Name of Academic Unit: Biosciences & Bioengineering
Level: Ph.D.
Program: Ph.D.

i	**Title of the Course**	Molecular Biology of Cancer
ii	**Credit Structure (L-T-P-C)**	(3-0-0-6)
iii	**Type of Course**	Ph.D. Course
iv	**Semester in which normally to be offered**	Autumn/Winter
v	**Whether full or half semester Course**	Full Semester
vi	**Pre-requisite(s), if any (for the students)- specify the course number(s)**	-
vii	**Course Content**	• Describe the six hallmarks of cancer • Explain the types of gene mutations possible and how these mutations can contribute to cancer formation • Describe an oncogene and why it is important in cancer development • Explain the cell cycle, its regulation, and how cell cycle dysfunction can lead to cancer • Describe the function of tumor suppressor genes • Explain how external or internal stimuli can lead to apoptosis • Clarify how cancer cells escape cell death • List and describe the steps that lead to metastasis • Give details on how chronic inflammation and infectious agents can lead to cancer • Explain the role of diet in cancer development and cancer prevention
viii	**Texts/References (separate sheet may be used, if needed)**	1. The Biology of Cancer: Robert A. Weinberg, Garland Science 2014, Second Edition. 2. Principles of Cancer Biology: Lewis J. Kleinsmith, Pearson 2016, First Edition. 3. Biology of Cancer: Dorothy Lobo, Pearson Education 2012, Second Revised Edition. 4. The Biology of Cancer: Janice Gabriel, John Wiley & Sons Inc 2007, Second Edition.
ix	**Name(s) of Instructor(s)**	Dr. Sudhanshu Shukla
x	**Name(s) of other departments/academic units to whom course is relevant**	NA
xi	**Is/Are there any Course(s) in the same/ other academic unit(s) which is/are equivalent to this course? If so, please give details**	No

xii	**Justification/ Need for introducing the course**	This course explores the biology of cancer. It focuses on the cellular and molecular biology of cancer. Specifically, study the nature of cancer, cellular oncogenes, cellular signaling mechanisms, tumor suppressor genes, and the maintenance of genomic integrity. It also includes the regulation of the cell cycle, apoptosis, cellular immortalization, tumorigenesis, angiogenesis, and metastasis. Finally, examining how modern molecular medicine is being used to treat cancer. It is necessary for students to undertake this course, as this will give basic background for the current research in the field.

4. Topics in Chemistry

Name of Academic Unit: Chemistry
Level: Ph.D.
Programme: Ph.D.

i	**Title of the course**	**Topics in Chemistry**
ii	**Credit Structure (L-T-P-C)**	**(3-0-1-8)**
iii	**Type of Course**	Core course
iv	**Semester in which normally to be offered**	Autumn
v	**Whether Full or Half Semester Course**	Full
vi	**Pre-requisite(s), if any (For the students) – *specify course number(s)***	Nil
vii	**Course Content***	**Organic and Inorganic: Chemistry of Materials** • Introduction to materials, Periodic table, its physical and chemical properties of elements, Introduction to solid state chemistry -1&2, Carbon chemistry – physical and chemical properties, Bulk to nano transition - physical phenomena, 3D, 2D, 1D, OD nano systems, Introduction to nanoscience and nanotechnology - Metals, semiconductors, Introduction to nanoscience and nanotechnology -Carbon nanotubes, fullerenes, Quantum dots. • Systems under technological importance - Naturally occurring materials, Optical and magnetic systems based on metals, • Inorganic semiconductors - optical materials, magnetic materials • Organic semiconductors -optoelectronic materials, optoelectronic materials Self-assemblies of nanoparticles, Nano systems - catalysis, Surface coating technology, High temperature superconductivity, Application of high temperature superconductivity, Complex metal oxide, Giant magneto resistance, Spintronic. •Chemical and non-chemical approach to materials synthesis - Solution based material synthesis - Precipitation methods, hydrothermal etc., Solution based materials synthesis - Micro-emulsion, Sol-gel, Phase transfer reactions, Synthesis and properties of monolayer capped metal nanoparticles, Material synthesis using microwave radiation and ultra-sonic waves, Solid state synthesis, Hybrid methods for materials synthesis - synthesis of rational shaped molecules and semiconductors.

		•Modern Characterization of materials (SEM, TEM, XPS, AFM, powder X-ray etc., Routine characterization tools-UV-visible spectrophotometer, Fluorimeter, NMR, IR, Particle size analyzer, Powder X-ray microscopy). **Physical: Ab Initio Molecular Orbital Theory** SCF and HartreeFock Methods, Roothan Equations, Configuration Interaction, Density Functional Theory, Perturbation theory and applications.
Viii	**Texts/References**	J. D. Lee, Concise Inorganic Chemistry, Fifth edition, Blackwell publishing (2008) Robert T. Morrison, Robert N. Boyd, and Robert K. Boyd, Organic Chemistry, 6th edition Benjamin Cummings, (1992) Charles P. Poole Jr. Frank J. Owens, Introduction to Nanotechnology, John Wiley & Sons, Inc. (2003) Nan Yao, Zong Lin Wang, Handbook of Microscopy for Nanotechnology, Kluwer academic publishers, London (2005) Pople, J.A. and Beveridge, D.L. Approximate Molecular Orbital Theory. McGraw-Hill, New York. (1970) Ab Initio Molecular Orbital Theory by W. J. Hehre, L. Radom, P. v. R. Schleyer, and J. A. Pople, John Wiley, New York, 548, (1986) Modern Quantum Chemistry: Introduction to Advanced Electronic Structure Theory, by Attila Szabo, Neil S. Ostlund, Dover Publications, New York (2000) Introductory Quantum Chemistry/Quantum Mechanics Books by authors such as Pilar, McQuarrie, Pauling and Wilson, NPTEL Web and Video courses in quantum chemistry and computational chemistry
ix	**Name(s) of Instructor(s) *** **	B.L.Tembe and Rajeswara Rao M
x	**Name(s) of other Departments/ Academic Unitsto whom the course is relevant**	NA
xi	**Is/Are there any course(s) in the same/ other academic unit(s) which is/ are equivalent to this course? If so, please give details.**	NA
xii	**Justification/ Need for introducing the course**	This course provides all round (physical, organic and Inorganic) essential concepts for PhD students

3. Optical and electronic properties of π-conjugated compounds

Name of Academic Unit: Chemistry
Level: Ph.D.
Programme: Ph.D.

i	**Title of the course**	**Optical and electronic properties of π-conjugated compounds**
ii	**Credit Structure (L-T-P-C)**	**(3-0-0-6)**
iii	**Type of Course**	Core course
iv	**Semester in which normally to be offered**	Spring
v	**Whether Full or Half Semester Course**	Full
vi	**Pre-requisite(s), if any (For the students) –** ***specify course number(s)***	Nil
vii	**Course Content***	Principles of photochemistry and electrochemistry• Optical and electronic properties of polycyclic aromatic compounds; Organic one-dimensional (1D) and 2D polymers and Metal based π-conjugated compounds• Applications of π-conjugated compounds; Principles of photochemistry • Resonance energy transfer (RET), Fluorescence resonance energy transfer (FRET), excited-state intramolecular proton transfer (ESIPT) mechanisms • Solid-state optical properties: aggregation-induced enhanced emissions • Optical and electronic properties of polycyclic aromatic compounds • metal-organic based p-conjugated molecules • Organic one-dimensional (1D) and 2D polymers and Metal-based π-conjugated compounds • Electronic properties of p-conjugated compounds: fundamentals of electrochemical techniques • HOMO and LUMO and band gap evaluations • spectroelectrochemistry • Electrochemical sensors • Applications of π-conjugated compounds for optoelectronic applications: OLEDs, solar cells, OLETs, etc.
Viii	**Texts/References**	1. Organic optoelectronic materials (lecture notes in Chemistry) 2015th edition by Yongfang Li 2. Photochemistry of organic compounds: from concepts to practice (first edition) by Petr Klan and JakobWirz
ix	**Name(s) of Instructor(s) *****	Rajeswara Rao M
x	**Name(s) of other Departments/ Academic Unitsto whom the course is relevant**	NA
xi	**Is/Are there any course(s) in the same/ other academic unit(s) which is/ are equivalent to this course? If so, please give details.**	NA
xii	**Justification/ Need for introducing the course**	

2. Molecular Spectroscopy

Name of Academic Unit: Chemistry
Level: Ph.D.
Programme: Ph.D.

i	**Title of the course**	**Molecular spectroscopy**
ii	**Credit Structure (L-T-P-C)**	**(3-0-0-6)**
iii	**Type of Course**	Core course
iv	**Semester in which normally to be offered**	Spring
v	**Whether Full or Half Semester Course**	Full
vi	**Pre-requisite(s), if any**	Nil
vii	**Course Content***	**NMR spectroscopy:** Basic principles of ^{1}H-NMR, instrumentation and interpretation of NMR spectrum, chemical shift: principles, chemical shift values of major organic compound classes, and factors affecting chemical shift**,** spin-spin coupling, spin systems, coupling with other nuclei, 2D-NMR (COSY, TOCSY), NOE (NOESY)**,** ^{13}C-NMR-principles and chemical shifts for major organic compound classes**,** ^{1}H-^{13}C-2D NMR (HSQC, HMBC), DEPT, ^{31}P and ^{19}F-NMR and applications of NMR in chemistry and biology. **Mass Spectrometry:** Instrumentation and techniques (ionization techniques, mass analysers, and detection techniques, tandem MS or MS/MS, LC-MS, GC-MS, MALDI-TOF-MS etc.)**,** interpretation of mass spectra**,** fragmentation patterns of major organic compound classes including rearrangement reactions and applications of mass spectrometry in chemistry and biology**.**
Viii	**Texts/References**	1. R. Silverstein, F. Webster, D. Kiemle, and D. Bryce "Spectrometric identification of organic compounds", 8th Ed., Wiley, 2015. 2. P. Crews, J. Rodriguez, and M. Jaspars, "Organic structure analysis", 2nd Ed., OUP USA, 2009. 3. D. Williams and I. Fleming, "Spectroscopic methods in organic chemistry", 6th Ed., McGraw Hill Education, 2011. 4. W. Kemp, "Organic spectroscopy", 2nd Ed., Red Globe Press, 2019. 5. D. Pavia "Introduction to spectroscopy" Cengage Learning India Private Ltd., 5th Ed., 2015. 6. C. Banwell and E. McCash "Fundamentals of molecular spectroscopy" 4th Ed., McGraw Hill Education, 2017. 7. K. Chary and G. Govil "NMR in biological systems: from molecules to human" 1st Ed., Springer, 2008.
ix	**Name(s) of Instructor(s) *****	Nilkamal Mahanta
x	**Name(s) of other Departments/ Academic Units to whom the course is relevant**	BSBE
xi	**Is/Are there any course(s) in the same/ other academic unit(s) which is/ are equivalent to this course? If so, please give details.**	NA
xii	**Justification/ Need for introducing the course**	This course will provide strong foundation for understanding the methods and techniques used for the identification and detection of chemical and biological compounds and their structure elucidation using the principles/applications of NMR spectroscopy and mass spectrometry. This course is suited for MS/PhD students of chemistry/biochemistry and will provide the platform to carry out further advanced courses and conduct research in different interdisciplinary areas of chemical sciences and life sciences.

Name of Academic Unit: Computer Science and Engineering
Level: MS/Ph.D.
Programme: MS/Ph.D.

i	**Title** of the course	Advanced Computer Architecture
ii	Credit Structure (**L-T-P-C**)	**(3 0 3 9)**
iii	**Type** of Course	Elective course
iv	Semester in which normally to be offered	Spring
v	Whether **Full or Half Semester** Course	Full
vi	**Prerequisite(s)**, if	Computer Architecture
vii	Course **Content***	Instruction-level parallelism: out-of-order pipelines; Thread-level parallelism: multi-core, multi-threading, memory hierarchies, coherence and consistency, on-chip networks; Data-level parallelism: vector processing, GPUs; optimizations and enhancements: modern branch predictors, instruction and data prefetchers, value speculation.
viii	Texts/References	*Textbook:* *(1) Computer Architecture: A Quantitative Approach, David Patterson and John L. Hennesy, Elsevier, Sixth edition. 2017* *Reference:* *(1) Processor Microarchitecture: An Implementation Perspective. Antonio Gonzalez, Fernando Latorre, and Grigorios Magklis. Synthesis Lectures on Computer Architecture. 2011. (available online)* *(2) A Primer on Memory Consistency and Cache Coherence, Daniel Sorin, Mark Hill, and David Wood, Morgan and Claypool Publishers, 2011* *(3) On-chip Networks: Second edition, Natalie Enright Jerger, Tushar Krishna, Li-Shiuan Peh, Morgan and Claypool Publishers, 2017* *(4) Parallel Computer Architecture, David Culler, Jaswinder Pal Singh, Anoop Gupta, Elsevier, 1998*
ix	Name(s) of **Instructor(s)** ***	Gayathri A/ Rajshekhar
x	Name(s) of **other Departments/ Academic Units to whom** the course is **relevant**	EE
xi	Is/Are there any course(s) in the same/ other academic unit(s) which is/ are **equivalent** to this course? If so, please give details.	No

xii	**Justification/ Need** for introducing the course	The basic Computer Architecture course introduces the student to processor design, and enables them to understand the working of simple embedded processors and controllers. The processors that go into servers and even desktops are significantly more advanced. This course will enable the student to understand many aspects of a modern processor. This course is essential for anyone who wishes to work/ research in the area of processor design.

Name of Academic Unit: Computer Science and Engineering
Level: B. Tech/MS/PhD
Program: B. Tech /MS/PhD

i	**Title of the course**	FPGA for communication networks prototyping
ii	**Credit Structure (L-T-P-C)**	3-0-0-6
iii	**Type of Course**	Elective
iv	**Semester in which normally to be offered**	Spring
v	**Whether Full or Half Semester Course**	Full
vi	**Pre-requisite(s), if any (For the students) – *specify course number(s)***	EE 224 Digital System Exposure on Computer Network
vii	**Course Content**	*History and evaluation of FPGAs* *FPGA architecture* *Introduction to Quartus Prime (vendors and design tools; vendors and programmable logic)* *Exploiting Simulation tools (e.g., ModelSim)* *Exploiting FPGAs for multi-domain technologies* *Introduction to radio access networks-fronthaul (e.g., common public radio interface), optical network (e.g, implementation of dynamic bandwidth allocation algorithms), metro and core networks* *Cross-layer design* *The role of FPGA in the above specified network segments and use case scenarios* *In and Out* *Clocks and Registers* *State Machines* *Modular Design* *Memories* *Managing Clocks* *I/O Flavors* *Qsys, Nios II* *Conversion of USB to Ethernet* *triple speed Ethernet* *Low Latency 10G Ethernet*
viii	**Texts/References**	1. C. Maxfield, “The Design Warrior's Guide to FPGAs: Devices, Tools and Flows”, Jun. 2004, eISBN 9780080477138 2. FPGAs For Dummies, 2nd Intel Special Edition. Published by. John Wiley & Sons, Inc 3. William J. Dally, R. Curtis Harting, “Digital Design: A Systems Approach 1st Edition”, Cambridge University Press, September 2012, ISBN 9780521199506 4. Verilog by Example: A Concise Introduction for FPGA Design, Blaine C. Readler 5. Course materials: Slides; Notes; Tutorials from Altera website https://www.altera.com/support/training/university/materials-tutorials.html

		6. R. Ramaswami, K. Sivarajan, G. Sasaki; "Optical Networks: A Practical Perspective," 3rd Ed., Morgan Kaufmann, ISBN: 9780123740922
ix	**Name(s) of Instructor(s)**	Koteswararao Kondepu
x	**Name(s) of other Departments/ Academic Units to whom the course is relevant**	EE
xi	**Is/Are there any course(s) in the same/ other academic unit(s) which is/ are equivalent to this course? If so, please give details.**	No
xii	**Justification/ Need for introducing the course**	The course explains how to perform the hardware programming and adopt the solutions for communication networks. The aim of the course is to develop hands-on skills and understanding how to apply developed skills into multi-domain technologies. Moreover, the course also teaches how to implement different interfaces (e.g., Ethernet to USB) conversion. Due to lack of required FPGA hardware, the course will be target to exploit simulation based tools (e.g., modelsim) without any-license requirement.

Name of Academic Unit: Computer Science and Engineering
Level: B. Tech./MS
Programme: B.Tech./MS

i	**Title of the course**	Reinforcement Learning
ii	**Credit Structure (L-T-P-C)**	3-0-2-8
iii	**Type of Course**	Elective
iv	**Semester in which normally to be offered**	Autumn
v	**Whether Full or Half Semester Course**	Full
vi	**Prerequisite(s), if any (For the students) – specify course number(s)**	Basic Probability and Linear Algebra
vii	**Course Content**	Bandit Algorithms -- Regret based - UCB, Thomson Sampling, PAC Based - Median Eliination, Markov Decision Process Modeling - Bellman Equation, Dynamic Programming Solutions - Value and Policy Iteration, Linear Programming, Model free methods - Monte Carlo and Temporal Difference Methods - Q-learning, Value function Approximation - State Aggregation ,Critic Only/Value Based Methods Methods - TD methods, Q-Learning, SARSA, Actor Only/Policy Based methods - Reinforce, Actor-Critic Methods - Policy Gradient, Natural Actor Critic, Deep RL - DQN, A3C
viii	**Texts/References**	1. Richard S. Sutton and Andrew G. Barto, Introduction to Reinforcement Learning, 2nd Edition, MIT Press. 2017. 2. Dimitri Bertsekas and John G. Tsitsiklis, Neuro Dynamic Programming, Athena Scientific. 1996. 3. Bertsekas, Dimitri P. Dynamic Programming and Optimal Control. Vol. 1 and 2. 4th edition, 2012. 4. Algorithms for Reinforcement Learning, Csaba Szepesvári, Morgan & Claypool, 2009. 5. Regret Analysis of Stochastic and Nonstochastic Multi-armed Bandit Problems, Sébastien Bubeck and Nicolò CesaBianchi, Foundations and Trends in Machine
		Learning, Volume 5, Number 1, 2012.
ix	**Name(s) of Instructor(s)**	Prabuchandran K.J.
x	**Name(s) of other Departments/ Academic**	EE

	Units to whom the course is relevant	
xi	**Is/Are there any course(s) in the same/ other academic unit(s) which is/ are equivalent to this course? If so, please give details.**	No
xii	**Justification/ Need for introducing the course**	Reinforcement Learning (RL) has found great success in recent times in the areas of computer games like atari and strategic games like Go and Chess by beating world champions and surpassing highest score records. It has become the workhorse for many robotics applications. RL algorithms are at the frontier of current success of AI. This course builds up from the foundations to the state of the art RL algorithms.

Name of Academic Unit: Computer Science and Engineering
Level: B. Tech./MS
Programme: B.Tech./MS

i.	Title of the Course	**Reinforcement Learning Laboratory**
ii.	Credit Structure	L T P C 0 0 3 3
iii.	Prerequisite, if any	Currently taking reinforcement learning theory course
iv.	Course Content (separate sheet may be used, if necessary)	The lab will closely follow the theory course. The idea is to have the students implement the basic algorithms on different topics studied in the reinforcement learning theory course.
v.	Texts/References (separate sheet may be used, if necessary)	1. Richard S. Sutton and Andrew G. Barto, Introduction to Reinforcement Learning, 2nd Edition, MIT Press. 2017. 2. Dimitri Bertsekas and John G. Tsitsiklis, Neuro Dynamic Programming, Athena Scientific. 1996. 3. Bertsekas, Dimitri P. Dynamic Programming and Optimal Control. Vol. 1 and 2. 4th edition, 2012. 4. Algorithms for Reinforcement Learning, Csaba Szepesvári, Morgan & Claypool, 2009. 5. Regret Analysis of Stochastic and Nonstochastic Multi-armed Bandit Problems, Sébastien Bubeck and Nicolò Cesa-Bianchi, Foundations and Trends in Machine Learning, Volume 5, Number 1, 2012.
vi.	Instructor (s)	Prabuchandran K J
vii.	Name of departments to whom the course is relevant	Computer Science and Engineering, Electrical Engineering and Mechanical Engineering
viii	Justification	RL Laboratory is important to reinforce different concepts that will be studied as part of the theory course.

Name of Academic Unit: Computer Science and Engineering
Level: B.Tech/M.S
Programme: B.Tech

i	**Title of the course**	Parallel Computing
ii	**Credit Structure (L-T-P-C)**	3-0-0-6
iii	**Type of Course**	Elective
iv	**Semester in which normally to be offered**	Spring
v	**Whether full or half semester course**	Full
vi	**Pre-requisite(s), if any (for the students) – specify course number(s)**	Exposure to C, C++ or Fortran programming
vii	**Course content**	Need for High Performance Computing (HPC) and applications. Sequential Computing model, Algorithms and their complexity. Taxonomy of computer architectures – SISD, SIMD (e.g. array processors), MISD (pipelined processing, vector processors), and MIMD (shared memory and distributed memory multiprocessors, computing clusters); dataflow computing; hardware accelerators (GPUs); interconnection networks (bus, loop, mesh and hypercube); Memory hierarchy; Case Studies. Implications of computer architectures to algorithm design, synchronous processing, single program multiple data (SPMD) and multiple program multiple data (MPMD) processing; functional and data parallelism; memory hierarchies. Performance evaluation: communication and computing costs, speedup, efficiency, Amdahl's law, parallel scalability. Parallel algorithm design and case studies: numerical algorithms (linear algebra, matrix-vector and matrix-matrix multiplications, finite difference method and PDEs, Monte Carlo method), and non-numerical algorithms (search, sorting, simple tree and graph algorithms) Parallel programming platforms, Open MP and MPI programming, GPU programming. Programing Assignments: 1. Parallel computing lab environment (system architecture, log on, hello world 2. Editors, job submission, optimization techniques for serial code. 3. MPI and simple program(s) 4. MPI and matrix-matrix multiplication 5. OpenMP and matrix-matrix multiplication OpenMP 6. Introduction to GPU programming – matrix-matrix multiplication.
viii	**Texts/References**	1. Ananth Grama, Anshul Gupta, George Karypis, Vipin Kumar: Introduction to Parallel Computing, Addison Wesley 2003 2. Eric Aubanel, Elements of Parallel Computing, CRC Press, 2017. 3.https://computing.llnl.gov/tutorials/mpi/

		4.https://computing.llnl.gov/tutorials/openMP/
ix	**Name (s) of the instructor (s)**	Virendra Bhavsar, Nikhil Hegde, Dhiraj Patil
x	**Name (s) of other departments / Academic Units to whom the course is relevant**	All Departments
xi	**Is/Are there any course(s) in the same/ other academic unit(s) which is/ are equivalent to this course? If so, please give details.**	No
xii	**Justification/ Need for introducing the course**	High performance computing is needed in all branches of engineering. This course introduces HPC applications, architectures, platforms, and programming.

EE Department

Name of Academic Unit: Electrical Engineering
Level: PG/UG
Programme: B. Tech/MS/PhD

1	**Title of the Course**	VLSI Technology
2	**Credit Structure**	L T P C 3 0 0 6
3	**Type of Course**	Elective
4	**Semester in which normally to be offered**	Even
5	**Whether Full or HalfSemester Course**	Full semester
6	**Prerequisite, if any**	Exposure to Electronic Devices
7	**Course Content (separate sheet may beused, if necessary)**	Introduction on VLSI Design, Bipolar Junction Transistor Fabrication, MOSFET Fabrication for IC, Crystal Structure of Si, Defects in Crystal Crystal growth techniques – Bridgeman, Czochralski method, Floating-zone method Epitaxy – Vapour phase Epitaxy, Doping during Epitaxy, Molecularbeam Epitaxy Oxidation – Kinetics of Oxidation, Oxidation rate constants, DopantRedistribution, Oxide Charges, Oxide Layer Characterization Doping – Theory of Diffusion, Infinite Source, Actual DopingProfiles, Diffusion Systems, Ion-Implantation Process, Annealing ofDamages, Masking during Implantation Lithography Etching – Wet Chemical Etching, Dry Etching, Plasma EtchingSystems, Etching of Si, Sio2, SiN and other materials, Plasma Deposition Process Metallization – Problems in Aluminum Metal contacts, IC BJT – From junction isolation to LOCOS, Problems in LOCOS, Trench isolation, Transistors in ECL Circuits, MOSFET Metal gate vs. Self-aligned Poly-gate, MOSFET II Tailoring of Device Parameters, CMOS Technology, Latch – up in CMOS, BICMOSTechnology.
8	**Texts/References (separate sheet may beused, if necessary)**	1. VLSI Technology by S. M. Sze 2. Silicon VLSI Technology by J.D. Plummer, M. Dealand P.D. Griffin 3. VLSI Fabrication Principles by S. K. Gandhi
9	**Instructor (s)**	Ruma Ghosh
10	**Name of departments to whom the course is relevant**	Electrical Engineering
11	**Justification**	VLSI is the process of integrating millions of components (transistors, resistors etc.) in a single small chip. This course introduces different concepts related to the processes and steps involved in fabrication of electronic devices and integrated circuits. This course develops an understanding of the limitations and strength of different fabrication techniques which in turn affect the device performances

Name of Academic Unit: Electrical Engineering Department

Level: Tick mark (or underline) only **one** of the these: ☐ UG ☐ Masters ☐ PhD

1	**Title of the course**	Optimization Theory & Algorithm
2	**Credit Structure (L-T-P-C)**	L: 3 T: 0 P: 0 C: 6
3	**Mention academic programme(s) for which this course will be a core course** (Write "elective" if not core for any)	EE (Elective)
4	**Semester in which normally it is offered** Tick mark (or underline) appropriate option(s)	☐ Autumn (August-Nov) ☐ **<u>Spring (Jan-Apr)</u>** ☐ Summer (May-July)
5	**Whether full or half semester course** Tick mark (or underline) appropriate option	☐ <u>Full Semester</u> ☐ Half Semester
6	**Course content**	**Introduction** · Mathematical optimization · Least-squares and linear programming · Convex optimization · Nonlinear optimization **Convex Sets** · Affine and convex sets · Operations that preserve convexity · Generalized inequalities · Separating and supporting hyperplanes · Dual cones and generalized inequalities **Convex functions** · Basic properties and examples · Operations that preserve convexity · Quasiconvex functions · Log-concave and log-convex functions **Convex Optimization problems** · Standard form · Convex and quasiconvex optimization problems · Linear and quadratic optimization · Geometric programming · Generalized inequality constraints · Semidefinite programming **Duality and KKT Conditions** · Lagrange dual problem · Weak and strong duality and geometric interpretation · Optimality and KKT conditions · Perturbation and sensitivity analysis **Algorithms**

		Gradient descent and Newton's method for unconstrained problems, Equality constrained minimization, Inequality constrained minimization
7	**Texts/References**	1. Convex Optimization by Stephen Boyd and Lieven Vandenberghe, Cambridge University Press. 2. Convex Analysis by Rockafellar
8	**Name (s) of the instructor (s)**	Rajshekhar V Bhat
9	**Name (s) of other departments / Academic Units to whom the course is relevant**	CSE
10	**Is/Are there any course(s) in the same/ other academic unit(s) which is/ are equivalent to this course? If so, please give details.**	No
11	**Mandatory Pre-requisite(s) - specify course number(s)**	Calculus and Linear Algebra
12	**Recommended Pre-requisite(s) - specify course number(s)**	
13	**Mention 8 to 12 keywords/phrases about this course that would facilitate automated course recommendation and course interdependency** (These may or may not be from the syllabus content)	Convex sets, Convex functions, Lagrangian Dual, KKT Conditions, Algorithms
14	**Justification/ Need for introducing the course**	This course is one the most important ones for conducting research on wireless communications, machine learning and allied fields. The concepts taught in the course are very generic and they will be useful to a wide set of audience.

Name of Academic Unit: Electrical EngineeringLevel: B. Tech. / MS(R) / PhD
Programme: B.Tech. / MS(R) / PhD

i	**Title of the course**	Wireless Communication
ii	**Credit Structure (L-T-P-C)**	3-0-0-6
iii	**Type of Course**	Elective
iv	**Semester in which normally to be offered**	Autumn
v	**Whether Full or Half Semester Course**	Full
vi	**Pre-requisite(s), if any (For the students) – specify course number(s)**	Signals and Systems, Probability (UG level), Principles/Fundamentals of Communications
vii	**Course Content**	Review of fundamentals in probability theory, random processes, spectral analysis of deterministic and random signals; review of digital modulation schemes, optimal receiver design under additive white Gaussian noise (AWGN) and error rate performance; orthogonal frequency division multiplexing (OFDM); channel modeling, capacity and diversity techniques in wireless communication; multi-input multi-output (MIMO) systems and space time block codes (STBC); cellular communication systems, multiple-access and interference management.
viii	**Texts/References**	1) David Tse and Pramod Viswanath, "Fundamentals Of Wireless Communication," Cambridge University Press, 2005. 2) Andrea Goldsmith, "Wireless Communications," Cambridge University Press, 2005.
ix	**Name(s) of Instructor(s)**	Naveen M B
x	**Name(s) of other Departments/ Academic Units to whom the course is relevant**	Engineering Physics
xi	**Is/Are there any course(s) in the same/ other academic unit(s) which is/ are equivalent to this course? If so, please give details.**	None
xii	**Justification/ Need for introducing the course**	This is an elective course for Communications spine.

Name of Academic Unit: Electrical Engineering
Level: PG/UG
Programme: B. Tech/MS/PhD

i.	Title of the Course	**Neural Networks And Deep Learning (NNDL)**
ii.	Credit Structure	L T P C 3 0 0 6
iii.	Prerequisite, if any	Exposure to basic concepts in calculus and probability
iv.	Course Content (separate sheet may beused, if necessary)	**Introduction to Artificial Neural Networks (ANN) and Deep Learning (DL):**Motivation, basics of ANN, overview of PRML, evolution deep learning and different architectures. Applications of ANN vs DL. **Feedforward Neural Networks (FFNN):** Working principle, basic architecture,analysis of FFNN for different PRML tasks. **Feedback Neural Networks (FBNN):** Working principle, basic architecture, Boltzmann machine, analysis of FFNN for different PRML tasks. **Competitive learning Neural Networks (CLNN):** Working principle, basicarchitecture, analysis of CLNN for different PRML tasks. **Deep Learning (DL) Architectures:** Deep FFNN, Convolutional neural networks (CNN), Recurrent neural network (RNN), Longterm shortterm memory (LSTM), Generative adversarial network (GAN), DL architectures with attention mechanism.Some recent DL architectures. **Applications of DL:** speech processing, image processing and other tasks.
v.	Texts/References (separate sheet may beused, if necessary)	1. B. Yegnanarayana, Artificial Neural Networks, PHI, 1999. 2. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep Learning, MITPress, 2016.
vi.	Instructor (s)	S. R. Mahadeva Prasanna
vii.	Name of departments towhom the course is relevant	Computer Science and Engineering, Electrical Engineering and MechanicalEngineering
viii	Justification	This course aims at providing an overview to the neural networks and deep learning areas. NNDL being an application area of probability, pattern recognition and machinelearning, the same will be suitable for both electrical engineering and computer science and engineering students. The course contents include introduction to review of key neural networks concepts, limitations of them, detailed study of mostly deep architectures. Comparison of NN and DL architectures on different applications like speech processing, image processing and NLP.

Name of Academic Unit: Electrical Engineering
Level: PG/UG
Programme: B. Tech/MS/PhD

i	**Title** of the course	**Advanced Topics in Speech Processing**
ii	Credit Structure (**L-T-P-C**)	**(3 0 0 6)**
iii	**Type** of Course	Elective course
iv	Semester in which normally to beoffered	Autumn or Spring
v	Whether **Full or Half Semester** Course	Full
vi	**Pre-requisite(s)**, if any (For thestudents) – *specify course number(s)*	Exposure to probability concepts.
vii	Course **Content***	Advanced modeling techniques on speech analysis, feature extraction andmodeling like deep learning. Advanced topics related to prosody modeling, health information modeling, cognitive speech processing etc. Also latest trends in the speech processing area.
Viii	Texts/References	1. J. R. Deller, Jr., J. H. L. Hansen and J. G. Proakis Discrete-Time Processing of Speech Signals, Wiley-IEEE Press, NY, USA, 1999. 2. D. O'Shaughnessy, Speech Communications: Human and Machine, Second Edition,University Press, 2005. 3. L. R. Rabiner, B. H. Jhuang and B. Yegnanarayana, "Fundamentals of speech recognition", Pearson Education, 2009. 4. J. Benesty, M M Sondhi and Y. Huang, "Springer Handbook of Speech Processing", 2008. 5. Journals like IEEE Trans on Audio, Speech and Language Processing, Acoustical Society of America, Speech Communicationand Interspeech Proceedings.
ix	Name(s) of **Instructor(s)** ***	S R Mahadeva Prasanna

x	Name(s) of **other Departments/Academic Units to whom** the course is **relevant**	Computer science
xi	Is/Are there any course(s) in the same/ other academic unit(s) which is/ are **equivalent** to this course? If so, please give details.	No
xii	**Justification/ Need** for introducing the course	This course aims at providing an exposure to the latest trends in speechprocessing.

Name of Academic Unit: Electrical Engineering
Level: PG/UG
Programme: B. Tech/MS/PhD

i.	Title of the Course	**Neural Networks And Deep Learning (NNDL) Laboratory**
ii.	Credit Structure	L T P C 0 0 3 3
iii.	Prerequisite, if any	Currently taking or already taken NNDL theory course
iv.	Course Content (separate sheet may be used, if necessary)	The lab will closely follow the theory course. The idea is to have the students implement the basic algorithms on different topics studied in the NNDL theory course.
v.	Texts/References (separate sheet may be used, if necessary)	1. B. Yegnanarayana, Artificial Neural Networks, PHI, 1999. 2. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, DeepLearning, MIT Press, 2016.
vi.	Instructor (s)	S. R. Mahadeva Prasanna
vii.	Name of departments to whom the course is relevant	Computer Science and Engineering, Electrical Engineering andMechanical Engineering
viii	Justification	NNDL Laboratory is important to reinforce different concepts that willbe studied as part of the theory course.

Name of Academic Unit: Electrical Engineering
Level: UG/PG
Programme: B.Tech./M.S./Ph.D.

i	**Title of the course**	System Design of Electronic Products
ii	**Credit Structure (L-T-P-C)**	(3-0-0-6)
iii	**Type of Course**	Elective
iv	**Semester in which normally to be offered**	Autumn
v	**Whether full or half semester course**	Full
vi	**Pre-requisite(s), if any (for the students) – specify course number(s)**	Strong performance in foundational core courses of a typical EE program as determined by the instructor and/or faculty advisor: Analog and digital design, control systems, communications, and embedded systems / programming. This is a upper undergraduate / graduate level course. B. Tech students would take up this course in 6th or 7th Semester of a typical 8-semester program in preparation for a hardware design project in the final semester.
vii	**Course content**	**Introduction to Systems Design:** Electronic system design workflow, elements of product design; industrial design, design partitioning **Analog, Digital and Mixed Signal Design:** Passive components: design, specification and selection, modelling and non-idealities, error budgeting, parasitics, temperature, aging and vibration effects, reliability; D2A and A2D fundamentals, ground planes, and signal integrity, power integrity and power distribution networks, cabling, connectors and bus bars. **Noise in Electronic Systems:** Sources, effects and mitigation, fundamentals of EMI/EMC, compliance standards, test processes **Electronic Systems Packaging, Prototyping and Production** Semiconductor packaging, PCB design, manufacture, and assembly, enclosures and interfaces, reliability and MTBF, materials, rapid prototyping, manufacturability, testability, etc. **Application Specific Aspects**: Automotive, Industrial, Space and Defense grade and cybersecurity **Case Studies, mini-projects and design exercises**
viii	**Texts/References**	References: 1. H. W. Ott, *Noise Reduction Techniques in Electronic Systems*, Singapore: J. Wiley, 1989. 2. R. Tummala, *Fundamentals of Device and Systems Packaging: Technologies and Applications*, Second Edition. United States, McGraw-Hill Education, 2019. 3. L. Umanand, *Power Electronics: Essentials & Applications*, India. Wiley India Pvt. Limited, 2009. 4. L. Marks, J. Caterina, *Printed Circuit Assembly Design*, Ukraine: McGraw-Hill Education, 2000.
ix	**Name (s) of the instructor (s)**	Abhijit Kshirsagar

x	**Name (s) of other departments / Academic Units to whom the course is relevant**	Mechanical Engg, Computer Science: Relevant to students working in EE-allied areas such as embedded systems, robotics, EVs etc.
xi	**Is/Are there any course(s) in the same/ other academic unit(s) which is/ are equivalent to this course? If so, please give details.**	No
xii	**Justification/ Need for introducing the course**	Core engineering courses give students a strong theoretical base, along with analytical and mathematical skills. However, real-world engineering tasks demand a synergistic understanding across multiple domains, “design-thinking”, and strong debugging and trouble-shooting skills. This course attempts to bridge that gap. Students will be given the knowledge and skills needed to translate a “circuit” into a “product”. The course will also cover case studies to help develop ‘intuitive’ engineering judgement which will enable them to identify a problem, check their diagnosis and then implement a solution. Students with these skills will become good circuit and system designers and will be valued in both industry and research.

EE Department

Name of Academic Unit: Electrical Engineering
Level: B.Tech./ DD
Programme: B.Tech./DD

i	**Title** of the course	**VLSI Design**
ii	Credit Structure (**L-T-P-C**)	**(3 0 0 6)**
iii	**Type** of Course	Elective
iv	Semester in which normally to be offered	Autumn
v	Whether **Full or Half Semester** Course	Full
vi	**Pre-requisite(s)**, if any (For the students) – *specify course number(s)*	Digital systems, Electronic Devices
vii	Course **Content***	Review of MOS transistor models, Technology scaling, CMOS logic families including static, dynamic and dual rail logic. Integrated circuit layout; design rules, parasitics. low power design, high performance design, logical effort, Interconnect aware design, clocking techniques. VLSI design: data and control path design, floor planning, Design Technology: introduction to hardware description languages(VHDL), logic, circuit and layout verification.
Viii	Texts/References	1. *N. Weste and D. M. Harris, "CMOS VLSI Design, A circuits and systems perspective" Pearson, 2010* 2. *S. Kang and Y. Leblebici, "CMOS Digital Integrated circuits", Tata McGraw Hill edition, 2003* 3. *Jan M. Rabaey, A. Chandrakasan and B. Nikolic, "Digital Integrated circuits" Pearson , 2016*
ix	Name(s) of **Instructor(s)** ***	NK
x	Name(s) of **other Departments/ Academic Units to whom** the course is **relevant**	
xi	Is/Are there any course(s) in the same/ other academic unit(s) which is/ are **equivalent** to this course? If so, please give details.	No
xii	**Justification/ Need** for introducing the course	Digital integrated circuits have revolutionized computers and the way we control and design electronic systems. This is a advanced course on CMOS digital integrated circuits, which gives exposure to high performance VLSI design in CMOS technologies.

Name of Academic Unit: Electrical Engineering
Level: UG/PG
Programme: B.Tech./M.S./Ph.D.

i	**Title of the course**	Advanced Electric Drives
ii	**Credit Structure (L-T-P-C)**	(3-0-0-6)
iii	**Type of Course**	Elective
iv	**Semester in which normally to be offered**	Autumn
v	**Whether full or half semester course**	Full
vi	**Pre-requisite(s), if any (for the students) – specify course number(s)**	Introduction to Power Electronics (EE209), Electric Machines (EE206), and basic foundational courses in EE (circuits, analog electronics, control theory), or equivalent courses, as determined by the instructor.
vii	**Course content**	**1. Electric Drives Overview:** Components, structure; performance, line-side and machine-side specifications **2. Rectifiers:** Diode and Thyristor rectifiers, multi-pulse rectifiers: 6-pulse, 12-pulse, etc; THD and Power Factor effects **3. Two-Level Inverters and PWM Techniques** Power circuit analysis, Switching states, and Loss models. Sinusoidal PWM, Space-vector PWM, Harmonic Analysis, Over-modulation, Third-harmonic injection, Bus clamping, Selective-harmonic-elimination, current and flux error space-vectors. **4. Multilevel Inverters:** Topologies for multilevel converters: NPC, CHB and FC, MMCs; T-type and I-type; modulation scheme, voltage balancing, PWM techniques for multilevel inverter (level / phase shifted, NLM, sorting, etc) **5. DC Drives:** Structure, power circuit, and control schemes, decoupled control concepts **6. Induction Motor Modelling:** Transformations of abc-α-β-dq quantities, machine modeling in dq-domain, and linearization **7. Induction Motor Drives:** V/f control, vector control; controller design; field-oriented control; direct-torque-control, wound-rotor induction machines (DFIG)

viii	**Texts/References**	References: 1. S. Raju, N. Mohan, *Analysis and Control of Electric Drives: Simulations and Laboratory Implementation*, United States, Wiley, 2020. 2. N. Mohan, *Advanced Electric Drives: Analysis, Control, and Modeling Using MATLAB / Simulink*, Germany, Wiley, 2009 3. M.G. Say, *The Performance and Design of Alternating Current Machines: Transformers, Three-Phase Induction Motors and Synchronous Machines*, India, CBS Publishers & Distributors, 2005 4. B. K. Bose, *Modern Power Electronics and AC Drives*, India, Prentice Hall PTR, 2002 5. B. Wu, *High-Power Converters and AC Drives*, United Kingdom, Wiley, 2007.
ix	**Name (s) of the instructor (s)**	Abhijit Kshirsagar
x	**Name (s) of other departments / Academic Units to whom the course is relevant**	N/A
xi	**Is/Are there any course(s) in the same/ other academic unit(s) which is/ are equivalent to this course? If so, please give details.**	None
xii	**Justification/ Need for introducing the course**	Electric drives are an indispensable part of most electric energy conversion systems. A thorough understanding of the electrical machine, power converter and control schemes is essential for development of efficient, reliable and high-performance drive system. Variable-frequency drives have now proliferated the low-power space such as consumer appliances; and are already seeing massive deployments in the e-mobility space.

Name of Academic Unit: Electrical Engineering
Level: PG
Programme: M.Tech./M.S./Ph.D.

i	**Title of the course**	**Stochastic Control and Learning for Networked Systems**
ii	**Credit Structure (L-T-P-C)**	(3-0-0-6)
iii	**Type of Course**	Elective
iv	**Semester in which normally to be offered**	January to April
v	**Whether full or half semester course**	Full
vi	**Prerequisite(s), if any (for the students) – specify course number(s)**	Undergraduate control course, linear algebra, probability
vii	**Course content**	**Introduction to Nonlinear Systems:** Nonlinear System Dynamics, Lyapunov Stability, Linearization **Introduction to Optimal Control:** Dynamic Programming, Markov Decision Process, Kalman Filter, Continuous Time Dynamic Programming, Stochastic integration, Introduction to differential games **Stochastic and Function Approximation:** Stochastic Gradient Descent, Statistical Learning, Linear Regression, Stochastic differential games **Dynamic Programming and Reinforcement Learning:** Review of Reinforcement learning, Relation between dynamic programming and reinforcement learning, Approximate dynamic programming, stochastic dynamic programming **Control Structures based on Reinforcement Learning:** Optimal control using synchronous online learning, Synchronous online-learning for zero-sum two player games and multi-player non-zero sum games **Networked Control System:** Introduction, Characterization and properties of information structures, Stochastic stability, stabilization of Decentralized systems, Agreement in teams and Dynamic Programming Approach under information constraints (**If time permits**): multi-agent reinforcement learning

viii	**Texts/References**	1. Hasan Khalil, **Nonlinear Systems**, *Pearson*, 3rd Edition, 2014. 2. A. E. Bryson, Y. Ho, **Applied Optimal Control: Optimization**, Estimation and Control", *CRC Press*, 2017. 3. D. Vrabie, K. G. Vamvoudakis, F. L. Lewis, **Optimal Adaptive Control and Differential Games by Reinforcement Learning Principles**, IET, 2013. 4. Dimitri Bertsekas, **Reinforcement Learning and Optimal Control**, Athena Scientific, 2019. 5. S. Yuksel, Tamer Basar, **Stochastic Networked Control Systems: Stabilization and Optimization under Information Constraints**, Birkhouser, 2013.
ix	**Name (s) of the instructor (s)**	EE (Ameer)
x	**Name (s) of other departments / Academic Units to whom the course is relevant**	Electrical Engineering and Computer Science Engineering
xi	**Is/Are there any course(s) in the same/ other academic unit(s) which is/ are equivalent to this course? If so, please give details.**	No
xii	**Justification/ Need for introducing the course**	This course related the concepts of optimal control and reinforcement learning and introduces online solution techniques for optimal control problems using reinforcement learning techniques. The techniques are also discussed for networked systems with communication constraints.

Name of Academic Unit: Electrical engineering
Level: PhD.
Programme: MS and PhD.

i.	Title of the Course	**Mixed signal VLSI Design**
ii.	Credit Structure	L T P C 3 0 0 6
iii.	Prerequisite, if any	CMOS Analog VLSI Design
iv.	Course Content (separate sheet may be used, if necessary)	1) CML logic for high speed mixed signal circuits 2) Switch design and switched capacitor circuits 3) Sampling theory and discrete-time signals 4) Comparators 4) Basics of data converters 5) Nyquist rate ADC's: Parallel (single-step converters), algorithmic (multi-step converters) and pipelined ADC'Architectures and design of Nyquist rate ADC's 6) High resolution data converters (Δ Σ data converters) 7) Digital to analog converters 8) Selected topics in mixed-signal VLSI circuits
v.	Texts/References (separate sheet may be used, if necessary)	1) R.Jacob Baker,H.W.Li, and D.E. Boyce CMOS Circuit Design ,Layout andSimulation, Prentice-Hall of ,1998. 2) R.Jacob Baker, CMOS: Mixed-Signal Circuit Design, Wiley (1 January 2008) 3) Pavan, Shanthi, Richard Schreier, and Gabor C. Temes. Understandingdelta-sigma data converters. John Wiley & Sons, 2017.
vi.	Instructor (s)	Naveen Kadayinti
vii.	Name of departments to whom the course isrelevant	Electrical Engineering
viii	Justification	This course discussed advanced topics in modern IC design which include both analog and digital circuit blocks in the same chip. The problems associated with such integrated circuits will be explored and the course will discuss the design of some typical applications of such kind. This exposure willbe necessary for any research in Mixed signal VLSI design.

Name of Academic Unit: Electrical Engineering
Level: PG/UG
Programme: B. Tech/MS/PhD

i	Title of the Course	**Probability Models and Applications (PMA)**
ii.	Credit Structure	L T P C 3 0 0 6
iii.	Prerequisite, if any	Data analysis and Introduction to probability (6 credits course that all batches are currently doing as core)
iv.	Course Content (separate sheet may be used, if necessary)	**Introduction to** Probability theory. **Review of** sample space, events, axioms of probability, introduction to probability as a measure, Random variables, Notion of independence and mutually exclusive events Probability Space, limits and sequence of events, continuity of probability, measurable functions, notions of induced measures, connection with cdf, change of measure, conditional probability and conditional expectation, simulating discrete and continuous random variables - accept-reject method, importance sampling. **Random vectors and Stochastic processes:** Introduction to random vectors, Gaussian vectors, notion of i.i.d random variables introduction to elementary stochastic processes like Bernoulli process and Poisson process. **Markov Process.** Discrete time and continuous time Markov chains**,** classification of states, notion of stationary distribution. Simulating stochastic processes like Gaussian process, Poisson process, Markov chains and Brownian motion. Introduction to Markov chain monte carlo methods, Hidden Markov chain and Markov decision process, Introduction to Brownian motion and stationary process. **Statistics:** MLE, MAP and Bayesian Estimation, sufficient statistics, Cramer-Rao bound
v.	Texts/References (separate sheet may be used, if necessary)	1. Sheldon Ross "Introduction to probability models" 9th Ed., Elsevier AP 2. Sheldon Ross, 'Stochastic process', John Wiley, 2nd Ed., April 1996. 3. David Stirzaker, 'Stochastic process and models', Oxford press.
vi.	Instructor (s)	Tejas Bodas
vii.	Name of dept to whom the course is relevant	Computer Science and Engineering, Electrical Engineering and Mechanical Engineering.
viii	Justification	A thorough knowledge of probability theory is a requisite for developing a strong foundation in ML While the course on data analysis and intro to probability (done in second year) introduces the students to concepts in probability, a deeper understanding of the subject is needed to appreciate the nuances in courses such as Reinforcement learning, deep learning, pattern recognition etc. This course would act as a bridge in laying down a firm foundation in probability.

Name of Academic Unit: Electrical Engineering

Level: B. Tech./MS

Programme: MS/Ph.D.

i	**Title of the course**	Linear Algebra and its applications
ii	**Credit Structure (L-T-P-C)**	3-0-0-6
iii	**Type of Course**	Core
iv	**Semester in which normally to be offered**	Autumn
v	**Whether Full or Half Semester Course**	Full
vi	**Pre-requisite(s), if any (For the students) – specify course number(s)**	Exposure to Basic calculus.
vii	**Course Content**	The following topics will be covered: Vector spaces, linear dependence, basis; Representation of linear transformations with respect to a basis.; Inner product spaces, Hilbert spaces, linear functions; Riesz representation theorem and adjoints.; Orthogonal projections, products of projections, orthogonal direct sums; Unitary and orthogonal transformations, complete orthonormal sets and Parseval's identity; Closed subspaces and the projection theorem for Hilbert spaces.; Polynomials: The algebra of polynomials, matrix polynomials, annihilating polynomials and invariant subspaces, forms, Solution of state equations in linear system theory; Relation between the rational and Jordan forms.; Numerical linear algebra: Direct and iterative methods of solutions of linear equations; Matrices, norms, complete metric spaces and complete normal linear spaces (Banach spaces); Least squares problems (constrained and unconstrained); Eigenvalue problem and SVD.
viii	**Texts/References**	1. K. Hoffman and R. Kunze, Linear Algebra, Prentice-Hall, (1986). 2. G.H. Golub and C.F. Van Loan, Matrix Computations, Academic, 1983.
ix	**Name(s) of Instructor(s)**	Ameer and Bharat

x	**Name(s) of other Departments/ Academic Units to whom the course is relevant**	Electrical Engineering
xi	**Is/Are there any course(s) in the same/ other academic unit(s) which is/ are equivalent to this course? If so, please give details.**	None
xii	**Justification/ Need for introducing the course**	This a core course for MS with specialization in Electrical Engineering.

Name of Academic Unit:
Level:
Programme:

i	**Title of the course**	Sustainable energy and energy materials
ii	**Credit Structure (L-T-P-C)**	3-0-0-6
iii	**Type of Course**	Elective
iv	**Semester in which normally to be offered**	Even semester
v	**Whether Full or Half Semester Course**	Full semester
vi	**Pre-requisite(s), if any (For the students) – specify course number(s)**	First year undergraduate chemistry course (CH101)
vii	**Course Content**	Fuel cells, catalysis for fuel cells and sustainable chemical processes • Batteries • Solar photovoltaics Wind power: practical aspects • Tidal power • Inorganic, Organic and functional biomaterials as energy materials
viii	**Texts/References**	
ix	**Name(s) of Instructor(s)**	Rajeswara Rao and Sudheer Siddapureddy
x	**Name(s) of other Departments/ Academic Units to whom the course is relevant**	Course is relevant for students across all the departments
xi	**Is/Are there any course(s) in the same/ other academic unit(s) which is/ are equivalent to this course? If so, please give details.**	No
xii	**Justification/ Need for introducing the course**	Developing sustainable/renewable energy methods are critical to meet the ever increasing global energy demands. This course will shed light on various methods which are currently under practice towards generating sustainable energy and their detailed mechanisms.

Name of Academic Unit: Mathematics
Level: PG
Programme: Ph.D..

1	**Title of the course**	Advanced Graph Theory
2	**Credit Structure (L-T-P-C)**	L: 3 T: 1 P: 0 C: 8
3	**Mention academic programme(s) for which this course will be a core course** (Write "elective" if not core for any)	Elective
4	**Semester in which normally it is offered** Tick mark (or underline) appropriate option(s)	☐ Autumn (August-Nov) ☐ Spring (Jan-Apr) ☐ Summer (May-July)
5	**Whether full or half semester course** Tick mark (or underline) appropriate option	☐ Full Semester ☐ Half Semester
6	**Course content**	Fundamental concepts of graph theory, Trees and distances, Planar graphs, Graphs on surfaces, Coloring and chromatic numbers, Edge coloring and chromatic index, Total coloring and total chromatic number, List coloring and choosability, Graph minors, Directed and Oriented graphs, Graph homomorphisms, Graph homomorphisms and colorings, Graph homomorphisms and minors, Extremal graph theory, Random graphs.
7	**Texts/References**	1. D. B. West, Introduction to Graph Theory 2nd edition. Prentice Hall. 2. Harary. Graph Theory. Reading, MA: Perseus Books, 1999. 3. R. Diestel, Graph Theory, 5th edition. Springer.
8	**Name (s) of the instructor (s)**	Sagnik Sen
9	**Name (s) of other departments / Academic Units to whom the course is relevant**	Computer Science and Engineering
10	**Is/Are there any course(s) in the**	No

	same/ other academic unit(s) which is/ are equivalent to this course? If so, please give details.	
11	**Mandatory Pre-requisite(s) - specify course number(s)**	N/A
12	**Recommended Pre-requisite(s) - specify course number(s)**	Basic Graph Theory
13	**Mention 8 to 12 keywords/phrases about this course that would facilitate automated course recommendation and course interdependency** (These may or may not be from the syllabus content)	Graphs, Graph Coloring, Graph homomorphisms, Graph minors, The Four-Color Theorem, Hadwiger's Conjecture, Tait's Theorem, List coloring.
14	**Justification/ Need for introducing the course**	This is an advanced course in graph theory which covers structural graph theory with a focus on graph coloring, graph homomorphism and graph minors. It will be beneficial for PhD students who wants to work in the domain of Discrete Mathematics and Graph theory and related topics.

Name of Academic Unit: Mathematics
Level: PG
Programme: Ph.D..

1	**Title of the course**	Advanced Algebra
2	**Credit Structure (L-T-P-C)**	L: 3 T: 1 P: 0 C: 8
3	**Mention academic programme(s) for which this course will be a core course** (Write "elective" if not core for any)	Elective
4	**Semester in which normally it is offered** Tick mark (or underline) appropriate option(s)	☐ Autumn (August-Nov) ☐ <u>Spring (Jan-Apr)</u> ☐ Summer (May-July)
5	**Whether full or half semester course** Tick mark (or underline) appropriate option	☐ <u>Full Semester</u> ☐ Half Semester
6	**Course content**	Semisimple and simple rings: Semisimple modules, Jacobson density theorem, semisimple and simple rings, Wedderburn-Artin structure theorems, Jacobson radical, the effect of a base change on semisimplicity Representations of finite groups: Basic definitions, characters, class functions, orthogonality relations, induced representations and induced characters, Frobenius reciprocity, decomposition of the regular representation, supersolvable groups, representations of symmetric groups Noetherian modules and rings: Primary decomposition, Nakayama's lemma, filtered and graded modules, the Hilbert polynomial, Artinian modules and rings, projective modules, Krull-Schmidt theorem, completely reducible modules
7	**Texts/References**	(1) Dummit, Foote: Abstract algebra, second edition, Wiley student editions, 2005 (2) Jacobson: Basic algebra, I, Dover publications, 2009 (3) Jacobson: Basic algebra, II, Dover publications, 2009 (4) Lang: Algebra, third edition, Springer-Verlag, GTM 211, 2002
8	**Name (s) of the instructor (s)**	Shreedevi K. Masuti

9	**Name (s) of other departments / Academic Units to whom the course is relevant**	1) Computer Science and Engineering 2) Electrical Engineering
10	**Is/Are there any course(s) in the same/ other academic unit(s) which is/ are equivalent to this course? If so, please give details.**	No
11	**Mandatory Pre-requisite(s) - specify course number(s)**	Introduction to Algebra
12	**Recommended Pre-requisite(s) - specify course number(s)**	Introduction to Algebra
13	**Mention 8 to 12 keywords/phrases about this course that would facilitate automated course recommendation and course interdependency** (These may or may not be from the syllabus content)	Semisimple and simple modules, Wedderburn-Artin structure theorems, Representations of finite groups, Frobenius reciprocity, Noetherian modules and rings, Hilbert polynomial, Artinian modules and rings, projective modules
14	**Justification/ Need for introducing the course**	This is an advanced course on algebra. The course includes topics that are useful for advanced research in not just Algebra but also in Geometry, Topology, Number Theory, Algebra and Representation theory. Undergraduates and postgraduates who are interested in cryptography, coding theory may also find the course appealing..

Office of Dean (Academic Programme), IIT Dharwad

Academic Course Approval Request Form

Name of Academic Unit: Mathematics

Level: Tick mark (or underline) only **one** of the these: ☐UG ☐Masters ☐✓ PhD

1	**Title of the course**	Algebraic Topology
2	**Credit Structure (L-T-P-C)**	L: 3 T: 0 P: 0 C: 6
3	**Mention academic programme(s) for which this course will be a core course** (Write "elective" if not core for any)	Elective
4	**Semester in which normally it is offered** Tick mark (or underline) appropriate option(s)	☐ Autumn (August-Nov) ✓ Spring (Jan–Apr) ☐Summer (May–July)
5	**Whether full or half semester course** Tick mark (or underline) appropriate option	☐✓ Full Semester ☐ Half Semester
6	**Course content**	Paths and homotopy, homotopy equivalence, contractibility, deformation retracts Basic constructions: cones, mapping cones, mapping cylinders, suspension Cell complexes, subcomplexes, CW pairs Fundamental groups. Examples (including the fundamental group of the circle) and applications (including Fundamental Theorem of Algebra, Brouwer Fixed Point Theorem and Borsuk-Ulam Theorem, both in dimension two). Van Kampen's Theorem. Covering spaces, lifting properties, deck transformations, universal coverings Simplicial complexes, barycentric subdivision, stars and links, simplicial approximation. Simplicial Homology. Singular Homology. Mayer-Vietoris sequences. Long

		exact sequence of pairs and triples. Homotopy invariance and excision Degree, Cellular Homology Applications of homology: Jordan-Brouwer separation theorem, Invariance of dimension, Hopf's Theorem for commutative division algebras with identity, Borsuk-Ulam Theorem, Lefschetz Fixed Point Theorem Optional Topics: Outline of the theory of: cohomology groups, cup products, Kunneth formulas, Poincare duality
7	**Texts/References**	(1) M.J. Greenberg and J. R. Harper, Algebraic Topology, Benjamin, 1981. (2) W. Fulton, Algebraic topology: A First Course, Springer-Verlag, New York, 1995. (3) A. Hatcher, Algebraic Topology, Cambridge Univ. Press, Cambridge, 2002. (4) W. Massey, A Basic Course in Algebraic Topology, Springer-Verlag, Berlin, 1991. (5) J. R. Munkres, Elements of Algebraic Topology, Addison-Wesley, Menlo Park, CA, 1984. (6) J. J. Rotman, An Introduction to Algebraic Topology, Springer (India), 2004. (7) H. Seifert and W. Threlfall, A Textbook of Topology, Academic Press, New York-London, 1980.
8	**Name (s) of the instructor (s)**	Shreedevi K. Masuti
9	**Name (s) of other departments / Academic Units to whom the course is relevant**	1) Computer Science and Engineering 2) Electrical Engineering
10	**Is/Are there any course(s) in the same/ other academic unit(s) which is/ are equivalent to this course? If so, please give details.**	No
11	**Mandatory Pre-requisite(s) - specify course number(s)**	Topology / Instructor's consent
12	**Recommended Pre-requisite(s) - specify course number(s)**	Topology / Instructor's consent
13	**Mention 8 to 12 keywords/phrases about this course that would facilitate automated course recommendation and course interdependency**	Fundamental groups, Covering spaces, Simplicial complexes, Cell complexes, CW pairs, Simplicial Homology, Singular Homology, Mayer-Vietoris sequences, Cellular Homology, Lefschetz Fixed Point Theorem

	(These may or may not be from the syllabus content)	
14	**Justification/ Need for introducing the course**	This is an advanced course on topology. The course includes topics that are useful for advanced research in not just topology but also in Algebra, Geometry, Number Theory, Representation theory. Undergraduates and postgraduates who are interested in sensor network, dynamics, combinatorics, complexity theory may also find the course appealing..

Name of Academic Unit : Mathematics

Level : PG

Programme : MS/PhD.

i	**Title of the course**	**Functional Analysis**
ii	**Credit Structure (L-T-P-C)**	(3-0-0-6)
iii	**Type of Course**	PhD course work
iv	**Semester in which normally to be offered**	
v	**Whether Full or Half Semester Course**	Full
vi	**Pre-requisite(s), if any (For the students) – specify course number(s)**	Basic topological concepts, Metric spaces, Measure theory
vii	**Course Content**	Stone-Weierstrass theorem, L^p spaces, Banach spaces, weak and weak* topology, Locally convex topological vector space, extreme points, Krein-Milman theorem. Bounded linear functionals and dual spaces, Hahn-Banach theorem. Bounded linear operators, open-mapping theorem, closed graph theorem, uniform boundedness principle. Hilbert spaces, Riesz representation theorem. Bounded operators on a Hilbert space. The spectral theorem for compact, self-adjoint, normal (including unbounded) operators.
viii	**Texts/References**	J. B. Conway: A course in functional analysis, Springer-Verlag, New York, 1990 B.V.Limaye: Functional Analysis, New Age International Limited,Publishers, New Delhi, 1996 Michael Reed, Barry Simon: Methods of modern mathematical physics. I. Functional analysis. Second edition. Academic Press, Inc, New York, 1980 E. Kreyszig: Introductory Functional Analysis with Applications, John Wiley & Sons, New York, 2001
	Name(s) of Instructor(s)	Dhriti Ranjan Dolai

x	**Name(s) of other Departments/ Academic Units to whom the course is relevant**	Physics
xi	**Is/Are there any course(s) in the same/ other academic unit(s) which is/ are equivalent to this course? If so, please give details.**	No
xii	**Justification/ Need for introducing the course**	The course will start from basic functional analysis, then it will cover the spectral theorem for normal operators. This course will be helpful to those phd students who wants to work in Schrodinger operator, Harmonic analysis, PDE, Banach space theory, and Operator theory.

Name of Academic Unit: Mechanical Engineering
Level: PG
Programme: PhD

i	**Title of the course**	Applied Elasticity
ii	**Credit Structure (L-T-P-C)**	2-1-0-3
iii	**Type of Course**	Core (PG)
iv	**Semester in which normally to be offered**	Spring
v	**Whether Full or Half Semester Course**	Full
vi	**Pre-requisite(s), if any (For the students) – specify course number(s)**	Mechanics of Materials
vii	**Course Content**	**Mathematical Preliminaries** Second-Order Tensors, Vector, Matrix, and Tensor Algebra, Calculus of Cartesian Tensors **Stress and Equilibrium** Stress Tensor , Stress Transformation, Principal Stresses, Spherical and Deviatoric Stresses, Equilibrium Equations , Relations in Curvilinear Cylindrical and Spherical Coordinates **Deformation: Displacements and Strains** Small Deformation Theory, Strain Transformation, Principal Strains, Spherical and Deviatoric Strains, Strain Compatibility, Curvilinear coordinate system: Cylindrical and Spherical system relations **Material Behavior** Linear Elastic Materials—Hooke's Law Physical Meaning of Elastic Moduli, Thermoelastic Constitutive Relations, Anisotropy - Basic Concepts, Material Symmetry, Restrictions on Elastic Moduli, Strain Energy **Formulation and Solution Strategies** Stress Formulation, Displacement Formulation, Principle of Superposition, Saint-Venant's Principle, Uniqueness theorem **Two-Dimensional Formulation** Plane Strain,Plane Stress, Generalized Plane Stress, Airy Stress Function, Polar Coordinate Formulation, Cartesian Coordinate Solutions ;Complex Variable Methods**:**Complex Formulation of the Plane Elasticity Problem, Resultant Boundary Conditions, General Structure of the Complex Potentials

		Extension, Torsion, and Flexure of Elastic Cylinders Extension Formulation; Torsion Formulation, Flexure Formulation, Flexure Problems Without Twist **Thermoelasticity** General Uncoupled Formulation, Two-Dimensional Formulation, Displacement Potential Solution, Stress Function Formulation **3D Elasticity: Displacement Potentials and Stress Functions** Helmholtz Displacement Vector Representation, Lame´’s Strain Potential, Galerkin Vector Representation, Papkovich-Neuber Representation; Spherical Coordinate Formulations, Stress Functions
viii	**Texts/References**	• Text 1. Martin H. Sadd , Elasticity: Theory, Applications, And Numerics, , 3rd Edition, Academic Press, 2014. 2. J. R. Barber ,Elasticity, 3rd edition, Kluwer Academic, 2009. • Reference 1. S. P. Timoshenko, J. N. Goodier ,Theory of Elasticity, , 3rd Edition, McGraw Hill Publishing Co. 1970. 2. Arthur P. Boresi, Ken Chong, James D. Lee, Elasticity in Engineering Mechanics, , 2010, Wiley. 3. Allan F. Bower ,Applied Mechanics of Solids , 1st Edition, 2009, CRC Press. 4. R. W. Soutas-Little, Elasticity, Dover Publications, 1999 5. PC Chou, NJ Pagano. Elasticity: Tensor, Dyadic and Engineering Approaches, Dover Publication, 1992
ix	**Name(s) of Instructor(s)**	TPG
x	**Name(s) of other Departments/ Academic Units to whom the course is relevant**	NA
xi	**Is/Are there any course(s) in the same/ other academic unit(s) which is/ are equivalent to this course? If so, please give details.**	NIL
xii	**Justification/ Need for introducing the course**	Applied Elasticity) is a course which investigates effect of external loads on deformable bodies. Unlike mechanics of materials, it is more rigorous as it relaxes many assumptions of mechanics of materials. Thus, it paves

		way to analyse solids beyond structural elements like beams, trusses and shafts. This approach for generalization invokes more mathematical rigor. In this course, we linearize strains and stress-strain relation to attempt problems from mechanics of materials in the new perspective e.i from TOE approach but not limited to it. In addition, we explore anisotropy, different methods of solution, flexure and extension of elastic cylinder and a brief introduction to 3D elasticity. Along with elasticity, it aims to appreciate the need for experimental mechanics techniques and the need for computational tools like FEM.

Course Title	**Engineering Mathematics for Advanced Studies**

Credit Structure

L	T	P	C
3/4	0	0	6/8

Prerequisite: NA

Targeted Audience

Graduate students taking up research activity
Research oriented bachelor students interested to hone their skill in specific math modules that they have not worked on extensively in previous courses/research

Objective

To make the student recall the basics of each course module and show them how it will be applicable for research in engineering domain
Expected outcome is the understanding of the basic contents in the respective module in engineering context and with hands-on practice.

Credit allocation

At least 6 modules to obtain minimum 6 credits.
At least 8 modules to obtain 8 credits.
Relative grading for each module followed by absolute grading will be adopted for final course grade assessment.

Targeted Course Content

Module-1: Linear Algebra: Linear algebraic equations, Vector Spaces, Orthogonality, Determinants, Eigen-values and Eigen-vectors of matrices, Singular-value decomposition

Module-2: Ordinary Differential Equations: Terminology, Solution of Homogeneous and non-homogeneous 1^{st} order linear ODE, Bernoulli, Riccatti and Logistic equations, Solution of Homogeneous and non-homogeneous 2^{nd} order linear ODE, System of 1^{st} order ODE

Module-3: Vector Calculus: Dot and Cross Product, Curves, Arc Length, Curvature, Torsion, Divergence and Curl of a Vector Field, Line Integrals, Green's Theorem, Stokes's Theorem, use of Vector Calculus in various engineering streams

Module-4: Laplace and Fourier transformation: First and Second Shifting Theorems, Transforms of Derivatives and Integrals, Fourier Cosine and Sine Transforms, Discrete and Fast Fourier Transforms, IVT and FVT significance

Module-5: Partial Differential Equations: Basic Concepts of PDEs, Laplace, Poisson, Heat, Wave Equations, Solution by Separating Variables, Solution by Fourier Series, Solution by Fourier Integrals and Transforms, Solution using similarity variable

Module-6: Numerical Methods: Methods for Linear Systems, Least Squares, Householder's Tridiagonalization and QR-Factorization, Numerical interpolation, Numerical integration, Methods for Elliptic, Parabolic, Hyperbolic PDEs,

Module-7: Optimization and Linear Programming: Introduction to convex sets and functions, and its properties, Important standard classes such as linear and quadratic programming, Lagrangian based method, Algorithms for unconstrained and constrained minimization (example gradient descent).

Module-8: **Probability Theory and Statistics:** Experiments, Outcomes, Events, Permutations and Combinations, Probability Distributions, Binomial, Poisson, and Normal Distributions, Distributions of Several Random Variables, Testing Hypotheses, Goodness of Fit, χ^2-Test

Module-9: Tensor Algebra: Index Notation and Summation Convection, Levi-

Module selection

A) PhD students: Module selection should be by mutual agreement between student and faculty advisor. Please ensure pre-requisite module completion requirement for each module

B) MS Students:

Modules mandatory for MS students-

EE: 1,3,4,6,7,8

ME: 1,2,3,4,5,6

C) B.Tech. Students:

Discussion with course instructor (SR) and faculty advisor with consideration to academic load and priorities is required

Civita symbol, Triple vector product, Tensor Product, Dyads, transpose, trace, contraction, projection, spherical and deviatoric tensors, tensorial transformation laws. Gradient of scalar valued tensor function, Gradient of tensor valued tensor function

Module-10: Complex Analysis and Potential Theory: The Cauchy-Riemann Equations, Use of Conformal Mapping, Electrostatic Fields, Heat and Fluid Flow Problems, <Poisson’s Integral Formula for Potentials >

Texts/References

E. Kreyszig. Advanced Engineering Mathematics, John Wiley & Sons, 2011.
A. Schrijver, Theory of Linear and Integer Programming, 1998.
Gilbert Strang, Linear Algebra and Its Applications, 4th Edition, 2004.
Gilbert Strang Differential Equations and Linear Algebra, 2014
Additional references-
P.V. O'Neil. Advanced Engineering Mathematics, CENGAGE Learning, 2011.
D.G. Zill. Advanced Engineering Mathematics, Jones & Bartlett Learning 2016.
B. Dasgupta. Applied Mathematical Methods, Pearson Education, 2006.

Instructor (s)

Prof. SamarthR (SR) >> Module 1, 2, 3, 5, 6, 8, 9

Prof. ShrikanthV (SV) >> Module 4, 10

Prof. Naveen MB (NMB) >> Module 7

Departments to whom the course is relevant

CS/EE/ME

Justification

Engineering mathematics is a key-tool necessary for the research students to be good in mathematical methods in order to model and analyze the experimental/computational data. In this course, students learn mathematical techniques in linear algebra, Vector calculus, Laplace and Fourier transformations, ODEs and PDEs, elementary numerical methods, probability foundations. Special modules Tensor algebra and complex numbers are facilitated for those who are interested. Modular structure of this course offers flexibility to students to optimally use this course for their specific needs.

Summary

10 modules : SR (7) + SV(2) + NMB(1), modular structure, Course grading - average of grades received in all modules selected by student.

Time slots:

Classroom instruction – Room215, Slot 3, (Mon 10:35-11:30, Tue ~~11:35-12:30~~ 12:00-01:00 pm; Thu 8:30-9:25), some modules to run in different slots

Walk in hrs – Thu-2:00-3:00pm (tentative)

	Module Name	**Instructor**	**Pre-requisite recommendation** (not mandatory)	**Mandatory modules for MS**	
				EE	**ME**
1	Linear Algebra	SR		Y	Y
2	ODE	SR			Y
3	Vector Calculus	SR		Y	Y
4	Laplace/Fourier	SV	2	Y	Y
5	PDE	SR	2,4		Y
6	Num. Methods	SR	1,2	Y	Y
7	OptimizationLPP	NMB	1	Y	
8	Probability&Stats	SR		Y	
9	Tensor Algebra	SR	1,3		
10	Complex Analysis	SV	2,5		

Course webpage - https://homepages.iitdh.ac.in/~sraut/Au19_EnggMath/index.html

Name of Academic Unit: Mechanical Engineering
Level: **PG Only**
Programme: M. Tech./M.S./PhD

i	**Title of the course**	**Fracture Mechanics**
ii	**Credit Structure (L-T-P-C)**	3-0-0-6
iii	**Type of Course**	Elective
iv	**Semester in which normally to be offered**	Even/Odd
v	**Whether Full or Half Semester Course**	Full
vi	**Pre-requisite(s), if any – specify course number(s)**	Theory of Elasticity or equivalent
vii	**Course Content**	**Module 1: Background** Kinds of Failure; Historical Aspects; Brittle and Ductile Fracture; Modes of Fracture Failure **Module 2: LEFM** Griffith's Theory of Brittle Fracture; Irwin-Orowan Modification; Stress Intensity Factor (SIF) Approach; Concepts of Strain Energy and Potential Energy Release Rates; Determination of Crack-Tip Stress and Displacement Field - Airy Stress Function Approach, Westergaard Stress Function Approach, Williams' Eigenfunction Expansion. Determination of Stress Intensity Factors: Analytical Methods, Numerical and Experimental Methods. Mixed Mode Brittle Fracture: Theory based on Potential Energy Release Rates, Maximum Tangential Stress Criterion, Maximum Tangential Principal Stress Criterion, Strain Energy Density Criterion **Module 3: Anelastic Deformation at Crack Tip** Irwin Plastic Zone Size Correction; Dugdale-Barenblatt Model for Plastic Zone Size; Crack-Tip Mode I, II and III Plastic Zone Shape; Thickness Dependence of Fracture Toughness KC; Crack Opening Displacement; Rice's Path-Independent Integral J; Resistance Curve; Stability of Crack Growth **Module 4: Elastic Plastic Fracture Mechanics** Crack Opening Displacement Criterion; Mode I Crack-Tip Field - Rice-Rosengren Analysis, Hutchinson's Analysis; Crack-Tip Constraints: T Stress and Q Factor; Crack Propagation and Crack Growth Stability **Module 5: Fatigue Crack Growth** Fatigue Crack Growth Rate under Constant Amplitude Loading; Factors Affecting Fatigue Crack Propagation; Crack Closure; Life Estimation Using Paris Law; Variable Amplitude Cyclic Loading **Module 6: Experimental Measurement of Fracture Tougness Data** Measurement of Plane Strain Fracture Toughness KIC, Critical COD δC, K-Resistance Curve - Linear Elastic Material and Elastic Plastic Material
viii	Texts/ References	**Text-books:** 1. T. L. Anderson, Fracture Mechanics: Fundamentals and Applications, 4th ed. – Boca Raton 2017. 2. D. Broek, Elementary Engineering Fracture Mechanics, 3rd Revised Edition, Springer Netherlands, 1982, 3. Maiti S.K, Fracture Mechanics: Fundamentals and Applications. – 1st Edition, Delhi: Cambridge University Press, 2015. **References:** 1. Prashant Kumar, Elements of Fracture Mechanics, Tata McGraw-Hill. Education, 2009, 2. CT Sun, Fracture Mechanics, Academic press, 2012, 3. T. Kundu, Fundamentals of Fracture Mechanics, CRC Press, 2008.
ix	**Name(s) of Instructor(s)**	TPG, AKG
x	**Name(s) of other Departments/ Academic Units to whom the course is relevant**	
xi	**Is/Are there any course(s) in the same/ other academic unit(s) which is/ are equivalent to this course? If so, please give details.**	Nil
xii	**Justification/ Need for introducing the course**	Development of fault-tolerant philosophy in design of aircrafts, structures and machines necessitates understanding of structural behaviour with cracks. This course is an introduction to the subject in context of engineering applications. The course begins with LEFM and then covers anelastic deformation at the tip. Subsequently, EPFM and fatigue behaviour of a structure with crack are explored. Numerical techniques (FE) & experimental techniques in context of fracture mechanics are then discussed.

Name of Academic Unit: Mechanical, Materials & Aerospace Engineering

Level: PG

Programme: M.Tech./MS/Ph.D./B. Tech.

i	**Title of the course**	**Multiphase Flow**
ii	**Credit Structure (L-T-P-C)**	3-0-0-6
iii	**Type of Course**	Elective course
iv	**Semester in which normally to be offered**	Spring
v	**Whether Full or Half Semester Course**	Full
vi	**Pre-requisite(s), if any – specify course number(s)**	None
vii	**Course Content**	• **Introduction and overview :** History, Motivation and Application • **Transport phenomena :** Introduction, Reynolds transport theorem, Continuity equation, Momentum equation • **Fluid mechanics with interface :** Interfacial tension and its role in multiphase flow, Surface energy and capillary forces, Measurement of surface tension, Laplace pressure and Young's law, Curvature computation, Capillary rise, Capillary force on floating bodies, Wetting, Wetting of a rough surface, Contact angle hysteresis, Singularities • **Boundary conditions in multiphase flows :** Kinematic and dynamic boundary conditions, Stress conditions at fluid interfaces, Stress on deforming surfaces • **Scaling analysis :** Introduction, Buckingham's theorem and dimensionless numbers for multiphase flow systems, Dimensional analysis and physical similarity, Self-similarity • **Introduction of asymptotic analysis :** Asymptotic expansion, Pulsatile flow : Analytical and asymptotic solution, Domain perturbation method • **Lubrication model/Thin film approximation :** Derivation of basic equation of lubrication theory, Thin film approximation with free surfaces : Derivation of governing equations and boundary conditions, Self-similar solution, Application of lubrication theory • **Flow instabilities:** Fluid jets, Rayleigh-Plateau Instability, Fluid sheets, Rupture of soap film and derivation of Taylor-Culick velocity, Rayleigh-Taylor Instability, Kelvin-Helmholtz instability • **Numerical solution of Navier-Stokes equation:** Time integration, Spatial discretization, Marker and Cell method, Boundary conditions • **Advection of fluid interfaces:** Fundamentals, Numerical definition of interface, Heaviside function, Advection of color function, Volume of fluid method, Level set method, Numerical model of surface tension driven flows • **Applications:** Bubbly flows, drop collision and splashing, Breakup and Atomization
viii	**Texts/ References**	<u>TEXTBOOKS</u> 1. L. Gary Leal, Advanced Transport Phenomena, First Edition, 2007, CUP. 2. G. Tryggvason, R. Scardovelli, and S. Zaleski, Direct numerical simulations of gas-liquidmultiphase flows, First Edition, 2011, Cambridge University Press <u>REFERENCE</u> 1. P.G. de Gennes, F. Brochard-Wyart and D. Quéré, Capillarity and Wetting Phenomena : Drops,Bubbles, Pearls, Waves, First Edition, 2003, Springer Publication 2. E. J. Hinch, Purterbation Methods, First Editions, 1991, Cambridge University Press 3. G. I. Barenblatt, Scaling, First Edition, 2003, Cambridge University Press. 4. J. Eggers & M.A. Fontelos, Singularities: Formation, structure & propagation, 1st Ed., 2015, CUP
ix	**Name(s) of Instructor(s)**	HD
x	**Name(s) of other Departments/ Academic Units to whom the course is relevant**	Chemical Engineering

xi	**Is/Are there any course(s) in the same/ other academic unit(s) which is/ are equivalent to this course? If so, please give details.**	No
xii	**Justification / Need for introducing the course**	This is a postgraduate level course that covers few fundamental aspects of multiphase flows. Understanding multiphase flow is essential in many industrial applications. For example, starting from the petroleum industry, food processing industry, ink-jet printing to the manufacturing of self-cleaning devices, painting and coating processes involve multiphase flow. The course can be offered as an elective course in B.Tech/M.Tech. /MS/Ph.D. to Mechanical and Chemical Engineering Departments.

Name of Academic Unit: Mechanical, Materials & Aerospace Engineering

Level: PG

Programme: M.Tech./MS/PhD/B.Tech.

i	Title of the course	**Compressible Flow & Gas Dynamics**
ii	Credit Structure (L-T-P-C)	3-0-0-6
iii	Type of Course	Elective course
iv	Semester in which normally to be offered	Spring
v	Whether Full or Half Semester Course	Full
vi	**Pre-requisite(s), if any- specify course number(s)**	Nil
vii	Course Content	• **Introduction**: Gas dynamics, review of basic mass, momentum and energy conservation lass for compressible flows, speed of sound, wave equation, regimes of Mach number, shocks, wave propagation, sound speed, Mach number, isentropic flow, static and stagnation properties • **One-dimensional flow**: Governing equations for one dimensional flow, Converging-diverging nozzles, shock waves, moving and reflected waves, blastwaves, wind tunnels, supersonic engines, 1D equations for stationary normal shock, Entropy change across a normal shock, Crocco's theorem, Hugoniot equation, moving normal shock and reflected shock waves • **Two Dimensional Flow**: Oblique shock wave theory, conical oblique shock waves, concepts of attached and detached shock waves, Prandtl-Mayer expansion fans, supersonic inlets and diffusers. • **Compressible Pipe Flow**: Fanno-Line flow, Rayleigh pipe flow, natural gas flow in pipelines • **Compressible Potential Flow**: Method of characteristics, supersonic nozzle design • **Introduction to Hypersonic Flows.** • **Introduction to Numerical Solutions**: Characteristic relations and Riemann invariants, representative model problems, convection-diffusion equation, Burgers' equation, Riemann problems, Roe's approximate Riemann solver for the Euler equations
viii	Texts/ References	• J.D. Anderson, Modern Compressible Flow, McGraw-Hill, (3rd Edition), 2017 • S.M. Yahya. Fundamentals Of Compressible Flow With Aircraft And RocketPropulsion, New Age International Publishers; 6th Edition, 2018. • Doyle D. Knight, Elements of Numerical Methods for Compressible Flows,Cambridge Aerospace Series, Cambridge University Press, 2012. • Hodge & Koenig, Compressible Fluid Dynamics, PEI, 1st edition, 2015. • H.W. Liepmann and A. Roshko, Elements of Gas Dynamics, Dover Pub., 2013. • Shapiro, Ascher H., Dynamics and thermodynamics of compressible fluid flow, JohnWiley 1953.
ix	Name(s) of Instructor(s)	DVP
x	Name(s) of other Departments/ Academic Units to whom the course is relevant	Nil

xi	Is/Are there any course(s) in the same/ other academic unit(s) which is/ areequivalent to this course? If so, please give details.		No
xii	Justification/ Need for introducing the course	The course aims to provide students understanding in compressible flow problems commonly encountered in basic engineering applications, including, but not limited to, nozzle flows, shock wave motion, moving and oblique shocks, natural gas flow in pipelines, Prandtl-Meyer Flow, Fanno Flow, Rayleigh Flow, and reaction propulsion systems.	

Academic Unit: Mechanical Engineering
Level: UG
Programme: B. Tech

i	**Title of the course**	ME 427 Fluid Flow and Heat Transfer in Porous Media
ii	**Credit Structure (L-T-P-C)**	(3-0-0-6)
iii	**Type of course**	Elective
iv	**Semester in which normally to be offered**	Odd/Even
v	**Whether Full or Half Semester Course**	Full
vi	**Pre-requisite(s), if any (For the students) – specify course number(s)**	Exposure to fluid mechanics and heat transfer
vii	**Course content**	**Module 1:** Mechanics of Fluid flow through Porous Medium: porosity, volume averaging procedure, Equation of continuity, momentum equation (Darcy's Law, Forchheimer equation, Brinkman equation), Turbulence in porous media. (10 hr) **Module 2:** Heat Conduction in Porous Medium: Local thermal equilibrium, effective stagnant thermal conductivity, thermal dispersion, local thermal non-equilibrium, interfacial heat transfer coefficient (8 hr) **Module 3:** Forced Convection through Porous Medium: external flow, internal flows and jet impinging flows (9 hr) **Module 4:** Natural Convection through Porous Medium: external flows (9 hr) **Module 5:** Radiation heat transfer through Porous Medium: Radiation transport equation, energy equation with radiation (6 hr)
viii	**Texts/References**	1. Donald A Nield and Adrian Bejan, Convection in Porous Medium, Springer publications, Newyork, 2017, Fifth Edition. 2. M. Kaviany, Principles of Heat Transfer in Porous Media, Springer publications, Newyork, 1999, Second Edition 3. Arunn Narasimhan, Essentials of Heat and Fluid Flow in Porous Media, Ane Books Private Limited, New Delhi, 2016, First Edition. 4.Faruk Civan, Porous Media Transport Phenomena, John Wiley and Sons, Singapore, 2011, First Edition. 5. F.A. L. Dullien, Porous Media: Fluid Transport and Pore Structure, Academic Press, London, 1992, Second Edition 6. Kambiz Vafai, Handbook of Porous Media, Taylor and Francis, Florida, 2005, Second Edition
ix	**Name(s) of the Instructor(s)**	SVP
x	**Name(s) of other Departments/ Academic Units to whom the course is relevant**	NA
xi	**Is/Are there any course(s) in the same/ other academic unit(s) which is/ are equivalent to this course? If so, please give details.**	No
xii	**Justification/ Need for introducing the course**	Knowledge of heat and fluid flow through porous media finds extensive applications in several engineering devices covering branches, mechanical, civil and chemical engineering. Recent ramifications include bioengineering and bio-technology.

Name of Academic Unit: Mechanical Engineering
Level: PhD
Programme: PhD

i	**Title of the course**	Combustion and Fire Dynamics
ii	**Credit Structure (L-T-P-C)**	(3-0-0-6)
iii	**Type of Course**	Core Course
iv	**Semester in which normally to be offered**	Autumn
v	**Whether Full or Half Semester Course**	Full
vi	**Pre-requisite(s), if any (For the students) – *specify course number(s)***	--
vii	**Course Content**	**Fundamentals** Motivation for studying combustion, Fuels and their combustion properties: diesel, gasoline, aviationfuels, natural gas, coal, Thermochemistry: the composition of a gas mixture: mass and mole fraction, Chemical reactions – theoretical and actual combustion processes, Enthalpy of formation and enthalpy of combustion, Adiabatic flame temperature, Introduction to mass transfer, Chemical equilibrium. Chemical kinetics – reaction rates, chemical time scales. **Flames** Conservation equations with chemical reaction, Laminar premixed flames – flame speed, governing equations, flammability limits, flame stability, Laminar diffusion flames – diffusive burning of liquids, stagnation layer model – pure convective burning, radiative convective burning, Droplet evaporation and burning – Spalding number. **Measurement in Fire** Measurement of temperature – thermocouples, plate thermometer for the measurement of temperature and heat flux, heat flux sensors, cone calorimetry, measurement of soot volume fraction, soot yield and spectral measurements. **Introduction to Numerical Fire Simulations** Governing equations – hydrodynamics model, combustion model, radiation model, solution algorithm, simulation of typical fires.
viii	**Texts/References**	1. Stephen R. Turns, An Introduction to Combustion: Concepts and Applications, Third edition, McGraw Hill Education (India) Private Limited, New Delhi, 2012. 2. James G. Quintiere, Fundamentals of Fire Phenomena, John Wiley and Sons, Wet Sussex, 2006. 3. The SFPE Handbook of Fire Protection Engineering, fourth edition, National Fire Protection Association (NFPA), Massachusetts, 2008.

ix	**Name(s) of Instructor(s)**	SSR
x	**Name(s) of other Departments/ Academic Units to whom the course is relevant**	NA
xi	**Is/Are there any course(s) in the same/ other academic unit(s) which is/ are equivalent to this course? If so, please give details.**	No
xii	**Justification/ Need for introducing the course**	The Syllabus for the proposed course is divided into four sections: Fundamentals, Flames, Measurement in fire, and Introduction to numerical fire simulations. This is specialized course important for postgraduate studies.

Name of Academic Unit: Mechanical Engineering

Level: PG

Programme: MS/Ph.D.

i	**Title of the course**	**Nonlinear Solid Mechanics for Finite Element Method**
ii	**Credit Structure (L-T-P-C)**	3-0-0-6
iii	**Type of Course**	Elective
iv	**Semester in which normally to be offered**	Even/Odd
v	**Whether Full or Half Semester Course**	Full
vi	**Pre-requisite(s), if any – specify coursenumber(s)**	Solid Mechanics and Finite Element is recommended
vii	**Course Content**	1. **Introduction to Tensors:** Overview of conventions & mathematical identities in vectorcalculus and tensor algebra 2. **Review of Linear Elasticity:** Linear strain tensor, compatibility conditions, stress tensor, equilibrium equation 3. **Kinematics of Deformation:** Material and spatial derivatives, Deformation gradient, Straintensor, Velocity gradients, Spin tensor, Lie time derivatives 4. **Concept of Stress:** Cauchy stress theorem, Piola transformation, First Piola-Kirchhof (PK) stress, Principal directions, Alternative stress definitions such as Second PK stress, Biot stress, Corrotated cauchy stress tensors 5. **Balance Principals and Constitutive relation:** Conservation of mass, Reynolds' Transport theorem, Principals of Momentum and Energy balance 6. **Hyperelasticity:** Various strain-energy constitutive formulations - invariant based model, isotropic model, incompressible model, composite material model, examples from the field of soft tissue biomechanics and tyre industry 7. **Viscoelasticity:** Generalized Maxwell Model, Relaxation time 8. **Finite Element for Non-linear material:** Variational Principles, Objective stress rates, Linear Consistent Tangent Modulus, numerical challenge due to incompressibility

viii	**Texts/ References**	**<u>Text-books:</u>** **1.** Gerhard A. Holzapfel, *Non-linear Solid Mechanics- A continuum approach for engineering*, John Wileyand Sons Ltd. 2000. **<u>References:</u>** **1.** J. Bonet, RD. Wood, *Non-linear Continuum Mechanics for Finite Element Analysis* (2nd Ed), Cambridge University Press., 2008. **2.** LA. Taber, *Non-linear Theory of Elasticity – Applications in Biomechanics*, World Scientific Publishing, 2004. **3.** Rene de Borst,Mike A. Crisfield, Joris J.C. Remmers, and Clemens V. Verhoosel, *Non-linear Finite Element Analysis of Solid and Structures*, (2nd Edition), John Wiley and Sons Ltd., 2012.
ix	**Name(s) of Instructor(s)**	Samarth S. Raut
x	**Name(s) of other Departments/ Academic Units to whom the course is relevant**	N/A
xi	**Is/Are there any course(s) in the same/ other academic unit(s) which is/ are equivalent to this course? If so, please give details.**	No
xii	**Justification/ Need for introducing the course**	Finite Element Method (FEM) is widely used for solving nonlinear solid mechanics problems. To gain proficiency in applying FEM one needs to get clear understanding of the underlying Continuum mechanics principles. Especially for non-linear problems, one needs proper prior technical orientation even to understand well written technical documentation of commercial FEM packages. This course will first expose student to the core concepts in non-linear solid mechanics theory with focus on the hyperelastic materials. Then, various FEM implementation aspects related to large-strain-large-deformation scenario are discussed, including numerical modeling of incompressible material constitutive model.