S. No	New Course code	Name of Course	L-T-P-C	Proposed Level (UG/PG)
1	EE 601	Analog IC Design	3-0-0-6	
2	EE 602	Probability Models	3-0-0-3	PG
3	EE 603	Electric Drives for EVs - I	3-0-0-3	PG
4	EE 604	Electric Drives for EVs - II	3-0-0-3	PG
5	EE 605	Probability Theory and Random Processes	3-0-1-6	PG
6	EE 606	Pattern Recognition and Machine Learning	3-0-0-6	PG
7	EE 607	Power System Dynamics and Control	2-0-1-6	PG
8	EE 608	Wireless Communication	3-0-0-6	
9	EE 609	Pattern Recognition and Machine Learning	3-0-3-9	PG
10	EE 610	VLSI Design	3-0-0-6	PG
11	EE 611	Neural networks and deep learning (NNDL) Laboratory	0-0-3-3	PG
12	EE 612	Pattern Recognition and Machine Learning (PRML) Laboratory	0-0-3-3	PG
13	EE 613	Speech Processing Laboratory	0-0-3-3	PG
14	EE 614	Data Analysis and Visualization Lab	0-0-3-3	PG
15	EE 620	Neural Networks and Deep Learning	3-0-0-6	PG
16	EE 621	Speech Processing	3-0-0-6	PG
17	EE 622	Multivariable Control Systems	3-0-0-6	PG
18	EE 623	Advanced Power Electronics and Drives	3-0-0-6	PG
19	EE 624	Optimization Theory and Algorithms	3-0-0-6	PG
20	EE 625	Design of Power Converters	2-0-1-6	PG
21	EE 626	VLSI Technology	3-0-0-6	PG
22	EE 627	Advanced Power Systems	3-0-0-6	PG
23	EE 628	Modelling and Control of Renewable Energy Resources	3-0-0-6	PG
24	EE 629	Probability Models and Applications (PMA)	3-0-0-6	PG
25	EE 630	Advanced Topics in Speech Processing	1-0-4-6 3-0-0-6	PG
26	EE 631	Advanced Electric drives	2-0-2-6	PG
27	EE 632	System design of electronic products	3-0-0-6	PG
28	EE 633	Mixed signal VLSI Design	3-0-0-6	PG
29	EE 634	Linear Algebra and its Applications	3-0-0-6	PG
30	EE 635	Speech Processing	3-0-3-9	PG
31	EE 636	Advanced Analog Circuits	3-0-0-6	PG
32	EE 637	Physics of Nanoscale Devices	3-0-0-6	PG
33	EE 638	Advanced Topics in Control Systems	3-0-0-6	PG
34	EE 639	Modern Statistics for Engineers	3-0-0-6	PG
35	EE 640	Game Theory with Control Applications	3-0-0-6	PG
36	EE 641	Renewable Energy	3-0-0-6	PG
37	EE 642	Microgrid Dynamics and Control	3-0-0-6	PG
38	EE 643	Power System Operation and Control	3-0-0-6	PG
39	EE 644	Power System II	3-0-0-6	PG
40	EE 645	Electrical Machines II	3-0-0-6	PG
41	EE 646	Advanced Topics in Artificial Intelligence	3-0-0-6	PG
42	EE 647	Introduction to Machine Learning	3-0-0-6	PG
43	EE 648	Nanoelectronics	3-0-0-6	PG
44	EE 650	Introduction to Aerial Robots	2-1-0-6	PG
45	EE 651	Dynamics and control of aerial robots	2-1-0-6	PG
46	EE 652	Autonomous navigation	2-1-0-6	PG
47	EE 653	Electric Vehicles: Systems and Components	3-0-0-6	PG
48	EE 654	Smart Grid	3-0-0-6	PG
49	EE 655	Data Science and Visualization Lab	0-0-3-3	PG

50	EE 656	VLSI Testing and Testability	3-0-0-6	PG
51	EE 657	Introduction to HIL testing methods	1-0-1-3	PG
52	EE 658	Battery Technology	3-0-0-6	PG
53	EE 659	Electric Vehicles: Systems and Components	2-0-2-6	PG
54	EE 660	Introduction to Electric Drives	3-0-0-6	PG
55	EE 661	EV Charging and Ancillary Services	3-0-0-6	PG
56	EE 662	Advanced Methods in HIL Testing of Electric Transportation Systems	2-0-2-6	PG
57	EE 664	Electric and Hybrid Vehicles	3-0-0-6	PG
58	EE 665	Robotics and Automation	3-0-2-8	PG
59	EE 666	Intro to EV Architecture	1.5-0-3-3	PG
60	EE 667	Stochastic Process and its Applications	3-0-0-3	PG
61	EE 668	Mathematics for Data Science I	3-0-0-3	PG
62	EE 669	Mathematics for Data Science II	3-0-0-3	PG
63	EE 670	Fundamentals of Speech Processing (FSP)	3-0-0-3	PG
64	EE 671	Machine Learning of Speech Processing (MLSP)	1.5-0-0-3	PG
65	EE 672	Deep Learning of Speech Processing (DLSP)	1.5-0-0-3	PG
66	EE 673	Pattern Recognition	3-0-0-3	PG
67	EE 693	Machine Learning (Ml)	1.5-0-0-3	PG
68	EE 675	Artificial Neural Networks (Ann)	3-0-0-3	PG
69	EE 676	Deep Learning (Dl)	1.5-0-0-3	PG
70	EE 677	Introduction to Battery Management Systems	3-0-0-3	PG
71	EE 678	PWM Techniques	3-0-0-3	PG
72	EE 679	Signals, Systems and Controls	3-0-0-3	PG
73	EE 680	Digital Signal Processing and Communications	3-0-0-3	PG
74	EE 681	Machine Learning (Ml)	1.5-0-3-3	PG
75	EE 682	Computational Techniques and Optimisation	1.5-0-3-3	PG
76	EE 683	Embedded Systems	1.5-0-3-3	PG
77	EE 684	Design of Power Converters	1.5-0-3-3	PG
78	EE 687	Optimization Methods for Wireless Communication and Machine Learning	3-0-0-6	PG
79	EE 688	Physics of Transistor	3-0-0-6	PG
80	EE 689	Semiconductor Radiation Detectors	3-0-0-6	PG
81	EE 701	Power Semiconductor Devices	3-0-0-6	PG
82	EE 706	Advanced Topics in Signal Processing	3-0-0-6	PG
83	EE 703	Stochastic Control and Learning for Networked systems	3-0-0-6	PG
84	EE 704	Theory of Machine Learning	3-0-0-6	PG
85	EE 705	Seminar	--	
86	EE 702	Introduction to Cyber-Physical Systems	2-0-2-6	PG

1	**Title of the course (L-T-P-C)**	**Analog IC design (3-0-0-6)**
2	**Pre-requisite courses(s)**	Electronic Devices, Analog Electronics
3	**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.
4	**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 editions

1	**Title of the course (L-T-P-C)**	**Probability Models** **(3-0-0-3)**
2	**Pre-requisite courses(s)**	
3	**Course content**	Introduction to Probability theory: Review of sample space, events, axioms of probability. Random variables, Joint distributions, Notion of independence, and mutually exclusive events Probability Space, limits and sequence of events, and continuity of probability. Conditional probability and conditional expectation, simulating discrete and continuous random variables - accept-reject method, importance sampling. Random vectors and Stochastic processes: Introduction to random vectors, Gaussian vectors, notion of i.i.d random variables
4	**Texts/References**	Sheldon Ross "Introduction to probability models" 9th Ed., Elsevier AP Sheldon Ross, 'Stochastic process', John Wiley, 2nd Ed., April 1996. David Stirzaker, 'Stochastic process and models,' Oxford press.

1	**Title of the course (L-T-P-C)**	**Electric Drives for EVs - I** **(3-0-0-3)**
2	**Pre-requisite courses(s)**	None; Core for Executive M. Tech
3	**Course content**	**1.** Fundamentals of Electric Power Technologies; review of sinusoidal steady state systems, Phasors, three-phase, and per-phase quantities; review of mathematical tools (ordinary differential equations, Laplace and Fourier Transforms, space vectors, etc.); fundamentals of magnetics and magnetic circuits. **2.** Electric Machines: Transformers, principle of transformer action, equivalent circuits, phasor diagram, efficiency, basics of three phase transformer. **3.** Introduction to Electric Motors and Generators: DC Machines; Induction Machines and Permanent Magnet Machines; steady state average modelling **4.** Basic structure of EV drive system and control architecture
4	**Texts/References**	**1.** P. S. Bimbhra, “Electrical machinery,” Khanna Publishers, 7th edition, 1977. **2.** M. G. Say, “The Performance and Design of Alternating Current Machines,” CBS, 3rd ed, 2002. **3.** Stephen Chapman, “Electric Machinery Fundamentals,” McGraw Hill, 4th edition, 2017. **4.** D.P. Kothari, I.J. Nagrath, “Electric Machines,” McGraw Hill, 5th edition, 2017. **5.** A Fitzgerald, C. Kingsley, and S. Umans, “Electric Machinery,” McGraw Hill, 6th ed. 2017. **6.** L. Umanand, ``Power Electronics – essentials and applications," Wiley 2009. **7.** M. H. Rashid “Power Electronics,” Pearson. 4th edition, 2017. **8.** Mohan, Robbins, Undeland “Power Electronics: Converters Applications and Design” 3rd Ed.; Wiley, 2007

1	**Title of the course** (L-T-P-C)	**Electric Drives for EVs - II** **(3-0-0-3)**
2	**Pre-requisite courses(s)**	Electric Drives for EVs - I
3	**Course content**	**1.** Introduction to Fundamentals of Power Electronics: switching circuits; switching power pole; averaging, filtering, ideal switch approximation, DC-DC conversion, DC/AC conversion. **2.** Introduction to basic topologies and power electronic circuits. **3.** Rectifiers, inverters, power factor control **4.** Power Converters for EVs: Electric Drives, LV and HV loads, regenerative operation; chargers; battery interfaces. **5.** Control of Power converters for Electric Drives: overall architecture; digital vs analog control; introduction to advanced control algorithms
4	**Texts/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, 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

1	**Title of the course** (L-T-P-C)	**Pattern Recognition and Machine Learning (PRML)** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Exposure to basic concepts in calculus and probability
3	**Course content**	**Overview of** Probability Theory, Linear Algebra, Convex Optimization. **Introduction:** History of pattern recognition & machine learning, distinction infocus 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 BayesianNetwork.
4	**Texts/References**	**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.

1	**Title of the course** (L-T-P-C)	**Power System Dynamics and Control** **(2-0-1-6)**
2	**Pre-requisite courses(s)**	Power System, Electrical Machines
3	**Course content**	Modelling of Synchronous Machines, Modelling of Exciters, Small Signal Stability Analysis, Modelling of Turbine and Governors, Simulation of Power System Dynamic Response, Improvement of Stability, Sub-synchronous Oscillations.
4	**Texts/References**	1. Power System Dynamics and Stability: With Synchrophasor Measurement and Power System Toolbox, 2nd Edition 2. Power System Stability and Control: Prabha Kundur Mc GrawHill 3. Power System Dynamics and Stability, J Machowski; J Bialek, J Bumby, John Wiley & Sons

1	**Title of the course** (L-T-P-C)	**Wireless Communication** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Signals and Systems, Probability (UG level), Principles/Fundamentals of Communications
3	**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.
4	**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.

1	**Title of the course** (L-T-P-C)	**Pattern Recognition and Machine Learning** **(3-0-3-9)**
2	**Pre-requisite courses(s)**	Exposure to basic concepts in calculus and probability
3	**Course content**	**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... **Lab Component:** Implementation of PRML approaches discussed in various lectures.
4	**Texts/References**	**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.

1	**Title of the course** (L-T-P-C)	**VLSI Design** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Exposure to basic concepts in calculus and probability
3	**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.
4	**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. RabaM. A. Chandrakasan and B. Nikolic, "Digital Integrated circuits" Pearson, 2016

1	**Title of the course** (L-T-P-C)	**Pattern Recognition and Machine Learning (PRML) Laboratory (0-0-3-3)**
2	**Pre-requisite courses(s)**	Currently taking or already taken PRML theory course
3	**Course content**	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.
4	**Texts/References**	**1.** C. Bishop, "Pattern Recognition and Machine Learning," Springer, 2006. **2.** S. Theodoridis and K. Kouroumas, "Pattern Recognition" Second Edn, Elsivier, 2003 **3.** B. Yegnanarayana, "Artificial Neural Networks," PHI, 1999. **4.** Simon Hayking, "Neural Networks and Learning Machines," Pearson, 1999.

1	**Title of the course** (L-T-P-C)	**Neural Networks and Deep Learning (NNDL) Laboratory (0-0-3-3)**
2	**Pre-requisite courses(s)**	Currently taking or already taken NNDL theory course
3	**Course content**	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.
4	**Texts/References**	**1.** B. Yegnanarayana, Artificial Neural Networks, PHI, 1999. **2.** Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep Learning, MIT Press, 2016.

1	**Title of the course** (L-T-P-C)	**Neural Networks and Deep Learning (NNDL)** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Exposure to basic concepts in calculus and probability
3	**Course content**	**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.
4	**Texts/References**	**1.** B. Yegnanarayana, Artificial Neural Networks, PHI, 1999. **2.** Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep Learning, MIT Press, 2016.

1	**Title of the course** (L-T-P-C)	**Speech Processing Laboratory** **(0-0-3-3)**
2	**Pre-requisite courses(s)**	Currently taking or already taken Speech Processing theory course
3	**Course content**	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.
4	**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.

1	**Title of the course** (L-T-P-C)	Multivariable Control Systems **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Exposure to control systems
3	**Course content**	**Review of basic mathematics:** Review of differential equations, Fourier and Laplace transform, basic linear algebra: matrices, rank,inverses, decompositions etc., **Review of frequency domain modelling:** revision of frequencydomain modelling, transfer functions **Introduction to State Variables:** Motivation for State Variables,Implementation of Differential Equations, Formal Definitions **Basic Realization Theory:** Similarity Transformation, Canonical Realizations: Jordan and real canonical forms, Minimal realization**Connections to Transfer Functions:** Characteristic/Minimal Polynomials, matrix. exponentials, Markov parameters and other invariants **Review of frequency domain analysis:** Recall root locus, stability analysis using Routh-Hurwitz criteria, bode plots, Nyquist plots etc.**Observability, Controllability:** Canonical Realizations, Decomposition of Uncontrollable and Unobservable realizations, State Feedback, Asymptotic Observers, Separation Principle and Pole Placement Theorem **Extensions to MIMO systems:** Transfer matrices, Controllability,Observability and Pole Placement, Controller/Observer forms, Minimality and relations to Controllability and observability, MIMO Realization theory
4	**Texts/References**	**1.** T. Kailath, Linear Systems, Prentice-Hall, New Jersey, 1stedition, (11 February 1980) **2.** Richard Dorf and Robert Bishop, Modern Control Systems,Pearson; 13th edition (5 January 2016) **3.** Karl Johan Aström, Richard M. Murray, Feedback Systems:An Introduction for Scientists and Engineers, Princeton University Press (21 April 2008) **4.** João P. Hespanha, Linear Systems Theory, Princeton University Press (2 October 2009) **5.** Karl Johan Aström, Richard M. Murray, Feedback Systems: AnIntroduction for Scientists and Engineers, Princeton University Press, 2nd edition (2 March 2021) **6.** João P. Hespanha, Linear Systems Theory, Princeton University Press (2 October 2009), 2nd edition, 13 February2018

1	**Title of the course** (L-T-P-C)	**Advanced Power Electronics and Drives** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Exposure to Circuits, semiconductor devices and Electric Machines &power electronics
3	**Course content**	Basics of semiconductor devices, gate drives for BJT, MOSFET and IGBT, heat sink selection, snubber circuits, non- isolated converters like buck, boost and buck-boost converters, isolated converters like forward, push pull, half bridge, full bridge and fly back, design of magnetics for inductors and transformers, inverters, PWM generation - SPWM, space vector PWM, dq axis theory for 2 and 3 phase applications. Introduction to electric drives, and speed control of electric machines. Design examples like, EV Battery chargers, and grid connected PV inverter.
4	**Texts/References**	**1.** L. Umanand, Power electronics and applications, Wiley India Pvt. Limited, 2009. **2.** Chryssis, G.C., High frequency switching power supplies, Second Edn, McGraw Hill, 1989. **3.** R. W. Erickson, Dragan Maksimovic, Fundamentals of Power Electronics, Springer, 2001. **4.** N. Mohan, Power Electronics: Converter, Applications & Design, John Wiley & Sons, 1989

1	**Title of the course** (L-T-P-C)	**Optimization Theory and Algorithms** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Exposure to Calculus or equivalent
3	**Course content**	The following topics will be covered: Quick Review of Linear Algebra and basic calculus. Introduction to convex sets and functions, and its properties. Duality theory, Lagrangian dual and KKT conditions. Algorithms for unconstrained and constrained minimization. Subgradient methods for non-differentiable functions. Important standard classes such as linear and quadratic programming, semidefinite programming etc. Applications of convex programming in electrical engineering. Recognizing and formulating convex optimization problems in practice. Beyond convex optimization. Introduction to functional optimization theory.
4	**Texts/References**	**1.** Stephen Boyd and Lieven Vandenberghe, "Convex Optimization," Cambridge university press. **2**. David G. Luenberger, "Optimization by Vector Space Methods," Wiley publications.

1	**Title of the course** (L-T-P-C)	**Design of Power Converters** **(2-0-2-6)**
2	**Pre-requisite courses(s)**	EE222: Introduction to Power Electronics or equivalent as determinedby the instructor or faculty advisor.
3	**Course content**	Rectifier analysis and design: Analysis and design of buck, boost; Intro to single-phase and 3-phase inverter: Intro to PWM generation and gate-drive basics; Intro to Flyback, Forward, Full Bridge; Switching and conduction loss calculation; Magnetics Design; Basics of Gate Drivers and PWM ICs; Basics of Snubbers.
4	**Texts/References**	**1.** L Umanand Power Electronics: Essentials & Applications. Wiley 2009. **2.** Robert W Erickson and Dragan Maksimovic, Fundamentals of Power Electronics, Springer, 3ed, 2020. **3.** Daniel W Hart, Introduction to Power ElectroniPrentice-Hall, 1997. **4**. Mohan, N., et al, Power Electronics, John Wiley, 1989. **5**. Daniel W Hart, Power Electronics, McGraw Hill Higher Education, 2010 **6**. Mohan, N., et al., Power Electronics, John Wiley, 3rd edition, 2007

1	**Title of the course** (L-T-P-C)	**VLSI Technology** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Exposure to Electronic Devices
3	**Course content**	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.
4	**Texts/References**	**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

1	**Title of the course** (L-T-P-C)	**Advanced Power Systems** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	EE223: Introduction to Power Systems or equivalent as determined by the instructor or faculty advisor.
3	**Course content**	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.
4	**Texts/References**	**1.** Power System Analysis, Bergen & Vittal, 2^{nd} 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, 3^{rd} Ed, 2019, ISBN-10: 9353165113.

1	**Title of the course** (L-T-P-C)	**Modeling and Control of Renewable Energy Resources** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Exposure to Power System Analysis, Electrical Machines, Power Electronics
3	**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.
4	**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.

1	**Title of the course** (L-T-P-C)	**Probability Models and Applications (PMA)** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Data analysis and Introduction to probability (6 credits course that all batches are currently doing as core)
3	**Course content**	**Introduction to** Probability theory. **Review of** sample space, events, axioms of probability, introduction to probability as a measure, Random variables, Notion of independence and mutually exclusive events Probability Space, limits and sequence of events, continuity of probability, measurable functions, notions of induced measures, connection with cdf, change of measure, conditional probability, and conditional expectation, simulating discrete and continuous random variables - accept-reject method, importance sampling. **Random vectors and Stochastic processes:** Introduction to random vectors, Gaussian vectors, notion of i.i.d random variables introduction to elementary stochastic processes like Bernoulli process and Poisson process. **Markov Process.** Discrete time and continuous time Markov chains**,** classification of states, notion of stationary distribution. Simulating stochastic processes like Gaussian process, Poisson process, Markov chains and Brownian motion. Introduction to Markov chain monte carlo methods, Hidden Markov chain and Markov decision process, Introduction to Brownian motion and stationary process. **Statistics:** MLE, MAP and Bayesian Estimation, sufficient statistics, Cramer-Rao bound
4	**Texts/References**	**1.** Sheldon Ross “Introduction to probability models” 9th Ed., Elsevier AP **2.** Sheldon Ross, ‘Stochastic process,’ John Wiley, 2nd Ed., April 1996. **3.** David Stirzaker, ‘Stochastic process and models,’ Oxford press.

1	**Title of the course** (L-T-P-C)	**Advanced Topics in Speech Processing** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Exposure to probability concepts
3	**Course content**	Advanced modeling techniques on speech analysis, feature extraction and modeling like deep learning. Advanced topics related to prosody modeling, health information modeling, cognitive speech processing etc. Also, latest trends in the speech processing area.
4	**Texts/References**	**1.** J. R. Deller, Jr., J. H. L. Hansen and J. G. Proakis Discrete-Time Processing of Speech Signals, Wiley-IEEE Press, NY, USA, 1999. **2.** D. O'Shaughnessy, Speech Communications: Human and Machine, Second Edition, University Press, 2005. **3.** L. R. Rabiner, B. H. Jhuang and B. Yegnanarayana, "Fundamentals of speech recognition", Pearson Education, 2009. **4.** J. Benesty, M M Sondhi and Y. Huang, "Springer Handbook of Speech Processing", 2008. **5.** Journals like IEEE Trans on Audio, Speech and Language Processing, Acoustical Society of America, Speech Communication and Interspeech Proceedings.

1	**Title of the course** (L-T-P-C)	**Advanced Electric Drives** **(2-0-2-6)**
2	**Pre-requisite courses(s)**	Exposure to basic Power Electronics, Electric Machines, and foundational courses in EE; Instructor consent is required.
3	**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 modelling 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)
4	**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.

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

1	**Title of the course** (L-T-P-C)	**Mixed signal VLSI Design** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	CMOS Analog VLSI Design
3	**Course content**	**1)** CML logic for high-speed mixed signal circuits **2)** Switch design and switched capacitor circuits. **3)** Sampling theory and discrete-time signals **4)** Comparators **4)** Basics of data converters **5)** Nyquist rate ADC's: Parallel (single-step converters), algorithmic (multi-step converters) and pipelined ADC' Architectures and design of Nyquist rate ADC's **6)** High resolution data converters (Δ Σ data converters) **7)** Digital to analog converters **8)** Selected topics in mixed-signal VLSI circuits
4	**Texts/References**	**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.

1	**Title of the course** (L-T-P-C)	**Linear Algebra and its applications** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Exposure to Basic calculus.
3	**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.
4	**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.

1	**Title of the course** (L-T-P-C)	**Mixed signal VLSI Design** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	CMOS Analog VLSI Design
3	**Course content**	**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 **5.** Basics of data converters **6.** Nyquist rate ADC's: Parallel (single-step converters), algorithmic (multi-step converters) and pipelined ADC' Architectures and design of Nyquist rate ADC's **7.** High resolution data converters ($\Delta\Sigma$ data converters) **8.** Digital to analog converters **9.** Selected topics in mixed-signal VLSI circuits
4	**Texts/References**	**1.** R. Jacob Baker, H.W.Li, and D.E. Boyce CMOS Circuit Design, Layout andSimulation, Prentice-Hall of ,1998. **2.** R. Jacob Baker, CMOS: Mixed-Signal Circuit Design, Wiley (1 January 2008) **3.** Pavan, Shanthi, Richard Schreier, and Gabor C. Temes. Understandingdelta-sigma data converters. John Wiley & Sons, 2017.

1	**Title of the course** (L-T-P-C)	**Speech Processing** **(3-0-3-9)**
2	**Pre-requisite courses(s)**	Exposure to basic concepts in probability
3	**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. Parameterized Algorithms, Kernelization, and Complexity of Graph Modification Problems
4	**Texts/References**	**Textbook:** • Parameterized Algorithms, Marek Cygan, Fedor V. Fomin, Lukasz Kowalik. Daniel Lokshtanov, Daniel Marx, Marcin Pilipczuk, Michal Pilipczuk, and Saket Sourabh. Springer. 2015 **Reference:** • Parameterized Complexity, R. G. Downey, and M. R. Fellows. Springer Science and Business Media. 2012

1	**Title of the course** (L-T-P-C)	**Advanced Analog Circuits** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Exposure to Electronic devices and UG analog circuits
3	**Course content**	I. Review of MOS transistor characteristics and small signal models. CS amplifier, cascade amplifiers, cascode and folded cascode – Design assignment with simulations in cadence. Passive components in CMOS, resistors, capacitors, mismatch and layout techniques to reduce effect of mismatch, current mirrors, voltage references. Differential amplifiers, 2 stage op-amps and miller compensation – Design assignment with simulations in cadence. II. Linear, non-linear Circuits using opamps. Oscillator circuits. III. Power Electronics: power switching devices: diode, BJT. MOSFET, IGBT; Gate Drive Circuits; Rectifiers - Single and three phase; Introduction to reactive elements - inductors and transformers; Protection Circuits for Semiconductor devices; Linear Regulators and DC/DC Converters.
4	**Texts/References**	**1.** Paul Horowitz, The Art of Electronics 2nd Edition, Cambridge University Press, 2006. **2.** L. Umanand, Power electronics and applications, Wiley India Pvt. Limited, 2009. **3.** Chryssis, G.C., High frequency switching power supplies, Second Edn, McGraw Hill, 1989.

1	**Title of the course** (L-T-P-C)	**Physics of Nanoscale devices** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Exposure to Basic Electronics, Electronic Devices
3	**Course content**	Quantum mechanics, solution of Schrodinger equation, Energy Bands in crystals, generation and recombination, carrier transport, PN junction diodes, MOS capacitors, Nanoscale MOSFETS, MOS electrostatics, MOS characteristics, MOS reliability.
4	**Texts/References**	**1.** S. M. Sze and K. K. Ng, "**Physics of Semiconductor Devices** ", 3rd Edition, Wiley-Interscience, **2.** R. F. Pierret, "**Semiconductor Device Fundamentals** ", Addison-Wesley **3.** Y. Taur and T.H. Ning, Fundamentals of Modern VLSI Devices, Cambridge University Press, Cambridge, UK 1998.

1	**Title of the course** (L-T-P-C)	**Advanced Topics in Control Systems** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Undergraduate level course on control systems
3	**Course content**	**Linear Systems:** • **Introduction to State Variables:** Motivation for State Variables, Implementation of Differential Equations, Formal Definitions. • **Basic Realization Theory:** Similarity Transformation, Canonical Realizations: Jordan and real canonical forms, Minimal realization • **Connections to Transfer Functions:** Characteristic/Minimal Polynomials, matrix exponentials, Markov parameters and other invariants. • **Observability and Controllability:** Duality, Decomposition of Uncontrollable and Unobservable realizations, Popov test, Separation Principle and Pole Placement Theorem, Asymptotic Observers: Full and reduced order, Controllability indices. **Optimal Control:** • **Dynamic Programming:** Principle of Optimality, Computation of Optimal Control using Dynamic Programming, Discrete LQR, Hamilton-Jacobi-Bellman Equation, Continuous LQR • **Calculus of Variations:** Constraints and End Point conditions, Necessary Conditions, Indirect methods: TPBVP using Shooting Methods and Collocation • **Constrained Optimal Control:** Pontryagins Minimum Principle, Min Time, Min Energy, Min Fuel Problems, Singular Arcs.
4	**Texts/References**	**1.** Donald E. Kirk, Optimal Control Theory, Prentice-Hall, New Jersey, 1970. **2.** Arthur E. Bryson and Yu-Chi Ho, Applied Optimal Control: Optimization, Estimation and Control, Blaisdell Publishing Company, 1969. **3.** T. Kailath, Linear Systems, Prentice-Hall, New Jersey, 1980.

1	**Title of the course** (L-T-P-C)	**Renewable Energy** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	None
3	**Course content**	Fundamentals of energy, energy resources, Thermal power plants, Hydroelectric power plants, nuclear power generation, environmental effects of conventional energy, photovoltaic power generation, wind energy, tidal energy, ocean thermal energy conversion, geothermal energy, energy storage
4	**Texts/References**	**1.** Gilbert M. Masters, "Renewable and Efficient Electric Power System," Wiley Interscience, 2nd edition, 2004. **2.** Boyle, " Renewable Energy: Power for Sustainable Future," Oxford University Press, 3rd edition ,2012.

1	**Title of the course** (L-T-P-C)	**Microgrid Dynamics and Control** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	exposure to electrical machines, power electronics, power system, renewable energy
3	**Course content**	Grid connected renewable energy resources, renewable power for control support, Microgrid concepts, structures and operation modes, microgrid dynamics and modeling, Hierarchical Microgrid Control, DC Microgrid Control, Virtual Synchronous Generators: Dynamic Performance and Characteristics, virtual inertia-based stability and regulation support, Robust microgrid control and emergency control
4	**Texts/References**	**1.** Gilbert M. Masters, "Renewable and Efficient Electric Power Systems," Wiley Interscience, 2nd edition, 2004. **2.** Hassan bevrani, Bruno Francois, and Toshifumi Ise, "Microgrid Dynamics and Control," Wiley, Black Well, 1st edition, 2017.

1	**Title of the course** (L-T-P-C)	**Power System Operation and Control** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	exposure to electrical machines, power system
3	**Course content**	Introduction to modern power systems, equipment and stability constraints, reactive power and voltage controls, economic load dispatch and unit commitment, active power and frequency control, line power flow controls, load dispatch center functions, Emergency Controls- Special Protection Schemes.
4	**Texts/References**	**1.** B F Wollenberg, "Power Generation, operation and control," 2nd edition, Wiley, 2006. **2.** Grainger and Steveson, "Power System Analysis, "1st edition, McGraw Hill Education, 2017. **3.** Prabha Kundur, "Power System Stability and Control," McGraw Hill Education, 1st edition, 2006.

1	**Title of the course** (L-T-P-C)	**Power System II** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	exposure to electrical machines, power system half semester courses
3	**Course content**	Recap: line parameters, three phase power, per unit system, complex power, line diagram, characteristics and performance of lines, load flow. Actual syllabus: power system fault analysis- symmetrical and unsymmetrical faults, power system protection- circuit breakers, line protection, generator protection, transformer protection, power system stability, automatic generation and voltage control.
4	**Texts/References**	**1.** Grainger and Stevenson, "Power System Analysis,"1st edition, McGraw Hill Education, 2017. **2.** Bergen and Vittal, "Power System Analysis," 2nd Edison, Pearson, 2002. **3.** Hadi Saadat, "Power System Analysis," PSA publishing, 3rd edition, 2011. **4.** B F Wollenberg, "Power Generation, operation and control," 2nd edition, Wiley, 2006. **5.** Nagrath and Kothari, "Power System Engineering," 2nd edition, McGraw Hill, 2012.

1	**Title of the course** (L-T-P-C)	**Electrical Machines II** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	exposure to electrical machines.
3	**Course content**	Recap: magnetic circuits, single phase transformer, synchronous generators. Actual syllabus: autotransformer; three phase transformers; Induction machines-construction, working principle, phasor diagram, equivalent circuit, torque-slip characteristics, stability, induction generator and applications; DC Machines-construction, commutator action, emf and torque equations, armature reaction, operating characteristics of Dc generators and motors, speed control of dc motors; special electric motors- stepper motors, variable reluctance motors, brushless dc motors
4	**Texts/References**	**1.** P. S. Bimbhra, "Electrical machinery," Khanna Publishers, 7th edition, 1977. **2.** P. S. Bimbhra, "Generalized theory of electrical machines," Khanna Publishers, 6th edition, 2017. **3.** A Fitzgerald, Charles Kingsley, and Stephen Umans, "Electric Machinery," McGraw Hill, 6th edition, 2017. **4.** Stephen Chapman, "Electric Machinery Fundamentals," McGraw Hill, 4th edition, 2017.

1	**Title of the course** (L-T-P-C)	**Advanced Topics in Artificial Intelligence** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Exposure to a first level course in artificial intelligence or pattern recognition and machine learning or artificial neural networks & deep learning or studied equivalent topics in any other course.
3	**Course content**	This course will cover selected topics from: advanced pattern recognition, machine learning, neural networks, learning theory, constraint processing, logic programming, probabilistic reasoning. The course will also discuss some practical applications of artificial intelligence like computer vision, speech processing and natural language processing.
4	**Texts/References**	**1.** Ian Goodfellow and Yoshua Bengio and Aaron Courville, "Deep Learning," MIT Press **2.** Bishop, C. M. Neural Networks for Pattern Recognition. Oxford University Press. 1995 **3.** B Yegnanarayana, "Artificial Neural Networks," PHI. **4.** Bishop, C. M. Pattern Recognition and Machine Learning. Springer. 2006.

1	**Title of the course** (L-T-P-C)	Introduction to Machine Learning **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Exposure to Calculus (MA 101)
3	**Course content**	**Recap** (a) Probability Theory, Linear Algebra, Convex Optimization. **Introduction to statistical decision theory** (a) Hypothesis testing (b) Regression, Classification, Bias Variance trade- off Regression and PCA (a) Linear Regression, Multivariate Regression, (b) Subset Selection, Shrinkage Methods, (c) Principal Component Regression, Partial Least squares (d) Linear Classification, Logistic Regression, Linear Discriminant Analysis Neural Networks (a)) Perceptron, Support Vector Machines (b) Neural Networks - Introduction, Early Models, Perceptron Learning, (c) Backpropagation, Initialization, Training and Validation, Parameter Estimation - MLE, MAP, Bayesian Estimation Decision Trees (a) Decision Trees, Regression Trees, Stopping Criterion and Pruning Loss functions, Categorical Attributes, Multiway Splits, Missing Values Decision Trees - Instability Evaluation Measures (b) Bootstrapping and Cross Validation, Class Evaluation Measures, ROC curve, MDL Ensemble Methods - Bagging, Committee Machines and Stacking, Boosting Boosting (a) Gradient Boosting, Random Forests, Multi-class Classification Naive Bayes, Bayesian Networks (b) Gaussian Mixture Models, Expectation Maximization
4	**Texts/References**	**1**. Trevor Hastie, Robert Tibshirani, Jerome H. Friedman "The Elements of Statistical Learning," Springer text in statistics. **2.** C. Bishop, "Pattern Recognition and Machine Learning," Springer text in information science and statistics.

1	**Title of the course** (L-T-P-C)	**Nanoelectronics** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	--
3	**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.
4	**Texts/References**	1. Nanoelectronics and Nanosystems: From Transistors to Molecular and Quantum Devices, Karl Goser, Peter Glössekötter, 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.

1	**Title of the course** (L-T-P-C)	**Introduction to Aerial Robots** **(2-1-0-6)**
2	**Pre-requisite courses(s)**	Exposure to Engineering mechanics
3	**Course content**	**T1. Types of vehicles** (1) B2. Applications: DDD (Dull Dirty Dangerous) . (2) (1-2) C3. Sub-systems. (3) D4. Principles of flight of fixed-wing vehicles (8-10) E5. Principles of flight of rotary-wing vehicles (8-10). (4) F6. Exposure to policy and regulations related to aerial robots (1) C7. Case studies (3-4).
4	**Texts/References**	**1.** Roland Siegwart, Illah Reza Nourbakhsh and Davide Scaramuzza, "Introduction to Autonomous Mobile Robots", Second Edition, MIT Press. **2.** Kenzo Nonami, Farid Kendoul, Satoshi Suzuki, Wei Wang, Daisuke Nakazawa, "Autonomous Flying Robots: Unmanned Aerial Vehicles and Micro Aerial Vehicles", Springer, 2010. **3.** Randal W. Beard, Timothy W. McLain, "Small Unmanned Aircraft: Theory and Practice", Princeton University Press, 2012.

1	**Title of the course** (L-T-P-C)	**Dynamics and Control of Aerial Robots** **(2-1-0-6)**
2	**Pre-requisite courses(s)**	Exposure to control theory
3	**Course content**	Rigid body dynamics (4), Trim conditions and vehicle primary control, linearization, stability (6), Sensors: accelerometer, rate gyros, pressure sensors, magnetometers, inertial measurement units (IMUs), GNSS (1-2), Arduino based tutorial, Actuators (1), Linear control, controllability, observability (8-10), Levels of autonomy, autopilot architecture and design (1-2)
4	**Texts/References**	**1.** Andrea L'Afflitto, "A Mathematical Perspective on Flight Dynamics and Control" Springer, 2017 **2.** Randal W. Beard, Timothy W. McLain, "Small Unmanned Aircraft: Theory and Practice", Princeton University Press, 2012. **3.** Matko Orsag, Christopher Korpela, Paul Oh, Stjepan Bogdan, "Aerial Manipulation", Springer, 2017. **4.** Duane T. McRuer, Dunstan Graham, Irving Ash kenas, "Aircraft Dynamics and Automatic Control" Princeton University Press, 2014.

1	**Title of the course** (L-T-P-C)	**Autonomous Navigation** **(2-1-0-6)**
2	**Pre-requisite courses(s)**	Exposure to Introduction to probability and control theory
3	**Course content**	Introduction to probability and random processes (3) State estimation: Kalman filter (KF), Extended Kalman filter (EKF) (8-10), Path planning and path following algorithms (8-10), Vision guided navigation (2), Cooperative control (2)
4	**Texts/References**	**1.** Sebastian Thrun, Wolfram Burgard, and Dieter Fox, Probabilistic robotics, MIT Press, 2006. **2.** Timothy D. Barfoot,D. tate Estimation for Robotics", Cambridge University Press, 2017 **3.** Richard Szelisk, "Computer Vision: Algorithms and Applications", Springer, 2010

1	**Title of the course** (L-T-P-C)	**Electric Vehicles: Systems and Components** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	EE222: Introduction to Power Electronics and EE206: Introduction to Electrical Machines for UG; but for PG students there are no prerequisites.
3	**Course content**	**Introduction to Electric Vehicles –** discussion on the importance of EV; classification of EVs: e-bike, 2-wheeler, 3-wheeler, and 4- wheelers; light/medium/heavy duty, etc **Electric Vehicle Components –** Components of EV, Electric Vehicle Supply Equipment (EVSE), Charging port, connector configuration, Charger, Battery, Drivetrain, BMS, AUX power converters, Electric motors, etc. **Electric Vehicle Supply Equipment –** Introduction to EVSE, basic requirements, different types, functional diagram, safety features, and requirements. **Electric Vehicle Battery Chargers –** Overview of EV Battery Chargers (onboard and stationary), different types, levels of charging, internal power electronic converters – Rectifiers, PFC, DC/DC converters, Communications, and control aspects. **Overview on EV Batteries and Battery Management Systems:** introduction to various electric vehicle batteries, typical energy requirements in EV, battery management systems. **Discussion on EV Drivetrain:** Overview of electric motors for EV applications, limitations of existing motors, control of electric motors, and design aspects. **Electric Vehicle Control Unit:** discussion on requirements of VCU, inverter topologies and their control strategy, VCU design methodology. **AUX Power Converter Unit:** requirements, power converter topologies, discussion on design difficulties for high current low voltage converters.
4	**Texts/References**	**1.** Ali Emadi, Mehrdad Ehsani, and John M. Miller, "Vehicular Electric Power Systems: Land, Sea, Air, and Space Vehicles (Power Engineering," CRC Press, 1ed, 2003 **2.** Iqbal Husain, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2ed, 2010. **3.** Who killed the Electric Car, a documentary, 2006. **4.** Michael Shnayerson "The Car that Could: The Inside Story of GM's Revolutionary Electric Vehicle", 1996 **5.** Application Notes of Texas Instruments, Infineon; Curtis Instruments.

1	**Title of the course** (L-T-P-C)	**Data Science and Visualization Lab** **(0-0-3-3)**
2	**Pre-requisite courses(s)**	Exposure to basics of probability theory, linear algebra, optimization and computer
3	**Course content**	**1.** A hands-on introduction to tools for data science and Machine Learning (ML), including Python, NumPy and TensorFlow basics/pytorch. Data visualization using real world data set: Matplotlib, histograms, bar charts, line/scatter plots, pie charts etc. (2 labs). **2.** Sampling from a distribution, hypothesis testing, model parameter estimation. (2 labs) **3.** A hands-on lab for classification and regression with various data sets using Bayesian classifier/ neural networks. (2 labs) **4.** Implementation of Stochastic Gradient Descent (SGD) algorithm and one momentum-based algorithm. (1 lab) **5.** Dimensionality reduction and principal component analysis. (1 lab) **6.** Integration of AI engine with web/mobile applications, embedded systems and hardware. (1-2 lab(s)) **7.** **Mini project:** End-to-end development cycle of an AI application (Deployable applications in various areas, such as AI in healthcare and AI in Finance). Students can choose the project but require the instructor's approval. (3 labs).
4	**Texts/References**	• Anirudh Koul, Siddha Ganju and Meher Kasam, **Practical Deep Learning for Cloud, Mobile, and Edge**, O'Reilly, 2019. • Itay Lieder, Tom Hope, and Yehezkel S. Resheff **Learning TensorFlow: A Guide to Building Deep Learning Systems**, O'Reilly, 2017.

1	**Title of the course** (L-T-P-C)	**VLSI Test & Testability** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	EE 224 Digital systems or equivalent
3	**Course content**	The course describes the theoretical aspects of VLSI Testing and verification. Starting from the basic concepts of verification and testing to advance processor level verification and testing are going to be discussed in this course. In addition, SoC testing strategy will also be addressed. The objective of this course is to deal with the study of VLSI design flow, Functional verification, verification flow, Timing verification of the circuit, simulator architecture and operation, assertions, need for electronic testing, fault modelling, test generation for combinational circuits, test generation for sequential circuits, fault simulation, Built- In Self-Test (BIST), Memory testing, In-circuit/On-chip emulation and validation, Design for Testability (DFT), SoC test, fault diagnosis, and Analog/RF test.
4	**Texts/References**	**1.** William K. Lam, Hardware Design Verification: Simulation and Formal Method-Based Approaches, Prentice Hall (2008). **2.** Michael. L. Bushnell, and Vishwani. D. Agrawal, Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits, Kluwer Academic Publishers, Third Edition, 2004. **3.** B. Wile, John C. Goss and W. Rosner, Comprehensive Functional Verification," Morgan Kaufmann, 2005. **4.** Chris Spear, "System Verilog for Verification," Springer Publications, second edition 2008. **5.** Stuart Sutherland, Simon Davidmann, Peter Flake "System Verilog for Design," Springer Publications, second edition 2006. **6.** M Abromovici, M A Breuer & A. D. Friedman "Digital Systems Testing and Testable Design ", Jaico Publications, Paperback Impression, 2001. **7.** H. Fujiwara, "Logic Testing and Design for testability," MIT Press, 1985. **8.** Pallab Dasgupta, "A roadmap for formal property verification," Springer (2006) **9.** Santanu Chattopadhyay, "Thermal-Aware Testing of Digital VLSI Circuits and Systems," CRC Press, 2018.

1	**Title of the course** (L-T-P-C)	**Introduction to HIL testing methods** **(1-0-1-3)**
2	**Pre-requisite courses(s)**	None for M. Tech SSM. For others, instructor consent is required.
3	**Course content**	Introduction to real-time simulation and hardware-in-the-loop systems; structure of HIL platforms; characteristics of discrete systems and simulations; introduction to mathematical and modelling constraints for real-time simulation: sampling, interpolation, parallelization; slow and fast interactions; computability; introduction to solvers: real-time vs non-real-time and faster-than-real-time; CPU vs FPGA based simulation of systems; step-time constraints; multi-core simulation; CPU time constraints; concurrent vs sequential programs for simulation; Rapid Control Prototyping (RCP) Mode; fundamentals of automated testing and verification; interfacing HIL system with DUT: signal constraints; sampling and acquisition; power hardware-in the loop (pHIL) and controller hardware-in the loop (cHIL) modes. **1.** Fundamentals of Model-based simulation: discretization; accuracy; simulation step time; convergence, etc. **2.** Parameterization of Simulation Models, library interfaces; abstractions **3.** Introduction to Real-time toolchains; Automated testing, model profiling **4.** Model parallelization: strong and weak coupling, design partitioning. **5.** Simulation of switched systems **6.** FPGA-based solvers **7.** Hardware interfacing: analog and digital I/O
4	**Texts/References**	**References:** **1.** L. Umanand, “Digital Control Series” (Video Lectures) **2.** A. V. Prokhorov, A. S. Gusev and Y. S. Borovikov, "Hardware-in-the- loop testbed based on hybrid real time simulator," IEEE PES ISGT Europe 2013, 2013, pp. 1-5, doi: 10.1109/ISGTEurope.2013.6695464. **3.** A. Samiee, N. Tiefnig, J. P. Sahu, M. Wagner, A. Baumgartner and L. Juhász, "Model-Driven-Engineering in Education," 2018 18th International Conference on Mechatronics - Mechatronika (ME), 2018, pp. 1-6. **4.** Whitepapers from OpalRT, Mathworks, Typhoon, etc

1	**Title of the course** (L-T-P-C)	**Battery Technology** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	None for M. Tech SSM. For others, instructor consent is required
3	**Course content**	Module 1: Battery Chemistry Electrochemistry, concept of electrochemical energy storage, primary and secondary batteries (Li-Ion, Li-Na, Li-S and Li-air batteries etc.), chemistry behind capacitors and supercapacitors, different energy storage materials and the material characterization. Module 2: Battery Management Systems Electrical Characteristics of Batteries; measurement and characterization; components of battery-powered electronic/electrical systems; safe-operating-area (SOA), Coulombic and electrical energy efficiency; Lithium-specific considerations; cell modelling and estimation; SOC, DOD; integration of cell/pack/module; Structure and function of BMS; cell balancing topologies and algorithms; coulomb-counting; second-life batteries; battery/supercapacitor integrated systems Module 3: Thermal Management Li-ion batteries & hazard levels, EV fire accidents and safety, Battery and heat transfer: methodologies, passive and active air-cooling systems, two phase cooling.
4	**Texts/References**	**References:** **1.** Electrochemical energy: Advanced materials and technologies, Edited by J Zhang (CRC press). **2.** Linden's Handbook of Batteries, 4th Edition. **References:** **1.** “Battery Management Systems for Large Lithium-ion Battery Packs”, Davide Andrea, Artech House, 2010. ISBN:1608071057 **2.** Introduction to Hybrid and Electric Vehicles (NPTEL Online Course), Dr. Praveen Kumar Department of Electronics and Prof. S. Majhi (IIT Guwahati) **3.** “Battery Cell Balancing: What to Balance and How”, Barsukov, Y, Texas Instruments (whitepaper) **References:** **1.** Sun, Peiyi, et al. "A review of battery fires in electric vehicles." Fire technology. (2020): 1-50. **2.** Chombo, Pius Victor, and Yossapong Laoonual. "A review of safety strategies of a Li-ion battery." Journal of Power Sources 478 (2020): 228649. **3.** Yu, Kuahai, et al. "Thermal analysis and two-directional air flow thermal management for lithium-ion battery pack." Journal of power sources 270 (2014): 193-200. **4.** Thermal Management of Electric Vehicle Battery Systems, Ibrahim Dinçer, Halil S. Hamut, Nader Javani, ISBN: 978-1-118-90024-6

1	**Title of the course** (L-T-P-C)	**Introduction to Electric Drives** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	None for M. Tech SSM
3	**Course content**	**1.** Fundamentals of Electric Power Technologies; review of sinusoidal, phasor, three-phase and per-phase quantities; review of mathematical tools (ordinary differential equations, Laplace and Fourier Transforms, space vectors, etc.) **2.** Electric Machines: Inductors and Transformers: Magnetic Circuits, principle of transformer action, equivalent circuits, phasor diagram, efficiency, basics of three phase transformer. **3.** Introduction to Electric Motors and Generators: Synchronous Machines: induced emf and torque in a rotating coil, rotating magnetic field, construction of synchronous Machines, induced emf, phasor diagram, equivalent circuit, OCC- SCC, power angle characteristics, V-curve and inverted V curve. **4.** Introduction to Induction Motor, introduction to DC Machine, Applications of Electrical Machines and special electrical motors. **5.** Principles of Power Conversion: AC/DC, Introduction to power semiconductor devices **6.** Rectifiers - single and three phase. **7.** Switching Power Pole and PWM **8.** Buck Converter **9.** Basics of inverters - single and three phase. **10.** Fundamentals of Isolated Converters
4	**Texts/References**	**1.** P. S. Bimbhra, "Electrical machinery," Khanna Publishers, 7th edition, 1977. **2.** M. G. Say, "The Performance and Design of Alternating Current Machines," CBS, 3rd ed, 2002. **3.** Stephen Chapman, "Electric Machinery Fundamentals," McGraw Hill, 4th edition, 2017. **4.** D.P. Kothari, I.J. Nagrath, "Electric Machines," McGraw Hill, 5th edition, 2017. **5.** A Fitzgerald, C. Kingsley, and S. Umans, "Electric Machinery," McGraw Hill, 6th ed. 2017. **6.** L. Umanand, ``Power Electronics – essentials and applications," Wiley 2009. **7.** M. H. Rashid "Power Electronics," Pearson. 4th edition, 2017. **8.** Mohan, Robbins, Undeland "Power Electronics: Converters Applications and Design" 3rd Ed.; Wiley, 2007

1	**Title of the course** (L-T-P-C)	**EV Charging and Ancillary Services** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Introduction to Power Systems or equivalent as determined by the instructor
3	**Course content**	1. Introduction to Electric Power System Dynamics and Distribution System Power Flow Analysis 2. Impact of EV Charging on Distribution Systems 3. Optimal Location of EV Charging Stations 4. Optimal Scheduling of EV Charging 5. Ancillary Services from EV- Frequency control, peak shaving, valley filling, congestion management. 6. Communication Technologies for EV Charging Stations
4	**Texts/References**	**1.** H. Xiao, Y. Huimei, W. Chen and L. Hongjun, "A survey of influence of electrics vehicle charging on power grid," *2014 9th IEEE Conference on Industrial Electronics and Applications*, 2014, pp. 121-126, doi: 10.1109/ICIEA.2014.6931143. **2.** E. Veldman and R. A. Verzijlbergh, "Distribution Grid Impacts of Smart Electric Vehicle Charging from Different Perspectives," in IEEE Transactions on Smart Grid, vol. 6, no. 1, pp. 333-342, Jan. 2015, doi: 10.1109/TSG.2014.2355494. **3.** O. Beaude, S. Lasaulce, M. Hennebel and I. Mohand-Kaci, "Reducing the Impact of EV Charging Operations on the Distribution Network," in IEEE Transactions on Smart Grid, vol. 7, no. 6, pp. 2666-2679, Nov. 2016, doi: 10.1109/TSG.2015.2489564. **4.** R. A. Verzijlbergh, M. O. W. Grond, Z. Lukszo, J. G. Slootweg and M. D. Ilic, "Network Impacts and Cost Savings of Controlled EV Charging," in IEEE Transactions on Smart Grid, vol. 3, no. 3, pp. 1203-1212, Sept. 2012, doi: 10.1109/TSG.2012.2190307. **5.** B. Sun, Z. Huang, X. Tan and D. H. K. Tsang, "Optimal Scheduling for Electric Vehicle Charging with Discrete Charging Levels in Distribution Grid," in IEEE Transactions on Smart Grid, vol. 9, no. 2, pp. 624-634, March 2018,doi: 10.1109/TSG.2016.2558585. **6.** N. Leemput, F. Geth, B. Claessens, J. Van Roy, R. Ponnette and J. Driesen, "A case study of coordinated electric vehicle charging for peak shaving on a low voltage grid," 2012 3rd IEEE PES Innovative Smart Grid Technologies Europe (ISGT Europe), 2012, pp. 1-7, doi: 10.1109/ISGTEurope.2012.6465656. **7.** A. M. A. Haidar and K. M. Muttaqi, "Behavioral Characterization of Electric Vehicle Charging Loads in a Distribution Power Grid Through Modeling of Battery Chargers," in IEEE Transactions on Industry Applications, vol. 52, no. 1, pp. 483-492, Jan.-Feb. 2016, doi: 10.1109/TIA.2015.2483705. **8.** J. C. Mukherjee and A. Gupta, "A Review of Charge Scheduling of Electric Vehicles in Smart Grid," in IEEE Systems Journal, vol. 9, no. 4, pp. 1541-1553, Dec. 2015, doi: 10.1109/JSYST.2014.2356559. **9.** C. Jin, J. Tang and P. Ghosh, "Optimizing Electric Vehicle Charging with Energy Storage in the Electricity Market," in IEEE Transactions on Smart Grid, vol. 4, no. 1, pp. 311-320, March 2013, doi:1109/TSG.2012.2218834. **10.** J. Hu, S. You, M. Lind and J. Østergaard, "Coordinated Charging of Electric Vehicles for Congestion Prevention in the Distribution Grid," in IEEE Transactions on Smart Grid, vol. 5, no. 2, pp. 703-711, March 2014, doi: 10.1109/TSG.2013.2279007. **11.** R. Li, Q. Wu and S. S. Oren, "Distribution Locational Marginal Pricing for Optimal Electric Vehicle Charging Management," in IEEE Transactions on Power Systems, vol. 29, no. 1, pp. 203-211, Jan. 2014, doi: 1109/TPWRS.2013.2278952. **12.** E. Sortomme and M. A. El-Sharkawi, "Optimal Scheduling of Vehicle-to-Grid Energy and Ancillary Services," in IEEE Transactions on Smart Grid, vol. 3, no. 1, pp. 351-359, March 2012, doi: 10.1109/TSG.2011.2164099. **13.** Y. He, B. Venkatesh and L. Guan, "Optimal Scheduling for Charging and Discharging of Electric Vehicles," in IEEE Transactions on Smart Grid, vol. 3, no. 3, pp. 1095-1105, Sept. 2012, doi: 10.1109/TSG.2011.2173507. **14.** E. Sortomme and M. A. El-Sharkawi, "Optimal Charging Strategies for Unidirectional Vehicle-to-Grid," in IEEE Transactions on Smart Grid, vol. 2, no. 1, pp. 131-138, March 2011, doi: 10.1109/TSG.2010.2090910. **15.** L. Gan, U. Topcu and S. H. Low, "Optimal decentralized protocol for electric vehicle charging," in IEEE Transactions on Power Systems, vol. 28, no. 2, pp. 940-951, May 2013, doi: 10.1109/TPWRS.2012.2210288. **16.** C. Wu, H. Mohsenian-Rad and J. Huang, "Vehicle-to-Aggregator Interaction Game," in IEEE Transactions on Smart Grid, vol. 3, no. 1, pp. 434-442, March 2012, doi: 10.1109/TSG.2011.2166414. **17.** M. H. K. Tushar, A. W. Zeineddine and C. Assi, "Demand-Side Management by Regulating Charging and Discharging of the EV, ESS, and Utilizing Renewable Energy," in IEEE Transactions on Industrial Informatics, vol. 14, no. 1, pp. 117-126, Jan. 2018, doi: 10.1109/TII.2017.2755465.

<table>
<tr><td>1</td><td>Title of the course
(L-T-P-C)</td><td>Advanced Methods in HIL Testing of Electric Transportation Systems
(2-0-2-6)</td></tr>
<tr><td>2</td><td>Pre-requisite courses(s)</td><td>“Intro to HIL Testing Methods” for M. Tech SSM. For others, instructor consent is required</td></tr>
<tr><td>3</td><td>Course content</td><td>Advanced topics in real-time simulation and hardware-in-the-loop systems; defining and determining mathematical and modelling constraints for real-time simulation Code profiling; testing through offline simulation, automatic code generation (using MATLAB coder, real-time engine, etc.) Design partitioning and parallelization; model synchronization; data streaming to file or digital I/O; interrupts

Automated testing; formal verification and test case development

Rapid Control Prototyping (RCP), sampling and acquisition; power hardware-in the loop (pHIL) and controller hardware-in the loop (cHIL) modes.

Hands-on-tasks:
1. Developing simple continuous time models, verification using offline and online models
2. Real-time simulations: Evaluation of trade-offs between step-time, accuracy, and solver complexity
3. Design for scalable models: design partitioning, model interface design, library development and management.
4. Simulation of steady-state power-system Models; power flow and phase computation
5. Simulation of Power system transients: faults and unbalance
6. Simulation of switched systems: Power Electronic Converters
7. Simulation of multi-scale systems: power electronic converters in power systems
8. Simulation of multi-domain system models: electrical machines
9. Mini project: Simulation of multi-domain system.</td></tr>
<tr><td>4</td><td>Texts/References</td><td>References:
1. L. Umanand, “Digital Control Series” (Video Lectures)
2. A. V. Prokhorov, A. S. Gusev and Y. S. Borovikov, "Hardware-in-the-loop testbed based on hybrid real time simulator," IEEE PES ISGT Europe 2013, 2013, pp. 1-5, doi: 10.1109/ISGTEurope.2013.6695464.
3. A. Samiee, N. Tiefnig, J. P. Sahu, M. Wagner, A. Baumgartner and L. Juhász, "Model-Driven-Engineering in Education," 2018 18th International Conference on Mechatronics - Mechatronika (ME), 2018, pp. 1-6.
4. Whitepapers from OpalRT, Mathworks, Typhoon, etc</td></tr>
</table>

1	**Title of the course** (L-T-P-C)	**Electric and Hybrid Vehicles** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	--
3	**Course content**	Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drivetrains on energy supplies. Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance. Hybrid Electric Drivetrains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Electric Drivetrains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency. Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies. EV Charging: system design, infrastructure requirements, and power system impacts, batteries and their characteristics, chemistries, "MPGe", range anxiety, intro to BMS and battery health Life-cycle Analysis and Costing for EVs, Drive cycles analysis and charging network design
4	**Texts/References**	**1.** Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003. **2.** Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004. **3.** James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

1	**Title of the course** (L-T-P-C)	**Robotics and Automation** **(3-0-2-8)**
2	**Pre-requisite courses(s)**	
3	**Course content**	Introduction to Embedded Systems & Robotics Introduction/Review of Circuits Embedded Software Design Power sources and voltage regulation General Purpose Input Output Managing Time Concurrent Multithreading Serial Port Interfacing Motor Interfacing Timers Introduction to Cameras and Visual Servoing. Elements of Mechanical Design of differential drive robot
4	**Texts/References**	**1.** Jonathan W. Valvano, "Embedded Systems: Introduction to Robotics," ISBN:9781074544300. (2019) **2.** Andrew Thomson and Jacky Baltes, "Mobile Robot Path Tracking using visual Servoing" http://web.cecs.pdx.edu/~mperkows/CLASS_479/S2006/thomson 02 mobil_robot_path_track_using_visual_servoin.pdf **3.** Design and Manufacturing I, MIT OCW Lecture Notes. https://ocw.mit.edu/courses/mechanical-engineering/2-007-design-and-manufacturing-i-spring-2009/lecture-notes

1	**Title of the course** (L-T-P-C)	**Stochastic Process and its Applications** **(3-0-0-3)**
2	**Pre-requisite courses(s)**	Exposure to Introduction to probability and Data analysis/Probability models.
3	**Course content**	• Introduction to stochastic processes: Definitions and examples, Bernoulli process and Poisson process. Markov Process, stationary and ergodic process. • Markov Chains: Discrete time and continuous time Markov chains, classification of states, notion of stationary distribution. • Simulating stochastic processes like Gaussian process, Poisson process, Markov chains and Brownian motion. • Introduction to Markov chain monte carlo methods, Hidden Markov chain and Markov decision process. • Statistics: MLE, MAP and Bayesian Estimation, sufficient statistics, and CramerRao lower bound.
4	**Texts/References**	Sheldon Ross "Introduction to probability models" 9th ed Elsevier AP. Sheldon Ross, 'Stochastic process', John Wiley, 2nd Ed., April 1996. David Stirzaker, 'Stochastic process and models', Oxford press.

1	**Title of the course** (L-T-P-C)	**Mathematics for Data Science I** **(3-0-0-3)**
2	**Pre-requisite courses(s)**	Introduction to probability and Data analysis or equivalent, basic calculus.
3	**Course content**	● Introduction to Data science and Motivation for the course. ● Review of calculus, notion of limits, series and its convergence. ● Introduction to Linear Algebra in Data science, the notion of vector space, dimension and rank, algorithms for solving linear equations, importance of norms and notion of convergence, matrix decompositions and its use. ● Importance of optimization in data science: Bird's view of Linear Regression, Multivariate Regression, Logistic Regression etc.
4	**Texts/References**	● Boyd, Stephen, and Lieven Vandenberghe. Introduction to applied linear algebra: vectors, matrices, and least squares. Cambridge university press, 2018. ● Aggarwal, Charu C., Aggarwal, and Lagerstrom-Fife. Linear algebra and optimization for machine learning. Springer International Publishing, 2020.

1	**Title of the course** (L-T-P-C)	**Mathematics for Data Science II** **(3-0-0-3)**
2	**Pre-requisite courses(s)**	Exposure to Introduction to probability and Data analysis or equivalent, basic calculus. Exposure to Mathematics for Data Science I.
3	**Course content**	● Convex Optimization: Convex sets, convex functions, cones and other useful geometries. ● Different types of optimization problems, Duality theory, KKT conditions, Introduction to linear program, solving constrained optimization problems using the Lagrangian method. Algorithms: Gradient descent methods and its convergence, Improved methods such as Nesterov acceleration, mirror descent/Nestrov dual averaging, ● Stochastic gradient descent methods and their convergence, Introduction to Rmsprop, ADAM algorithm etc.
4	**Texts/References**	● Boyd, Stephen, and Lieven Vandenberghe. Introduction to applied linear algebra: vectors, matrices, and least squares. Cambridge university press, 2018. ● Aggarwal, Charu C., Aggarwal, and Lagerstrom-Fife. Linear algebra and optimization for machine learning. Springer International Publishing, 2020. ● C. Bishop, "Pattern Recognition and Machine Learning," Springer, 2006. ● S. Boyd and L. Vandenberghe, "Convex Optimization," Cambridge university press, 2018 (reprint). ● Prateek Jain and Purushotam Kar, "Non-Convex Optimization for Machine Learning," Now publisher, 2017.

1	**Title of the course** (L-T-P-C)	**Fundamentals of Speech Processing (FSP)** **(3-0-0-3)**
2	**Pre-requisite courses(s)**	Exposure to calculus and probability
3	**Course content**	**Introduction** to speech processing area: History, initial electrical mode till latest trends **Speech production, perception and cognition:** Study of these mechanisms and important findings for technology development. **Nature of speech signal:** Stationary vs non-stationary, voiced/unvoiced/silence classification, vowels and consonants. **Speech signal processing:** Time, frequency and cepstral domain processing **Overview of important applications**: Speech recognition, speech synthesis, speaker
4	**Texts/References**	**1.** Rabiner, Jhuang and Yegnanarayana, "Fundamentals of Speech Recognition", Pearson LPE, 2009. **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.** Xuedong Huang, Alejandro Acero and Hsiao-Wuen Hon, "Spoken Language Processing: A guide to Theory, Algorithms, and System Development", Prentice Hall, USA, 2001.

1	**Title of the course** (L-T-P-C)	**Machine Learning of Speech Processing (MLSP)** **(1.5-0-3-3)**
2	**Pre-requisite courses(s)**	Exposure to calculus and probability
3	**Course content**	**Introduction** to machine learning **Introduction** to MATLAB / Python programming **Overview of machine learning models:** Gaussian mixture model (GMM), hidden Markov model (HMM), support vector machine (SVM), Neural Networks (NNs), etc **Applications development:** ML based speech recognition, speech synthesis, speaker recognition and language identification.
4	**Texts/References**	**1.** Rabiner, Jhuang and Yegnanarayana, "Fundamentals of Speech Recognition", Pearson LPE, 2009. **2.** C. Bishop, "Pattern Recognition and Machine Learning," Springer, 2006. **3.** B. Yegnanarayana, "Artificial Neural Networks", PHI, 1999. **4.** J. R. Deller, Jr., J. H. L. Hansen and J. G. Proakis, "Discrete-Time Processing of Speech Signals", Wiley-IEEE Press, NY, USA, 1999. **5.** Xuedong Huang, Alejandro Acero and Hsiao-Wuen Hon, "Spoken Language Processing: A guide to Theory, Algorithms, and System Development", Prentice Hall, USA, 2001.

1	**Title of the course** (L-T-P-C)	**Deep Learning of Speech Processing (DLSP)** **(1.5-0-3-3)**
2	**Pre-requisite courses(s)**	Exposure to calculus and probability
3	**Course content**	**Introduction** to deep learning **Introduction** to MATLAB / Python programming, open-source toolkits for speech technology development **Overview of machine learning models:** Deep feedword neural networks (DFNN), convolution neural network (CNN), recurrent neural networks (RNNs) and its variations, time delay neural networks (TDNN) **Applications development:** Deep learning-based speech recognition, speech synthesis, speaker recognition and language identification.
4	**Texts/References**	**1.** Rabiner, Jhuang and Yegnanarayana, "Fundamentals of Speech Recognition", Pearson LPE, 2009. **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.** Xuedong Huang, Alejandro Acero and Hsiao-Wuen Hon, "Spoken Language Processing: A guide to Theory, Algorithms, and System Development", Prentice Hall, USA, 2001. **4.** Michael Nielsen "Neural Networks and Deep Learning" Open Book. **5.** Ian Goodfellow, Yoshua Bengio and Aaron Courville, "Deep Learning", MIT Press, 2016. **6.** Charu Agarwal, "Neural Networks and Deep Learning", Springer 2018.

1	**Title of the course** (L-T-P-C)	**Pattern Recognition** **(3-0-0-3)**
2	**Pre-requisite courses(s)**	Exposure to calculus and probability
3	**Course content**	**Introduction** to pattern recognition, pattern vs data, human computer interaction, pattern recognition systems, design cycle, learning and adaptation. **Bayesian Decision Theory:** Introduction, theory, classifiers, discriminant functions and decision surfaces, maximum likelihood and Bayesian parameter estimation. **Nonparametric Techniques:** Introduction, nearest neighbor estimation, nearest neighbor rule, nearest neighbor classifier. **Dimensionality Reduction:** Principal component analysis and Linear discriminant analysis. **Nonparametric Methods:** Introduction, decision trees, CART, other tree methods.
4	**Texts/References**	**1.** Duda, R.O., Hart, P.E., and Stork, D.G. Pattern Classification. Wiley-Interscience. 2nd Edition. 2001. **2.** Theodoridis, S. and Koutroumbas, K. Pattern Recognition. Edition Academic Press, 2008. **3.** Bishop, C. M. Neural Networks for Pattern Recognition. Oxford University Press. 1995. **4.** Hastie, T., Tibshirani, R. and Friedman, J. The Elements of Statistical Learning. Springer. 2001.

1	**Title of the course** (L-T-P-C)	**MACHINE LEARNING (ML)** **(1.5-0-3-3)**
2	**Pre-requisite courses(s)**	Exposure to basic concepts in calculus and probability
3	**Course content**	**Introduction to Machine Learning:** What is machine learning? learning approaches: supervised, unsupervised, semi-supervised and reinforcement learning **Regression**: Linear Regression, Multivariate Regression, Logistic Regression. **Clustering:** Partitional Clustering, Hierarchical Clustering, Density-based Clustering **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, and Naive Bayes Classifier.
4	**Texts/References**	**1.** C. Bishop, "Pattern Recognition and Machine Learning," Springer, 2006. **2.** K. P. Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press, 2012. **3.** "Introduction to Machine Learning" wikipedia guide **4.** M. Nielsen "Mathematics and Applications of Machine Learning", online book.

1	**Title of the course** (L-T-P-C)	**ARTIFICIAL NEURAL NETWORKS (ANN)** **(3-0-0-3)**
2	**Pre-requisite courses(s)**	Exposure to basic concepts in calculus and probability
3	**Course content**	Introduction to Artificial Neural Networks (ANN): Motivation, basics of ANN, different architectures. Applications of ANN. Feedforward Neural Networks (FFNN): Working principle, basic architecture, analysis of FFNN for different ML tasks. Feedback Neural Networks (FBNN): Working principle, basic architecture, Boltzmann machine, analysis of FFNN for different ML tasks. Competitive learning Neural Networks (CLNN): Working principle, basic architecture, analysis of CLNN for different ML tasks. Applications of ANN: speech processing, image processing and other tasks.
4	**Texts/References**	1. B. Yegnanarayana, "Artificial Neural Networks", PHI, 1999. 2. Simon Haykin, "Neural Networks and Learning Machines", Pearson Prentice Hall, 2008. 3. Rumelhart, "Parallel distributed processing: explorations in the microstructure of cognition (Vol. 1 and 2)", MIT Press, 1986

1	**Title of the course** (L-T-P-C)	**DEEP LEARNING (DL)** **(1.5-0-3-3)**
2	**Pre-requisite courses(s)**	Exposure to basic concepts in calculus and probability
3	**Course content**	**Introduction to Deep Learning (DL):** Motivation, evolution of deep learning and different architectures. Applications of DL. **Deep Learning (DL) Architectures:** Deep FFNN, Convolutional neural networks (CNN), Recurrent neural network (RNN), Long-Term short-term memory (LSTM), Generative adversarial network (GAN), autoencoders, variational autoencoders, DL architectures with attention mechanism. Some recent DL architectures.
4	**Texts/References**	**1.** Ian Goodfellow Yoshua Bengio Aaron Courville, Deep Learning, MIT Press, 2016. **2.** Charu Agarwal, "Neural Networks and Deep Learning", Springer, 2018. **3.** Michael Nielsen" Neural Networks and Deep Learning" Open Book.

1	**Title of the course** (L-T-P-C)	**Introduction to Battery Management Systems** **(3-0-0-3)**
2	**Pre-requisite courses(s)**	None for EE candidates; all core courses for ME candidates
3	**Course content**	Introduction to Battery electrochemistry and electrical characteristics, cell types and models, SOC, SOA, SOH estimation, BMS systems; charging algorithms; charge balancing
4	**Texts/References**	Application notes and technical documentation from vendors

1	**Title of the course** (L-T-P-C)	**PWM Techniques** **(3-0-0-3)**
2	**Pre-requisite courses(s)**	Electric Drives for EVs - I and II
3	**Course content**	Basics of PWM, generation of PWM using analog and digital methods (triangle comparison); single and dual slope PWM; leading vs trailing edge PWM; current mode control and hysteresis vs PWM; spectral properties and dithering; three-phase PWM: sine triangle, space-vector, etc; low frequency vs high frequency PWM; space-vector analysis of PWM methods.
4	**Texts/References**	**1.** L. Umanand, ``Power Electronics – essentials and applications," Wiley 2009. **2.** M. H. Rashid "Power Electronics," Pearson. 4th edition, 2017. **3.** Mohan, Robbins, Undeland "Power Electronics: Converters Applications and Design" 3rd Ed.; Wiley, 2007

1	**Title of the course** (L-T-P-C)	**Signals, Systems and Controls** **(3-0-0-3)**
2	**Pre-requisite courses(s)**	None
3	**Course content**	Review of basic signal processing techniques; time and frequency domain transformations; inferring time-and frequency domain behaviors of physical systems from mathematical models, ODEs, eigen values. Review of control theory: classical control theory; SISO systems, stability analysis. Linear Algebra for MIMO systems and State Space models; eigenvalue analysis. Modern control methods: Estimation; model-based control; sliding mode control; predictive control.
4	**Texts/References**	**1.** Signals and systems / Alan V. Oppenheim, Alan S. Willsky, with. S. Hamid Nawab. - 2nd ed. p. **2.** Next Generation Wireless LANs: 802.11n and 802.11ac 2nd Edition, by Eldad Perahia (Author), Robert Stacey (Author) **3.** Relevant IEEE Standards and publications **4.** Modern Control Engineering, Katsuhiko Ogata, Prentice Hall, 2010 ISBN 0136156738

1	**Title of the course** (L-T-P-C)	**Digital Signal Processing and Communications** **(3-0-0-3)**
2	**Pre-requisite courses(s)**	Signals, Communications and Controls
3	**Course content**	● Digital Modulation - Signal constellations, Nyquist's Sampling Theorem and Criterion for ISI Avoidance, Linear modulation Optimal Demodulation – Review of Hypothesis Testing, ML and MAP decision rules, Signal Space Concepts, Optimal Reception in AWGN and performance analysis of various modulation schemes. ● DFT and FFT, Digital Filter Design, Analysis and Implementation.
4	**Texts/References**	**1.** Discrete-time signal processing / Alan V. Oppenheim, Ronald W. Schafer, with John R. Buck. — 2nd ed **2.** Upamanyu Madhow, ``Introduction to Communication Systems," Cambridge university press, 2008 edition.

1	**Title of the course** (L-T-P-C)	**Design of Power Converters** **(1.5-0-3-3)**
2	**Pre-requisite courses(s)**	At least one course on Power Electronics at the undergraduate level. Not suitable for candidates with no prior exposure to power electronics.
3	**Course content**	Introduction to power converter topologies for EV applications, functional and operational constraints, design procedures, introduction to magnetics, thermal and mechanical aspects, packaging
4	**Texts/References**	None. Relevant material will be provided by the **external instructor** from datasheets, app notes and manuals.

1	**Title of the course** (L-T-P-C)	**Computational Techniques and Optimisation** **(1.5-0-3-3)**
2	**Pre-requisite courses(s)**	Previous exposure to computing systems; strong mathematical background in especially calculus
3	**Course content**	Introduction to convex functions, types of optimization problems, Linear programming, duality theory and Lagrange formulation of optimization problems, algorithms to solve different optimization problems. Understanding computational systems and computational power, mapping of problem to computational systems, computational performance, introduction to computing platforms, methods to handle large data volumes, parallelisation, etc.
4	**Texts/References**	**1.** Ian Goodfellow Yoshua Bengio Aaron Courville, Deep Learning, MIT Press, 2016. **2.** Charu Agarwal, “Neural Networks and Deep Learning”, Springer, 2018. **3.** Michael Nielsen” Neural Networks and Deep Learning” Open Book.

1	**Title of the course** (L-T-P-C)	**Optimization Methods for Wireless Communication and Machine Learning (3-0-0-6)**
2	**Pre-requisite courses(s)**	Nil
3	**Course content**	-Introduction to properties of Vectors, Norms, Positive Semi-Definite matrices, Gaussian Random Vectors -Introduction to Convex Optimization – Convex sets, Hyperplanes/ Half-spaces, etc. **Application**: Power constraints in Wireless Communication Systems -Convex/ Concave Functions, Examples, Conditions for Convexity. **Application**: Beamforming in Wireless Systems, Multi-User Wireless, and Cognitive Radio Systems Convex Optimization problems, Linear Programs (interior point method), -**Application**: Power allocation in multi-cell cooperative OFDM -QCQP, SOCP Problems, **Application**: Channel shortening for Wireless Equalization, Robust Beamforming in Wireless Systems -Duality Principle and KKT Framework for Optimization. -**Application**: Optimization for MIMO Systems, OFDM Systems, and MIMO-OFDM systems -Optimization for signal estimation, LS, WLS, and Regularization. -**Application**: Wireless channel estimation -**Application**: Convex optimization for Machine Learning, Principal Component Analysis (PCA), Support Vector Machines -**Application**: Cooperative Communication, Optimal Power Allocation for cooperative Communication, Geometric Program, Communication Optimization -**Application**: Cooperative Communication, Optimal Power Allocation for cooperative Communication, Geometric Program
4	**Texts/References**	**References:** **1.** Boyd S. and Vandenberghe B., **Convex Optimization**, Cambridge University Press, 2004. **2.** Tse D. and Viswanath P., **Fundamentals of Wireless Communication**, Cambridge University Press, 2005.

1	**Title of the course** (L-T-P-C)	**Physics of Transistors** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Not applicable
3	**Course content**	**Semiconductor Physics Review**. **The MOS transistor:** MOS Capacitor Fundamentals, Fixed Oxide and Interface Charge Effects, Carrier Transport in MOS capacitor, Basic MOSFET operation, Measurement of MOS transistor parameters, Small Signal Equivalent Circuit, Non-ideal effects, MOSFET scaling and Short channel effects, Advanced MOSFET structures (High-k gate, SOI MOSFET and FinFET), Radiation and Hot-electron effects in transistors, MOSFET reliability, CMOS technology, Charged Coupled Device (CCD). **Bipolar transistor:** Basic BJT operation, Minority carrier distribution, Ideal current-voltage characteristics, non-ideal effects, Base width modulation, High injection, Emitter bandgap narrowing, Current crowding, Nonuniform base doping, Breakdown voltage, Equivalent circuit models, switching characteristics, Insulated-gate bipolar transistor (IGBT). **Heterojunction Transistors:** Heterostructure fundamentals, High electron mobility transistor (HEMT), and Heterojunction bipolar transistor (HBT).
4	**Texts/References**	**References:** **1.** Tsividis Y. and Mcandrew C., **The MOS Transistor**, New York, Oxford University Press, 2012. **2.** Taur Y. and Ning T. H., **Fundamentals of Modern VLSI Devices**, 2nd edition, New Delhi, Cambridge University Press, 2009. **3.** Sze S. M. and Ng K. K., **Physics of Semiconductor Devices**, 3rd edition, New Jersey, John Wiley & Sons, 2007. **4.** Shur M., **Physics of Semiconductor Devices**, Noida, Pearson, 2019. **5.** Neamen D. A., **Semiconductor Physics and Technology: Basic Principles**, 4th edition, New York, McGraw Hill, 2012

1	**Title of the course** (L-T-P-C)	**Semiconductor Radiation Detectors** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Not applicable
3	**Course content**	**Photodetectors:** Optical absorption in Semiconductor, Essential properties of photodetectors, Photoconductor, PiN photodetectors, Schottky Barrier Photodiode, Metal-Semiconductor-Metal (MSM) photodiode, Avalanche Photodiode, State-of-the-art Infra-red (IR) detectors and UV detectors. **Radiation Detection:** Interaction of X-rays, gamma-rays, charged particles, and neutrons with semiconductor, Penetration of radiation through Matter, Simplified detector model, Modes of detector operation, Pulse height spectra, Counting curves, Energy resolution, Detection efficiency, Dead time. **Detector Physics:** Signal formation and acquisition, Ramo's theorem, Incomplete charge collection due to trapping, electronic noise, Readout electronics, Energy and radiation-level measurement, Position and energy measurement, Trap characterization in detectors, Radiation induced damage effects in detectors, Application of Silicon, CdZnTe and Diamond detectors. **Detector Systems:** Particle trackers, Vertex detectors at Large Hadron Collider, Pixel detectors, Nuclear Instrumentation systems, Astronomical and Medical Imaging detectors.
4	**Texts/References**	**References:** **1.** Bhattacharya P., **Semiconductor Optoelectronic Devices**, 2nd edition, Pearson, 1997. **2.** Knoll G. F., **Radiation Detection and Measurement**, 4th edition, U.S., John Wiley & Sons Inc. 2010. **3.** Lutz G., **Semiconductor Radiation Detectors**, Berlin, Springer, 2007. **4.** Spieler H., **Semiconductor Detector Systems**, New York, Oxford University Press, 2005. **5.** Tsoulfanidis and Landsberger S., **Measurement and Detection of Radiation**, 4th edition, Bosa Raton, CRC Press, 2015.

1	**Title of the course** (L-T-P-C)	**Power Semiconductor Devices** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Electronic Devices (EE229), Introduction to Power Electronics (EE209)
3	**Course content**	**Introduction:** Ideal and Typical Power Device Characteristics, Fundamental Material and Carrier Transport Properties, Recombination Lifetime, and Breakdown Voltage, Power Electronics Challenges. **Diode Rectifiers:** Schottky Rectifiers – Forward Conduction, Reverse Blocking, Device Capacitance, Barrier Height Adjustment, Edge Termination. PiN Rectifiers – Bipolar Current Transport, Switching Performance, Junction-Barrier Schottky (JBS) and Merged pin-Schottky (MPS) Diodes. **Power MOSFETs:** Power MOSFET structures such as V-MOSFET, VD-MOSFET and U-MOSFET and their working operation, Blocking Voltage, Specific On-Resistance, and Silicon Power MOSFETs. **Bipolar Power Switching Devices:** Power Bipolar Junction Transistor (BJT), Thyristors and Insulated Gate Bipolar Transistors (IGBTs): Current-Voltage Relationship, Blocking, On-state and Switching characteristics. **Wide Bandgap Power Devices:** Introduction to Silicon Carbide (SiC) Power Diodes and MOSFETs, Fundamentals of High-electron Mobility Transistors (HEMTs), Introduction to Gallium Nitride (GaN) - based Power HEMTs, Potential Applications and Challenges.
4	**Texts/References**	**1.** B. J. Baliga, Fundamentals of Power Semiconductor Devices, 2nd edition, Switzerland, Springer International Publishing AG, 2008. **2.** S. M. Sze, K. K. Ng, Physics of Semiconductor Devices, 3rd edition, New Jersey, John Wiley & Sons Inc., 2007. **3.** Y.C Liang, G. S Samudra, C.-F. Huang, Power Microelectronics: Device and Process Technologies, 2nd edition, Singapore, World Scientific Publishing, 2017. **4.** T. Kimoto, J. A. Cooper, Fundamentals of Silicon Carbide Technology, Singapore, John Wiley & Sons Inc., 2014. **5.** F. Iannuzzo, Modern Power Electronic Devices: Physics, applications, and reliability, UK, The Institution of Engineering and Technology, 2020. **6.** H. Yu, T. Duan, Gallium Nitride Power Devices, Singapore, Pan Stanford Publishing Ptv. Ltd, 2017.

1	**Title of the course** (L-T-P-C)	**Stochastic Control and Learning for Networked Systems** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Undergraduate control course, linear algebra, probability
3	**Course content**	**Introduction to Nonlinear Systems:** Nonlinear System Dynamics, Lyapunov Stability, Linearization **Introduction to Optimal Control:** Dynamic Programming, Markov Decision Process, Kalman Filter, Continuous Time Dynamic Programming, Stochastic integration, Introduction to differential games **Stochastic and Function Approximation:** Stochastic Gradient Descent, Statistical Learning, Linear Regression, Stochastic differential games **Dynamic Programming and Reinforcement Learning:** Review of Reinforcement learning, Relation between dynamic programming and reinforcement learning, Approximate dynamic programming, stochastic dynamic programming **Control Structures based on Reinforcement Learning:** Optimal control using synchronous online learning, Synchronous online learning for zero-sum two player games and multi-player non-zero-sum games **Networked Control System:** Introduction, Characterization and properties of information structures, Stochastic stability, stabilization of Decentralized systems, Agreement in teams and Dynamic Programming Approach under information constraints. (**If time permits**): multi-agent reinforcement learning
4	**Texts/References**	**1.** Hasan Khalil, **Nonlinear Systems**, *Pearson*, 3rd Edition, 2014. **2.** A. E. Bryson, Y. Ho, **Applied Optimal Control: Optimization**, Estimation and Control," *CRC Press*, 2017. **3.** D. Vrabie, K. G. Vamvoudakis, F. L. Lewis, **Optimal Adaptive Control and Differential Games by Reinforcement Learning Principles**, IET, 2013. **4.** Dimitri Bertsekas, **Reinforcement Learning and Optimal Control**, Athena Scientific, 2019. **5.** S. Yuksel, Tamer Basar, **Stochastic Networked Control Systems: Stabilization and Optimization under Information Constraints**, Birkhouser, 2013.

1	**Title of the course** (L-T-P-C)	**Theory of Machine Learning** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Should have taken probability models and applications or equivalent, exposure to linear algebra, optimization, and algorithms.
3	**Course content**	● Recap of Probability tools and concentration inequalities, introduction to convex optimization. ● Probability Approximately Correct (PAC) model, learning guarantees under finite hypothesis assumption, Infinite hypothesis case: Rademacher complexity, growth function, VC-dimension. ● Introduction to Perceptron, Support vector machines (SVMs), computing VC dimension and Rademacher complexity for SVM. ● Kernel methods: Introduction to Hilbert spaces, Reproducing Kernel Hilbert Spaces (RKHS), kernel algorithm. ● On-line learning: Introduction to online setting, prediction with expert advice, halving algorithms, weighted majority and exponential weighted algorithms, bounds and guarantees of these algorithms. ● Density estimation, maximum entropy models, Logistic regression, conditional maximum entropy models, Regression problems and algorithms ● Other topics (if time permits): Ranking, MDP etc.
4	**Texts/References**	**1.** Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar, **Foundations of Machine Learning**, MIT Press, second edition, 2018. **2.** Yaser S. Abu-Mostafa, Malik Magdon- Ismail, and Hsuan-Tien Lin, **Learning from Data: A short course**, AMLbook.com.