INDIAN INSTITUTE OF TECHNOLOGY INDORE

PG Courses of Study

July, 2012

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Rules and Regulations of PhD program at IIT Indore

In general, IIT Indore follows **Rules, Regulations, Guidelines, and Conventions of PhD programme of its mentor IIT i.e. IIT Bombay** (June 2011 undated version is available at the following web-link). Some deviations are detailed in the following paragraphs.

http://www.iitb.ac.in/newacadhome/rules/RulesforPh.D.201128june.pdf

1. **Teaching Assistantship (TA) Work:** ALL the Full-time PhD students irrespective of their category of admission (i.e. **MHRD/Institute TA, external agency Fellowship Awardees (FA) / Sponsored (SW) / Self Finance (SF)** have to do Teaching Assistantship (TA) duties assigned by the Institute or Competent Authority **to the extent of 8-12 hours of work per week**.

   Under the TA duties, a PhD student is supposed to assist the concerned faculty member (to be known as TA Supervisor) in the academic work related to conducting of practical classes, tutorial classes, preparing assignments/tutorials and their solutions, invigilation duties, etc. and the other academic work assigned by the concern TA Supervisor or the Competent authority.

   TA **must NOT** be assigned **confidential work** such as setting up question papers of different examinations and quizzes, final evaluation of answer sheets of different exams, and finalizing the grades, etc. Under no circumstances,

   TAs **cannot** be assigned the duties of taking lecture classes of any course.

   Monthly release of PhD scholarship/Fellowship requires submission of TA work report the specified format duly signed the TA Supervisor and Thesis supervisor or Faculty Advisor.

2. **RA Category Students:** The PhD students admitted under the category of **Research Assistantship (RA)** are **part-time students** and each Department/Centre/School may induct one Research Assistant every year. These RAs have to look after the laboratories and also assist in teaching or research or other work assigned by the Head of the Department/Centre/School or Convener, inter-disciplinary program (IDP). They are required to work for about **08-12 hours a week**. **They have to complete the Ph.D. Programme in five/six years,** depending on their qualifying degrees.

3. **Release of PhD Scholarship/Fellowship:** Each PhD student must come to the Institute daily unless he/she has been sanctioned some entitled leave or is sick. Each PhD student has to sign an attendance register daily during the specified time kept in the office of the concerned Discipline/ School/ institute.

   The scholarship/fellowship of the PhD students admitted under different category shall be processed for payment on the monthly basis by the respective Head of Schools only after receiving a report in the preconcerned TA supervisor and/or thesis supervisor/advisor duly signed by him/her (as the case may be).

4. **PhD Course Credit Requirements:** The minimum and maximum number of courses and credits for the different categories will be as follows.

   In addition to the course requirements mentioned below, each PhD student has to do a **compulsory** course on **English Language Communication (pass or no pass course) within its first year of joining the PhD program.**

   Category I: PhD students with **M.Tech./M.Phil. Or equivalent qualification** shall do 2-3 PG level courses of at least 3 credits each and 1 PhD seminar course of at least 2 credits.

   Minimum number of courses will be 2 PG level courses and one PhD seminar course (i.e. *(minimum coursework of 8 credits)*.

   Category II: PhD students having **M.Sc./M.A/M.Com./M.B.A. or equivalent qualification** admitted to a **Science or HSS discipline** shall do 5-7 courses of at least 3 credits each and 1-2 PhD seminar courses at least 2 credits each.

   Minimum number of courses will be 5 PG level courses and one PhD seminar course *(minimum coursework of 17 credits).*

   Category III: PhD students having **B.Tech. /M.Sc. or equivalent qualification** admitted to Ph.D. programme in an **Engineering discipline** shall do 6-8 courses of at least 3 credits each and 1-2 PhD Seminar courses of at least 2 credits each. .

   Minimum number of courses will be 6 PG level courses and one PhD seminar course *(minimum coursework of 20 credits).*

5. **Duration of PhD Coursework:** All the Ph.D. students are required to do course work, which shall normally be completed:

   (a) Within **one semester** from the date of joining by the students having **M.Tech./M.Phil. Or equivalent qualification**.
   (b) Within the **first two semesters** from the date of joining by the students having **B.Tech. /M.Sc. /M.A. / M.Com. / M.B.A. or equivalent qualification**
   (c) All the PhD students MUST complete their course under normal circumstances **maximum work within ONE year** of joining the PhD program.
   (d) For any variation other than the requirements mentioned in (a)-(c), **permission from the Institute Post Graduate Committee (IPGC)** will be required which will consider the recommendations of the School Post Graduate Committee (SPGC) while deciding on the matter.

6. **Minimum CPI requirement:** Each PhD student must maintain a minimum CPI of 6.0 at the end of each semester. Below this CPI, the PhD student will be placed on **Academic Probation** (AP) which is one time exercise during the entire duration of the PhD programme with maximum deduction of PhD Scholarship up to 50%.

   During Academic Probation, the PhD student must secure a CPI of 6.0 for continuation in the PhD programme. In this regard, all PhD Rules and Conventions of IIT Bombay will be applicable and will be followed.

7. **Confirmation of Registration for PhD Degree:** PhD students shall be granted **Confirmation of Registration for the PhD degree** from the first working day of the

semester following the one in which they have successfully completed the required course work.

8. **Selection of Thesis Supervisor:** A PhD student will formally select his/her thesis supervisor(s) either within **ONE semester** of joining the PhD programme or after completing the **required course-work**.

   One thesis supervisor will be from the discipline/department and other supervisor(s) can be taken from within/outside the department/institute. **Maximum number of thesis supervisors** should NOT be more than **three** under normal circumstances.

   Till a PhD student finally and formally selects his/her PhD thesis supervisor, the concerned *Head of the School* (HOS) shall be the Faculty Adviser to that PhD student

9. **Constitution of PhD Student's Progress Committee (PSPC):** Progress of thesis work of each PhD student will be monitored through a committee called **PhD Student's Progress Committee (PSPC)**.

   Composition of PSPC: The PSPC will consist of the thesis supervisor(s), one faculty within the discipline/ department/ and one faculty/expert outside the discipline/department. One of the thesis supervisors will be Convener of the PSPC.

   The processes of constitution the PSPC can be initiated by a PhD student once the Thesis Supervisor(s) is (are) finalized. The composition of the PSPC is to suggest to the respective SPGC and based up on recommendations of the SPGC, it is to be finally approved by IPGC and to be notified by the Academic Office.

10. **Finalization of the PhD thesis Topic:** Once the thesis topic of a PhD student is decided then it should be brought to IPGC for formal approval and institute-wide circulation to avoid the duplication of the thesis work.

11. **Monitoring the Progress of the PhD Student:** The PSPC will monitor the progress of the thesis work of the PhD student **annually** through a **Research Progress Seminar (RPS)**.

    The **first RPS** is to be conducted after completing one year of joining the PhD programme.

    Based on the RPS, the PSPC will evaluate the progress of the work of the PhD student in terms of satisfactory or unsatisfactory. The progress report duly signed by the PSPC members must be submitted to the Academic Office for further action latest by **31st July** for the PhD students registered in the PhD programme in the **Autumn semester** and by **31st January for** the PhD students registered in the PhD programme in the **Spring Semester** admission and**.**

    In case the RPS report of a PhD student is found **unsatisfactory** then he/she will have to make another RPS before the PSPC within maximum THREE months of the corresponding RPS. The second time RPS must be satisfactory; if it is still unsatisfactory then the matter must be reported to IPGC for the further action.

    If required, the thesis supervisor(s) may arrange additional RPS between two consecutive RPS

12. **Eligibility for PhD Thesis Submission,** A PhD student will be eligible to submit the PhD thesis ONLY after

    He/she has **at least TWO publications** in the **peer reviewed Journals/International Conferences**

    OR

    Has been granted a Patent for his/her research work done in the PhD programme.

    OR

    Has made significant contribution in the development/dissemination of Science/Technology/Art.

13. **Minimum and Maximum Time for PhD Thesis Submission: Minimum time period** for submission of PhD thesis will be of TWO years under **Category-I** and TWO and HALF years under **Category-II** and **Category-III** from the **Confirmation of Registration for the PhD degree**.

    Maximum time period for submitting the PhD thesis will be **FIVE years** from the admission in to the PhD program. Request for further extension beyond the maximum duration must be sent to the IPGC.

14. **Course code for PhD Seminar Course and PhD Thesis:** The codes for the PhD Seminar course will be **XX 797** (for the autumn semester) and **XX 798** (for the spring semester) while, the **code of the PhD thesis** will be **XX 899**, where XX is the departmental code (i.e. CS, EE, ME, HS, CH, MA, PH).

Syllabi of Computer Science and Engineering Courses

Course Structure for PhD Programme in Computer Science and Engineering

(A) Semester-I (autumn / spring)

Sr. No.	Course code	Course Name (L-T-P-Credits)	Type (Core/Elective)
1	CS 701	Selected Topics in Advanced Algorithms (3-0-0-3)	Core
2	ZZ xxx	Elective-I	Elective
3	ZZ xxx	Elective-II +	Elective
4	CS 797* / CS 798*	Ph.D. Seminar Course (0-2-0-2)	Core

(B) Semester-II (spring / autumn)

Sr. No.	Course code	Course Name (L-T-P-Credits)	Type (Core/Elective)
1	ZZ xxx	Elective - III +	Elective
2	ZZ xxx	Elective - IV +	Elective
3	CS 798* / CS 797*	Ph.D. Seminar Course (0-2-0-2)	Core

Computer Science & Engineering courses for Elective

CS 617: Cryptography and Network Security

For rest elective courses, the student should choose any PG-level course from other disciplines/schools in consultation with thesis supervisor/faculty advisor and the concerned course coordinator.

Note:

+ Additional elective course to be taken by the students with BTech/BE/MSc qualification only.

* Depending upon the semester of admission (CS 797 for Autumn Semester and CS 798 for the Spring Semester).

Core courses are compulsory.

1.	Course Code	**CS 617**
2.	Title of the Course	**Cryptography and Network Security**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Discipline/Department	Computer Science and Engineering
5.	Pre–requisite, if any (for the students)	Discrete Mathematical Structures, Design and Analysis of Algorithms, Computer Networks
6.	Objectives of the Course	To understand the basic concepts of cryptography, get familiarized with encryption and authentication protocols and look at system level security. We will study block ciphers, stream ciphers, hash functions and public key cryptography and security mechanisms in networks and Internet. In the process we will learn some number theory and algebra.
7.	Course Syllabus	**Introduction:** What is cryptography, classical ciphers, cryptanalysis. **Shannon's theory:** Concept of perfect secrecy, entropy **Symmetric-key Cryptography:** Pseudorandomness, Stream ciphers, Block ciphers, Data Encryption Standards, Advanced Encryption Standards, Modes of operation **Hash-functions:** Data Integrity, Merkle-Damgard construction, Message Authentication Codes **Number Theory:** Euclidean Algorithm, Chinese Remainder Theorem, Primality Testing algorithms, Factoring algorithms **Public-key Cryptography:** RSA, Discrete log problem, Diffie-Hellman key exchange protocol, Signatures schemes Public key Infrastructure, Digital certificates **Network Security:** Network security at application,Security issues in electronic mail, IP Security, Web security, transport layer security and Secure Socket Layer, intrusion detection, malicious software, viruses, worms and related threats, firewalls, trusted systems.
8.	Suggested Books	**Suggested Textbook:** 1. D. R. Stinson: Cryptography theory and practices, 3rd Edition, CRC Press, (2006) 2. W. Stalling: Cryptography and Network security Principles and Practices, 4th or 5th Edition PHI, 2006/2010 **Other References:** 3. A. Menezes, P. Oorschot, S. Vanstone: Handbook of Applied Cryptography 4. (individual chapters are freely available online at http://www.cacr.math.uwaterloo.ca/hac/) 5. J. Katz and Y. Lindell: Introduction to Modern Cryptography. Chapman & Hall/CRC 2008 6. S. Singh: The Code Book. (A good popular introduction to the subject) 7. Other web resources will be posted on the course website from time to time.

1.	Course Code	**CS 701**
2.	Title of the Course	**Selected Topics in Advanced Algorithms**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Computer Science & Engineering
5.	Pre–requisite, if any	Courses on Automata Theory and Logic, Design and Analysis of Algorithms & associated lab, Artificial Intelligence & associated lab, and Parallel Computing & associated lab
6.	Course Syllabus	**Complexity:** Turing Complexity. Computationally hard problems. Polynomial Reducibility and its implications for algorithm design. **Data Structures and Algorithm Design:** Data Structure oriented algorithm design. Data structures for computationally hard problems. Software design, implementation and testing for selected computationally hard problems. **Parallel Algorithms:** Data structures and algorithms for parallel computing models like MPI and OpenMP. **Examples and applications** of the above methods for a few selected recent problems.
7.	Suggested Books	1. D. E. Knuth, **The Art of Computer Programming**, Vol. 1 and 3, (2nd Edition), Addison-Wesley, 1998. 2. J.E. Hop croft, R. Motwani, and J. D. Ullman, **Introduction to Automata Theory**, Languages and Computation, Pearson Education Asia, 2006. 3. H.R. Lewis, and C.H.Papadimitrou, **Elements of the Theory of Computation**, Prentice Hall Inc, 1981. 4. T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, **Introduction to Algorithms**, (2nd Edition), Prentice Hall India, 2002.

1.	Course Code	**CS 797 (Autumn Semester)** **CS 798 (Spring Semester)**
2.	Title of the Course	**Seminar Course**
3.	Credit Structure	L-T-P-Credits 0-2-0-2
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	None
6.	Course Syllabus	In this course a PhD student has to present seminar/presentation or a series of presentations on a topic(s) chosen by him/her in consultation with his/her PhD Thesis Supervisor/ Faculty Advisor. The frequency of seminar/presentation will be decided by the Course Coordinator.
7.	Textbook	None
8.	Other references	Books and research publications in various relevant journals.

Syllabi of Electrical Engineering Courses

Course Structure for PhD program in Electrical Engineering

(A) Semester-I (Autumn/Spring)

Sr. No.	Course code	Course Name (L-T-P-Credits)	Type (Core/Elective)
1	ZZ xxx	Elective-I	Elective
2	ZZ xxx	Elective-II	Elective
3	ZZ xxx	Elective-III +	Elective
4	EE 797 * / EE 798*	Seminar Course (0-2-0-2)	Core

(B) Semester-II (Spring/Autumn)

Sr. No.	Course code	Course Name (L-T-P-Credits)	Type (Core/Elective)
1	ZZ xxx	Elective-IV +	Elective
2	ZZ xxx	Elective-V +	Elective
3	ZZ xxx	Elective-VI +	Elective
4	EE 798 * / EE 797*	Seminar Course (0-2-0-2)	Core

Electrical Engineering courses for Electives-I to VI

EE 601: Power Electronics (3-0-0-3)
EE 607: Power System Operation and Control
EE 619: Biomedical Optics (3-0-0-3)
EE 620: IC Fabrication Technology (3-0-0-3)
EE 621: MOS Devices & Modeling (3-0-0-3)
EE 622: Digital Circuit Design (3-0-0-3)
EE 623: Introduction to VLSI Design (3-0-0-3)
EE 626: MOSFET Reliability Issues (3-0-0-3)
EE 627: Fundamentals of Analog CMOS IC Design (3-0-0-3)
EE 628: Advanced Memory Technology (3-0-0-3)
EE 629: Nanotechnology and Nanoelectronics (3-0-0-3)
EE 631: Organic Electronics
EE 641: Advanced Signal Processing (3-0-0-3)
EE 643: Detection and Estimation Theory
EE 701: Time-Frequency Analysis (3-0-0-3)
EE 722: Optoelectronics (3-0-0-3)
EE 724: Advanced Micro-processes and Nanotechnology (3-0-0-3)
EE 740: Speech Signal processing (3-0-0-3)
EE 742: MIMO Wireless Communications

Note:
+ Additional elective course to be taken by the students with BTech/BE/MSc qualification only.

* Depending upon the semester of admission (EE 797 for Autumn Semester and EE 798 for the Spring Semester).
Core courses are compulsory.

1.	Course Code	**EE 601**
2.	Title of the Course	**Power Electronics**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any (for the students)	Power electronics at UG level
6.	Course Syllabus	Power Switches: BJT, MOSFET, IGBT, SCR and GTO characteristics, control and protection. Electromagnetic components: Design of Inductor and Transformers. Review of Line Commutated Converters. Switched Mode Rectifiers: Circuits and Techniques. DC-DC converters: steady state analysis and dynamic modeling of DC-DC converters. Voltage Source Inverters: Single Phase Inverters, Three Phase Inverters, Multilevel Inverters, PWM strategies for Inverters. Current Source Inverters: Single phase and three phase circuit configuration. Overview of modeling and simulation of power electronic converters
7.	Suggested Books	1. N.Mohan, T.M. Undeland & W.P.Robbins, Power Electronics: Converter, Applications & Design, John Wiley & Sons, 2007. 2. Umanand L, Power Electronics: Essentials and Applications, Wiley India, 2009. 3. Erickson, R.W. and Maksimovic, D., Fundamentals of Power Electronics, 2nd Edition, Kluwer Academic Publishers, 2002. 4. Patil M.B., Ramanarayanan V., Ranganathan, V.T., Simulation of Power Electronic Circuits, Narosa Publishers, 2009

1.	Course Code	**EE 607**
2.	Title of the Course	**Power System Operation and Control**
3.	Credit Structure	L-T- P-Credits 3-0-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	Power Systems at UG level
6.	Objectives of the Course	
7.	Course Syllabus	Overview of power system operations and control, load flow analysis, security analysis, stability analysis, automatic generation control, state estimation, brief introduction to power system restructuring and power market operations.
8.	Suggested Books	1. A. J. Wood and B. F. Wollenberg, **Power generation, Operation and Control,** 2nd ed., New York: John Wiley and Sons, 1996. 2. Prabha Kundur, **Power System Stability and Control,** 1st edition, Tata Mcgraw Hill Education Private Limited, 2006. 3. Loi Lei Lai, **Power System Restructuring and Deregulation: Trading, Performance and Information Technology,** John Wiley & Sons, 2001.

1.	Course Code	**EE 619**
2.	Title of the Course	**Biomedical Optics**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Discipline/Department	Electrical Engineering
5.	Pre–requisite, if any (for the students)	Fundamentals of Electromagnetic wave theory and optics
6.	Course Syllabus	**Introduction to tissue engineering:** Cells as therapeutic agents, cellular fate processes, cell differentiation, cell division, cell death/apoptosis, Types of tissues and their functions, tumors and cancers Interaction of light with cells and tissues, spectroscopy, optical biopsy, optics of blood, tissue phantoms, absorption and fluorescence spectroscopy **Bioimaging:** Transmission microscopy, Phase contrast Microscopy, Fluorescence Microscopy, Multiphoton Microscopy, Optical Coherence Tomorgaphy. **Optical Biosensors:** Principles of optical biosensing, Fiber-optic biosensors, Interferometric biosensors, Surface Plasmon Resonance biosensors Case studies of cellular and biomolecular imaging
7.	Suggested Books	**Text Books** 1. Valery V. Tuchin, Handbook of Optical Biomedical Diagnostics, Kluwer Academic Publishers, 2004, ISBN: 1402075766 2. Paras N Prasad, Introduction to Biophotonics, John Wiley and Sons, 2003, ISBN: 9780471287704. **Reference Books** 1. M.H. Niemz, Laser-Tissue Interactions: Fundamental and Applications (Biological and Medical Physics, Biomedical Engineering), Springer, 2007, ISBN: 978-3540721918. 2. R.W. Waynant, Lasers in Medicine, CRC Press, 2002, ISBN: 0-8493-1146-2. 3. Bernhard O. Palsson, Tissue Engineering, CRC Press 2003.

1.	Course Code	**EE 620**
2.	Title of the Course	**IC Fabrication Technology**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any (for the students)	
6.	Course Syllabus	**Introduction** to microelectronic fabrication **Semiconductor substrate:** Phase diagram and solid solubility, Crystal structure, Crystal defects, Crystal growth **Diffusion:** Atomistic models of diffusion, Analytic solutions of Fick's law, Diffusion coefficients, Two step diffusion, Diffusion system **Thermal Oxidation:** The Deal-Grove model, The initial oxidation, Oxide characterization, Oxidation induced stacking faults, Oxidation systems **Ion implantation:** Ion implantation system, Vertical projected range, Channeling effect, Implantation damage, Problems and concerns **Optical lithography:** Overview, Source systems, Contact/proximity printers. Projection printers, Alignment **Photo resist:** Contrast curves, Applying and developing photo resist **Etching:** Wet etching, Plasma etching, Ion milling, Reactive ion etching, Liftoff **Chemical Vapor Deposition:** CVD system, Advanced CVD systems, **Epitaxial growth:** Wafer cleaning and native oxide removal, The thermal dynamics, Surface reactions, Do pants, Defects in epitaxial growth, MOCVD, MBE and CBE **Contacts and metallization:** Junction and oxide isolation, Si on insulator, Schottky and Ohmic contacts, Multilevel metallization **CMOS technologies:** Device behavior, Basic 3 μm technologies, Device scaling **Circuit Manufacturing:** Yield, Particle control, Design of experiments, Computer integrated manufacturing
7.	Suggested Books	1. Stephen A. Campbell, *The Science and Engineering of Microelectronic Fabrication*, 2nd edition (Oxford University Press, 2001) 2. Sorab K. Gandhi, *VLSI Fabrication Principles, Second Edition* (John Wiley & Sons, Inc., 1994)

1.	Course Code	**EE 621**
2.	Title of the Course	**MOS Devices & Modeling**
3.	Credit Structure	L-T- P-Credits 3-0-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any (for the students)	Knowledge of basic physics of diodes, BJTs, FETs, MOS structure. Semiconductors, Junctions and MOSFET
6.	Course Syllabus	**Overview:** Introduction, Semiconductors, Conduction, Contact Potentials, P-N Junction, Overview of the MOS Transistor. **Two Terminal MOS Structure:** Flat-band voltage, Potential balance & charge balance, Effect of Gate-substrate voltage on surface condition, Inversion, Small signal capacitance; **Three Terminal MOS Structure:** Contacting the inversion layer, Body effect, Regions of inversion, Pinch-of f voltage. **Four Terminal MOS Transistor :** Transistor regions of operation, general charge sheet models , regions of inversion in terms of terminal voltage, strong inversion, weak inversion, moderate inversion, interpolation models , effective mobility, temperature effects, breakdown p-channel MOS FET, enhancement and depletion type, model parameter values , model accuracy etc. **Small dimension effects:** channel length modulation, barrier lowering, two dimensional charge sharing and threshold voltage, punch- through, carrier velocity saturation, hot carrier effect s, scaling, and effect s of surf ace and drain series resistance, effects due to thin oxides and high doping. Sub threshold regions, Advanced SOI structures. **CMOS Device Design**: Scaling, Threshold voltage, MOSFET channel length.
7.	Suggested Books	**Text:** 1. Fundamentals of Modern VLSI Devices by Yuan Taur & Tak H. Ning (Cambridge) 2. The MOS Transistor (second edition) Yannis Tisividi s (Oxford) **Reference:** 1. B.G. Streetman, Solid State Electronics Devices, Prentice Hall of India, New Delhi. 2. D.A. Neaman, Semiconductor Physics and Devices, McGraw-Hill.

1.	Course Code	**EE 622**
2.	Title of the Course	**Digital Circuit Design**
3.	Credit Structure	L-T- P-Credits 3-0-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any (for the students)	MOS Transistor theory and CMOS Circuit Design
6.	Course Syllabus	**Module 1:** MOS scaling, Short channel effects, MOSFET models, Nano CMOS, Effects of gate oxide tunnelling, high-k dielectrics, Advanced CMOS structures, SOI, MOSFET capacitances, MOSFET models for calculation-Transistors and Layout, CMOS layout elements, SPICE simulation of MOSFET I-V characteristics and parameter extraction. **Module 2:** CMOS inverter, static characteristics, noise margin, dynamic characteristics, inverter design for a given VTC and speed, effect of input rise time and fall time, power dissipation, energy & power delay product, sizing chain of inverters, latch up effect-Simulation of static and dynamic characteristics, layout **Module 3:** Combinational and sequential MOS logic design, static properties, propagation delay, Elmore delay model, power consumption, low power design techniques, rationed logic, pseudo NMOS inverter, DCVSL, PTL, DPTL & Transmission gate logic, dynamic CMOS design, speed and power considerations, Domino logic and its derivatives, C2MOS, TSPC registers, NORA CMOS. **Module 4:** Semiconductor memories, SRAM and DRAM, BiCMOS logic - static and dynamic behavior -Delay and power consumption in BiCMOS Logic
7.	Suggested Books	**Text:** 1. Sung-Mo Kang & Yusuf Leblebici, CMOS Digital Integrated Circuits Analysis & Design, MGH, Third Ed., 2003. 2. Jan M. Rabaey, Digital Integrated Circuits - A Design Perspective, Prentice Hall, Second Edition, 2005. **Reference:** 1. David A. Hodges, Horace G. Jackson, and Resve A. Saleh, Analysis and Design of Digital Integrated Circuits, Third Edition, McGraw-Hill, 2004.

1.	Course Code	**EE 623**
2.	Title of the Course	**Introduction of VLSI Design**
3.	Credit Structure	L-T- P-Credits 3-0-2-4
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any (for the students)	Basic of MOS Transistor Theory
6.	Course Syllabus	**UNIT 1:** MOS theory, scaling and characteristics, MOS capacitance, CMOS Processing Technology, Layout and VLSI Design Flow. **UNIT 2**: CMOS Inverter and Characteristics, Inverter switching Characteristics, delay and power analysis, CMOS layout design rule and layout of complex circuits, Transistor sizing, Inverter Chain, power dissipation, design corner. **UNIT 3:** Combinational circuit design, Transmission gate and pass transistor logic, design, Sequential circuit design, Data processing circuit design, Semiconductor memories. **UNIT 4:** Dynamic circuits, Introduction of Low power CMOS logic design techniques, Adiabatic logic circuits. **LAB: Exposure on Cadence EDA Tool** Design and analysis (Circuit simulation and layout design) of CMOS inverter characteristic with the given design goal (power, delay etc), Parametric variation on CMOS characteristics. Design and analysis of Combinational and Sequential logic design (NOT, NAND, NOR, FF etc) and data processing circuits. Design and analysis of Memory Cells and Low Power Circuits.
7.	Suggested Books	**Text:** 1. Cadence Design Software and Manual. 2. Fundamentals of Modern VLSI Devices by Yuan Taur & Tak H. Ning (Cambridge) 3. Neil H.Weste, David Harris, Ayan Banerjee, CMOS VLSI Design- A Circuit and System Perspective, Third Edition, Pearson Publishers. 4. Sung-Mo Kang & Yusuf Leblebici, CMOS Digital Integrated Circuits - Analysis & Design, , MGH, Third Ed., 2003. **Reference:** 1. B.G. Streetman, Solid State Electronics Devices, Prentice Hall of India, New Delhi. 2. D.A. Neaman, Semiconductor Physics and Devices, McGraw-Hill. 3. David A. Hodges, Horace G. Jackson, and Resve A. Saleh, Analysis and Design of Digital Integrated Circuits, Third Edition, McGraw-Hill, 2004.

1.	Course Code	**EE 626**
2.	Title of the Course	**MOSFET Reliability Issues**
3.	Credit Structure	L-T- P-Credits 3-0-0-3
4.	Name of the Concerned Department	Electrical
5.	Pre–requisite, if any	Basic knowledge of MOS device and technology.
6.	Course Syllabus	**Evolution of VLSI Device Technology:** Modern CMOS Devices, MOSFET I-V characteristics, Substrate bias and temperature dependence of threshold voltage, Channel mobility, inversion layer capacitance effect. Short channel effects, velocity saturation, channel length modulation, source-drain series resistance, MOSFET breakdown. **High Field Effects**: Impact ionization and avalanche breakdown, Band to band tunneling, Tunneling into and through silicon dioxide, Injection of hot carriers from silicon into silicon dioxide, High field effects in gated diodes. **Modeling Hot carrier Effects:** Substrate current model, Gate current model, Correlation between gate and substrate current, Mechanism of MOSFET degradation, Impact of degradation on circuit performance, Temperature dependence of device degradation. **Electrostatic Discharge Damage:** Introduction to reliability concepts and modeling. Triboelectricity, ESD control, On-chip protection, ESD models and testing, ESD models and testing procedures, failure models. **Metal Electro migration:** Phenomenon of Electro migration, Theoretical and empirical relations, Effects of stress and gases on electro migration, effects of geometric variation and defects, Electro migration at the contacts and windows, layered metallization, Electro migration in polysilicon, Electro migration under pulsed currents. **Dielectric Breakdown:** Introduction, Complex nature of oxide breakdown, Oxide breakdown strength distribution, TDDB life test, Oxide defects, Concept of distance to fail, Step stress techniques, correlation of ramp test data to TDDB data. **Packaging Relation Reliability Issues:** Effects of moisture, Detection and package evaluation, stress in packaging, Issues related to die bonding, Solder joint problem, Electrolytic corrosion, Accelerated reliability tests for packages.
7.	Suggested Books	1. Y. Taur and T.H. Ning, Fundamentals of Modern VLSI Devices, Cambridge University Press (ISBN: 0-521-55959 6). 2. N. Arora, MOSFET Modeling for VLSI Simulation: Theory and Practice, World Scientific, (ISBN-13 978-981-256-862-5). 3. Y. Leblebici, S.-M. Kang, Hot-Carrier Reliability of MOS VLSI Circuits, Springer, 1993 (ISBN 978-0-792393528). 4. A.W. Strong, E.Y. Wu, R.-P. Vollertsen, J. Sune, G.L. Rosa, T.D. Sullivan, S.E. Rauch III, Reliability Wearout Mechanisms in Advanced CMOS Technologies, Wiley-IEEE Press, 1999 (ISBN: 978-0471731726).

1.	Course Code	**EE 627**
2.	Title of the Course	**Fundamentals of Analog CMOS IC Design**
3.	Credit Structure	L-T- P-Credits 3-0-0-3
4.	Name of the Concerned Department	Electrical
5.	Pre–requisite, if any	Knowledge of MOSFET device operation, physics and technology.
6.	Course Syllabus	**Basic MOS Device Physics:** MOSFET as a switch, MOSFET structure and symbol, MOSFET I-V characteristics, Threshold voltage, Second Order Effects, MOSFET layout, capacitances, small signal model, long channel and short channel models. **Short Channel Effects and Device Models:** Scaling theory, short channel effects, threshold voltage variation, mobility degradation with vertical field, velocity saturation, hot carrier effects, output impedance variation with drain source voltage, BSIM model, charge and capacitance modeling, temperature dependence. **Single-Stage Amplifiers:** Basic concepts, Common-source stage, source follower, common-gate stage, cascade stage. **Differential Amplifiers:** Single ended and differential operation, basic differential pair, common mode response, differential pair with MOS loads, Gilbert cell. **Passive and Active Current Mirrors:** Basic current mirrors, Cascade current mirrors, Active current mirrors. **Nonlinearity and Mismatch:** Nonlinearity of differential circuits, effect of negative feedback on nonlinearity, capacitor nonlinearity, linearization techniques, offset cancellation techniques, reduction of noise by offset cancellation, alternative definition of CMRR.
7.	Suggested Books	1. B. Razavi, Design of Analog CMOS Integrated Circuits, Tata McGraw-Hill, New Delhi, 2002 (ISBN: 978-0-07-052903-8). 2. P.E. Allen and D.R. Holberg, CMOS Analog Circuit Design, Oxford University Press, New Delhi, 2010 (ISBN: 978-0-19-806440-4). 3. D.M. Binkley, Tradeoffs and Optimization in Analog CMOS Design, Wiley, 2008 (ISBN: 978-0-470-03136-0).

1.	Course Code	**EE 628**
2.	Title of the course	**Advanced Memory Technology**
3.	Credit structure	L-T-P-Credits 3-0-0-3
4.	Name of the concerned department	Electrical Engineering
5.	Pre-requisite, if any (for the students)	EE 203 Electronic Devices EE 401 VLSI Systems and Technology
6.	Course syllabus	**Introduction to memory devices**: Evolution and history; archival data storage; advances in optical memories. **Nonvolatile memories:** Magnetic memories, HDDs; Silicon based thin film transistor nonvolatile memories; Flash memories, classification and operation; challenges; advancements. **Volatile memories:** Random access memories, classification and operation; SRAMs; DRAMs; history and challenges. **Emerging memory technologies:** Phase Change Memory (PCM); Magnetoresistive Random Access Memory (MRAM); Ferroelectric Random Access Memory (FeRAM); Comparison and future directions.
7.	Suggested books	1. Tseung-Yuen Tseng and Simon M. Sze, **Nonvolatile memories-Materials, Devices and Applications,** Volume 1 and 2, ISBN: 1-58883-250-3 2. Joe Brewer and Manzur Gill, **Nonvolatile memory technologies with emphasis on Flash**, IEEE Press series on microelectronic systems, WILEY-INTERSCIENCE 2008, ISBN: 978-0471-77002-2 3. Simone Raoux and Matthias Wuttig, **Phase change materials-Science and Applications**, Springer 2009**,** ISBN:978-0-387-84873-0 **References** 1. Review article: S. Lai, **Flash memories: Successes and challenges**, IBM Journal of Res. and Dev. Vol.52, p529, 2008. 2. Review article: H-S. Philip Wong et. al., **Phase change memory**, Proceedings of the IEEE, Vol.98, p2201, 2010.

1.	Course Code	**EE 629**
2.	Title of the Course	**Nanotechnology and Nano electronics**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any (for the students)	
6.	Course Syllabus	**Fundamentals of solid state engineering:** Future of semiconductor device and research, Applications in food, energy, transportation, communication, entertainment, health and medicine etc. Necessity of innovative technology and prospect for future. **Crystalline properties of solid:** Crystal lattice and seven crystal systems, The unit cell concept, The Weigner-Seitz cell, Bravais lattices, Space and point groups, Miller indices, reciprocal lattice, Brillouin zone. **Semiconductor heterostructures and low-dimensional quantum structures:** Energy bands, Application of model solid theory, Anderson model for heterojunctions, Multiple quantum wells (MQWs) and super lattices, Two-dimensional nanostructure: quantum well, One-dimensional nanostructure: quantum wire, Zero-dimensional nanostructure: quantum dot, Optical properties of low-dimensional structures, Examples and applications in real world. **Fabrication of nanostructures:** Basic compound semiconductors, Bulk single crystal growth techniques, Epitaxial growth techniques, Physical vapor deposition and sputtering, Thermodynamics and kinetics of growths, Nan scale growth modes **Characterization Techniques:** Structural, X-ray diffraction, Electron microscopy, Energy dispersive analysis using X-rays, Auger electron spectroscopy, X-ray photoelectron spectroscopy, Secondary ion mass spectroscopy, Rutherford backscattering, Scanning probe microscopy, Optical, Photoluminescence spectroscopy, Cathodoluminescence spectroscopy, Reflectance measurement, Absorbance measurement, Ellipsometry, Raman spectroscopy, Fourier transform spectroscopy, Electrical Resistivity, Hall effect, Capacitance techniques, Electrochemical capacitance-voltage profiling **Innovative devices based on nanostructures:** Resonant tunneling diode, Quantum cascade laser, Carbon nanotube devices, Single electron transistor
7.	Suggested Books	1. M. Razeghi, *Fundamentals of Solid State Engineering*, 2nd Edition (Springer, 2006) 2. W. R. Fahrner, *Nanotechnology and Nan electronics: Materials, Devices, Measurement Techniques* (Springer-Verlag Berlin Heidelberg 2005) 3. R. W. Kelsall, I. W. Hamley, and M. Geoghegan, *Nanoscale Science and Technology* (John Wiley & Sons Ltd, England 2005)

1.	Course Code	**EE 631**
2.	Title of the Course	**Organic Electronics**
3.	Credit Structure	L-T-P-Credits (3-0-0)-3
4.	Name of the Concerned Discipline/Department	Electrical Engineering Department
5.	Pre–requisite, if any (for the students)	Basic Semiconductor Physics/ Basic electronics
6.	Course Syllabus	Background towards molecular electronics, surfaces and interfaces, structures and organization. Introduction to Schrodinger equation, Hartree-Fock Theory, Density Functional Theory. Molecular Solids, π-conjugated polymers, one dimensional band structure of linear conjugated polymers, optical absorption and emission in conjugated oligomers/polymers. Device motivation for interface studies, Metal-semiconductor and Metal-Insulator-Semiconductor Interface. Charge transport in conjugated polymers. Hopping and Multiple trap and release model. Interface effects viz. Dipole, doping, band bending etc. in organic semiconductor devices. Materials and Interface Engineering in Organic Light Emitting Diodes (OLEDs). OLED materials and device architecture for full color displays and solid state lighting. Theory and operation principle of Organic Field Effect Transistors (OFETs). Interface Characterization, Threshold Voltage and subthreshold swing and charge carrier mobility in OFETs. Application of OFETs in Displays. Organic Photovoltaic Devices (OPDs) using Polymer-Fullerene Bulk heterojunction thin films. Interface effects and improvement in Polymer Solar Cells (PSCs) efficiency. Introduction to some other advanced concepts viz. Organic electrochromic materials and devices, multiphoton absorbing materials and devices and Nonvolatile Organic Thin Film Memory Device.
7.	Suggested Books	1. S. M. Sze, *Physics of semiconductor devices*, John Wiley and Sons, 1981, ISBN: 0-471-05661-8 2. R. Kelsall, I. Hamley and M. Geoghegan, *Nanoscale Science and Technology*, John Wiley and Sons Ltd, 2005, ISBN: 0-470-85086-8. 3. K. Morigaki, *Physics of amorphous semiconductors*, Imperial College Press, 1999, ISBN: 981-02-1381-6. 4. G. Hadziioannou and G. Malliaras, *Semiconducting Polymers: Chemistry, Physics and Engineering*, Wiley Interscience, 2007, ISBN: 978-3-527-31271-9. 5. F. So, Organic Electronics: Materials Processing, Devices and Applications, CRC Press, 2010, ISBN: 978-1-4200-7290-7. 6. Conjugated Polymer Surfaces and Interfaces, Cambridge University Press, 1996, ISBN: 0-521-47206-7.

1.	Course Code	**EE 641**
2.	Title of the Course	**Advanced Signal Processing**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Discipline/Department	Department of Electrical Engineering
5.	Pre–requisite, if any (for the students)	Signals and Systems
6.	Course Objective	The goal of advanced digital signal processing course is to provide a comprehensive coverage of signal processing methods and tools, including leading algorithms for various applications.
7.	Course Syllabus	Review of discrete-time signals and systems concepts, Z-transform properties, Sampling, Multirate signal processing, discrete Fourier transform (DFT), Fourier-Bessel expansion, discrete cosine transform (DCT), short time Fourier transform (STFT), continuous wavelet transform (CWT), discrete wavelet transform (DWT), Wigner-Ville distribution (WVD), adaptive signal decomposition, empirical mode decomposition, parametric signal processing, data compression, signal and image processing applications.
8.	Suggested Books	1. Digital Signal Processing, 4th Edition, Proakis and Manolakis, Prentice Hall, 2007, ISBN:0131873741 2. Time-Frequency Analysis, 1st Edition, L. Cohen, Prentice-Hall, 0135945321 3. A Wavelet Tour of Signal Processing, 2nd Edition, Academic Press, 012466606X 4. Todd K. Moon and Wynn C. Stirling, Mathematical Methods and Algorithms for Signal Processing, Prentice Hall, August 1999, ISBN-10: 0201361868, ISBN-13: 978-0201361865. 5. Selected research papers

1.	Course Code	**EE 643**
2.	Title of the Course	**Detection and Estimation Theory**
3.	Credit Structure	L-T- P-Credits 3-0-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any (for the students)	Concepts of probability theory
6.	Objectives of the Course	
7.	Course Syllabus	**Review of Probability Theory:** Selected concepts of probability theory, random variables and stochastic processes. **Binary Decisions: Single Observation:** Maximum-likelihood decision criterion, Neyman-Pearson criterion, probability-of-error criterion, Bayes risk criterion, and min-max criterion. **Multiple Observations:** Vector observations, general Gaussian problem, waveform observations and additive Gaussian noise. **Multiple Decisions:** Bayes risk, minimum probability of error decision rule, Gaussian case, erasure decision problems. **Composite and Nonparametric Decision Theory:** Composite decisions, sign test, Wilcoxon test. **Classical Estimation Theory:** Random parameter estimation, Bayes cost method, relationship of estimators, non-random parameter estimation, CRLB, linear minimum variance and least-squares methods, multiple parameter estimation. **State Estimation:** Problem statement, Kalman filter, miscellaneous estimation techniques.
8.	Suggested Books	**1.** James L. Melsa and David L. Cohn, Decision and Estimation Theory, McGraw-Hill Book Company. **2.** Harry L. Van Trees, “Detection, Estimation and Modulation Theory”, Part I, John Wiley & Sons. **3.** Steven M. Kay, Fundamentals of Statistical Signal Processing - Estimation Theory (Vol. 1), Prentice-Hall, Inc., 1993. **4.** H. Vincent Poor, An Introduction to Signal Detection and Estimation, 2nd Edition, Springer, 1998.

1.	Course Code	**EE 701**
2.	Title of the Course	**Time-Frequency Analysis**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	Basic knowledge of Fourier analysis
6.	Course Objective	Many signals exhibit frequency characteristics that change over time. Examples include such as speech, marine mammal sounds, heart rate, electroencephalogram, machine vibrations, sonar, radar, and communication signals. Understanding these changes is important because they are often indicative of the underlying processes that generated the signal. Time-frequency analysis, also called time-varying spectral analysis, is a technique for studying the time-dependent spectral changes in a signal.
7.	Course Syllabus	Basics of Fourier Analysis, Spectral Theory, Fundamentals of Time-Frequency Analysis, Instantaneous Frequency and Instantaneous Bandwidth, Gabor Transform, The Short-Time Fourier Transform/Spectrogram, Time-Frequency Localization, Continuous Wavelet Transform/Scalogram, Multiresolution Analysis, Quadratic Time-Frequency Transform, Wigner-Ville Distribution, Signal Processing Applications, Image Processing Applications.
8.	Suggested Books	1. Stephane Mallat, **A Wavelet Tour of Signal processing** (2nd edition), Academic Press, 1999. 2. Leon Cohen, **Time-Frequency Analysis**, Prentice Hall, 1995. 3. Boualem Boashash, Time-Frequency Signal Analysis and Processing: A Comprehensive Reference, Elsevier Science; 1 edition, ISBN-10: 0080443354, ISBN-13: 978-0080443355, 2003. 4. Raghuveer M. Rao and Ajit S. Bopardikar, Wavelet Transforms: Introduction to Theory & Applications, Prentice Hall, ISBN-10: 0201634635, ISBN-13: 978-0201634631, August 1998.

1.	Course Code	**EE 722**
2.	Title of the Course	**Optoelectronics**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any (for the students)	
6.	Course Syllabus	**Fundamentals of Lasers:** The Einstein A and B coefficient approach to the photon-atom interaction, Based on this approach, examines semi-classical quantum theory of the laser to illustrate the general applicability of the rate equation, Description of light detection. **Laser Physics and Dynamics:** Threshold condition for laser oscillation, Gain saturation, Multimode Oscillation, Amplified spontaneous emission, Laser efficiency, CW laser **Different Sources of Lasers:** Solid state lasers, Color center lasers, Gas lasers, Dye lasers, Chemical lasers, Semiconductor lasers
7.	Suggested Books	1. Joseph T. Verde yen, Laser Electronics, 3rd edition (prentice-Hall, 1995) 2. E. Siegman, Introduction to Lasers and Masers (New York: McGraw-Hill Company, 1971) 3. C. Casey, Jr. and M. B. Panish, Heterostructure lasers (New York: Academic Press, 1978)

1.	Course Code	**EE 724**
2.	Title of the Course	**Advanced Micro-processes and Nanotechnology**
3.	Credit Structure	L-T- P-Credits 3-0-0-3
4.	Name of the Concerned Department	Electrical Engineering Department
5.	Pre–requisite, if any (for the students)	A course on semiconductor device physics, MOSFETs and VLSI
6.	Course Syllabus	**Methodologies for nanotechnology:** Introduction and classification, general properties of atoms and solids, effects at the nanometer scale, Fabrication methods for nanostructures. **Characterization methodologies for Nanotechnology:** classification of characterization methods, microscopic techniques, Electron microscopy, Scanning probe techniques, Diffraction techniques, spectroscopic techniques. **Semiconductor nanostructures:** General aspects of semiconductor physics, Quantum confinement in semiconductor nanostructures, fabrication techniques, Physical processes nanostructures, some applications of semiconductor nanostructures. **Silicon MOSFETs:** Moore's Law, Scaling down of devices, Low frequency noises in MOSFETs, Short Channel Effect, DIBL, GIDL, recent developments and challenges in MOSFETs. **Single electron devices:** Coulomb blockade effect, Single Electron Transistor, SET based detector, RF-SET, Single Electron Spectroscopy etc. **Molecular materials and devices:** Organic materials, some examples of organic semiconductors, charge carrier injection and transport, Optical properties of organic semiconductors, applications and devices involving organic semiconductors viz. Organic Field Effect Transistors, Organic Light Emitting Diodes, Organic Photovoltaic's including Dye sensitized solar cells.
7.	Suggested Books	7. S. M. Sze, *Physics of semiconductor devices*, John Wiley and Sons, 1981, ISBN: 0-471-05661-8 8. R. Kelsall, I. Hamley and M. Geoghegan, *Nanoscale Science and Technology*, John Wiley and Sons Ltd, 2005, ISBN: 0-470-85086-8. 9. K. Morigaki, *Physics of amorphous semiconductors*, Imperial College Press, 1999, ISBN: 981-02-1381-6. 10. P. Richman, *MOS Field Effect Transistors and Integrated Circuits*, John Wiley and Sons Ltd, 1973, ISBN: 0-471-72030-5. 11. Y. Taur and T-H. Ning, *Fundamentals of Modern VLSI Devices*, Cambridge University Press, 1998, ISBN: 978-0-521-55959-1. 12. G. Hadziioannou and G. Malliaras, *Semiconducting Polymers: Chemistry, Physics and Engineering*, Wiley Interscience, 2007, ISBN: 978-3-527-31271-9.

1.	Course Code	**EE 740**
2.	Title of the Course	**Speech Signal Processing**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Department of Electrical Engineering
5.	Pre–requisite, if any (for the students)	Signals and Systems, Digital Signal Processing
6.	Course Syllabus	**Signal processing tools:** Digital filters, Fourier series, Fourier transform, DFT, FFT, short term Fourier transform (STFT), continuous wavelet transform, discrete wavelet transform **Speech acquisition and digitization** **Speech analysis and parameter extraction:** Short time analysis, frames and windows, time-domain analysis: energy, zero-crossings, statistic parameters, autocorrelation, frequency-domain analysis: spectra and spectrograms, cepstral analysis, linear prediction analysis, pitch and formant estimation, static and dynamic features **Speech signal synthesis** **Speech coding** **Speech enhancement**
7.	Suggested Books	1. J.R. Deller, J.G. Proakis, J.H.L. Hansen, Discrete-Time Processing of Speech Signals, Macmillan Coll Div, ISBN 9780023283017 2. Thomas F. Quatieri, Discrete-Time Speech Signal Processing: Principles and Practice, Prentice Hall, ISBN: 013242942X 3. Lawrence R. Rabiner, Ronald W. Schafer, Digital Processing of Speech Signals, Prentice Hall, ISBN 9780132136037

1.	Course Code	**EE 742**
2.	Title of the Course	**MIMO Wireless Communications**
3.	Credit Structure	L-T- P-Credits 3-0-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any (for the students)	Concepts of random variable and communication theory.
6.	Objectives of the Course	
7.	Course Syllabus	**Review of Matrix Algebra:** Trace, Frobenius norm, positive definite matrix, singular value decomposition, vectorization, Kronecker product. **MIMO System and Channel Models:** Frequency-flat and frequency-selective MIMO channel, Matrix formulations. **MIMO Information Theory:** Entropy and mutual information, capacity of MIMO channel, MIMO capacity with and without transmit CSI, ergodic channel capacity, outage capacity. **Receive Diversity:** SIMO receivers, flat and frequency-selective channels, linear processing and MRC, orthogonal frequency division multiplexing (OFDM). **Transmit Diversity and Space-Time Coding:** Optimal beamforming with transmit CSI, beamforming for MISO systems, achieving transmit diversity, space-time coding concepts. **Linear Space-Time Block Codes:** A general framework for Linear STBC, spatial multiplexing, orthogonal space-time block codes, error performance analysis, mutual information properties, diversity-multiplexing tradeoff analysis. **Applications:** Multiuser MIMO, Collaborative MIMO, MIMO in WiFi and WiMAX, Large MIMO systems.
8.	Suggested Books	1. Erik G. Larsson and Petre Stoica, “Space-Time Block Coding for Wireless Communications”, Cambridge University Press, USA, 2003. 2. Arogyaswami Paulraj, Rohit Nabar, and Dhananjay Gore, “Introduction to Space-Time Wireless Communications”, Cambridge University Press, USA, 2003. 3. Ezio Biglieri, Robert Calderbank, Anthony Constantinides, Andrea Goldsmith, Arogyaswami Paulraj, “MIMO Wireless Communications”, Cambridge University Press, USA, 2007. 4. David Tse and Pramod Vishwanath, Fundamentals of Wireless Communication, Cambridge University Press, 2005.

1.	Course Code	**EE 797 (Autumn Semester)** **EE 798 (Spring Semester)**
2.	Title of the Course	Seminar Course
3.	Credit Structure	L-T-P-Credits 0-2-0-2
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Course Syllabus	In this course a PhD student has to present seminar/presentation or a series of presentations on a topic(s) chosen by him/her in consultation with his/her PhD Thesis Supervisor/ Faculty Advisor. The frequency of seminar/presentation will be decided by the Course Coordinator.
7.	Textbook	None
8.	Other references	Books and research publications in various relevant journals.

Syllabi of Mechanical Engineering Courses

Course Structure for PhD Programme in Mechanical Engineering

(A) Semester-I (autumn / spring)

Sr. No.	Course code	Course Name (L-T-P-Credits)	Type (Core/Elective)
1	ZZ xxx	Elective-I	Elective
2	ZZ xxx	Elective-II	Elective
3	ME 797* / ME 798*	Ph.D. Seminar Course (0-2-0-2)	Core

(B) Semester-II (spring / autumn)

Sr. No.	Course code	Course Name (L-T-P-Credits)	Type (Core/Elective)
1	ZZ xxx	Elective- III +	Elective
2	ZZ xxx	Elective-IV +	Elective
3	ZZ xxx	Elective-V +	Elective
3	ME 798* / ME 797*	Ph.D. Seminar Course (0-2-0-2)	Core

Mechanical Engineering course for the Elective-I to V (in addition these courses students can take courses from the other disciplines/schools also)

ME 601: Principles of Measurements (3-0-2-4)
ME 602: Advanced Heat transfer (3-1-0-4)
ME 603: Advanced Fluid Dynamics (3-0-0-3)
ME 605: Simulation of Thermal Systems (3-0-2-4)
ME 607: Biofluid Mechanics
ME 644: Robotics
ME 651: Mechatronic System Design
ME 658: Laser based Measurements and micro-manufacturing
ME 680: Reliability and Maintenance Engineering
ME 732: Finite Element Methods (3-0-0-3)
ME 736: Theory of Elasticity (3-0-0-3)
ME 738: Composite Materials (3-0-0-3)
ME 750: Material Characterization Techniques (2-0-2-3)
ME 751: Advanced Machining Processes (3-0-0-3)
ME 752: Micro and Precision Manufacturing (3-0-0-3)
ME 754: Materials Science and Engineering (3-0-0-3)
ME 756: Industrial Automation (3-0-0-3)

Note:

+ Additional elective course to be taken by the students with BTech/BE/MSc qualification only.

* Depending upon the semester of admission (ME 797 for Autumn Semester and ME 798 for the Spring Semester).

Core courses are compulsory.

1.	Course Code	**ME 601**
2.	Title of the Course	**Principles of Measurements**
3.	Credit Structure	L-T- P-Credits 3-0-2-4
4.	Name of the Concerned Department	Mechanical
5.	Pre–requisite, if any	None
6.	Course Syllabus	**Basics of Measurement Systems:** Introduction, Classification of measurement systems, Errors in measurements, Statistical analysis of measured data, Regression analysis, Introduction to uncertainty, uncertainty analysis, Estimation of overall uncertainty, Presentation of data, Design of experiments. **Measurement of Fundamental Quantities:** (I) Measurement of Temperature: Science and art of temperature measurement, Temperature measurement by mechanical effects, Thermo electric thermometry, Resistance thermometry, Pyrometer, Measurement of transient temperature, systematic errors in temperature measurement, Laboratory practice. (ii) Measurement of Pressure: Manometers, Bourdon gauge, Pressure transducers, Measurement of transient pressure, Measurement of vacuum, Laboratory practice. (iii) Measurement of Flow Velocity: Pitot static and impact probes, Velocity measurement based on thermal effects, Doppler velocimeter, Laboratory practice. **Measurement of Derived Quantities:** (I) Measurement of Heat flux and Heat Transfer Coefficient: Foil type heat flux gauge, Thin film sensors, Cooled thin wafer heat flux gauge, Axial conduction, Guarded probe, Slug type sensor, Film coefficient transducers, cylindrical heat transfer coefficient probe, Laboratory practice. (ii) Measurement of Volume Flow Rate: Variable area type flow meters, Rota meter, Miscellaneous type of flow meters, Factors to be considered in the selection of flow meters, Calibration of flow meters, Laboratory practice. (iii) Measurement of Stagnation and Bulk Mean Temperature: Introduction, Shielded thermocouple stagnation temperature probe, Dual thin film enthalpy probe, flow in rectangular duct, Laboratory practice. **Measurement of Thermo-physical Properties, Radiation Properties of Surfaces and Gas Concentration:** (I) Measurement of Thermo-physical Properties: Thermal conductivity- steady and transient methods, Measurement of heat capacity, Calorific values of fuel, Viscosity of fluids, Laboratory practice. (ii) Measurement of Radiation Properties of Surfaces: Introduction, Features of radiation measuring instruments, Integrating sphere, Measurement of emissivity, Laboratory practice. (iii) Measurement of Gas Concentration: Introduction, Non separation methods, Separation methods, Laboratory practice. **Measurement of Other Engineering Quantities:** Fundamentals of measurements of force, torque, strain, vibration, noise, surface roughness, geometrical or form tolerances. **Data Acquisition, Manipulation and Presentation:** Introduction, Mechanical signals conditioning, Electrical signal conditioning, Examples from laboratory practices.
7.	Suggested Books	1. S. P. Venkatesan, **Mechanical Measurements**, Ane Books Pvt. Ltd, New Delhi, 2010 (ISBN: 978-81-8052-234-5). 2. T. G. Beckwith, R.D. Marangoni, J. h. Lien hard, **Mechanical Measurements**, Sixth edition, Pearson Prentice Hall, New Delhi, 2009 (ISBN:978-81-317-1718-9). 3. E. O. Doebelin, D. N. Manik, **Measurement Systems Application and Design**, Fifth Edition, Tata McGraw Hill, New Delhi, 2007 (ISBN-13:978-0-07-061672-8). 4. J. P. Holman, **Experimental Methods for Engineers**, Seventh Edition, Tata McGraw Hill, New Delhi, 2010 (ISBN-13:978-0064776-3).

1.	Course Code	**ME 602**
2.	Title of the Course	**Advanced Heat transfer**
3.	Credit Structure	L-T-P-Credits 3-1-0-4
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre-requisite, if any (for the students)	Heat Transfer
6.	Course Syllabus	**Conduction:** Derivation of energy equation for conduction in three dimensions – Initial and boundary conditions. Transient conduction- Concept of Biot number – Lumped capacitance formulation unsteady conduction from a semi-infinite solid-solution by similarity transformation method. Solution of the general 1D unsteady problem by separation of variables, Laplace equation – solution by variable separable method – concept of superposition and homogeneous boundary conditions. Numerical solution of conduction problems-Basic ideas of finite difference method – forward, backward and central differences – Discretization for the unsteady heat equation. **Convection:** Derivation of governing equation for convection. 2D laminar coquette flow and nondimensional numbers. Concept of Adiabatic wall temperature. Integral methods for momentum and thermal boundary layers. Pipe flow – concept of developed temperature profile and solutions for constant wall flux and constant wall temperature boundary conditions. Solution of entry length problem for constant wall and constant wall flux boundary conditions. Natural convection – governing equation, integral solution for flat surface. **Radiation:** Introduction. Concept of black body, derivation of black body radiation laws from first principles Need for view factors, concept of view factors, mathematical definition. Shape factor calculations. Radiosity, Irradiation method for gray diffuse enclosures. Gas Radiation.
7.	Suggested Books	1. D. Poulikakos, Conduction Heat transfer, Prentice Hall, 1994. 2. G.E. Mayers, Analytical methods in Conduction Heat Transfer, McGraw Hill, 1971. 3. Kays W M and Crawford M E, Convective Heat and Mass Transfer, McGraw Hill Int Edition, 3rd edition, 1993. 4. Spalding D B, Introduction to Convective Mass Transfer, McGraw Hill, 1963. 5. R. Siegel and J.R. Howell, Thermal Radiation Heat Transfer, Taylor and Francis, 2002.

1.	Course Code	**ME 603**
2.	Title of the Course	**Advanced Fluid Dynamics**
3.	Credit Structure	L-T- P-Credits 3-0-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	Nil
6.	Course Syllabus	Fundamental Concepts, Kinematics of Fluid, Control Volume Equations, Navier-Stokes Equations and their use, Boundary Layer Theory and Applications, Concept of Compressible flows, 1-D Isentropic flow, Flow with Friction and Heat Transfer.
7.	Suggested Books	1. R. W. Fox and A. T. McDonald, *Introduction to Fluid Mechanics*, 5th Ed, John Wiley, 1998. 2. F. M. White, *Fluid Mechanics*, 4th Ed, McGraw-Hill, 1999. 3. S. W. Yuan, *Foundations of Fluid Mechanics*, Prentice Hall of India, 1988. 4. Batchelor G.K., An Introduction to Fluid Dynamics, 2nd edition, Cambridge University Press, 2000. 5. H. Schlichting, Boundary Layer Theory, McGraw-Hill, 1979. 6. S. M. Yaha, Fundamentals of compressible flow, Wiley Eastern Limited, New York, 1982. 7. A. H. Shapiro, The dynamics and thermodynamics of compressible flow, Ronald Press, New York, 1953.

1.	Course Code	**ME 605**
2.	Title of the Course	**Simulation of Thermal Systems**
3.	Credit Structure	L-T- P-Credits 3-0-2-4
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	Nil
6.	Course Syllabus	Information flow diagram, systems identification and description, component and system design, Types of simulation, Solution techniques and curve fitting, Modeling of typical thermal equipments i.e. evaporative cooler, heat exchangers, steady state simulation, Typical case studies, Dynamic response of thermal systems, Introduction to optimization techniques, Compressive case studies of some thermal systems.
7.	Suggested Books	1. Wilbert Stoecker, “Design of thermal systems”, Third edition, McGraw-Hill 1989, ISBN: 978-0070616202. 2. Yogesh Jaluria, “Design and optimization of thermal Systems”, CRC press, Second edition, 2007, ISBN: 978-0849337536. 3. N.V. Suryanarayana & Oner Arici, “Design and simulation of thermal systems”, First edition, 2002, ISBN: 978-0072497984.

1	Course Code	**ME 607**
2	Title of the course	**Biofluid Mechanics**
3	Credit Structure	L-T-P-Credits 3-0-0-3
4	Name of Department	Mechanical Engineering
5	Pre-requisites, if any	None
6	Objectives of the Course	(a)To understand the physiology and anatomy of different systems in the human body (b) To integrate fluid mechanics concepts to model biological flows in the human body (c) To identify specific diseases and to analyze how they are related to fluid mechanics.
7	Course Syllabus	**Introduction:** Introduction to fluid mechanics, and human physiology in relation to heart, lungs and blood vessels. **Cardiovascular structure and function:** Electro-cardiogram, heart valves, cardiac cycles, heart sounds, coronary circulation, microcirculation, lymphatic circulation. **Pulmonary Anatomy, Pulmonary physiology and Respiration:** Respiratory system, alveolar ventilation, mechanics of breathing, airway resistance, gas exchange and transport, pulmonary pathophysiology, respiration in extreme environment. **Hematology and Blood Rhelogy:** Elements of blood, blood characteristics, viscosity measurement, erythorcytes, leukocytes; blood types, plasma. **Anatomy and Physiology of Blood vessels:** General structure & types of arteries, mechanics of arterial walls, compliance, vascular pathologies, stents, coronary artery bypass grafting. **Mechanics of Heart Valves:** Aortic and pulmonic valves; Mitral and Tricuspid valves; Pressure gradients across a stenotic heart valve; Prosthetic mechanical valves; Prosthetic tissue valves. **Pulsatile flow in large arteries:** Introduction to blood flow in large arteries, pulsatile flow in tubes, instability in pulsatile flow. **Mathematical modeling:** Introduction to finite difference, finite volume & finite element methods, non-Newtonian flow models, modeling of flow through Mitral valve, modeling of blood flow in vascular system.
8	**Suggested Books**	**Text Book** 1. Applied biofluid mechanics, L. White and J.M. Fine, *McGraw Hill*, 2007 (ISBN: 5551694623). 2. Biofluid Mechanics, J.N. Mazumdar, *World Scientific*, Singapore, 2004 (ISBN: 981-02-3801-0) **Reference Books** 1. L. White, Biomechanics in Cardiovascular Systems, *McGraw Hill*, 2006. 2. C. Kleinstruer, Biofluid Dynamics: Principles and Applications, *CRC Press*, *Taylor and Francis Group*, 2006. 3. M. Zamir, The Physics of Pulsatile Flow, Springer Verlag, New York, 2000. 4. Sir James Lighhill, Mathematical Biofluid Dynamics, , *Society for Industrial and Applied Mathematics, Philadelphia*, 1975 (**ISBN**: 0-89871-014-6)

1.	Course Code	**ME 644**
2.	Title of the Course	**Robotics**
3.	Credit Structure	L-T-P-Credit 3-0-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Course Syllabus	**Introduction:** Introduction to robots – Robot manipulators – Mobile robots – Robot anatomy – Coordinate systems, Work envelope – Types and classification – Specifications – Sensors – Actuators and drives. **Forward and Inverse Kinematics:** Introduction – Representation of position and orientation of a rigid body – Homogeneous transformations – Forward and inverse kinematics problems – Denavit-Hartenberg (D-H) notations and parameters – Representation of joints, link representation using D-H parameters – Closed-form solutions – Geometric and Numerical methods. **Velocity and Statics analysis:** Linear and angular velocity of links – Velocity propagation – Jacobians for robotic manipulators – Statics and force transformation of robotic manipulators – Singularity analysis. **Robot Dynamic analysis:** Introduction – Forward and inverse dynamics – Mass and inertia of links - Lagrangian formulation for equations of motion for robotic manipulators – Newton-Euler formulation method – Dynamic modelling – State space representation of dynamic equations of robotic manipulators. **Trajectory Planning and Control:** Joint and Cartesian space trajectory planning and generation – Classical control concepts using the example of control of a single link – Independent joint PID control – Control of a multi-link manipulator – Nonlinear model based control schemes – Simulation and experimental case studies on robotic manipulators.
7.	Suggested Books	1. Introduction to Robotics: Mechanics and Control by John J. Craig, John Wiley & Sons Inc., 2004. 2. Robot Modeling and Control by M.W. Spong, Seth Hutchinson, M. Vidyasagar, John Wiley & Sons Inc., 2006. 3. Fundamentals of Robotics: Analysis and Control by J.R. Schilling, Prentice Hall India, 1992. 4. Robotics: Control, Sensing, Vision and Intelligence by K. Fu, R. Gonzalez, and C.S.G. Lee, McGraw- Hill, 1987. 5. Robotics: Fundamental Concepts and Analysis by A. Ghosal, Oxford University Press, 2008.

1.	Course Code	**ME 651**
2.	Title of the Course	**Mechatronic System Design**
3.	Credit Structure	L-T-P-Credit 3-0-1-3.5
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Course Syllabus	**Mechatronics System design:** Introduction to Mechatronics-Integrated design issues- Key elements and design processes- Physical system modelling - Electrical systems- Micro processor based controller and micro electronics- Mechanical translation and rotational systems-Electromechanical coupling-Fluid system **Actuating devices:** Direct current motor, Permanent magnet stepper motor, Mechanical actuation, Hydraulic and pneumatic power actuation devices, Linear and latching linear actuators, Rotatory actuators, Piezo electric actuators, Actuator parameters and characteristics. **Sensors and Transducers:** An introduction to sensors and transducers, sensors for motion and position, Force torque and tactile sensors, Flow sensors, Temperature sensing devices, Ultrasonic sensors, Range sensors, Active vibration control using magnetostructive transducers, Lasers and Opto-mechatronics based devices. **Software and Hardware components in Mechatronics systems:** Signals , system and controls, system representation, Signal conditioning and devices, PLC, system representation, linearization of nonlinear systems, Time delays and measurement of system performance, Elements of Data acquisition and control systems, real time interfacing. **MEMS and Microsystems:** Microsystems and miniaturization- lithography technique- Micro actuators- actuation using shape memory alloys, piezo electric crystals and electrostatic forces- micro valves and pumps- micro sensors- Overview on applications of Robotics in automobiles and other industries.
7.	Suggested Books	**Text books:** 1) W. Bolton, Mechatronics, Pearson publications (ISBN 978-81-3176253-3) 2) Devdas Shett, Richard A. Kolk, Mechatronics System Design, Brooks/Cole, Thomson learning(ISBN 0-534-95285-2). **Reference Books:** 1) John Watton, Fundamentals of Fluid power and control, Cambridge university press (ISBN 9780521762502) 2) Andrejz M.Pawlak, Sensor and Actuators in Mechatronics Design, Taylor and Francis (ISBN-13:978-0-8493-9013-5) 3) Tai-Ran Hsu, MEMS and Microsystems design and manufacture, Tata McGraw-Hill(ISBN0-07-048709-X) 4) Stephen A.Campbell, The Science and Engineering of microelectronic fabrication, Oxford university press(ISBN 0-19-568144-4)

1	Course Code	**ME 658**
2	Title of the course	**Laser based Measurements and micro-manufacturing**
3	Credit Structure	L-T-P-Credit 3-0-0-3
4	Name of the Concerned Department	Mechanical Engineering
5	Pre-Requisite, if any (for the students)	None
7	Course Syllabus	**Thermal Process in laser material interaction:** Introduction to working of Laser- Absorption of laser radiation-optical properties of materials-Macroscopic transport-conductive heat transfer. Thermal effects using laser – laser heating- melting- vapor expansion and recoil pressure-Plasma formation-Hydrodynamic stability of transient melts-modelling of laser ablation and plume prorogation **Laser based micro-manufacturing:**Laser based micro-manufacturing-casting-forming/shaping-joining-micro-drilling- Laser micromachining mechanism-laser cutting of various materials- -Three dimensional machining- laser micro-machining mechanism-laser ablation-laser assisted chemical etching **Laser induced surface processing** Laser based hardening, Laser cladding Laser ablation-Laser assisted chemical etching-laser micromachining-direct writing technique-mask projection-laser based interference processing and combined techniques. Laser shock processing, laser dressing of grinding wheels, Laser marking, laser direct writing, Laser micro-stereo lithography, and Laser tissue interaction –(Photochemical-photo disruptive interactions) **Ultra fast laser interaction and dynamics of laser based micro fabrication** Femto-second laser interaction with metals- Femto-second laser interaction with semiconductor materials-Laser induced periodic surface structure formation(LIPSS) formation by Femto second laser-second laser- Laser processing of organic materials, Ultrafast phase explosion-nonlinear absorption and breakdown in dielectric materials-generation of highly energetic particle-vapour kinetics-Pico-second laser plasma's **Characterization and diagnosis using lasers** In situ and Ex-situ diagnostics measurements- Surface topographical measurements using-optical Instruments-scanning optical technique-Triangulation instruments-Confocal instruments-Laser's in AFM. Surface composition and property diagnosis using, In- situ measurement techniques- Laser Induced Break down Spectroscopy (LIBS)- Shadow graphic techniques, Ex-situ measurements-Raman Spectroscopy analysis. Surface evaluation using Holographic techniques.
6	Suggested books	**Text books:** 1) John.C.Ion, Laser processing of engineering materials-principal, procedures and industrial applications,Elsevier Butterworth-Heinemann, ISBN 0750660791. 2) Narendra B.Dahotre, Sandip P.Harimkar,Laser fabrication and maching of materials, ISBN (978-0-387-7234-3) 3) Jacques Perriere, Eric Million, Eric Fo Garassy, Recent advances in Laser processing of materials, European Material research Society, Elsevier Publictaions. 4) K.Ding and L.Ye,Laser shock peening performance and processes simulations, Woodhead publishing in materials. 5) Richard K.Leach, Fundamental principles of engineering nanometrology, Elesevier publication 6) R.Hull, R.M.Osgood, J.Parisi, H. Warlimont, The Theory of laser material processing,heat and mass transfer in modern technology-springer series in material science.

1.	Course Code	**ME 680**
2.	Title of the Course	**Reliability and Maintenance Engineering**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre-requisite, if any (for the students)	Introductory course in probability and statistics
6.	Objective of the course	To introduce the various concepts of reliability and maintenance and its applicability to different products and processes. Also to introduce the concepts of remaining useful life prediction for condition based maintenance.
7.	Course Syllabus	**Fundamentals of reliability:** Scope of reliability engineering, concept of bath tub curve, types of failure data, reliability estimations, constant failure rate models, time dependent failure rate models, concept of failure on demand, reliability estimation of series/parallel/mixed/complex system configuration, concepts of availability and maintainability. **Design for Reliability**: Capturing user's reliability requirements, reliability and/or redundancy allocation/optimization, design methods, FMEA/FMECA, reliability testing (burn-in testing, reliability assurance testing, reliability growth testing, accelerated life testing), fault tree analysis. **Availability Assessment**: Markov modeling approach for availability estimation. **Maintenance Management:** Corrective, preventive and predictive maintenance. Age and time based preventive maintenance, opportunistic maintenance, concepts of imperfect maintenance, concept of TPM and RCM, maintenance optimization. **Remaining useful life prediction of equipments subject to condition monitoring:** ANN models, ARMA models, Markov models, proportional hazard models**.**
8.	Suggested Books	1. Charles Ebeling, **An Introduction To Reliability and Maintainability Engineering**, Waveland Pr Inc; 2 Har/Cdr edition, 2009. 2. Igor Bazovsky, **Reliability Theory and Practice**, Dover Publications (October, 2004). 3. Patrick O'Connor, **Practical Reliability Engineering**, John Wiley & Sons Inc.2002. 4. Gregg K. Hobbs, **Accelerated Reliability Engineering: HALT and HASS**, Wiley, 2000. 5. G. Vachtsevanos, F.L. Lewis, M. Roemer, A. Hess and B. Wu, **Intelligent Fault Diagnosis and Prognosis for Engineering Systems**. John Wiley & Sons, 2006. Suggested web page: WWW.weibull,com

1.	Course Code	**ME 732**
2.	Title of the Course	**Finite Element Methods**
3.	Credit Structure	L-T- P-Credits 3-0-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	Nil
6.	Course Syllabus	**Introduction:** Historical background, basic concept of the finite element method, comparison with finite difference method. **Variation Methods:** Calculus of variation, Rayleigh-Ritz and Galerkin methods; **Finite Element Analysis of 1-D problems:** Formulation by different approaches (direct, potential energy and Galerkin); Derivation of elemental equations and their assembly, solution and its post processing, Applications in heat transfer, fluid mechanics and solid mechanics: bending of beams analysis of truss and frame. **Finite Element Analysis of 2-D problems:** Finite element modelling of single variable problems, triangular and rectangular elements; Applications in heat transfer, fluid mechanics and solid mechanics; **Numerical Considerations:** numerical integration, error analysis, meshes refinement. Plane stress and plane strain problems; Bending of plates; Eigen value and time-dependent problems. Discussion about pre-processors, post-processors and finite element packages.
7.	Suggested Books	1. J N Reddy, An introduction to the Finite Element Method, McGraw-Hill, New York, 1993. 2. R D Cook, D S Malkus and M E Plesha, Concepts and Applications of Finite Element Analysis, 3d ed., John Wiley, New York, 1989. 3. K J Bathe, Finite Element Procedures in Engineering Analysis, Prentice-Hall, Englewood Cliffs, NJ, 1982. 4. T J R Hughes, the Finite Element Method, Prentice-Hall, Englewood Cliffs, NJ, 1986. 5. O C Zienkiewicz and R L Taylor, the Finite Element Method, 3d ed. McGraw-Hill, 1989.

1.	Course Code	**ME 736**
2.	Title of the Course	**Theory of Elasticity**
3.	Credit Structure	L-T- P-Credits 3-0-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	Nil
6.	Course Syllabus	Analysis of stress and strain; Equilibrium, Compatibility and constitutive equations; Plane problems; Stress functions; Applications; Complex potentials in two dimensional and axi-symmetric problems; Variation methods; Anisotropic elasticity; Finite deformation elasticity.
7.	Suggested Books	1. Timoshenko and Goodier, *Theory of Elasticity*, McGraw-Hill International, 3rd edition, 1970. 2. I. S. Sokolnikoff, *Mathematical Theory of Elasticity*, McGraw-Hill International, 2nd ed., 1957. 3. Y C Fung, *Foundation of Solid Mechanics*, Prentice Hall Inc., 1965. 4. Xu Zhilun, *Applied Elasticity*, Willey Eastern Ltd., 1992

1.	Course Code	**ME 738**
2.	Title of the Course	**Composite Materials**
3.	Credit Structure	L-T- P-Credits 3-0-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	Nil
6.	Course Syllabus	**Introduction:** classifications, terminologies, manufacturing processes. **Macro-mechanical analysis of lamina:** Hooke's law for anisotropic, monoclinic, orthotropic, transversely isotropic and isotropic materials–2D Unidirectional and angle ply lamina – Strength theories of lamina. **Micro-mechanical analysis of lamina:** Volume and mass fraction, density and void content – Evaluation of Elastic module, Ultimate strength of unidirectional lamina. **Macro-mechanical analysis of laminates:** Laminate code, Stress strain relations – In-plane and Flexural modulus, Hydrothermal effects. **Failure Analysis and Design:** Special cases of laminates, symmetric, cross ply, angle ply and antisymmetric laminates, failure criteria and failure modes
7.	Suggested Books	1. Jones, R M, *Mechanics of Composite Materials*, Scripta Book Co. 2. Agarwal, B D and Broutman, J. D, *Analysis and Performance of Fiber Composites*, New York, John Willey and Sons, 1990 3. Mallik, P. K, *Fiber reinforced composites : materials, manufacturing and design,* New York- Marcel and Dekker, 1993 (2nd edition) 4. Arthur, K Kaw, *Mechanics of Composite Materials*, CRC Press, 1997. 5. Reddy J N, *Mechanics of Laminated Composite Plates*, CRC Press 6. Mallik, P. K, *Composite Engineering Hand Book*, New York, Marcel and Dekker, 1997 (2nd edition)

1.	Course Code	**ME 750**
2.	Title of the Course	**Material Characterization Techniques**
3.	Credit Structure	L-T-P-Credits 2-0-2-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Course Syllabus	**Introduction:** Requirement of different techniques of material characterization for different situations. Mechanical and physical characterization. **Optical Metallographic Techniques:** Observation of microstructure. Preparation of samples (polishing, etching etc.) **Mechanical Characterization Processes:** Measurement of hardness. Measurement of fracture toughness through nano-indentation. Adhesion test. Surface profilometry. Tribological studies of materials. **Physical Characterization Processes:** Introduction to different methods and their applications. Diffraction methods for phase, residual stresses, texture analysis etc.; Electro-optical and related techniques like SEM, TEM, EDS, WDS/EPMA etc.; Surface analysis and related techniques like XPS, AFM etc.; Spectroscopic techniques.
7.	Suggested Books	1. C. R. Brundle, Charles A. Evans, Shaun Wilson, Encyclopedia of materials characterization: surfaces, interfaces, thin films, Material Characterization Series, Surfaces, Interfaces, Thin Films, Butterworth-Heinemann. 2. B.D. Cullity, Elements of X-Ray Diffraction (3rd Edition), Prentice Hall 3. Said Jahanmir, Friction and Wear of Ceramics, CRC Press 4. P J Goodhew, J Humphreys, R Beanland, Electron Microscopy and Analysis, 3rd edition, Taylor and Francis, London

1.	Course Code	**ME 751**
2.	Title of the Course	**Advanced Machining Processes**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Course Syllabus	**Introduction:** Types of advanced machining processes (AMPs); evolution, and need. **Mechanical Type AMPs:** process principle and elements; Mechanism of material removal, parametric analysis; Shape and material applications; Operational characteristics; Limitations of USM, AJM, WJM, AWJM processes. **Advanced Fine Finishing Process:** Process principle, process equipment, Parametric analysis, Applications of Abrasive Flow Machining (AFM); Magnetic Abrasive Finishing; Magneto Rheological Abrasive Finishing (MRF) processes. **Chemical Type AMPs:** Process principle and details of Chemical Machining (CHM); Photo-Chemical Machining (PCM), and Bio-Chemical Machining processes (BCM). **Electro Chemical Type AMPs:** ECM-Process principle, mechanism of material removal; Kinematics and dynamics and dynamics of ECM; Tooling design; Choice and analysis of process parameters; Surface finish and accuracy. **Thermal Type AMPs:** Working principle; Power circuits; Mechanism of material removal; Process parameters and characteristics; Surface finish and accuracy, Shape and materials applications, limitations of EDM, LBM, EBM, IBM, PAM processes. **Derived and Hybrid AMPs:** Introduction of processes like rotary ultra sonic machining (RUM), electro stream drilling (ESD), shaped tube electro machining (STEM), wire electro discharge machining (WEDM), electro chemical grinding (ECG), electro chemical honing (ECH), electro chemical debarring (ECD), and electro-chemical spark machining (ECSM).
7.	Suggested Books	1. G.F. Benedict, **Nontraditional Manufacturing Processes**, Marcel Dekker, Inc. New York, 1987. 2. V.K. Jain **Advanced Machining Processes**, Allied Publishers, New Delhi, 2002. 3. A. Ghosh, and A.K. Mallik, **Manufacturing Science**, Affiliated East-West Press Ltd, New Delhi, 1985. 4. P.C. Pandey, and H.S. Shan, **Modern Machining Processes**, Tata McGraw-Hill Publishing Co. Ltd, New Delhi, 1980. 5. J.A. McGeough, **Advance Methods of Machining**, Chapman and Hall, London, 1988.

1.	Course Code	**ME 752**
2.	Title of the Course	**Micro and Precision Manufacturing**
3.	Credit Structure	L-T- P-Credits 3-0-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any (for the students)	Basic courses related to manufacturing engineering ME 154, ME 208, ME 305
6.	Objectives of the course	To expose the students about the concepts of micro and precision manufacturing, the various processes involved in it and, the metrology of the micro and precision manufactured components
7.	Course Syllabus	**Micro-manufacturing:** Introduction to different mili-machining, micromachining, Nano-machining processes, Micro and nano-finishing processes, Micro-forming, Micro-joining techniques, nanotechnology processes, the related process mechanism, process parameters of these processes and their applications to production of miniaturized components. **Micro-machines:** - Introduction, Mesoscopic domain, Biological systems, cells as machines, Role of proteins, Physics of micro-mechanism, Future prospects. **Precision manufacturing:** Introduction, concept of accuracy, tolerance and fits, influence of different factors on the maintainability of accuracy of the machine tools and the product, compensation of thermal errors and location errors, effects of vibration and tool wear, dimensioning and dimensional chains. **Metrology and Characterization Techniques for Micro and Precision Manufactured Products:** Profilometric, Microscopic, diffractometric, and electron beam based techniques.
8.	Suggested Books	8. I. Fujimasa, "Micromachines: A New Era in Mechanical Engineering", Oxford Science Publications. 9. J. Paulo Davim, Mark J. Jackson, “Nano and Micromachining”, Wiley-ISTE 10. N.P. Mahalik, “Micromanufacturing and Nanotechnology", Springer 11. P.C. Pandey and H.S. Shan, "Modern Machining Processes", Tata McGraw Hill Publication. 12. V. K. Jain (Ed.), Introduction to Micromachining, Narosa Publishing House, New Delhi, 2010. 13. Yi Qin, Micromanufacturing Engineering and Technology, Elsevier, 2010 (ISBN 13: 978-0-8155-1545-6) 14. R.L. Murty, "Precision Engineering in Manufacturing", New Age International Publishers. 15. C. R. Brundle, Charles A. Evans, Shaun Wilson, Encyclopedia of materials characterization: surfaces, interfaces, thin films, Material Characterization Series, Surfaces, Interfaces, Thin Films, Butterworth-Heinemann.

1.	Course Code	**ME 754**
2.	Title of the Course	**Materials Sciences and Engineering**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Course Syllabus	**Introduction:** Materials and Engineering, Types of materials and their usage, Future trends in materials usage; **Atomic structure and bonding:** Structure of atoms, Electronic structure, Types of atomic and molecular bonding; **Crystal structure and crystal geometry:** Space lattice, crystal systems and Bravais lattices, principal metallic crystal structures, Miller indices, crystallographic planes and directions, comparisons of principle metallic crystal structures, volume and density calculations, crystal structure analysis **Phase diagram and phase transformation:** Gibbs phase rule, Binary alloy system, Iron-iron carbide diagram, Heat treatment of steels and other non ferrous materials Solidification, crystalline imperfections and diffusion in solids Electrical, optical and mechanical properties of materials **Corrosion:** Electrochemical corrosion, corrosion rates, types of corrosion, oxidation of metals and corrosion control Economic, environment and societal issues related to materials science and engineering.
7.	Suggested Books	1. W.D.Callister, Jr., "Materials Science and engineering", Wiley India (P) LTD., 2007 2. G.E.Dieter, Mechanical Metallurgy, McGraw Hill book Company (UK LTD. London, 1988 3. R.E.Reed-Hill; Physical Metallurgy Principles (4th Edition), Cengage Learning, 2003 4. Willam F. Smith, Foundations of Materials Science and Engineering, McGraw-Hill series in materials science, third edition, 2003

1.	Course Code	**ME 756**
2.	Title of the Course	**Industrial Automation**
3.	Credit Structure	L-T- P-Credits 3-0-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Course Syllabus	**Basic Concepts:** Introduction of Mechanization and Automation, Classification and Strategies of Automation, Reasons for and Arguments against Automation. Mechanical, Electrical, Hydraulic, and Pneumatic Devices and Controls **High Volume Manufacturing or Hard Automation:** Automated Flow Lines, Types of Automatic Transfer Mechanisms, Design and Fabrication Considerations, Analysis of Automated Flow Lines. **Assembly Automation:** Assembly Systems and their Types, Manual Assembly Lines and Line Balancing, Automated Assembly Lines and their Types, Automatic Assembly Transfer Systems, Automatic Feeding and Orienting Devices:- Vibratory and Mechanical Feeders and their types, Orientation of Parts, Performance and Economics of Assembly Systems, Feasibility Study for Assembly Automation. **Design for Assembly:** Design for Manual Assembly, Design for High-Speed Automatic Assembly, Design for Robotic Assembly **Programmable Automation:** Brief Introduction of Numerical Control (NC), Computer Numerical Control (CNC), Machining Centers, Programmable Robots, Direct Numerical Control (DNC), and Adaptive Control. **Flexible Automation:** Introduction of Group Technology (GT), Steps in Implementing GT, Part Families and Machine Cell Formation, Introduction of Flexible Manufacturing Systems (FMS).
7.	Suggested Books	1. M. P. Groover, *"Automation, Production systems and Computer Integrated Manufacturing"*, Prentice-Hall Inc. Englewood Cliffs, 1987. [Indian Edition from Prentice Hall of India, New Delhi]. 2. G. Boothroyd *"Assembly Automation and Product Design"*, Marcel Dekker, New York, 1992. 3. G. Boothroyd, P. Dewhurst, and W. Knight *"Product Design for Manufacture and Assembly (2nd Edition)",* Marcel Dekker, New York, 2002. 4. G. Boothroyd, C. Poli, and L. E. Murch, *"Automatic Assembly"*, Marcel Dekker Inc. New York, 1982. 5. G. Boothroyd, and A. H. Redford, *"Mechanized Assembly: Fundamentals of Parts Feeding, Orientation and Mechanized Assembly"*, McGraw Hill Publishing Co. Ltd., London, 1968.

1.	Course Code	**ME 797 (Autumn Semester)** **ME 798 (Spring Semester)**
2.	Title of the Course	Seminar Course
3.	Credit Structure	L-T-P-Credits 0-2-0-2
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Course Syllabus	In this course a PhD student has to present seminar/presentation or a series of presentations on a topic(s) chosen by him/her in consultation with his/her PhD Thesis Supervisor/ Faculty Advisor. The frequency of seminar/presentation will be decided by the Course Coordinator.
7.	Textbook	None
8.	Other references	Books and research publications in various relevant journals.

Syllabi of HSS Courses

Course Structure for PhD Programme in Philosophy

(A) Semester-I (Autumn / Spring)

Sr. No.	Course code	Course Name (L-T-P-Credits)	Type (Core/Elective)
1	HS xxx	Elective-I	Elective
2	HS xxx	Elective-II	Elective
3.	HS xxx	Elective-III^{+}	Elective
4	HS 797 * / HS 798*	Ph.D. Seminar Course (0-2-0-2)	Core

(B) Semester-II (Spring / Autumn)

Sr. No.	Course code	Course Name (L-T-P-Credits)	Type (Core/Elective)
1	HS xxx	Elective-IV $^{+}$	Elective
2	HS xxx	Elective-V $^{+}$	Elective
3	HS xxx	Elective-VI $^{+}$	Elective
4	HS 798 * / HS 797*	Ph.D. Seminar Course (0-2-0-2)	Core

Philosophy course for the Elective-I to VI (in addition these courses students can take courses from the other disciplines/schools also)

HS 602: Foundations of Knowledge (3-0-0-3)
HS 603: Epistemology (3-0-0-3)
HS 605: Social and Political Philosophy (3-0-0-3)
HS 606: Moral Philosophy (3-0-03)
HS 607: Foundation of Social Sciences (3-0-0-3)
HS 608: Nations & Nationalism (3-0-0-3)
HS 611: Philosophy of Natural Sciences (3-0-0-3)
HS 612: Contemporary Indian Thought (3-0-0-3)

+ Additional elective course to be taken by the students with MA/ MSc /BTech/BE qualification only.

* PhD Seminar course can be taken either in Autumn (HS 797) or in Spring Semester (HS 798) or both as suggested by the Faculty Advisor/Thesis Supervisor.

Core courses are compulsory.

1.	Course Code	**HS 602**	
2.	Title of the Course	**Foundations of Knowledge**	
3.	Credit Structure	L-T- P-Credits 3-0-0-3	
4.	Name of the Concerned Department	Philosophy	
5.	Pre–requisite, if any (for the students)	None	
6.	Course Syllabus	**Epistemology**	Belief-Knowledge-Truth Relationship Knowledge & Justification
		Analysis	Reason vs. Unreason Objectivity vs. Subjectivity The Relativity Problem
		Paradigms	Philosophy, Science and Society Evolutionary Epistemology vs. Social Epistemology
		Culture	Human Diversity: Need for Epistemology
7.	Suggested Books	1. Appiah, Kwame Anthony, *Thinking it Through: A Introduction to Contemporary Philosophy* (New York: OUP, 2003). 2. Boghassian, Paul A., *The Importance of Subjectivity: Selected Essays in Metaphysics and Ethics* (Oxford: Clarenden Press, 2006). 3. Cherry, Mark J. (Ed), *The Death of Metaphysics; The Death of Culture: Epistemology, Metaphysics, and Culture* (Dordrecht: Springer, 2006). 4. Edgar, Andrew and Peter Sidgwick, *Cultural Theory: Key Thinkers* (London: Routledge, 2002). 5. Goldman, Alvin I., *Knowledge in a Social World* (New York: OUP, 1995). 6. Kazen, Jean, *Philosophy and the Good Life* (Oxford: Blackwell Publishing, 1989). 7. MacIntyre, Alasdair, *The Tasks of Philosophy: Selected Essays, Vol I* (Cambridge: CUP, 2006). 8. Psillos, Stathis and Martin Curd, *The Routledge Companion to the Philosophy of Science* (London: Routledge, 2008). 9. Recanati, Francois, *Perspectical Thought: A Plea for (Moderate) Relativism* (Oxford: OUP, 2007). 10. Rorty, Richard, *Philosophy as cultural Politics: Philosophical Papers, Vol 4* (Cambridge: CUP, 2007).	

1.	Course Code	**HS 603**
2.	Title of the Course	Epistemology
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Philosophy
5.	Pre–requisite, if any	NIL
6.	Course Syllabus	1. Epistemology: Knowledge as Justified True Belief or Something *Else?* 2. Value Problem for Knowledge: Analysis and Structure of Knowledge 3. Philosophy: Use, Abuse and Redundancy of Truth 4. Philosophy and Naturalism 5. Moral Knowledge - Epistemic or Something *Else? Analytical vs. Continental Approaches*
7.	Background Readings	1. Audi, Robert, *Belief, Justification and Knowledge* (California: Wordsworth Publishing company, 1988). 2. Campbell, Richard & Bruce Hunter, *Moral Epistemology Naturalized* (Calgary: University of Calgary Press, 2000). [Canadian Journal of Philosophy Special Supplement Vol 26 (2000)] 3. Gadamer, Hans-Georg, *A Century of Philosophy: A Conversation with Riccardo Dattorir* 4. Haught, John F., *Is Nature Enough?: Meaning and Truth in the Age of Science* (Cambridge: Cambridge University Press, 2006). 5. Lihoreau, Franck, *Knowledge and Questions* (New York: Rodopi, 2008). 6. Maddy, Penelope, *Second Philosophy: A Naturalistic Method* (Oxford: Oxford University Press 7. Nagel, Thomas, *The Last Word* (New York: Oxford University Press, 1997). 8. Prichard, Duncan, Alan Millar & Adrain Haddock, *The Nature and Value of Knowledge: Three Investigations* (Oxford: Oxford University Press, 2010). 9. Thomas, Lawrence, “Moral Equality and Natural Inferiority”, *Social Theory and Practice* (2005). 10. Williams, Bernard, *Truth and Truthfulness: An Essay in Genealogy* (Princeton: Princeton University Press, 2002). 11. Williams, Bernard, *Philosophy as a Humanistic Discipline*, Ed. By A. W. Moore (Princeton: Princeton University Press, 2008).

1.	Course Code	**HS 605**
2.	Title of the Course	**Social and Political Philosophy**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Philosophy
5.	Pre–requisite, if any (for the students)	None
6.	Course Syllabus	The concept of Modernity and its philosophical underpinnings, Nationalism and its moral basis, Democracy and its forms, Secularism and its critiques, Socialism and its alternatives.
7.	Suggested Books	1. Part I in *Hegel* by Charles Taylor, Cambridge University Press, 1975 2. *The Morality of Nationalism* by Robert McKim and Jeff McMahan, Oxford University Press, 1997 3. *The Ethics of Nationalism* by Margaret Moore , Oxford University Press, 2001 4. *Secularism and its Critics* by Rajeev Bhargava, Oxford University Press, 1998 5. *Political Philosophy* edited by Anthony Quinton. Oxford University Press, 1967 6. 'Why Socialism' *in Ideas and Opinions* by Albert Einstein. Rupa and Co. Calcutta 1992 7. Selected Chapters in *Open Society and its Enemies* Volume II by Karl Popper, Princeton University Press, 1971 8. *The Burden of Democracy* by Pratap Bhanu Mehta, Penguin India, 2003 9. *Rethinking Democracy* by Rajini Kothari, Zed books, 2007

Course Code	**HS 606**
Title of the Course	**Moral Philosophy**
Credit Structure	L-T-P-Credits 3-0-0-3
Name of the Concerned Department	Philosophy
Pre–requisite, if any (for the students)	None
Course Syllabus	The Rationality of the Emotions, Objective Moral Reasons, Moral reasons in Context, Respect for persons, Obligation, Happiness, Moral Responsibility, Facts and Values, Egoism and Altruism, Utilitarianism and its rivals
Suggested Books	1. **Ethics: Key Concepts in Philosophy** by Dwight Furrow, Continuum, 2008 2. **The Moral Philosophers: An Introduction to Ethics** by Richard Norman, , 1998 3. **Moral Epistemology** by Aaron Zimmerman, Routledge, 2010 4. **Being Good: A Short Introduction to Ethics** by Simon Blackburn, Oxford University Press, 2001 5. **The Elements of Moral Philosophy** by James Rachels, McGraw-Hill Publishing, 2009 6. **Ethics: History, Theory, & Contemporary Issues** edited by Steven Cahn & Peter Markie, Oxford University Press, 2005 7. **Ethical Theory: An Anthology** edited by Russ Shafer-Landau, Blackwell, 2007

Course Code	**HS 607**
Title of the Course	**Foundations of Social Sciences**
Credit Structure	L-T-P-Credits (3-0-0-3)
Name of the Concerned Department	Philosophy
Pre–requisite, if any (for the students)	For Research Scholars
Course Syllabus	Philosophy of Social Sciences : *The Location of the Social* The Natural and the Social Order *Law and Explanation in Social Sciences* Explanation and Understanding The Interpretative Science: Uncertainty Problem Making the Social World
Suggested Books	1. Elster, Jon, *Explaining Social Behavior: More Nuts and Bolts for Social Sciences* 2. Gordon, Scoot, *The History and Philosophy of Social Science* (London: Routledge, 1991). 3. Habermas, Jurgen, *On the Logic of Social Sciences* (Harvard: MIT Press, 1988). 4. Kincaid, Harold, *Philosophical Foundations of Social Scienes: Analyzing Controversies in Social Research* (Cambridge: Cambridge University Press, 1996). 5. Manicas, Peter T., *A Realist Philosophy of Social Science: Explanation and Understanding* (ambridge: Cambridge University Press, 2006). 6. Mantzavinos, Ed., *Philosophy of the Social Sciences: Philosophical Theory and Scientific Practice* (Cambridge: Cambridge University Press, 2009). 7. Martin, Michael & Lee C. McIntyre, Ed., *Readings in the Philosophy of Social Sciences* (Messachussets: MIT Press, 1994). 8. Searle, John, *Making the Social World: The Structure of Human Civilization* (London: OUP, 2010). 9. Turner, Stephen & Paul A. Roth, *The Blackwell Guide to the Philosophy of Social Sciences* (Oxford: Blackwell Publishing, 2003).

Course Code	**HS 608**
Title of the Course	**Nations and Nationalism**
Credit Structure	L-T-P-Credits (3-0-0-3)
Name of the Concerned Department	Philosophy
Pre–requisite, if any (for the students)	None
Course Syllabus	Modernity and Nationalism, Moral Psychology of Nationalism, Co-national Partiality, Nationalism and Liberalism, Self-Determination, Citizenship.
Suggested Books	1. Anderson, Benedict. 1991. *Imagined Communities: Reflections on the Origin and Spread of Nationalism*. New York: Verso. 2. Balakrishnan, Gopal. 1996. *Mapping the Nation.* New York: Verso. 3. Chatterjee, Partha. 1999. *Nationalist Thought and the Colonial World: A Derivative Discourse?* in *The Partha Chatterjee Omnibus*. New Delhi: Oxford University Press. 4. Couture, J., K. Nielsen and M. Seymour (eds.). 1998. *Rethinking Nationalism*, *Canadian Journal of Philosophy*, Supplement Volume 22. 5. Gans, Chaim. 2003. *The Limits of Nationalism*. Cambridge: Cambridge University Press 6. Gellner, Ernest. 1983. *Nations and Nationalism*. Oxford: Blackwell. 7. Gilbert, P. 1998. *The Philosophy of Nationalism*. Boulder, Co.: West View Press. 8. Hutchinson, John and Anthony D. Smith (eds.). 1994. *Nationalism.* Oxford: Oxford University Press. 9. McKim, Robert and Jeff McMahan (eds.). 1997. *The Morality of Nationalism.* New York: Oxford University Press. 10. Moore, Margaret. 2001. *The Ethics of Nationalism*. Oxford: Oxford University Press

Course Code	**HS 611**
Title of the Course	**Philosophy of Natural Sciences**
Credit Structure	L-T-P-Credits (3-0-0-3)
Name of the Concerned Department	Philosophy
Pre–requisite, if any (for the students)	None
Course Syllabus	The Sciences of Philosophy and Philosophy of sciences, Sciences and Nature (Scientific Knowledge), Science and Progress of Knowledge, Explanation and Understanding (Physical Sciences and Biological Sciences), Inductive and Deductive Science, Philosophy and Science: Convergence and Difference.
Suggested Books	Books related to Philosophical Foundations of Science, Philosophy of Biology and critical approaches to Philosophy and Science will be referred in this course.

Course Code	**HS 612**
Title of the Course	**Contemporary Indian Thought**
Credit Structure	L-T-P-Credits (3-0-0-3)
Name of the Concerned Department	Philosophy
Pre–requisite, if any (for the students)	None
Course Syllabus	Rabindranath Tagore, Swami Vivekananda, M.K. Gandhi, V.D. Savarkar, Sri Aurobindo, Krishnachandra Bhattacharyya, B.R.Ambedkar and Jawaharlal Nehru. (The course deals with key ideas of some of the contemporary Indian thinkers. The attempt will be to focus on important debates in contemporary Indian Philosophy)
Suggested Books	1. Bhattacharya, Sabyasachi. *The Mahatma and the Poet: letters and debates between Gandhi and Tagore, 1915-1941*. 1997. New Delhi: National Book Trust. 2. Lal, B.K. *Contemporary Indian Philosophy.* 2010. Delhi: Motilal Banarasi Das. 3. Raghurama Raju, A. *Debates in Indian Philosophy: Classical, Colonial and Contemporary*. 2007. New Delhi: Oxford University Press. 4. Raju, P.T. *Structural Depths of Indian Thought.*1985. New Delhi: South Asian Publishers. 5. Moolchand. *Nationalism and Internationalism of Gandhi, Nehru and Tagore.*1989.New Delhi: M.M. Publishers. 6. Naravane, Vishwanath S. 1964. *Modern Indian Thought.* Bombay: Asia Publishing House. 7. Nagaraj D.R. "Self-purification versus Self–respect" in Raghurama Raju. A (Ed) *Debating Gandhi.* 2006.New Delhi: Oxford University Press. 8. Nehru, Jawaharlal. *The Discovery of India.*1994. New York: Oxford University Press, Centenary Edition. 9. Sharma, Chandradhar *A Critical Survey of Indian Philosophy.* 2000. Delhi: Motilal Banarasi Das.

Course Structure for PhD Programme in Economics

(A) Semester-I (Autumn / Spring)

Sr. No.	Course code	Course Name (L-T-P-Credits)	Type (Core/Elective)
1	HS 601	Research Methods in Social Sciences (3-0-0-3)	Core
2	HS 623	Advance Microeconomics-I (3-0-0-3)	Core
3.	ZZ xxx	Elective-I	Elective
4	HS 797 * / HS 798*	Ph.D. Seminar Course (0-2-0-2)	Core

(B) Semester-II (Spring / Autumn)

Sr. No.	Course code	Course Name (L-T-P-Credits)	Type (Core/Elective)
1	HS 624	HS 624: Econometrics-I (3-0-0-3)	Core
2	HS xxx	Elective-II	Elective
3	ZZ xxx	Elective-III +	Optional
4	HS 798 * / HS 797*	Ph.D. Seminar Course (0-2-0-2)	Core

Economics course for the Elective-I, II, and III (in addition these courses students can take courses from the other disciplines/schools also)

HS 626: Environmental and Natural Resource Economics (3-0-0-3)
HS 628: Institutional Economics (3-0-0-3)
HS 630: Intellectual Property Rights (2-0-0-2)
HS 724: Econometrics-II (3-0-0-3)

+ Additional elective course to be taken by the students with MA/ MSc /BTech/BE qualification only.

* PhD Seminar course can be taken either in Autumn (HS 797) or in Spring Semester (HS 798) or both as suggested by the Faculty Advisor/Thesis Supervisor.

Core courses are compulsory.

1.	Course Code	**HS 601**
2.	Title of the Course	**Research Methods in Social Sciences**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Economics
5.	Pre–requisite, if any	None
6.	Course Syllabus	Foundations- language, philosophy, conceptualization and evaluation of research; Sampling-probability and non-probability sampling; Measurement- construct validity and reliability; Survey research- types of surveys and interviews; Scaling- Thurston, Likert and Guttman scaling; Qualitative Measures- data, approaches and validity, Design- Experimental and quasi-experimental, Analysis- data preparation, descriptive statistics, hypothesis testing, multivariate analysis (inferential statistics), Report Writing.
7.	Suggested Books	1. W.T. Trochim, **Research Methods: The Concise Knowledge Base,** Atomic Dog Publisher, 2004. (ISBN: 1592601464) 2. C.R. Kothari, **Research Methodology: Methods and Techniques** (2nd edition), New Age International, 2009. 3. R.V. Hogg, A. Craig, and McKean. **Introduction to Mathematical Statistics** (6th Edition), Prentice Hall, 2004. (ISBN 130085073)

1.	Course Code	**HS 623**
2.	Title of the Course	**Advanced Microeconomics-I**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Economics
5.	Pre–requisite, if any	Some UG/PG level course on Microeconomics
6.	Course Objective	The course aims at providing students with the recent advancements in the theory of Microeconomics and take up the concepts covered at undergraduate level at higher level.
7.	Course Syllabus	Preference and Choice; Classical Demand Theory; Production; Choice Under Uncertainty Game Theory Market Equilibrium and Market Failure: Competitive Markets, Externalities and Public Goods, Market Power, Asymmetric Information Theory of Welfare, General equilibrium theory.
8.	Suggested Books	1. H.R. Varian, Microeconomic Analysis (3rd edition), W.W. Norton and Company. 1992. 2. A. Mas-Colell, M.D. Whinston, and J.R. Green, Microeconomic Theory, 2006. 3. Reading Material in form of research articles to be provided to the students.

1.	Course Code	**HS 624**
2.	Title of the Course	**Econometrics-I**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Economics
5.	Pre–requisite, if any	Research Methods in Social Sciences; Basic Statistics
6.	Course Objective	This aim of the course is to cover basic econometrics with focus on regression modeling and the problems encountered in dealing with cross-section and time series data.
7.	Course Syllabus	Methodology of econometrics; Regression analysis; Assumptions of the classical linear regression Models; Two variable regression analyses; Multiple regression analyses; Heteroscedasticity; Autocorrelation and Multicollinearity; Dummy variable regression models; Model Selection; Time Series Econometrics (introduction); Panel data regression models (introduction).
8.	Suggested Books	1. D.N. Gujarati, Basic Econometrics, The McGraw-Hill Companies. 2005. 2. G.S. Maddala, Introduction to Econometrics, (3rd Edition) Wiley, 2001. 3. J.M. Wooldridge, Introductory Econometrics: A Modern Approach, South Western, 2009.

1.	Course Code	**HS 626**
2.	Title of the Course	**Environmental and Natural Resource Economics**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Economics
5.	Pre–requisite, if any	None
6.	Course Syllabus	Environmental Challenges- Role of economics, Valuing the environment- concepts and methods, Property rights, externalities and environmental problems, sustainable development, Allocation of resources- depletable and renewable- energy, minerals, water, land; Environmental pollution- air, water; Environmental justice, Sustainability of development.
7.	Suggested Books	1. T. Tietenberg, and L. Lewis, Environmental and Natural Resource Economics (International Edition) Pearson Education, 2008 (ISBN 9780321560469). 2. J. Conrad, Resource Economics, Cambridge University Press, 1999. 3. Hanley, N., Shogren, J., and B.White, Environemntal Economics in Theory and Practice (Second Edition), Palgrave MacmIllan: UK, 2007. 4. Pearce, D., Turner, K., and I. Bateman, Environmental Economics: An Elementary Introduction, Pearson Education Ltd. : England, 1994. 5. Birnie, P., Boyle, A., and C. Redgwell, International Law and the Environment (Third Edition), Oxford University Press: Oxford, New York, 2009.

1.	Course Code	**HS 628**
2.	Title of the Course	**Institutional Economics**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Economics
5.	Pre–requisite, if any (for the students)	Microeconomics, History of Economic Thought
6.	Course Syllabus	**Introduction:** Institutions and Organizations, Structure of Institutions (formal and informal), Old and New Institutional Economics; **Transaction costs:** types and cost measurement; **Theory of property rights:** Externalities, Internalization of externalities, Coase Theorem, Common property, Collective action; **Contracts:** legal and economic approach, Asymmetric information, adverse selection, Asset plasticity and moral hazard; Institutional theory of firm, market, regulation; Institutional Change.
7.	Suggested Books	1. Eggertson, T. *Economic Behaviour and Institutions.* Cambridge: Cambridge University Press, 1990. 2. North D. *Institutions, Institutional Change and Economic Performance.* Cambridge: Cambridge University Press, 1990. 3. Furubotn, E, and R. Richter. *Institutions and Economic Theory.* The University of Michigan Press, 1997. 4. Claude, M. and M.M. Shirley (Eds.) Handbook of New Institutional Economics, US: Springer, 2008.

1.	Course Code	**HS 630**
2.	Title of the Course	**Intellectual Property Rights**
3.	Credit Structure	L-T-P-Credits 2-0-0-2
4.	Name of the Concerned Department	Economics
5.	Pre–requisite, if any (for the students)	None
6.	Course Objective	The course aims at providing the basic understanding of intellectual property rights, the rationale behind making provision for these rights and the recent concerns in the field.
7.	Course Syllabus	History and concept of Property; Introduction to intellectual property rights (IPRs); Patent, Industrial design; Copyrights, Trademarks, Geographical Indications; Trade Secrets ; International aspect of IPRs ; Developments at the International level regarding IPRs; The debate: Copyright vs Copy left ; Research ethics
8.	Suggested Books	1. Cornish, W.R. and L. David. 2010. 7th Edition. Intellectual Property: Patents, Copyrights, Trademarks and Allied Rights. Sweet and Maxwell. 2. Narayan, P. 2002. Intellectual Property, Law in India, 3rd Ed. New Delhi, Delhi Law House. 3. Ganguli, P. 2001. Intellectual Property Rights: Unleashing the Knowledge Economy. Tata McGraw Hills (Reference) 4. Watal, J. 2001. Intellectual Property Rights in the WTO and Developing Countries. New Delhi: Oxford University Press

1.	Course Code	**HS 724**
2.	Title of the Course	**Econometrics-II**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Economics
5.	Pre–requisite, if any (for the students)	**Econometrics I**
6.	Course Objective	The aim of the course is to cover econometric modeling for panel data as well as time series. It will also focus on simultaneous equation modeling and models dealing with discrete data.
7.	Course Syllabus	Classical linear regression model; Specification Analysis and Model Selection; Heteroscedasticity; Serial Correlation; Models for Panel Data; Systems of Regression Equations; Simultaneous-equation models; Models with lagged variables; Time-series models; Models for discreet choice.
8.	Suggested Books	1. Greene, W. H. 2005. *Econometric Analysis*. 5th ed. New Delhi: Pearson Education. 2. Baltagi, B.H. 2005. Econometric Analysis of Panel Data. 3rd ed. West Sussex: John Wiley & Sons. 3. J.M. Wooldridge, 2001. Econometric Analysis of Cross Section and Panel Data, MIT Press. 4. W.Enders, 2004. Applied Econometric Times Series (2nd Edition), Wiley.

Course Structure for PhD Programme in English

(A) Semester-I (Autumn / Spring)

Sr. No.	Course code	Course Name (L-T-P-Credits)	Type (Core/Elective)
1	HS xxx	Elective-I	Elective
2	HS xxx	Elective-II	Elective
3.	HS xxx	Elective-III^{+}	Elective
4	HS 797 * / HS 798*	Ph.D. Seminar Course (0-2-0-2)	Core

(B) Semester-II (Spring / Autumn)

Sr. No.	Course code	Course Name (L-T-P-Credits)	Type (Core/Elective)
1	HS xxx	Elective-IV $^{+}$	Elective
2	HS xxx	Elective-V $^{+}$	Elective
3	HS xxx	Elective-VI $^{+}$	Elective
4	HS 798 * / HS 797*	Ph.D. Seminar Course (0-2-0-2)	Core

English course for the Elective-I to VI (in addition these courses students can take courses from the other disciplines/schools also)

HS 741: Black Literary Cultures and the Slave Tradition (3-0-0-3)
HS 742: Twentieth Century and the European Novel (3-0-0-3)
HS 743: Indian English Fiction (3-0-03)
HS 744: South Asian Diaspora Literature (3-0-0-3)
HS 745: Post Colonial Theory and Criticism (3-0-0-3)
HS 746: Translation Studies (3-0-0-3)

+ Additional elective course to be taken by the students with MA/ MSc /BTech/BE qualification only.

* PhD Seminar course can be taken either in Autumn (HS 797) or in Spring Semester (HS 798) or both as suggested by the Faculty Advisor/Thesis Supervisor.

Core courses are compulsory.

1.	Course Code	**HS 741**
2.	Title of the Course	**Black Literary Cultures and the Slave Tradition**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	English
5.	Pre–requisite, if any	NIL
6.	Course Objective	The Course will focus on selected writings and excerpts from the above authors. The attempt will be to study some of these works and writers in tandem so as to trace the evolution of Black Intellectual thought and its ideational influence on Black Narratives
7.	Course Syllabus	Phillis Wheatley, **Iola Leroy,** Frances E.W. Harper, **Our Nig,** Harriet E. Wilson, Martin Delany , **Narrative of the Life of Frederick Douglass,** Frederick Douglass **The Souls of Black Folk,** W E B Du Bois, Langston Hughes, Zora Neale Hurston, James Baldwin, Richard Wright, Ralph Ellison, Harold Cruse, Angela Davis, CLR James, V.Y. Mudimbe, Achille Mbembe, Leopold Senghor, Franz Fanon, Cornel West, Samuel R Delany, Octavia Butler, Randall Keenan, Colson Whitehead,
8.	Background Readings	1. An Introduction to Africana Philosophy, Lewis Gordon 2. African American Perspectives and Philosophical Traditions, John P. Pittman 3. Blacks and Social Justice, Bernard R. Boxill. 4. The Signifying Monkey, Henry Louis Gates. 5. The Practice of Diaspora: Literature, Translation and the Rise of Black Internationalism, Brent Hayes Edwards 6. Playing in the Dark: Whiteness and the Literary Imagination, Toni Morrison. 7. African American Literary Theory: A Reader, Winston Napier

1.	Course Code	**HS 742**
2.	Title of the Course	**Twentieth Century and the European Novel**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	English
5.	Pre–requisite, if any	NIL
6.	Course Objective	An attempt will be made to position the genre as a mode of response to a period of volatility and turbulence on the European continent. The course could include selections from other genres and alternative media in order to examine concepts such as nation, state and citizenship and the way in which these concepts pan out in literary narrative.
7.	Course Syllabus	Marcel Proust – *Swan in Love* Thomas Mann – *Dr. Faustus* Franz Kafka – *The Trial* Albert Camus – *The Outsider* Joseph Roth- *The Radetsky March* Italo Calvino- *If on a winter's night a traveler*
8.	Background Readings	1. Mikhail Bakhtin, *Dialogic Imagination* 2. Milan Kundera, *The Art of the Novel* 3. Roland Barthes, **A Barthes Reader, ed. by Susan Sontag** 4. André Brink, **The Novel: Language and Narrative from Cervantes to Calvino** 5. Georg Lukács, **The Theory of the Novel** 6. Jenny Mander, **Remapping the Rise of the European Novel** 7. Christopher Nash, **World-games: the tradition of anti-realist revolt** 8. Vladimir Nabokov, *Lectures on Literature* 9. Jacques Derrida*, Spectres of Marx* 10. Giorgio Agamben*, State of Exception* 11. Alain Badiou*, Being and Event* 12. Sigmund Freud, *Civilization and its Discontents*

1.	Course Code	**HS 743**
2.	Title of the Course	**Indian English Fiction**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	English
5.	Pre–requisite, if any	NIL
6.	Course Objective	The course will make an attempt at examining the varied ways in which the notion of India has been explored by the various practitioners of Indian English fiction. Through an analysis of some of the representative Indian fiction in English and close reading of some relevant excerpts from the texts, some of the issues which may be discussed in some detail in the class are: "anxiety of Indianness", "the role of target audience in the author's depiction of India", "India as a nation state", "postcolonial India", "urban-rural divide in India", "portrayal of marginalized India on the basis of caste, class, religion, gender, region", "stereotypes and realities in depicting India", "India of Indian English Fiction versus India of Regional Language Literatures", "Indian identity", "notions of 'local', 'global', 'glocal'",etc. The list of texts mentioned are only indicative and other relevant texts could be included to explore these issues further or to bring in new perspectives. The background readings will be helpful in familiarizing the students with some of the issues at hand and their complexities.
7.	Course Syllabus	Rao, Raja. *Kanthapura,;* Narayan, R. K. *Malgudi Days;* Anand, Mulk Raj. *Untouchable;* Singh, Khushwant. *A Train To Pakistan;* Desani, G. V. *All About H. Hatter;* Rushdie, Salman. *Midnight's Children;* Tharoor, Shashi. *The Great Indian Novel;* Mathur, Anurag. *The Inscrutable Americans;* Das, Manoj. *Cyclones;* Roy, Arundhati. *God of Small Things;* Lahiri, Jhumpa. *Interpreter of Maladies;* Swarup, Vikas. *Q & A;* Deb, Siddhartha. *Surface;* Adiga, Aravind. *The White Tiger;* Raj, M. C. *Raachi*
8.	Background Readings	1. Mukherjee, Meenakshi. *The Perishable Empire: Essays on Indian Writing in English* 2. Mukherjee, Meenakshi. *The Twice Born Fiction* 3. Vijay Kumar, T, Mukherjee, Meenakshi, Harish Trivedi, et al, eds. *Focus India: Postcolonial Narratives of the Nation* 4. Mukherjee, Meenakshi. *Realism and Reality: The Novel and Society in India*. 5. Mukherjee, Meenakshi, Vijayasree, C. *Nation in Imagination* 6. Khair, Tabish. *Babu Fictions: Alienation in Contemporary Indian English Novels* 7. Naik, M. K., Narayan, Shymala, A. *Indian English Fiction: A Critical Study* 8. Bates, Crispin. *Beyond Representation: Colonial and Postcolonial Constructions of Indian Identity*

1.	Course Code	**HS 744**
2.	Title of the Course	**South Asian Diaspora Literature**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	English
5.	Pre–requisite, if any	NIL
6.	Course Objective	The concept of Diaspora as a state of deterritorialization is perhaps a common theme that runs across the various implications of the term extending but not confined to ideas of exile, displacement and migration, forced or otherwise. While recognizing that there is always a hint or trace of the roots / home that defines the cultural and historical identity of the exile / migrant the course will seek to build a healthy wariness of essentializing threads of race or ethnicity that limit discussions to those that revolve around nationhood.
7.	Course Syllabus	Paranjape, Makarand. *In Diaspora: Theories, Histories, Texts*. New Delhi: Indialog Publications, 2001; Bose, Neilesh, Ed. *Beyond Bollywood and Broadway: Plays from the South Asian Diaspora*. Bloomington: Indiana University Press, 2009 (selected plays); Baldwin, Shauna Singh. *We Are Not in Pakistan*. New Delhi: Rupa, 2009; Refiq, Fauzia, Ed. *Aurat Durbar: Writings by Women of South Asian Origin.* Toronto: Second Story Press, 1995; Diane McGifford, Ed. *Geography of Voice: Canadian Literature of the South Asian Diaspora*. Toronto: TSAR, 1992; Ghosh, Amitav. *The Shadow Lines*. London: Bloomsbuy, 1988; Kureishi, Hanif. *The Buddha of Suburbia*. New York: Viking, 1990; Mathur, Anurag. *The Inscrutable Americans*. Kolkata: Rupa & Co, 1991.
8.	Background Readings	1. Mishra, Vijay. *The Literature of the Indian Diaspora: Theorizing the Diasporic Imaginary*. New York: Routledge, 2007. 2. Nasta, Susheila. *Home Truths: Fictions of the South Asian Diaspora in Britain*. London: Palgrave Mcmillan, 2001. 3. Pirbhai, Mariam. *Mythologies of Migration, Vocabularies of Indenture: Novels of the South Asian Diaspora in Africa, the Caribbean, and Asia-Pacific.* Toronto: University of Toronto Press, 2009. 4. Rushdie, Salman. *Imaginary Homelands: Essays and Criticism, 1981-1991*. London: Granta Books, 1991.

1.	Course Code	**HS 745**
2.	Title of the Course	**Postcolonial Theory and Criticism**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	English
5.	Pre–requisite, if any	NIL
6.	Course Objective	The course will build on introductory concepts in the field of post-colonialism using them to see if a move can be made away from the advocacy of the conventional empire model. The readings of texts such as *The travels of Dean Mohammed*, *A Passage to India*, *Oroonoko*, *Mansfield Park*, *Wide Sargasso Sea*, *Heart of Darkness* and the stories of Tagore among others will strive to establish a premise for the study of postcolonial texts based on more intimate spaces such as folkways, societal ritual, language and religion, eventually helping the reader to think in terms of "imagined communities" rather than ones that are historically generated.
7.	Course Syllabus	1. Ashcroft, Bill, Gareth Griffiths, and Helen Tiffin. *The Empire Writes Back: Theory and Practice in Post-colonial Literatures.* New York: Routledge, 1989. 2. ---. *The Post-Colonial Studies Reader*. New York: Routledge, 1995. 3. Loomba, Ania. *Colonialism / Postcolonialism*. New York: Routledge, 1998. 4. Bhabha, Homi K. *The Location of Culture*. New York: Routledge, 1994. 5. ---. *Nation and Narration*. New York: Routledge, 1990. 6. Said, Edward W. *Culture and Imperialism*. New York: Knopf, 1994. 7. ---. *Orientalism*. New York: Pantheon, 1978. 8. Spivak, Gayatri Chakravorty. *In Other Worlds: Essays in Cultural Politics*. New York: Routledge, 1987. 9. Trivedi, Harish, and Meenakshi Mukherjee, eds. *Interrogating Post-Colonialism: Theory, Text and Context*. Shimla: IIAS, 1996.
8.	Background Readings	1. Fanon, Frantz. *Black Skin, White Masks*. Tr. Constance Farrington. New York: Grove Press, 1994. 2. ---. *The Wretched of the Earth*. Tr. Richard Philcox. New York: Grove Press, 2005. 3. Williams, Patrick, and Laura Chrisman, eds. *Colonial Discourse and Post-colonial Theory: A Reader*. New York: Columbia University Press, 1994. 4. Chrisman, Laura and Benita Parry. *Postcolonial Theory and Criticism.* New York: D. S. Brewer, 2000.

1.	Course Code	**HS 746**
2.	Title of the Course	**Translation Studies**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	English
5.	Pre–requisite, if any	NIL
6.	Course Objective	The course will involve a study of primary texts that have been self translated by authors such as Manoj Das, Girish Karnad, O.V.Vijayan and Rabindranath Tagore. The background readings will be helpful in familiarizing the students with some of the issues at hand and their complexities.
7.	Course Syllabus	Amos, F. R. R. *Early Theories of Translation*. New York: Octagon, 1973. Anderman, G. *Europe on Stage: Translation and Theatre*. London: Oberon Books, 2005. Bassnett, S. Translation Studies. London: Routledge, 1980. Bassnett, S. and Lefevere, A. *Constructing Cultures: Essays on Literary Translation*. Clevedon: Multilingual matters, 1998. Bassnett, S. and Trivedi, H, eds. *Postcolonial Translation: Theory and Practice*. London: Routledge, 1999. Chaudhuri, S. *Translation and Understanding*. Delhi: Oxford University Press, 1999. Cheyfitz, E. *The Poetics of Imperialism: Translation and Colonization from The Tempest to Tarzan*. London: Oxford University Press, 1991. Kothari, R. *Translating India*. Manchester: St Jerome, 2003. Lefevere, A. *Translation, Rewriting and the Manipulation of Literary Fame*. London: Routledge, 1992. Toury, G. *In Search of a Theory of Translation*. Tel Aviv: Porter Institute, 1980.
8.	Background Readings	1. Bly, R. *The Eight Stages of Translation*. Boston: Rowan Tree, 1983. 2. Cronin, M. *Translation and Globalization*. London, Routledge, 2003. 3. Katan, D. *Translating Cultures*. Manchester: St. Jerome, 2004. 4. Kreiswirth, M. and Cheetham, M. A., eds. *Theory Between the Disciplines: Authority / Vision / Politics*. Ann Arbor: The University of Michigan Press, 1990.

1.	Course Code	**HS 797 (Autumn Semester)** **HS 798 (Spring Semester)**
2.	Title of the Course	Seminar Course
3.	Credit Structure	L-T-P-Credits 0-2-0-2
4.	Name of the Concerned Department	HSS
5.	Pre–requisite, if any	None
6.	Course Syllabus	In this course a PhD student has to present seminar/presentation or a series of presentations on a topic(s) chosen by him/her in consultation with his/her PhD Thesis Supervisor/ Faculty Advisor. The frequency of seminar/presentation will be decided by the Course Coordinator.
7.	Textbook	None
8.	Other references	Books and research publications in various relevant journals.

Syllabi of Psychology Courses

Course Structure for PhD Programme in Psychology

(A) Semester-I (Autumn / Spring)

Sr. No.	Course code	Course Name (L-T-P-Credits)	Type (Core/Elective)
1	HS xxx	Elective-I	Elective
2	HS xxx	Elective-II	Elective
3.	HS xxx	Elective-III^{+}	Elective
4	HS 797 * / HS 798*	Ph.D. Seminar Course (0-2-0-2)	Core

(B) Semester-II (Spring / Autumn)

Sr. No.	Course code	Course Name (L-T-P-Credits)	Type (Core/Elective)
1	HS xxx	Elective-IV $^{+}$	Elective
2	HS xxx	Elective-V $^{+}$	Elective
3	HS xxx	Elective-VI $^{+}$	Elective
4	HS 798 * / HS 797*	Ph.D. Seminar Course (0-2-0-2)	Core

Psychology course for the Elective-I to VI (in addition these courses students can take courses from the other disciplines/schools also)

HS 671: Human Factors and Higher Cognitive Processes (2-0-2-3)

For rest elective courses, the student should choose any PG-level course from other disciplines/schools in consultation with thesis supervisor/faculty advisor and the concerned course coordinator.

+ Additional elective course to be taken by the students with MA/ MSc /BTech/BE qualification only.

* PhD Seminar course can be taken either in Autumn (HS 797) or in Spring Semester (HS 798) or both as suggested by the Faculty Advisor/Thesis Supervisor.

Core courses are compulsory.

1.	Course Code	**HS 671**
2	Title of the Course	**Human Factors and Higher Cognitive Processes**
3.	Credit Structure	L-T-P-Credit 2-0-2-3
4.	Name of the Concerned Discipline/ School	Psychology/Humanities & Social Sciences
5.	Pre-requisite, if any (for the students)	Basic Understanding of Psychology
6.	Course Objective	The aim of the course is to familiarise students with a wide range of theories and research investigating human factors. As an advanced course, the course normally covers all the areas specified in the syllabus, but students wishing to concentrate especially on particular topic areas may do so by agreement with the instructor as a part of project/practicum portion. The course has been developed to be as interesting and challenging as possible. The following are the objectives of the course: 1. To develop understanding of the breadth of different approaches to human factors practices. 2. To gain awareness of the principles and perspectives of human factors through the study of theories, concepts, and research. 3. To develop the ability to apply human factors research to real-world issues. 4. To understand how to critically appraise concepts, theories, and empirical evidence. 5. To be familiar with a range of research methods.
7.	Course Syllabus	**Understanding Human Factors:** Introduction and Background to Human Factors, Defining Design, System Thinking, and Sociotechnical System. **Human System Interaction: Affective and Cognitive Processes in System Development, Design, and Evaluation:** User & Interactive Systems, User Cognition, Emotion, HCI, Complex Systems, Human Error, Human Performance, Human Centered Engineering, Usability & Human-Centered Systems Design. **Cognitive Ergonomics:** Visual Cognition & Attention, Eye Movement, Visual Perception, and Computer Vision Syndrome. **Ergonomics Standards:** Displays, The EC directives, Technical standards. **Strategic Practices:** Social & Cultural Contexts, Design thinking, Business Design, Social Innovation, Democratic Design, Transformation. **Research Practitioner:** • Research Methods, Usability Evaluation, Reporting, Recent Developments. • Professional Issues: ISE, HFES; EACE, FEES, IEA, EAEFS, SEAES, SEANES, BCPE; Accreditation; Training & Employment.
8.	Suggested Books	**Textbooks:** 1. C. D. Wickens, J. G. Hollands. **Engineering Psychology and Human Performance** (3rd Ed.), Prentice Hall, 1999. 2. C. D. Wickens, J. L. Lee, Y. D., & Gordon-Bekcer, S. **An Introduction to Human Factors Engineering** (2nd Ed.). Upper Saddle River, NJ: Prentice Hall. 2004. **Reference Readings:** 1. M. S. Sanders & E. J. McCormick. **Human factors in Engineering and Design** (7th Ed.). New York: McGraw-Hill. 1993. 2. Pamela McCauley Bush. **Ergonomics Foundational Principles, Applications, and Technologies**. 2011. 3. Norman, D. A. **The design of everyday things**. New York: Basic Books. 2002. 4. Casey, S. M. **Set Phasers on Stun**. Santa Barbara, CA: Aegean. 1998. 5. Stanton, N., Hedge, A., Brookhuis, K., & Salas, E. (Eds.). **Handbook of human factors and ergonomics methods**. 2004.

Syllabi of Chemistry Courses

Course Structure for PhD Programme in Chemistry

(A) Semester-I (Autumn / Spring)

Sr. No.	Course code	Course Name (L-T-P-Credits)	Type (Core/Elective)
1	CH 701	Spectroscopic Techniques (2-1-0-3)	Core
2	CH XXX	Elective I	Elective
3.	CH XXX	Elective II	Elective
4	CH 797 * / CH 798*	Ph.D. Seminar Course (0-2-0-2)	Core

(B) Semester-II (Spring / Autumn)

Sr. No.	Course code	Course Name (L-T-P-Credits)	Type (Core/Elective)
1	CH XXX	Elective III	Elective
2	CH XXX	Elective IV	Elective
3	CH XXX	Elective V	Optional
4	CH 798 * / CH 797*	Ph.D. Seminar Course (0-2-0-2)	Core

Elective Courses in Chemistry

CH 703: Biological Chemistry (2-1-0-3)
CH 704: Chemistry at Surfaces and Interfaces (3-0-0-3)
CH 705: Materials Chemistry (2-1-0-3)
CH 706: Photochemistry (2-1-0-3)
CH 720: Asymmetric Synthesis (3-0-0-3)

Note:

1. MTech/MPhil qualified candidates have to do one semester coursework (with two-three PG level courses) while MSc/BTech qualified candidates have to do two semester course work (with minimum five PG level courses).

2. Core courses are compulsory.

* PhD Seminar course can be taken either in Autumn or in Spring Semester or both as suggested by the Faculty Advisor/Thesis Supervisor.

1.	Course Code	**CH 701**
2.	Title of the Course	**Spectroscopic Techniques**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Chemistry
5.	Pre–requisite	Nil
6.	Course Syllabus	**Infrared Spectroscopy:** General principles, factors influencing vibrational frequencies, selection rules, Analysis of Infra-red technique, Fourier- transform IR– Spectroscopies. Introduction to terahertz spectroscopy, Application of IR and terahertz spectroscopy Spectroscopy to inorganic and organic compounds. **Raman Spectroscopy:** Principles, normal, resonance and laser Raman Spectroscopies. Structure determination by symmetry selection rules (normal coordinate analysis). Application of Raman Spectroscopy to structural chemistry. Nuclear magnetic resonance Spectroscopy. **Elctronic spectroscopy:** General principles, Electronic absorption spectra of organic and inorganic molecules, Selection rules and their implications. Instrumentation: analytical applications: qualitative and quantitative analyses. **Luminescence Spectroscopy:** Introduction, characteristics of fluorescence and phosphorescence emission, effects of solvents on fluorescence spectra. Lippert equation, Time scale of excited state molecular processes in solution, Life times and quantum yields. Basic instrumentation, The Biochemical applications of solvent effects: localization of membrane-bound and protein- bound fluorophores, Polarization of emission, Measurements of fluorescence Polarization, Extrinsic causes of fluorescence depolarization. Effect of rotational diffusion on fluorescence anisotropies: the perrin equation. Chemical and biochemical applications of anisotropy measurements. **NMR Spectroscopy:** Nuclear magnetic resonance Spectroscopy: General principles, sensitivity of the method, CW and FT-NMR, instrumentation. Application in chemical analysis (with special reference to 1H – NMR): Chemical shift, spin-spin splitting, area of peak, shift reagents, off-resonance decoupling, Nuclear Overhauser Effect, solid state and gas phase NMR spectra. **Mass Spectrometry:** Mass spectrometry: Principles, advantages and limitations of Mass Spectrometry. Instrumentation, Methods of ionization, Metastable ions. Theory of Mass Spectrometry. Structure elucidation of inorganic and organic compounds. **X-ray-diffraction and X-ray photoelectron spectroscopy:** Basics Principles and applications. **Electron Paramagetic Resonance:** Basic Principles, Isotropic hyperfine effects, Zeeman energy, anisotropy, hyperfine anisotropy, applications **Mössbauer Spectroscopy:** Fundamentals of Mössbauer spectroscopy and applications.
7.	Suggested Books	1. C.N. Banwell, **Fundamentals of Molecular Spectroscopy** (4th edition), Tata McGraw Hill, New Delhi, 1994. 2. R.M. Silverstein, G.C. Bassler, C. Morril, **Spectrometric Identification of Organic Compounds** (5th edition), John Wiley & Sons, 1991. 3. J. R. Lakowicz**, Principles of Fluorescence Spectroscopy** (3rd edition), 2006. 4. M. Rose, and R.A.W. Johnston, **Mass Spectrometry for Chemists and Biochemists** (2nd edition), Cambridge University Press, 1996. 5. D.L. Pavia, G.M. Lampman, G.S. Kriz, **Introduction to Spectroscopy** (3rd edition), Thomson Brooks/Cole, 2000. 6. Fritz Helmet, **Mössbauer Spectroscopy** 7. J.A. Weil, and J.R. Bolton, **Electron Paramagnetic Resonance: Elementary Theory and Practical Applications.**

1.	Course Code	**CH 703**
2.	Title of the Course	**Biological Chemistry**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Chemistry
5.	Pre–requisite, if any	Nil
6.	Course Syllabus	**Bioinorganic Chemistry:** Role of metal ions in biology, principles of coordination chemistry related to bioinorganic research. Metal binding biological molecules, Metalloproteins in hydrolysis, structural role, nitrogen fixation and cycle, photosystem II, oxygen carrying agent, uptake and storage of iron, redox reactions. Use of coordination complex as model, role of metals ion in medicial chemistry and as diagonistic tool, chelation therapy. **Bio-organic Chemistry:** Weak interactions, Buffering against pH changes in biological systems. Amino acids, Peptides and proteins, The structure of proteins: primary structure, secondary structure, Protein tertiary and quaternary structures, Protein mis-folding and related to diseases. Protein data bank (pdb), Peptide self-assembly at the nanoscale. IR spectroscopy - Intra and intermolecular hydrogen bonding, effect of concentration, temperature and solvent, Application of FT-IR in the structural elucidation of protein structures. An introduction to enzymes, Enzyme kinetics, Examples of enzymatic reactions, Enzyme inhibitors. Nucleotides and nucleic acids, Nucleic acid structures, Function of nucleotides, DNA based self-assembling nanostructures. Systems chemistry: Dynamic combinatorial chemistry and molecular self-replication. **Chemistry at the cellular level:** Cell constituents, Cell separation and culture; manipulating cells, proteins, DNA and RNA; physical methods for visualizing cells and cellular events; membrane transport of small molecules across a membrane; cytoskeletal filaments and molecular motors; signal transduction; basics of stem-cell engineering; Materials in biomedical applications.
7.	Suggested Books	1. J.M. Berg, J.L. Tymoczko, L. Stryer, **Biochemistry** (6th edition) W.H. Freeman and Company, 2006. 2. M.M. Cox, D. L. Nelson, Lehninger **Principles of Biochemistry** (5th edition), W.H. Freeman and Company, 2008. 3. B. Alberts et. al. **Molecular Biology of the Cell** (4th edition) Taylor and Francis. 4. B.D. Ratner et. al. **Biomaterials Science** (2nd edition) Elsevier Academic Press, 2004. 5. S.J Lippard, J.M. Berg , **Principles of Bioinorganic Chemistry**

1.	Course Code	**CH 704**
2.	Title of the Course	**Chemistry at Surfaces and Interfaces**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Chemistry
5.	Pre–requisite, if any	Undergraduate courses on surface chemistry or physics
6.	Course Syllabus	**Introduction** to nanoscale and colloidal systems, Fundamentals of surface and interfacial chemistry. Surface tension and wettability. Insoluble monolayers. **Self-assembled monolayers (SAMs):** Growth processes, Phase transitions, Mixed monolayers, applications of SAMs. Electrostatic interactions in self-assembling systems. Self-assembly of amphiphiles. Monolayers, micelles, and microemulaions. **Adsorption phenomena:** Adsorption of surfactants at solid surfaces. Langmuir adsorption and models describing multilayer adsorption. **Immobilization of biomolecules:** strategies and applications in nanobiotechnology. Enzyme responsive surface. **Nanofabrication methods:** Bottom-up methods, photolithography, scanning probe methods, soft lithography, e-beam lithography. **Chemical functionalization:** Recent advances in thiol-Au and silane chemistry. Layer-by- layer synthesis of multilayer assemblies. Applications. **Spectroscopic and Imaging techniques:** AFM, STM, SEM, Confocal microscopy, Surface enhanced Raman spectroscopy (SERS), Imaging ellipsometry, X-ray based techniques. **Heterogeneous Catalysis:** Historical Background, Catalysis, difference between homogeneous and heterogenous catalysis, reactive interfaces, effect of structures on reactivity, catalytic materials and their preparation, activity and selectivity, measurement of catalytic properties, applications in raw materials and their conversions, environmental protection and daily life, future of catalysis.
8.	Suggested Books	1. The Colloidal Domain: Where Physics, Chemistry, Biology and Technology Meet by D. Fennell Evans and Håkan Wennerström; 1999 John-Wiley and Sons, Inc. 2. Handbook of Surface and Colloid Chemistry by K. S. Birdi, 2008 CRC press. 3. Introduction To Surface Chemistry And Catalysis by Gabor A. Somorjai, Yimin Li, 2010 John Wiley and Sons. 4. Nano: The Essentials by T. Pradeep, 2007 Tata McGraw-Hill. 5. Nanobiotechnology II: More Concepts And Applications by Chad A. Mirkin, Christof M. Niemeyer, 2007 Wiley-vch Verlag Gmbh. 6. The Basis and Applications of Heterogeneous Catalysis by Bowker Michael, 1998 Oxford University Primer. Research articles in the journals.

1.	Course Code	**CH 705**
2.	Title of the Course	**Materials Chemistry**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Chemistry
5.	Pre–requisite, if any	Nil
6.	Course Syllabus	**Chemistry at the Nano-dimension:** Introduction: definition of a nano system, top-down and bottom up approach, dimensionality and size dependent phenomena, properties of Individual nanoparticles: Metal nanoparticles, semi-conducting nanoparticles, metal oxide nanoparticles, composite nanostructures, optical properties. Synthesis of Nanomaterials: Solution chemical methods, Gas or vapor based methods of synthesis: CVD, MOCVD and MBE, Sol-gel processing, Bioconjugation, Toxicity and green chemistry approaches of synthesis. Carbon nanotubes: synthesis, properties and surface functionalization, zeolites and graphenes. Magnetic nanoparticles: Synthetic methods and properties, Diamagnetism, paramagnetism and superparamagnetism, proton relaxation, surface modification. Applications in magnetic seperation, development of MRI contrast agents. Characterization of Nanomaterials: Electron microscopes-Scanning Electron Microscope, Transmission Electron Microscopes, Scanning Tunneling Microscopy, Atomic Force Microscopy, nano-tweezers, Dynamic Light scattering, Surface enhanced Resonance Raman spectroscopy, ICP-mass. Applications of Nanomaterials: Chemical and biomedical detection, imaging and therapy, Energy conversion: PV solar cells and Photo electro-chemical cells, Lasers, LEDs, photonic crystals. **Metal Organic Frameworks:** Development of metal organic materials, guest removal and uptake, flexibility, topology and interpenetration, highly connected metal-organic framework, organometallic network, acentric and chiral network, application of metal-organic framework in nonlinear optics, selective absorption of gas and vapour, hydrogen, methane, carbon dioxide storage, magnetic materials. **Organic Electronics:** OLED, WOLED, Liquid crystalline materials. NLO materials (2nd and 3 rd order NLO materials), 2Photon and multiphoton process. Organic solar cell, OFET (n-channel and P-channel) materials.
7.	Suggested Books	1. C.P. Poole, and F.J. Owens, **Introduction to Nanotechnology**, Wiley-India, 2006. 2. G.A. Ozin, C. Andre, and L. Arsenault, Cademartiri, **Nanochemistry: A chemical Approach to Nanomaterials**, Royal Society of Chemistry, 2005. 3. T. Pradeep, **NANO: The Essentials**, Tata-McGraw Hill, New Delhi, 2007. 4. K.J. Klabunde, **Nanoscale Materials in Chemistry**, Wiley-interscience, 2001. 5. Bharat Bhushan (Ed.) **Springer Handbook of Nanotechnology**, Springer, 2007. Some recent publications in the reputed journals.

1.	Course Code	**CH 706**
2.	Title of the Course	**Photochemistry**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Chemistry
5.	Pre–requisite, if any	Nil
6.	Course Syllabus	**Theories of electronic spectroscopy:** Introduction: Absorption, Scattering, reflection and emission, Light/Photon: Sources of light/photon, light detectors, Chromophores: From synthetic to naturally occurring chromophores **Reactivity of electronic excited states of molecules:** Excited state deactivation pathways, Excited state reactions: excimers, exciplexes, electron transfer, energy transfer, proton transfer. Some photochemical organic reactions. **Natural photochemical processes and application:** Mechanism of vision, Photosynthesis, Photo dynamic therapy (PDT)
7.	Suggested Books	1) “Fundamentals of photochemistry” by K.K. Rahatgi and K. K. Mukherjee. 2) “Modern Molecular photochemistry” by Nicholas J. Turro.

1.	Course Code	**CH 720**
2.	Title of the Course	**Asymmetric Synthesis**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Chemistry
5.	Pre–requisite	Nil
6.	Course Syllabus	**Part-I: Principles of asymmetric synthesis** **Introduction and terminology:** Topocity in molecules Homotopic, stereoheterotopic (enantiotopic and diastereotopic) groups and faces- symmetry, substitution and addition criteria. Prochirality nomenclature: Pro-R, Pro-S, Re and Si. **Selectivity in synthesis:** Stereo specific reactions (substrate stereoselectivity). Stereo selective reactions (product stereoselectivity): Enantioselectivity and diastereoselectivity. Conditions for stereoselectivity: Symmetry and transition state criteria, kinetic and thermodynamic control. Methods for inducing enantio and diastereoselectivity. **Analytical methods:** % Enantiomer excess, % enantioselectivity , optical purity, % diastereomeric excess and % diastereoselectivity. Techniques for determination of enantioselectivity: Specific rotation, Chiral 1H NMR, Chiral lanthanide shift reagents and Chiral HPLC, Chiral GC. **Part-II: Methodology of asymmetric synthesis:** Classification of asymmetric reactions into 1.substrate controlled, 2. chiral auxiliary controlled, 3. chiral reagent controlled and 4. chiral catalyst controlled. **1. Substrate controlled asymmetric synthesis:** Nucleophilic additions to chiral carbonyl compounds. 1, 2- asymmetric induction, Cram's rule and Felkin-Anh model. **2. Chiral auxiliary controlled asymmetric synthesis:** α-Alkylation of chiral enolates, azaenolates, imines and hydrazones. Chiral sulfoxides. 1, 4-Asymmetric induction and Prelog's rule. Use of chiral auxiliaries in Diels-Alder and Cope reactions. **3. Chiral reagent controlled asymmetric synthesis**: Asymmetric reductions using BINAL-H. Asymmetric hydroboration using IPC2 BH and IPCBH2. Reductions with CBS reagent. **4. Chiral catalyst controlled asymmetric synthesis**: Sharpless, Jacobsen and Shi asymmetric epoxidations. Sharpless asymmetric dihydroxylation and amino hydroxylation. Asymmetric hydrogenations using chiral Wilkinson biphosphine and Noyori catalysts. Chiral catalyst controlled Diels- Alder and Michael reactions, Organocatalytic mediated asymmetric synthesis. **Part-III: Total Synthesis of Biological Active Compounds**
7.	Suggested Books	1. Nasipuri, D., **Stereochemistry of Organic Compounds,** New Age Publications, 2nd Ed, 1994 2. Eliel, E. *et. al.* **Stereochemistry of Organic Compounds**, Wiley-Interscience, 1994. 3. Carruthers, *et. al.* **Modern Methods of Organic Synthesis**, Cambridge University Press, 4th Ed. 2005 4. Robert E. Gawley, R. E. Gawley, J. Aube, **Principles of Asymmetric Synthesis** Pergamon Title, Annotated Ed. 2004, 5. Nogradi, M.; **Stereoselective Synthesis: A Practical Approach,** Wiley-VCH, 2nd Ed. 1994. 6. List. B. et.al. **Asymmetric Organocatalysis**, Springer 1st Ed. 2010 7. Song, C. E.; **Cinchona Alkaloids in Synthesis and Catalysis: Ligands, Immobilization and Organocatalysis,** Wiley-vch Verlag Gmbh, 2009

1.	Course Code	**CH 797 (Autumn Semester)** **CH 798 (Spring Semester)**
2.	Title of the Course	Seminar Course
3.	Credit Structure	L-T-P-Credits 0-2-0-2
4.	Name of the Concerned Department	Chemistry
5.	Pre–requisite, if any	None
6.	Course Syllabus	In this course a PhD student has to present seminar/presentation or a series of presentations on a topic(s) chosen by him/her in consultation with his/her PhD Thesis Supervisor/ Faculty Advisor. The frequency of seminar/presentation will be decided by the Course Coordinator.
7.	Textbook	None
8.	Other references	Books and research publications in various journals

Syllabi of Mathematics Courses

Course Structure for PhD program in Mathematics

(A) Semester-I (Autumn / Spring)

Sr. No.	Course code	Course Name (L-T-P-Credits)	Type (Core/Elective)
1	MA 601	Topology (3-0-0-3)	Core
2	MA 703	Topics in Analysis (3-0-0-3)	Core
3	ZZ xxx	Elective-I (3-0-0-3)	Elective
4	MA 797 */ MA 798*	Seminar Course (0-2-0-2)	Core

(B) Semester-II (Spring / Autumn)

Sr. No.	Course code	Course Name (L-T-P-Credits)	Type (Core/Elective)
1	MA 702	Conformal Mappings (3-0-0-3)	Core
2	MA 704	Probability Theory (3-0-0-3)	Core
3	MA 706	Numerical Linear Algebra (3-0-0-3)	Core
2	ZZ xxx	Elective-II	Elective
5	MA 798 * / MA 797*	Seminar Course (0-2-0-2)	Core

Mathematics course for the Elective-I and Elective-II (in addition these courses students can take courses from the other disciplines / School)

MA 701: Experimental Designs and Data Analysis (3-0-0-3)
MA 705: Applied Operator Theory
MA 707: Special Functions
MA 708: Ergodic Theory (3-0-0-3)
MA 709: Advance Numerical Methods for Linear Control Systems
MA 710: Fractional Differential Equations
MA 712: Advanced Analysis

Note:

1. MTech/MPhil qualified candidates have to do one semester coursework (with two-three PG level courses) while MSc/BTech qualified candidates have to do two semester course work (with minimum five PG level courses).

2. Core courses are compulsory.

* PhD Seminar course can be taken either in Autumn or in Spring Semester or both as suggested by the Faculty Advisor/Thesis Supervisor.

1.	Course Code	**MA 601**
2.	Title of the Course	**Topology**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Discipline/Department	Mathematics
5.	Pre–requisite, if any (for the students)	An M. Sc. Level course in real and complex analysis
6.	Course Syllabus	**Overview of General Topology:** Topological spaces, separation axioms, products, metrisation, function spaces, uniform spaces, topological groups **Overview of Algebraic Topology:** Paths, homotopy, fundamental group, category theory, chain complexes, homology and cohomology, simplicial and singular homology and cohomology, applications, cup product **Overview of Differential Topology:** Differentiable manifolds, tangent spaces, embeddings, differential forms, deRham cohomology
7.	Suggested Books	1. James R. Munkres, Topology, Second Edition,Prentice Hall, 2000 2. James R. Munkres, Elements of Algebraic Topology,Addison-Wesley, 3. Edwin H. Spanier, Algebraic Topology, Springer, 1994 4. Marvin J. Greenberg and John R. Harper,Algebraic Topology – A First Course,Benjamin/Cummings, 1981 5. Victor Guillemin and Alan Pollack, Differential Topology,Prentice-Hall, 1974 6. John Milnor,Topology from the Differential Viewpoint,Princeto University Press, 1997 7. D. B. Fuks and V. A. Rokhlin, Beginner's course in Topology, Springer-Verlag 1984

1.	Course Code	**MA 701**
2.	Title of the Course	**Experimental Designs and Data Analysis**
3.	Credit Structure	L-T- P-Credits 3-0-0-3
4.	Name of the Concerned Department	All the Engineering Departments
5.	Pre–requisite, if any	Nil
6.	Course Syllabus	Review of standard discrete and continuous statistical distributions. Sampling distributions such as chi-square, Student's t and, F-distribution. Estimation and Tests of Hypotheses. Regression and Correlation Analysis. Test for independence and goodness of fit. Non-parametric tests. Analysis of Variance (ANOVA): One way and Two way classification. Analysis of Covariance (ANCOVA). Experimental Designs: CRD, RBD, LSD, BIBD. Split plot and missing plot technique. Orthogonal Arrays: Application to Taguchi Method. Introduction to Response Surface Methodology (RSM).
7.	Suggested Books	1. R.E. Walpole, **Probability and Statistics for Engineers and Scientists**, Prentice-Hall-Gale, 1998. (ISBN:0138402086.) 2. D.C. Montgomery, **Design and Analysis of Experiments** (5^{th} edition), John Wiley & Sons (Asia) Pte. Ltd. Singapore, 2004. (ISBN: 0471316490). 3. R. Y. Myers, et al., **Response Surface Methodology: Process and Product Optimization using Designed Experiments** (3^{rd} edition), Wiley, 2009. 4. M.S. Phadke, **Quality Engineering Using Robust Design**, Prentice Hall, Englewood Cliff, New Jersey, 1989.

1.	Course Code	**MA 702**
2.	Title of the Course	**Conformal Mappings**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Mathematics
5.	Pre–requisite, if any (for the students)	Complex Analysis
6.	Course Syllabus	**Preliminaries:** Analytic functions, Basic theorems, The Riemann sphere, Möbius transformations, Cross ratio, Inverse points, Characterization of maps between special domains. **Conformal Mappings:** Definition of conformal maps, Disk automorphism, Schwarz's lemma, Schwarz-Pick's lemma, The hyperbolic metric in the unit disk, The upper half plane model. **The Riemann Mapping Theorem:** Normal families, The Riemann mapping theorem, the hyperbolic metric in simply connected domains, The Schwarz reflection principle, The Schwarz-Christoffel mappings. **Quasiconformal Mappings:** Conformal and quasiconformal maps, Introduction to Grötzsch problem, Complex dilatation, Definition of quasiconformal maps, Solution to Grötzsch problem, Composition maps, Extremal length, Geometric definition of quasiconformal maps, Mori's theorem.
7.	Suggested Books	1. Lars V. Ahlfors, Complex Analysis, McGrawHill, 1996. 2. T.W. Gamelin, Complex Analysis, Springer (Corrected edition), 2001. 3. S. Ponnusamy and H. Silverman, Complex Variables with Applications, Birkhauser, 2006. 4. Zeev Nehari, Conformal Mapping, Dover Publications, 1982. 5. L. Keen and N. Lakic, Hyperbolic Geometry from a Local Viewpoint (London Mathematical Society Student Texts), Cambridge University Press, 2007. 6. Lars V. Ahlfors, Lectures on Quasiconformal Mappings, American Mathematical Society (Second Edition with additional chapters by C.J. Earle and I. Kra, M. Shishikura, J.H. Hubbard), 2006. (Originally published by D. Van Nostrand Company, Inc. 1966) 7. O. Lehto and K.I. Virtanen, Quasiconformal mappings in the plane, Springer, 1973. 8. O. Lehto, Book Title: Univalent functions and Teichmüller spaces, Springer, 1986. 9. K. Asthala, T. Iwaniec, and G. Martin, Elliptic Partial Differential Equations and Quasi-conformal Mappings in the Plane, Princeton University Press, 2008.

16.	Course Code	**MA 703**
17.	Title of the Course	**Topics in Analysis**
18.	Credit Structure	L-T-P-Credits 3-0-0-3
19.	Name of the Concerned Discipline/Department	Mathematics
20.	Pre–requisite, if any (for the students)	Real Analysis, Complex Analysis, Functional Analysis, Fourier Series
21.	Course Syllabus	Functions of bounded variations, Riemann-Stieltjes Integration, Riemann Mapping Theorem, Univalent Functions, Bieberbach's Theorem, Hadamard's three circle theorem, Riemann's Zeta Function, Continuous but no where differentiable functions (example), Weierstrass approximation theorem (Stone-Weierstrass Theorem), Hahn Banach Theorem, Fourier series, Dirichlet's Theorem, Fejer's Theorem.
22.	Suggested Books	1. H.M. Edwards, Riemann's Zeta Function, Dover Publications; Dover 2. Ed edition, 2001, ISBN: 9780486417400. 3. E.C. Titchmarsh, The theory of the Riemann Zeta-Function, Oxford 4. University Press, USA; 2 edition, 1987, ISBN: 9780198533696. 5. Walter Rudin, Principles of mathematical analysis (3rd. ed.), McGraw-Hill, 1976, ISBN: 978-0070542358. 6. Walter Rudin, Functional analysis, McGraw-Hill, 1973, ISBN: 7. 9780070542365. 8. Peter L. Duren, Univalent Functions, Springer-Verlag Berlin and 9. Heidelberg GmbH & Co. K, 1983, ISBN: 9783540907954. 10. Georgi P. Tolstov, Fourier Series, Dover Publications, 1976, ISBN: 978-0486633176. 11. G.H. Hardy and W.W. Rogosinski, Fourier Series, Dover Publications 1999, 978-0486406817.

1.	Course Code	**MA 704**
2.	Title of the Course	**Probability Theory**
3.	Credit Structure	L-T-P-Credits 3-0- 0-3
4.	Name of the Concerned Department	Mathematics
5.	Pre–requisite, if any (for the students)	Measure Theory
6.	Course Syllabus	Probability Space, Random Variables, Kolmogorov Consistency Theorem, Independence and Dependence, Weak and Strong law of large numbers, Central Limit Theorem, Characteristic Function, Levy's Inversion Formula, Levy's Continuity Theorem, Conditional Expectation, Martingales, Markov Chains, Wiener Process, Stationary Process, Entropy and its Applications, Large Deviations.
7.	Suggested Books	1. Daniel W. Stroock, Probability Theory, an Analytic View, Cambridge University Press; Revised edition (January, 2000), ISBN-10: 0521663490, ISBN-13: 978-0521663496. 2. Krishna B. Athreya and Soumendra Lahiri, Probability Theory, Hindusthan Book Agency, 2006, ISBN: 978-81-85931-70-8. 3. A.N. Kolmogorov, Foundations of the Theory of Probability, Chelsea Pub Co, 2nd edition,1960 (ISBN: 9780828400237) 4. K.R. Parthasarathy, Introduction to Probability and Measure (Texts & Readings in Mathematic), Hindustan Book Agency, New Delhi, 2005. (ISBN: 9788185931555) 5. W. Feller, An Introduction to Probability Theory and Its Applications, Wiley, 3 edition,1968. (ISBN: 9780471257080)

1.	Course Code	**MA 705**
2.	Title of the Course	**Applied Operator Theory**
3.	Credit Structure	L-T- P-Credits 3-0-0-3
4.	Name of the Concerned Department	Mathematics
5.	Pre–requisite, if any (for the students)	Real Analysis, Complex Analysis and Linear Algebra.
6.	Objectives of the course	Familiarize the basic concepts of functional analysis and their application in solving various operator equations
7.	Course Syllabus	Normed Linear Space, Linear Transformations, Zorn's Lemma, Hamel Basis and Hahn-Banach Theorem, The Baire Theorem and Uniform Boundedness Theorem, The interior mapping and closed mapping Theorems, Weak convergence, Reflexive Space. Hilbert Spaces, Orthogonality and Bases, Linear functonals and operators, Spectral Theory, Strum-Liouville Theory. Calculus in Banch spaces, The Frechet Derivative, The chain Rule and Mean value Theorems Basic Approximate methods of Analysis, The method of iteration, Regularization method, Projection methods, The Galerkin method, The Rayleigh-Ritz method, Conjucate Direction methods, Methods Based on Homotopy and continuation.
8.	Suggested Books	1. W. Cheney, *Analysis for Applied Mathematics,* Springer, 2001. ISBN: 978-0-387-95279-6 2. E. Zeidler, *Applied Functional Analysis: Applications to Mathematical Physics,* Springer 1995. ISBN: 978-0387944425 3. L.P. Lebedev, I.I. Vorovich and G.M.L. Gladwell, *Functional Analysis: Applications in Mechanics and Inverse Problems,* Kluwer Academic Publishers, 2002. ISBN: 978-1402006678 4. L. Collatz, *Functional Analysis and Numerical Mathematics*, Springer-Verlag New York ,1966. 5. J.T. Oden and L.F. Demkowicz, *Applied Functional Analysis* CRC-Press, 1996. ISBN: 978-0849325519

1.	Course Code	**MA 706**
2.	Title of the Course	**Numerical Linear Algebra**
3.	Credit Structure	3-0-0-3
4.	Name of the Concerned Department	Mathematics
5.	Pre–requisite, if any (for the students)	Knowledge of basic linear algebra.
6.	Course Objective	Problems in Numerical Linear Algebra arise in a wide variety of scientific and engineering applications including the control theory, the analysis of electrical networks, and the modeling of chemical processes. This course will cover the analysis and implementation of algorithms used to solve linear algebra problems. We will study algorithms for linear systems solution, linear least-square problems, and eigenvalue and singular value problems. Further, we study the sensitivity and stability analysis of the above algorithms to improve efficiency of problems by using various structures of matrices.
6.	Course Syllabus	Floating point error, Round off error, Gram-Schmidt orthonormal process, Modified Gram-Schmidt orthonormal process, **Solution of linear system:** Triangular systems and Inverse of a triangle matrix, Gauss elimination and LU Factorization method, QR factorization, QR Algorithm. Rank deficient least square problems, SVD, Moore Penrose inverse, Linear iterative methods – Convergence results for Jacobi & Gauss - Seidel and relaxation method. Stationary & non stationary iterative methods Convergence analysis of the Richardson method, the gradient method, the Conjugate gradient method. Method based on Krylov subspace Arnoldi method, the GMRES, The Lanczos method. Approximation of Eigen value: Power method, Inverse iteration, Sensitivity analysis of Eigen values and Eigen vectors, canonical forms of matrices, Reduction to Hessenberg and tridiagonal form, conditioning of numerical algorithms. Applications to control, H_∞ control, Distance problems. Analysis of electric network. Finite Difference analysis of ordinary differential equation- Beam bending problem. Finite difference analysis of partial differential equation-Heat equation. Applications to Internet search engine-Google Matrix.
7.	Suggested Books	1. G. H. Golub and V. Van Loan, Matrix Computations, third edition, John Hopkins U.Press, Baltimore, 1996. 2. C. Pozrikidis, Numerical Computation in Science and Engineering, Oxford University Press, 1998. 3. A. Quarteroni, R. Sacco, and S. Fausto, Numerical Mathematics, second edition Springer-Berlin Heidelberg, 2007. 4. K. Bryan and T. Leise, The $ 25,000,000,000 eigenvector: The Linear Algebra Behind Google, SIAM Review, 48, 569-581. 5. David S. Watkins, Fundamentals of Matrix Computations, Wiley 3rd edition. 6. James W. Demmel, Applied Numerical Linear Algebra, 1st edition, SIAM 1997. 7. B. N. Datta, Numerical Linear Algebra and Application 2nd edition SIAM 8. B. N. Datta, Numerical Methods for Control Systems Design and Analysis, Elsevier Academic Press, 2003.

1.	Course Code	**MA 707**
2.	Title of the Course	**Special Functions**
3.	Credit Structure	3-0-0-3
4.	Name of the Concerned Department	Mathematics
5.	Pre–requisite, if any (for the students)	Basic complex analysis and differential equations
6.	Course Syllabus	**Preliminaries:** Infinite product; Gamma function; Beta function **Hypergeometric Functions:** Integral form; The contiguous function relation; Hypergeometric differential equation; Logarithmic solution; Relation between functions of z and 1-z **Bessel's Functions:** Definition; Bessel's differential equation; Recurrence relation; A generating function; Bessel's integral; Modified Bessel's function **Generating Functions:** Functions of the form G(2xt-t^2); Functions of the form exp(t) ψ(xt); Functions of the form A(t) exp(-xt/(1-t)) **Orthogonal Polynomials:** Legendre polynomial; Hermite polynomial; Laguerre polynomial; Jacobi polynomial
7.	Suggested Books	1. Earl D. Rainville, *Special Functions*, Chelsea Pub. Co. NY, 1971. ISBN: 978-0828402583 2. G.E. Andrews, R. Askey, and R. Roy, *Special Functions*, Cambidge University Press, 1999. ISBN: 978-0521623216 3. R. Beals and R. Wong, *Special Functions: A Graduate Text*, Cambidge University Press, 2010. ISBN: 978-0521197977 4. N.M. Temme, *Special Functions, An Introduction to the Classical Functions of Mathematical Physics*, Wiley-Interscience, 1996. ISBN:978-0471113133 5. A.M. Mathai and H.J. Haubold, *Special Functions for Applied Scientists*, Springer, 2008. ISBN: 978-0387758930 6. W.W. Bell, *Special Functions for Scientists and Engineers*, Dover Publication, 2004. ISBN: 978-0486435213

1.	Course Code	**MA 708**
2.	Title of the Course	**Ergodic Theory**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Mathematics
5.	Pre–requisite, if any (for the students)	Measure Theory
6.	Course Syllabus	Measure Preserving and Continuous Transformation, Poincare's recurrence Lemma, Ergodic Theorems, Ergodicity, Mixing and weak mixing and their Spectral Characterizations, isomorphism invariants, Discrete Spectrum Theorem, Entropy and Kolmogorov, Sinai Theorem, Stacking method of constructing transformations, Ambrose theorem on representation of flows. Van der Waerden's theorem on arithmetical Progressions.
7.	Suggested Books	1. I.P. Cornfeld, S.V. Fomin, and Ya G. Sinai, Ergodic Theory, Springer-Verlag Berlin and Heidelberg GmbH Co. K (December 31,1982), ISBN-10: 3540905804, ISBN-13: 978-3540905806. 2. P. Walters, An Introduction to Ergodic Theory (Graduate Texts in Mathematics), Springer, 2000. (ISBN: 9780387951522) 3. M.G. Nadkarni, Basic Ergodic Theory, Hindusthan Book Agency, 1995.

1.	Course Code	**MA 709**
2.	Title of the Course	**Advance Numerical Methods for Linear Control Systems**
3.	Credit Structure	3-0-0-3
4.	Name of the Concerned Discipline/Department	Mathematics
5.	Pre–requisite, if any (for the students)	Basic Linear Algebra and Numerical Linear Algebra Techniques
6	Objectives of the course	Modern Numerical linear techniques for mathematical problems arising in the design and analysis of linear control systems both for the first-order and second-order models. In this course we impose systematic descriptions and implementations of numerical algorithms based on well-established, efficient, and stable manner so that it will be help full to solve the various problems on design and analysis of linear control systems.
7.	Course Syllabus	Review of Basic Concepts and Results from Theoretical Linear Algebra; Fundamental Tools and Concepts from Numerical Linear Algebra; Canonical Forms Obtained via Orthogonal Transformations; Linear State Space Models and Solutions of the State Equations; Controllability, Observability and Distance to Uncontrollability; Stability, Inertia and Robust Stability; Numerical Solutions and Conditioning of Lyapunov and Sylvester Equations; Numerical Methods and Conditioning of the Eigenvalue Assignment Problems; State Estimation; Numerical Solutions and Conditioning of Algebraic Riccati Equations;
8.	Suggested Books	1. B. N. Dutta, *Numerical Methods for Linear Control System,* Elsevier Academic Press, 2003 2. G. H. Golub and V. Van Loan, *Matrix Computations,* 3rd edition, John Hopkins U. Press, Baltimore, 1996. 3. B. N. Dutta, *Numerical Linear Algebra and Application,* 2nd edition, SIAM.

1.	Course Code	**MA 710**
2.	Title of the Course	**Fractional Differential Equations**
3.	Credit Structure	L-T- P-Credits 3-0-0-3
4.	Name of the Concerned Department	Mathematics
5.	Pre–requisite, if any (for the students)	Real Analysis
6.	Objectives of the course	Answering the following questions 1. Why do we need fractional calculus / fractional differential equation? 2. How to solve the fractional differential equations explicitly? 3. When does the fractional differential equations have unique solutions?
7.	Course Syllabus	Introduction to Fractional calculus, Grunwald-Letnikov Fractional Derivatives, Riemann-Liouville Fractional Derivatives, Caputo's Fractional Derivative. Introduction to Fractional Differential Equation, Explicit solution of fractional differential equation via Integral Transform Methods. Existence and Uniqueness Theorem for initial value problem, boundary value problem. Fractional delay differential equation.
8.	Suggested Books	1. A.A. Kilbas, H.M. Srivastava and J.J. Trujillo, *Theory and Applications of fractional differential equations*, Elsevier, USA, 2006. ISBN: 978-0-444-51832-3. 2. I. Podlubny, *Fractional Differential Equations*, Academic Press, USA, 1999. ISBN: 978-0-12-558840-2. 3. K. Diethelm, *The analysis of fractional differential Equations*, Springer, New York, 2010. ISBN: 978-3-642-14573-5. 4. R. Hilfer, *Applications of fractional calculus in physics*, World Scientific, Singapore, 2000. ISBN: 978-9810234577

1.	Course Code	**MA 712**
2.	Title of the Course	**Advanced Analysis**
3.	Credit Structure	3-0-0-3
4.	Name of the Concerned Discipline/Department	Mathematics
5.	Pre–requisite, if any (for the students)	Basic functional analysis
6.	Objectives of the Course	It is the fundamental course for research scholars in the Discipline of Mathematics. This course will enable them to understand various branches in Mathematics.
7.	Course Syllabus	Review of general measure and integral; Positive Borel measures; Riesz representation theorem; Luzin's theorem; Vitali Caratheodory theorem. Lp-spaces and their dense subspaces, Elementary Hilbert space theory, Examples of Banch space Techniques, Complex measures; Absolute continuity; Radon-Nykodym theorem, Product measures; Fubini's theorem; Convolutions.
8.	Suggested Books	1. W. Rudin, *Real and Complex Analysis*, Third edition, McGraw-Hill, International Editions, 1986. ISBN: 978-0070542341 2. H.L. Royden, *Real Analysis* (3rd ed.), Prentice Hall, 1988, ISBN: 978-0024041517 3. I.K. Rana, *An Introduction to Measure and Integration*, Alpha Science International Limited, 2004. ISBN: 978-1842651049 4. P.R. Halmos, *Measure Theory*, Springer-Verlag, 1974. ISBN: 978-0387900889

1.	Course Code	**MA 797 (Autumn Semester)** **MA 798 (Srping Semester)**
2.	Title of the Course	PhD Seminar Course
3.	Credit Structure	L-T-P-Credits 0-2-0-2
4.	Name of the Concerned Department	Mathematics
5.	Pre–requisite, if any	None
6.	Course Syllabus	In this course a PhD student has to present seminar/presentation or a series of presentations on a topic(s) chosen by him/her in consultation with his/her PhD Thesis Supervisor/ Faculty Advisor. The frequency of seminar/presentation will be decided by the Course Coordinator.
7.	Textbook	None
8.	Other references	Books and research publications in various journals

Syllabi of Physics Courses

Course Structure for PhD Programme in Physics

(A) Semester-I (Autumn / Spring)

Sr. No.	Course code	Course Name (L-T-P-Credits)	Type (Core/Elective)
1	PH 601	Electrodynamics (3-0-0-3)	Core
2	PH 651	Mathematical Methods (3-0-0-3)	Core
3.	PH xxx	Elective-I	Elective
4	PH 797 * / PH 798*	Ph.D. Seminar Course (0-2-0-2)	Core

(B) Semester-II (Spring / Autumn)

Sr. No.	Course code	Course Name (L-T-P-Credits)	Type (Core/Elective)
1	PH 610	Quantum Mechanics (3-0-0-3)	Core
2	PH 620	Statistical Mechanics (3-0-0-3)	Core
3	PH 650	Numerical Methods (2-0-2-3)	Core
4	PH 798 * / PH 797*	Ph.D. Seminar Course (0-2-0-2)	Core

Physics course for the Elective-I

PH 621: Solid State Physics (3-0-0-3)
PH 671: Relativity, Cosmology and Early Universe
PH 761: Theoretical Particle Physics (3-0-0-3)
PH 765: Experimental Techniques in High Energy Physics (3-0-0-3)
PH 781: Theory of complex systems (2-0-2-3)

Note:

1. MTech/MPhil qualified candidates have to do one semester coursework (with two-three PG level courses) while MSc/BTech qualified candidates have to do two semester course work (with minimum five PG level courses).

2. All core courses are compulsory in semester-I (Autumn).

3. Only two courses out of the three core courses PH 610, PH 620 and PH 650 are compulsory in semester-II (Spring).

* PhD Seminar course can be taken either in Autumn or in Spring Semester or both as suggested by the Faculty Advisor/Thesis Supervisor.

1.	Course Code	**PH 601**
2.	Title of the Course	**Electrodynamics**
3.	Credit Structure	L-T- P-Credits 3-0-0-3
4.	Name of the Concerned Department	Physics
5.	Pre–requisite, if any (for the students)	Vector calculus and Special Theory of Relativity
6.	Course Syllabus	Review of Electromagnetism: Vector Calculus, Greens Function, Coulomb's law, Gauss theorem, Laplace's equation, Poisson's equation, electrostatics with conductors, capacitors, dielectrics, Biot Savart's law, Ampere's law, Lorentz force. Faradays' law, Lenz's law, self and mutual inductance, energy in a magnetic field Electrodynamics: Maxwell's equations, displacement current, electromagnetic waves, plane wave solutions of Maxwell's equations, Maxwell's equations in conducting media, Poynting vector, wave propagation through a boundary, reflection, refraction, absorption and skin depth. Wave Guides, Resonant Cavities, Potentials and Fields, Radiating systems, Multipole Fields and Radiation, Scattering and diffraction, Relativistic Electrodynamics
7.	Suggested Books	**Text:** 1. Classical Electrodynamics- J.D. Jackson, 3rd edition, John-Wiley & Sons, 1998 2. Classical Electrodynamics- W. Greiner, Springer International Edition **References:** 1. David J. Griffiths, Introduction to Electrodynamics, 3rd edition, Prentice Hall, 1989 2. The Feynman Lectures on Physics, R. P. Feynman et al, Narosa Publishing, 2008 3. Foundations of Electromagnetic Theory, J. R. Ritz et al., Pearson, 4th edition

1.	Course Code	**PH 610**
2.	Title of the Course	**Quantum Mechanics**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Physics
5.	Pre–requisite, if any	An undergraduate course in Quantum Mechanics is preferred, though not necessary.
6.	Course Objective	To impart a systematic exposition of basic concepts, techniques and methods in quantum mechanics to the graduate students so that they can confidently apply them in various fields of study and research.
7.	Course Syllabus	**Fundamental Concepts** : The Stern-Gerlach experiment, Kets bras and operators, Base kets and matrix representations, Measurements, observables and the uncertainty relations, change of basis, position , momentum and translation, wave functions in position and momentum space **Quantum dynamics** : Time evolution and the Schrodinger equation, The Schrodinger versus the Heisenberg picture, Simple harmonic oscillator, Schrodinger's wave equation **Theory of angular momentum** : Rotation and angular momentum commutation relations, spin ½ systems and finite rotations, SO(3), SU(2) and Euler rotations, Density operators and pure vs mixed ensembles, Eigenvalues and eigenstates of angular momentum, Orbital angular momentum, addition of angular momenta, Tensor operators **Approximation methods** : Time independent perturbation theory (Non degenerate case), Time-independent perturbation theory (The dependent case), hydrogen like atoms (Fine structure and Zeeman effect), Variational methods, Time dependent potentials (The interaction picture), Time dependent perturbation theory, Energy shift and decay width **Scattering theory**: The Lippman-Schwinger equation, Optical theorem. Born approximation, Free particle states (Plane waves vs spherical waves), method of partial waves.
8.	Textbook	1. Modern quantum mechanics by J.J. Sakurai.
9.	Other references	1. "Quantum mechanics" by E. Merzbacher, 3rd edition. 2. "Quantum mechanics" by A. Messiah. 3. "Quantum mechanics", Course of theoretical physics, Vol. 3, 3rd edition by L. Landau and L. Liftshitz. 4. "A Modern Approach to Quantum Mechanics" by J. Townsend. 5. "Quantum Mechanics" (Feynman lectures of physics vol. 3) by R. Feynman. 6. "Quantum mechanics" by Schiff. 7. "Lectures on Quantum Mechanics" by G Baym. 8. "Quantum Mechanics" by C. Cohen-Tannoudji, B. Diu, F. Laloë. 9. "Quantum mechanics" by A. S. Davydov. 10. "Principles of Quantum Mechanics" by R. Shankar

1.	Course Code	**PH 620**
2.	Title of the Course	**Statistical Mechanics**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Physics
5.	Pre–requisite, if any	
6.	Course Syllabus	Review of thermodynamics, Basic Principles, Microcanonical ensemble, Canonical ensemble, Grand canonical ensemble. Semi-classical systems, Unified treatment of ideal Fermi and Bose systems, Bose condensation, Degenerate Fermi gas, Basic phenomenology of phase transitions, Ising model, **Phase transition:** the renormalization group approach, Dynamics of thermal fluctuations, The Langevin and generalized Langevin equations.
7.	Textbook	1. R. K. Pathria, Statistical Mechanics. Oxford, New York
8.	Other references	1. K. Huang, Statistical Mechanics 2. W. Greiner, L. Neise and H. Stoker, Thermodynamics and statistical Mechanics 3. D. Chandler, Introduction to Modern Statistical Physics. 4. Recommendation for background to the mathematics: G. Arfken, Mathematical methods for physicists.

1.	Course Code	**PH 621**
2.	Title of the Course	**Solid state physics**
3.	Credit Structure	3-0-0-3
4.	Name of the Concerned Discipline/Department	Physics
5.	Pre–requisite, if any (for the students)	None
6.	Course Objective	To expose graduate students to a broad range of theoretical concepts, ideas and approaches applied in solid state physics and condensed matter, emphasizing those based on quantum mechanics and collective phenomena. In addition, this course gives exposure to students to major current fields of research in this subject.
6.	Course Syllabus	Sommerfield theory, Crystal structure and symmetry, Reciprocal lattice, Bloch Theorem, electrons in weak periodic potential, Band structure, tight binding method, semiclassical method of electron dynamics, de Haas-van Alphen effect and other Fermi surface probes, Hartree-Fock equations, Screening, Thomas-Fermi theory, Fermi Liquid theory, classical and quantum theory of harmonic crystals, phonons, electron-phonon interactions, diamagnetism and paramagnetism, magnetic structure, ordering and properties, superconductivity and superfluids.
7	Textbook	"Solid State physics" by Ashcroft and Mermin
8.	Suggested References	1. "Introduction ot solid state physics" by Charles Kittel 2. "Condensed matter physics" by Micheal P. Marder 3. "Solid State Physics" by Grosso and Parravicini 4. "Advanced solid state physics" by Philips and Philips 5. "Theory of solids" by Ziman 6. "Introduction to superconductivity" by Tinkham 7. "Quantum phase transitions" by Subir Sachdev 8. "Condensed matter field theory" by Atlands and Simons 9. "Quantum field theory of many particle systems" by Fetter and Walecka

1.	Course Code	**PH 650**
2.	Title of the Course	**Numerical Methods**
3.	Credit Structure	L-T-P-Credits 2-0-2-3
4.	Name of the Concerned Department	Physics
5.	Pre–requisite, if any	Basic Knowledge of Computer and any computer language
6.	Course Syllabus	**Computational Algorithms**: Structure of a Computer, some examples of algorithms **Computer Arithmetic**: Floating point representation of numbers, errors in numbers, Binary representation of numbers **Iterative Methods**: The method of successive bisection, the method of false position, Newton Raphson Iterative method, The Secant method, The method of successive approximations **Solution of simultaneous Algebraic Equations:** Gauss elimination method, gauss Siedel iterative method **Interpolation:** Lagrange interpolation **Least Squares approximation of Functions:** Linear regression, polynomial regression A**pproximation of functions:** Taylor Series representation, Chebyshev series **Differentiation and Integration:** Simpson's rule, Gaussian quadrature formulae **Numerical Solution of Differential equations:** Euler's method, Taylor Series method, Runge-Kutta method, Predictor-corrector method
7.	Textbook	23. 1. V. Rajaraman, Computer oriented numerical methods , Prentice-Hall of India
8.	Other references	1. James M. Ortega, Andrew S. Grimshaw, An Introduction to C++ and Numerical Methods , Oxford University Press, USA 2. B.H. Flowers An Introduction to Numerical Methods in C++, Oxford university Press 3. Bradley L. Jones, Sams Teach Yourself C++ in 21 Days Sams; 5 edition (December, 2004)

1.	Course Code	**PH 651**
2.	Title of the Course	**Mathematical Methods**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Discipline/Department	Physics
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	To provide with the concept and understanding of mathematical methods to students.
6.	Course Syllabus	Single and multiple valued complex variables, singularities, poles and branch points, Cauchy's conditions and theorem, mapping, dispersion relations Ordinary differential equations, partial differential equations, first and second order equations, homogeneous and nonhomogeneous equations, singular points, series solutions. Review of linear algebra, vector analysis, tensors, determinants and matrices. General properties of Fourier series, advantages and applications of Fourier series, Fourier transforms.
7.	Suggested Books	1. G. B. Arfken and H. J. Weber, Mathematical Methods for Physicists, 6th Edition, Academic Press, 2005. 2. S. Hassani, Mathematical Physics: A modern introduction to its foundations, Springer-Verlag, 1999. 3. J. Mathews and R. L. Walker, Mathematical Methods of Physics. 4. Mathematical Physics: Basics by S. D. Joglekar, Universities Press (India) Prv. Ltd. (2009) 5. Mathematical Methods for Physics and Engineering by K. F. Riley, M. P. Hobson and S. J. Bence (3rd Edition), Cambridge University Press.

1.	Course Code	**PH 671**
2.	Title of the Course	**Relativity, Cosmology and the Early Universe**
3.	Credit Structure	L-T- P-Credits 3-0-0-3
4.	Name of the Department	Physics
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	This course aims to introduce students to cosmology through an understanding of the General Theory of Relativity. Special emphasis will be placed on linear perturbation theory in the early universe, leading to the formation of the cosmic microwave background, as this illustrates basic undergraduate physics in the context of the frontiers of research in cosmology.
7.	Course Syllabus	1. Introduction to Special Relativity 2. Introduction to General Relativity, Newtonian approximation, Schwarzschild metric, Classic test(s) of General Relativity 3. Friedmann equations, density parameters and cosmological models, Redshift, Particle and event horizon, Cosmic distance ladder 4. Cosmic Microwave Background, Structure Formation, Inflation 5. Current Research Topics in Cosmology (Dark Matter, Galaxy Clusters, Dark Energy, Secondary Effects in the Cosmic Microwave Background
8.	Suggested Books	1. Ryden, Barbara, *Introduction to Cosmology,* Addison Wesley, 2003. ISBN: 0-8053-8912-1 2. Dodelson, Scott, *Modern Cosmology,* Academic Press, 2003. ISBN: 0-1221-9141-2. 3. Carroll, Sean, *Spacetime and Geometry: An Introduction to General Relativity,* 2003. ISBN: 0-8053-8732-2. 4. Peacock, John A. *Cosmological Physics,* Cambridge University Press, 1998. ISBN: 9780521422703 5. Longir, Malcolm S., *Galaxy Formation,* Springer, 2008. ISBN 6. Peebles, P. J. E., Principles of Physical Cosmology, Princeton University Press, 1993. ISBN: 0-6910-1933-9. 7. Peebles, P. J. E., *Large-Scale Structure of the Universe,* Princeton University Press, 1980. ISBN: 0-6910-8240-5. 8. Lyth, David H. & Liddle, Andrew R., *The Primordial Density Perturbation,* Cambridge University Press, 2008. ISBN: 0-5218-2849-X. 9. Mukhanov, Viatcheslav, *Physical Foundations of Cosmology,* Cambridge University Press, 2005. ISBN: 0-5215-6398-4. 10. Weinberg, Steven, *Cosmology,* Oxford University Press, 2008. ISBN: 0- 1985-2682-7. 11. Durrer, Ruth, *The Cosmic Microwave Background,* CUP 2008. 12. Overbye, Dennis, *Lonely Hearts of the Cosmos,* Back Bay Books, 1999. ISBN: 0-3166-4896-5. 13. Weinberg, Steven, *The First Three Minutes,* Basic Books, 1993. ISBN: 0- 4650-2437-8. Of these, 1-3 to be used as core texts and 4-6 as supplementary texts.

1.	Course Code	**PH 761**
2.	Title of the Course	**Theoretical Particle Physics**
3.	Credit Structure	L-T- P-Credits 3-0-0-3
4.	Name of the Concerned Department	Physics
5.	Pre–requisite, if any (for the students)	Quantum Mechanics, Special Theory of Relativity.
6.	Course Syllabus	Relativistic Quantum Mechanics: Klein Gordon Equation, Dirac Equation, Dirac Algebra. Quantum Filed Theory: Canonical Quantization, S-Matrix. Feynman Diagrams. Quantum Electrodynamics: Tree level and higher order processes, Renormalization. Lie groups. Gauge theory, weak interactions and standard model. Beyond standard model physics.
7.	Suggested Books	1. Quarks and Leptons: Introductory Course in Modern Particle Physics, Halzen & Martin. 2. Introduction to Elementary Particles, Griffiths. 3. Quantum Field Theory, Peskin & Schroeder. 4. Gauge Theory of elementary particle physics, Cheng & Li.

1.	Course Code	**PH 765**
2.	Title of the Course	**Experimental Techniques in High Energy Physics**
3.	Credit Structure	L-T- P-Credits 3-0-0-3
4.	Name of the Concerned Department	Physics
5.	Pre–requisite, if any (for the students)	Special Theory of Relativity and Particle Physics
6.	Objective	To familiarize students in the frontiers of detectors used in high energy experiments, the physics of quark-gluon plasma, hadron physics and techniques to handle large-scale data.
7.	Course Syllabus	Interaction of Radiation with Matter: The Bethe-Bloch formula for energy loss, Minimum Ionizing particle (MIP), Cherenkov Radiation, Radiation length, Bremsstrahlung, Interaction of Photon, Electron-Photon Showers Detectors for Particle Identification (principles and applications): Energy Resolution, The Fano Factor, Detector Efficiency, Read-out and Dead Time, Gaseous Ionization Detectors, Proportional Counters, Multi Wire Proportional Counter, Photon Multiplicity Detector, Drift Chamber, Time Projection Chamber, Time of Flight Detector, Muon Chamber, Transition Radiation Detector, Calorimeters (Electromagnetic and Hadronic Calorimeters), Silicon Detectors for tracking, Scintillation Detectors and Photomultipliers. Accelerator Physics: Concepts of van de Graff, Cyclotron and Linac, Colliders and Fixed target Experiments, Luminosity, Cross-sections, Concept of Event Triggering Data Analysis Techniques, Error Analysis in High Energy Experiments, Analysis framework and ROOT. Hadron Physics: Transition form factors, Medium modification of vector mesons, Verification of chiral perturbation theory Relativistic Kinematics and Quark Gluon Plasma (QGP): Signals of QGP, QGP Physics from AGS, SPS, RHIC to LHC.
8.	Suggested Books (Authors, Book Title, Publisher, Year of Publication, ISBN)	1. Techniques for Nuclear and Particle Physics Experiments- W.R. Leo, 2nd edition, Narosa Publishing 2. Radiation Detection and Measurement- G.F. Knoll, 3rd edition, John-Wiely and Sons. 3. Introduction to High Energy Heavy-Ion Collisions- C.Y. Wong, World Scientific publishing, 1994 4. Ultra-Relativistic Heavy Ion Collisions- R. Vogt, 1st edition, Elsevier Publishing, 2007 5. The Physics of the Quark-Gluon Plasma- S. Sarkar et al, Springer, 2010, ISBN 978-3-642-02285-2 6. An Introduction to Error Analysis- J. R. Taylor, 2nd edition, University Science Books 7. Data Reduction and Error Analysis- P.R. Bevington, D.K. Rabinson, 3rd edition, Mc Graw Hill. 8. Hadron Physics- Ralf Kaiser, Taylor & Francis, 2006 9. Hadron Physics- Alex H. Blin, American Institute of Physics, 2000

1.	Course Code	**PH 781**
2.	Title of the Course	**Theory of Complex Systems**
3.	Credit Structure	L-T- P-Credits 2-0-2-3
4.	Name of the Concerned Department	Physics
5.	Pre–requisite, if any (for the students)	Knowledge of elementary probability, statistics and differential equations. Programming knowledge of language such as Fortran, C or JAVA.
6.	Course Syllabus	**Introduction to Dynamical systems and Chaos:** Discrete dynamical systems: iterative maps; attractor; orbits; fixed and periodic points; graphical analysis; phase portraits; bifurcations; higher dimensional flows (Lorenz attractor) **Methods in Complex Systems: the basic concepts:** emergence (with emphasis on synchronization, pattern formation), complexity and evolution; relation with fractals and chaos. **Network theory:** random graph, the small-world phenomenon and preferential attachment; random networks; small-world networks; scale-free networks. Examples of complex systems studied under complex network framework: physical, biological, chemical, social and engineered (e.g. neural networks; traffic flow; artificial life; financial markets and human societies, WWW; brain as a complex network; human metabolic chemical system etc.). **Spectral graph theory:** structural versus spectral analysis, spectra of random matrices/graphs, spectra of networks with structure, eigenvector localization, graph L:aplacian and its applications. Adaptative dynamics: various models (examples from social systems, and neural systems)** **Introduction to Cellular automata:** cellular automation rules; Cellular automata as models of complex systems: artificial life; stock market dynamics sandpile model; percolation** **Game theory:** Competition and cooperation; prisoner's dilemma; rock-scissor-paper model (depending upon time and interests of audience).
7.	Suggested Books	1. D. Sornette, Critical Phenomena in Natural Sciences: Chaos, Fractals, Self-organization and Disorder: Concepts and Tools Springer-Verlag, 2nd Edition (2003). 2. Robert Hilborn, Chaos and non-linear dynamics: An introduction for scientists and Engineers, Oxford University Press, Oxford (2000) 3. Robert Devaney, Differential equations, dynamical systems, and introductions to chaos (pure and applied mathematics) Academic Press, USA (2004). 4. Michael Tabor, Chaos and Integrability in non-linear dynamics: An introduction, John Wiley and Sons (1989). 5. B. Bollobas, Modern graph theory, Springer-Verlag, New York (1998). 6. N. Dorogovtsev and J. F. F. Mendes, Evolution of Networks, Oxford University Press, Oxford (2003). 7. S. Wasserman and K. Faust, Social Network Analysis, Cambridge University Press, Cambridge (1994). 8. C. D. Meyer, Matrix analysis and applied linear algebra, SIAM, Philadelphia, PA (2000).

1.	Course Code	**PH 797 (Autumn Semester)** **PH 798 (Spring Semester)**
2.	Title of the Course	PhD Seminar Course
3.	Credit Structure	L-T-P-Credits 0-2-0-2
4.	Name of the Concerned Department	Physics
5.	Pre–requisite, if any	None
6.	Course Syllabus	In this course a PhD student has to present seminar/presentation or a series of presentations on a topic(s) chosen by him/her in consultation with his/her PhD Thesis Supervisor/ Faculty Advisor. The frequency of seminar/presentation will be decided by the Course Coordinator.
7.	Textbook	None
8.	Other references	Books and research publications in various journals