i	**Title of the course**	Biomedical Spectroscopy and Imaging
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**	Spring
v	**Whether Full or Half Semester Course**	Full
vi	**Pre-requisite(s), if any (For the students) – *specify course number(s)***	--
vii	**Course Content**	Module 1: Medical Imaging Module 2: Spectrometry and Instrumentation Module 3: Hyperspectral Imaging, line scanning, and Point spectroscopy Module 4: Fluorescence spectroscopyand applications Module 5: Infrared spectroscopyand applications Module 6: Raman spectroscopyand applications
viii	**Texts/References**	Laser fundamentals, William. T Silfvast, 2004 Photonics, Volume 4: Biomedical spectroscopy, photonics and microscopy, David L Andrews,2015 Biophotonics: vibrational spectroscopic diagnostics, Mathew baker, Caryn Hughes, Katherine A Hollywood,2016 Fundamentals of Medical imaging, Suetens P, 2017
ix	**Name(s) of Instructor(s)**	Surya Pratap Singh
x	**Name(s) of other Departments/ Academic Units to whom the course is relevant**	Chemistry 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 primary aim of this course will be to introduce the participant to the field of medical imaging and bio spectroscopy. The basic theory, instrumentation and working principle will be discussed for routinely employed techniques. An introduction to different imaging approaches with a special focus to diagnosis and therapy monitoring will be provided.

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

i	**Title of the Course**	**Genetic Engineering**
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**	August-December
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**	Role of genes within cells, genetic code, genetic elements that control gene expression, Method of creating recombinant DNA molecules, Types, biology and salient features of vectors in recombinant DNA technology–I: Plasmids, Phages, Cosmids, Fosmids, Phagemids, and Artificial chromosomes, Safety guidelines for recombinant DNA research, Control of spills and mechanism of implementation of biosafety guidelines Enzymes in genetic engineering: Restriction nucleases: exo & endo nucleases, Enzymes in modification- Polynucleotide phosphorylase, DNase and their mechanism of action, Enzymes in modification- Methylases and phosphatases and their mechanism of action, Enzymes in modification- Polynucleotide kinase, Ligases, RNase and their mechanism of action. Methods of nucleic acid detection, Polymerase chain reaction (PCR) and its applications, Variations in PCR and their applications, Methods of nucleic acid hybridization, Probe andtarget sequences, Nucleic acid mutagenesis in vivo and in vitro Unit 4: Isolation and purification of nucleic acid (genomic/plasmid DNA and RNA), Quantification and storage of nucleic acids, Construction of cDNA library, Construction of Genomic library, Screening and preservation of DNA libraries, DNA Sequencing and cloning strategies. Gene transfer techniques: biological methods, Gene transfer techniques: chemical methods, Gene transfer techniques: physical or mechanical methods, Agrobacterium- mediated gene transfer in plants, Chloroplast transformation. Gene therapy: Introduction and Methods, Gene targeting and silencing, Gene therapy in the treatment of diseases, Challenges and future of gene therapy
viii	**Texts/References (separate sheet may be used, if needed)**	1.Introduction to Genetic Engineering - Nicholl. Cambridge Low Price Edition, 2006. 2.Principles of gene manipulation and Genomics - Primrose S.B. and Twyman R.M.,Blackwell Scientific Publications, 2008
ix	**Name(s) of Instructor(s)**	Prof. 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 genetic engineering methods required in molecular biology experiments.

New PhD course approval from BSBE department

Name of the course	Molecular biology techniques and applications
Credit Structure	L:3 T:0 P:0 C:6
Full or half semester	Full semester; Autumn (August- Nov) and Spring (Jan-Apr)
Name of the instructor	Prof. Surya Pratap Singh
Course content and Justification	This course will introduce students with the techniques such as biochemical estimation, microbial culture, chromatography, protein purification and estimation methods, PCR, immunological assays, and gene sequencing. This course will cover a wide array of research areas such as molecular biology, immunology, cell biology, genetics, biochemistry, animal biotechnology. The course module will be designed in such a way to cover the principles, procedure, result interpretation, the dos, and don't in most of the wet lab procedures. The primary focus will be to familiarize students with the basic principle and application of each of the techniques.

- Circulated to DPGC on Oct., 28th 2020; deliberated and approved by DPGC on Oct. 29th 2020

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

	any (For the students) – *specify course number(s)*	
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*
x	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
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 : PhD
Programme : PhD

Title of the course	Formal Models for Concurrent and Asynchronous Systems
Credit Structure (**L-T-P-C**)	**(3-0-0-6)**
Type of Course	Core course
Semester in which normally to be offered	Spring
Whether **Full or Half Semester** Course	Full
Pre-requisite(s), if any (For the students) – *specify course number(s)*	Discrete Mathematics, Theory of computation
Course **Content***	*(1) Petri nets :* *Elementary nets, Place/Transition nets,* Behaviors - traces, posets, unfoldings, Decision problems - reachability, coverability, Tools, implementations and case-studies. *(2)* Well structured transition systems Ageneralized abstraction for infinite-state systems, Well-quasi orders and well-founded systems, Applications to show termination of infinite systems, Theoretical bounds on complexity. *(3)* Distributed automata models : Asynchronous automata, Message passing automata: Also called Communicating finite-state machines, Lossy channel machines.

Texts/References	(1) Elementary Net Systems, Grzegorz Rozenberg and Joost Engelfriet, Lectures on Petri Nets I: Basic Models, Advances in Petri Nets, Springer LNCS 1491 (1998) 12-121. (2) Some Behavioural Aspects of Net Theory P.S. Thiagarajan, Theoretical Computer Science, 71 (1990) 133-153 (3) Basic Linear Algebraic Techniques for Place/Transition Nets, Jörg Desel, (4) Lectures on Petri Nets I: Basic Models, Advances in Petri Nets, Springer LNCS 1491 (1998) 257-308. (5) (6) Well-Structured Transition Systems Everywhere!, Alain Finkel and Philippe Schnoebelen, (7) Automata on Distributed Alphabets(Madhavan Mukund, In Deepak D'Souza and Priti Shankar (eds), Modern Applications of Automata Theory, World Scientific.
Name(s) of **Instructor(s)** ***	Ramchandra Phawade
Name(s) of **other Departments/ Academic Units to whom** the course is **relevant**	Nil
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
Justification/ Need for introducing the course	This is an advanced course in concurrency which is essential for doing research in Formal methods of verification, Concurrency and in general Theoretical Computer Science.

Name of Academic Unit: Computer Science and Engineering

Level: MS/PhD

Programme: MS/PhD

i	**Title of the course**	Software Defined Networking (SDN) and Network Function Virtualization (NFV)
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 Computer Networks
vii	**Course content**	History and evolution of SDN; SDN Architecture (Application, Control, Infrastructure Layer); SDN Interfaces (East/West/North/South-bound interfaces); SDN Security; SDN routing; SDN standards; SDN Controllers; Network Operating Systems and Languages; OpenFlow; Software Switches (e.g. OpenVSwitch); SDN Simulation/Emulation Platforms (e.g. Mininet); Federated SDN networks; SDN Applications and Use Cases; Programming assignment/project; Need for NFV; NFV and SDN Relationship; Virtual Network Functions; Service Function Chaining; NFV Specifications; NFV Architecture; NFV Use Cases; NFV Management and orchestration (MANO); Open-source NFV; Hands-on exercises based on OpenStack/Docker.
viii	**Texts/References**	• Software Defined Networks: A Comprehensive Approach by Paul Goransson and Chuck Black, Morgan Kaufmann Publications, 2014 • SDN – Software Defined Networks by Thomas D. Nadeau & Ken Gray, O'Reilly, 2013 • Software Defined Networking with OpenFlow, By Siamak Azodolmolky, Packt Publishing, 2013 • Gray, Ken, and Thomas D. Nadeau. Network function virtualization. Morgan Kaufmann, 2016. • Zhang, Ying. Network Function Virtualization: Concepts and Applicability in 5G Networks. John Wiley & Sons, 2018. • Foundations of modern networking- SDN, NFV, QoE, IoT, and Cloud, William Stallings • James Kurose and Keith Ross, "Computer Networking, A Top-Down Approach"
ix	**Name (s) of the instructor (s)**	Tamal Das
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**	Contemporary end-user and application requirements demand flexible, dynamic network control and management. As a result, the telecom sector is gearing towards programmable control and data planes. This course would shed light on the fundamentals of software defined networking and network function virtualization – primary enablers for network softwarization. This topic is particularly relevant at present, with more and more programmable networking devices being developed – both open-source and proprietary. This course will better equip the students to understand contemporary telecom network operations. The objective of this course to learn about SDN and NFV – both in theory and practice.

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

i	**Title of the course**	Statistical Pattern Recognition
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	**Prerequisite(s), if any (For the students) – specify course number(s)**	Multivariate Calculus and Linear Algebra, Probability, Programming
vii	**Course Content**	Bayesian Decision Making and Bayes Classifier, Parametric and Non Parametric Estimation of Densities, General Linear Models, Discriminative Learning based Models, Dimensionality Reduction Techniques, Empirical and Structural risk minimization, Ensemble Methods, Pattern Clustering
vii i	**Texts/References**	1.R.O.Duda, P.E.Hart and D.G.Stork, Pattern Classification, John Wiley, 2001. 2.C.M.Bishop, Pattern Recognition and Machine Learning, Springer, 2006.
ix	**Name(s) of Instructor(s)**	Prabuchandran K.J.
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**	This course provides theoretical/statistical underpinnings of pattern recognition and machine learning methods.

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.

CSE

Name of Academic Unit: Mathematics
Level: Doctoral
Programme: PhD

i	**Title of the course**	Perfect graphs and graph algorithms
ii	**Credit Structure (L-T-P-C)**	3-1-0-8
iii	**Type of Course**	Elective
iv	**Semester in which normally to be offered**	Even
v	**Whether Full or Half Semester Course**	Half
vi	**Pre-requisite(s), if any (For the students) – specify course number(s)**	Exposure to CS 201,211 Data Structures and Algorithms, Lab,CS 203 Discrete Structures or equivalent.
vii	**Course Content**	Perfect graphs, The Weak Perfect Graph Theorem, The Strong Perfect Graph Theorem (statement only), Chrodal graphs, Perfect Elemination Order and Scheme, Split graphs, degree sequence, Erdos-Gallai Theorem, Comparability graphs, Permutation graphs, Intersection graphs, Interval graphs and some of its properties, Circular arc graphs
viii	**Texts/References**	1) M. C. Golumbic. *Algorithmic Graph Theory and Perfect Graphs*. Academic Press, New York, 1980**.**
ix	**Name(s) of Instructor(s)**	Sagnik Sen
x	**Name(s) of other Departments/ Academic Units to whom the course is relevant**	Computer Science and 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 an advanced course in graph theory which covers structural and algorithmic graph theory. It will be beneficial for PhD students who wants to work in the domain of Discrete Mathematics, Graph theory and Theoretical Computer Science.

1. Bioorganic chemistry and chemical biology

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

i	**Title of the course**	**Bioorganic chemistry and chemical biology**
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**	Fall
v	**Whether Full or Half Semester Course**	Full
vi	**Pre-requisite(s), if any**	Nil
vii	**Course Content***	Enzyme chemistry and reaction mechanisms, chemistry of biological pathways, fundamental principles of chemical biology and their applications, chemistry of biomolecules (DNA, RNA, proteins, lipids, and carbohydrates), natural products biosynthesis (PKS, NRPS, RiPP, terpenes, alkaloids etc.), chemical control of signal transduction, antibiotics and resistance, chemistry of drug design and drug action, introduction to metabolomics and proteomics.
Viii	**Texts/References**	1. R. Silverman, "The organic chemistry of enzyme catalyzed reactions" Revised ed., Academic Press, 2002. 2. D. Vranken and G.A. Weiss "Introduction to Bioorganic Chemistry and Chemical Biology" 1st Ed., Garland Science, 2012. 3. McMurry and Begley "The Organic Chemistry of Biological Pathways" 2nd ed., WH Freeman, 2015 4. Nelson and Cox, "Lehninger Principles of Biochemistry", 7th Ed., WH Freeman, 2017 5. Silverman and Holladay "The Organic Chemistry of Drug Design and Drug Action" 3rd Ed., Academic press, 2014 6. P. Frey and A. D. Hegeman, "Enzymatic Reaction Mechanisms", 1st Ed., OUP USA, 2007. 7. P. Bruice, "Organic Chemistry"7th Ed., Pearson, 2013. 8. Wiley Encyclopedia of Chemical Biology (Editor: T. Begley), 1st ed., Wiley-Blackwell, 2009 (4 volumes)
ix	**Name(s) of Instructor(s) *** **	Nilkamal Mahanta
x	**Name(s) of other Departments/ Academic Unitsto 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**	NA

	this course? If so, please give details.	
xii	**Justification/ Need for introducing the course**	This course provides foundation for bioorganic chemistry and principles/applications of chemical biology for MS/PhD students of chemistry and biochemistry to carry out further advanced courses. In addition, it is relevant to different fields of research in chemical sciences and life sciences.

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

i	Title of the course	**Fundamentals and Applications of Organic Photochemistry**
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 •Resonance energy transfer (RET), Fluorescence resonance energy transfer (FRET), excited state intra-molecular 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. Petr Klan and Jakob Wirz "Photochemistry of organic compounds: from concepts to practice (postgraduate chemistry series)", 1st Ed., Wiley-Blackwell, 2009. 2. N. J. Turro, V. Ramamurthy, J. C. Scaiano "Modern Molecular Photochemistry for Organic Molecules" 1st Ed.' Viva books, 2017. 3. Yongfang Li (editor) "Organic optoelectronic materials (lecture notes in chemistry)" 1st Ed., Springer, 2015. 4. K.K.Rohtagi-Mukhejee "Fundamentals of photochemistry", 3rd Ed., New age international publishers, 2017. 5. J. R. Lakowicz "Principles of Fluorescence Spectroscopy", 2nd Ed., Springer, 1999.
ix	Name(s) of **Instructor(s)** ***	MRR
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 will provide fundamentals of photochemistry of organic materials and compounds to MS/PhD students.

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

i	**Title of the course**	Organic 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 (For the students) – *specify course number(s)***	Nil
vii	**Course Content**	Infrared spectroscopy • Mass spectrometry • nuclear magnetic resonance spectroscopy
Viii	**Texts/References**	Organic spectroscopy by William Kemp
ix	**Name(s) of Instructor(s)**	Prof. Nilkamal Mahanta
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.**	NA
xii	**Justification/ Need for introducing the course**	

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 materialssynthesis - 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 Hartree Fock Methods, Roothan Equations, Configuration Interaction, Density Functional Theory, Perturbation theory and applications.
Viii	**Texts/References**	1. J. D. Lee, Concise Inorganic Chemistry, Fifth edition, Blackwell publishing (2008) 2. Robert T. Morrison, Robert N. Boyd, and Robert K. Boyd, Organic Chemistry, 6th edition Benjamin Cummings, (1992) 3. Charles P. Poole Jr. Frank J. Owens, Introduction to Nanotechnology, John Wiley & Sons, Inc. (2003) 4. Nan Yao, Zong Lin Wang, Handbook of Microscopy for Nanotechnology, Kluwer academic publishers, London (2005) 5. Pople, J.A. and Beveridge, D.L. Approximate Molecular Orbital Theory. McGraw-Hill, New York. (1970) 6. 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) 7. Modern Quantum Chemistry: Introduction to Advanced Electronic Structure Theory, by Attila Szabo, Neil S. Ostlund, Dover Publications, New York (2000) 8. Introductory Quantum Chemistry/Quantum Mechanics Books by authors such as Pilar, McQuarrie, Pauling and Wilson, 9. NPTEL Web and Video courses in quantum chemistry and computational chemistry
ix	**Name(s) of Instructor(s) *****	Prof B L Tembe and Prof. Rajeswara Rao M
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.**	NA

xii	**Justification/ Need for introducing the course**	This course provides all round (physical, organic and Inorganic) essential concepts for PhD students

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 be used, 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, basic architecture, 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 be used, if necessary)	1. B. Yegnanarayana, Artificial Neural Networks, PHI, 1999. 2. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep Learning, 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 and Mechanical Engineering
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 machine learning, 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	**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 be offered	Autumn or Spring
v	Whether **Full or Half Semester** Course	Full
vi	**Pre-requisite(s)**, if any (For the students) – *specify course number(s)*	Exposure to probability concepts.
vii	Course **Content***	**Introduction:** Speech production and perception, nature of speech; short-term processing: need, approach, time, frequency and time-frequency analysis. **Short-term Fourier transform (STFT):** overview of Fourier representation, non-stationary signals, development of STFT, transform and filter-bank views of STFT. **Cepstrum analysis:** Basis and development, delta, delta-delta and mel-cepstrum, homomorphic signal processing, real and complex cepstrum. **Linear Prediction (LP) analysis:** Basis and development, Levinson-Durbin's method, normalized error, LP spectrum, LP cepstrum, LP residual. **Sinusoidal analysis:** Basis and development, phase unwrapping, sinusoidal analysis and synthesis of speech. **Applications:** Speech recognition, speaker recognition, speech synthesis, language and dialect identification and speech coding.
Viii	Texts/References	1. L.R. Rabiner and R.W. Schafer, Digital Processing of Speech Signals Pearson Education, Delhi, India, 2004 2. J. R. Deller, Jr., J. H. L. Hansen and J. G. Proakis, Discrete-Time Processing of Speech Signals, Wiley-IEEE Press, NY, USA, 1999. 3. D. O'Shaughnessy, Speech Communications: Human and Machine, Second Edition, University Press, 2005. 4. T. F. Quatieri, "Discrete time processing of speech signals", Pearson Education, 2005. 5. L. R. Rabiner, B. H. Jhuang and B. Yegnanarayana, "Fundamentals of speech recognition", Pearson Education, 2009.
ix	Name(s) of **Instructor(s)** ***	S R Mahadeva Prasanna
x	Name(s) of **other Departments/ Academic Units to whom** the course is **relevant**	CS

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 overview to the speech processing area. Speech processing being an application area of probability, signal processing and pattern recognition, the same will be suitable for both electrical engineering and computer science and engineering students. The course contents include introduction to speech processing, speech signal processing methods like short term Fourier transform, Cepstral analysis, linear prediction analysis, sinusoidal analysis. Some of the applications like speech recognition and speech synthesis will also be taught.

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

	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, Deep Learning, 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 and Mechanical Engineering
viii	Justification	NNDL Laboratory is important to reinforce different concepts that will be studied as part of the theory course.

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

i.	Title of the Course	**Speech Processing Laboratory**
ii.	Credit Structure	L T P C 0 0 3 3
iii.	Prerequisite, if any	Currently taking or already taken Speech Processing 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 speech processing theory course.
v.	Texts/References (separate sheet may be used, if necessary)	1. L.R. Rabiner and R.W. Schafer, Digital Processing of Speech Signals Pearson Education, Delhi, India, 2004 2. J. R. Deller, Jr., J. H. L. Hansen and J. G. Proakis, Discrete-Time Processing of Speech Signals, Wiley-IEEE Press, NY, USA, 1999. 3. D. O'Shaughnessy, Speech Communications: Human and Machine, Second Edition, University Press, 2005. 4. T. F. Quatieri, "Discrete time processing of speech signals", Pearson Education, 2005. 5. L. R. Rabiner, B. H. Jhuang and B. Yegnanarayana, "Fundamentals of speech recognition", Pearson Education, 2009.
vi.	Instructor (s)	S. R. Mahadeva Prasanna
vii.	Name of departments to whom the course is relevant	Computer Science and Engineering, Electrical Engineering and Mechanical Engineering
viii	Justification	Speech Processing Laboratory is important to reinforce different concepts that will be studied as part of the theory course.

Name of Academic Unit: Electrical Engineering
Level: 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

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 Half Semester Course**	Full semester
6	**Prerequisite, if any**	Exposure to Electronic Devices
7	**Course Content** **(separate sheet may be used, 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, Molecular beam Epitaxy Oxidation – Kinetics of Oxidation, Oxidation rate constants, Dopant Redistribution, Oxide Charges, Oxide Layer Characterization Doping – Theory of Diffusion, Infinite Source, Actual Doping Profiles, Diffusion Systems, Ion-Implantation Process, Annealing of Damages, Masking during Implantation Lithography Etching – Wet Chemical Etching, Dry Etching, Plasma Etching Systems, 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, BICMOS Technology.
8	**Texts/References (separate sheet may be used, if necessary)**	1. VLSI Technology by S. M. Sze 2. Silicon VLSI Technology by J.D. Plummer, M. Deal and 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.
Level: UG
Programme: B.Tech.

i	**Title of the course**	EE 204 Analog Circuits
ii	**Credit Structure (L-T-P-C)**	(2-1-0-6)
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)**	Exposure to EE 101, EE 201
vii	**Course Content**	• BJT and MOSFET based amplifiers: Cascaded amplifiers. • Introduction to operational amplifiers: The difference amplifier and the ideal operational amplifier models, concept of negative feedback and virtual short, Analysis of simple operational amplifier circuits, • Frequency response of amplifiers, Bode plots. • Feedback: Feedback topologies and analysis for discrete transistor amplifiers, stability of feedback circuits using Barkhausen criteria. • Linear applications of operational amplifiers: Instrumentation and Isolation amplifiers, Current and voltage sources, Active filters. • Non-linear applications of operational amplifiers: Comparators, clippers and clampers, Linearization amplifiers; Precision rectifiers, Logarithmic amplifiers, multifunction circuits and true rms convertors. • Waveform Generation: sinusoidal feedback oscillators, Relaxation oscillators, square-triangle oscillators • Real operational amplifiers: Current sources and active loads, difference, intermediate and output stages including Miller capacitors for frequency computation, • Operational amplifier parameters; Effects of real operational amplifier parameters on circuit performance. • Analog and Digital interface circuits: A/D, D/A Converters, S/H circuits and multiplexers.

viii	**Texts/References**	1. J. V. Wait, L. P. Huelsman and GA Korn, Introduction to Operational Amplifier theory and applications, 2nd edition, McGraw Hill, New York, 1992. 2. J. Millman and A. Grabel, Microelectronics, 2nd edition, McGraw Hill, 1988. 3. A. S. Sedra and K.C. Smith, Microelectronic Circuits, Saunder's College Publishing, Edition IV 4. Ramakant Gayakwad, Op-amps and Linear Integrated Circuit, 4th edition, Pearson, 2000. 5. P. Horowitz and W. Hill, The Art of Electronics, 2ndedition, Cambridge University Press, 1989.
ix	**Name(s) of Instructor(s)**	NK
x	**Name(s) of otherDepartments/ Academic Units to whom the course is relevant**	None
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 core course which introduces analog amplifiers and their applications in different circuits which are used in several real life devices.

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) ☐ **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**	**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 Engineering

Level: UG

Programme: B.Tech.

i	**Title of the course**	EE 304 Robotics
ii	**Credit Structure (L-T-P-C)**	(2-0-2-6)
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 (For the students) specify course number(s)**	Undergraduate Control Systems or Engineering Mechanics
vii	**Course Content**	• Introduction • Actuators and Drives: DC motors, dynamics of single axis drive systems, Power Electronics basics etc. • Sensors and control components: Robot control using PWM amplifiers, microcontrollers etc. • Robot Mechanisms: Robot linkages and joints • Planar Kinematics: Planar kinematics of serial link mechanisms, Kinematics of Parallel Link Mechanisms etc. • Differential motion: Properties of Jacobians • Mechanics of Robots: Statics, Duality of differential kinematics and statics, robot dynamics, non-holonomic systems • Inverse kinematics and trajectory generation • Concepts of Control: PID control, Hybrid position-force control, compliance control, torque control etc. • Advanced topics and case studies • Demonstrations and assignments using MATLAB and ARM based experimental set-ups

viii	**Texts/References**	1. Asada, H., and J. J. Slotine. Robot Analysis and Control. New York, NY: Wiley, 1986. 2. John J. Craig Introduction to Robotics: Mechanics andControl, Addison-Wesley Publishing Company, 3rd Edition, 2003. 3. M. Spong, M. Vidyasagar, S. Hutchinson, Robot Modeling and Control, Wiley & Sons, 2005. 4. R. M. Murray, Z. Li, S. Sastry, A Mathematical Introduction to Robotic Manipulation, CRC press, 1994.
ix	**Name(s) of Instructor(s)**	AM
x	**Name(s) of other Departments/ Academic Units to whom the course is relevant**	Mechanical 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**	Robotics are being used in the industries for more than two decades now. With decreasing cost of Electronics, computational resources, now a day's robots are being used, now a day, by not only in industries, but also in the fields of medicine, prosthesis, home assistance, agriculture and so on. Even after the wide-spread use, the challenges in the field of Robotics are far from over and a wide range of problems demanding research in this field are still open. Due to the blend of immediate applications as well as scope of research, a course on Robotics is useful for students who will join the industries as well as those who wish to pursue research in this field.

Name of Academic Unit: Electrical engineering

Level : B.Tech

Programme : B.Tech

i	Title of the course	Information theory
ii	Credit Structure (L-T-P-C)	(3 0 0 6)
iii	Type of Course	Institute elective
iv	Semester in which normally to be offered	Fall
v	Whether Full or Half Semester Course	Full
vi	Pre-requisite(s), if any (For the students) – *specify course number(s)*	Basic calculus, Introduction to Probability Theory
vii	Course Content*	● **Introductio**n: Revision of probability theory, revision of basic digital communications, motivation to information theory through examples from basic statistics and communications. ● **Introduction to basic tools and concepts in information theory:** Entropy and mutual information, Chain rules and inequalities, Data processing, Fano's inequality, Asymptotic equipartition property. ● **Source coding:** Guessing game, and its connection to Source coding problem, Kraft's inequality, Optimal code length and Huffman code, Shannon-Fano-Elias and arithmetic codes. ● **Statistics and information theory:** Hypothesis testing, estimation theory, and its connection to information theory. ● **Channel capacity:** Channel coding theorem, joint typicality, Proof of channel coding theorem, Hamming codes and its properties. ● **Continuous channel case:** Differential entropy, Gaussian channel, and its capacity, sphere packing argument, High-level introduction to Quantization theory.

		● **Introduction to Kolmogorov Complexity:** Models of Computation, Kolmogorov Complexity and entropy, Universal Gambling, MDLP.
viii	Texts/References	1. T. Cover, and J. Thomas, "Elements of Information Theory," Second Edition. Wiley-Interscience, 2006. 2. David J. C. Mckay, "Information theory, Inference, and Learning Algorithms," Cambridge university press, 2003.
ix	Name(s) of Instructor(s) ***	B. N. Bharath
x	Name(s) of other Departments/ Academic Units to whom the course is relevant	Computer science, physics, mathematics.
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	Information theory is a fundamental tool in communications and computer science fields in particular, and statistics in general. In the recent times, it has been used as tools in machine learning theory. The course aims to develop these tools in a general context with historical motivation to the subject.

Name of Academic Unit: Electrical Engineering

Level: B. Tech./MS

Programme: MS/Ph.D.

i	**Title of the course**	Modeling and Control of Renewable Energy Resources
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)**	Exposure to Power System Analysis, Electrical Machines, Power Electronics
vii	**Course Content**	Microgrids and distributed generation; Introduction to renewable energy technologies; electrical systems and generators used in wind energy conversion systems, diesel generators, combined heat cycle plants, inverter based generation, solar PV based systems, fuel cell and aqua-electrolyzer, battery and flywheel based storage system; Voltage and frequency control in a microgrid; Grid connection interface issues.
viii	**Texts/References**	1) Anaya-Lara, Jenkins, Ekanayake, Cartwright and Hughes, WIND ENERGY GENERATION Modelling and Control" Wiley, 1st Edison, 2009. 2) Bevrani, Francois and Ise, Microgrid Dynamics and Control, Wiley; First edition, 2017. 3) Gilbert M. Masters, Renewable and Efficient Electric Power Systems, Wiley Interscience, 1st Edison, 2004.
ix	**Name(s) of Instructor(s)**	
x	**Name(s) of other Departments/ Academic Units to whom the course is relevant**	None
xi	**Is/Are there any course(s) in the same/ other academic unit(s) which is/ are equivalent to this course?**	None
xii	**Justification/ Need for introducing the course**	This a core course for MS with specialization in Power and Energy Systems.

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 ($\Delta\ \Sigma$ 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 and Simulation, 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. Understanding delta-sigma data converters. John Wiley & Sons, 2017.
vi.	Instructor (s)	Naveen Kadayinti
vii.	Name of departments to whom the course is relevant	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 will be necessary for any research in Mixed signal VLSI design.

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

i	**Title of the course**	Nanoelectronics
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**	**Introduction:** Shrinking of dimensions from micrometers to nanometers, scaling and limitations of scaling of conventional devices. **Quantum Nanostructures:** Introduction to quantum wells, quantum wires and quantum dots. Fundamentals of carrier transport in quantum structures. **Advanced Electronic Devices:** Single electron transistors, HEMTs, FINFETs, resonant tunneling transistors, optoelectronic and spintronic devices. **Nanomanufacturing:** Top-down and Bottom-up approaches of synthesis of nanomaterials. Introduction to different characterization techniques of nanomaterials like FESEM, TEM, XRD, XPS, FTIR. **Carbon Nanostructures and Applications:** Carbon nanotubes, graphene, fullerenes, band structures and their applications in sensing, energy storage, nanogeneration and in biomedical domain.
viii	**Texts/References**	1.Nanoelectronics and Nanosystems: From Transistors to Molecular and Quantum Devices, Karl Goser, Peter Glösseköttter, Jan Dienstuhl, Springer, 2004. 2. Introduction to Nanotechnology, C.P. Poole Jr., F.J. Owens, Wiley (2003). 3. Emerging nanotechnologies for manufacturing by Waqar Ahmed& M.J Jackson William Andrew Publishing, 2009. 4. Research papers.
ix	**Name(s) of Instructor(s)**	RG
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**	No

	give details.	
xii	**Justification/ Need for introducing the course**	Nanomaterial based electronic devices find wide applications in different industries, environmental monitoring and biomedical domain. This course would help in understanding the necessity, origination, and concepts of different nanoelectronics devices.

Name of Academic Unit: Mechanical Engineering
Level: B. Tech/MTech.
Programme: B.Tech/MTech.

i	**Title of the course**	**Advanced Finite Element Methods**
ii	**Credit Structure (L-T-P-C)**	(3-0-0-6)
iii	**Type of Course**	Elective (PG)
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)**	Finite Element Methods
vii	**Course Content**	**FEM formulation for time dependent problems (16 hours)** - Transient heat transfer problems - Structural dynamics problem - Explicit and Implicit methods of solutions - stability, accuracy and convergence study of solution methods **Introduction to reduced order modelling technique: (6 hours)** - Introduction to reduced order modeling - Methods of reduced order modeling o Static condensation, o mode superposition, o component mode synthesis, o Krylov subspace technique. **Nonlinear Finite Element Method (18 hours)** - Introduction to Nonlinear FEM - FEM for geometric nonlinearity and forcing nonlinearity, - FEM for elastic-plastic analysis o Strain hardening model o Kinematic hardening model - Methods to solve nonlinear problems o Newton Raphson method o Secant method o Continuation method - Convergence of nonlinear solutions o Force convergence o Displacement convergence
viii	**Texts/ References**	1. J.N. Reddy, Introduction to Finite Element Method, Tata McGraw-Hill, 2006 2. J. N. Reddy, An Introduction to Nonlinear Finite Element Analysis, Oxford University Press, 2004. 3. K. J. Bathe, Finite Element Procedures, PHI Learning Pvt. Ltd., 1996 4. T. J. R. Hughes, The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, Dover Publications, 2000 5. Zu-Qing Qu, Model Order Reduction Techniques with Applications in Finite Element Analysis, Springer, 2004
ix	**Name(s) of Instructor(s)**	Amar Keshav Gaonkar and Amlan Barua
x	**Name(s) of other Departments/ Academic Units to whom the course is relevant**	Mechanical Engineering, 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.**	No
xii	**Justification/ Need for introducing the course**	This course is an extension to the introduction to finite element course. A student will get exposure to the advance topics in FEM such as nonlinear FEM, plate theory, dynamic problems, etc which will be helpful for finite element problems in industry and research.

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

i	**Title of the course**	**Applied Elasticity**
ii	**Credit Structure (L-T-P-C)**	2-1-0-6
iii	**Type of Course**	Elective
iv	**Semester in which normally to be offered**	Even
v	**Whether Full or Half Semester Course**	Full
vi	**Pre-requisite(s), if any – specify course number(s)**	Mechanics of Materials
vii	**Course Content**	**Mathematical Preliminaries: (2 hrs)** Second-Order Tensors, Vector, Matrix, and Tensor Algebra, Calculus of Cartesian Tensors **Stress and Equilibrium: (6 hrs)** Stress Tensor, Stress Transformation, Principal Stresses, Spherical and Deviatoric Stresses, Equilibrium Equations, Relations in Curvilinear Cylindrical and Spherical Coordinates **Deformation: Displacements and Strains (6 hrs)** Small Deformation Theory, Strain Transformation, Principal Strains, Spherical and Deviatoric Strains, Strain Compatibility, Curvilinear coordinate system: Cylindrical, Spherical system relations **Material Behavior: (3 hrs)** 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: (2 hrs)** Stress Formulation, Displacement Formulation, Principle of Superposition, Saint-Venant's Principle, Uniqueness theorem, Reciprocal theorem **Two-Dimensional Formulation: (9 hrs)** Plane Strain, Plane Stress, Generalized Plane Stress, Airy Stress Function, Polar Coordinate Formulation, Cartesian Coordinate Solutions; Curvilinear coordinates; 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 (6 hrs)** Extension Formulation; Torsion, Flexure Formulations, Flexure Problems without Twist **Thermoelasticity (2 hrs)** General Uncoupled Formulation, Two-Dimensional Formulation, Displacement Potential Solution, Stress Function Formulation **3D Elasticity: Displacement Potentials and Stress Functions (4 hrs)** Helmholtz Displacement Vector Representation, Lame´'s Strain Potential, Galerkin Vector Representation, Papkovich-Neuber Representation; Spherical Coordinate Formulations, Stress Functions
viii	**Texts/ References**	**Texts:** 1. MH. Sadd, Elasticity: Theory, Applications, and Numerics, 3rd Edition, Academic Press, 2014. 2. J. R. Barber ,Elasticity, 3rd edition, Kluwer Academic, 2009. **References:** 1. S. P. Timoshenko, J. N. Goodier, Theory of Elasticity, 3rd Edition, McGraw Hill Pub. 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. P Chou, N Pagano. Elasticity: Tensor, Dyadic and Engineering Approaches, Dover Pub., 1992. 6. A. S. Saada, "Elasticity Theory and Applications", Cengage Learning, New Delhi, 2014.

		7. Mark Kachanov, Igor Tsurkov, Handbook of Elasticity Solutions, Evener, 2003 8. W. S. Slaughter, The Linearized Theory of Elasticity, Birkhäuser, 2002 9. V. V. Novozhilov, Theory of Elasticity, Pergamon Press, 1961.
ix	**Name(s) of Instructor(s)**	TPG
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.**	NA
xii	**Justification/ Need for introducing the course**	Applied Elasticity is a course which investigates effect of external loads on deformable bodies. This approach for generalization invokes more mathematical rigor. Employing tensorial formulation, this course revisits the problems in structural mechanics 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.

Name of Academic Unit: Mechanical Engineering
Level: B. Tech.
Programme: B. Tech.

i	**Title of the course**	'Composite Materials: Manufacturing, Properties & Applications'
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)**	Nil
vii	**Course Content**	• Introduction: Definition and classification, Importance of composites over other materials. Revision of some mechanical properties. • Reinforcements: Functions of reinforcements and their forms, Glass fibers: Production, composition and properties, Production and properties of carbon and aramid fibers, Ceramic particulate and whisker reinforcements. • Micromechanics: Estimation of modulus and tensile strength. Prediction of thermal and electrical properties • Role of matrix and characteristics of different matrix materials. • Reinforcement-matrix Interfaces: wettability, interactions at the interfaces. Mechanical, physical and chemical bonding. • Polymer matrix composites (PMC): Important polymeric matrices, Manufacturing methods: Unit operations, hand lay-up, spray-up, pressure bag molding, vacuum bagging, prepags, compression molding, autoclaving, RTM, filament winding and pultrusion. • Metal matrix composites (MMC): Property advantages, comparison between MMCs & PMCs. Manufacturing of MMCs: Solid state processes: Diffusion bonding and P/M routes, Liquid state

		processes: Melt-infiltration, stir casting, in-situ processing, spray deposition and electrodeposition. • Properties and applications of selected PMCs and MMCs in industry. • Ceramic matrix composites (CMC): Types of CMCs, main processing methods, and important applications. • Introduction to Nanocomposites.
viii	**Texts/References**	Text Books: (1) K.K. Chawla, 'Composite Materials: Science and Engineering', 3rd Ed. Springer-Verlag, N.Y. (2012). (2) F.L. Matthews and R.D. Rawlings, 'Composite Materials: Engineering and Science', CRC, Woodhead Pub. Ltd., Cambridge, England (2008). References: (1) N. Chawla and K. K. Chawla, 'Metal Metrix Composites' 2nd Ed, Springer, N.Y. (2013). (2) ASM Handbook Vol.21: Composites, Eds. D.B. Miracle and S. L. Donaldson , ASM International, Ohio (USA) (2001).
ix	**Name(s) of Instructor(s)**	ANT
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/ are equivalent to this course? If so, please give details.**	Nil
xii	**Justification/ Need for introducing the course**	The objectives of the course are to provide the students with - • An understanding of basics of reinforcements, matrices and composite materials. • Structure, processing and properties of reinforcements and matrix materials. • Basic understanding of composite micromechanics and interfacial bonding. • Manufacturing methods and engineering applications of Polymer-, metal- and ceramic- matrix composites (PMC, MMC, &CMC). • Introduction to nanocomposites and their application.

Name of Academic Unit: Mechanical Engineering Department

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

1	**Title of the course**	Design of Heat Exchangers
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)	Mechanical Engineering (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**	Classification of heat exchangers, Basic design methods of heat exchangers Single phase heat exchangers: Forced Convection Correlations for the Single-Phase Side of Heat Exchangers, Design of double pipe heat exchangers, shell and tube heat exchangers, compact heat exchangers Fundamentals of two phase flow, Essentials for the design of two phase heat exchangers, Design Correlations for Condensers and Evaporators, Design of evaporators and condensers
7	**Texts/References**	1. Ramesh K. Shah, Dusan P. Sekulic, Fundamentals of Heat Exchanger Design, John Wiley and Sons, USA, 2003, ISBN:9780471321712, First Edition 2. Sadik Kakac, Hongtan Liu, Anchasa Pramuanjaroenkij, Heat Exchangers: Selection, Rating, and Thermal Design, CRC Press, 2020, ISBN 9781138601864, Fourth Edition 3. W.M. Kays and A.L. London, Compact heat exchangers, McGrawhill Book Company, 1984, ISBN: 9780070334182, Third Edition 4. Arthur P Fraas, Heat Exchanger Design, John Wiley and Sons, 1989, ISBN: 978-0-471-62868-2.

		Second Edition
8	**Name (s) of the instructor (s)**	S.V.Prabhu, Sudheer S, Dhiraj V. Patil
9	**Name (s) of other departments / Academic Units to whom the course is relevant**	Nil
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)**	Fluid Mechanics and Heat Transfer
12	**Recommended Pre-requisite(s) - specify course number(s)**	ME 203 and ME 301
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)	Design, heat exchangers, condensers, evaporators, single phase correlations, two phase correlations, two phase
14	**Justification/ Need for introducing the course**	Thermal design of the heat exchangers is essential as heat exchangers are extensively used in several practical applications.

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

i	**Title of the course**	Tribology
ii	**Credit Structure (L-T-P-C)**	3-0-0-6
iii	**Type of Course**	Core
iv	**Semester in which normally to be offered**	Even
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**	**Introduction – Materials and surfaces:** Tribology — Historical perspective, Industrial Significance, Economic considerations; Solid structure and properties — Atomic Structure, Bonding and Coordination, Disorders in Solid Structures, Elastic and Plastic Deformation, Fracture and Fatigue, Time Dependent Viscoelastic & Viscoplastic Deformation. Surfaces — Nature of surfaces, Characteristics of Surface Layers, Surface texture, Surface parameters, Measurement of surface parameters, Statistical properties of surfaces, Analysis of Surface Roughness. **Contacts:** Analysis of Contacts — Single Asperity, Multiple Asperity Contacts, Measurement of the Real Area of Contact, Stress distribution, Displacements due to loading, Hertzian and non-Hertzian contacts, Rough surfaces in contact, Deformation mode, Thermal effects; Adhesion — Solid–Solid Contact, Contact with liquid mediation. **Friction:** Friction — Measurement, Causes, Theories, Plastic interaction of surface asperities, Ploughing effect, Elastic hysteresis losses, Solid–Solid Contact, Liquid-Mediated Contact, Friction of Materials; Rolling Motion — Free rolling, Microslip in rolling, Tyre-road contacts. **Wear:** Wear — Definitions, Mechanisms, Wear Debris, Wear of Materials, Indentation cracking, Factors affecting wear, Experimental considerations, Wear control, Application of wear in design, Characteristics of friction induced vibrations. **Lubrication:** Lubricants — Viscosity, Measurement of viscosity, Lubricating oils,

		Greases; Lubrication — Regimes of Fluid Film Lubrication, Viscous Flow and Reynolds Equation, Hydrostatic Lubrication, Hydrodynamic Lubrication, Elasto-hydrodynamic Lubrication.
viii	**Texts/References**	1. Introduction to Tribology, Bharat Bhushan, John Wiley & Sons. 2. Principles of Tribology, Halling, J. (Ed), Macmillan, 1975.
ix	**Name(s) of Instructor(s)**	Dr. Shrikanth V.
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**	Tribology concerns the application of **science** and **engineering** to the understanding of **interacting surfaces** in **relative motion**. In its modern usage tribology is taken to mean the study of any situation that involves **friction**, **wear** and **lubrication**. In reality, there are few situations which don't involve one or more of these. Just taking a few examples: • Without friction, we wouldn't even be able to stand up • Without wear processes, coastal erosion would not happen • Without lubrication, skiing would be a *really* dull sport! Whether we realise it or not, tribology pervades our everyday lives. The act of choosing different footwear, or changing the tyres on our bicycles or cars depending on the weather, are just some examples of our innate understanding of the importance of friction. However, in manufacturing, in sports, in medical devices and implants, even in personal hygiene products, the understanding of tribology and its effects requires a rigorous application of scientific understanding and engineering practice.

Name of Academic Unit: Mechanical Engineering
Level: B. Tech.
Programme: B.Tech.

i	**Title of the course**	Introduction to Computational Fluid Dynamics
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 – specify course number(s)**	ME 203 Fluid Mechanics; Numerical Analysis; Computer Programming
vii	**Course Content**	1. Review of Governing Equations: General conservation equation; specific mass, momentum, energy conservation equations. 2. Fundamentals of Numerical Methods: Direct and iterative solvers for linear equations; PDE, Classification, Basics of finite-difference, finite-volume finite-volume methods; Notion of accuracy, consistency, stability, convergence; Verification and validation. 3. Diffusion Equation: 1-D steady conduction; Source terms and non-linearity; 2-D steady conduction; Unsteady conduction; Non-trivial boundary conditions. 4. Advection-Diffusion Equation: Steady 1-D advection-diffusion equation; Upwinding, numerical diffusion, higher-order schemes; 2-D advection-diffusion equation 5. Incompressible Navier-Stokes equations, Incompressibility and pressure-velocity coupling; Staggered vs collocated grids; SIMPLE and PISO algorithms. 6. Special Topics: Non-Cartesian coordinate systems; Curvilinear grids; Unstructured grids; Advanced linear solution methods such as multigrid methods, preconditioning; Use of numerical libraries; Introduction to parallel programming for CFD. 7. Mesoscopic approaches to discrete simulation of fluid dynamics

		8. Tutorial on a commercial CFD code & an open-source code (e.g. OpenFOAM).
viii	**Texts/References**	1. "An Introduction to Computational Fluid Dynamics", by H. W. Versteeg and W. Malalasekera; 2nd edition, Pearson Education Ltd., 2007. (ISBN: 9780131274983) 2. "Introduction to Computational Fluid Dynamics: Development, Application and Analysis", by Atul Sharma; Wiley, 2016. (ISBN: 9781119002994)
ix	**Name(s) of Instructor(s)**	Dhiraj V Patil
x	**Name(s) of other Departments/ Academic Units to whom the course is relevant**	Departments of Mathematics, Chemical, Civil, 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.**	NA
xii	**Justification/ Need for introducing the course**	CFD is an integral part of the design process in mechanical, aerospace, and chemical industries, as well as a topic of active research. Training at the undergraduate and early-postgraduate level will enable students to take advantage of opportunities in these areas. The course aims to provide an introduction to discretization and solution of the equations of fluid dynamics and heat transfer. Students will gain an appreciation of the principles of the finite-volume method, experience in writing and debugging scientific codes, and solving and analysing a problem using a commercial/open-source package. Students should expect to devote significant time to learning via coding assignments and project.

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 course number(s)	Knowledge of linear elasticity and Finite Element Method (FEM) is recommended
vii	Course Content	Module I: Non-linear Solic Mechanics (27 hrs) Introduction to Tensors: Overview of conventions & mathematical identities in vector calculus and tensor algebra. (2 hr) Review of Linear Elasticity: Linear strain tensor,compatibility conditions,stress tensor, equilibrium equation. (3 hr) Kinematics of Deformation: Material and spatial derivatives, Deformation gradient, Strain tensor, Velocity gradients, Spin tensor, Lie time derivatives. (5 hr) 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. (4 hr) Balance Principals and Constitutive relation: Conservation of mass, Reynolds' Transport theorem, Principals of Mometum and Energy balance. (5 hrs) 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 (8 hrs) Module II: Non-linear Finite Element Method (15 hrs) Essentials concepts for Non-linear FEM : Linearization, Directional derivative, Objective stress rates (Oldroyd, Green-Naghdi, Jaumann-Zaremba, Truesdell), Variational method (5 hrs) Large Elastoplastic Deformations: Multiplicative decomposition, Rate kinematics, Incremental kinematics (5 hrs) Numerical Techniques for Incompressibility: Volumetric locking, Numerical approach to handle incompressibility – Lagrange multiplier, Penalty method, Hu-Washizu variational principal, Mean dilatation (5 hrs)
viii	Texts/ References	Text-books: 1. Gerhard A. Holzapfel, *Non-linear Solid Mechanics- A continuum approach for engineering,*

		John Wiley and Sons Ltd. 2000. 2. J. Bonet, RD. Wood, *Non-linear Continuum Mechanics for Finite Element Analysis* (2nd Ed), Cambridge University Press., 2008. References: 1. LA. Taber, *Non-linear Theory of Elasticity – Applications in Biomechanics*, World Scientific Publishing, 2004. 2. 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 documetation 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 tor large-strain-large-deformation scenario are discussed, including numerical modeling of incompressible material constituive model with appropriately designed assignments to ensure hands-on exposure for the students.

Name of Academic Unit: Electrical Engineering

Level: UG

Programme: B.Tech.

i	**Title of the course**	EE 304 Robotics
ii	**Credit Structure (L-T-P-C)**	(2-0-2-6)
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 (For the students) specify course number(s)**	Undergraduate Control Systems or Engineering Mechanics
vii	**Course Content**	• Introduction • Actuators and Drives: DC motors, dynamics of single axis drive systems, Power Electronics basics etc. • Sensors and control components: Robot control using PWM amplifiers, microcontrollers etc. • Robot Mechanisms: Robot linkages and joints • Planar Kinematics: Planar kinematics of serial link mechanisms, Kinematics of Parallel Link Mechanisms etc. • Differential motion: Properties of Jacobians • Mechanics of Robots: Statics, Duality of differential kinematics and statics, robot dynamics, non-holonomic systems • Inverse kinematics and trajectory generation • Concepts of Control: PID control, Hybrid position-force control, compliance control, torque control etc. • Advanced topics and case studies • Demonstrations and assignments using MATLAB and ARM based experimental set-ups

viii	**Texts/References**	1. Asada, H., and J. J. Slotine. Robot Analysis and Control. New York, NY: Wiley, 1986. 2. John J. Craig Introduction to Robotics: Mechanics andControl, Addison-Wesley Publishing Company, 3rd Edition, 2003. 3. M. Spong, M. Vidyasagar, S. Hutchinson, Robot Modeling and Control, Wiley & Sons, 2005. 4. R. M. Murray, Z. Li, S. Sastry, A Mathematical Introduction to Robotic Manipulation, CRC press, 1994.
ix	**Name(s) of Instructor(s)**	AM
x	**Name(s) of other Departments/ Academic Units to whom the course is relevant**	Mechanical 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**	Robotics are being used in the industries for more than two decades now. With decreasing cost of Electronics, computational resources, now a day's robots are being used, now a day, by not only in industries, but also in the fields of medicine, prosthesis, home assistance, agriculture and so on. Even after the wide-spread use, the challenges in the field of Robotics are far from over and a wide range of problems demanding research in this field are still open. Due to the blend of immediate applications as well as scope of research, a course on Robotics is useful for students who will join the industries as well as those who wish to pursue research in this field.