i.	Title of the Course	**PATTERN RECOGNITION AND MACHINE LEARNING (PRML)**
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)	**Overview of** Probability Theory, Linear Algebra, Convex Optimization. **Introduction:** History of pattern recognition & machine learning, distinction in focus of pattern recognition and machine learning. **Regression**: Linear Regression, Multivariate Regression, Logistic Regression. **Clustering:** Partitional Clustering, Hierarchical Clustering, Birch Algorithm CURE Algorithm, Density-based Clustering **PCA and LDA:** Principal Component Analysis, Linear Discriminant Analysis. **Kernel methods:** Support vector machine **Graphical Models**: Gaussian mixture models and hidden Markov models **Introduction to Bayesian Approach:** Bayesian classification, Bayesian Learning, Bayes Optimal Classifier, Naive Bayes Classifier and Bayesian Network..
v.	Texts/References (separate sheet may be used, if necessary)	1. C. Bishop, "Pattern Recognition and Machine Learning," Springer, 2006. 2. S. Theodoridis and K. Koutroumbas, "Pattern Recognition" Second Edn, Elsivier, 2003 3. B. Yegnanarayana, "Artificial Neural Networks", PHI, 1999. 4. Simon Haykin, "Neural Networks and Learning Machines", Pearson, 1999.
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	Pattern Recognition and Machine Learning (PRML) has become an integral tool to solve real world challenges in many engineering fields. This course gives an exposure to topics in pattern recognition and machine learning.

i.	Title of the Course	**PRML LABORATORY**
ii.	Credit Structure	L T P C 0 0 3 3
iii.	Prerequisite, if any	Currently taking or already taken PRML 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 PRML theory course.
v.	Texts/References (separate sheet may be used, if necessary)	1. C. Bishop, "Pattern Recognition and Machine Learning," Springer, 2006. 2. S. Theodoridis and K. Koutroumbas, "Pattern Recognition" Second Edn, Elsivier, 2003 3. B. Yegnanarayana, "Artificial Neural Networks", PHI, 1999. 4. Simon Hayking, "Neural Networks and Learning Machines", Pearson, 1999.
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	PRML Laboratory is important to reinforce different concepts that will be 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**	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 the Academic Unit: Computer Science & Engineering

Level: UG/PG.

Programme: B. Tech

i	**Title of the course**	**CS 423 Advanced topics in Embedded 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**	July to December (Odd)
v	**Whether Full or Half Semester Course**	Full
vi	**Pre-requisite(s), if any (For the students) – specify course number(s)**	CS 301 (Computer Architecture). Exposure to Operating Systems is preferred.
vii	**Course Content**	Introduction to systems software in embedded platforms Boot loader, Embedded Linux kernel (Processes, Threads, Interrupts), Device Drivers, Scheduling Policies (including Real Time), Memory Management, Optimizations (Data level and Memory level), Embedded Systems Security, Introduction to Embedded GPUs and Accelerators, Embedded Heterogenous Programming with Open CL Application Case Study on Embedded Platforms – eg. Neural Network inferencing on Embedded Platforms, Advanced Driver Assistance Systems
viii	**Texts/References**	Building Embedded Linux Systems, 2nd Edition by Gilad Ben-Yossef, Jon Masters, Karim Yaghmour, Philippe Gerum, O'Reilly Media, Inc. 2008 Linux Device Drivers, Third Edition By Jonathan Corbet, Alessandro Rubini, Greg Kroah-Hartman, O'Reilly Media, Inc. 2005 Embedded Systems: ARM Programming and Optimization by Jason D Bakos, Elsevier, 2015 Learning Computer Architecture with Raspberry Pi by Eben Upton, Jeff Duntemann, Ralph Roberts, Tim Mamtora, Ben Everard, Wiley Publications, 2016 Real Time Systems by Jane S. Liu, 1 edition, Prentice Hall; 2000 Practical Embedded Security: Building Secure Resource-Constrained Systems by Timothy Stapko, Elsevier, 2011
ix	**Name(s) of Instructor(s)**	Dr Gayathri Ananthanarayanan
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.**	No

Name of Academic Unit : Computer Science and Engineering

Level : MS/B.Tech

Programme : MS/B.Tech

i	**Title** of the course	**CS 407 Parameterized Algorithms and Complexity**
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	**Prerequisite(s)**, if any (For the students) – *specify course number(s)*	Data Structures and Algorithms, Design and Analysis of Algorithms
vii	Course **Content***	Introduction. Kernelization, Bounded Search Trees, Iterative Compression, Treewidth, Advanced kernelization algorithms. Lower bounds: Fixed-parameter intractability, lower bounds based on ETH, lower bounds for kernelization.
Viii	Texts/References	*Textbook:* *(1) Parameterized Algorithms, Marek Cygan, Fedor V. Fomin, Lukasz Kowalik. Daniel Lokshtanov, Daniel Marx, Marcin Pilipczuk, Michal Pilipczuk, and Saket Sourabh. Springer. 2015* *Reference:* *(1) Parameterized Complexity, R. G. Downey, and M. R. Fellows. Springer Science and Business Media. 2012*
x	Name(s) of **Instructor(s)** ***	SRB
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) whichis/ are **equivalent** to this course? If so, please give details.	No
xii	**Justification/ Need** for introducing the course	Parameterized Algorithms and Complexity is a relatively new and vibrant subfield in Theoretical Computer Science. The main focus of this area is to improve the understanding of computationally hard algorithmic problems and to device practically efficient algorithms for the same.

Name of Academic Unit: Computer Science and Engineering

Level: B. Tech./MS

Programme: B.Tech./MS

i	**Title of the course**	CS 601 Software Development for Scientific 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**	Autumn
v	**Whether full or half semester course**	Full
vi	**Pre-requisite(s), if any (for the students) – specify course number(s)**	Exposure to Data Structures and Algorithms, C / C++ / Java / Matlab
vii	**Course content**	Algorithmic Patterns in Scientific Computing: dense and sparse linear algebra, structured and unstructured grid methods, particle methods (N-body, Particle-Particle, Particle-in-cell, Particle-in-a-mesh), Fast Fourier Transforms, Implementing PDEs, C++ standard template library (STL), Introduction to debugging using GDB, GMake, Doxygen, Version Control System, Profiling and Optimization, asymptotic analysis and algorithmic complexity. Mixed-language programming using C, Fortran, Matlab, and Python, Performance analysis and high-performance code, Data locality and auto tuning, Introduction to the parallel programming world.
viii	**Texts/References**	- Stroustrup C++ Language Reference (https://www.stroustrup.com/4th.html) - Suely Oliveira, David Steward: Writing Scientific Software: A Guide to Good Style. Cambridge University Press, 2006 - Web references to GNU Make, GDB, Git, GProf, Gcov. - Code Complete: A Practical Handbook of Software Construction - https://www2.eecs.berkeley.edu/Pubs/TechRpts/2006/EECS-2006-183.html
ix	**Name (s) of the instructor (s)**	Nikhil Hegde
x	**Name (s) of other departments / Academic Units to whom the course is relevant**	EE, ME
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**	Creating software in Computational Science and Engineering requires

	introducing the course	skills and tools from many disciplines. This course focuses on how the skills and tools are applied towards larger software development goals in the context of dominant algorithmic patterns or *motifs* found in scientific computing. The aim of the course is to provide knowledge on how advanced numerical methods and complex algorithms in Scientific Computing can be implemented using C++ to engineer larger systems through software development principles of refactoring, composition, correctness and performance analysis, and debugging. The course initiates students into CS305: Software engineering, a rigorous study of software development principles. Also, the course provides a base for subsequent parallelization optimizations, which is the subject of CS410: Parallel Computing that focuses on parallelizing scientific code (often) using different parallel programming paradigms.

Name of Academic Unit: Computer Science

Level: B.Tech/MS/PhD

Program: B.Tech /MS/PhD

i	**Title of the course**	**CS 433 Cloud Software Development**
ii	**Credit Structure (L-T-P-C)**	1.5-0-0-3
iii	**Type of Course**	Elective
iv	**Semester in which normally to be offered**	Autumn
v	**Whether Full or Half Semester Course**	Half
vi	**Pre-requisite(s), if any (For the students) – *specify course number(s)***	**Desirable**: Exposure on Operating System, Database, Cloud Programming language (Java, .Net, NodeJS, HTML/CSS, etc.)
vii	**Course Content**	*Module 1 - Introduction to Cloud Computing Landscape* ● *Understand how industries rely on the cloud computing global infrastructure, Identify the applications and use cases* ● *Identify the principles and characteristics of Cloud Computing - IaaS, PaaS, SaaS* ● *Validate the different patterns of cloud computing adoption including public cloud services, private and hybrid approaches* ● *Identify common challenges associated with the adoption of cloud computing solutions and associated myths* ● *Compare and contrast with on-premise/traditional versus cloud* ● *Understand in-country data regulations, data sovereignty considerations* *Module 2 - Cloud Computing Technology* ● *Understand Virtualization Concepts - data, compute, network, operating system, HCI* ● *Understand Cloud Infrastructure -Backup, Restore, Migration, DC/DR, HA use cases* ● *Understand Programming concepts Cloud-native apps, Serverless, Containers* ● *Learn Containers– Kubernetes, Docker, containers* *Module 3 - Using Managed Cloud Services* ● *Learn 12-factor Application Architecture, api, Microservices, databases - sql, no-sql, object store* ● *Application and Microservice Security- OAuth, access tokens*

		• *Understand Autoscale - horizontal and vertical scaling, logging and monitoring aspects of apps and infrastructure* • *Learning DevOps frameworks - toolchains, ci/cd, blue/green deployment, canary deployment* *Module 4 - Case Studies - Public Cloud Provider – aws, azure, ibmcloud*
viii	**Texts/References**	Text Books: - Thomas Erl, Zaigham Mahmood, Ricardo Puttini, "Cloud Computing Concepts, Technology & Architecture", Pearson, 2013. Reference Books: - Boris Scholl, Trent Swanson, Peter Jausovec, "Cloud Native", O'Reilly, 2019. Resources from Internet: - Public Cloud Documentations: - https://learning.oreilly.com/library/view/cloud-computing-concepts/9780133387568/ - https://www.amazon.in/Cloud-Computing-Concepts-Technology-Architecture/dp/0133387526/ Class Notes/Lectures
ix	**Name(s) of Instructor(s)**	Girish Dhanakshirur Supported by Rajshekar K
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 aims at preparing the students for the next technology frontier - Cloud computing. While the field is vast, this course prepares students in core cloud concepts, architectures, programming languages, frameworks, deployments, etc., with hands-on labs. The course will act as a foundation for further research or certification. Many Public Cloud vendors offer free students access to get hands-on experience on what they learn in the course. Students will complete few labs using those Public Cloud platforms.

Name of Academic Unit: Electrical Engineering

Level: UG/PG

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

i.	**Title of the Course**	**EE 429 Design of Power Converters**
ii.	**Credit Structure**	(2-0-1-6)
iii.	**Type of Course**	Elective
iv.	**Prerequisite, if any**	EE222: Introduction to Power Electronics or equivalent as determinedby the instructor or faculty advisor.
v.	**Course Content (separate sheet may be used, if necessary)**	Gate drives for BJT, MOSFET and IGBT, heatsink selection, snubber circuits, buck, boost, and buck-boost converters, isolated converters like forward, push-pull, half-bridge, full-bridge, and flyback types, design of magnetics for inductors and transformers, inverters, PWM generation, control of power converters: single loop and double loop controls; voltage mode and current mode control, peak current control, hysteresiscontrol space vector PWM, d-q axis theory for 2 and 3 phase applications, intro to induction machine design and winding.
vi.	**Texts/References (separate sheet may be used, if necessary)**	1. Power Electronics: Essentials & Applications., L Umanand, Wiley 2009. 2. Fundamentals of Power Electronics, Robert W Erickson and Dragan Maksimovic, Springer, 3ed, 2020. 3. Daniel W Hart, Introduction to Power Electronics, Prentice-Hall, 1997. 4. Mohan, N., et al, Power Electronics, John Wiley, 1989.
vii.	**Instructor (s)**	Satish Naik
viii.	**Name of dept to whom the course is relevant**	Electrical Engineering
ix	**Justification**	This course is a design-oriented course aimed at power converter system design. The course focuses on the design of switched-mode converter circuits. The following topics are discussed with emphasis on design: gate drives for BJT, MOSFET and IGBT, heatsink selection, snubber circuits, buck, boost, and buck-boost converters, isolated converters likeforward, push-pull, half-bridge, full-bridge, and flyback types, design ofmagnetics for inductors and transformers, inverters, PWM generation, space vector PWM, d-q axis theory for 2 and 3 phase applications, introto induction machine design and winding.

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

i.	Title of the Course	**EE 431 Advanced Power Systems**
ii.	Credit Structure (L-T-P-C)	3-0-0-6
iii.	Type of Course	Elective
iv.	Semester in which normally to beoffered	Autumn
v.	Whether full or half semester course	Full
vi.	Prerequisite, if any	EE223: Introduction to Power Systems or equivalent as determined by the instructor or faculty advisor.
vii.	Course Content (separate sheet may be used, if necessary)	Symmetrical Components; Fault Analysis in Power Systems; Power System Stability; Power System Transients; Circuit Breakers; Protection ofTransmission Lines, Generators, Transformers; Economic Dispatch; Automatic Generation Control.
viii.	Texts/References (separate sheetmay be used, if necessary)	1. Power System Analysis, Bergen & Vittal, 2nd Ed, Pearson, 1999. 2. Power System Analysis, Hadi Saadat, 2011, ISBN-10: 0984543864. 3. Power System Analysis, Grainger & Stevenson, McGraw Hill, 2017, ISBN-10: 9780070585157 4. Power System Engineering, Nagrath & Kothari, McGraw-Hill, 3rd Ed, 2019, ISBN-10 : 9353165113.
ix.	Instructor (s)	Pratyasa Bhui
x.	Name (s) of other departments / Academic Units to whom the courseis relevant	Electrical Engineering
xi	Is/Are there any course(s) in the same/ other academic unit(s) whichis/ are equivalent to this course? If so, please give details.	No
xii.	Justification	This course is important to learn essential topics like fault calculations, stability analysis of power systems after disturbances, transients in voltage during with fault clearing, designing power system protection for lines transmission lines, generators and transformers. This will also cover some aspects of power system operation like economic dispatch and automatic generation control. There will be MATLAB based simulation experiments on every topic covered in this course.

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

i	**Title** of the course	**EE 406 Speech Processing**
ii	Credit Structure (**L-T-P-C**)	**(3 0 0 6)**
iii	**Type** of Course	Elective course
iv	Semester in which normally tobe offered	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***	**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 Fourierrepresentation, non-stationary signals, development of STFT, transform and filter-bank views of STFT. **Cepstrum analysis:** Basis and development, delta, delta-delta andmel-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 SpeechSignals Pearson Education, Delhi, India, 2004 2. J. R. Deller, Jr., J. H. L. Hansen and J. G. Proakis, Discrete-TimeProcessing of Speech Signals, Wiley-IEEE Press, NY, USA, 1999. 3. D. O'Shaughnessy, Speech Communications: Human andMachine, 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
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

i.	Title of the Course	**EE 414 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 thatwill be studied as part of the theory course.

Name of Academic Unit: Mechanical, Materials and Aerospace Engineering
Level: **UG-PG**
Programme: B.Tech./M. Tech./M.S./PhD

i	**Title of the course**	**ME 435 Design of Mechatronic 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**	Even/Odd
v	**Whether Full or Half Semester Course**	Full
vi	**Pre-requisite(s), if any – specify course number(s)**	
vii	**Course Content**	Introduction: Elements of mechatronics system: Sensor, actuator, plant, and controller. Applications of mechatronics system. Systems like CDROM, scanner opened to see whats there inside and why?. Integrated mechanical-electronics design philosophy. Examples of real life systems. Smart sensor concept and utility of compliant mechanisms in mechatronics. Microprocessor building blocks, combinational and sequential logic elements, memory, timing and instruction execution fundamentals with example of primitive microprocessor. Microcontrollers for mechatronics: Philosophy of programming interfaces, setting sampling time, and Getting started with TIVA programming Microcontroller programming philosophy emphasis on TIVA, programming different interfaces PWM, QEI etc. Mathematical modeling of mechatronic systems, Modeling friction, DC motor, Lagrange formulation for system dynamics. Dynamics of 2R manipulator, Simulation using Matlab, Selection of sensors and actuators. Concept of feedback and closed loop control, mathematical representations of systems and control design in linear domain, Basics of Lyapunov theory for nonlinear control, notions of stability, Lyapunov theorems and their application Trajectorytracking control development based on Lyapunov theory, Basics of sampling of a signal, and signal processing Digital systems and filters for practical mechatronic system implementation. Research example/ case studies of development of novel mechatronics system: 3D micro-printer, Hele Shaw system for microfabrication.
viii	Texts/ References	• Devdas Shetty, Richard A. Kolk, "Mechatronics System Design," PWS Publishing company • Boukas K, Al-Sunni, Fouad M "Mechatronic,Systems Analysis, Design and Implementation," Springer, • Sabri Cetinkunt, "Mechatronics with Experiments," 2nd Edition, Wiley • Janschek, Klaus, "Mechatronic Systems Design," Springer
ix	**Name(s) of Instructor(s)**	SDR, MM
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.**	Nil
xii	**Justification/ Need for introducing the course**	This course is geared towards developing skills of candidates towards conceiving new mechatronics products based on raw ideas and develop them. The course focuses on hands-on experience along with a project, and offers a lot of practical tips to make theory work in practice. Furthermore, the course catalyzes integrated thinking in mechanical and electronics domain, which is crucial to successful product design and development.

Chemistry Department

Name of Academic Unit: Chemistry
Level: UG/PG
Programme: B.Tech. / MS /M.Tech. /Ph.D.

i	**Title of the course**	**CH 405 Our Health and Medicine**
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 Semester
vi	**Pre-requisite(s), if any (for the students) – specify course number(s)**	None
vii	**Course content**	Health and nutrition**,** role of different nutrients (carbohydrates, proteins, fats, vitamins, and minerals), diet and metabolism, basic introduction to human physiology, communicable diseases (common bacterial and fungal infections, antibiotics and resistance, common viral infections, corona virus (SARS, MERS, SARS-COV-2), vaccine and antivirals, non-communicable diseases (diabetes, cancer), basic medicinal chemistry, preventative and community medicine, health policies, healthcare system, health awareness and best practices
viii	**Texts/References**	1. Oxford textbook of medicine: Infection ed. by David Warrell and Timothy Cox, 1st edition, OUP, 2012. 2. Textbook of community medicine ed. by Rajvir Bhalwar, 2nd edition, Wolters Kluwer, 2017. 3. Koneman's textbook of diagnostic microbiology, 7th edition, Wolters Kluwer, 2017. 4. Principles of therapeutic nutrition and dietetics, by Avantina Sharma, 1st edition, CBS, 2017. 5. Textbook of medical biochemistry by Rajinder Chawla, E.H. El-Metwally and Suchanda Sahu, 2nd edition, Wolters Kluwer, 2017. 6. An introduction to medicinal chemistry by Graham L. Patrick, 3rd edition, OUP, 2005.
ix	**Name (s) of the instructor (s)**	Nilkamal Mahanta
x	**Name (s) of other departments / Academic Units to whom the course is relevant**	All departments with B. Tech/MS and PhD courses are encouraged

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 designed to spread awareness among students on the best practices to maintain a good health and to emphasize on the role of diet and nutrition. It will also encompass common diseases that we encounter often and various ways to prevent and mitigate them with the basic understanding of human physiology and medicinal chemistry. In the wake of this global COVID-19 pandemic, fundamental information on good health and community medicine as well as healthcare system/policies has become indispensable. This course will provide the necessary foundation on the mechanism of various commonly used drugs, preventative medicine, and suitable family health practices which will facilitate one in making informed decisions on prevention, diagnosis, treatment, care, and support when required.

Name of Academic Unit : Chemistry

Level : B.Tech

Programme : B.Tech.

i	**Title** of the course	**CH 402 Quantum field theory**
ii	Credit Structure (**L-T-P-C**)	2-1-0-6
iii	**Type** of Course	Elective 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)*	Exposure to Physics, Chemistry and Mathematics
vii	Course **Content***	Introduction: Review of Classical Field Theories and the need for Quantum Field Theory Bosonic Fields: Second quantization of bosons; non-relativistic quantum fields and the Landau Ginzburg theory; relativistic free particles and the KleinGordon field; causality and the Klein-Gordon propagator; quantum electromagnetic fields and photons. Fermionic Fields: Second quantization of fermions; particle-hole formalism; Dirac equation and its nonrelativistic limit; quantum Dirac field; spinstatistics theorem; Dirac matrix techniques; Lorentz and discrete symmetries. Interacting Fields and Feynman Rules: Perturbation theory; correlation functions; Feynman diagrams; S-matrix and crosssections; Feynman rules for fermions; Feynman rules for QED. Functional Methods: Path integrals in quantum mechanics; "path" integrals for classical fields and functional quantization; functional quantization of QED; QFT and statistical mechanics; symmetries and conservation laws. Quantum Electrodynamics: Some elementary processes; radiative corrections; infrared and ultraviolet divergencies; renormalization of fields and of the electric charge; Ward identity. Renormalization Theory: Systematics of renormalization; `integration out' and the Wilsonian renormalization; `running' of the coupling constants and the renormalization group. Non-Abelian Gauge Theories: Non-abelian gauge symmetries; Yang-Mills theory; interactions of gauge bosons and Feynman rules; Fadde'ev-Popov ghosts and BRST; renormalization of the YM theories and the asymptotic freedom; the Standard Model.
Viii	Texts/References	1. "An Introduction to Quantum Field Theory", Michael Peskin and Daniel Schroeder (Addison Wesley) 2. "Introduction to Quantum Field Theory", A. Zee 3. "Quantum Field Theory", Lewis H. Ryder 4. "Quantum Field Theory and Critical Phenomena", by Jean Zinn-Justin. 5. "Quantum field Theory for the Gifted Amateur", T. Lancaster and Stephen J. Blundell 6. NPTEL lectures in Quantum Field Theory (https://nptel.ac.in/courses/115106065/)

ix	Name(s) of **Instructor(s)** ***	Prof. B. L. Tembe
x	Name(s) of **other**	B.Tech. students of all departments
	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?	No
xii	**Justification/ Need** for introducing the course	Quantum Field Theory is one of the basic theories in physics which has met with great success in explaining a large number of natural phenomena. This could be of interest to most students with a desire to learn physics and mathematics and who have a basic background in science in engineering of up to the third year of IIT B.Tech courses.

Name of Academic Unit: HSS

Level: Ph.D./B.Tech.

Programme: Ph.D./B.Tech. (may be admitted with some CPI criterion)

i	Title of the course	**HS 405 Macroeconomics**
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 (For the students) – *specify course number(s)*	HS201 (for B.Tech. students)
vii	Course **Content***	1. Introduction: The major macroeconomic issues-Economic Growth, Inflation, Unemployment, Inequalities in Distribution of Income and Wealth, Financial Stability, Sustainable Balance of payments. 2. National Income (NI): Concepts, Definitions and Identities, Approaches to measurement of NI, Limitations and Omissions in Measurement of NI 3. Major Schools of thought in Macroeconomics: Classical and Neoclassical Schools of Thought: Theories of output, employment, prices and interest rate, Quantity theory ofmoney, Cash Transactions and Cash Balance versions, Classical dichotomy. Keynes and Keynesians-Aggregate Demand, Aggregate Supply, Consumption (Savings) Function and Investment Multiplier, Output Determination, Role of Government-Monetary and FiscalPolicies in Growth Promotion, Demand for Money: Active and Idle cash balances, Liquidity Preference and Liquidity Trap, Phillips Curve, Inflation-Unemployment trade-off, IS-LM Model and Policy Effectiveness Monetarism: Restatement of Quantity Theory of Money, Stabilityof Demand Function for Money, Expectations Augmented PhillipsCurve, Adaptive Expectations, Short-run vs Long-run Phillips Curve New Classicists: Rational Expectations, Lucas Critique and Policy Ineffectiveness, Rules vs Discretion, Monetary Policy Rules: Friedman, Taylor and McCallum Rules New Keynesians: Sticky Wages and Prices and Coordination Failures, Asymmetric Information and Moral Hazard, AdverseSelection New Consensus Macroeconomics. 4. Inflation: Measurement, Causes, Consequences and Remedies

		5. Fiscal Policy: Growth and Equity, concepts of deficits, internal and external debt, debt vs money financing, sustainability of debt. 6. Opening Up the Economy: Balance of payments, Exchange rates- nominal and real, bilateral and effective, exchange rate systems, fixed vs flexible exchange rates

Viii	Texts/References	1. Dilip M. Nachane, 2019, Critique of the New Consensus Macroeconomics and Implications for India, Springer Nature Switzerland AG 2. Macroeconomics by G. Mankiw, Worth Publishers, 7th edition (2009). 3. Macroeconomics by R. Dornbusch, S. Fisher & R. Startz, McGraw-Hill education, 11th edition (2017). 4. Errol D'Souza, Macroeconomics, 2/e, Pearson Education, 2012. 5. Macroeconomics Theories and Practices by R. T. Froyen, Pearson Education India, 10th edition (2013).
ix	Name(s) of **Instructor(s)** ***	Gopal Sharan Parashari
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 essential concepts of Macroeconomics for PhD students. It may also be offered to senior B.Tech. students with good CPI and may help them understand different Macroeconomic concepts.

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

<table>
<tr><td>i</td><td>Title of the Course</td><td colspan="5">HS 403 Happiness and Well-Being</td></tr>
<tr><td>ii</td><td>Credit Structure</td><td>L</td><td>T</td><td>P</td><td>C</td><td></td></tr>
<tr><td></td><td></td><td>2</td><td>1</td><td>0</td><td>6</td><td></td></tr>
<tr><td>iii</td><td>Type of Course</td><td colspan="5">Elective</td></tr>
<tr><td>iv</td><td>Semester in which normally to be offered</td><td colspan="5">Autumn/Spring</td></tr>
<tr><td>v</td><td>Whether Full or Half Semester Course</td><td colspan="5">Full</td></tr>
<tr><td>vi</td><td>Prerequisite(s), if any (For the students) – specify course number(s)</td><td colspan="5">None</td></tr>
<tr><td>vii</td><td>Course Content</td><td colspan="5" rowspan="2">In this course, we will explore the concept and different definitions ofhappiness and well-being, and the connection between happiness, positive attitude, relationships and the purpose and meaning of life. Techniques to achieve happiness in life will be studied. The course will be primarily participatory in nature with class discussions, presentations and journal assignments. The course material will be taken from a variety of sources. The causes that disturb the harmony inlife will be analysed and practices to address these satisfactorily will beinvestigated. The methods of yoga, pranayama different meditation paths and healing techniques will be evaluated so that each student can adopt a suitable combination to suit her needs. Assignments will be aimed at a better understanding of oneself and the society and the environment that we live in.
Learning Objectives.
After studying this course, the students will be able to:
● Identify key psychological, social, cultural and biological factors in happiness and well being
● Understand the relationship between happiness, human connections,and qualities such as compassion, altruism, and gratitude
● Describe the principles behind the specific activities that boosthappiness
● Apply lessons from positive & social psychology to their personal and professional lives, enhancing their self-understanding
● Practice research-tested techniques for enhancing happiness
● Analyse human nature in terms of the three gunas and thepanchakosha model of beings.
● Adopt methods of yoga and meditation for self-improvement andsocial well-being</td></tr>
<tr><td></td><td></td></tr>
</table>

		Course Contents Happiness and wellbeing: definitions and measurement. The Hedonictradition. Role of social connections in fostering happiness. Kindness and compassion, altruism and happiness, Success, money andhappiness. Cooperation, reconciliation and happiness. Mindfulness, attention and focus. Mental habits of happiness: self-compassion, flow, and optimism. The Pursuit of Happiness: Does Being Good or Bad Produce More Happiness? Understanding the Causes of "Suffering." Cultivating Right" Attention and "Right" Desire. Meaningful Relationships. The strong links between gratitude and happiness.Curiosity, Play, and Creativity. The art of letting go. Finding Your Happiness Fit and the New Frontiers. Happiness and Meaning in Life Yoga, Panchakoshas and Gunas: Guna concept: satwa, rajas and tamasand balancing the gunas. Ashtanga Yoga: Yama, Niyama, Aasana and Pranayama Pratyahar, Dharana and Dhyana. Vipassana Meditation and Reiki
		Kindness and compassion, altruism and happiness, Success, money andhappiness. Cooperation, reconciliation and happiness. Mindfulness, attention and focus. Mental habits of happiness: self-compassion, flow, and optimism. The Pursuit of Happiness: Does Being Good or Bad Produce MoreHappiness? Understanding the Causes of "Suffering." Cultivating Right" Attentionand "Right" Desire. Meaningful Relationships. The strong links between gratitude and happiness.Curiosity, Play, and Creativity. The art of letting go. Finding Your Happiness Fit and the New Frontiers.Happiness and Meaning in Life Yoga, Panchakoshas and Gunas: Guna concept: satwa, rajas and tamasand balancing the gunas. Ashtanga Yoga: Yama, Niyama, Aasana and Pranayama Pratyahar,Dharana and Dhyana. Vipassana Meditation and Reiki

Mathematics Department

Name of Academic Unit: Mathematics

Level: UG/PG

Programme: UG/PG

I	**Title of the course**	**MA 501 Measure Theory**
Ii	**Credit Structure (L-T-P-C)**	3-1-0-8 (8 credit full semester course)
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)**	Real analysis
Vii	**Course Content**	Construction of Lebesgue measure on Real line, Introduction to abstract measure theory, Measurable functions, Caratheodory's Extension Theorem, MCT, Fatou's Lemma, DCT, Product space, Product measure, Fubini's Theorem, Definition of signed measures, Positive and negative sets. Hahn-Jordan Decomposition. Absolute continuity of two σ-finite measures. Radon-Nikodyme Theorem and Lebesgue Decomposition.
Viii	**Texts/References**	H. L. Royden; Real analysis. Third edition. Macmillan Publishing Company, New York, 1988. W. Rudin; Real and complex analysis. Third edition. McGraw-Hill Book Co., New York, 1987. S. Athreya and V.S. sunder; Measure & probability. CRC Press, Boca Raton, FL, 2018. K.R. Parthasarathy; Introduction to probability and measure, Hindustan Book Agency, 2005.
	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**	This course will be beneficial for PhD students who wants to work in the area of analysis (like functional analysis, Harmonic analysis, PDE).

Name of Academic Unit: Electrical Engineering
Level: B. Tech. / MS(R) / PhD
Programme: MS/Ph.D. / MS(R) / PhD

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
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.

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: Biosciences & Bioengineering
Level: Ph.D.
Program: Ph.D.

i	**Title of the Course**	Cellular & Molecular Immunology
ii	**Credit Structure (L-T-P-C)**	(3-0-0-6)
iii	**Type of Course**	NPTEL Web Course
iv	**Semester in which normally to be offered**	Autumn
v	**Whether full or half semester Course**	Full Semester
vi	**Pre-requisite(s), if any (for the students)- specify the course number(s)**	Basic Understanding of Biology up to Secondary standard.
vii	**Course Content**	• Introduction, Properties of Immune System. • Innate Immune System, Adaptive Immune System. • Antibodies and Antigens. • Major Histocompatibility Complex. • Antigen Processing and Presentation. • Antigen Receptors and Accessory Molecules of T cell. • Development and Activation of Lymphocytes. • B cell activation and Antibody Production. • Immune Memory Response. • Cytokines. • Mechanism of Cell Mediated Immune Response. • Mechanism of Antibody Mediated Immune Response. • Immunity to Microbes. • Transplant Immunology. • Tumor Immunology. • Hypersensitivity. • Congenital and Acquired Immunodeficiency. • Laboratory Techniques commonly used in Immunology.
viii	**Texts/References (separate sheet may be used, if needed)**	1. Roitt's Essential Immunology: Peter J. Delves, Willey Blackwell, Thirteenth Edition. 2. Kuby Immunology: Stanford Punt Owen, W. H. Freeman & Co, Seventh Edition. 3. Cellular and Molecular Immunology: Abbas Litchman Pillai: Elsevier 2017, Ninth Edition. 4. Immunology and Microbiology: Jeffrey K. Actor, Elsevier 2006, Second Edition.
ix	**Name(s) of Instructor(s)**	Dr. Sachin Kumar (Lectures)/ Dr. Sudhanshu Shukla (Exam)

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**	Immunology is a science that attempts to understand why and how the body recognizes foreign cells, such as virus-infected cells, bacteria, tumor cells and transplanted organs. It also helps in the study of the interaction of the immune system with cancer cells that can lead to diagnostic tests and therapies with which to find and fight cancer. It is necessary for students to undertake this course, as this will give basic background for the current research in the field.

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

i	**Title of the Course**	Introduction to Biostatistics
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 Semester
vi	**Pre-requisite(s), if any (for the students)- specify the course number(s)**	NA
vii	**Course Content**	• Introduction, Data Representation & Plotting. • Arithmetic mean, Geometric mean. • Measure of variability, standard deviation. • SME, Z-score, Box Plot. • Kurtosis, R programming. • Correlation and regression. • Interpolation and extrapolation. • Nonlinear data fitting. • Concept of probability. • Permutation and combination. • Conditional probability and random variables. • Probability mass function. • Probability density function. • Probability distribution. • Poisson, uniform and exponential distribution. • Sampling distribution, Central limit theorem. • Confidence interval. • Test of Hypothesis. • T-test, Chi-square test. • ANOVA, ANOVA for linear regression.
viii	**Texts/References (separate sheet may be used, if needed)**	1. Introduction to Probability and Statistics: Medenhall, Beaver, Beaver 14th Edition. 2. Introduction to Probability and Statistics for engineers and scientists: S M Ross, 3rd Edition.
ix	**Name(s) of Instructor(s)**	NPTEL Dr. Sudhanshu Shukla (Exam)
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**	No

	is/are equivalent to this course? If so, please give details	
xii	**Justification/ Need for introducing the course**	Observations from biological laboratory experiments, clinical trials, and health surveys always carry some amount of uncertainty. In many cases, especially for the laboratory experiments, it is inevitable to just ignore this uncertainty due to large variation in observations. Tools from statistics are very useful in analyzing this uncertainty and filtering noise from data. Also, due to advancement of microscopy and molecular tools, a rich data can be generated from experiments. To make sense of this data, we need to integrate this data a model using tools from statistics. In this course, discussion about different statistical tools will be required to i. analyze our observations, ii. design new experiments, and iii. integrate large number of observations in single unified model. It will include discussion about both the theory of these tools and hand-on exercise on open source software R.

		basic theory, instrumentation and working principles of routinely employed techniques in biomedical and chemistry research will be discussed. Participants will be introduced initially to human physiology followed by a detailed orientation todifferent imaging approaches with a special focus on disease diagnosis and monitoring and instrumentation engineering applications.

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: HSS
Level: PhD
Programme: PhD

i	**Title of the course**	Communication Skills
ii	**Credit Structure (L-T-P-C)**	
iii	**Type of Course**	Common to All
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**	Why Communication Skills? , Types of Communication, Communication and Research: Academic Reading, Writing, Listening and Appreciation, Grammar and Style, Research Ethics, Gender and Cultural Issues.
viii	**Texts/References**	1. The Craft of Research by Wayne C. Booth, Gregory G. Colomb, Joseph M. Williams. 2. A Manual for Writers of Research Papers, Theses, and Dissertations, Eighth Edition, 3. The Elements of Style by William Strunk Jr., 4. Communication Skills for Engineers and Scientists Sangeeta Sharma & Binod Mishra. 5. A New Approach to Research Ethics: Using Guided Dialogue to Strengthen Research Communities by Henriikka Mustajoki, Arto Mustajoki.
ix	**Name(s) of Instructor(s)**	RT
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 course is designed to offer training in different forms of communication relevant to researchers, as well as in research ethics and perspectives.

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

i.	Title of the Course	Smart Grid
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.	Prerequisite, if any	EE223: Introduction to Power Systems or equivalent as determined by the instructor or faculty advisor.
vii.	Course Content (separate sheet may be used, if necessary)	1. Synchrophasor & PMU, IEEE standards 2. State estimation- WLS, Linear, Hybrid 3. Cyber Security in Smart Grid 4. Dynamic Security Assessment, Prediction and Control 5. Wide Area Damping Control 6. Mode Estimation- Ringdown & Ambient 7. Dynamic State and Parameter Estimation 8. Ancillary Services from Renewables, grid forming converter, Virtual Inertia.
viii.	Texts/References (separate sheet may be used, if necessary)	1. Power System Grid Operation Using Synchrophasor Technology, Nuthalapati Sarma, Springer, 2019, ISBN 978-3-319-89378-5.2. Phasor Measurement Units and Wide Area Monitoring Systems, Antonello Monti, Carlo Muscas and Ferdinanda Ponci, ISBN: 9780128031407, Academic Press, 2016.3. Wide area smart grid architectural model and control: A survey, Renewable and Sustainable Energy Reviews, Vol. 64, pp. 311-328, 2016.4. Application of Time-Synchronized Measurements in Power System Transmission Networks, Mladen Kezunovic, Sakis Meliopoulos, Vaithianathan Venkatasubramanian, Vijay Vittal, Springer, 978-3-319-06217-4, Edition 1, 2014. 5. F. Aminifar et. al. "Synchrophasor Measurement Technology in Power Systems: Panorama and State-of-the-Art," IEEE Access, Vol. 2., No. 1, pp. 1607-1628, 2014.
ix.	Instructor (s)	Pratyasa Bhui
x.	Name (s) of other departments /Academic Units to whom the course is relevant	Electrical Engineering
xii.	Justification	This course is focused on synchrophasor applications in smart grid. It covers basics of synchrophasor technology and communication protocols and different energy management systems (EMS) applications like state estimation, stability monitoring, prediction and control, model validation etc. It also covers recent research trends in cyber security and ancillary services from renewables and battery.

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

i	**Title of the course**	**Turbomachinery Aerodynamics**
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)**	Thermodynamics, Fluid Mechanics during UG
vii	**Course Content**	**Introduction to Turbomachineries** **Axial flow compressors and Fans:** Introduction; Aero-Thermodynamics of flow through an Axial flow Compressor stage; Losses in axial flow compressor stage; Losses and Blade performance estimation; Secondary flows (3-D); Tip leakage flow and scrubbing; Simple three dimensional flow analysis; Radial Equilibrium Equation; Design of compressor blades; 2-D blade section design: Airfoil Data; Axial Flow Track Design; Axial compressor characteristics; Multi-staging of compressor characteristics; Transonic Compressors; Shock Structure Models in Transonic Blades; Transonic Compressor Characteristics; 3-D Blade shapes of Rotors and Stators; Instability in Axial Compressors; Loss of Pressure Rise; Loss of Stability Margin; Noise problem in Axial Compressors and Fans **Axial flow turbines:** Introduction; Turbine stage; Turbine Blade 2-D(cascade) analysis Work Done; Degree of Reaction; Losses and Efficiency; Flow Passage; Subsonic, transonic and supersonic turbines, Multi-staging of Turbine; Exit flow conditions; Turbine Cooling; Turbine Blade design – Turbine Profiles: Airfoil Data and Profile construction. **Centrifugal Compressors:** Introduction; Elements of centrifugal compressor/ fan; Inlet Duct Impeller; Slip factor; Concept of Rothalpy; Modified work done; Incidence and lag angles; Diffuser; Centrifugal Compressor Characteristics; Surging; Choking; Rotating stall; Design **Radial Turbine:** Introduction; Thermodynamics and Aerodynamics of radial turbines; Radial Turbine Characteristics; Losses and efficiency; Design of radial turbine. Use of CFD for Turbomachinery analysis and design.
viii	Texts/ References	1. Dixon, S. Larry, and Cesare Hall, "Fluid mechanics and thermodynamics of turbomachinery," Butterworth-Heinemann, 2013. 2. Lakshminarayana, Budugur, "Fluid dynamics and heat transfer of turbomachinery," John Wiley & Sons, 1995. 3. Cumpsty, Nicholas A., "Compressor aerodynamics," Longman Scientific & Technical, 1989. 4. Hill, Philip G., and Carl R. Peterson, "Mechanics and thermodynamics of propulsion," AW (1992). 5. Johnsen, Irving A., and Robert O. Bullock, eds., "Aerodynamic Design of Axial-Flow Compressors," NASA SP-36, 1965. 6. Glassman, Arthur J., ed., "Turbine design and application," NASA-SP-290, 1975.
ix	**Name(s) of Instructor(s)**	KMC
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**	Turbomachines using air or other gases as the working fluid are present in various systems of industrial and societal importance such as gas turbine engines, power plants, and process industries. The compressible nature of a gas requires a specialized application of the principles of fluid mechanics and thermodynamics relevant for gaseous flows. The present course addresses these aspects and the learning will help a student apply the knowledge gained in fundamental courses and will be highly beneficial to those who do research in related topics.

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

i	**Title of the course**	**Metal Forming and Plasticity**
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)**	Exposure to Manufacturing Science
vii	**Course Content**	**Introduction:** Different metal forming processes, importance of plasticity in the course. **Module 1:** Analysis of stress: transformation relations, principal stresses and directions, maximum normal and shear stresses, invariants, hydrostatic and deviatoric parts; Analysis of (infinitesimal) strain: transformation relations, principal strains, invariants, hydrostatic and deviatoric parts; (Infinitesimal) rotation, Stress strain relations for isotropic, linearly elastic material. **Module 2:** Experimental observations on plasticity: yielding, strain hardening, visco plasticity, temperature softening, Baushinger effect, hysteresis, incompressibility of plastic deformation, anisotropy, plastic instability. **Module 3:** Yield criterion for isotropic materials: von Mises and Tresca yield criterion, their geometric interpretation, convexity of the yield surfaces, experimental validation. **Module 4:** Incremental and rate forms of the measures of plastic deformation: linear incremental strain tensor, strain rate (i.e. the rate of deformation) tensor and their relation, incremental rotation tensor and spin tensor. **Module 5:** Change in yield criteria due to isotropic hardening: strain hardening and work hardening hypotheses, experimental validation of the hypotheses. **Module 6:** Plastic stress strain relations for isotropic materials: plastic potential and associated flow rule, incremental and rate forms of elastoplastic stress strain relations, simplifications for non-hardening and rigid plastic materials (Prandtl Reuss and Levy-Mises relations), Objective measures of stress rate and incremental stress.
viii	Texts/ References	1. The Mathematical Theory of Plasticity by R. Hill, Oxford University Press 2. Theory of Plasticity by J. Chakrabarty, Butterworth-Heinemann, 3rd edition 3. Metal Forming Mechanics and Metallurgy, William F. Hosford, Robert M. Caddell Cambridge University Press; 4th edition
ix	**Name(s) of Instructor(s)**	RL
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**	In the production of metal parts, the material will be subjected to at least one metal forming operation, where the material is given shape by plastic deformation. Therefore, knowledge of plasticity is essential to understand and model any metal forming process. This course aims to introduce the fundamentals of plastic deformation in metal forming processes.

Electrical Engineering course work

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

i	**Title of the course**	Engineering Mathematics for Advanced Studies
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**	**Module-1:** Linear Algebra: Vector Spaces, Matrices, Linear algebraic equations, Eigen-values and Eigen-vectors of matrices, Singular-value decomposition **Module-2:** Tensor Algebra: Index Notation and Summation Convection, Tensor Algebra **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:** Ordinary Differential Equations: Initial Value Problem, Method to solve first order ODE, Homogeneous, linear, 2nd order ODE, Non-homogeneous, linear, 2nd order ODE, System of 1st order ODE **Module-5:** Laplace and Fourier transformation: First and Second Shifting Theorems, Transforms of Derivatives and Integrals, Fourier Cosine and Sine Transforms, Discrete and Fast Fourier Transforms **Module-6:** Partial Differential Equations: Basic Concepts of PDEs, Modeling: Wave Equation, Heat Equation, Solution by Separating Variables, Solution by Fourier Series, Solution by Fourier Integrals and Transforms **Module-7:** Numerical Methods: Methods for Linear Systems, Least Squares, Householder's Tridiagonalization and QR-Factorization, Methods for Elliptic, Parabolic, Hyperbolic PDEs **Module-8:** 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 **Module-9:** Optimization and Linear Programming: Method of Steepest Descent, Linear Programming, Fundamental theorem of linear inequalities, Cones,

		polyhedra. and polytopes, Farkas' lemma, LP-duality, max-flow min-cut, Simplex Method, primal-dual, Fourier-Motzkin elimination, relaxation methods **Module-10:** 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, $\chi 2$-Test **Module-11:** Abstract Algebra: Groups, Sub-groups, Cosets and Lagrange's theorem, Group actions, direct and semi-direct products
viii	**Texts/References**	1. E. Kreyszig. Advanced Engineering Mathematics, John Wiley & Sons, 2011. 2. P.V. O'Neil. Advanced Engineering Mathematics, CENGAGE Learning, 2011. 3. D.G. Zill. Advanced Engineering Mathematics, Jones & Bartlett Learning 2016. 4. B. Dasgupta. Applied Mathematical Methods, Pearson Education, 2006. 5. A. Schrijver, Theory of Linear and Integer Programming, 1998. 6. D.S. Dummit, R.M. Foote, Abstract Algebra, 2004.
ix	**Name(s) of Instructor(s)**	DVP/BBN/PRB
x	**Name(s) of other Departments/ Academic Units to whom the course is relevant**	CS/EE/ME
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**	Engineering mathematics is a key-tool to understand physical or natural phenomena. Often, mathematics involved in the explain of engineering devices is not trivial, as complex set of linear/non-linear equations have to be solved. It is necessary for the research students to be good in mathematical methods in order to analyze the experimental/computational data. In this course, students learn mathematical techniques in linear and tensor algebra, calculus, Laplace and Fourier transformations, ODEs and PDEs with elementary numerical methods. Students are encouraged to apply these techniques to their respective engineering discipline.

Name of Academic Unit: Mechanical Engineering
Level: PG
Programme: MS/Ph.D.

i	**Title of the course**	**Mechanical Vibrations**
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)**	
vii	**Course Content**	**Module 1:** Concepts of Vibrations: Harmonic motion and definitions and terminology, Harmonic analysis, Fourier series expansion, Importance of vibration, Basic concepts of vibration, Classification of Vibration, Vibration analysis procedure; Discrete System Components – Springs, Dampers and Masses. **Module 2:** One DOF systems: Free Vibrations, Harmonic Oscillator, Types of damping, Viscously Damped Single DOF Systems, Measurement of Damping, Coulomb Damping – Dry Friction. Forced Vibrations – Response of Single DOF System to Harmonic Excitations, Response to Periodic Excitations, Response of Single DOF systems to Nonperiodic Excitations. **Module 3:** Two DOF Systems: System Configuration, Equations of Motion of 2 DOF Systems, Free Vibration of Undamped Systems Natural Modes, Response to Initial Excitations, Coordinate Transformations – Coupling, Orthogonality of Modes - Natural Coordinates, Beat Phenomenon, Response of Two-Degree-of-Freedom Systems to Harmonic Excitations, Undamped Vibration Absorbers. **Module 4:** Vibrations of Continuous Systems: Vibrating String, Longitudinal vibrations of Bar, Torsional vibrations of Rod. Lateral vibrations of Beam. Analytical Dynamics: Degrees of Freedom and Generalized Coordinates, Principle of Virtual Work, Principle of D'Alembert, Hamilton's Principle, Lagrange's Equations. **Module 5:** Multi-Degree-of-Freedom Systems: Equations of Motion for Linear Systems; Flexibility, Stiffness Influence Coefficients and Mass Coefficients; Lagrange's Equations; Linear Transformations; The Eigenvalue Problem; Orthogonality of Modal Vectors; Systems Admitting Rigid-Body Motions; Decomposition of the Response in Terms of Modal Vectors; Response to Initial Excitations by Modal Analysis;Eigenvalue Problem in Terms of a Single Symmetric Matrix; Geometric Interpretation of the Eigenvalue Problem; Rayleigh's Quotient and Its Properties; Response to Harmonic External Excitations; Response to External Excitations by Modal Analysis – Undamped systems, Systems with proportional damping; Systems with Arbitrary Viscous Damping; Discrete-Time Systems.
viii	**Texts/ References**	**Text-books:** 1. S S Rao, Mechanical Vibrations, Pearson Education, 5 th Edition, 2004. **References:** **1.** W T Thomson, M D Dahleh and C Padmanabha, Theory of Vibration with applications, Pearson Education, 2008. **2.** Leonard Meirovitch, Fundamentals of Vibrations, McGraw-Hill, 2000. **3.** Den Hartog, Mechanical Vibrations, Dover Publications, 4 th Edition.
ix	**Name(s) of Instructor(s)**	Shrikanth V.
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**	This course deals with the study of vibration in mechanical systems which is concerned with the oscillatory motions of bodies and the forces associated with them. This course aims to provide you with an understanding of the nature and behaviour of dynamic engineering systems and the capability of applying the knowledge of mathematics, science, and engineering to solve engineering vibration problems.

Syllabi

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: Chemistry
Level: Ph.D.
Programme: Ph.D.

i	Title of the course	Organic reactions and mechanisms
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	Nil
vii	Course **Content***	**Reactive Intermediates:** An overview and revision of the chemistry of carbenes, nitrenes, radicals, carbocations, carbanions and benzynes. **Classification of reactions:** A brief introduction to substitution, elimination, addition, oxidation, reduction, rearrangement and pericyclic reactions. **Named reactions, mechanisms and applications:** **Condensation reactions**: Aldol, Acyloin and benzoin, Claisen, Darzens, Dieckmann, Knoevenagel, Stobbe. **Oxidation reactions**: Baeyer-Villiger, Criegee, Dakin, Dess-Martin, Jones, Swern, Wacker, Oppenauer. **Epoxidation reactions**: Jacobsen, Sharpless. **Reduction reactions**: Birch, Wolff-Kishner, Clemmensen, Stephen, Rosenmund, Staundinger, Meerwein-Ponndorf-Verley. **Olefination reactions**: Julia, Wharton, Peterson, Tebbe. **Coupling reactions**: Buchwald-Hartwig, Negishi, Sonogashira, Suzuki, Wurtz, Ullmann, McMurry, Heck, Stille. **Rearrangement reactions**: Beckmann, Benzilic acid, Curtius, Lossen, Hoffmann, Fries, Favorskii, Pinacol, Pummerer, Smiles, Stevens, Wagner- Meerwein, Wolff, Wittig. **Pericyclic reactions**: Diels-alder cycloaddition, Danishefsky's diene cycloaddition, Ene reaction, Cope rearrangement (including aza-Cope and oxy Cope), Claisen rearrangement (including Johnson, Ireland and Eschenmoser). **Miscellaneous reactions**: Alkene and alkyne metathesis, Barton reaction, Bergman cycloaromatization, Brown hydroboration, Buchner reaction, Burgess dehydration, Cannizzaro reaction, Cope reaction, Corey reactions, Eschenmoser-Tanabe Fragmentation, Fischer indole synthesis, Friedel- Crafts reaction, Gabriel synthesis, Grignard reaction, Hell Volhard Zelinski reaction, Hoffmann reaction and elimination, Kolbe-Schmitt reaction, Mannich reaction,

		Michael addition, Mitsunobu reaction, Paterno-Buchi reaction, Perkin reaction, Pictet-Spengler reaction, Prevost reaction, Reformatsky reaction, Reimer-Tiemann reaction, Robinson annulation, Schmidt reaction, Sandmeyer reaction, Sharpless dihydroxylation, Shapiro reaction, Staundinger reaction, Strecker reaction, Tsuji-Trost reaction, Ugi reaction, Williamson ether synthesis, Witting reaction.
Viii	Texts/References	1. Jerry March and Michael Smith, "Advanced Organic Chemistry", 7th Ed., Wiley, 2015. 2. F. A. Carey and R. J. Sundberg, "Advanced Organic Chemistry, Part A and B", 5th Ed., Springer, 2008. 3. J. Clayden, N. Greeves, and S. Warren, "Organic Chemistry", 2nd Ed., Oxford University Press, 2014. 4. W. Carruthers and I. Coldham, "Modern Methods of Organic Synthesis", 4th Ed., Cambridge University Press, 2015. 5. Laszlo Kurti and Barbara Czako, "Strategic applications of named reactions in organic synthesis", 1st Ed., Elsevier, 2005. 6. R. Norman and J. Coxon, "Principles of organic synthesis, 3rd Ed., CRC press, 2017. 7. R. B. Grossman, "Art of writing reasonable organic reaction mechanisms", 2nd Ed., Springer, 2010. 8. P. Bruice, "Organic Chemistry" 7th Ed., Pearson, 2013.
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 provides foundation for organic chemistry and reaction mechanisms for MS/PhD students of chemistry and biochemistry to carry out further advanced courses as well as it is relevant to different fields of research in chemical sciences.

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

i	Title of the course	Coordination chemistry, Organometallics and organometallic reagents
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)*	Nil
vii	Course **Content***	• Coordination chemistry: Fundamentals, theory and applications. • History and types of Organometallic compounds, 18 Valence Electron Rule and Classification. • Sigma-Donor ligands: Preparation and Properties and its application. • C−H activation, characterization and bonding. C−C Bond activation, Transition Metal Perfluoroalkyl (RF−TM) Complexes and its preparation. C−F Activation • Transition Metal Alkenyl/Aryl/Alkyne/Carbene/carbynes Complexes • Transition Metal Carbonyls: Bonding properties, Reactivity, Carbonyl Metallates, Carbonyl Hydrides and its application, application of Metal Halides and Metal Alkenes • Transition Metal Olefin Complexes: Reactivity, Bonding Properties. • Transition Alkyne Complexes: Reactivity.
Viii	Texts/References	Organometallics by Christoph Elschenbroich Organometallic Chemistry of Transition Metals by Robert H Crabtree.
ix	Name(s) of **Instructor(s)** ***	MRR and NPTEL Web and Video classes
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 enables to learn all essential coordination and organometallics concepts and relevant applications which are important to carry out research in the fields of inorganic and organicchemistry.

i	**Title** of the course	**CS 701 Logic and Applications**
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)*	Discrete Mathematics, Theory of computation.
vii	Course **Content***	**Module 1 :** Propositional Logic: Natural deduction, semantics, soundness, completeness, compactness, normal forms, Horn clauses and satisfiability. **Module 2:** Predicate Logic: Natural deduction, resolution, undecidability, expressiveness. **Module 3:** Some decidable fragments of first-order logic and their decision procedures: propositional logic, equality with uninterpreted functions, linear arithmetic, Presburger logic ,bit vectors, arrays, pointer logic. **Module 4:** SAT and SMT solvers: theory and practice: Decision procedures for combinations of first-order theories: Nelson-Oppen, Shostak, Satisfiability Modulo Theories(SMT) Combination with SAT solvers: eager, lazy approaches. *Student is required to do a small project using a SAT/SMT solver.*
Viii	Texts/References	(1) Logic in Computer Science, Michael Huth and Mark Ryan, Cambridge University Press. (2) Mathematical Logic for Computer science, Mordechai Ben-Ari, Springer. (3)Logic for Computer Scientists, Uwe Schoning, Birkhauser. (4) SAT/SMT by example, Dennis Yurichev.
ix	Name(s) of **Instructor(s)** ***	Ramchandra Phawade
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.	No
xii	**Justification/ Need** for introducing the course	This foundational course in Logic in essential for doing research in Formal methods of verification, Concurrency and in general Theoretical Computer Science.

i	**Title of the course**	**Differential Topology**
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)**	Multivariable Calculus, General Topology and Linear Algebra
vii	**Course Content**	Differentiable manifolds, smooth maps between manifolds Tangent spaces and cotangent spaces, Vector fields, tangent and cotangent bundles, Vector bundles Sub manifolds, submersion and immersions Lie groups Tensors and differential forms, integration on manifolds and de Rham theory
viii	**Texts/References**	John M. Lee, Introduction to Smooth Manifolds, Springer Verlag, New York, 2003. Frank Warner, Foundations of Differentiable Manifolds and Lie Groups, Springer Verlag, New York, 1983 . Glen Bredon, Topology and Geometry, Springer Verlag, New York, 1993.
	Name(s) of Instructor(s)	N. S. N. Sastry
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**	Differential Geometry is a fundamental topic in mathematics and is required for research in geometry, partial differential equations and mathematical physics. The current course provides an introduction to the subject. Graduate students from Physics and Mechanics may also opt for this course.

i	**Title of the course**	**Introduction to Graduate Algebra**
ii	**Credit Structure (L-T-P-C)**	(3-1-0-8)
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)**	Basics of Group Theory, Ring Theory and Module Theory, Linear Algebra, Field Theory and Galois Theory
vii	**Course Content**	Review of Group theory: Sylow's theorem and Group Actions, Ring theory: Euclidean Domains, PID and UFD's, Module theory: structure theorem of modules over PID Review of field and Galois theory, Infinite Galois extensions, Fundamental Theorem of Galois theory for infinite extensions, Transcendental extensions, Luroth`s theorem Review of integral ring extensions, prime ideals in integral ring extensions, Dedekind domains, discrete valuations rings, Categories and functors, Basic Homological algebra: Complexes and homology, long exact sequences, homotopy, resolutions, derived functors, Ext, Tor, cohomology of groups
viii	**Texts/References**	M. Artin, Algebra, 2nd Edition, Prentice Hall of India, Delhi, 1994. N. Jacobson, Basic Algebra, Vol. 1, 2nd Edition, Hindustan Publishing Corporation, Delhi, 1985. N. Jacobson, Basic Algebra, Vol. 2, 2nd Edition, Hindustan Publishing Corporation, Delhi, 1989. S. Lang, Algebra, 3rd Edition, Addison Wesley, Boston, 1993. O. Zariski and P. Samuel, Commutative Algebra, Vol.1, Corrected reprinting of the 1958 edition, Springer-Verlag, New York, 1975. O. Zariski and P. Samuel, Commutative Algebra, Vol.2, Reprint of the 1960 edition, Springer-Verlag, New York, 1975.
	Name(s) of Instructor(s)	Shreedevi Masuti
x	**Name(s) of other Departments/ Academic Units to whom the course is relevant**	1) Computer Science and Engineering 2) 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 is a foundational course for any student pursuing doctoral studies in Mathematics. Undergraduates and postgraduates who are extremely interested in Mathematics may also find the course appealing. The course includes the topics which are useful for Geometry, Topology, Number Theory, Algebra and Combinatorics.

Name of Academic Unit: Computer Science and Engineering
Level: MS, PhD.
Programme: MS, PhD

i	**Title of the course**	**Advanced Distributed 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**	VII
v	**Whether Full or Half Semester Course**	Full
vi	**Pre-requisite(s), if any (For the students) – specify course number(s)**	Operating Systems, Data Structures and Algorithms, Programming in C++
vii	**Course Content**	Synchronization, Global Snapshot and Distributed Mutual Exclusion, Consensus & Agreement, Checkpointing & Rollback Recovery, Deadlock Detection, Termination Detection, Message Ordering & Group Communication, Fault Tolerance and Self-Stabilization, Peer to Peer Systems Mining Data Streams in a distributed systems: filtering data streams, queries on streams, pattern detection Key-Value Storage: Cassandra, HBase Virtualization and Cloud Computing: virtual machines containers Message oriented communication, Publish Subscribe Systems (use case Apache Kafka) Security: Distribution of security mechanisms, access control, and security management.
viii	**Texts/References**	1.Distributed Computing: Principles, Algorithms, and Systems- Ajay D. Kshemkalyani and Mukesh Singhal 2.Mining Massive data sets- Jure Leskovec, Anand Rajaraman, Jeff Ullman 3.Distributed Algorithms – An Intuitive Approach (The MIT Press) by Wan Fokkink 4.Distributed Algorithms-Nancy Lynch
ix	**Name(s) of Instructor(s)**	Prof. Kedar Khandeparkar
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

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

i	**Title of the course**	Analog IC design
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)**	Electronic Devices, Analog Electronics
vii	**Course Content**	Active and passive CMOS devices, MOS transistors and small signal models, Noise sources, current mirrors, Single stage opamp, cascode amplifier, folded cascode amplifier, 2 stage opamp and compensation, Negative feedback, fully differential amplifiers, Common mode feedback, PLL's.
viii	**Texts/References**	1) Jacob Baker, CMOS Circuit Design, Layout, and Simulation, Wiley; 1 edition (2009) 2) Behzad Razavi, Design of Analog CMOS Integrated Circuits,McGraw Hill Education; Second edition 3) Hurst, Lewis, Meyer Gray Analysis and Design of Analog Integrated Circuits, Wiley; 5 edition
ix	**Name(s) of Instructor(s)**	Naveen Kadayinti
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 a core course for specialization in VLSI circuits.