and breakdown; Applications of high-k materials, ferroelectricity, pyroelectricity and piezoelectricity, electrical memory/hysteresis loop, fatigue testing, pyro and piezo coefficients; Shape Memory alloys: types, working, properties, manufacturing and applications.

PHY 570: Biosensors: General Principles & Advanced Sensing Techniques (3 Credits: 3 Lectures/week)
This course covers the basic sensor terminologies (linearity, sensitivity, selectivity, response time, etc.), analyte surface interactions, Bio-MEMS, concepts of microfluidic devices, and various advanced detection techniques such as, fluorescence, surface plasmon resonance (SPR), impedance spectroscopy, scanning probe microscopy (SPM), surface enhanced Raman spectroscopy (SERS), and electrochemical methods.

PHY 574: Materials Characterization Techniques – I (3 Credits: 3 Lectures/week)
This course covers the basic interaction of matter with photons, elastic and non-elastic scatterings, and characterization techniques: Ultra-violet photoelectron spectroscopy (UPS), Raman spectroscopy, Extended X-ray absorption fine structure (XAFS), X-ray fluorescence, Fourier transform infrared spectroscopy (FTIR), UV-Visible-IR spectroscopy, Photoluminescence (PL), Electroluminescence (EL) and Cathode luminescence (CL).

PHY 575: Materials Characterization Techniques – II (3 Credits: 3 Lectures/week)
This course covers the basic interaction of matter with electrons, neutrons, ions, energetic particles, elastic and non-elastic scatterings, and characterization techniques: Optical microscopy, Transmission electron microscopy (TEM), Scanning electron microscopy (SEM), Scanning probe microscopy (SPM), Atomic force microscopy (AFM), X-ray diffraction, Energy dispersive X-ray analysis. X-Ray photoelectron spectroscopy (XPS), Secondary ion mass spectrometry (SIMS).

PHY 578: Introduction to Thin Films (3 Credits, 3 Lectures/week)
This course covers the crystals structure, defects, bonding, phase diagram, kinetics, diffusion, nucleation and growth, trapping, surface diffusion, growth models, vacuum techniques; thin film deposition techniques: thermal evaporation, e-beam evaporation, sputtering, molecular beam epitaxy, chemical vapor deposition, pulsed laser deposition; thin film properties: materials surface, structural, mechanical, optical, electrical, magnetic properties; thin film based devises and applications

PHY 588: Fundamentals of Ion-Solid Interactions (3 Credits: 3 Lectures /week)
Introduction to ion beam processes, ion implanter and applications, interatomic potential, Thomas-Fermi statistical model, classical two-particle scattering theory, differential scattering cross-section, energy-loss process in solid, Fermi-Teller model, ZBL universal scattering function, ion range & distribution, straggling, radiation damage in solid, thermal spikes, Mono-Carlo simulation, diffusion in solid, sputtering, applications of ion beam, ordering-disordering, alloying, Hume-Rothery rules, ion-mixing, phase transition, doping semiconductors, location of dopants via Rutherford backscattering and ion channeling.
PHY 589: Ion Beam Based Materials Characterization Techniques (3 Credits: 3 Lectures/week)
This course introduces various ion accelerators and associated instruments, basic interaction of matter with ions, energy loss process, elastic and non–elastic scatterings, characterization techniques: Rutherford backscattering spectrometry (RBS), Ion channeling, Resonance channeling, Proton induced X-ray emission (PIXE), Elastic recoil detection analysis (ERDA), Nuclear reaction analysis (NRA), pitfalls in ion beam analysis, and radiation safety.

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# 4. Department of Life Sciences

## a) M.S. Biotechnology

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<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Contact Hours</th>
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<tbody>
<tr>
<td>BIO 501</td>
<td>Cell Biology &amp; Genetics</td>
<td>3</td>
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<tr>
<td>BIO 502</td>
<td>Biochemistry</td>
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<tr>
<td>BIO 503</td>
<td>Microbiology</td>
<td>3</td>
<td>3</td>
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<tr>
<td>BIO 504</td>
<td>Biophysics &amp; Analytical Techniques Biostatistics</td>
<td>3</td>
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<tr>
<td>BIO 505</td>
<td>Bioenergetics</td>
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<td>2</td>
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<tr>
<td>BIO 506</td>
<td>Lab-I: Microbiology &amp; Cell Biology</td>
<td>8</td>
<td>2</td>
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<tr>
<td>BIO 507</td>
<td>Lab-II: Biochemistry &amp; Analytical Techniques</td>
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### Semester II

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<td>Immunology</td>
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<td>BIO 512</td>
<td>Bioprocess Technology</td>
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<tr>
<td>BIO 513</td>
<td>Enzymology</td>
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<td>BIO 514</td>
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<td>BIO 516</td>
<td>Lab-III: Enzymology &amp; Immunology</td>
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<td>BIO 517</td>
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<td>BIO 602</td>
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<td>BIO 607</td>
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<td>BIO 609</td>
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Graduate Course Details

SEMESTER I

BIO 501: Cell Biology & Genetics
Overview: This course gives a clear understanding of structural and functional aspects of different cell organelle. It also emphasizes on principles of genetics and inheritance of gene and genetically transmitted diseases etc.
Content: Mammalian cell and its environment; structural and functional aspects of different cell organelle, Principles of genetic, inheritance of gene, Mendelian genetics, Population genetics, Drosophila genetics, Alleles, Genetically transmitted diseases, eukaryotic cell structure; cell growth and division. Bacterial genetics, structure of the bacterial chromosome, bacterial genome gazing, comparative genomics. Medical Genetics: genetic analysis of human disease; modern methods of mapping susceptibility alleles; yeast as a human disease model; clinical genetics of complex diseases; ethics in Genetics.

BIO 502: Biochemistry
Overview: This course will focus on the classification of different biomolecules based on their chemical properties and structure. It will also give an understanding of the anabolism and catabolism of these molecules and their importance in biological systems.
Contents: Carbohydrates: Classification, configuration, conformations, sugar derivatives, structural and storage polysaccharides. Amino acids: General properties, peptide bond, essential and non-essential amino acids. Lipids: Classification, properties of lipid aggregates, biological significance. Protein chemistry: Classification, different levels of protein structure, forces stabilizing protein structure, protein folding, protein modification, signal sequences. Nucleic acid: Chemical structure and base composition, double helical structures, Tm, supercoiled DNA. Protein nucleic acid interaction, DNA replication; DNA Sequencing and the human genome DNA integration, Transcription, Translation, Medical Biochemistry, Plant Biochemistry.

BIO 503: Microbiology
Overview: This course helps in studying life of micro-organisms, their visualization, characterization and culturing of various microbes like bacteria, viruses etc.
Contents: Pasteur’s experiments, Sterilization (dry heat, wet heat, radiation, chemical and filtration), microscopy (light, phase contrast, fluorescence, TEM and SEM), microbial species and strains, growth curve, various forms of microorganism (bacteria, fungi, viruses, protozoa), gram positive and gram negative bacteria, serotypes, Mutant analysis, Industrial microbiology, Production of food (dairy and SCP) and antibiotics, fermentation, Bacteriology, Virology.

BIO 504: Biophysics & Analytical Techniques
Overview: This course gives a clear understanding of the principles of biophysics and instrumentation of various biochemical techniques used in biotechnology.
Contents: Principles of biophysics and physics applied to biological problems, Biological cells and their molecules, Molecular motion, Energy, Thermodynamics and chemical forces, Interactions study: DNA DNA, DNA RNA, DNA; Protein, Biophysical techniques including Optical microscopy (confocal microscopy), Spectroscopic techniques (fluorescence
microscope) X-ray diffraction in structural biology, Electron microscopy and
electrophysiological techniques, MSMS, LCMS, Solid phase amino acid synthesis, Vascular
permeability analysis, Molecular Biology techniques, Biochemical Techniques,
Immunological techniques, Enzymological techniques, Microbiological techniques.

BIO 505: Bioenergetics
Overview: Bioenergetics is the multidisciplinary study of how energy is transferred in cells,
tissues and organisms. This course gives an understanding of the various metabolic
pathways that a cell activates for the turnover of various bio-molecules for its survival.
Contents: Energy and cellular metabolism: Glycolysis, Krebs cycle, pentose phosphate
pathways, glycogen metabolism, oxidative phosphorylation, fatty acid biosynthesis and
oxidation and photosynthesis, TCA cycle; oxidative phosphorylation; gluconeogenesis;
glycogen metabolism; fat metabolism; basic amino acid metabolism; alcohol metabolism,
amino acids, purine and pyrimidine bases, fatty acids and sugars. Small molecules of
biological importance: vitamins and minerals. Bioenergetics and thermodynamics of
biological systems.

BIO 506: Lab-I: Microbiology & Cell Biology
Overview: This lab course gives hands-on experience on all the theoretical aspects learnt in
BIO 501 and 503.

BIO 507: Lab-II: Biochemistry & Analytical Techniques
Overview: This course gives hands-on experience in different biochemical and analytical
techniques used in biotechnology to understand biological systems.

SEMESTER II

BIO 511: Immunology
Overview: This course gives basic understanding of the immune system, and how body
generates immune response in different diseased conditions.
Contents: T cells, B cells-their function , Different types of antibodies IgG, IgM, IgE, IgA &IgD
and their function, MHC and its role in transplantation immunology, Immune therapy,
Immune memory, antibody assay like diffusion double diffusion, ring, Bio-Core assay.
Production of monoclonal antibodies, tagging of antibodies, Identification and
characterization of the epitopes of antibody, Cancer immunology, Techniques like Western,
ELISA, Chemi-luminiscence, Regulations of Immune systems of different organisms.

BIO 512: Bioprocess Technology
Overview: This course emphasize on the upstream and downstream processing of
fermentation technologies. It gives an understanding of the different types of fermenters and
their usage in different applications.
Contents: The fermentation technology, selection of industrial microorganisms, production
process: fermentation media aeration, pH, temperature, batch versus continuous culture,
immobilized enzymes, protein engineering, downstream processing and product recovery,
food industry, waste as fermentation substrate, solid state fermentation and designing of
various bioreactors for various applications.
**BIO 513: Enzymology**

*Overview:* This course emphasizes on the biochemical reactions and gives an understanding of mechanisms of interactions among different biomolecules and roles of Enzyme in controlling and mediating different biochemical reactions.

*Contents:* Enzymes Classification, catalysis, kinetics, regulation (fine, coarse and metabolic control) Nomenclature, apoenzyme and holoenzyme, substrate specificity, coenzymes, factors affecting enzyme activity, regulation of enzyme activity, enzyme inhibition, isozymes, ribozymes, abzymes. Nomenclature, classification of enzymes, Enzyme structure, properties, Enzyme specificity; factors affecting enzyme action, Mechanism of enzyme action, activators & inhibitors; characterization of active site, enzyme catalysis, interactions between enzymes and substrates; enzyme catalysis; enzyme inhibition and allosteric regulation; transition state theory; the mechanism of action of several biological catalysts included protein-enzymes (RNA polymerase), catalytic RNA and catalytic antibodies. Multienzyme complex; single and multi-substrate systems; Regulatory enzymes; ATPase, glutamine synthetase, hemoglobin and myoglobin Membrane bound enzymes: extraction, purification and assay.

**BIO 514: Molecular Biology**

*Overview:* Molecular biology is the study of biology at a molecular level. The field overlaps with other areas of biology and chemistry, particularly genetics and biochemistry. Molecular biology chiefly concerns itself with understanding the interactions between the various systems of a cell, including the interactions between DNA, RNA and protein biosynthesis as well as learning how these interactions are regulated.


**BIO 515: Elective**

*Contents:* TBD

**BIO 516: Lab-III: Enzymology & Immunology**

*Overview:* This lab course teaches how to study the activity and kinetics of different enzyme mediated reactions. This also teaches the evaluation of immune system on exposure to different antigenic conditions.
BIO 517: Lab-IV: Molecular Biology

Overview: This course enables us to experimentally manipulate cell systems at molecular level and use them in different applications for better life forms.

SEMESTER III

BIO 601: Genetic Engineering

Overview: Genetic engineering is the direct manipulation of an organism's genome using modern DNA technology. It involves the introduction of foreign DNA into the organism of interest. The introduction of new DNA is done by advanced molecular techniques to generate recombinant organisms.


BIO 602: Plant Biotechnology

Overview: Plant biotechnology teaches in depth the molecular aspects of plant system and various application of biotechnological techniques for development of superior varieties of plant species regarding yield, disease resistance etc.

Contents: Terms and definitions, use of growth regulators, beginning of in-vitro cultures in India, ovary and ovule culture in vitro pollination and fertilization, embryo culture, endosperm culture and production of triploids. Introduction to the process of embryogenesis and organogenesis and their practical applications: Clonal multiplication of elite species (micropropagation), practical applications of tissue and organ culture and their applications in selection of variants mutants with and without treatment single cell suspension, Protoplast isolation: principle and application, testing of viability of isolated protoplasts, regeneration of protoplasts. practical applications of somatic hybridization (hybrid vs. cybrids). Use of plant cell, protoplast and tissue culture of genetic manipulation of plant: Tumor formation on plants using rot formation using A. rhizogenes, practical application of genetic transformation. Transgenic plant for the production of human therapeutics, edible vaccines, herbicides, insect resistance, production of secondary metabolites, biotransformation, elicitors, immobilized cells.
BIO 603: Animal Biotechnology
Overview: Animal biotechnology teaches in depth the different biotechnological principles and technologies used to manipulate animal sciences for the betterment of livestock regarding disease resistance and higher yield etc.

BIO 604: Bioinformatics
Overview: Bioinformatics emphasizes the importance of different computer programs and computational techniques used in biology to solve different problems which requires tremendous labor to solve in-vitro.

BIO 605: Elective
Contents:TBD

BIO 606: Lab-V: Industrial Biotechnology & Genetic Engineering
Overview: This course provides basics pertaining to the different technologies in genetic engineering that are used in different industrial set up for human betterment.

BIO 607: Lab-VI: Plant & Animal Biotechnology
Overview: This gives hands on experience on the different principles and techniques that used in fields of plant and animal biotechnology that are taught in BIO 302 and 303.
SEMESTER IV

BIO 608: Biostatistics
Overview: This course explains the importance of statistics in evaluating the biological results showing the significance of the research work.

BIO 609: Project
Overview: The candidate should submit a dissertation report by the end of the fourth semester in any area relevant to biotechnology, based on original research work carried out in Universities/ Institutes/ Biotechnology related Industries/ Biotechnology related Laboratories and defend their dissertation work.

Electives:
Industrial biotech/ Pharmaceutical and medical biotech, Advanced computational biology, Nanobiotechnology.
### M.S. Cheminformatics and Bioinformatics

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<thead>
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<th>Course Code</th>
<th>Course Title</th>
<th>Contact Hours/Week</th>
<th>Credits</th>
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<td>Cell Molecular Biology &amp; Genetics</td>
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<td>MAT 600</td>
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<td>CHE 512</td>
<td>Molecular Modeling &amp; Dynamics</td>
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<td>Java &amp; RDBMS</td>
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<td>BIO 611</td>
<td>Informatics &amp; Drug Discovery</td>
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<td>BIO 612</td>
<td>Systems Biology, Molecular Network &amp; Molecular Phylogenetics</td>
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</table>
Graduate Course Details

SEMESTER I

1. **BIO 500: Concepts in Biology** (L:T:P 2:0:1; Credits: 3)
   Prerequisites: None
   Course Classification: for students from non-biology streams
   Preamble: This course will enable the students to understand the basic nature and diversity of microbial, plant and animal life with classification of organisms and function.
   Instructors: Jayadev and Seema Sehrawat

2. **BIO 501: Cell Molecular Biology and Genetics** (L:T:P 3:0:1; Credits: 4)
   Prerequisites: None
   Course Classification: Biology Core
   Brief Description: This course will enable students to study the principles of structure and function of cells, membranes, organelles and give understanding of the laws of inheritance and principles of population genetics.
   Instructors: Deepak Sehgal and Seema Sehrawat

3. **BIO 518: Concepts in Bioinformatics** (L:T:P 3:0:1; Credits: 4)
   Prerequisites: None
   Course Classification: Bioinformatics Core
   Brief Description: This course will provide basic understanding of biological databases, sequence analysis and the bioinformatics approaches for the same and applications of algorithms for sequence analysis.
   Instructor: Ashutosh Singh

4. **MAT 600: Basic Tools in Mathematics** (L:T:P 3:0:0; Credits: 3)
   Prerequisites: None
   Course Classification: Mathematics Core
   Brief Description: Give skills in mathematics that are essential for application in Bioinformatics.
   Instructor: Maths Faculty

5. **MAT TBA: Basic Statistical Techniques** (L:T:P 3:0:1; Credits: 4)
   Prerequisites: None
   Course Classification: Statistics Course
   Brief Description: Course include application of Statistical techniques that are essential to process and interpret biological data.
   Course Coordinator: Maths Faculty

6. **BIO 519: Basic Concepts in Programming** (L:T:P 3:0:1; Credits: 4)
   Prerequisites: None
   Course Classification: Programming concepts using PERL
   Brief Description: Give fundamental concepts of computers and networking, operating systems and PERL Programming.
   Course Coordinator: TBA/ Ashutosh Singh
SEMESTER II

7. CHE 512: Molecular Modeling & Dynamics (L:T:P 1:0:1; Credits: 2)
   Prerequisites: None
   Course Classification: Bioinformatics and Cheminformatics Core
   Brief Description: This course will bring much deeper knowledge in Protein modeling and
dynamics study also involve some simulation experiments.
   Course Coordinator: N. Sukumar

8. CHE 501: Medicinal Chemistry (L:T:P 3:0:1; Credits: 4)
   Prerequisites: None
   Course Classification: Chemistry Core
   Brief Description: It deals with the basic medicinal chemistry principals and methods also
involve molecules in therapeutics.
   Course Coordinator: TBA

9. BIO 520: Computational Biology (L:T:P 3:0:1; Credits: 4)
   Prerequisites: Bioinformatics concepts
   Course Classification: Bioinformatics Core
   Brief Description: Algorithms in biology and advanced methods in bioinformatics.
   Course Coordinator: Ashutosh Singh

10. BIO 521: Structure Biology (L:T:P 3:0:1; Credits: 4)
    Prerequisites: None
    Course Classification: Bioinformatics Core
    Brief Description: This will give detailed understanding about protein and nucleic acid
structures and the forces which stabilizes these structures.
    Course Coordinator: Ashutosh Singh

11. BIO 522: Java & RDBMS (L:T:P 3:0:1; Credits: 4)
    Prerequisites: None
    Course Classification: Java and Database
    Brief Description: This will give detailed understanding about programming and database
concepts for biomolecular repository creations.
    Course Coordinator: TBA.

12. BIO 523: R Language (L:T:P 1:0:1; Credits: 2)
    Prerequisites: None
    Course Classification: Bioinformatics Core
    Brief Description: statistical methods and application using R language.
    Course Coordinator: TBA

SEMESTER III

13. BIO 610: Comparative Genomics, Proteomics & Metabolomics (L:T:P 3:0:1; Credits: 4)
    Prerequisites: Basic Molecular Biology and Bioinformatics
    Course Classification: Bioinformatics Core
Brief Description: It will develop basic understanding of advanced methods in Omics technology and role of Bioinformatics in managing high throughput data.
Course Coordinators: Ashutosh Singh and Seema Sehrawat

14. BIO 611: Informatics & Drug Discovery (L:T:P 3:0:1; Credits: 4)
Prerequisites: Bioinformatics Basics
Course Classification: Bioinformatics Core
Brief Description: The course will be majorly discussing Drug Designing principle and Virtual screening methods.
Course Coordinators: Ashutosh Singh and Seema Sehrawat

15. BIO 612: Systems Biology, Molecular Networks & Molecular Phylogenetics (L:T:P 3:0:1; Credits: 4)
Prerequisites: Basic Biology and Bioinformatics
Course Classification: Bioinformatics Core
Brief Description: The course will be focusing on Systems biology as reversed engineering process also discussing Systems engineering and molecular biology, Systems approach in molecular, cellular and developmental biology, Biological network, Hubs, Network motif, random network, scale free network. This course will also enable students to know the process of evolution through Phylogenetics.
Course Coordinator: Ashutosh Singh

16. BIO 613: Project (L:T:P 0:0:6; Credits: 6)
Prerequisites: All Bioinformatics and Cheminformatics courses
Course Classification: Project
Brief Description: This will be a five-month internal project. Students will be allowed to work with the faculty along with the courses and defend the thesis after completion of the project.
Course Coordinator: Project Supervisor

SEMESTER IV

17. BIO 614: Project Dissertation (L:T:P 0:0:12; Credits: 12)
Prerequisites: All courses of Bioinformatics and Cheminformatics
Course Classification: Project
Brief Description: External Project for five months followed by Report, Presentation and Viva voce
Course Coordinator: Project Supervisor

18. BIO 615: Nanotechnology (L:T:P 3:0:0; Credits: 3)
Prerequisites: None
Course Classification: Elective
Brief Description: This would be a special elective on Nanotechnology and will deals with the recent advancement in Nanobiotechnology, Nanotoxicology and other applications.
Course Coordinator: TBA and Seema Sehrawat

19. BIO 616: Spl. Top. Comp. Biology (L:T:P 3:0:0; Credits: 3)
Prerequisites: For Final Year students
Course Classification: Bioinformatics Elective
Brief Description: this will be highly specialized courses students majorly learn by doing hands on experiments and self study on computational biology applications.  
Course Coordinator: TBA

20. CHE TBA: Spl. Top. Comp. Chemistry (L:T:P 3:0:0; Credits: 3)  
Prerequisites: For Final Year students  
Course Classification: Cheminformatics Elective  
Brief Description: this will be highly specialized courses students majorly learn by doing hands on experiments and self study on computational chemistry applications.  
Course Coordinator: TBA
c) **PhD in Life-Sciences**

<table>
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<tr>
<th>Course Code</th>
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<th>Contact hours/week</th>
<th>Credits</th>
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<td>BIO 701</td>
<td>Advanced Molecular &amp; Cellular Biology</td>
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<td>BIO 702</td>
<td>Analytical Methodologies</td>
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<tr>
<td>BIO 703</td>
<td>Cancer &amp; Gene Therapy</td>
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<tr>
<td>BIO 704</td>
<td>Bioinformatics Essentials</td>
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<tr>
<td>BIO 705</td>
<td>Research Methodology</td>
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<td>BIO 706</td>
<td>IPR &amp; Biosafety</td>
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</table>

**Graduate Course Details**

**BIO 701: Advanced Molecular & Cell Biology** (Credits 2)

Coordinator: Jayadev

Conducted by: Deepak Sehgal, Seema Sehrawat and Jayadev

This course delivers the molecular description of cell with advance understanding in biological systems. **Gene Expression**: Bacterial, Yeast, Insect (Baculovirus Expression Vector System), Mammalian and Viral expression systems, **Gene Regulation**: DNA Replication, Transcription, Translation, Protein structure, Modifications, and Signaling pathways; Structure and function of mRNA, tRNA, siRNA, rRNA, micro RNAs, Ribozymes, Inducers and repressors; Structural and functional dynamics of cell and cell organelles and their Structure, Function Biogenesis; Protein aggregation, Protein misfolding and Membrane transport. Cellular immune control, parasitic, bacterial and viral infections; Structural implications of mitochondrial dynamics in apoptosis; Organelle networking and cellular metabolism; nanotechnology applications in Biotechnology.

**BIO 702: Analytical Methodologies** (Credits 2+1)

Coordinator: Deepak Sehgal

Conducted by: Seema Sehrawat, Jayadav, Deepak Sehgal and faculty (TBD)

UV-Visible spectrophotometry, Fluorescence, Absorption and Emission Spectrophotometry, IR, NMR, Lumionometry. Raman and Mass spectrophotometry, MS MS; LC MS, NMR, X-ray Diffraction, Protein synthesizer and analyzer, Nexgen sequencing method.

Chromatography: Basic principles of partition, adsorption, gel filtration, affinity, ion exchange chromatography. Concept of GLC and HPLC.

Vascular permeability analysis: ECIS based permeability analysis on Applied Biosystems ECIS® (Electric Cell-substrate Impedance Sensing) will be discussed. It is basically a real-time, label-free, impedance-based method to study the activities of cells grown in tissue culture. These include morphological changes, cell locomotion, and other behaviors directed by the cell’s cytoskeleton.

Electrophoresis: Gel electrophoresis (gel electrophoresis Agarose), Disc and Gradient electrophoresis, Pulsed field gel electrophoresis, Capillary electrophoresis: Basic principles,

**BIO 703: Cancer & Gene Therapy (Credits 2)**
Coordinator: Seema Sehrawat
Conducted by: Seema Sehrawat, Jayadev
The new cancer biology program seeks to provide training and an integrated community for those students interested in pursuing cancer-related research. The curriculum will emphasize topics relevant to cancer biology, including signaling, basic cell biology, disease pathology, and translational research. Additional activities, including an oncology seminar series and a student data club, will provide opportunities for students to extend their studies and community beyond the classroom and thesis laboratory. The related practical research projects in the fully equipped state-of-the-art laboratory at SNU will examine the molecular and systems basis of cancer including alterations in signal transduction, cell cycle, apoptosis and DNA repair.

**Molecular Mechanisms of Cancer** will also be covered in the coursework. This area will examine the molecular basis of human cancer, including lung, breast, prostate, melanoma and leukemia. Concepts including stem cells, senescence, genomic instability, angiogenesis, oncogenes, tumor suppressors and viruses in human cancer will be examined. What is cancer, Types of cancer, How cancer spreads, Tumor Physiology, Tumor Immunology, Characterization techniques using Cellular and Molecular Biology, Molecular Basis of Cancer, Molecular cancer studies, signaling pathways, Radiobiology Applied to Therapy, Chemotherapy, Gene therapy, Diagnostic Pathology of Cancer, Drug Design and Pharmacology, Cancer Statistics and Epidemiology, Cancer therapies, Post therapy surveillance.

**BIO 704: Bioinformatics Essentials (Credits 2 +1)**
Coordinator: Ashutosh Singh
Conducted by: Ashutosh Singh and Seema Sehrawat
The course is designed for multidisciplinary students to give better understanding in Bioinformatics from concepts to advance methods. It also involves case studies and applications in solving complex biological problems. The chapters covered will be Database searching methodologies, Nucleic acid sequence databases, Protein sequence database, Structure Databases, Pathway databases, Sequence file formats: Various file formats for bio-molecular sequences, Protein and nucleic acid properties: Various tools at the ExPASy server, searching methodologies. Sequence Analysis: Basic concepts of sequence similarity, identity and homology concept, Scoring matrices, Matrices for nucleic acid and proteins sequences Sequence alignment: Pairwise sequence alignment: Basic concepts of sequence alignment, Needleman and Wunsch, Smith and Waterman algorithms for pairwise

**BIO 705: Research Methodology** (3 Credits)
Coordinator: N. Sukumar
Conducted by: N. Sukumar, Deepak Sehgal, Seema Sehrawat, External experts

1. **Quantitative Methods:** This module will deal with Data handling and Data Analysis, the elements of Quantitative Logic, including Hypothesis testing, Weight of Evidence, and Domain of Applicability estimation. **Research Literature:** This part of the course will be conducted as a Journal Club. Each week one student will be expected to read and summarize a research paper from the recent literature in an area outside their immediate domain of research. The student will familiarize himself/herself with the background necessary to understand the research paper, and will be expected to critically analyze the work and to answer questions from other students and from the faculty moderator(s).

2. **Grantsmanship:** This module will deal with identification of a research problem, formulation of a testable hypothesis and design of experiments to address the question. Strategies for writing a fundable research proposal will be discussed, with particular emphasis on the Specific Aims, and succinctly conveying the significance of the problem to both technical and non-technical readership. Students will refine both writing and presentation skills during this module.

3. **Research Seminar:** In this module, faculty members from the department (and possibly beyond) will present seminars about their areas of interest, the proposed research in their respective groups and the experimental (or computational) techniques used in their field. Students will be expected to participate actively in the seminars by asking questions. This module will also serve to introduce new students to the possibilities for research, preparatory to selection of their research advisors.

**BIO 706: IPR & Biosafety** (Credits 2)
Coordinator: Deepak Sehgal
Conducted by: Jayadev, Seema Sehrawat, External experts and Deepak Sehgal

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### III. School of Humanities and Social Sciences

#### 1. **Department of English**

**GRADUATE COURSES**

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<th>Course #</th>
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<th>Core Courses</th>
<th>Elective &amp; Specialization Courses</th>
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M.A. ENGLISH = 60 credits minimum
Ph.D. ENGLISH = 72 credits minimum

CR = Credit only, Status reported of ‘Pass/Fail/Revise’ etc.
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Note: ENG 699 carries a Second Language proficiency requirement at intermediate or advanced level.
Students may take 3 additional courses for 12 credits to earn M.A. by coursework and comprehensive exam

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OR: Students may opt to write a research-based M.A. *Thesis for 12 credits to earn M.A. by thesis & research

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<td>ENG 703</td>
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Ph.D. Field Definition & Exam

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2.
3. **Department of Economics**

**Graduate Course Details**

**ECO 581: Mathematical Methods – Monsoon**

*Reading Materials:*
- D. Gale, Theory of Linear Economic Models.
- R. Sundaram, First Course in Optimization Theory, Cambridge University Press

*Suggested Reference Books, Mathematics:*
- T. Rockafeller, Convex Analysis, Princeton Press.
- W. Novshek, Mathematics for economists, Academic Press
- Hal Varian, Microeconomics, (Various editions) Norton
- Martin, Osborne, A Course in Game Theory, MIT Press
- E. Silberberg, Structure of Economics, (Various editions), McGraw Hill
- B. Binger, Microeconomics with Calculus, Addison Wesley
- A. Dixit, Optimization in Economic Analysis, Oxford Press

*Grading:*
The course grade is based on a midterm and a final each weighted 40% of grade. The remaining 20% of the grade will include assignments and quizzes.

*Course Topic Outline:*
1. Linear Algebra
   - A. Vectors
   - B. Matrices
   - C. Simultaneous Linear Equations
   - D. Characteristic Value and Vectors
2. Parameterized optimization: Concave Case
   - A. Unconstrained Optimization
   - B. Constrained Optimization with Equality constraints; and Classical Lagrangians Method
   - C. Concave Programming and KKT theory
   - D. Applications
3. Parameterized optimization: Quasi-Concave Case
   - A. Quasi concave Programming
   - B. Envelope Theorems
   - C. Applications

**ECO 582: Dynamic Programming – Spring**

*Course Outline:*

1. A Typical Problem
2. A Deterministic Finite Horizon Problem
   2.1) Finding necessary conditions
   2.2) A special case
   2.3) Recursive solution
3. A Deterministic Infinite Horizon Problem
   3.1) Recursive formulation
   3.2) Envelope theorem
   3.3) A special case
3.4) An analytical solution
3.5) Solution by conjecture
3.6) Solution by iteration

(4) A Stochastic Problem
4.1) Introducing uncertainty
4.2) Our special case again
4.3) Finding distributions

Reference:

Grading:
The course grade is based on a midterm and a final each weighted 40% of grade. The remaining 20% of the grade will include assignments and quizzes.

ECO 521: Econometrics I
Instructor: Nishant Chadha, Office: SF A2, Email: nishant.chadha@snu.edu.in
Office hours: TBD in first class

Course Description:
This is the first course in the graduate econometrics sequence at SNU. It aims at providing the students with an overview of the powerful statistical tools that appear in modern econometric and applied economics literature. The students will be introduced to probability theory, matrix algebra, conditional expectations and related concepts in econometrics and basic asymptotic theory before we move on to the discussion of the work horse of modern econometrics: the static linear regression model. We may briefly discuss extensions to dynamic and non-linear models and simultaneous equations. Estimation and testing methods discussed will include those based on ordinary least squares (OLS), generalized least squares (GLS), generalized method of moments (GMM) and instrumental variables (IV), and maximum likelihood (ML).

The students are assumed to be familiar with basic concepts in linear algebra, basic statistics and multivariate calculus. Some training in undergraduate econometrics may be useful but not required.

Textbooks and reference:
Wooldridge, Jeffery M. (2001): *Econometric analysis of cross section and panel data*
Bruce Hansen’s Notes on Econometrics available online at [www.ssc.wisc.edu/~bhansen/econometrics](http://www.ssc.wisc.edu/~bhansen/econometrics)

Evaluation: Assignments (20%), Mid-term examination (35%), Final examination (45%)

Course Outline:
1. Basic probability theory and matrix algebra
2. Conditional expectations
3. Basic asymptotic theory - Convergence in probability, convergence in distribution, delta method, laws of large numbers, central limit theorems.
4. Simple linear regression model and Ordinary Least Squares estimation
5. Statistical inference, hypothesis testing and confidence intervals
6. Generalized least squares
7. Endogeneity and Instrumental variables estimation
8. Generalized Methods of Moments
9. Maximum likelihood
ECO 522: Econometrics II

Instructor: Nishant Chadha, Office: SF A2, Email: nishant.chadha@snu.edu.in
Office hours: TBD in first class

Course Description
This is the second course in the graduate econometrics sequence at SNU. We build on the first course in Econometrics to gain an understanding of the use of econometric tools in applied economic literature. Topics covered will include panel data models, heterogeneous average treatment effects, the econometrics of randomized control trials, discrete choice models, censored regression models and quantile regressions. A brief introduction to semi parametric methods will also be provided.

Prerequisites: Econometrics I

Textbooks and references:
Wooldridge, Jeffery M. (2001), *Econometric analysis of cross section and panel data*
Cameron, C. and P. Trivedi (2005), *Microeconometrics*
Angrist, Joshua D and Pischke, J. *Mostly harmless econometrics: An empiricist’s companion.*
Bruce Hansen’s Notes on Econometrics available online at [www.ssc.wisc.edu/~bhansen/econometrics](http://www.ssc.wisc.edu/~bhansen/econometrics)

Evaluation: TBD

Course Outline:
1. Topics in single equation estimation
2. Panel data models – the linear panel data model, basic linear unobserved effects panel data models, additional topics in linear panel data models.
3. Estimating average treatment effects.
4. Experiments and the econometrics of randomized control trials.
5. Discrete response models
6. Censored regression models
7. Quantile regression
8. Semi-parametric methods

ECO 511: Macroeconomics I -- Monsoon

Course Outline
(1) Dynamic Programming under Certainty
   Bounded Returns
   Unbounded Returns
(2) Applications of Dynamic Programming under Certainty
   One Sector Model of Optimal Growth
   Optimal Growth with Linear Utilities
   Human Capital Accumulation
   Investment with Convex Cost
   Recursive Preference
(3) Dynamic Programming under Uncertainty
   Bounded Returns
   Unbounded Returns
(4) Applications of Dynamic Programming under Uncertainty
   One Sector Model of Optimal Growth
   Optimal Growth with Two Capital goods
Optimal Growth with Many Capital goods

References
Methods of Macroeconomic Dynamics by S.J. Turnovsky.
Recursive Macroeconomic Theory L.Lungqvist, Lars and Thomas J. Sargent

Grading
The course grade is based on a midterm and a final each weighted 40% of grade. The remaining 20% of the grade will include assignments and quizzes.

ECO 512: Macroeconomics II -- Spring
Course Overview
This course starts with an introduction to modern inter-temporal macroeconomics using techniques of dynamic optimization, and then ventures into the ‘recently’ developed areas in macroeconomics: real Business Cycles and New Keynesian Macroeconomics.

Books:

Topics to be covered:
A. Expectations Formation and Macroeconomic Dynamics
The Adaptive and Rational Expectations Hypotheses, Forward and Backward-Looking Solutions, the Cagan Monetary Model.
• Turnovsky (Chapter 3)

B. Representative Agent Model
1. Basic Infinite Horizon Model
• Blanchard and Fischer, Chapter 2.
• Turnovsky, Chapter 8.

2. Overlapping Generations Model
• Blanchard and Fischer, Chapter 3.
3. Fiscal and Monetary Policy in Basic Intertemporal Model
   - Turnovsky, Chapters 9 and 10.

4. Optimal Policy in Basic Intertemporal Model
   - Turnovsky, Chapter 11.
   - L. Ljungqvist and T.J. Sargent, Recursive Macroeconomic Theory, Chapter 12.

C. The Real Business Cycle Model
   - L. Lungqvist, Lars and Thomas J. Sargent, Ch. 12.

D. The New Keynesian Model
   - Walsh, Chapter 5.4,11

ECO 501: Microeconomics I – Monsoon
Instructor: Shubhro Bhattacharya (Office: SF A12. Office hours: TBD)
Course Description: Microeconomics I is the first course on microeconomics offered to masters students. This course is designed to provide a solid analytical foundation of microeconomic theory. We begin with some real analysis concepts that is barely essential to the analysis. Following closely the textbook (MWG), the course will mainly focus on classical demand theory, theory of firm and choice under uncertainty.
Evaluation: Assignments (20%), Midterm(40%), Final (40%).
Topics: Basic Real analysis
Preferences and Choice
Consumer Choice
Classical demand Theory
Aggregate Demand
Production Theory
Choice under Uncertainty

45
Special Topics.

**ECO 502: Microeconomics II – Spring**

*Instructor:* Shubhro Bhattacharya  

*Course Description:* This is an advanced course on microeconomics that mainly focuses on the theory of general equilibrium. We begin by analyzing equilibrium in a pure exchange economy. Then, we introduce production and prove the fundamental theorems of welfare economics. Next, we turn our attention to the existence of equilibrium and the core. Finally, we study the general equilibrium under uncertainty and some special topics.  

*Evaluation:* TBD  


*Topics:*  
Equilibrium in a Pure Exchange Economy  
Equilibrium and Its Welfare Properties  
Existence and Uniqueness of Walrasian Equilibrium  
Core and Equilibria  
General Equilibrium under Uncertainty  
Special Topics

**ECO 531: Political Economy (Course Coordinator: Nishant Chadha) -- Year II, 2013-14**  

The first part of this course will deal with collective choice and political institutions. We will analyze political institutions from a rational choice perspective. The chief focus will be on voting models and understanding the equilibria in different models with differing assumptions and will cover elections, legislatures, juries etc. Some amount of time will also be spent on the agency model of politics and the disciplining role of elections. The second part will deal with interactions between profit-maximizing firms and a vast class of non-market agents, such as governments, political, legal and regulatory institutions. Topics covered can include analysis of economic and political institutions, economic policy, lobbying and special interest activity.  
An attempt will be made to relate the ideas from the literature on the above topics to the Indian context, specially the interaction between typical features of Indian society (caste and religious divisions) and institutions of democracy.

**ECO 532: Economic Development: Issues and Policy Models (Course Coordinator: Nishant Chadha) -- Year II**  

This course will explore the issues facing poor economic agents living in developing countries. We will begin with a brief discussion of how to measure poverty and then try to understand reasons for the existence of poverty. Topics covered will be drawn from productivity effects of health, private and social returns to education, education quality, education policy and market equilibrium, gender discrimination, public finance, decision making within families, firms and contracts, technology, labor and migration, land, and the markets for credit and savings and maybe some questions in political economy. The second part of this course will deal with issues in policy making in developing countries. The goal is to spell out various policy options and to quantify the trade-offs between them. Some of the questions the course will deal with include: What determines the decisions of poor households in developing countries? What constraints are they subject to? Is there a scope
for policy (by government, international organizations, or non-governmental organizations (NGOs))? What policies have been tried out? Have they been successful?

**ECO 541: Fundamentals of Environmental Economics (Course Coordinator: Ashokankur Datta) -- Year II**
The fundamental theorem of welfare economics tells us that, under ‘certain conditions’, a market system can solve the problem of efficient allocation of resources. However the absence of these conditions often characterizes mankind's interaction with the natural/ bio-physical world. Environmental Economics borrows tools from various sub-disciplines of economics, namely public economics, economics of information, industrial organization, to analyze human interaction with the bio-physical world. It tries to locate the source of environmental problems and suggests instruments to deal with it. In each section of this course, the first few readings will introduce the students with the theoretical aspects of the problem being discussed. This will be followed by empirical studies that will analyze these issues at a specific geographical setting.

**ECO 542: Environment and Development (Course Coordinator: Ashokankur Datta) -- Year II**
Environmentalism in the west is to a large extent a post-materialist phenomenon. However, in developing countries, which depend heavily on natural resources, environmental concerns share space with concerns about industrial progress, poverty removal, social justice etc. Moreover, most of these countries have weak institutions to tackle these problems. Thus traditional theories of environmental economics have to be adapted to understand the complexities of environmental problems in the developing world. These ‘adapted’ theories provide sophisticated explanations for environmental problems compared to superficial explanations of over-population and excessive consumption. This course deals with few important environmental issues of the developing world and makes use of basic economic theory and econometrics to understand the problems and formulate policies to deal with them.

**ECO 543: Law and Economics (Course Coordinator: Suchismita Tarafdar) -- Year II**
The objective of this course is to introduce the economic approach to the analysis of law. This approach confronts challenges by seeking to identify how best to design legal rules in order to maximize social welfare. To do so, we will ask: (1) How do legal rules affect the behavior of individuals and of organizations? (2) How do legal rules compare to each other, in terms of promoting overall social welfare? The principles of law and economics also take into account considerations such as discrimination and unequal wealth distribution in evaluating what is best for society. We will examine applications of to tort, property, contract, criminal law and intellectual property rights, among others.

**ECO 551: Theory of Corporate Finance (Course Coordinator: Shubhashis Gangopadhyay) -- Year II**
This course starts with how agency costs affect the Modigliani-Miller theorem. Starting with moral hazard, the course develops the tension between management and investors before distinguishing debt and other instruments of investment. It goes on to develop models under adverse selection and how markets read signals sent out by managers. Topics covered will include borrowing capacity, credit rationing, the pecking order theory, liquidity management,
debt as a disciplining device, and the interaction between the structure of the product market and financial decisions.

ECO 563: Social Choice (Course Coordinator: Suchismita Tarafdar) -- Year II
Social choice theory primarily concentrates on the incentives that voters face under alternative voting arrangements. Conflicts naturally occur, and so there must be methods to resolve these conflicts. Voting is considered to be the democratic way to proceed. This involves selecting representatives or specific proposals. However more often than not, it might be the case that the entire group does not agree. How should one proceed in this case? There are various voting rules to address the conflict. In this course these different voting rules, with different implications both in terms of individual voting incentives and aggregation to group decisions will be considered. We also determine how well these different voting rules lead to outcomes which best represent the desires of the group members. Unfortunately, group members as voters may not reveal their true preferences if they determine that voting differently would better their chance for a more preferred outcome. Voting rules will therefore be considered for their impact on voting incentives, by making comparisons under "sincere" versus "strategic" voting.

ECO 571: Public Economics (Course Coordinator: Shubhro Bhattacharya) -- Year II
Course Outline: The objective of this course is to present a broad range of topics in modern public economics to graduate students. The traditional issues of externalities and public good will provide the foundation of this course. There will be a detailed treatment of topics such as taxation, public sector pricing, and investment. This course will also introduce the students to the latest development in this area, namely economics of institutions and efficient government intervention.