Syllabus and Scheme

M.Tech in Digital Communication

(2023-24)

RAJASTHAN TECHNICAL UNIVERSITY

M.Tech. (Digital Communication)

Teaching & Examination Scheme (Full Time) w.e.f. 2020-21

Semester I

SN	Course Type	Course code	Course Name	Teaching Scheme			Marks			Cr
				L	T	P	I	E	T	
1.	PCC	1MDC1-01	Digital Communication system	3	0	0	30	70	100	3
2.	PCC	1MDC1-02	Advanced Digital Signal Processing	3	0	0	30	70	100	3
3.	PEC-1	1MDC2-11	High Frequency Electronics	3	0	0	30	70	100	3
		1MDC2-12	Optimization Techniques							
		1MDC2-13	Detection & Estimation Theory							
4.	PEC-2	1MDC2-14	Advanced Computer Networks	3	0	0	30	70	100	3
		1MDC2-15	Statistical signal processing							
		1MDC2-16	Satellite Communication							
5.	MCC	1MCC3-21	Research Methodology and IPR	2	0	0	30	70	100	2
6.	PCC	1MDC1-06	Digital Communication System Lab	0	0	4	60	40	100`	2
7.	PCC	1MDC1-07	Modelling & Simulation Lab	0	0	4	60	40	100	2
8.	SODECA	1MDC5-00	Social Outreach Discipline & Extra Curriculum Activities					0	100	2
			Total				**270**	**430**	**800**	**20**

Semester II

SN	Course Type	Course code	Course Name	Teaching Scheme			Marks			Cr
				L	T	P	I	E	T	
1.	PCC	2MDC1-01	Wireless and Mobile Communication	3	0	0	30	70	100	3
2.	PCC	2MDC1-02	Antenna Theory & Techniques	3	0	0	30	70	100	3
3.	PEC-1	2MDC2-11	Micro-Electro-Mechanical-Systems	3	0	0	30	70	100	3
		2MDC2-12	Advanced Optical Communication							
		2MDC2-13	Artificial Neural Networks							
4.	PEC-2	2MDC2-14	Information Theory & Coding	3	0	0	30	70	100	3
		2MDC2-15	Digital Image Processing							
		2MDC2-16	Telecommunication Switching & Networks							
5.	MCC	2MCC3-XX	Audit course-I	2	0	0	0	0	0	
6.	PCC	2MDC1-06	Antennas and Radiating Systems lab	0	0	4	60	40	100`	2
7.	PCC	2MDC1-07	Wireless and Mobile Communication Lab	0	0	4	60	40	100	2
8.	REW	2MDC4-50	Mini Project with seminar	2	0	4	60	40	100	2
9.	SODECA	1MDC5-00	DECA(ANANDAM)						100	2
			Total				**300**	**400**	**800**	**20**

Semester III

SN	Type	Course code	Course Name	Teaching Scheme			Marks			Credit
				L	T	P	I	E	T	
1.	PEC	3MDC2-11	MIMO Systems	3	0	0	30	70	100	3
		3MDC2-12	RF and Microwave Circuit Design	3	0	0				
		3MDC2-13	Pattern Recognition and Machine Learning	3	0	0				
2.	MCC	3MCC3-XX	Audit course-II	2	0	0	0	0	0	
3.	MCC	3MCC3-XX	Open elective	3	0	0	30	70	100	3
4.	REW	3MDC4-60	Dissertation phase I:Industrial Project	0	0	20	240	160	400	10
			Total				**300**	**300**	**600**	**16**

Semester IV

SN	Course code	Course Name	Teaching Scheme			Marks			Credit
			L	T	P	I	E	T	
1.	4MDC4-70	Dissertation phase II	0	0	32	360	240	600	16
		Total				**360**	**240**	**600**	**16**

RAJASTHAN TECHNICAL UNIVERSITY
M.Tech. (Digital Communication)
Syllabus (Full Time) w.e.f. 2020-21

SEMESTER I

1MDC1-01: DIGITAL COMMUNICATION SYSTEM

CONTENTS	CONTACT HOURS
Deterministic and Random Signal Analysis: band pass and low pass signal representation, signal space representation, representation of random processes (via sampling, K-L expansion and narrow band representations)	8
Baseband Pulse Transmission: Nyquist criterion, matched filter, optimum receivers for channels with ISI and AWGN, equalization.	8
Pass band Digital Transmission: binary and M-ary modulation techniques, optimum receivers for AWGN channels, coherent detection, detection of signals with unknown phase, non-coherent orthogonal modulation techniques, power spectrum of digitally modulated signals, bandwidth efficiency, carrier and symbol synchronization.	14
Spread-Spectrum Modulation: Pseudo-Noise sequences, direct sequence spread spectrum, signal-space dimensionality and processing gain, error rate performance, frequency-hopped spread spectrum.	10
Total	**40**

Reference books:

1. John G. Proakis and MasoudSalehi, "Digital Communications", 5th Edition, Mc-Graw Hill Education, 2007.
2. Simon Haykin, "Digital Communication Systems", 2nd Edition, Wiley, 2006.
3. Sklar and Ray, "Digital Communications", 2nd Edition, Pearson, 2008.
4. Glover and Grant, "Digital Communications", 3rd Edition, Pearson, 2010.
5. B. P. Lathi, "Modern Digital and Analog Communication Systems", 4th Edition, Oxford, 2011.
6. Taub and Schilling, "Taub's Principles of Communication Systems", 4th Edition, TMH, 2013.

1MDC1-02: ADVANCE DIGITAL SIGNAL PROCESSING

CONTENTS	CONTACT HOURS
The DFT: properties and efficient computation of DFT using FFT Algorithms.	4
Digital filter design and structures: design of FIR filters using windows and frequency sampling method, IIR filter design by impulse invariance, bilinear transformation, structures for FIR and IIR systems.	16
Finite word length effects in FIR and IIR digital filters: coefficient quantization and round-off noise.	4
Multirate DSP: Decimators and Interpolators, Sampling rate conversion, multistage decimator and interpolator, poly phase representation, poly phase structures for Decimation and Interpolation filters, digital filter banks, quadrature mirror filter bank (QMF), perfect reconstruction (PR) systems. Application of multirate DSP in design of phase shifters and sub band coding of speech signals.	10
Introduction to wavelets: the wavelet transform and its relation to multirate filter banks, overview of wavelet applications.	6
Total	**40**

Reference books:

1. A.V.Oppenheim, R.W.Schafer and J.R.Buck, "Discrete-Time Signal Processing", 2nd Edition, Pearson, 1999.
2. J.G.Proakis and D.G.Manolakis, "Digital signal processing: Principles, Algorithm andApplications", 4th Edition, Pearson, 2009.
3. P.P.Vaidyanathan, "Multirate Systems and Filter Banks", Pearson, 1992.
4. V.M.Gadre and A.S.Abhyankar ,"Multiresolution and Multirate Signal Processing", McGraw Hill Education, 2017.
5. Andreas Antoniou, "Digital Signal Processing: Signals, Systems, and Filters", 1st Edition, McGraw-Hill Education, 2005.
6. Andreas Antoniou, "Digital filters:, 2ndt Edition, McGraw-Hill Education, 2000.

1MDC2-11: HIGH FREQUENCYELECTRONICS

CONTENTS	CONTACT HOURS
Analysis of planar transmission lines: Variational method. losses in microstrip lines, analysis & design of devices; passive circuits, impedance transformers, couplers, power dividers, filters, oscillators, mixers, switches, amplifiers (narrow band /broad band) oscillators, active & passive phase shifters.	18
Microstrip lines on ferrite and garnet substrate; Isolators and circulators; lumped elements in MICs Analysis of basic transmission lines for millimeter wave frequencies. Integrated finline, image guide and its variants, non-radiative guide, H-guide and groove guide. Millimetre wave devices for generation and detection. Transitions, bends anddiscontinuities.	18
Monolithic circuit components planar transmission lines, lumped and distributed passive elements.	4
Total	**40**

Reference books:

1. D.M.Pozar, " Microwave engineering" ,Wiley, 4th edition, 2011.
2. Bahl, I. and Bhartia, P., "Microwave Solid State Circuit Design", 2nd Ed., John Wiley & Sons. 2003
3. Chang, K., Bahl, I. and Nair, V., "RF and Microwave Circuit and Component Design for Wireless Systems", Wiley Interscience. 2002
4. Bhat, B. and Koul, S.K., "Stripline Like Transmission Lines", John Wiley & Sons. 1989
5. Edwards, T.C. and Steer M.B., "Foundations for Interconnects and Microstrip Design", 3rd Ed., John Wiley & Sons. 2001
6. Koul, S.K., "Millimeter Wave and Optical Dielectric Integrated Guides and Circuits", John Wiley & Sons. 1997
7. Bhat, B. and Koul, S. K., "Analysis, Design and Applications of Finlines", Artech House. 1987
8. Koul, S.K., "Millimeter Wave and Optical Dielectric Integrated Guides and Circuits", John Wiley & Sons. 1997
9. Gonzalez, G., "Microwave Transistor Amplifiers: Analysis and Design", 2nd Ed., Prentice-Hall. 1997
10. Chang, K., Bahl, I. and Nair, V., "RF and Microwave Circuit and Component Design for Wireless Systems", Wiley Interscience. 2002

1MDC2-12: OPTIMIZATION TECHNIQUES

CONTENTS	CONTACT HOURS
Introduction: Historical development, application to engineering problems, statement of optimization, classification of optimization, examples of optimization problems.	5
Linear Programming: Graphical method, simplex method, revised simplex method, Big-M method, 2- phase method, alternate optimal solutions, unbounded LPs, degeneracy and convergence, duality in linear programming, sensitivity analysis, dual simplex method, Transportation, assignment and other applications.	10
Non-Linear Programming: Unconstrained optimization techniques, direct search methods (Fibonacci method, golden section, quadrature and cubic interpolation) descent methods, constrained optimization, direct and indirect methods, optimization with calculm, kuhn-tucker conditions.	10
Dynamic Programming: Multistage decision process, principles of optimality, computational procedures in dynamic programming.	5
PID parameters optimization by using these techniques: Particle Swarm Optimization (PSO), Bacteria Foraging Algorithm (BFA), Genetic Algorithm (GA), and Ant colony optimization (ACO), Swarm Optimization Method (SMO), Artificial bee colony (ABC), grey wolf optimization (GWO), whale optimization algorithm (WOA), Sine Cosine algorithm (SCA)	10
Total	**40**

Reference books:

1. Hiller and Lieberman, "Introduction to Operation Research" 7th Edition, Tata McGrawHill, 2000.
2. Ravindran Philips and Solberg, "Operation Research Principles and Practice"2nd Edition, Wiley India, 2007.
3. Research Papers in PID Parameter Optimization.

1MDC2-13: DETECTION AND ESTIMATION THEORY

CONTENTS	CONTACT HOURS
Hypothesis testing: bayes, minimax and Neyman-Pearson criteria. Types of estimates and error bounds.	12
Parameter Estimation: Least square, generalized and recursive least square, Estimator properties including error bounds and convergence, MES, ML and MAP estimators. General Gaussian problem.	14
Detection and estimation in colored noise. Elements of sequential and non-parametric detection.	8
Applications to communication, radar and sonar systems.	6
Total	**40**

Reference books:

1. S. M. Kay, "Fundamentals of statistical signal processing: Estimation theory," 2nd Edition, Englewood Cliffs, NJ: Prentice-Hall, 1993.
2. H.V. Poor, "An Introduction to Signal Detection and Estimation", 2nd Edition, Springer-Verlag, 1994.
3. Gelman, J.B. Carlin, H.S. Stern, and D.B. Rubin, "Bayesian Data Analysis", 2nd Edition, Chapman &Hall, 2004.
4. L. Wasserman, "All of Statistics" New York:Wiley, 2004.

1MDC2-14: Advanced Computer Network

CONTENTS	CONTACT HOURS
Overview of Internet-Concepts, challenges and history. Overview of -ATM. TCP/IP Congestion and Flow Control in Internet-Throughput analysis of TCP congestion control. TCP for high bandwidth delay networks. Fairness issues in TCP.	8
Real Time Communications over Internet. Adaptive applications. Latency and throughput issues. Integrated Services Model (intServ). Resource reservation in Internet. RSVP.;Characterization of Traffic by Linearly Bounded Arrival Processes (LBAP). Leaky bucket algorithm and its properties.	8
Packet Scheduling Algorithms-requirements and choices. Scheduling guaranteed service connections. GPS, WFQ and Rate proportional algorithms. High speed scheduler design. Theory of Latency Rate servers and delay bounds in packet switched networks for LBAP traffic.;Active Queue Management - RED, WRED and Virtual clock. Control theoretic analysis of active queue management.	8
IP address lookup-challenges. Packet classification algorithms and Flow Identification- Grid of Tries, Cross producting and controlled prefix expansion algorithms.	4
Admission control in Internet. Concept of Effective bandwidth. Measurement based admission control. Differentiated Services in Internet (DiffServ). DiffServ architecture and framework.	8
IPV4, IPV6, IP tunneling, IP switching and MPLS, Overview of IP over ATM and its evolution to IP switching. MPLS architecture and framework. MPLS Protocols. Traffic engineering issues in MPLS.	4
Total	**40**

Reference books:

1. Jean Wairand and PravinVaraiya, "High Performance Communications Networks", 2nd edition, 2000.
2. Jean Le Boudec and Patrick Thiran, "Network Calculus A Theory of Deterministic Queueing Systems for the Internet", Springer Veriag, 2001.
3. Zhang Wang, "Internet QoS", Morgan Kaufman, 2001.
4. Anurag Kumar, D. Manjunath and Joy Kuri, "Communication Networking: An Analytical Approach", Morgan Kaufman Publishers, 2004.
5. George Kesidis, "ATM Network Performance", Kluwer Academic, Research Papers, 2005

1MDC2-15: STATISTICAL SIGNAL PROCESSING

CONTENTS	CONTACT HOURS
Linear Algebra: vectors, matrices, eigenvalues and eigenvectors. \	4
Discrete-time Random Processes: Gaussian processes, filtering, types-MA, AR, ARMA processes.	6
Linear prediction and optimum linear filters: forward and backward linear prediction, solution of normal equations, AR Lattice and ARMA Lattice-Ladder Filters, Wiener Filters for Filtering and Prediction.	10
Adaptive Filters: FIR adaptive filters, LMS algorithm, and Recursive Least Square algorithm, frequency domain & sub-band adaptive filters, applications.	10
Spectrum Estimation: Nonparametric Methods, Parametric Methods, Minimum-Variance Spectrum Estimation, Eigen analysis Algorithms for Spectrum Estimation.	10
Total	**40**

Reference books:

1. M.H.Hayes, "Statistical Digital Signal Processing and Modeling", John Wiley & Sons Inc., 2002.
2. S.Haykin, "Adaptive Filter Theory", 4th Edition, Prentice Hall, 2001.
3. D.G.Manolakis, V.K.Ingle and S.M.Kogon,"Statistical and AdaptiveSignal Processing", McGraw Hill, 2000.

1MDC2-16: SATELLITE COMMUNICAITON

CONTENTS	CONTACT HOURS
Architecture of Satellite Communication System: Principles and architecture of satellite Communication, Brief history of Satellite systems, advantages, disadvantages, applications, and frequency bands used for satellite communication and their advantages/drawbacks.	8
Orbital Analysis: Orbital equations, Kepler's laws of planetary motion, Apogee and Perigee for an elliptical orbit, evaluation of velocity, orbital period, angular velocity etc. of a satellite, concepts of Solar day and Sidereal day.	8
Satellite sub-systems: Architecture and Roles of various sub-systems of a satellite system such as Telemetry, tracking, command and monitoring (TTC & M), Attitude and orbit control system (AOCS), Communication sub-system, power sub-systems, antenna sub-system.	8
Typical Phenomena in Satellite Communication: Solar Eclipse on satellite, its effects, remedies for Eclipse, Sun Transit Outage phenomena, its effects and remedies, Doppler frequency shift phenomena and expression for Doppler shift.	4
Satellite link budget: Flux density and received signal power equations, Calculation of System noise temperature for satellite receiver, noise power calculation, drafting of satellite link budget and C/N ratio calculations in clear air and rainy conditions, Case study of Personal Communication system (satellite telephony) using LEO.	8
Modulation and Multiple Access Schemes used in satellite communication. Typical case studies of VSAT, DBS-TV satellites and few recent communication satellites launched by NASA/ ISRO. GPS.	4
Total	**40**

Reference books:

1. Timothy Pratt and Others, "Satellite Communications", 2nd edition Wiley India, 2010.
2. S. K. Raman, "Fundamentals of Satellite Communication", PearsonEducation India,2011.
3. Tri T. Ha, "Digital Satellite Communications", Tata McGraw Hill, 2009.
4. Dennis Roddy, "Satellite Communication", 4th Edition, McGraw Hill, 2008.

1MCC3-21: Research Methodology and IPR

CONTENTS	CONTACT HOURS
Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.	5
Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations	4
Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee	5
Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.	5
Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.	4
New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.	5
Total	**28**

Reference books:

1. Stuart Melville and, WayneGoddard,"Researchmethodology: An introductionfor science & engineering students" 2nd Edition, Juta & Company, 2004
2. Ranjit Kumar, "Research Methodology: A Step by Step Guide for beginners" 5th edition, AGE Publications Ltd, 2019.
3. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
4. Mayall, "Industrial Design", McGraw Hill, 1992.
5. Niebel, "Product Design", McGraw Hill, 1974.
6. Asimov, "Introduction to Design", Prentice Hall, 1962.
7. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in NewTechnologicalAge", 2016.
8. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

1MDC1-06: DIGITAL COMMUNICAITON SYSTEM LAB

1. PCM AND LINK ANALYSIS: Link establishment, Noise on PCM link, Error detection, BER calculation, Error correction.
2. TDM. DIGITAL MODULATION TECHNIQUES: ASK, FSK, PSK, QPSK Modulation and Demodulation.
3. CDMA – DSSS: Modulation, Demodulation & BER measurement.

REAL TIME SIGNAL ANALYSIS ON DSP KITS:

4. FIR Digital Filter Design
5. IIR Digital Filter Design
6. FFT of a given signal
7. Plot PSD/Power Spectrum of a signal
8. Adaptive Filter Design using Standard LMS Algorithm
9. Speech analysis using L.P.C.

1MDC1-07: MODELING & SIMULATION LAB

SIMULATION IN MATLAB ENVIRONMENT

1. Perform simulation to estimate the performance of the following Digital Communication Systems in the presence of noise (AWGN) using coherent detection of signals in noise. (Maximum Likelihood Decoding). Plot the bit error rate (BER) as a function of signal energy per bit-to-noise spectral density ratio, E_b/N_o.
   (i). Binary Phase Shift Keying (BPSK)
   (ii). Binary Frequency Shift Keying (BFSK)
   (iii). Quadrature Phase Shift Keying (QPSK)
   (iv).16-Quadrature Amplitude Modulation (16-QAM)
2. Design FIR filters (low pass, high pass, band pass and band stop), using window techniques.
3. Design IIR filters (low pass, high pass, band pass and band stop), using bilinear transformation.
4. Investigate the effect of coefficient quantization on the following aspects of filter behavior for the filters designed in 2 and 3.
   (i). pole-zero movement
   (ii). frequency response
   (iii). impulse response
5. Perform simulation to estimate the performance of Direct-Sequence Spread Spectrum with coherent Binary Phase-Shift Keying in the presence of noise and interference.
6. Implement the LMS algorithm for coefficient adjustment of the adaptive FIR filter for a given input signal and a desired response.
7. Decomposition & denoising of signal using Wavelet Transform.

SEMESTER II

2MDC1-01: WIRELESS AND MOBILE COMMUNICATION

CONTENTS	CONTACT HOURS
Cellular Communication Fundamentals: Cellular system design, Frequency reuse, cell splitting, handover concepts, Co channel and adjacent channel interference, interference reduction techniques and methods to improve cell coverage, Frequency management and channel assignment.	4
GSM architecture and interfaces, GSM architecture details, GSM subsystems, GSM Logical Channels, Data Encryption in GSM, Mobility Management, Call Flows in GSM.2.5 G Standards: High speed Circuit Switched Data (HSCSD), General Packet Radio Service (GPRS), 2.75 G Standards: EDGE,	6
Spectral efficiency analysis based on calculations for Multiple access technologies: TDMA, FDMA and CDMA, Comparison of these technologies based on their signal separation techniques, advantages, disadvantages and application areas. Wireless network planning (Link budget and power spectrum calculations).	6
Mobile Radio Propagation: Large Scale Path Loss, Free Space Propagation Model, Reflection, Ground Reflection (Two-Ray) Model, Diffraction, Scattering, Practical Link Budget Design using Path Loss Models, Outdoor Propagation Models, Indoor Propagation Models, Signal Penetration into Buildings. Small Scale Fading and Multipath Propagation, Impulse Response Model, Multipath Measurements, Parameters of Multipath channels, Types of Small-Scale Fading: Time Delay Spread; Flat, Frequency selective, Doppler Spread; Fast and Slow fading.	10
Equalization, Diversity: Equalizers in a communications receiver, Algorithms for adaptive equalization, diversity techniques, space, polarization, frequency diversity, Interleaving.	4
Code Division Multiple Access: Introduction to CDMA technology, IS 95 system Architecture, Air Interface, Physical and logical channels of IS 95, Forward Link and Reverse link operation, Physical and Logical channels of IS 95 CDMA, IS 95 CDMA Call Processing, soft Handoff, Evolution of IS 95 (CDMA One) to CDMA 2000, CDMA 2000 layering structure and channels.	6
Higher Generation Cellular Standards:3G Standards: evolved EDGE, enhancements in 4G standard, Architecture and representative protocols, call flow for LTE, VoLTE, UMTS, introduction to 5G	4
Total	**40**

Reference books:

1. V.K.Garg, J.E.Wilkes, "Principle and Application of GSM", Pearson Education, 5th edition, 2008.
2. V.K.Garg, "IS-95 CDMA & CDMA 2000", Pearson Education, 4th edition, 2009.
3. T.S.Rappaport, "Wireless Communications Principles and Practice", 2nd edition, PHI,2002.
4. William C.Y.Lee, "Mobile Cellular Telecommunications Analog and Digital Systems", 2nd edition, TMH, 1995.
5. Asha Mehrotra, "A GSM system Engineering" Artech House Publishers Bosten, London,1997.

2MDC1-02: ANTENNA THEORY AND TECHNIQUES

CONTENTS	CONTACT HOURS
Review of the theory of electromagnetic radiation. Introduction to various antenna types wire, loop and helical antennas, analysis using assumed current distribution.	8
Aperture antennas: slot, wave guide, horn, and reflector antennas. Analysis using field equivalence principle and Fourier transform methods. Linear arrays. Traveling wave & broadband antennas. Antenna measurements.	12
Printed antennas: Feeding methods, transmission line & cavity models, analysis and design of rectangular & circular microstrip antenna. Arrays: pattern synthesis, planar arrays, phased arrays. Active antennas andarrays.	12
Paraboloidal reflector antenna, different feed configurations, shaped beam antennas, lens antenna. Antennas for biomedical applications. Smart antennas for mobile communications. Antenna for infrared detectors.	8
Total	**40**

Reference books:

1. John D. Kraus, Ronald J. Marhefka, "Antennas", 3rd Edition, McGraw-Hill Science, 2001.
2. ,E.C. Jordan And K.G. Balmain, "Electromagnetic Waves And Radiating Systems",2nd EditionPrentice Hall India, 1964.
3. Constantine A. Balanis, "Antenna Theory: Analysis And Design", 4th Edition, John Wiley &Sons, 2016.
4. Robert S. Elliott, John, "Antenna Theory & Design", Revised Edition, Wiley &Sons, 2003.
5. G. S. N. Raju, "Antennas AndWave Propagation",Pearson, 2004.
6. A.R. Harish, M. Sachidananda, "Antennas AndWave Propagation",Oxford, 2007.
7. Y. T. Lo, S. W. Lee, "Antenna Handbook: Antenna Theory",Springer, 1994.
8. ,Chatterjee, R, "Antenna Theory And Practice", New AgeInternational, 1998.

2MDC2-11: MICRO-ELECTRO-MECHANICAL-SYSTEMS (MEMS)

CONTENTS	CONTACT HOURS
Micro electro mechanical system (MEMS) origins. MEMS impetus/ motivation. Material for MEMS.	8
The toolbox: processes for micro machining. MEMS fabrication technologies.	10
Fundamentals MEMS device physics: Actuation.	5
Fundamental MEMS devices: The cantilever beam.	5
Microwave MEMS applications: MEM switch design considerations. The micro-machined transmission line. MEMS-based microwave circuit and system.	12
Total	**40**

Reference books:

1. Max J. Madou: "Fundamentals of Micro Fabrication", The science of miniaturization-, Nanogen corporation, USA, CRCpress, 2002.
2. Sergey Edward Lyshevski, "Nano-And Micro Electro Mechanical Systems", 2nd Edition, CRC press, Boca RatronLondon, 2002.
3. Sherifsedky: "Integrated MEMS"- Artech House, BostonLondon.
4. N. Maluf,"Introduction To Micro Mechanical Systems Engineering", 2nd Edition, ArtechHouse, 2004.
5. Tai – Ran Hsu,"Memsand Micro Systems: Design and Manufacture" Tata Mc GrawHill 2002.

2MDC2-12: ADVANCED OPTICAL COMMUNICATION

CONTENTS	CONTACT HOURS
Optical fibers: review of fundamentals, Signal distortion and attenuation, Intermodal and intramodal dispersion, dispersion flattened and dispersion compensated fibers, Profile dispersion, study of PMD. Laser diode and photodiode, Photodetector noise analysis, Analog and Digital communication link design.	12
WDM, DWDM, optical couplers, Mach-Zehnder interferometer multiplexer, optical add/drop multiplexers, isolators, circulators, optical filters, tunable sources and tunable filters, arrayed waveguide grating, diffraction grating, optical amplifiers, optical integrated circuits. Characterization of optical fibers,	10
OTDR SONET: frame format, overhead channels, payload pointer, Virtual tributaries, multiplexing hierarchy.	6
SDH: Standards, frame structure and features.Optical switching, WDM networks,	6
Classification of optical sensors. Intensity modulated, phase modulated and spectrally modulated sensors.	6
Total	**40**

Reference books:

1. De, Anuradha, "Optical FiberandLaserPrinciples and Applications", NewAge, 2009.
2. Sarkar,D.C, "Opto Electronics andFiber Optics Communication, New Age publishers, 2001
3. G P Agrawal, Govind P Agrawal, "Optical Fiber Communications: Principles And Practice", 3rd Edition, Wiley, 2007.
4. Johan Gowar, "Optical Communication System", 2nd Edition, Prentice Hall, 1993.
5. R.P. Khare, "Fiber Optics andOptoelectronics",Oxford, 2004.
6. BiswanathMukherjee, "Optical WdmNetworks - Principles andPractice", 6th Edition, Oxford, 2013.
7. John M Senior , "Optical Fiber Communication: Principles andPractice", 3rd Edition,Pearson, 2009.
8. Joseph C. Palais, "Optical Communication", 5th Edition, Pearson, 2005.
9. Gerd Keiser, "Optical Fiber Communications", 4th Edition, TMH, 2008.
10. Selvarajan A, Kar S, Srinivas T, "Optical Fiber Communication: Principles andSystems",TMH, 2003.

2MDC2-13: ARTIFICIAL NEURAL NETWORKS

CONTENTS	CONTACT HOURS
Introduction: Biological neurons and memory: Structure and function of a single neuron, artificial neural networks (ANN), typical applications of ANNs: classification, clustering, vector quantization, pattern recognition, function approximation, forecasting, control, optimization, basic approach of the working of ANN - training, learning and generalization.	10
Supervised Learning: single-layer networks, perceptron-linear separability, training algorithm, limitations; multi-layer networks-architecture, back propagation algorithm (BTA) and other training algorithms, applications. Adaptive multi-layer networks-architecture, training algorithms, recurrent networks, feed- forward networks, radial-basis-function (RBF) networks.	10
Unsupervised Learning: Winner-takes-all networks, hamming networks, maxnet, simple competitive learning, vector-quantization, counter propagation networks, adaptive resonance theory, Kohonen's Self- organizing Maps, principal component analysis.	10
Associated Models: Hopfield Networks, brain-in-a-box network, Boltzmann machine. Optimization Methods: Hopfield Networks for-TSP, solution of simultaneous linear equations, Iterated gradient descent, simulated annealing, genetic algorithm.	10
Total	**40**

Reference books:

1. S. Shivanandam, S.Sumathi, “Introduction To Neural Network Using Matlab”, Tata McGraw-Hill, 2006.
2. Jacek M. Zurada, “Introduction to Artificial Neural Systems”, West Group, 1992.
3. B. YEGNANARAYANA, “ARTIFICIAL NEURAL NETWORKS”
4. RobertSchalloff, “Artificial Neural Network”, TMH.
5. Laurene V. Fausett, “Fundamental of Neural Network Architecture and Application”,Pearson.
6. JamesAFreeman, “Neural Networks: Algorithms, Applications, and Programming Techniques”,Pearson, 1991.
7. Cristopher,M.Bhishop, “Neural N/W For Pattern Recognition”, Oxford.
8. Raymond S.T. Lee, “Fuzzy Neuro Approach to Agent Application”,NewAge, 2006.

2MDC2-14: INFORMATION THEORY & CODING

CONTENTS	CONTACT HOURS
Shannon's fundamental coding theorems, Differential entropy & mutual information for discrete & continuous ensembles, source coding, Rate distortion theory.	16
Introduction to Algebra: Groups, fields, Binary field arithmetic, Basic properties of Galois field GF(2m)and vector spaces.	12
Channel coding & decoding: Run length limited codes, LBC, cyclic code, BCH code, convolutional code, Trellis coded modulation, Reed-Solomon code.	12
Total	**40**

Reference books:

1. Golomb, Solomon W., Peile, Robert E., Scholtz, Robert A, "Basic Concepts In Information Theory And Coding", Springer, 1994.
2. Raymond W. Yeung, "Information Theory And Network Coding",Springer, 2008.
3. by Herbert Taub, Donald Schilling, GoutamSaha, "Taub'sPrinciples Of Communication Systems", 3rd Edition, McGraw Hill Education, 2007.
4. Ian Glover, "Digital Communication", 3rd Edition, Pearson, 2010.
5. B.P. Lathi and Zhi Ding, "Modern Digital And Analog Communication Systems",5th Edition,Oxford, 2018.
6. Digital Communications, Simon Haykin,Wiley
7. Digital And Analog Communication Systems, K.SamShanmugam,Wiley
8. An Introduction To Analog And Digital Communication System, Simon Haykin,Wiley
9. Principle Of Digital Communication, J.Das, NewAge
10. Digital Commnunication, Barry John, Le, Edward, David.G,Springer

2MDC2-15: DIGITAL IMAGE PROCESSING

CONTENTS	CONTACT HOURS
Human visual system and image perception, monochrome &color vision models, color representation; image sampling & quantization; 2-D systems.	10
Image transforms; image coding, stochastic models for image representation, image enhancement, restoration & reconstruction, image analysis using multiresolution techniques.	15
Wavelet Transform for Image Processing: Continuous wavelet transform, discrete wavelet transform, multi-resolution analysis, image compression.	15
Total	**40**

Reference books:

1. Digital Image Processing Using MATLAB, Gonzalez, Woods and Eddins, GatesmarkPublishing
2. Digital Image Restoration, Andrews, H.C. Hunt, B.R., Prentice Hall, EnglewoodCliffs.
3. Applications of Digital Signal Processing, Oppenheim, A.V.,Prentice Hall EnglewoodCliffs.
4. Digital Image Processing, Gonzalez, R.C. and Wintz, P.A., Reading,Addison-Wesley.
5. Digital Image Processing, Pratt, W.K., New York:Wiley
6. Digital Image Processing of Remotely Sensed Data, Hord, R.M., AcademicPress.
7. Fundamentals of Digital Image Processing, Jain, A.K., PrenticeHall
8. Algorithms for Graphics and Image Processing, Pavlidis, T., Computer SciencePress
9. Selected Papers on Digital Image Processing, Trivedi, M.M., Optical EngineeringPress.
10. The Image Processing Handbook, Ross, J.C., CRC Press, BocaRaton

2MDC2-16: TELECOMMUNICATION SWITCHING & NETWORKS

CONTENTS	CONTACT HOURS
Principles of circuit switching &signaling schemes, space time & space time division switching, single stage & multi stage switching network. Traffic engineering and teletraffic theory.	10
Markov processes representing traffic, calculation of blocking probability.	6
Modeling and analysis of important media access control protocols:ALOHA, slotted ALOHA, CSMA, CSMA/CD.	8
LAN: Ethernet, token ring, FDDI.	4
B-ISDN architecture, B-ISDN protocols, ATM traffic & congestion control, signaling, routing and addressing, Internetworking: switches, bridges, routers, gateways. ATM switching.	12
Total	**40**

Reference books:

1. John C. Bellamy, "Digital Telephony",3rd Edition,Wiley, 2002.
2. Simon Ramo, John R. Whinnery, Theodore Van Duzer, "Fields and Waves inCommunication Electronics", 3rd Edition, Wiley, 1994.

2MDC1-06: Antennas and Radiating Systems Lab.

List of Experiments:

1. Study of antenna parameters i.e., S-parameters, VSWR, Gain, Directivity, Radiation Mechanism, Field Zones, Axial ratio, Polarization, HPBW, Impedance matching, antenna modeling.
2. Design and Simulation of half wave dipole antenna.
3. Design and Simulation of quarter wave, full wave antenna and comparison of their parameters.
4. Design and Simulation of a half wave dipole antenna array (Broadside and End fire array).
5. Design and simulation of various types of Horn antenna.
6. Design & simulation of Pyramidal Horn antenna.
7. Study of different types of Reflector antenna. Design and Simulation of Parabolic reflector antenna.
8. Design and Development of Rectangular Microstrip antenna with microstrip inset feed. Compare the simulated and measured parameters (Return loss, VSWR, E- and H-plane radiation Pattern, Directivity, Gain, HPBW, etc.).
9. Design and Development of Circular Microstrip antenna with probe feed. Compare the simulated and measured parameters (Return loss, VSWR, E- and H-plane radiation Pattern, Directivity, Gain, HPBW, etc.).
10. Design and Simulation of 4-element microstrip antenna array using power divider.
11. Study the recent developments in antennas for wireless technologies and submit a report.

2MDC1-07: Wireless and Mobile Communication Lab.

List of Experiments:

1. Understanding Cellular Fundamentals like Frequency Reuse, Interference, cell splitting, multi path environment, Coverage and Capacity issues using communication software.
2. Knowing GSM and CDMA architecture, network concepts, call management, call setup, call release, Security and Power Control, Handoff Process and types, Rake Receiver etc.
3. Study of GSM handset for various signaling and fault insertion techniques (Major GSM handset sections: clock, SIM card, charging, LCD module, Keyboard, User interface).
4. To study transmitters and receiver section in mobile handset and measure frequency band signal and GMSK modulating signal.
5. To study various GSM AT Commands their use and developing new application using it. Understating of 3G Communication System with features like; transmission of voice and
6. videocalls, SMS, MMS, TCP/IP, HTTP, GPS and File system by AT Commands in 3G
7. network.
8. Study of DSSS technique for CDMA, observe effect of variation of types of PN codes, chip rate, spreading factor, processing gain on performance.
9. To learn and develop concepts of Software Radio in real time environment by studying the building blocks like Base band and RF section, convolution encoder, Interleaver and De-Interleaver.
10. To study and analyze different modulation techniques in time and frequency domain using SDR kit.

SEMESTER III

3MDC2-11: MIMO Systems

CONTENTS	CONTACT HOURS
Introduction to Multi-antenna Systems, Motivation, Types of multi-antenna systems, MIMO vs. multi-antenna systems.	4
Diversity, exploiting multipath diversity, transmit diversity, Space-time codes, The Alamouti scheme, Delay diversity, Cyclic delay diversity, Space-frequency codes, receive diversity, The rake receiver, Combining techniques, Spatial Multiplexing, Spectral efficiency and capacity, Transmitting independent streams in parallel, Mathematical notation.	8
The generic MIMO problem, Singular Value Decomposition, Eigenvalues and eigenvectors, Equalizing MIMO systems, Disadvantages of equalizing MIMO systems, Pre- distortion in MIMO systems, Disadvantages of pre-distortion in MIMO systems, Pre-coding and combining in MIMO systems, Advantages of pre-coding and combining, Disadvantages of pre- coding and combining, Channel state information.	8
Codebooks for MIMO, Beamforming, Beamforming principles, Increased spectrum efficiency, Interference cancellation, Switched beamformer, Adaptive beamformer, Narrowband beamformer, Wideband beamformer.	6
Case study: MIMO in LTE, Codewords to layers mapping, Pre-coding for spatial multiplexing, Pre-coding for transmit diversity, Beamforming in LTE, Cyclic delay diversity based pre-coding, Pre-coding codebooks, Propagation Channels, Time & frequency channel dispersion, AWGN and multipath propagation channels, Delay spread values and time variations, Fast and slow fading environments, Complex baseband multipath channels, Narrowband and wideband channels, MIMO channel models.	8
Channel Estimation, Channel estimation techniques, Estimation and tracking, Training based channel estimation, Blind channel estimation, Channel estimation architectures, Iterative channel estimation, MMSE channel estimation, Correlative channel sounding, Channel estimation in single carrier systems, Channel estimation for CDMA, Channel estimation for OFDM.	6
Total	**40**

Reference books:

1. Claude Oestges, Bruno Clerckx, "MIMO Wireless Communications: From Real-world Propagation to Space-time Code Design",Academic Press, 1st edition, 2010.
2. MohinderJanakiraman, “Space - Time Codes and MIMO Systems”, Artech House Publishers, 2004.

3MDC2-12: RF and Microwave Circuit Design

Course objective:

- To explain radio frequency design concept and impart knowledge on design and implementation of RF and microwave circuit.
- To develop an ability to analyze various component of radio frequency communication system architecture.

CONTENTS	CONTACT HOURS
Review of basics of Passive and Active Circuits.	2
Microwave Amplifier Design: Comparison of active devices such as BJT, MOSFET, MESFET, HEMT, and HBT; Circuit models for FETs and BJTs; Two-port power gains; Stability of transistor amplifier circuits; Amplifier design using S-parameters: Design for maximum gain, maximum stable gain, design for specified gain.	6
RF power amplifiers: Introduction, class A, AB, B, and C power amplifiers, class D amplifiers, class E amplifiers, Class F amplifiers, summery of PA characteristics, RF PA design examples LNA design: Introduction, LNA topologies- power match vs. noise match, Power constrained noise optimization, Design examples, Linearity and large-signal performance, Spurious free dynamic range	8
Mixers: Mixer characteristics: Image frequency, conversion loss, noise figure; Devices for mixers: p-n junctions, Schottky barrier diode, FETs; Diode mixers: Small-signal characteristics of diode, single-ended mixer, large-signal model, switching model; FET Mixers: Single-ended mixer, other FET mixers; Balanced mixers; Image reject mixers, Analysis of microwave mixers.	8
Mixers: Introductions, Mixer fundamentals, Nonlinear systems as linear mixers, Multiplier-based mixers, Sub sampling mixers.	6
Oscillators and Frequency Synthesizers: General analysis of RF oscillators, transistor oscillators, voltage-controlled oscillators, dielectric resonator oscillators, frequency synthesis methods, analysis of first and second order phase-locked loop, oscillator noise and its effect on receiver performance	6
Switches: Devices for microwave switches: PIN diode, BJT, FET; Device models; Types of switches; Switch configurations; Basic theory of switches; Multi-port, broad-band and isolation switches.	4
Total	**40**

Reference books:

1. Pozar, D.M. “Microwave and RF Design of Wireless Systems”, John Wiley & Sons. 2001
2. Gonzalez, G., “Microwave Transistor Amplifiers: Analysis and Design”, 2nd Ed., Prentice-Hall. 1997
3. Bahl, I. and Bhartia, P., “Microwave Solid State Circuit Design”, 2nd Ed., John Wiley & Sons. 2003
4. Chang, K., Bahl, I. and Nair, V., “RF and Microwave Circuit and Component Design for Wireless Systems”, Wiley Interscience. 2002
5. Rohde, U.L. and Newkirk, D.P., “RF/Microwave Circuit Design for Wireless Applications”, John Wiley & Sons. 2000
6. Larson, L.E., “RF and Microwave Circuit Design for Wireless Applications”, Artech House. 1996
7. Egan, W. F., “Practical RF Circuit Design”, John Wiley & Sons. 1998

3MDC2-13 Pattern Recognition and Machine Learning

CONTENTS	CONTACT HOURS
Introduction to Pattern Recognition: Problems, applications, design cycle, learning and adaptation, examples, Probability Distributions, Parametric Learning - Maximum likelihood and Bayesian Decision Theory- Bayes rule, discriminant functions, loss functions and Bayesian error analysis Linear models: Linear Models for Regression, linear regression, logistic regression Linear Models for Classification	10
Neural Network: perceptron, multi-layer perceptron, backpropagation algorithm, error surfaces, practical techniques for improving backpropagation, additional networks and training methods, Adaboost, Deep Learning	8
Linear discriminant functions - decision surfaces, two-category, multi-category, minimum- squared error procedures, the Ho-Kashyap procedures, linear programming algorithms, Support vector machine	8
Algorithm independent machine learning – lack of inherent superiority of any classifier, bias and variance, re-sampling for classifier design, combining classifiers	6
Unsupervised learning and clustering – k-means clustering, fuzzy k-means clustering, hierarchical clustering	8
Total	**40**

Reference books:

- Richard O. Duda, Peter E. Hart, David G. Stork, "Pattern Classification", 2nd Edition John Wiley & Sons, 2001.
- Trevor Hastie, Robert Tibshirani, Jerome H. Friedman, "The Elements of Statistical Learning", 2nd Edition, 2009.

(Dissertation)
3MDC4-60: Dissertation Phase – I
3MDC4-70: Dissertation Phase – II

Syllabus Contents:

The dissertation / project topic should be selected / chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the world of work and the world of study. The dissertation should have thefollowing

- Relevance to social needs ofsociety
- Relevance to value addition to existing technologies & advancement in theinstitute
- Relevance to industry.
- Problems of nationalimportance
- Research and development in various domain. The student should complete thefollowing:
- Literature survey ProblemDefinition
- Motivation for study and Objectives
- Preliminary design / feasibility / modularapproaches
- Implementation andVerification
- Report andpresentation

The dissertation stage II is based on a report prepared by the students on dissertation allotted to them. It may be based on:

- Experimental verification / Proof ofconcept.
- Design, fabrication, testing of CommunicationSystem.
- The viva-voce examination will be based on the above report andwork.

Guidelines for Dissertation Phase – I and II

- As per the AICTE directives, the dissertation is a yearlong activity, to be carried out and evaluated in two phases i.e. Phase – I: July to December and Phase – II: January toJune.
- The dissertation may be carried out preferably in-house i.e. department's laboratories and centers OR in research lab/ industry allotted through department's/T & Pcoordinator.
- After multiple interactions with guide and based on comprehensive literature survey, the student shall identify the domain and define dissertation objectives. Thereferred literature should preferably include IEEE/IET/IETE/Springer/Science Direct/ACM journals in the areas of Computing and Processing (Hardware and Software), Circuits-Devices and Systems, Communication-Networking and Security, Robotics and Control Systems, Signal Processing and Analysis and any other related domain. In case of Industry sponsored projects, the relevant application notes, while papers, product catalogues should be referred and reported.
- Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and phase wise work distribution, and submit the proposal within a month from the date of registration.
- Phase – I deliverables: A document report comprising of summary of literature survey, detailed objectives, project specifications, paper and/or computer aided design, proof of concept/functionality, part results, A record of continuous progress.
- Phase – I evaluation: A committee comprising of guides of respective specialization shall assess the progress/performance of the student based on report, presentation and Q

& A. In case of unsatisfactory performance, committee may recommend repeating the Phase-I work.

- During phase – II, student is expected to exert on design, development and testing of the proposed work as per the schedule. Accomplished results/contributions/innovations should be published in terms of research papers in reputed journals and reviewed focused conferences OR IP/Patents.
- Phase – II deliverables: A dissertation report as per the specified format, developed system in the form of hardware and/or software, A record of continuous progress.
- Phase – II evaluation: Guide along with the university appointed examiner shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend for extension or repeating the work.

Syllabus and Scheme

M.Tech in Power System

(2023-24)

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

1st Year - I Semester: M.Tech. (Power System)

SN	Course Type	Course Code	Course Name	Contact Hours per Week			Marks				Credits
				L	T	P	Exam Hrs	IA	ETE	Total	
1	PCC	1MPS1-01	Modern Power System Analysis	3	0	0	3	30	70	100	3
2	PCC	1MPS1-02	Power System Dynamics	3	0	0	3	30	70	100	3
3	PCC	1MPS1-03	Modern Power System Protection	3	0	0	3	30	70	100	3
4	PEC	1MPS2-11	Electrical Power Distribution System	3	0	0	3	30	70	100	3
		1MPS2-12	Mathematical Methods for Power Engineering								
		1MPS2-13	Pulse Width Modulation for PE Converters								
5	MCC	1MCC3-21	Research Methodology and IPR	2	0	0	2	30	70	100	2
6	PCC	1MPS1-06	Power System Protection Lab	0	0	4		60	40	100	2
7	PCC	1MPS1-07	Power System Dynamics Lab	0	0	4		60	40	100	2
8	SODE-CA	1MPS5-00	Social Outreach Dissertation & Extra Curriculum Activities							100	2
			Total					**270**	**430**	**800**	**20**

RAJASTHAN TECHNICAL UNIVERSITY, KOTA
SYLLABUS

1st Year - II Semester: M.Tech. (Power System)

S. No	Course Type	Course Code	Course Name	Contact Hours per Week			Marks				Credits
				L	T	P	Exam Hrs	IA	ETE	Total	
1	PCC	2MPS1-01	Distributed generation system	3	0	0	3	30	70	100	3
2	PCC	2MPS1-02	Power System Operation and Control	3	0	0	3	30	70	100	3
3	PCC	2MPS1-03	AI Application to Power Systems	3	0	0	3	30	70	100	3
4	PEC	2MPS2-11	Embedded system design	3	0	0	3	30	70	100	3
		2MPS2-12	SCADA System and Applications								
		2MPS2-13	Modern control System and design								
5	MCC	2MCC3-XX	Audit Course-I	2	0	0					
6	PCC	2MPS1-06	Power System Steady State Analysis Lab	0	0	4	4	60	40	100	2
7	PCC	2MPS1-07	Power Electronics Applications to Power Systems Lab	0	0	4	4	60	40	100	2
8	REW	2MPS4-50	Mini Project with Seminar	0	0	3	4	60	40	100	2
9	SODE-CA	2MPS5-00	Social Outreach Dissertation & Extra Curriculum Activities							100	2
			Total					**300**	**400**	**800**	**20**

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

2nd Year - III Semester: M.Tech. (Power System)

S. No	Course Type	Course Code	Course Name	Contact Hours per Week			Marks				Cr
				L	T	P	Exam Hrs	IA	ETE	Total	
1	PEC	3MPS2-11	Power System Transients	3	0	0	3	30	70	100	3
		3MPS2-12	FACTS and Custom Power Devices								
		3MPS2-13	Industrial Load Modeling and Control								
2	MCC	3MCC3-XX	Open Elective	3	0	0	3	30	70	100	3
3	MCC	3MCC3-XX	Audit Course-II	2	0	0					
4	REW	3MPS4-60	Dissertation-I / Industrial Project	0	0	20		240	160	400	10
			Total					**300**	**300**	**600**	**16**

2nd Year - IV Semester: M.Tech. (Power System)

S. No	Course Type	Course Code	Course Name	Contact Hours per Week			Marks				Cr
				L	T	P	Exam Hrs	IA	ETE	Total	
1	REW	4MPS4-70	Dissertation-II	0	0	32		360	240	600	16
			Total					**360**	**240**	**600**	**16**

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

1st Year - I Semester: M.Tech. (Power System)

1MPS1-01: Modern Power System Analysis

Credit: 3 **Max. Marks: 100(IA:30, ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

S.No.	CONTENTS	CONTACT HOURS
1.	**Introduction:** Objective, scope and outcome of the course.	01
2.	**Load flow:** Overview of Newton-Raphson, Gauss-Siedel, Fast decoupled methods, convergence properties, sparsity techniques, handling Qmax and Qmin violations in constant matrix, inclusion in frequency effects AVR in load flow, handling of discrete variable in load flow.	08
3.	**Fault Analysis:** Simultaneous faults, open conductors faults, generalized method of fault analysis.	04
4.	**Security Analysis:** Different operating state with state classification Security state diagram, contingency analysis, generator shift distribution factors, line outage distribution factor, single line outages, contingency analysis overload index ranking	08
5.	**Power System Equivalents :** WARD equivalents, Dynamic WARD equivalent , Static Ward-Injection Equivalent, REI equivalents	08
6.	**State Estimation :** Power system state estimation, various methods, formation of Hx, Virtual and Pseudo Measurement, Observability, Tracking state estimation, Weighted least square method, bad data detection, identification and suppression, Application of power system state estimation	04
7.	**Voltage Stability :** Voltage Stability, Reactive power flow andVoltage collapse, Mathematical formulation of voltage stability problem and analysis, Prevention of voltage collapse, future trends and challenges	07

Text/Reference Books

1. J.J. Grainger &W.D.Stevenson, “Power system analysis ”, McGraw Hill ,2003
2. A. R. Bergen & Vijay Vittal , “Power System Analysis” ,Pearson , 2000
3. L.P. Singh , “Advanced Power System Analysis and Dynamics”, New Age International, 2006
4. G.L. Kusic, “Computer aided power system analysis” ,Prentice Hall India, 1986
5. A.J. Wood, “ Power generation, operation and control” , John Wiley, 1994
6. P.M. Anderson, “Faulted power system analysis” , IEEE Press , 1995
7. D.P Kothari,” Modern power system analysis”, Tata McGraw hill, New Delhi

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

1st Year - I Semester: M.Tech. (Power System)

1MPS1-02: Power System Dynamics

Credit: 3 **Max. Marks: 100(IA:30, ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

S.No.	CONTENTS	CONTACT HOURS
1	**Introduction :** Objective, scope and outcome of the course.	1
2	**Introduction to power system Dynamics and stability:** Basic Concepts of Dynamic Systems and Stability Definition, Small Signal Stability (Low Frequency Oscillations) of Unregulated and Regulated System,Effect of Damper, Detailed study of technique to improve stability. Asynchronous Operation and Resynchronization, Multi-Machine Stability, Dynamic Analysis of Voltage Stability , Voltage Collapse, Frequency Stability	8
3	**Transients:** Per unit system**,** Sub-transient, steady state, transient inductance and Time constants, Simplified models of synchronous machines	4
4	**Dynamics of synchronous machines:**Mathematical description of synchronous machine, fundamental of magnetic circuit, basic equation of synchronous machine, Park's transformation. Equivalent circuit for direct and quadrature axis for the synchronous generator. Steady state analysis with phasor diagram, equation of motion. Synchronous machine representation in stability studies. Rotor angle stability, Power V/s angle relationship and transient stability.	8
5	**Excitation System:** Excitation system requirements in terms of generator consideration, Power system consideration, Elements of excitation system, Types of excitation system, Dynamic performance measure, Indices, Modelling of excitation system components, Philips-Heffron model, PSS	8
6	**Machine Modelling:**Modelling of SMIB(single machine infinite bus) for small signal stability classical model, Multi-machine modelling and Modelling of induction machine.	4

Text/Reference Books

1. P. M. Anderson & A. A. Fouad "Power System Control and Stability", Galgotia , New Delhi, 1981
2. J Machowski, J Bialek& J. R W. Bumby, "Power System Dynamics and Stability", John Wiley & Sons, 1997
3. P.Kundur, "Power System Stability and Control", McGraw Hill Inc., 1994.
4. E.W. Kimbark, "Power system stability", Vol. I & III, John Wiley & Sons, New York 2002

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

1st Year - I Semester: M.Tech. (Power System)

1MPS1-03: Modern Power System Protection

Credit: 3 **Max. Marks: 100(IA:30, ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

S.No.	CONTENTS	CONTACT HOURS
1.	**Introduction :** Objective, scope and outcome of the course.	01
2.	**Digital Relays:** Evolution of digital relays from electromechanical relays, Performance and operational characteristics of digital protection	05
3	**Interpolation:** Interpolation formulae, Forward, backward and central difference interpolation, Numerical differentiation, Curve fitting and smoothing, Least squares method,	10
4	**Digital Protection:** Basic elements of digital protection, Signal conditioning: transducers, surge protection, analog filtering, analog multiplexers, Conversion subsystem: the sampling theorem, signal aliasing Error, sample and hold circuits, multiplexers, analog to digital conversion, Digital filtering concepts, The digital relay as a unit consisting of hardware and software	08
5	**Algorithm:** Mathematical background to protection algorithms, Finite difference techniques, Sinusoidal wave based algorithms, Sample and first derivative (Mann and Morrison) algorithm.	08
6	**Fourier Algorithm:** Full cycle window algorithm, fractional cycle window algorithm. Walsh function based algorithm. Least Squares based algorithms. Differential equation based algorithms. Traveling Wave based Techniques. Digital Differential Protection of Transformers. Digital Line Differential Protection. Recent Advances in Digital Protection of Power Systems.	08

Text/Reference Books

1. A.G. Phadke and J. S. Thorp, "Computer Relaying for Power Systems", Wiley/Research studies Press, 2009
2. A.T. Johns and S. K. Salman, "Digital Protection of Power Systems", IEEE Press,1999
3. Gerhard Zeigler, "Numerical Distance Protection", Siemens Publicis Corporate Publishing, 2006
4. S.R.Bhide "Digital Power System Protection" PHI Learning Pvt.Ltd.2014

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

1st Year - I Semester: M.Tech. (Power System)

1MPS2-11: Electrical Power Distribution System

Credit: 3 **Max. Marks: 100(IA:30, ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

S.No.	CONTENTS	CONTACT HOURS
1	**Introduction :** Objective, scope and outcome of the course.	1
2	**Power Distribution:** Distribution of Power, Management, Power Loads, Load Forecasting Short-term & Long-term, Load forecasting, Power System Loading, Technological Forecasting. Advantages of Distribution Management System (D.M.S.)	7
3	**Distribution Automation:** Definition, Restoration / Reconfiguration of Distribution Network, Different Methods and Constraints Power Factor Correction, Interconnection of Distribution, Control & Communication Systems, Remote Metering, Automatic Meter Reading and its implementation	8
4	**SCADA:** Introduction, Block Diagram, SCADA Applied To Distribution Automation. Common Functions of SCADA, Advantages of Distribution Automation through SCADA, DCADA with WAM and SCADA with PMU's	8
5	**Optimal Placement of Various Components:** Calculation of Optimum Number of Switches, Capacitors, Optimum Switching Device Placement in Radial, Distribution Systems, Sectionalizing Switches – Types, Benefits, Bellman's Optimality Principle, Remote Terminal Units, Energy efficiency in electrical distribution & Monitoring	8
6	**Maintenance and Difficulties inDistribution Systems:** Maintenance of Automated Distribution Systems, Difficulties in Implementing Distribution. Automation in Actual Practice, Urban/Rural Distribution, Energy Management, AI techniques applied to Distribution Automation	8

Text/Reference Books

1. A.S. Pabla, " Electric Power Distribution", Tata McGraw Hill Publishing Co. Ltd., Fourth Edition.
2. M.K. Khedkar, G.M. Dhole, "A Text Book of Electrical power Distribution Automation", University Science Press, New Delhi
3. Anthony J Panseni, "Electrical Distribution Engineering", CRC Press
4. James Momoh, "Electric Power Distribution, automation, protection & control", CRC Press

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

1st Year - I Semester: M.Tech. (Power System)

1MPS2-12: Mathematical Methods for Power Engineering

Credit: 3 **Max. Marks: 100(IA:30, ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

S.No.	CONTENTS	CONTACT HOURS
1	**Introduction :** Objective, scope and outcome of the course.	1
2	**Transformation:** Vector spaces, Linear transformations, Matrix representation of linear transformation. Eigen values and Eigen vectors of linear operator	11
4	**Linear Programming:** Linear Programming Problems, Simplex Method, Duality, Non Linear Programming problems	10
5	**Problems:** Unconstrained Problems, Search methods, Constrained Problems, Lagrange method, Kuhn-Tucker conditions, Random Variables, Distributions	10
6	**Variables:** Independent Random Variables, Marginal and Conditional distributions, Elements of stochastic processes	8

Text/Reference Books

1. Kenneth Hoffman and Ray Kunze, "Linear Algebra", 2nd Edition, PHI, 1992
2. Erwin Kreyszig, "Introductory Functional Analysis with Applications", John Wiley & Sons, 2004
3. Irwin Miller and Marylees Miller, John E. Freund's "Mathematical Statistics", 6th Edn, PHI, 2002
4. J. Medhi, "Stochastic Processes", New Age International, New Delhi., 1994
5. A Papoulis, "Probability, Random Variables and Stochastic Processes", 3rd Edition, McGraw Hill, 2002
6. John B Thomas, "An Introduction to Applied Probability and Random Processes", John Wiley, 2000
7. Hillier F S and Liebermann G J, "Introduction to Operations Research", 7th Edition, McGraw Hill, 2001
8. Simmons D M, "Non Linear Programming for Operations Research", PHI, 1975

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

1st Year - I Semester: M.Tech. (Power System)

1MPS2-13: Pulse Width Modulation for PE Converters

Credit: 3 **Max. Marks: 100(IA:30, ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

S.No.	CONTENTS	CONTACT HOURS
1	**Introduction:** Objective, scope and outcome of the course.	1
2	**PE converters :** Introduction to PE converters Modulation of one inverter phase leg , Modulation of single phase, VSI and 3 phase VSI	8
3	**Modulation**: Zero space vector placement modulation strategies, Losses-Discontinuous modulation, Modulation of CSI Over modulation of converters, programme modulation strategies	10
4	**Isolated single-phase ac-dc flyback converter:** Dc-dc flyback converter, output voltage as a function of duty ratio and transformer turnsratio. Power circuit of ac-dc flyback converter, steady state analysis, unity power factoroperation, closed loop control structure.	11
5	**PWM:** Pulse width modulation for multilevel inverters, Implementation of modulation controller, Continuing developments in modulation as random PWM, PWM for voltage unbalance, Effect of minimum pulse width and dead time	10

Text/Reference Books

1. D. Grahame Holmes, Thomas A. Lipo, “Pulse width modulation of Power Converter: Principles and Practice”, John Wiley & Sons, 03-Oct-2003
2. Bin Vew, “High Power Converter”, Wiley Publication
3. Marian K. Kazimicrczuk, “Pulse width modulated dc-dc power converter”, Wiley Publication

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

1st Year - I Semester: M.Tech. (Power System)

1MCC3-21: Research Methodology and IPR

Credit: 2 **Max. Marks: 100(IA:30, ETE:70)**

2L+0T+0P **End Term Exam: 2 Hours**

S.No.	CONTENTS	CONTACT HOURS
1	**Introduction :** Objective, scope and outcome of the course.	1
2	**Research Problem:** Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations	6
3	**literature studies:** Effective literature studies approaches, analysis Plagiarism, Research ethics,	5
4	**Effective technical writing:** how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee	5
5	**Nature of Intellectual Property:** Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.	5
6	**Patent Rights:** Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.	5

Text/Reference Books

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Ranjit Kumar, 2nd Edition , "Research Methodology: A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
5. Mayall , "Industrial Design", McGraw Hill, 1992.
6. Niebel , "Product Design", McGraw Hill, 1974.
7. Asimov , "Introduction to Design", Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.
9. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

1st Year - I Semester: M.Tech. (Power System)

1MPS1-06: Power System Protection Lab

Credit: 4 **Max. Marks: 100(IA:60, ETE:40)**

0L+0T+4P

1. Write the code for Modelling of relay for
   a) phase sequence,
   b) phase failure and
   c) voltage asymmetry to a three-phase circuit
2. Develop a microcontroller based model to show zone protection with different time setting.
3. Write the code for using a timer with different time functions to extend the protective relays operation.
4. Write the code for Modellinga differential relay and design a differential relay model using a microcontroller.
5. Study to perform Radial and Parallel feeder protection and also design a simulink model to compare both hardware setup and simulink results.
6. Study to perform Differential protection of a3-Phase Transformerand Design a& simulate a model to compare both hardware setup and simulink results.
7. Write the code to study time v/svoltage characteristics of over voltage induction relay
8. Design and simulate a model to perform the differential protection of generator for internal and external fault.
9. Write the code to obtain generator protection using negative sequence relay.
10. Write the code to perform over voltage and under voltage protection of generator.
11. Model the Impact of Induction Motor Starting on system.
12. Mini Project " Design and simulate a model of power system having protection of all component i.e Generator, transformer, transmission line etc for different types of fault".

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

1st Year - I Semester: M.Tech. (Power System)

1MPS1-07: Power System Dynamics Lab

Credit: 4 **Max. Marks: 100(IA:60, ETE:40)**

0L+0T+4P

1. To Study and Write the Program to obtain P-V Curves at different Power factors.
2. Write the Program for Transient and Small Signal Stability Analysis: Single& Multi -Machine Infinite Bus System
3. Write the Program for Transient analysis of single machine infinite bus system with STATCOM
4. To study the PV MPPT testing and see effect of Shading.
5. To study the Current Sharing in DC microgrid and Communication enabled DC micro-grid.
6. Design & simulate a model for Load – Frequency Dynamics of Single- Area and Two-Area Power Systems.
7. Design & simulate a model to test the Capabilities of the Hydrogen Fuel Cells and Capacitors when connected to grid
8. To Study and Design & simulate a model of solar panel observe the effect of Temperature and other different variable on Solar Panel Outputs.
9. To Study and Design & simulate a model of solar panel and observe an Load Effect on Solar Panel Output
10. Design & simulate a model to test the Capabilities of Solar Panels and Wind Turbines, when integrated with common grid.
11. Mini Project " Design & simulate a model of Power Generation System"
    A) Have minimum 3 different Power generating source.
    B) 2 transformer
    C) Minimum 3 Load.

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

1st Year - II Semester: M.Tech. (Power System)

2MPS1-01: Distributed Generation System

Credit: 3 **Max. Marks: 100(IA:30, ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

S. No.	CONTENTS	CONTACT HOURS
1	**Introduction :** Objective, scope and outcome of the course.	1
2	**Distributed Generations and Smart Grid:** Grid connection of wind, solar, hydro etc. powerstations. **Introduction to Smart Grid:** Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Concept of Robust & Self Healing Grid Present development & International policies in Smart Grid	07
3	**Geographic Information System(GIS):** Intelligent Electronic Devices(IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System(WAMS), Phase Measurement Unit(PMU)	07
4	**Introduction to Smart Meters& Networks:** Real Time Prizing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Smart Substations, Substation Automation, Feeder Automation . Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN), Local Area Network (LAN), Bluetooth, ZigBee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network,Cyber Security for Smart Grid, IP based protocols	10
5	**Power Quality & EMC in Smart Grid:** Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit	07
6	**Micro-Grid:** Concept of micro-grid, need & applications of micro-grid, formation of micro-grid, Issues of interconnection, protection & control of micro-grid., Plastic & Organic solar cells, Thin film solar cells, Variable speed wind generators, fuel-cells, micro-turbines, Captive power plants, Integration of renewable energy sources. DC microgrid: Basic concept of Photovoltaic, Basics of DC/DC converter, DC load detail, AC/DCload detail,DC Microgrid control, PV MPPT testing, Shading, Current Sharing inDC microgrid, Communication enabled DC microgrid	09

Text/Reference Books

1. Ali Keyhani, “Design of smart power grid renewable energy systems”, Wiley IEEE, 2011
2. Clark W. Gellings, “The Smart Grid: Enabling Energy Efficiency and Demand Response”, CRC Press , 2009
3. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, “Smart Grid: Technology and Applications”, Wiley 2012
4. Stuart Borlase, “Smart Grid: Infrastructure, Technology and solutions “ CRC Press
5. A.G.Phadke, “Synchronized Phasor Measurement and their Applications”, Springer

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

1st Year - II Semester: M.Tech. (Power System)

2MPS1-02:Power System Operation and Control

Credit: 3 **Max. Marks: 100(IA:30, ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

S.No.	CONTENTS	CONTACT HOURS
1	**Introduction:** Objective, scope and outcome of the course.	1
2	**Optimal Power System Operation:** System constraints, Optimal Operation of generators on a bus bar, algorithm and flow chart, Optimal Unit Commitment, Constraints in unit commitment, spinning reserve, Thermal Unit Constraints, Other constraints, Hydro constraints, Must Run, Fuel constraints.	10
3	**Unit commitment Solution methods:** Priority-List methods, Dynamic Programming solution. Backward DP Approach, Forward DP Approach, Restricted Search Ranges, Strategies.Reliability Considerations, Patton's Security Function, Security constrained Optimal Unit Commitment, Start-up considerations,	10
4	**Optimal Generation Scheduling:** Representation of Transmission Loss by B-coefficients, Derivation of Transmission Loss formula. Representation of Transmission Loss by Power Flow equations, Optimal Load Flow solution. Optimal Scheduling of Hydrothermal System	09
5	**Automatic generation and Load frequency Control:** Introduction Load Frequency Control, Turbine Speed Governing System, Model of Speed governing system. Turbine Model, Generator Load Model, Block diagram representation of Load Frequency Control. Economic Dispatch Control, single area and Two-area load frequency control, Optimal Load Frequency Control (two- area), Voltage Control, Introduction to Digital LF Controllers, Decentralized Control.	11

Text/Reference Books

1. Wood, A.J. and B.F. Wollenberg, Power Generation Operation and Control, John Wiley & Sons, ThirdEdition, 2013.
2. P. Kundur, Power system stability and control, McGraw-Hill, 1994.
3. A. Chakrabati and S. Halder, Power System Analysis Operation and Control, PHI, 2011
4. Jizhong Zhu, Optimization of Power System Operation, John Wiley & Sons, 2009.
5. D.P.Kothari and I.J.Nagrath, Modern Power System Analysis, Fourth Edition, TMH, 2011
6. Dhillon, Kothari, Power System Optimization, PHI.
7. O.E. Elgerd: Electric Energy Systems Theory. TMH Publishing Company.

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

1st Year - II Semester: M.Tech. (Power System)

2MPS1-03: AI Application to Power System

Credit: 3 **Max. Marks: 100(IA:30, ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

S.No.	CONTENTS	CONTACT HOURS
1	**Introduction:** Objective, scope and outcome of the course.	1
2	**Introduction to AI:** Definition, Applications, Components of an AI program production system. Problem Characteristics. Overview of searching techniques. Knowledge representation: Knowledge representation issues; and overview. Representing knowledge using rules; procedural versus declarative knowledge. Logic programming, forward versus backward reasoning, matching. Control knowledge.	07
3	**Statistical Reasoning:** Probability and Daye's theorem. Certainty factor and rule based systems. Baysian Networks, Dampster Shafer theorem. Semantic nets and frames, Scripts. Examples of knowledge based systems.	07
4	**Pattern Recognition:** Introduction, automatic pattern recognition scheme. Design Concepts, Methodologies, Concepts of Classifier, concept of feature selection. Feature selection based on means and covariances. Statistical classifier design algorithms; increment-correction and LMS algorithms. Applications.	07
5	**Artificial Neural Networks:** Biological Neuron, Neural Net, use of neural 'nets, applications, Perception, idea of single layer and multilayer neural nets, back propagation, Hopfield nets, supervised and unsupervised learning.	07
6.	**Expert Systems:** Introduction. Study of some popular expert systems, Expert System building tools and Shells, Design of Expert Systems.	06

Text/Reference Books

1. ClArtificial Intelligence Techniques in Power Systems (Energy Engineering), by Kevin Warwick (Editor), Arthur Ekwue (Editor), Rag Aggarwal (Editor),1997
2. Artificial Intelligence Techniques in Power Systems Edited by Kevin Warwick, Arthur Ekwue, Rag Aggarwal
3. AI Application Areas in Power Systems, Iraj Dabbaghchi, American Electric Power Richard D. Christie, Gary W. Rosenwald, and Chen-Ching Liu, University of Washington
4. N.P Pandey," Artificial Intelligence and intelligent system" by Oxford.
5. N.K. Bose, " Neural network fundamental with graph algorithm and application" by Tata McGraw hill.

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

1st Year - II Semester: M.Tech. (Power System)

2MPS2-11: Embedded System Design

Credit: 3 **Max. Marks: 100(IA:30, ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

S.No.	CONTENTS	CONTACT HOURS
1	**Introduction:** Objective, scope and outcome of the course.	1
2	**Computer Organization:** Basic Computer Organization, Accumulator based Processes-Architecture, Memory Organization-I/O Organization	7
3	**Micro-Controllers-**Intel 8051, Intel 8056- Registers, Memories, I/O Ports, Serial Communication, Timers, Interrupts, Programming	8
4	**Intel 8051 –** Assembly language programming, Addressing-Operations, Stack & Subroutines, Interrupts-DMA	8
5	**PIC 16F877-** Architecture Programming, Interfacing Memory/ I/O Devices, Serial I/O and data communication **Digital Signal Processor (DSP)**: Architecture – Programming ,Introduction to FPGA	8
6	**Motor Control:** Microcontroller development for motor control applications, Stepper motor control using micro controller	8

Text/Reference Books

1. John.F.Wakerly: “Microcomputer Architecture and Programming”, John Wiley and Sons 1981
2. Ramesh S.Gaonker: “Microprocessor Architecture, Programming and Applications with the 8085”,Penram International Publishing (India), 1994
3. Raj Kamal: “The Concepts and Features of Microcontrollers”, Wheeler Publishing, 2005
4. Kenneth J. Ayala, “The 8051 microcontroller”, Cengage Learning, 2004
5. John Morton,” The PIC microcontroller: your personal introductory course”, Elsevier, 2005
6. Dogan Ibrahim,” Advanced PIC microcontroller projects in C: from USB to RTOS with the PIC18F Series”, Elsevier, 2008
7. Microchip datasheets for PIC16F877

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

1st Year - I Semester: M.Tech. (Power System)

2MPS2-12: SCADA System and Applications

Credit: 3 **Max. Marks: 100(IA:30, ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

S.No.	CONTENTS	CONTACT HOURS
1	**Introduction :** Objective, scope and outcome of the course.	1
2	**SCADA System:** Introduction to SCADA, Data acquisition systems, Evolution of SCADA, Communication technologies	7
3	**SCADA Functions :**Monitoring and supervisory functions, SCADA applications in Utility Automation, Industries SCADA	6
4	**Industries SCADA:** Industries SCADA System Components, Schemes-Remote Terminal Unit (RTU), Intelligent Electronic Devices(IED), Programmable Logic Controller (PLC), Communication Network, SCADA Server, SCADA/HMI Systems	7
5	**SCADA Architecture:** Various SCADA architectures, advantages and disadvantages of each system, single unified standard architecture -IEC 61850.	7
6	**SCADA Communication:** various industrial communication technologies, wired and wireless methods and fiber optics, Open standard communication protocols	7
7	**SCADA Applications:** Utility applications, Transmission and Distribution sector operations, monitoring, analysis and improvement, Industries - oil, gas and water , Case studies, Implementation, Simulation Exercises	7

Text/Reference Books

1. Stuart A. Boyer: "SCADA-Supervisory Control and Data Acquisition", Instrument Society of America Publications,USA,2004
2. Gordon Clarke, Deon Reynders: "Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems", Newnes Publications, Oxford, UK,2004
3. William T. Shaw, "Cybersecurity for SCADA systems", PennWell Books, 2006
4. David Bailey, Edwin Wright, "Practical SCADA for industry", Newnes, 2003
5. Michael Wiebe, "A guide to utility automation: AMR, SCADA, and IT systems for electric power", PennWell 1999

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

1st Year - II Semester: M.Tech. (Power System)

2MPS2-13: Modern Control System and Design

Credit: 3 **Max. Marks: 100(IA:30, ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

S.No.	CONTENTS	CONTACT HOURS
1	**Introduction :** Objective, scope and outcome of the course.	1
2	**State Variable Analysis and Design:** State space models, state space representation of simple electrical and mechanical systems,canonical forms, solution of state equation, state transition matrix, relation between transferfunction and state variable representations; controllability and observability, pole- placementusing state variable feedback; design of full order and reduced order observer, observer basedand state feedback controller, optimal control concept, solution of linear quadratic regulator.	9
3	**Discrete Control** Discrete Time Systems and the Z-Transform Method: Sampled Data Control Systems, DigitalController, Sample &Hold Operation, Frequency consideration in Sampling and Reconstruction.Z-transformation, Solution of Differential & State Equations by Z Transform Method, TheInverse Z-Transform, Pulse Transfer Function and Stability in Z-plane.	8
4	**Sample Data Control System:** Mathematical preliminaries- difference equations, Z Transform and properties; samplingquantization and reconstruction process, discrete time systems, system response, transferfunction stability, bilinear transformation and the jury stability criterion, implementation ofdigital controllers and digital controllers for deadbeat performance. Root loci - Frequencydomain analysis - Bode plots - Gain margin and phase margin - Design of Digital ControlSystems based on Root Locus Technique, state space analysis of discrete system.	6
5	**Nonlinear Control Systems:** Characteristics of nonlinear systems; linearization techniques; phase plane analysis, singularpoints, limit cycle vs closed trajectory; stability analysis using phase plane analysis- describingfunction (DF) of common nonlinearities, stability analysis using DF; stability in the sense ofLyapunov, Lyapunov's stability theorems for linear and nonlinear systems; effect of nonlinearity in root locus and Nyquistplot. Introduction to Modern Nonlinear control system.Introduction to modern nonlinear control system. Generalized Stability Creterion (d-partitiontechnique), Pole Assignment method, LURE's transformation, POPOV's criterion.	8

Text/Reference Books

1. Modern Control Theory, 3rd Edition by William L Brogan
2. Modern Control System Theory, by Madan Gopal (Author), New Edge publications
3. Modern control theory By U.A.Bakshi, M.V.Bakshi , Technical Publications Pune

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

1st Year - II Semester: M.Tech. (Power System)

2MPS1-06: Power System Steady State Analysis Lab

Credit: 2 **Max. Marks: 100(IA:60, ETE:40)**

0L+0T+4P

1. Write the program to determine transmission line performance.
2. Write the program to obtain steady state, transient and sub-transient short circuit currents in an alternator also trace their curve.
3. Write the program to obtain formation of Y-bus matrix and perform load flow analysis.
4. Write the program to perform symmetrical fault analysis in a power system
5. Write the program for performing unsymmetrical fault analysis in a power system
6. Write the program for Short circuit analysis of a power system with IEEE 9 bus system.
7. Write the program for Power flow analysis of a slack bus connected to different loads
8. Design & simulate a model for Load flow analysis of 3 motor systems connected to slack bus.
9. To study Swing curve for sustained fault and critical clearing angle & time

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

1st Year - II Semester: M.Tech. (Power System)

2MPS1-07: Power Electronics Applications to Power Systems

Credit: 2 **Max. Marks: 100(IA:60, ETE:40)**

0L+0T+4P

1. To Study a) Single phase controlled / uncontrolled converter
   b) three phase Semi controlled / uncontrolled converters
   c) Full controlled / uncontrolled converters and obtain results for R & RL loads. and also Design & simulate a model to compare both hardware setup and simulation results.
2. To study an open & close loop for DC-DC Choppers.
   a) Buck Converter
   b) Boost Converter
   c) Buck- Boost Converter and trace the curve of output voltage.
   and also Design & simulate a model to compare both hardware setup and simulation results.
3. To study an open & close loop for a) Single phase Inverter
   b) Three phase inverters using IGBTs, and trace the output curve for different values of input voltage and also Design & simulate a model to compare both hardware setup and simulation results.
4. Design & simulate a model ofAC-AC voltage regulators and trace the output curve for different values of input voltage.
5. Design & simulate a model of single phase cyclo-converter and trace the curve of output voltage.
6. Design & simulate a model of CuK converter and trace the curve of output voltage.
7. To Study, Design & simulate a model for grid integration of DFIG and PMSG.
8. Mini project Design and fabricate power electronic switching based converters using Aurdino, microcontroller, DSP.

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

2nd Year - III Semester: M.Tech. (Power System)

3MPS2-11: Power System Transients

Credit: 3 **Max. Marks: 100(IA:30, ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

S.No.	CONTENTS	CONTACT HOURS
1.	**Introduction :** Objective, scope and outcome of the course.	01
2.	**Power System Transients:** Fundamental circuit analysis of electrical transients, Laplace Transform method of solving simple Switching transients, Damping circuits -Abnormal switching transients, Three-phase circuits and transients, Computation of power system transients	08
3.	**Digital Computation:** Principle of digital computation – Matrix method of solution, Modal analysis- Z transform- Computation using EMTP, Lightning, switching and temporary over voltages, Lightning, Physical phenomena of lightning.	07
4.	**Lightning and Power System:** Interaction between lightning and power system, Influence of tower footing resistance and Earth Resistance, Switching: Short line or kilometric fault, Energizing transients - closing and re-closing of lines, line dropping, load rejection – over voltages induced by faults	08
5.	**HVDC:** Switching HVDC lineTravelling waves on transmission line, Circuits with distributed Parameters Wave Equation, Reflection, Refraction, Behaviour of Travelling waves at the line terminations, Lattice Diagrams – Attenuation and Distortion, Multi-conductor system and Velocity wave	08
6.	**Insulation co-ordination:** Principle of insulation co-ordination in Air Insulated substation (AIS) and Gas Insulated Substation (GIS) Coordination between insulation and protection level, Statistical approach	08
7	**System Protection :** Protective devices, Protection of system against over voltages, lightning arresters, substation earthling	

Text/Reference Books

1. Allan Greenwood, “Electrical Transients in Power System”, Wiley & Sons Inc. New York, 1991

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

2nd Year - III Semester: M.Tech. (Power System)

3MPS2-12: FACTS and Custom Power Devices

Credit: 3 **Max. Marks: 100(IA:30, ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

S.No.	CONTENTS	CONTACT HOURS
1	**Introduction :** Objective, scope and outcome of the course.	1
2	**General system consideration and FACTs concepts:** Reactive power flow control in Power Systems, Control of dynamic power unbalances in Power System, Constraints of maximum transmission line loading, Need of FACTs controller in power system, Transmission line compensation, Uncompensated line -Shunt compensation, Series compensation Phase angle control, Reactive power compensation Shunt and Series compensation principles, Reactive compensation at transmission and distribution level	09
3	**Static Shunt Compensator:** Static versus passive VAR compensator, Static shunt compensators: SVC and STATCOM, Operation and control of TSC, TCR and STATCOM - Compensator control, Comparison between SVC and STATCOM	07
4	**Static Series Compensator:** TSSC,TCSC, Sub Synchronous characteristics SSSC -Static voltage and phase angle regulators, TCVR and TCPAR Operationand Control, Applications, Static series compensation, GCSC,TSSC, TCSC their application, operating principle and characteristics Static synchronous series compensators:Operation characteristics and application, comparison of TCSC and SSSC, Voltage & phase angle regulation and stability improvement by TCVR and TCPAR, SSR and its damping.	07
5	**UPFC and IPFC:** SSR and its damping Unified Power Flow Controller, Circuit Arrangement, Operation and control of UPFC, Basic Principle of P and Q control, Independent real and reactive power flow control- Applications.	07
6	**Interline power flow controller:** Introduction to interline power flow controller, Basic operating principle, characteristics and application, Modeling and analysis of FACTS, Controllers, Simulation of FACTS controllers Power quality problems in distribution systems, harmonics, loads that create harmonics, modeling, harmonic propagation, series and parallel resonances mitigation of harmonics, passive filters, active filtering – shunt , series and hybrid and their control	07
7	**Power Quality issues and modelling of FACTs:** Voltage swells , sags, flicker, unbalance and mitigation of these problems by power line conditioners, IEEE standards on power quality. Modelling of TCSC, STATCOM, UPFC	04

Text/Reference Books

1. K R Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New Age InternationalPublishers, 2007
2. X P Zhang, C Rehtanz, B Pal, “Flexible AC Transmission Systems- Modelling and Control”, SpringerVerlag, Berlin, 2006
3. N.G. Hingorani, L. Gyugyi, “Understanding FACTS: Concepts and Technology of Flexible ACTransmission Systems”, IEEE Press Book, Standard Publishers and Distributors, Delhi, 2001.
4. K.S.Sureshkumar ,S.Ashok , “FACTS Controllers & Applications”, E-book edition, Nalanda DigitalLibrary, NIT Calicut,2003
5. G T Heydt , “Power Quality”, McGraw-Hill Professional, 2007
6. T J E Miller, “Static Reactive Power Compensation”, John Wiley and Sons, Newyork, 1982.

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

2nd Year - III Semester: M.Tech. (Power System)

3MPS2-13: Industrial Load Modeling and Control

Credit: 3 **Max. Marks: 100(IA:30, ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

S.No.	CONTENTS	CONTACT HOURS
1	**Introduction:** Objective, scope and outcome of the course.	1
2	**Electric Energy:** Electric Energy Scenario-Demand Side Management-Industrial Load Management, Load Curves-Load Shaping Objectives, Methodologies-Barriers, Classification of Industrial, Loads, Continuous and Batch processes - Load Modeling	07
3	**Electricity pricing** – Dynamic and spot pricing -Models, Direct load control- Interruptible load control, Bottom up approach- scheduling- Formulation of load, Models, Optimization and control algorithms - Case studies	07
4	**Power Management:** Reactive power management in industries, controls-power quality impacts, application of filters Energy saving in industries	07
5	**OptimalLoading &Control-** Cooling and heating loads, load profiling, Modeling-Cool storage, Types-Control strategies, Optimal operation, Problem formulation-Case studies	06
6	**Energy control strategies:** Captive power units, Operating and control strategies, Power Pooling- Operation models, Energy banking, Industrial Cogeneration	06
7	**Operating Strategies:** Selection of Schemes Optimal Operating Strategies, Peak load saving, Constraints Problem formulation- Case study, Integrated Load management for Industries	07

Text/Reference Books

1. C.O. Bjork " Industrial Load Management - Theory, Practice and Simulations", Elsevier, the Netherlands,1989
2. C.W. Gellings and S.N. Talukdar,. Load management concepts. IEEE Press, New York, 1986, pp. 3-28
3. Y. Manichaikul and F.C. Schweppe ," Physically based Industrial load", IEEE Trans. on PAS, April 1981
4. H. G. Stoll, "Least cost Electricity Utility Planning", Wiley Interscience Publication, USA, 1989.
5. I.J.Nagarath and D.P.Kothari, .Modern Power System Engineering., Tata McGraw Hill publishers, NewDelhi, 1995
6. IEEE Bronze Book- "Recommended Practice for Energy Conservation and cost effective planning in Industrial facilities", IEEE Inc, USA

Syllabus and Scheme

M. Tech. in Renewable Energy Technology

(2023-24)

Teaching & Examination Scheme
M.Tech.: Renewable Energy Technology

1st Year –I Semester											
SN	**Course Type**	**Course Code**	**Course Name**	**Contact hrs/week**			**Marks**				**Cr**
				L	**T**	**P**	**Exm Hrs**	**IA**	**ETE**	**Total**	
1	PCC	1MRE1-01	Renewable Energy Sources	3	0	0	3	30	70	**100**	**3**
2	PCC	1MRE1-02	Solar Photovoltaics	3	0	0	3	30	70	**100**	**3**
3	PEC		**Elective-I:**	3	0	0	3	30	70	**100**	**3**
		1MRE2-11	a. Solar Heating & Cooling								
		1MRE2-12	b. Numerical Methods								
		1MRE2-13	c. Advanced Thermodynamics								
4	PEC		**Elective-II:**	3	0	0	3	30	70	**100**	**3**
		1MRE2-14	a. Energy Storage Technology								
		1MRE2-15	b. Optimization Techniques & Computer Applications								
		1MRE2-16	c. Advanced Heat Transfer								
5	MCC	1MCC3-21	Research Methodology & IPR	2	0	0	2	30	70	**100**	**2**
6	PCC	1MRE1-06	Renewable Technology Lab	0	0	4	4	60	40	**100**	**2**
7	PCC	1MRE1-07	Solar Photovoltaic Lab	0	0	4	4	60	40	**100**	**2**
8	SODECA	1MRE5-00	Social Outreach, Discipline & Extracurricular Activities							**100**	**2**
		TOTAL OF I SEMESTER		**14**	**0**	**8**		**270**	**430**	**800**	**20**

L: *Lecture,* ***T:*** *Tutorial,* ***P:*** *Practical,* ***Cr:*** *Credits*
ETE: *End Term Exam,* ***IA:*** *Internal Assessment*

Office of Dean Academic Affairs
Rajasthan Technical University, Kota

Teaching & Examination Scheme
M.Tech.: Renewable Energy Technology

1st Year – II Semester											
SN	**Course Type**	**Course Code**	**Course Name**	**Contact hrs/week**			**Marks**				**Cr**
				L	**T**	**P**	**Exm Hrs**	**IA**	**ETE**	**Total**	
1	PCC	2MRE1-01	Wind Energy Technology	3	0	0	3	30	70	**100**	**3**
2	PCC	2MRE1-02	Fuel Cell Technology	3	0	0	3	30	70	**100**	**3**
3	PEC		**Elective-III:**	3	0	0	3	30	70	**100**	**3**
		2MRE2-11	a. Geothermal Power Plants and Analysis								
		2MRE2-12	b. Green Buildings								
		2MRE2-13	c. Analysis of Power Plants								
4	PEC		**Elective-IV:**	3	0	0	3	30	70	**100**	**3**
		2MRE2-14	a. Solar Thermal Energy								
		2MRE2-15	b. Advanced Photovoltaic Technology								
		2MRE2-16	c. Solid Waste Management								
5	MCC	2MCC3-XX	Audit Course-I :	2	0	0					
6	PCC	2MRE1-06	Wind Energy Simulation Lab	0	0	4	4	60	40	**100**	**2**
7	PCC	2MRE1-07	Solar Energy Simulation Lab	0	0	4	4	60	40	**100**	**2**
8	REW	2MRE4-50	Mini Project with Seminar	0	0	4	4	60	40	**100**	**2**
9	SODECA	2MRE5-00	Social Outreach, Discipline & Extracurricular Activities							**100**	**2**
		TOTAL OF II SEMESTER		**14**	**0**	**12**		**300**	**400**	**800**	**20**

L: *Lecture,* ***T:*** *Tutorial,* ***P:*** *Practical,* ***Cr:*** *Credits*
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Office of Dean Academic Affairs
Rajasthan Technical University, Kota

Teaching & Examination Scheme
M.Tech.: Renewable Energy Technology

2nd Year – III Semester											
SN	**Course Type**	**Course Code**	**Course Name**	**Contact hrs/week**			**Marks**				**Cr**
				L	**T**	**P**	**Exm Hrs**	**IA**	**ETE**	**Total**	
1	PEC	3MRE2-11	**Elective-V:** a. Advanced Applications in Solar Energy Technology	3	0	0	3	30	70	**100**	**3**
		3MRE2-12	b. Hydrogen Energy								
		3MRE2-13	c. Biofuel Technology & Mechanism								
2	MCC	3MCC3-XX	Open Elective:	3	0	0	3	30	70	**100**	**3**
3	MCC	3MCC3-XX	Audit Course-II	2	0	0					
4	REW	3MRE4-60	Dissertation Phase-I	0	0	20	4	240	160	**400**	**10**
		TOTAL OF III SEMESTER		**8**	**0**	**20**		**300**	**300**	**600**	**16**

L: *Lecture,* ***T:*** *Tutorial,* ***P:*** *Practical,* ***Cr:*** *Credits*
ETE: *End Term Exam,* ***IA:*** *Internal Assessment*

Office of Dean Academic Affairs
Rajasthan Technical University, Kota

Teaching & Examination Scheme

M.Tech.: Renewable Energy Technology

2nd Year – IV Semester											
SN	Course Type	Course Code	Course Name	Contact hrs/week			Marks				Cr
				L	T	P	Exm Hrs	IA	ETE	Total	
1	REW	4MRE4-70	Dissertation Phase-II	0	0	32	4	360	240	**600**	**16**
		TOTAL OF IV SEMESTER		**0**	**0**	**32**		**360**	**240**	**600**	**16**

L: *Lecture,* ***T:*** *Tutorial,* ***P:*** *Practical,* ***Cr:*** *Credits*
ETE: *End Term Exam,* ***IA:*** *Internal Assessment*

Convener
BOS (Renewable Energy Technology)
RTU, Kota

Office of Dean Academic Affairs
Rajasthan Technical University, Kota

Syllabus
M. Tech. (Renewable Energy Technology)

1MRE1-01: Renewable Energy Sources
M. Tech. (Renewable Energy Technology)

Question Paper Pattern: Attempt any **Five** questions out of **Seven** questions.
All questions carry equal marks.

Teaching Scheme: 3 hrs/week;
End Term Exam Maximum Marks: 70; Exam Hrs: 3

Syllabus Contents with Breakup of Number of Lecture Hours	Hours
Introduction: Objectives, scope, and outcomes of the course.	**1**
Unit 1: Energy Sources & Availability: Conventional, non-conventional, renewable, non-renewable sources of energy, prospects, perspectives, & advantages. Introduction to different types of non-conventional source of energy: solar, wind, biomass, Ocean Thermal Energy Conversion (OTEC), geothermal, hydrogen energy, fuel cells, MHD, thermionic power conversion, thermoelectric power conversion.	**8**
Unit 2: Solar Energy: Solar constant, solar radiation geometry, local solar time, day length, solar radiation measurement, radiation on inclined surface, solar radiation data, & solar charts.	**8**
Unit 3: Wind Energy: Wind as a source of energy, Characteristics of wind, wind data. Horizontal & vertical axis wind turbines.	**7**
Unit 4: Biomass Energy: Introduction to biomass, biofuels & their heat content, biomass conversion technologies. Aerobic & anaerobic digester, Factors affecting bio-digestion, biogas plants–types, description, utilisation of biogas, & use in I.C. engines. Biomass gasification: Gasifier types, direct thermal application of gasifiers. Advantages & problems in development of gasifiers.	**8**
Unit 5: Other Renewable Energy Sources: Geothermal Energy: Status & estimates, geothermal resources, geothermal systems & their characteristics. Hydrogen energy. Fuel Cells: Principle & classification, types, conversion, efficiency, polarization, & advantages. Magneto HydroDynamic (MHD) power conversion: Principle, types, closed & open cycle system, materials. Ocean Thermal Energy Conversion (OTEC). Tidal energy. Wave energy.	**8**
Total Lecture Hours	**40**

Suggested Readings:

1. B. H. Khan, “Non-Conventional Energy Resources”.
2. Godfrey Boyle, “Renewable Energy”.
3. D. P. Kothari, K. C. Singhal, and Rakesh Ranjan, “Renewable Energy Sources and Emerging Technologies”.
4. S. P. Sukhatme and J. K. Nayak, “Solar Energy: Principles of Thermal Collection and Storage”.

1MRE1-02: Solar Photovoltaics

M. Tech. (Renewable Energy Technology)

Question Paper Pattern: Attempt any **Five** questions out of **Seven** questions.
All questions carry equal marks.

Teaching Scheme: 3 hrs/week;

End Term Exam Maximum Marks: 70; Exam Hrs: 3

Syllabus Contents with Breakup of Number of Lecture Hours	Hours
Introduction: Objectives, scope, and outcomes of the course.	**1**
Unit 1: Photovoltaic effect: Principle of direct solar energy conversion into electricity in a solar cell. Semiconductor properties, energy levels, basic equations. Solar cell, p-n junction, structure. I-V characteristics of a PV module, maximum power point, cell efficiency, fill factor, effect of irradiation and temperature.	**8**
Unit 2: Commercial solar cells: Production process of single crystalline silicon cells, multicrystalline silicon cells, amorphous silicon, cadmium telluride, copper indium gallium diselenide cells, high efficiency solar cells. Design of solar PV systems and cost estimation.	**8**
Unit 3: Classification: Central Power Station System, Distributed PV System, Standalone PV system, Grid Interactive PV System, small system for consumer applications, hybrid solar PV system, concentrator solar photovoltaic. System components: PV arrays, inverters, batteries, charge controls, net-meters. PV array installation, operation, costs, reliability.	**8**
Unit 4: Building-integrated photovoltaic units, grid-interacting central power stations, stand-alone devices for distributed power supply in remote and rural areas, solar cars, aircraft, space solar power satellites, solar PV lantern, stand-alone PV system - Home lighting and other appliances, solar water pumping systems.	**8**
Unit 5: Socio-economic and environmental analysis of photovoltaic systems.	**7**
Total Lecture Hours	**40**

Suggested Readings:

1. Chetan Singh Solanki, “Solar Photovoltaic: Fundamentals, Technologies and Application”.
2. A. R. Jha, “Solar Cell Technology and Applications”.
3. John Balfour, Michael Shaw, and Sharlene Jarosek, “Introduction to Photovoltaics”.
4. Antonio Luque and Viacheslav Andreev, “Concentrator Photovoltaic”.

1MRE2-11: Solar Heating and Cooling

M. Tech. (Renewable Energy Technology)

Question Paper Pattern: Attempt any **Five** questions out of **Seven** questions.
All questions carry equal marks.

Teaching Scheme: 3 hrs/week;

End Term Exam Maximum Marks: 70; Exam Hrs: 3

Syllabus Contents with Breakup of Number of Lecture Hours	Hours
Introduction: Objectives, scope, and outcomes of the course.	**1**
Unit 1: Potential and scope of solar heating and cooling, Types of solar heating and cooling systems, Solar collectors and storage systems for solar refrigeration and air-conditioning. Solar thermoelectric refrigeration and air-conditioning. Economics of heating and cooling systems.	**8**
Unit 2: Thermal comfort: Heat transmission in buildings - Bioclimatic classification. Passive heating concepts - Direct heat gain, indirect heat gain, isolated gain, and sunspaces. Passive cooling concepts - Evaporative cooling, radiative cooling, application of wind, water and earth for cooling, roof cooling, earth air-tunnel. Energy efficient landscape design - Concept of solar temperature and its significance, calculation of instantaneous heat gain through building envelope.	**8**
Unit 3: Flat plate collector: Liquid and air heating - Evacuated tubular collectors - Overall heat loss coefficient, heat capacity effect - Thermal analysis. Design of solar water heating systems, with natural and pump circulation, solar cookers. Solar dryers and applications. Thermal energy storage systems. Solar pond - Solar greenhouse.	**8**
Unit 4: Solar thermo-mechanical refrigeration system: Carnot refrigeration cycle, solar electric compression air conditioning, simple Rankine cycle air conditioning system.	**7**
Unit 5: Absorption refrigeration: Thermodynamic analysis – Energy and mass balance of Lithium bromide water absorption system, Aqua-ammonia absorption system, Calculations of COP and second law efficiency. Solar desiccant dehumidification.	**8**
Total Lecture Hours	**40**

Suggested Readings:

1. Soteris A. Kalogirou, “Solar Energy Engineering: Processes and Systems”.
2. J. A. Duffie and W. A. Beckman, “Solar Engineering of Thermal Process”.
3. D. Yogi Goswami, “Principles of Solar Engineering”.
4. H. P. Garg and J. Prakash, “Solar Energy: Fundamentals and Applications”.

1MRE2-12: Numerical Methods

M. Tech. (Renewable Energy Technology)

Question Paper Pattern: Attempt any **Five** questions out of **Seven** questions.
All questions carry equal marks.

Teaching Scheme: 3 hrs/week;

End Term Exam Maximum Marks: 70; Exam Hrs: 3

Syllabus Contents with Breakup of Number of Lecture Hours	Hours
Introduction: Objectives, scope, and outcomes of the course.	**1**
Unit 1: Approximations: Accuracy and precision, definitions of round off and truncation errors, error propagation.	**5**
Unit 2: Algebraic Equations: Formulation and solution of linear algebraic equations, Gauss elimination, LU decomposition, iteration methods (Gauss - Siedel), convergence of iteration methods, eigen values, and eigen vectors.	**10**
Unit 3: Interpolation Methods: Newton's divided difference, interpolation polynomials, and Lagrange interpolation polynomials.	**8**
Unit 4: Differentiation and Integration: High accuracy differentiation formulae, extrapolation, derivatives of unequally spaced data, Gauss quadrature, and integration.	**8**
Unit 5: Introduction to Optimization Methods: Local and global minima, Line searches, Steepest descent method, Conjugate gradient method, Quasi Newton method, Penalty function.	**8**
Total Lecture Hours	**40**

Suggested Readings:

1. A. Gourdin and M. Boumahrat, “Applied Numerical Methods”.
2. S. K. Gupta, “Numerical Methods for Engineers”.
3. S. S. Rao, “Engineering Optimization: Theory and Practice”.

1MRE2-13: Advanced Thermodynamics

M. Tech. (Renewable Energy Technology)

Question Paper Pattern: Attempt any **Five** questions out of **Seven** questions.
All questions carry equal marks.

Teaching Scheme: 3 hrs/week;

End Term Exam Maximum Marks: 70; Exam Hrs: 3

Syllabus Contents with Breakup of Number of Lecture Hours	Hours
Introduction: Objectives, scope, and outcomes of the course.	**1**
Unit 1: Review of basic thermodynamic principles; entropy; availability; irreversibility; first and second law analysis of steady and unsteady systems.	**8**
Unit 2: General thermodynamics relations; Fundamentals of partial derivatives; relations for specific heats; internal energy, enthalpy, and entropy; Joule-Thompson coefficient; Clapeyron equation.	**8**
Unit 3: Multi component systems; Review of equation of state for ideal and real gases; thermodynamic surfaces; gaseous mixtures; fugacity; ideal solutions.	**8**
Unit 4: Multi component phase equilibrium; Criteria of equilibrium; stability; heterogeneous equilibrium; Gibbs Phase rule.	**7**
Unit 5: Thermodynamics of chemical reaction (combustion); internal energy and enthalpy - first law analysis and second law analysis; basic relations involving partial pressures; third law of thermodynamics; chemical equilibrium and chemical potential equilibrium constants.	**8**
Total Lecture Hours	**40**

Suggested Readings:

1. Yunus Cengel and Boles, “Thermodynamics: An Engineering Approach”.
2. P. K. Nag, “Engineering Thermodynamics”.
3. Richard Edwin Sonntag, Claus Borgnakke, and Gordon John Van Wylen, “Fundamentals of Thermodynamics”.

1MRE2-14: Energy Storage Technology

M. Tech. (Renewable Energy Technology)

Question Paper Pattern: Attempt any **Five** questions out of **Seven** questions.
All questions carry equal marks.

Teaching Scheme: 3 hrs/week;

End Term Exam Maximum Marks: 70; Exam Hrs: 3

Syllabus Contents with Breakup of Number of Lecture Hours	Hours
Introduction: Objectives, scope, and outcomes of the course.	1
Unit 1: Introduction of energy storage technology, requirement for energy storage, Current status, Future prospect of storage.	5
Unit 2: Mechanical energy storage systems: Flywheel energy storage (FES), pumped hydropower storage (PHS), and compressed-air energy storage (CAES). Comparison and application of state-of-arts including principle, function and deployments. Technical characteristics in terms of power rating and discharge time, storage duration, energy efficiency, energy density, cycle life and life time etc.	9
Unit 3: Electrochemical energy storage: Battery, Fuel Cell, and Capacitor. Comparison and application of state-of-arts including principle, function and deployments. Technical characteristics of various electrochemical energy storage systems. Capacitor-battery hybrid systems.	9
Unit 4: Hydrogen energy: Hydrogen economy, Hydrogen production, Hydrogen Transportation, and Hydrogen storage methods.	6
Unit 5: Thermal energy storage: Sensible heat storage (SHS), latent heat storage (LHS) or phase-change materials (PCMs), and thermo-chemical energy storage (TCES). Comparison and technical characteristics. Hybrid PCMs energy storage.	10
Total Lecture Hours	**40**

Suggested Readings:

1. B. H. Khan, “Non-Conventional Energy Resources”.
2. Godfrey Boyle, “Renewable Energy”.
3. D. P. Kothari, K. C. Singhal, and Rakesh Ranjan, “Renewable Energy Sources and Emerging Technologies”.
4. S. P. Sukhatme and J. K. Nayak, “Solar Energy: Principles of Thermal Collection and Storage”.

1MRE2-15: Optimization Techniques and Computer Applications

M. Tech. (Renewable Energy Technology)

Question Paper Pattern: Attempt any **Five** questions out of **Seven** questions.
All questions carry equal marks.

Teaching Scheme: 3 hrs/week;

End Term Exam Maximum Marks: 70; Exam Hrs: 3

Syllabus Contents with Breakup of Number of Lecture Hours	Hours
Introduction: Objectives, scope, and outcomes of the course.	**1**
Unit 1: Introduction to Optimization: Classification and formulation of optimization problem.	**7**
Unit 2: Classical Optimization Methods: Single variable optimization, Multivariable optimization with no constraints, Multivariable optimization with equality constraints: Solution by Direct Substitution, Solution by the Method of Constrained Variation, & Solution by the Method of Lagrange Multipliers. Multivariable Optimization with Inequality Constraints: Kuhn–Tucker Conditions, Constraint Qualification.	**8**
Unit 3: One-Dimensional Minimization Methods: Unimodal Function, Elimination Methods: Unrestricted Search (Search with Fixed Step Size, Search with Accelerated Step Size), Exhaustive Search, Dichotomous Search, Interval Halving Method, Fibonacci Method, Golden Section Method.	**8**
Unit 4: Unconstrained Optimization Techniques: Indirect search (Descent) methods- Gradient of a Function, Steepest Descent (Cauchy) Method, Conjugate Gradient (Fletcher–Reeves) Method, & Newton's Method.	**8**
Unit 5: Constrained Optimization Techniques: Indirect Methods-Basic Approach of the Penalty Function Method, Interior Penalty Function Method, Exterior Penalty Function Method, Checking the Convergence of Constrained Optimization Problems: Testing the Kuhn–Tucker Conditions. Modern Method of Optimization: Neural-Network Based Optimization.	**8**
Total Lecture Hours	**40**

Suggested Readings:

1. S. S. Rao, "Engineering Optimization: Theory and Practice".
2. J. S. Arora, "Introduction to Optimum Design".
3. R. Saravanan, "Manufacturing Optimization through Intelligent Techniques".

1MRE2-16: Advanced Heat Transfer

M. Tech. (Renewable Energy Technology)

Question Paper Pattern: Attempt any **Five** questions out of **Seven** questions.
All questions carry equal marks.

Teaching Scheme: 3 hrs/week;

End Term Exam Maximum Marks: 70; Exam Hrs: 3

Syllabus Contents with Breakup of Number of Lecture Hours	Hours
Introduction: Objectives, scope, and outcomes of the course.	**1**
Unit 1: Review of the basic laws of conduction, convection, and radiation.	**5**
Unit 2: Conduction (a): One dimensional steady state conduction with variable thermal conductivity and with internal distributed heat source; local heat source in non-adiabatic plate. Extended surfaces-review; optimum fin of rectangular profile; straight fins of triangular and parabolic profiles; optimum profile; circumferential fin of rectangular profile.	**10**
Unit 3: Conduction (b): Unsteady state conduction; sudden changes in the surface temperatures of infinite plate, cylinders and spheres; solutions using Groeber's and Heisler's charts for plates, cylinders, and spheres suddenly immersed in fluids.	**8**
Unit 4: Convection: Heat transfer in laminar flow; free convection between parallel plates; forced internal flow through circular tubes, fully developed flow; velocity and thermal entry lengths solutions with constant wall temperature and with constant heat flux; forced external flow over a flat plate.	**10**
Unit 5: Radiation: Review of radiation principles; diffuse surfaces and the Lambert's Cosine law. Radiation through non-absorbing media; Hottel's method of successive reflections. Radiation through absorbing media; logarithmic decrement of radiation.	**6**
Total Lecture Hours	**40**

Suggested Readings:

1. J.P. Holman and S. Bhattacharyya, “Heat Transfer”.
2. F. P. Incropera and D. P. Dewitt, “Fundamentals of Heat and Mass Transfer”.
3. R. C. Sachdeva, “Fundamentals of Engineering Heat and Mass Transfer”.
4. S. P. Venkateshan, “Heat Transfer”.

1MCC3-21: Research Methodology & IPR

M. Tech. (Renewable Energy Technology)

Question Paper Pattern: Attempt any **Five** questions out of **Seven** questions.
All questions carry equal marks.

Teaching Scheme: 2 hrs/week;

End Term Exam Maximum Marks: 70; Exam Hrs: 2

Syllabus Contents with Breakup of Number of Lecture Hours	Hours
Introduction: Objectives, scope, and outcomes of the course.	**1**
Unit 1: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.	**7**
Unit 2: Effective literature studies approaches, analysis. Plagiarism, Research ethics,	**5**
Unit 3: Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee	**5**
Unit 4: Nature of Intellectual Property: Patents, Designs, Trade Marks, and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.	**5**
Unit 5: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.	**5**
Total Lecture Hours	**28**

Suggested Readings:

1. Stuart Melville and Wayne Goddard, “Research methodology: An introduction for science and engineering students”.
2. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”.
3. Ranjit Kumar, “Research Methodology: A Step by Step Guide for beginners”.
4. C. R. Kothari, “Research Methodology: Methods and Techniques”.
5. Neeraj Pandey and Khushdeep Dharni, “Intellectual Property Rights”.

1MRE1-06: Renewable Technology Lab
M. Tech. (Renewable Energy Technology)

Teaching Scheme: 4 hrs/week;

End Term Exam Maximum Marks: 40; Exam Hrs: 4

The experiments may be designed based on the course of "Renewable Energy Sources". Suggested list of experiments are as follows:

1. Study of energy systems: Conventional & Non-conventional.
2. Measurement of wind speed and wind direction using anemometer and wind vane.
3. Estimation of solar radiation: Pyranometer and pyrheliometer.
4. Study of biomass briquetting technique.
5. Study of a biomass gasifier.
6. Study of biogas appliances.
7. Wind energy experimental set up.

1MRE1-07: Solar Photovoltaic Lab
M. Tech. (Renewable Energy Technology)

Teaching Scheme: 4 hrs/week;

End Term Exam Maximum Marks: 40; Exam Hrs: 4

The experiments may be designed based on the course of "Solar Photovoltaics". Suggested list of experiments are as follows:

1. Study of solar photovoltaic module.
2. To demonstrate the I-V and P-V characteristics of PV Module.
3. To demonstrate the I-V and P-V characteristics of PV module with varying insolation and temperature level.
4. To show the effect of variation in tilt angle on PV module power.
5. To demonstrate the effect of shading on PV module output power.
6. Determination of maximum power point and fill factor of a solar photovoltaic module.
7. Analysis of working of solar photovoltaic water pumping system.
8. Analysis of working of grid connected rooftop solar photovoltaic power system.
9. Analysis of working of solar PV based street lighting system.

2MRE1-01: Wind Energy Technology

M. Tech. (Renewable Energy Technology)

Question Paper Pattern: Attempt any **Five** questions out of **Seven** questions.
All questions carry equal marks.

Teaching Scheme: 3 hrs/week;

End Term Exam Maximum Marks: 70; Exam Hrs: 3

Syllabus Contents with Breakup of Number of Lecture Hours	Hours
Introduction: Objectives, scope, and outcomes of the course.	**1**
Unit 1: Wind Resource Assessment: Modern wind energy and its origins**.** Modern wind turbines: Horizontal axis wind turbines, other wind turbine concepts. Wind characteristics and resources: General characteristics of wind resource, mechanics of wind motion. Wind data analysis and resource estimation: available power in the wind, turbulence intensity, wind speed probability density functions, effect of terrain on wind, & wind turbine power curve. Present status of wind energy in India, Wind measurements and instrumentations: Wind speed & wind direction.	**8**
Unit 2: Aerodynamics of Horizontal-Axis Wind Turbines: One-dimensional momentum theory and Betz limit, Ideal horizontal axis wind turbine with wake rotation, Airfoils and general concepts of Aerodynamics: lift, drag, lift versus drag machines. Momentum theory and Blade Element Theory.	**8**
Unit 3: Electrical Aspects of Wind Turbines: Synchronous generators, Induction generators. Fixed-speed generator systems: Synchronous generator directly coupled to the grid, Induction generator directly coupled to the grid, Variable-slip induction generator, & Multi-speed generator systems. Variable speed generator systems with inverter: Synchronous generator with inverter, Induction generator with over-synchronous cascade, & Double-Fed Induction Generator. Directly rotor-driven variable-speed generators: Synchronous generator with electric excitation & Generators with permanent magnets.	**8**
Unit 4: Wind Turbine Siting, System Design, and Integration: Wind turbine siting. Installation and operation issues. Wind farms. Wind turbines and wind farms in electrical grids. Offshore wind farms. Hybrid wind systems.	**8**
Unit 5: Environmental Aspects & Impacts: Avian interaction with wind turbines. Visual impact of wind turbines. Wind turbine noise. Electromagnetic interference effects. Land-use environmental impacts. Other environmental considerations.	**7**
Total Lecture Hours	**40**

Suggested Readings:

1. J. F. Manwell, J. G. McGowan, and A. L. Rogers, “Wind energy explained: Theory, Design and Application”.
2. E. Hau, “Wind Turbines: Fundamentals, Technologies, Application, Economics”.
3. T. Burton, D. Sharpe, N. Jenkins, & E. Bossanyi, “Wind Energy Handbook”.

2MRE1-02: Fuel Cell Technology

M. Tech. (Renewable Energy Technology)

Question Paper Pattern: Attempt any **Five** questions out of **Seven** questions.
All questions carry equal marks.

Teaching Scheme: 3 hrs/week;

End Term Exam Maximum Marks: 70; Exam Hrs: 3

Syllabus Contents with Breakup of Number of Lecture Hours	Hours
Introduction: Objectives, scope, and outcomes of the course.	**1**
Unit 1: Introduction: Fuel cells basics, relevance and importance. Stack design, gas supply, and cooling, classification of fuel cells. Electrochemistry basis of fuel cells. Efficiency and open circuit voltage. Influence of pressure and gas concentration: Nernst Equation, hydrogen partial pressure. Voltage-current behaviour of fuel cell, Fuel-cell irreversibility. Activation losses- Tafel equation, Internal current and fuel crossover, ohmic losses, mass-transportation losses. Hydrogen processing and Storage: Processing from Alcohols, Hydrocarbons and other sources. Hydrogen as an engine fuel, methods of hydrogen storage.	**8**
Unit 2: Alkaline Fuel Cell (AFC): Description, working principle, components, general performance characteristics, operating temperature and pressure. Ammonia as AFC fuel.	**7**
Unit 3: Phosphoric Acid Fuel Cell (PAFC): System design: Fuel processing, fuel utilization. Principles of Operation: electrolyte, electrode, catalyst, stack construction, stack cooling & manifolding. Performance: operating pressure & temperature, effects of carbon monoxide and sulphur.	**8**
Unit 4: High Temperature Fuel Cells: Solid Oxide Fuel Cell (SOFC): History, benefits and limitations, cell components, Cathode and Anode materials, fuel, configuration and performance. Environmental impact of SOFC. Application and future of SOFC. Molten Carbonate Fuel Cell (MCFC): General principle, cell components, mechanisms of electrode reactions, Influence of pressure & temperature, status of MCFC.	**8**
Unit 5: Proton-Exchange Membrane Fuel Cell (PEMFC): Principles of operation, Electrodes & electrodes structure, components. Water management, cooling and air supply. Introduction to Direct Methanol Fuel Cell (DMFC).	**8**
Total Lecture Hours	**40**

Suggested Readings:

1. Andrew L. Dicks and David A. J. Rand, “Fuel Cell Systems Explained”.
2. B. Viswanathan and M. Aulice Scibioh, “Fuel Cells: Principles and Applications”.

2MRE2-11: Geothermal Power Plants and Analysis

M. Tech. (Renewable Energy Technology)

Question Paper Pattern: Attempt any **Five** questions out of **Seven** questions.
All questions carry equal marks.

Teaching Scheme: 3 hrs/week;

End Term Exam Maximum Marks: 70; Exam Hrs: 3

Syllabus Contents with Breakup of Number of Lecture Hours	Hours
Introduction: Objectives, scope, and outcomes of the course.	**1**
Unit 1: Introduction: Earth structure**,** Thermal structure of the Earth, Heat flow and temperature distribution within Lithosphere. Volcanoes, earthquakes & plate tectonics. Types of Geothermal systems: Vapour dominated, Hot water, Geopressured, Hot Dry Rock, & Magma.	**8**
Unit 2: Analysis of Geothermal Resources: Calculations for hot dry rock system: (a) Heat energy content; and (b) Energy extraction. Calculations for hot aquifer system: (a) Heat energy content; and (b) Energy extraction.	**7**
Unit 3: Geothermal power generating systems: Single-flash steam power plants, Double-flash steam power plant, Dry-steam power plant, Binary Cycle Power Plant. Solar-Geothermal Hybrid Plants: Solar-geothermal binary plant with superheating of the binary working fluid, Solar-geothermal double-flash plant.	**8**
Unit 4: Environmental impact of geothermal power plant: Environmental Advantages of Geothermal Plants: Gaseous Emissions, Land Usage, Solids Discharge, Water Usage, & Water Pollution. Environmental Challenges of Geothermal Plants: Land Subsidence, Induced Seismicity, Induced Landslides, Noise Pollution, Disturbance of Natural Hydrothermal Manifestations, Disturbance of Wildlife Habitat, Vegetation and Scenic Views, Catastrophic Events, & Thermal Pollution.	**8**
Unit 5: Geothermal power plant case studies: Worldwide status of geothermal power plant development. Geothermal Energy in India. Larderello Dry-Steam Power Plants (Tuscany, Italy). The Geysers Dry-Steam Power Plants (California, USA).	**8**
Total Lecture Hours	**40**

Suggested Readings:

1. Harsh K. Gupta and Sukanta Roy, “Geothermal Energy: An Alternative Resource for the 21st Century”.
2. B. H. Khan, “Non-Conventional Energy Resources”.
3. Ronald Dipippo, “Geothermal Power Plants: Principles, Applications, Case Studies, and Environmental Impact”.

2MRE2-12: Green Buildings

M. Tech. (Renewable Energy Technology)

Question Paper Pattern: Attempt any **Five** questions out of **Seven** questions.
All questions carry equal marks.

Teaching Scheme: 3 hrs/week;

End Term Exam Maximum Marks: 70; Exam Hrs: 3

Syllabus Contents with Breakup of Number of Lecture Hours	Hours
Introduction: Objectives, scope, and outcomes of the course.	**1**
Unit 1: Introduction: Environmental implications of buildings energy, carbon emissions, water use, waste disposal; Building materials: sources, methods of production and environmental implications. Embodied Energy in Building Materials: Transportation Energy for Building Materials; Maintenance Energy for Buildings.	**8**
Unit 2: Comforts in Building: Thermal Comfort in Buildings-Issues; Heat Transfer Characteristic of Building Materials and Building Techniques. Incidence of Solar Heat on Buildings-Implications of Geographical Locations. Utility of Solar energy in buildings: Concepts of Solar Passive Cooling and Heating of Buildings. Low Energy Cooling. Case studies of Solar Passive Cooled and Heated Buildings.	**8**
Unit 3: Green Building Techniques: Concepts of Green Composites. Water Utilisation in Buildings, Low Energy Approaches to Water Management. Management of Solid Wastes. Management of Sewage. Urban Environment and Green Buildings. Green Cover and Built Environment. Provisions for Rain Water Harvesting, Solar PV systems, Solar Water Heaters.	**8**
Unit 4: Green Building Rating Systems: Features of green building rating systems in India: Indian Green Building Council (IGBC), Green Rating for Integrated Habitat Assessment (GRIHA), & LEED (Leadership in Energy and Environmental Design) etc. Sustainable site, water, energy, material, and indoor environment issues for green buildings; Intent and documentation for credits/points for green rating systems; Difference in evaluation and documentation for new construction and existing buildings. Green home rating, green factory rating, green neighbourhood concept.	**8**
Unit 5: Concept of Net Zero Energy Building, Costs of green buildings. Energy Conservation Building Code: requirements of code, applicability, compliance options: prescriptive, trade-off, whole building performance routes for compliance.	**7**
Total Lecture Hours	**40**

Suggested Readings:

1. Mili Majumdar, "Energy-efficient buildings in India".
2. K. S. Jagadish , B.V. Venkatarama Reddy , and K. S. Nanjunda Rao , "Alternative Building Materials & Technologies".
3. Ursula Eicker, "Low energy cooling for sustainable buildings".
4. Jerry Yudelson, "Green Building through Integrated Design".
5. Osman Attmann, "Green Architecture: Advanced Technologies & Materials".

2MRE2-13: Analysis of Power Plants

M. Tech. (Renewable Energy Technology)

Question Paper Pattern: Attempt any **Five** questions out of **Seven** questions.
All questions carry equal marks.

Teaching Scheme: 3 hrs/week;

End Term Exam Maximum Marks: 70; Exam Hrs: 3

Syllabus Contents with Breakup of Number of Lecture Hours	Hours
Introduction: Objectives, scope, and outcomes of the course.	1
Unit 1: Introduction: Power and energy, sources of energy, review of thermodynamic cycles related to power plant. Load estimation, load curves, various terms and factors involved in power plant calculations. Effect of variable load on power plant operation, Selection of power plant units. Power plant economics and selection. Effect of plant type on: costs, rates, fixed elements, energy elements, customer elements, and investor's profit; depreciation and replacement. Economics in plant selection, other considerations in plant selection.	8
Unit 2: Steam Power Plant: General layout of steam power plant, Power plant boilers including critical and super critical boilers. Fluidized bed boilers, boilers mountings and accessories, Different systems such as coal handling system, pulverisers and coal burners, combustion system, draft, ash handling system, Dust collection system, Feed water treatment and condenser and cooling towers and cooling ponds, Turbine auxiliary systems such as governing, feed heating, reheating, flange heating and gland leakage. Operation and maintenance of steam power plant, heat balance and efficiency, Site selection of a steam power plant.	8
Unit 3: Hydroelectric and Non-conventional Power Plants: Hydroelectric power plants, classification, typical layout and components, Types of turbine- Pelton, Francis, Kaplan, Propeller, Deriaz and Bulb turbines. Performance of turbines and comparison. Principles of wind, tidal, solar PV, solar thermal, geothermal, biogas, and fuel cell power plants.	8
Unit 4: Diesel and Gas Turbine Power Plants: General layout of Diesel and Gas Turbine power plants, Performance of Diesel and Gas Turbine power plants, comparison with other types of power plants.	7
Unit 5: Nuclear power plant: Layout and subsystems of nuclear power plants, Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), CANDU Reactor, Pressurized Heavy Water Reactor (PHWR), Fast Breeder Reactors (FBR), gas cooled and liquid metal cooled reactors, safety measures for nuclear power plants.	8
Total Lecture Hours	**40**

Suggested Readings:

1. P. K. Nag, "Power Plant Engineering".
2. M. M. El Wakil, "Power Plant Technolog

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2MRE2-14: Solar Thermal Energy

M. Tech. (Renewable Energy Technology)

Question Paper Pattern: Attempt any **Five** questions out of **Seven** questions.
All questions carry equal marks.

Teaching Scheme: 3 hrs/week;

End Term Exam Maximum Marks: 70; Exam Hrs: 3

Syllabus Contents with Breakup of Number of Lecture Hours	Hours
Introduction: Objectives, scope, and outcomes of the course.	**1**
Unit 1: **Solar Radiation:** Solar radiation outside the earth atmosphere and at earth surface. Instruments for measuring solar radiation and sunshine. Solar Radiation Geometry, sunrise, sunset, day length, Local Apparent Time. Empirical equations for predicting the availability of solar radiation: Monthly average daily global radiation, monthly average daily diffuse radiation, monthly average hourly global radiation, monthly average hourly diffuse radiation. Hourly global, beam, and diffuse radiation under cloudless skies. Solar radiation on tilted surfaces.	**8**
Unit 2: Liquid Flat-Plate Collectors (FPC): Introduction of FPC, Performance analysis, Transmissivity of the cover system: Transmissivity based on reflection-refraction, absorption, and for diffuse radiation. Transmissivity-Absorptivity product. Overall loss coefficient. Effects of various parameters on performance (Selective surfaces, Number of covers, Spacing, Effect of shading, collector tilt, Fluid inlet temperature, Cover transmissivity, Dust on the top cover). Testing procedures of FPC. Alternatives to FPC (Evacuated Tube Collectors).	**8**
Unit 3: Solar Air Heaters: Introduction, various types of solar air heaters, Testing procedures. Matrix air heater. Plastic air heater. Inflatable-tunnel plastic solar heater.	**7**
Unit 4: Concentrating Collectors: Concentrating collectors for medium and high temperature applications. Line-focusing and point-focusing concentrators: Cylindrical parabolic collector, compound parabolic collector (CPC), paraboloid dish collector, Central Receiver Collector (heliostat field with central receiver), Linear Fresnel lens collector, Circular Fresnel lens concentration.	**8**
Unit 5: Thermal Energy Storage & Applications of Solar Energy: Introduction to three basic methods for storing thermal energy. Sensible heat storage in liquids & solids, Thermal Stratification. Latent Heat Storage. Thermochemical Storage. Applications: Solar water heaters, Solar pond, its principle of working, and solar-pond electric-power plant. Solar furnaces. Solar Cookers. Solar Chimney Plant. Solar greenhouses. Solar passive space heating and cooling systems. Solar Industrial Heating Systems.	**8**
Total Lecture Hours	**40**

Suggested Readings:

1. John A. Duffie and William A. Beckman, “Solar Engineering of Thermal Processes”.
2. B. H. Khan, “Non-Conventional Energy Resources”.
3. H. P. Garg and J. Prakash, “Solar Energy: Fundamentals and applications”.
4. Sukhatme & Nayak, “Solar Energy: Principles of thermal collection & storage”.

2MRE2-15: Advanced Photovoltaic Technology

M. Tech. (Renewable Energy Technology)

Question Paper Pattern: Attempt any **Five** questions out of **Seven** questions.
All questions carry equal marks.

Teaching Scheme: 3 hrs/week;

End Term Exam Maximum Marks: 70; Exam Hrs: 3

Syllabus Contents with Breakup of Number of Lecture Hours	Hours
Introduction: Objectives, scope, and outcomes of the course.	**1**
Unit 1: Overview of different types of solar cells/panels. Photovoltaic industries in India and World. International certification of solar panels and Indian scenario.	**7**
Unit 2: Wafer based silicon solar cells and its market trend. Cost breakup of wafer based solar panels, future trends. Concentrator solar cells, reflector and lens based versions. Performance in Indian climatic conditions. Low, medium and high concentration, combined thermal and concentration PV system.	**8**
Unit 3: Semi-transparent solar cells and related materials, applications in buildings (BIPV), thin film and wafer based versions, appearance and structure of thin film solar cells, Flexible solar cells.	**8**
Unit 4: Multi-junction solar cells, its working principles. Hetero-junction with intrinsic thin layer (HIT) solar cells, structure and working principle, comparison with conventional bulk solar cells.	**8**
Unit 5: Polymer, organic, dye sensitized, and quantum dot solar cells, structure, working principle, present applications, near future trends.	**8**
Total Lecture Hours	**40**

Suggested Readings:

1. Chetan Singh Solanki., "Solar Photovoltaic: Fundamentals, Technologies and Application".
2. A. R. Jha, "Solar Cell Technology and Applications".
3. John Balfour, Michael Shaw, and Sharlene Jarosek., "Introduction to Photovoltaics".
4. Antonio Luque and Viacheslav Andreev, "Concentrator Photovoltaic".

2MRE2-16: Solid Waste Management

M. Tech. (Renewable Energy Technology)

Question Paper Pattern: Attempt any **Five** questions out of **Seven** questions.
All questions carry equal marks.

Teaching Scheme: 3 hrs/week;
End Term Exam Maximum Marks: 70; Exam Hrs: 3

Syllabus Contents with Breakup of Number of Lecture Hours	Hours
Introduction: Objectives, scope, and outcomes of the course.	**1**
Unit 1: Fundamentals of Solid Waste Management: Definition of solid wastes –types of solid wastes –Sources -Industrial, mining, agricultural, and domestic –Characteristics. Solid waste Problems -impact on environmental health –Concepts of waste reduction, recycling and reuse. **Collection and Transport of Municipal Solid Waste:** Determination of composition of MSW –storage and handling of solid waste –Future changes in waste composition. Waste collection systems, analysis of collection system – alternative techniques for collection system. Need for transfer operation, transport means and methods, transfer station types and design requirements.	**8**
Unit 2: Processing of Solid Waste and Energy recovery: Unit operations for separation and processing, Materials Recovery facilities, Waste transformation through combustion and aerobic composting, anaerobic methods for materials recovery and treatment –Energy recovery –Incinerators	**7**
Unit 3: Disposal of Solid wastes: Land farming, deep well injections. Landfills: Design and operation including: site selection, Geo-environmental investigations , engineered sites, liners and covers, leachate control and treatment, gas recovery and control, including utilization of recovered gas (energy), and landfill monitoring and reclamation.	**8**
Unit 4: Integrated Waste Management: Requirements and technical solution designated waste landfill remediation, Integrated waste management facilities. TCLP (Toxicity Characteristic Leaching Procedure) tests and leachate studies. Economics of the onsite v/s offsite waste management options. Natural attenuation process and its mechanisms. Hazardous waste –legislations –RCRA process –superfund process –toxicological principles –dose response –toxic effects –toxic response-Various industrial hazardous waste (textiles, tanneries, electroplating, distilleries etc.) disposal and handling methods-case studies.	**8**
Unit 5: Biomedical, Radiation Risk Assessment, and E-Waste Management: Biomedical waste: Definition, sources, classification-infectious wastes –handling –storing and disposal of medical wastes –collection, segregation, treatment and disposal. Principles of radiation protection–quantifying and combining risks–uncertainty assessments–site specific considerations. E-Waste characteristics, generation, collection, transport, and disposal.	**8**
Total Lecture Hours	**40**

Suggested Readings:

1. William A. Worrell and P. Aarne Vesilind, “Solid waste Engineering”.
2. George Tchobanoglous, Hilary Theisen, and Samuel A. Vigil, “Integrated Solid Waste Management: Engineering principles and management issues”.

2MRE1-06: Wind Energy Simulation Lab **M.Tech. (Renewable Energy Technology)**
Teaching Scheme: 4 hrs/week; **End Term Exam Maximum Marks: 40; Exam Hrs: 4**
The experiments may be designed based on the course of "Wind Energy Technology". Suggested list of experiments are as follows: 1. Study of wind energy conversion devices. 2. Designing of a grid connected wind farm using software. 3. Field visit of students to a grid connected wind farm. 4. Analysis of small wind turbines and hybrid system. 5. Wind resource assessment techniques. 6. Electrical aspects of wind turbine generators.

2MRE1-07: Solar Energy Simulation Lab **M. Tech. (Renewable Energy Technology)**
Teaching Scheme: 4 hrs/week; **End Term Exam Maximum Marks: 40; Exam Hrs: 4**
The experiments may be designed based on the course of "Solar Energy". Suggested list of experiments are as follows: 1. Study of flat plate collector and evacuated tube collector. 2. Study of a box type solar cooker and calculation of its thermal efficiency. 3. Study of natural convection type solar water heater. 4. Study of natural convection type solar dryer. 5. Study and simulation of smart energy homes. 6. Simulation of grid connected 1 MW solar photovoltaic power plant using PVSyst software. 7. Field visit to grid connected rooftop solar photovoltaic power plant. 8. Simulation of hybrid solar PV system.

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3MRE2-11: Advanced Applications in Solar Energy Technology

M. Tech. (Renewable Energy Technology)

Question Paper Pattern: Attempt any **Five** questions out of **Seven** questions.
All questions carry equal marks.

Teaching Scheme: 3 hrs/week;

End Term Exam Maximum Marks: 70; Exam Hrs: 3

Syllabus Contents with Breakup of Number of Lecture Hours	Hours
Introduction: Objectives, scope, and outcomes of the course.	**1**
Unit 1: Introduction to advanced solar energy applications. Thermal comfort; Sun motion. Solar water heating: Water heating systems; Freezing, boiling & scaling. Auxiliary energy; Forced-circulation systems. Natural-circulation systems; Integral collector storage systems. Water heating in space heating and cooling systems; Swimming pool heating. Hot water industrial process heat system.	**7**
Unit 2: Solar based Building Heating & Cooling: Passive Heating of Buildings: Direct Gain, Thermal storage wall, Sunspaces, Thermal storage roof, Convective loop. Passive cooling of buildings: Shading, ventilation, evaporation, radiation cooling, ground coupling, dehumidification. Building heating-Hybrid methods: Solar active heating of buildings: General aspects, Components of solar heating system (solar collector, thermal storage system, Auxiliary heat supply system, control systems). Three ways of solar space heating: solar air systems, solar liquid systems, and solar heat pump systems.	**8**
Unit 3: Solar Refrigeration and Air conditioning: Carnot refrigeration cycle. Solar absorption cooling: Principle of absorption cooling, Basics of absorption cooling, LiBr-H_2O absorption system, H_2O-NH_3 absorption system, Intermittent absorption refrigeration system. Solar Vapour Compression Refrigeration. Solar Desiccant Cooling: Triethylene glycol open-cycle air conditioning system using solar air heating collectors for regeneration, LiCl-H_2O open-cycle cooling system. Ventilation desiccant cycle and Recirculation desiccant cycle. Solar thermoelectric refrigeration and air-conditioning.	**8**
Unit 4: Solar Drying of Food & Solar Desalination: Basics of solar drying. Types of solar dryers: Natural convection or Direct type solar dryers. Forced circulation type dryers: Hybrid dryer, Bin type grain dryer, solar timber drying. Hot air industrial process heat system. Solar Desalination: Simple solar still, Basics of solar still, material problems in solar still, Performance prediction of Basin-Type still. Wick type solar still. Multi-stage solar still. Active solar still. Future material advancements.	**8**
Unit 5: Solar Photovoltaic Power Applications: Rooftop Solar PV Systems: Introduction, system components, typical schematic diagram of rooftop solar PV systems, costing, net-metering of rooftop grid connected system, system performance analysis (Performance Ratio and Levelized Cost of Electricity). Solar PV water pumping system. Solar PV battery charging system. Solar PV street lighting system. Floating solar PV systems.	**8**
Total Lecture Hours	**40**

Suggested Readings:

1. Chetan S. Solanki., "Solar Photovoltaic: Fundamentals, Technologies and Application".
2. S. P. Sukhatme and J. K. Nayak, "Solar Energy: Principles of Thermal Collection and Storage".
3. J. A. Duffie and W. A. Beckman, "Solar Engineering of Thermal Process".
4. H. P. Garg and J. Prakash, "Solar Energy: Fundamentals and Applications".

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3MRE2-12: Hydrogen Energy

M. Tech. (Renewable Energy Technology)

Question Paper Pattern: Attempt any **Five** questions out of **Seven** questions.
All questions carry equal marks.

Teaching Scheme: 3 hrs/week;

End Term Exam Maximum Marks: 70; Exam Hrs: 3

Syllabus Contents with Breakup of Number of Lecture Hours	Hours
Introduction: Objectives, scope, and outcomes of the course.	**1**
Unit 1: Introduction of Hydrogen Energy Systems: Hydrogen pathways introduction – current uses, General introduction to infrastructure requirement for hydrogen production, storage, dispensing and utilization, and Hydrogen production power plants. Fuel properties of hydrogen.	**8**
Unit 2: Hydrogen Production Processes: **Thermal**-Steam Reformation – Thermo chemical Water Splitting – Gasification – Pyrolysis, Nuclear thermo catalytic and partial oxidation methods. **Electrochemical** – Electrolysis – Photo electro chemical. **Biological** – Anaerobic Digestion – Fermentative Micro-organisms. **Renewable Sources**: Hydrogen production methods using solar energy and wind energy.	**8**
Unit 3: Hydrogen Storage: Physical and chemical properties – General storage methods, compressed storage – Composite cylinders – Glass micro sphere storage - Zeolites, Metal hydride storage, chemical hydride storage and cryogenic storage.	**8**
Unit 4: Hydrogen Utilization: Overview of Hydrogen utilization: I.C. Engines, gas turbines, hydrogen burners, power plant, refineries, domestic and marine applications. Hydrogen fuel quality, performance, COV, emission and combustion characteristics of Spark Ignition engines for hydrogen, back firing, knocking, volumetric efficiency, hydrogen manifold and direct injection, fumigation, NO_x controlling techniques, dual fuel engine, durability studies, field trials, emissions and climate change.	**8**
Unit 5: Hydrogen Safety: Safety barrier diagram, risk analysis, safety in handling and refueling station, safety in vehicular and stationary applications, fire detecting system, safety management, and simulation of crash tests.	**7**
Total Lecture Hours	**40**

Suggested Readings:

1. Michael Ball and Martin Wietschel, "The Hydrogen Economy: Opportunities and Challenges".
2. M. K. G. Babu and K. A. Subramanian, "Alternative Transportation Fuels: Utilization in Combustion Engines".
3. Krishnan Rajeshwar, Robert McConnell, and Stuart Licht, "Solar Hydrogen Generation: Toward a Renewable Energy Future".
Ram B. Gupta, "Hydrogen Fuel: Production, Transport, and Storage".

3MRE2-13: Biofuel Technology & Mechanism

M. Tech. (Renewable Energy Technology)

Question Paper Pattern: Attempt any **Five** questions out of **Seven** questions.
All questions carry equal marks.

Teaching Scheme: 3 hrs/week;

End Term Exam Maximum Marks: 70; Exam Hrs: 3

Syllabus Contents with Breakup of Number of Lecture Hours	Hours
Introduction: Objectives, scope, and outcomes of the course.	**1**
Unit 1: Biofuel Technology: Introduction, potential of biofuels in the energy scenario of India, Biofuels in relation to environment, ecology, agriculture, health and sanitation, Factors enhancing/inhibiting biofuel production.	**7**
Unit 2: Bio-chemical and Microbial Aspects of Biogas: Biogas mechanism, enhancement of biogas production by different additives (Chemicals, organic substances, enzymes), pre-treatment process, etc. Scrubbing process, bottling, need for bottling of biogas, liquefaction of biogas. Various uses of biogas and its merits and demerits.	**8**
Unit 3: Biogas Plants and Applications: Types of biogas plants, design of a biogas plant (cow dung and organic waste) and structural strength, selection of site and size, construction technique, material requirement, recent advances in high rate bio-methanation reactors design and material, night soil linked biogas plant. Cold condition biogas plant design concept, cost and financial viability. Principles of dual fuel biogas engines, its limitations, biogas appliances including thermal and cooking efficiency test.	**8**
Unit 4: Production and Applications of Biodiesel: Trans-esterification reaction and process, Raw materials and pre-treatment, Environmental conditions and operational process, Separation and purification stages, Qualities of biodiesel and associated regulations, properties of biodiesel, application in diesel engines and environmental effects, economic impact of biodiesel.	**8**
Unit 5: Alcohols and other Biofuels: Types of feedstock for alcohols and other biofuels and their availability. Types of alcohols (methanol, ethanol, butanol, etc.) and other oxygenated biofuels, their production methods, applications, advantages and limitations. Physico-chemical properties of biofuels. Combustion characteristics of biofuels in spark ignition and compression ignition engines.	**8**
Total Lecture Hours	**40**

Suggested Readings:

1. K. C. Khandelwal and S. S. Mahdi, “Biogas Technology: A Practical Handbook”.
2. N. S. Rathore and A. K. Kurchania, “Biomethanation Technology”.
3. A. N. Mathur and N. S. Rathore, “Biogas: Production management and utilization”.
4. Liangwei Deng, Yi Liu, and Wenguo Wang, “Biogas Technology”.
5. Wim Soetaert and Erick J. Vandamme, “Biofuels”.
6. Caye M. Drapcho and Terry H. Walker, “Biofuels Engineering Process Technology”.
7. Ahindra Nag, “Biofuels Refining and Performance”.

3MRE4-60: Dissertation Phase-I

M. Tech. (Renewable Energy Technology)

Teaching Scheme: 20 hrs/week;

Guidelines:

- The Dissertation Work will start in semester III and should preferably be a problem with research potential and should involve scientific research, design, generation/collection and analysis of data, determining solution and must preferably bring out the individual contribution.
- Seminar should be based on the area in which the candidate has undertaken the dissertation work as per the common instructions for all branches of M. Tech. The examination shall consist of the preparation of report consisting of a detailed problem statement and a literature review. The preliminary results (if available) of the problem may also be discussed in the report. The work has to be presented in front of the examiners panel set by the Head of Department.
- Candidate will have the right to select the M. Tech. dissertation supervisor based on their research interest. As this course is interdisciplinary in nature, candidate may also chose supervisor from academic departments other than where this course is being run. Candidate will submit an application along with consent of supervisor chosen by the candidate to the Head of Department. Head of Department will assign that supervisor to the candidate based on the application. If candidate is not able to select supervisor by himself, than only Head of Department will allot supervisor to that student. The candidate has to be in regular (daily) contact with his supervisor and the topic of dissertation must be from renewable energy area which is mutually decided by the supervisor and the candidate.

4MRE4-70: Dissertation Phase-II

M. Tech. (Renewable Energy Technology)

Teaching Scheme: 32 hrs/week;

Guidelines:

- It is a continuation of Project work started in semester III. Student has to submit the thesis in prescribed format and also present a seminar. The dissertation should be presented in standard format as provided by the university. The candidate has to prepare a detailed thesis consisting of introduction of the problem, problem statement, literature review, objectives of the work, methodology (experimental set up or numerical details as the case may be) of solution and results and discussion. The thesis must bring out the conclusions of the work and future scope for the study.
- Candidate will have the right to select the M. Tech. dissertation supervisor based on their research interest. As this course is interdisciplinary in nature, candidate may also chose supervisor from academic departments other than where this course is being run. Candidate will submit an application along with consent of supervisor chosen by the candidate to the Head of Department. Head of Department will assign that supervisor to the candidate based on the application. If candidate is not able to select supervisor by himself, than only Head of Department will allot supervisor to that student. The candidate has to be in regular (daily) contact with his supervisor and the topic of dissertation must be from renewable energy area which is mutually decided by the supervisor and the candidate.

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Syllabus and Scheme

M. Tech. in Transportation Engineering

(2023-24)

Teaching and Examination Scheme
M. Tech.: Transportation Engineering
I Semester

SN	Category	Course		Contact hrs./ week			Marks				Cr
		Code	Title	L	T	P	Exam Hrs.	IA	ETE	Total	
1	PCC	1MTR1-01	Transportation Planning	3		-	3	30	70	**100**	**3**
2	PCC	1MTR1-02	Advanced Highway Material Characterization	3		-	3	30	70	**100**	**3**
3	PEC	1MTR2-11	Railway, Airports, Ports and Harbours	3	0	0	3	30	70	**100**	**3**
4		1MTR2-12	Statistical Methods in Transportation Engineering								
5		1MTR2-13	Road transport management and economics								
6	PEC	1MTR2-14	Management of quality and safety in highway construction	3	0	0	3	30	70	**100**	**3**
7		1MTR2-15	Tunnel engineering								
8		1MTR2-16	Geometric Design								
9	MCC	1MCC3-21	Research Methodology & IPR	2	-	-	2	30	70	**100**	**2**
10	PCC	1MTR1-06	Highway Material Testing Laboratory	-	-	4	-	60	40	**100**	**2**
11	PCC	1MTR1-07	Pavement Design Laboratory	-	-	4	-	60	40	**100**	**2**
12	SODECA	1MTR5-00	SODECA	-	-					**100**	**2**
			TOTAL					**270**	**430**	**800**	**20**

Teaching and Examination Scheme
M. Tech.: Transportation Engineering
II Semester

SN	Category	Course		Contact hrs./ week			Marks				Cr
		Code	Title	L	T	P	Exam Hrs.	IA	ETE	Total	
1	PCC	2MTR1-01	Pavement Analysis, Design and Construction	3	-	-	3	30	70	**100**	**3**
2	PCC	2MTR1-02	Traffic Engineering & Modeling	3	-	-	3	30	70	**100**	**3**
3	PEC	2MTR2-11	Transportation-Environment Interaction and Analysis	3	0	0	3	30	70	**100**	**3**
4		2MTR2-12	Urban Mass Transportation System								
5		2MTR2-13	Sustainable Construction Engineering								
6	PEC	2MTR2-14	Road construction equipment	3	0	0	3	30	70	**100**	**3**
7		2MTR2-15	Pavement Maintenance and Management System								
8		2MTR2-16	Planning, Design and Construction of Rural Roads								
9	MCC	2MCC3-XX	Audit Course-I	2	0	0					
10	PCC	2MTR1-06	Traffic engineering lab	-	-	4	-	60	40	**100**	**2**
11	PCC	2MTR1-07	Statistical and Numerical analysis lab	-	-	4	-	60	40	**100**	**2**
12	REW	2MTR4-50	Mini project with Seminar	-	-	4	-	60	40	**100**	**2**
14	SODECA	2MTR5-00	Social Outreach discipline & Extra Curriculum Activities							**100**	**2**
			TOTAL					**300**	**400**	**800**	**20**

Teaching and Examination Scheme
M. Tech.: Transportation Engineering
III Semester

SN	Category	Course		Contact hrs./week			Marks				Cr
		Code	Title	L	T	P	Exam Hrs.	IA	ETE	Total	
1	PEC	3MTR2-11	Remote sensing and GIS	3	0	0	3	30	70	**100**	**3**
		3MTR2-12	Advanced Concrete Technology								
		3MTR2-13	Ground improvement technique								
2	MCC	3MCC3-XX	Open Elective (Choose from attached list)	3	-	-	3	30	70	**100**	**3**
3	MCC	3MCC3-XX	Audit Course-II	2	0	0					
4	REW	3MTR4-60	Dissertation phase I - Industrial project	0	0	20	-	240	160	**400**	**10**
			TOTAL					**300**	**300**	**600**	**16**

Teaching and Examination Scheme
M. Tech.: Transportation Engineering
IV Semester

SN	Category	Course		Contact hrs./week			Marks				Cr
		Code	Title	L	T	P	Exam Hrs.	IA	ETE	Total	
1	REW	4MTR4-70	Dissertation II	0	0	32	-	360	240	**600**	**16**
			TOTAL					**360**	**240**	**600**	**16**

TRANSPORTATION ENGINEERING
1MTR1-01: TRANSPORTATION PLANNING

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Introduction to transportation planning:** Fields of transportation Engineering; System- Environment Ensemble; Transportation planning process; Transportation problems and problem solving process.	7
3	**Transportation data and survey methods:** Type of Transportation data and its sources, Data quantity and quality, Accuracy and Precision, Sampling techniques, sample sizes, Transportation Planning surveys – Documentation searches, Person surveys, Household surveys, In-transit surveys, Road-side surveys, etc.	8
4	**Transportation Modes and Technologies:** Technologies of Transport and System Components, Network Analysis; Minimum Path Algorithms, Path Characteristics, Path-Vehicle Interaction – Discrete Flows and Continuous Flows, Vehicle and its Performance, System Performance, Vehicle and Container, Weight to Volume relation, Terminal Planning, Operational Planning.	8
5	**Four-stage Sequential Planning:** Urban transportation planning process; trip generation, correlation analysis and regression analysis; trip distribution, Growth factor methods and Synthetic methods; modal split models, first generation, second generation, behavioural models; minimum travel path computations; Trip assignments, route assignment, multiple assignment and network assignment.	8
6	**Land use–Transportation Planning:** Urban Forms, mobility and activity hierarchy; accessibility-based early-era models; Lowery's model and its derivatives; Modern era models.	8
	Total	**40**

Textbooks:

1. B. G. Hutchinson, "Principles of Urban Transport Systems Planning" Scripta Book Co., Washington – 1974
2. Anthony J. Richardson, Elizabeth S. Ampt and Arnim H. Meyburg, "Survey Methods for Transport Planning" Eucalyptus Press, Australia- 1995
3. Roy Thomas, "Traffic Assignment Techniques", Avebury Technical, Aldershot, England – 1991

Reference books:

1. C A O'Flaherty, ed , "Transport Planning and Traffic Engineering", Butterworth Heinemann, Elsevier, Burlington, MA - 2006
2. C Jotin Khisty and B Kent Lall, "Transportation Engineering – An Introduction", Prentice Hall of India Pvt Ltd., New Delhi -2003

TRANSPORTATION ENGINEERING
1MTR1-02: Advanced Highway Material Characterization

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Aggregates:** Classification, physical and strength characteristics, proportioning of aggregates, Aggregate texture and skid resistance, polishing of aggregates.	7
3	**Soil:** Classification, Structural and Constructional problems in soil subgrade, Identification and strength tests, Soil-moisture movement, Sub-soil drainage, Soil stabilization, Characteristics and use of Fly Ash, Bottom ash and Pond Ash	8
4	**Bitumen:** Bitumen sources and manufacturing, Bitumen constituents, structure and Rheology, Mechanical and engineering properties of bitumen, Tests on bitumen, Emulsions, Tar – Properties, types, modifications, Durability of bitumen, Adhesion of bitumen, Modified bitumen.	8
5	**Bituminous Mixes:** Desirable properties of mixes, Design of bituminous mixes, Tests on bituminous mixes, Fillers, Theory of fillers and specifications. Marshall, Hubbard Field & Hveam Methods.	8
6	**Cement Concrete:** Constituents and their requirements, Physical, plastic and structural properties of concrete, Factors influencing mix design, Design of concrete mixes for DLC and PQC with appropriate admixtures like flyash and high range water reducing admixtures etc.	8
	Total	**40**

Textbooks:

1. Krebs, Robert D. And Walker, R. D., "*Highway Materials*", McGraw Hill Book Co., New York-1971
2. Her Majesty's Stationery Office, "*Soil Mechanics for Road Engineers*", Ministry of Transport, Road Research Laboratory, UK- 1966
3. Her Majesty's Stationery Office, "*Bituminous Materials in Road Construction*", Ministry of Transport, Road Research Laboratory, UK -1966
4. Her Majesty's Stationery Office, "*Concrete Roads Design and Construction*", Ministry of Transport, Road Research Laboratory, UK-1966

Reference books:

1. Read, J. And Whiteoak, D., "*The Shell Bitumen Handbook*", Fifth edition, Shell Bitumen, Thomas Telford Publishing, London-2003
2. Relevant IRC and IS codes

TRANSPORTATION ENGINEERING
1MTR2-11: RAILWAY, AIRPORTS, PORTS AND HARBOURS

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	Railway: Transportation and its development, Long term operative plans for Indian Railways. Classification of Railway lines and their track standards, Railway terminology, Traction and tractive Resistance, Hauling capacity and tractive effort of locomotives, different Types of Tractions. Permanent Way: Alignment Surveys, Requirement, gauges, track section, Coning of wheels, Stresses in railway track, high speed track. Geometric design of railway track, Gauge, Gradient, speed, super elevation, cant deficiency, Negative super elevation, curves, length of transition curves, grade compensations.	15
3	Airports: Development of Air Transportation in India :, Airport site election. Modern aircraft's. Airport obstructions: Zoning Laws, Imaginary surfaces, Approach and Turning zone, clear zone, vert. Clearance for Highway & Railway. Runway and taxiway design : Windrose, cross wind component, Runway Orientation and confuguration. Basic runway length and corrections, runway geometric design standards. Taxiway Layout and geometric design standards. Taxiway and other areas. Air traffic control : Need, Network, control aids, Instrumental landing systems	14
4	Ports and Harbours: Importance of ports and harbours. Impact on Indian trade and economy, Plan of harbour, various components, jetty, dolphins, bollards, their design and functions.	10
	Total	**40**

Textbooks:

1. Railway Engineering, Saxena;, Dhanpat Rai Publication,
2. Airport Planning & Design, Goyal & Praveen Kumar, Galgotia Publication
3. Harbour, Dock And Tunnel Engineerin, R. Srinivasan ,Charoter publishing house

Reference books:

1. Railway Engineering by Rangwala
2. Airport Engineering Planning And Design (Pb 2020) by SAXENA S.C.

TRANSPORTATION ENGINEERING
1MTR2-12: STATISTICAL METHODS IN TRANSPORTATION ENGINEERING

S.N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Probability distributions:** Introduction to probability and random variables, Binomial distribution, Poisson distribution, Geometric distribution, Hyper Geometric distribution, Normal distribution, Log-Normal distribution, Uniform distribution, Exponential distribution, Gamma distribution, Beta distribution, and Weibull distribution.	7
3	**Parameter Estimation and hypothesis Testing:** Random samples, sampling distributions of mean and variance. Point estimators, the method of maximum likelihood, and the method of moments. Confidence interval. Statistical hypothesis tests, Operations characteristic curve. Tests of hypothesis on the mean of a Normal Distribution, Tests of hypothesis on the means of two Normal distributions, The paired t-test, Tests of hypothesis on one variance, Tests of hypothesis for the equality of two variances, The testing of goodness of fit.	12
4	**Design and Analysis of Experiments:** Fundamental assumptions of analysis of variance, single factor experiments, Latin square and Greeco-Latin square designs, Design of experiments with several factors- Two factor factorial experiments.	10
5	**Regression and Correlation Analysis**: Introduction, Bi-Variate Normal distribution and the associated marginal and conditional distributions, estimation and analysis of simple regression models, correlation coefficients, analysis of correlation coefficients, Hypothesis tests associated with regression and correlation coefficients, curvilinear regression models, Multiple regression models, multiple and partial correlation coefficients. Applications should be taken from transportation planning and traffic engineering.	10
	Total	**40**

Textbooks:

1. Hines, W. W. and Montgomery, D. C., et. al.; "Probability and Statistics in Engineering andManagementScience", John Wiley and Sons, New York, (1990).
2. Freund, J. E.; "Mathematical Statistics", PHI, New Delhi, (1998)
3. Montgomery, D. C.; "Design and Analysis of Experiments", 5th edition, John Wiley and Sons,INC., New York. (2007).

Reference books:

1. Johnston, J. and Dinardo, J.; "Econometric Methods", 4th edition, McGraw-Hill InternationalEditions, (1997).
2. Benjamin, J. R. and Cornell, C. A.; "Probability Statistics and Decision for Civil Engineers",McGraw-Hill, (1960).

TRANSPORTATION ENGINEERING

1MTR2-13: ROAD TRANSPORT MANAGEMENT AND ECONOMICS

SN	Syllabus	Contact hours
1	INTRODUCTION : Objective, scope and outcome of the course	1
2	Motor Vehicles Act - statutory provision for road transport and connected organisations. Route scheduling, Freight transport, Vehicle scheduling, Optimum fleet size, Headway control strategies, Crew scheduling.	7
3	Depots and Terminals - Principles and types of layout, Depot location, Twin depot concept, Crew facilities. Design of parking facilities – Bus terminal, bus stops and bus bays	8
4	Transportation costs - Supply and demand - elasticity of demand; Supply of transport services - Economics of traffic congestion - Pricing policy. Vehicle operating costs - Fuel costs - Maintenance and spares - Depreciation - Crew costs - Value of travel time savings - Accident costs.	8
5	Economic analysis of projects - Methods of evaluation - Cost-benefit ratio, first year rate of return, net present value, and internal-rate of return methods; Indirect costs and benefits of transport projects.	8
6	Financing of road projects - methods – Private Public Partnership (PPP) - Toll collection - Economic viability of Build-Operate-Transfer Schemes – Risk Analysis - Case Studies.	8
	Total	**40**

Textbooks:

1. Winfrey, Economic analysis for Highways, International Textbook Company, Pennsylvania, 1969.

Reference books:

1. CRRI, Road User Cost Study in India, New Delhi, 1982

2. IRC, Manual on Economic Evaluation of Highway Projects in India, SP30, 2007

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TRANSPORTATION ENGINEERING

1MTR2-14: MANAGEMENT OF QUALITY AND SAFETY IN HIGHWAY CONSTRUCTION

SN	Syllabus	Contact hours
1	INTRODUCTION : Objective, scope and outcome of the course	1
2	Total quality Management (TQM) to the construction industry: Evolution, philosophy and principles for building client, the Deming Philip Crosby, J. M. Juran contribution to TQM. Quality as a management process, contractual options and integration.	7
3	TQM to Construction Projects : General application, TQM in pre contract, post contract, commissioning and maintenance phase, Project quality management.	8
4	Auditing: First party auditing, second party auditing, Contraction management adjudication. Accidents: types, causes, direct and indirect cost of accidents, objective of accident prevention programmes.	8
5	Preventative measures: personal protective equipments, job requirements, tools, equipments and fire protection measures. Protection from radioactive,/ toxic material, laser and X-ray equipments.	8
6	Safety Organization and Management: Safety policies, safety organization, safety committees, safety representatives, outside agencies – Govt. intervention, international agreements	8
7	**Total**	**40**

Textbooks:

1. Total Quality in Construction Projects, Ron Baden Hellard ,Thomas Telford, London
2. Engineering Quality in Construction,Michael T Kubal,Mc Graw Hill Inc.

Reference books:

1. Handbook of OSHA Construction Safety & Health, Charles D Reese & James V Eidson

TRANSPORTATION ENGINEERING
1MTR2-15: TUNNEL ENGINEERING

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	Historical: Natural caves, archeological caves and their construction, tunnels for road, rail and hydropower.	9
3	Need for Underground Space: Congestion driven needs for development of infrastructure for transport, water, power supply, vehicle movement in cities, storage of materials.	10
4	Modern Developments: Underground ring roads in mega cities, submerged and floating tunnels, underground libraries, museums, dwelling units, resorts.	10
5	Traffic surveillance and control system (TSCS) in tunnels: Traffic control signs, signals, lights, cameras.	10
	Total	**40**

Textbooks:

1. Engineering Geology & Tunnels Engineering, Jaafar Mohammed
2. Tunnel Engineering Handbook, John O. Bickel and T. R. Kuesel, Krieger Publishing Company

Reference books:

1. Art of Tunnelling, K. Szechy

TRANSPORTATION ENGINEERING
1MTR2-16: GEOMETRIC DESIGN

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Introduction:** Design Controls - Topography and physical features, traffic, vehicular characteristics, speed and safety; Space standards for urban, rural and hill roads, Sight distance requirements, Access controls	7
3	**Cross-section Elements :** Single lane, Two lane, Multi-lane highways, Expressways, Urban roads; Street design concepts, bicycle tracks, pedestrian facilities, street furniture, Design of Speed Breaker	6
4	**Alignment : Horizontal Alignment -** Curve design, Super-elevation design, Transition curve design, Attainment of super-elevation, Pavement widening, Sight distance on horizontal curves; Vertical Alignment - Gradients, Grade compensation, Design of vertical curves, Combination of horizontal and vertical alignment, vertical clearance for underpasses and elevated structures	6
5	**Highway Capacity:** Two lane, Four lane, Six lane non-urban highways, Urban roads, Expressways, HCM USA and IRC Specifications	6
6	**Intersection Geometry:** Visibility requirements, Principles of channelization, Layout design for types of intersections, on-ramps and off-ramps (flyovers and Access controlled facilities), Acceleration and deceleration lanes, Two-way turn lanes	6
7	**Design of Facilities:** Design of on-street and off-street parking facilities, multi-storyed Parking; Design of bus shelters and bus lay-bye, Bus terminal, Truck terminals and truck lay-bye, Container terminal, Toll Plaza, Foot-over bridge and sky-walk	8
	Total	**40**

Textbooks:

1. Wright, P.H. & Dixon, K.K., "Highway Engineering", 7th Ed., John Wiley & Sons. 2004
2. Transportation Research Board (TRB), Highways Capacity Manual, National Research Council, Washington D.C. 2010

Reference books:

1. Khisty, C.J. and Lal, B.K., "Transportation Engineering - An Introduction", Prentice Hall of India Pvt. Ltd. 2006
2. Kadiyali, L.R., "Traffic Engineering and Transport Planning", Khanna Publishers. 2008

TRANSPORTATION ENGINEERING
1MCC3-21: RESEARCH METHODOLOGY AND IPR

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.	5
3	Effective literature studies approaches, analysis, Plagiarism, Research ethics.	6
4	Effective technical writing, how to write report, Paper. Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.	6
5	Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.	6
6	Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR.	6
	Total	**30**

Text books:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science &engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"

Reference books:

1. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
3. Mayall, "Industrial Design", McGraw Hill, 1992.
4. Niebel, "Product Design", McGraw Hill, 1974.
5. Asimov, "Introduction to Design", Prentice Hall, 1962.
6. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in NewTechnological Age", 2016.
7. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

TRANSPORTATION ENGINEERING
1MTR1-06: HIGHWAY MATERIAL TESTING LABORATORY

Course Objectives:

- To conduct various standard tests on soil, aggregate and bitumen.
- To learn bituminous and concrete mix design

List of Practical:

S. N.	Tests for Characterization anduse of Highway materials
1	To conduct identification tests on soils; Heavy compaction test on subgrade soil
2	To perform triaxial test on pure subgrade soil
3	To perform California Bearing Ratio test
4	To perform tests on flyash, pondAsh and bottomash- gradation and other engineering properties required for use as embankment material
5	To perform tests on Bitumen – Penetration Test and Ductility test
6	To perform tests on Bitumen – Softening point test and Thin Film Oven test
7	To perform Elastic recovery/recovery test on binder
8	To conduct Marshall Bituminous Mix design, Bitumen viscosity test (Rotational viscometer);Retained stability test
9	To perform Concrete Mix design – Sample preparations for DLC and PQC with proper ingredients and admixtures for economy.
10	To perform PQC Mix design – as per IRC

Textbooks:

1. Highway Engineering – S.K. Khanna & C.E.G. Justo. New Chand & Brothers.

Reference books:

1. Highway material Testing - S.K. Khanna & C.E.G. Justo.

TRANSPORTATION ENGINEERING
1MTR1-07: PAVEMENT DESIGN LAB

List of Practical:	
S No.	**Tests for Pavement design and Evaluation**
1	To do estimation of Design MSA for a road
2	To do estimation of Design CBR
3	To perform Design of flexible pavement
4	To perform Design of Rigid pavement
5	To conduct Benkelman Beam test on road
6	To assess road safety features on a stretch of road
7	To perform Plate load test for calculating modulus of subgrade reaction
8	To do estimation of Group Index Value
9	To study california Resistance Value Method

Textbooks:

1. Highway Engineering – S.K. Khanna & C.E.G. Justo. New Chand & Brothers.

Reference books:

1. Highway material Testing - S.K. Khanna & C.E.G. Justo.

TRANSPORTATION ENGINEERING
2MTR1-01: PAVEMENT ANALYSIS, DESIGN AND CONSTRUCTION

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Introduction:** Components of pavement structure, importance of sub-grade soil properties on pavement performance. Functions of sub-grade, sub-base, base course and wearing course.	4
3	**Stresses in Flexible Pavements:** Stresses in homogeneous masses and layered systems, deflections, shear failures, equivalent wheel and axle loads.	5
4	**Elements in Design of Flexible Pavements:** Loading characteristics-static, impact and repeated loads, effects of dual wheels and tandem axles, area of contact and tyre pressure, modulus or CBR value of different layers, equivalent single wheel load, equivalent stress and equivalent deflection criterion, equivalent wheel load factors, climatic and environmental factors.	5
5	**Design Methods for Flexible Pavements:** California bearing ratio (CBR), U.S. Navy method. Triaxial method, Mcleod method, Boussinesq's and Burmister's analysis and design method, IRC method for Flexible Pavement Design	5
6	**Rigid Pavements:** Wheel load stresses, Westergaard's analysis, Bradbury's approach Arlington test, Pickett's corner load theory and charts for liquid, elastic and soil of finite and infinite depths of subgrade. IRC Method of rigid pavement design.	5
7	**Temperature Stresses:** Westergaard's and Thomlinson's analysis of warping stresses, Combination of stresses due to different causes, Effect of temperature variation on Rigid Pavements.	5
8	**Reinforced Concrete Slabs:** Prestressed concrete slabs-general details. Design of Tie Bars and Dowel Bars.	3
9	**Road Construction:** Bituminous road construction procedures and specifications, Quality control requirements. Concrete Road construction: Construction methods, Quality control requirements, Joints in cement concrete pavements, reinforced cement concrete road construction. IRC & MORTH recommendations for construction of Bituminous and Concrete roads. Present practices being followed for quality assurance and speedy construction in the country like by NHAI.	7
	Total	**40**

Textbooks:

1. Yoder, E.J. and Witczak, M.W., "Principles of Pavement Design 2nd Ed", John Wiley & Songs, Inc. – 1975
2. O'Flaherty, A. Coleman, "Highways : the Location, Design, Construction and Maintenance of Road Pavements", 4th Ed., Elsevier - 2006
3. Fwa, T.F., "The Hand Book of Highway Engineering", CRC Press Taylor & Francies Group – 2006

Reference books:

1. Khanna, S.K. and Justo, C.E.G., "Highway Engineering Nem Chand Jain & Bros, - 2005
2. Papagiannakis, A.T. and Masad, E.A., "Pavement Design and Materials, John Wiley & Sons Inc - 2008

TRANSPORTATION ENGINEERING
2MTR1-02: TRAFFIC ENGINEERING & MODELING

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Introduction:** Elements of traffic engineering, issues for traffic engineers; road users, vehicles, highways and control devices, modelling concepts.	6
3	**Traffic Stream Characteristics**: Traffic stream parameters, Time Space diagram, relationship among q,k,u, Macroscopic Fundamental Diagrams (MFD).	6
4	**Traffic Studies:** Traffic volume studies, speed, travel time and delay studies, parking studies, RSI Survey, WTP Survey, accident data collection and analysis, pedestrian studies	6
5	**Design concept for intersection & facilities**: Concept of capacity and LOS, Operational analysis of two-way and all-way stop controlled intersections and Roundabouts by US and Indian methods, design of parking facilities, types of signals, Design of signals by Indian, US and British methods, signal coordination.	9
6	**Time Series Analysis:** Basic Components of Time Series, Smoothening and Decomposition Methods, Data Filters, Auto Correlations and Moving Averages.	6
7	**Management Techniques:** Traffic calming; Congestion and road user pricing; priority movements; traffic regulations and control systems; use of intelligent systems.	6
	Total	**40**

Textbooks:

1. William R. Mcshane and Roger P. Roess, "Traffic Engineering", Pearson (4th Edition). 2013
2. Kadiyali, L.R., "Traffic Engineering and Transport Planning", Khanna Publishers. 2012
3. C A O'Flaherty, Ed , "Transport Planning and Traffic Engineering", ButterworthHeinemann, Elsevier, Burlington, MA2006

Reference books:

1. May, A.D., "Fundamentals of Traffic Flow", Prentice Hall, Inc. 2nd Ed. 1990
2. Carlos F. Daganzo. "Fundamentals of Transportation and Traffic Operations", Pergamon 1997
3. Simon P. Washington, Matthew G. Karlaftis and Fred L. Mannering, "Statistical and Econometric Methods for Transportation Data Analysis", 2nd Edition, CRC Press2011

TRANSPORTATION ENGINEERING
2MTR2-11: TRANSPORTATION ENVIRONMENT INTERACTION AND ANALYSIS

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Introduction:** Interaction of transportation systems and facilities with surrounding environment, Impact of transportation on surrounding environment, impact of surrounding environment on transportation systems.	7
3	**Impact on Natural Environment:** Air quality impacts - sources of air pollutants, effects of air pollutants, key legislations and regulations, impact prediction approaches, identification and incorporation of mitigation measures; Noise Impacts - Basic information, key legislation and guidelines, impact prediction methods, identification and incorporation of mitigation measures, Noise barriers and their design; Ground water and marine pollution impacts; Environmental capacities of streets, Environmental Impact statements.	8
4	**Impact on Land Use and Value:** Conceptual approach for addressing socio-economic impacts; Visual impacts and criteria, scoring methodologies for visual impact analysis; Relocation impacts; Land value impacted due to transportation facility; Spatial reorganization and Regional Development impacts.	8
5	**Environmental Impact Analysis:** Concepts of environmental impact analysis, key features of National environmental policy act and its implementation, screening in the EIA process, utility and scope of EIA process, Environmental protection acts EIA at national level, Conceptual approach for environmental impact studies, planning and management of impact studies, matrix and network methodologies for impact identification, description of the affected environmental – environmental indices; Public Participation – Objectives, and techniques for conflict management and dispute resolution, verbal communication in EIA studies .	8
6	**Energy Issues in Transportation:** Energy consumption, alternate transportation fuels, energy conservation, energy contingency strategies, energy analysis information and methods, Transportation alternatives.	8
	Total	**40**

Textbooks:

1. CANTER, L.W., Environmental impact assessment, McGraw-Hill, 1997
2. Peter Morris & Riki Therivel, Methods of Environmental Impact Assessment, Routledge, 2001.
3. Denver Tolliver, Highway Impact Assessment, Greenwood Publishing Group, 1993.
4. Edward K Morlok, Introduction to transportation Engineering and Planning, Mc-Graw Hill Book Company, New Delhi

Reference books:

1. John W. Dickey and others, Metropolitan Transportation Planning, Tata McGraw-Hill Publishing Compant Ltd., New Delhi
2. C. Jotin Khisty and B Kent lall, Transportation Engineering – An introduction, Prentice-Hall of India Pvt Ltd, New Delhi.

TRANSPORTATION ENGINEERING

2MTR2-12: URBAN MASS TRANSPORTATION SYSTEM`

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Introduction:** Mass transit systems, Elements / components of transit systems; Urban Mass Transit systems- types, characteristics, suitability and adaptability of these systems; Evolution of urban transportation.	5
3	**Transit System Planning:** Planning needs; Short-range and long-range planning; Planning procedures and methodology, Data collection; Medium performance transit systems and high performance transit systems; trends in transit planning	6
4	**Transit Demand Estimation and Evaluation:** Transit demand forecasting; transit mode evaluation; comparison and selection of most suitable transit mode.	6
5	**Transit System Operations:** Basic operational elements; transit travel characteristics; transit scheduling; transit line analysis – planning objectives, geometry, types and their characteristics, capacity of transit lines, system procedures for improving transit line capacity.	6
6	**Transit Networks and System Analysis:** Transit networks – types and their characteristics; transfers in transit networks; system analysis in transit – conceptual models, modeling procedures; terminal or station location planning – issues, objectives, station spacing decisions.	6
7	**Economics and Financing of Transit Systems:** Transit system performance and economic measures; transit fares – structure, collection and levels; financing of transit services; public and private integration of transit services.	6
8	**Case studies of urban mass transportation systems adopted in India in recent years including Delhi Metro, Jaipur Metro, metro bus service, mono rail etc.**	4
	Total	**40**

Textbooks:

1. Vukan R. Vuchic, “Urban Transit – Operations, Planning and Economics”, John Willey and Sons, Inc., USA - 2004
2. Vukan R. Vuchic, “Urban Transit – Operations, Planning and Economics”, John Willey and Sons, Inc., USA - 1980
3. Vukan R. Vuchic, “Urban Transit – Operations, Planning and Economics”, John Willey and Sons, Inc., USA -2006

Reference books:

1. C Jotin Khisty and B Kent Lall, “Transportation Engineering” PrenticeHall of India Pvt Ltd., New Delhi - 2003

TRANSPORTATION ENGINEERING
2MTR2-13: SUSTAINABLE CONSTRUCTION ENGINEERING

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	Fundamentals of Sustainable Construction Engineering- Sustainability and resources, need, present practices at national and international level, The Sustainability Quadrant- challenges & Issues, Government initiatives	7
3	Construction Product, Process Design and Development- Sustainability of construction resources, process modifications, product performance evaluation.	8
4	Sustainability assessment using standard approaches- LEED/GRIHA rating evaluation process.	8
5	Socio-economic feasibility of sustainable construction products- Innovative & customized sustainable product design based on social constraints, tools & aids available for sustainable construction products.	8
6	Life Cycle Assessment and Costing-Various aspects related to construction cost, present value analysis, life cycle stages, cost calculation & measures, evaluation criteria, uncertainty assessment, sensitivity analysis, break even analysis.	8
	Total	**40**

Textbooks:

1. Sustainable Engineering Practice ASCE Publication 2010.
2. Hagger Sustainable Industrial Design and Waste Management, Techniz Book 2010.
3. Helmut Rechberger, Practical handbook of Material Flow Analysis, Taylor & Francis. 2010

Reference books:

1. Michael Z. Hou, Heping Xie, Jeoungseok Yoon Underground Storage of CO2 and Energy Taylor & Francis, 2010
2. LEED for India: Reference Guide, 2011.

TRANSPORTATION ENGINEERING

2MTR2-14: ROAD CONSTRUCTION EQUIPMENT

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Introduction:** Working principle, capacity, rate of production, applications, advantages and limitations of various types of construction equipment	7
3	**Equipment for earthwork excavation, hauling and spreading :** Dozers; power shovels, Scrappers, Tippers and trucks, Motor graders, - application, types, production capacity, factors affecting production, optimum number of equipments for construction. Different types of soil compactors and their applications	8
4	**Plants for aggregates production** – different types of crushers, Mixing plants: Pug mill for WMM, other cold mix plants, Hot mix Plants for bituminous mixes; factors affecting production capacity, Optimum number and location. Mixing plants for cement concrete	8
5	**Paving and compacting equipment:** Different types of pavers and compacting equipment for bituminous mixes, Fixed form type paver and Slip form type paver for CC pavements –their advantages **Miscellaneous Equipment:** Kerb casting equipment, road marking equipment, bitumen sprayers, water tankers	8
6	**Equipment Management:** Equipment planning, forecasting equipment requirement, maintenance, workshop, work study, Selection of Construction Equipment – task considerations, cost considerations, equipment acquisition options	8
	Total	**40**

Textbooks:

1. Peurifoy/ Schexnayder "Construction Planning, Equipment and Methods"- McGraw-Hill Higher Education
2. Sharma S.C. "Construction Equipment and its Management"- Khanna Publishers, Delhi

Reference books:

1. K.K. Chitkara, "Construction Project Management,-Planning, Scheduling and Controlling"- Tata McGraw –Hill Publications
2. "Operation Manuals of various equipment manufacturers".

TRANSPORTATION ENGINEERING
2MTR2-15: PAVEMENT MAINTENANCE AND MANAGEMENT SYSTEM

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Pavement Evaluation and Performance:** General concept of pavement evaluation, evaluation of pavement performance, evaluation of pavement structural capacity, evaluation of pavement distress, evaluation of pavement safety.	5
3	**Types of Distress:** Structural and functional, serviceability, fatigue cracking, pavement deformation and behaviour in flexible and rigid pavements. Low temperature shrinkage cracking, Factors affecting performance, relation between performance and distress.	6
4	**Pavement Evaluation & Measuring Equipments:** Functional & Structural Evaluation, Functions Parameters such as Roughness, Distress, Rutting, Skid Resistance etc. Structural Parameters such as Structural Capacity. Benkelman Beam, Bump Integrators of various types, dynaflect. Demonstration of equipments for dynamic testing of pavements. Digital ultrasonic concrete tester. Radiographic and infra red testing. Pavement skid resistance measuring equipments, fatigue testing equipments, on-site and on- line testing with sensors, strain-gages LVDTs and data acquisition system.	8
5	**Pavement Overlays:** Flexible overlays and determination of overlay thickness. Rigid overlays and determination of overlay thickness including thin toppings. Design of Overlay by Benkelman Beam and Falling Weight Deflect meter.	4
6	**Design Alternatives –** Analysis, Evaluation and Selection: Framework for pavement design, design objectives and constraints, Basic structural response models, characterization of physical design inputs, Generating alternative pavement design strategies. Economic evaluation of alternative pavement design strategies, analysis of alternative design strategies. Predicting distress, predicting performance, selection of optimal design strategies.	8
7	**Pavement Management System:** Introduction to Pavement Management System (PMS) & Maintenance Management System (MMS), construction, maintenance and rehabilitation. Feedback data system. Examples of Working Design and Management Systems. Implementation of a pavement management system.	8
	Total	**40**

Textbooks:

1. Hass, R., Hudson, W.R. and Zaniewski, J. "Modern Pavement Management" Krieger.-1994
2. Fwa, T.F., "The Hand Book of Highway Engineering", CRC Press, Taylor & Francies Group.-2006
3. Shain, M.Y., "Pavement Management for Airports, Roads and Parking Lots", Kluwer Academic Publishers Group-2004
4. Khanna, S.K. and Justo, C.E.G., "Highway Engineering" Nem Chand & Bros, Roorkee (U.A.) 8th Ed. -2005

Reference books:

1. Hudson, W.R., Haas, R. and Uddin, W., "Infrastructure Management", McGraw Hill -1997
2. Hass R. & Hudson, W.R., "Pavement Management System", Mc Graw Hill Company, Inc. New York -1978

TRANSPORTATION ENGINEERING
2MTR2-16: PLANNING, DESIGN AND CONSTRUCTION OF RURAL ROADS

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Planning of Rural Roads:** Classification of Roads, Brief introduction to earlier 20 year Plans, System's Approach, NATPAC Model, Gravity Model, CRRI Model, FBRNP Model, Concepts of PMGSY	5
3	Geometric Design: Geometric Design Standards for Rural Roads with special reference to PMGSY, Hill Road Standards	4
4	**Pavement Design**: Various pavement design methods for Rural roads including Flexible and Rigid pavements using IRC:SP-20, IRC-72, IRC-37, IRC:SP-62, CRRI Nomograms	4
5	**Mix Design Methods:** CRRI Method, Triangular Chart Method, Fuller's Method, Rothfuch method, PI based Method	4
6	**Materials:** Brief introduction to conventional materials, Marginal and Waste Materials including Fly Ash, GBFS, BFS, SMS, Bagasse, CRMB, etc	4
7	**Construction:** Case Studies of Waste Material Utilization in Rural Roads, Low Cost Techniques for Rural Road Construction, Tractor Bound Technology, Special Considerations for Hill Areas	8
8	**Drainage:** Transverse and Longitudinal Drainage, Design of drains, Minor CD Works, Filter Design etc	6
9	**Maintenance:** Type and Causes of Failures, Remedies	4
	Total	**40**

Textbooks:

1. Khanna S.K., Justo C.E.G, "Highway Engineering", Nem Chand & Bros, Roorkee- 2004
2. L R Kadiyali, "Traffic Engineering and Transport Planning", Khanna Publishers, Delhi - 1999
3. Quality Assurance Handbook for Rural Roads, NRRDA, Govt. of India – 2007

Reference books:

1. Rural Roads Manual , SP-20, IRC - 2002
2. Document on Rural Road Development, Vol I & II, CRRI -1990
3. PMGSY Operation Manual, NRRDA, Govt of India -2005
4. Specifications for Rural Roads, MoRD, IRC -2004

TRANSPORTATION ENGINEERING
2MTR1-06: TRAFFIC ENGINEERING LAB

S. No.	The experiments may include:
1	To conduct Traffic volume data collection at midblock section in urban area and its analysis
2	To conduct Traffic volume data collection at rural highway section and its analysis
3	To conduct Categorized vehicle speed data collection at urban and rural sections and its analysis
4	To Derive flow relationships between flow characteristics based on volume and speed data collected
5	To do Speed and delay study using Moving observed method
6	To peform Volume study at a roundabout to examine its capacity
7	To perform Volume and speed study at a four legged intersection
8	To perform Parking study in a market or commercial area (accumulation and duration analysis)
9	To Analysis accident data procured from police stations

TRANSPORTATION ENGINEERING
2MTR1-07: STATISTICAL AND NUMERICAL ANALYSIS LAB

S No.	The experiments/activities may include:
1	To study Newton's forward interpolation method
2	To study Newton's backward interpolation method
3	To study Lagrange's interpolation method
4	To study Newton Raphson method
5	To determine Solution of ODE by Runge-Kutta method
6	To perform Calculation of eigen values and eigen vector method
7	To Analysis variance and application
8	To study Linear regression analysis and their application
9	To study Multiple regression analysis and their application

TRANSPORTATION ENGINEERING
2MTR4-50: MINI PROJECT WITH SEMINAR

S No.	Some suggested topics are:
1	To Study and perform evaluation of an intersection in a city
2	To Study and evaluate mode of transport in a city
3	To Study accidents in a city and remedial measures
4	To conduct study on Futuristic transportation planning
5	To analysis Parking pattern of a given area
6	To conduct Study of congestion and to suggest remedial measures
7	To Study various road safety measures adopted

Note: The student can take real time problem, collect data, analyze and present in a seminar.
Latest developments in the area of transportation can be studied from literature and presented in the form of seminar.

TRANSPORTATION ENGINEERING
3MTR2-11: Remote sensing and GIS

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Introduction: Definitions of GIS** – Components of GIS – Geographic data presentation: maps – mapping process – coordinate systems – transformations – map projections – geo referencing - data acquisition.	9
3	**Geographic Data Representation, Storage, Quality and Standards**: Storage - Digital representation of data – Data structures and database management systems – Raster data representation – Vector data representation – Concepts and definitions of data quality – Components of data quality – Assessment of data quality – Managing data errors – Geographic data standards.	10
4	**GIS Data Processing, Analysis and Modeling:** Raster based GIS data processing – Vector based GIS data processing – Queries – Spatial analysis – Descriptive statistics – Spatial autocorrelation – Quadrant counts and nearest neighbour analysis – Network analysis – Surface modeling – DTM.	10
5	**GIS Applications:** Applications of GIS in Environment monitoring – Natural hazard management, Transport Planning, Analysis and monitoring. Use of softwares related to GIS applications in Transportation Engineering.	10
	Total	**40**

Text books:

1. Lo, C.P. & Yeung A.K.W., Concepts and Techniques of Geographic Information Systems, Prentice Hall of India, New Delhi, 2006.
2. Anji Reddy, M., Remote Sensing and Geographical Information Systems, B.S.Publications, Hyderabad, 2001.
3. Burrough, P.A., Principles of Geographical Information Systems, Oxford Publication, 1998.
4. Clarke, K., Getting Started with Geographic Information Systems, Prentice Hall, New Jersy, 2010.
5. DeMers, M.N., Fundamentals of Geographic Information Systems, John Wiley & Sons, New York, 2002.

Reference books:

1. Geo Information Systems – Applications of GIS and Related Spatial Information Technologies, ASTER Publication Co., Chestern (England), 1992
2. Jeffrey, S. & John E., Geographical Information System – An Introduction, Prentice-Hall, 1990
3. Marble, D.F., Galkhs HW & Pequest, Basic Readings in Geographic Information Systems, Sped System Ltd., New York, 1984.

TRANSPORTATION ENGINEERING
3MTR2-12: ADVANCED CONCRETE TECHNOLOGY

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Cement:** composition and reaction mechanism	4
3	**Concrete containing cementitious material:** Use of fly ash, silica fume and GGBFS in concrete, reaction mechanism, properties of fresh and hardened concrete	8
4	**Structural Concrete:** High Strength concrete, high performance concrete, Self-compacting concrete, ready mix concrete, polymer concrete: materials, admixtures, applications and properties of fresh and hardened concrete	8
5	**Fiber Reinforced Concrete**: constituent materials and properties, mechanics of fiber reinforced concrete, properties of fresh and hardened concrete	7
6	**Durability of concrete:** Carbonation, chloride ingress, corrosion, sulphate attack, freezing and thawing: Factors affecting, effects, mechanisms, prevention and control	6
7	**Creep and Shrinkage**: Factors affecting, effects, mechanisms, prevention and control	6
	Total	**40**

Text Books:

1. A.M. Neville, “Properties of Concrete”, Pearson Education, 1995

2. A.M. Neville & J.J. Brooks, “Concrete Technology”, Addison- Wesley, 1999

Reference books:

1. P.K. Mehta & P.J.M. Monterio, “Concrete”, ICI, 1999

TRANSPORTATION ENGINEERING
3MTR2-13: GROUND IMPROVEMENT TECHNIQUE

S. N.	Course Content	Contact Hours
1	**INTRODUCTION :** Objective, scope and outcome of the course	1
2	**Introduction:** Typical situations where ground improvement becomes necessary, Historical review of methods adopted in practice, Current status and the scope in the Indian context.	7
3	**Methods of Ground Improvement:** Mechanical compaction, Dynamic compaction, Impact loading, Compaction by blasting, Vibro-compaction; Pre-compression, Dynamic consolidation, Design aspects of stone columns; Use of admixtures, Injection of grouts; Design guidelines and quality control, Design examples on preloading with sand drains, Road designs with Geo-synthetics.	8
4	**Reinforced Earth:** Basic mechanism, Constituent materials and their selection; Engineering applications – Shallow foundations on reinforced earth, Design of reinforced earth retaining walls, Reinforced earth embankments structures, Wall with reinforced backfill, Analysis and design of shallow foundations on reinforced earth.	8
5	**Geo-textiles:** Selection and engineering applications, Design examples, Stabilisation/Improvement of ground using Geo-membranes, Geo-cells, Geonets, Geosynthetic walls.	8
6	**Soil Nailing:** Construction of underground structures, Landslide controls, Deep vertical cuts, contiguous piles.	4
7	**Problematic Soils:** Use of ply soils, Improvement of saline soils, Improvement of black cotton soils, Collapsible soil, Dune Sand.	4
	Total	**40**

Text Books:

1. Moseley, M. P. and Kirsch K.," Ground Improvement", Spon Press, Taylor and Francis2004
2. Mittal, Satyendra, "Ground Improvement Engineering", Vikas Publishing House 2010
3. Koerner, R.M.," Designing with Geosynthetics"' Prentice Hall 1990
4. Saran, S., "Reinforced Soil and Its Engineering Applications", I.K. International 2005

Reference books:

1. Rao, G.V., Geosynthetics – An Introduction, Sai Master Geoenvironmental Services(P) Ltd. 2007
2. Jones, CJFP, "Earth Reinforcement and soil structure", Thomas Telford 1996
3. Shukla, S.K., Yin, Jian-Hua, "Fundamentals of Geosynthetic Engineering", Taylor & Francis

Syllabus and Scheme

M.Tech in Computer Science

(2023-24)

Teaching & Examination Scheme
M.Tech.: Computer Science and Engineering
1st Year –I Semester

S. No	Course Type	Course Code	Course Name	Contact Hours per Week			Marks				Credits
				L	T	P	Exam Hrs	IA	ETE	Total	
1	PCC	1MCS1-01	Statistical Methods in Computer Science	3	0	0	3	30	70	100	3
2	PCC	1MCS1-02	Digital Forensics	3	0	0	3	30	70	100	3
3	PEC	1MCS2-11	Machine Learning	3	0	0	3	30	70	100	3
		1MCS2-12	Security Assessment and Risk Analysis								
		1MCS2-13	Computer Vision								
4	PEC	1MCS2-14	Computational Intelligence	3	0	0	3	30	70	100	3
		1MCS2-15	Malware Analysis & Reverse Engineering								
		1MCS2-16	Data Preparation and Analysis								
5	MCC	1MCC3-21	Research Methodology and IPR	2	0	0	2	30	70	100	2
6	PCC	1MCS1-06	IoT Based Systems Design Lab	0	0	4	4	60	40	100	2
7	PCC	1MCS1-07	Network Simulation and Security Analysis Lab	0	0	4	4	60	40	100	2
8	SODECA	1MCS5-00	Social Outreach Discipline & Extra Curriculum Activities							100	2
			Total	**14**	**0**	**8**		**270**	**430**	**800**	**20**

L: *Lecture,* ***T:*** *Tutorial,* ***P:*** *Practical,* ***Cr:*** *Credits*
ETE: *End Term Exam,* ***IA:*** *Internal Assessment*

Office of Dean Academic Affairs
Rajasthan Technical University, Kota

Teaching & Examination Scheme
M.Tech.: Computer Science and Engineering
1st Year – II Semester

S. No	Course Type	Course Code	Course Name	Contact Hours per Week			Marks				Cr
				L	T	P	Exam Hrs	IA	ETE	Total	
1	PCC	2MCS1-01	Data Science	3	0	0	3	30	70	100	3
2	PCC	2MCS1-02	Distributed and Parallel Algorithms	3	0	0	3	30	70	100	3
3	PEC	2MCS2-11	Big Data Analytics	3	0	0	3	30	70	100	3
		2MCS2-12	Data Security and Access Control								
		2MCS2-13	Data Storage Technologies and Networks								
4	PEC	2MCS2-14	Knowledge Discovery	3	0	0	3	30	70	100	3
		2MCS2-15	Secure Software Design and Enterprise Computing								
		2MCS2-16	Wireless Sensor Networks								
5	MCC	2MCC3-XX	Audit Course-I	2	0	0					
6	PCC	2MCS1-06	High Performance Computing Lab	0	0	4	4	60	40	100	2
7	PCC	2MCS1-07	Data Analytics Lab	0	0	4	4	60	40	100	2
8	REW	2MCS4-50	Mini Project with Seminar	0	0	4	4	60	40	100	2
9	SODECA	2MCS5-00	Social Outreach Discipline & Extra Curriculum Activities							100	2
			Total	**14**	**0**	**12**		**300**	**400**	**800**	**20**

L: *Lecture,* ***T:*** *Tutorial,* ***P:*** *Practical,* ***Cr:*** *Credits*
ETE: *End Term Exam,* ***IA:*** *Internal Assessment*

Office of Dean Academic Affairs
Rajasthan Technical University, Kota

Teaching & Examination Scheme
M.Tech.: Computer Science and Engineering
2nd Year – III Semester

S. No	Course Type	Course Code	Course Name	Contact Hours per Week			Marks				Credits
				L	T	P	Exam Hrs	IA	ETE	Total	
1	PEC	3MCS2-01	Business Intelligence	3	0	0	3	30	70	100	3
		3MCS2-02	Block-Chain Technologies								
		3MCS2-03	Social Network Analysis								
2	MCC	3MCC3-XX	Open Elective	3	0	0	3	30	70	100	3
3	MCC	3MCC3-XX	Audit Course-II	2	0	0	2				
4	REW	3MCS4-60	Dissertation-I / Industrial Project	0	0	20		240	160	400	10
			Total					**300**	**300**	**600**	**16**

L: *Lecture,* ***T:*** *Tutorial,* ***P:*** *Practical,* ***Cr:*** *Credits*
ETE: *End Term Exam,* ***IA:*** *Internal Assessment*

*: *Not to be considered for award of divison*

Office of Dean Academic Affairs
Rajasthan Technical University, Kota

Teaching & Examination Scheme
M.Tech.: Computer Science and Engineering
2nd Year – IV Semester

S. No	Course Type	Course Code	Course Name	Contact Hours per Week			Marks				Credits
				L	T	P	Exam Hrs	IA	ETE	Total	
1	REW	4MCS4-70	Dissertation-II	0	0	32		360	240	600	16
			Total					**360**	**240**	**600**	**16**

L: *Lecture,* ***T:*** *Tutorial,* ***P:*** *Practical,* ***Cr:*** *Credits*
ETE: *End Term Exam,* ***IA:*** *Internal Assessment*

Office of Dean Academic Affairs
Rajasthan Technical University, Kota

1MCS1-01: Statistical Methods in Computer Science

Core Subjects:

Course Name	**Statistical Methods in Computer Science**
Credits	3
Pre-Requisites	Discrete Mathematics

CONTENT	CONTACT HOURS
Unit 1 Introduction: Probability mass, density, and cumulative distribution functions, Parametric families of distributions, Expected value, variance, conditional expectation, Applications of the univariate and multivariate Central Limit Theorem, Probabilistic inequalities, Markov chains	6
Unit 2 Sampling: Random samples, sampling distributions of estimators, Methods of Moments and Maximum Likelihood,	4
Unit 3 Introduction to multivariate statistical models: Statistical inference, Introduction to multivariate statistical models: regression and classification problems, principal components analysis, The problem of overfitting model assessment.	5
Unit 4 Graph Theory: Isomorphism, Planar graphs, graph colouring, Hamilton circuits and Euler cycles. Permutations and Combinations with and without repetition. Specialized techniques to solve combinatorial enumeration problems.	10
Unit 5 Computer science and engineering applications: Data mining, Network protocols, analysis of Web traffic, Computer security, Software engineering, Computer architecture, operating systems, distributed systems, Bioinformatics, Machine learning.	10
Unit 6 Recent Trends: Recent Trends various distribution functions in mathematical field of computer science for varying fields like bioinformatic, soft computing, and computer vision.	5

References:

1. John Vince, Foundation Mathematics for Computer Science, Springer.
2. K. Trivedi Probability and Statistics with Reliability, Queuing, and Computer Science Applications. Wiley.
3. M. Mitzenmacher and E. Upfal.Probability and Computing: Randomized Algorithms and Probabilistic Analysis.
4. Alan Tucker, Applied Combinatorics, Wiley
5. An Introduction to Statistical. Learning. Gareth James. Daniela Witten. Trevor Hastie.

1MCS1-02: Digital Forensics

Course Name	Digital Forensics
Credits	3
Pre-Requisites	Cybercrime and Information Warfare, Computer Networks

CONTENT	CONTACT HOURS
Unit 1: Digital Forensics Science: Forensics science, computer forensics, and digital forensics. **Computer Crime:** Criminalistics as it relates to the investigative process, analysis of cyber-criminalistics area, holistic approach to cyber-forensics	7
Unit 2: Cyber Crime Scene Analysis: Discuss the various court orders etc., methods to search and seizure electronic evidence, retrieved and un-retrieved communications, Discuss the importance of understanding what court documents would be required for a criminal investigation.	7
Unit 3: Evidence Management & Presentation: Create and manage shared folders using operating system, importance of the forensic mindset, define the workload of law enforcement, explain what the normal case would look like, define who should be notified of a crime, parts of gathering evidence, Define and apply probable cause.	7
Unit 4: Computer Forensics: Prepare a case, begin an investigation, understand computer forensics workstations and software, conduct an investigation, complete a case, Critique a case. **Network Forensics:** open-source security tools for network forensic analysis, requirements for preservation of network data.	8
Unit 5: Mobile Forensics: mobile forensics techniques, mobile forensics tools. **Legal Aspects of Digital Forensics:** IT Act 2000, amendment of IT Act 2008.	7
Unit 6: Recent Trends: Recent Trends Mobile forensic technique and methods to search and seizure electronic evidence.	4

References:

1. John Sammons, The Basics of Digital Forensics, Elsevier
2. John Vacca, Computer Forensics: Computer Crime Scene Investigation, Laxmi Publications
3. A Practical Guide to Digital Forensics Investigations Darren R. Hayes.
4. Digital Forensics and Incident Response Incident response techniques and procedures to respond to modern cyber threats, 2nd Edition Gerard Johansen.
5. B. Nelson, A. Phillips, F Enfinger, C Steuart, Guide to Computer Forensics and Investigations, 4th Edition, Course Technology, 2010

1MCS2-11: Machine learning

Course Name	Machine learning
Credits	3
Pre-Requisites	

CONTENT	CONTACT HOURS
Unit 1: **Supervised Learning (Regression/Classification):** • Basic methods: Distance-based methods, Nearest-Neighbours, Decision Trees, Naive Bayes • Linear models: Linear Regression, Logistic Regression, Generalized Linear Models • Support Vector Machines, Nonlinearity and Kernel Methods • Beyond Binary Classification: Multi-class/Structured Outputs, Ranking	10
Unit 2: **Unsupervised Learning:** • Clustering: K-means/Kernel K-means • Dimensionality Reduction: PCA and kernel PCA • Matrix Factorization and Matrix Completion • Generative Models (mixture models and latent factor models)	5
Unit 3 **Machine Learning Algorithm and Models:** Evaluating Machine Learning algorithms and Model Selection, Introduction to Statistical Learning Theory, Ensemble Methods (Boosting, Bagging, Random Forests)	5
Unit 4 **Modelling in Machine Learning:** Sparse Modelling and Estimation, Modelling Sequence/Time-Series Data, Deep Learning and Feature Representation Learning.	6
Unit 5 **Advanced Topics in Machine Learning:** Scalable Machine Learning (Online and Distributed Learning) A selection from some other advanced topics, e.g., Semi-supervised Learning, Active Learning, Reinforcement Learning, Inference in Graphical Models, Introduction to Bayesian Learning and Inference	9
Unit 6: **Recent trends:** Recent trends in various learning techniques of machine learning and classification methods for IOT applications. Various models for IOT applications.	5

References:

1. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer 2009 (freely available online)
3. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007.
4. Tom Mitchel, Machine Learning, McGraw Hill Science, 1997
5. G. James, D. Witten, T. Hastie, R. Tibshirani, An introduction to statistical learning with applications in R, Springer, 2013.
6. Wasserman, All of Statistics, 1 st Edition, Springer, 2004

1MCS2-12: Security Assessment and Risk Analysis

Course Name	Security Assessment and Risk Analysis
Credits	3
Pre-Requisites	Computer and Network Security

CONTENT	CONTACT HOURS
Unit 1: SECURITY BASICS: Information Security (INFOSEC) Overview: critical information characteristics – availability information states – processing security counter measures education, training and awareness, critical information characteristics – confidentiality critical information characteristics – integrity, information states – storage, information states – transmission, security counter measures policy, procedures and practices, threats, vulnerabilities.	7
Unit 2: Threats to and Vulnerabilities of Systems: Definition of terms (e.g., threats, vulnerabilities, risk), major categories of threats (e.g., fraud, Hostile Intelligence Service (HOIS), malicious logic, hackers, environmental and technological hazards, disgruntled employees, careless employees, HUMINT, and monitoring), threat impact areas, Countermeasures: assessments (e.g., surveys, inspections), Concepts of Risk Management: consequences (e.g., corrective action, risk assessment), cost/benefit analysis of controls, implementation of cost-effective controls, monitoring the efficiency and effectiveness of controls (e.g., unauthorized or inadvertent disclosure of information), threat and vulnerability assessment	7
Unit 3: Security Planning: Directives and procedures for policy mechanism, Risk Management: acceptance of risk (accreditation), corrective actions information identification, risk analysis and/or vulnerability assessment components, risk analysis results evaluation, roles and responsibilities of all the players in the risk analysis process, Contingency Planning/Disaster Recovery: agency response procedures and continuity of operations, contingency plan components, determination of backup requirements, development of plans for recovery actions after a disruptive event, development of procedures for offsite processing, emergency destruction procedures, guidelines for determining critical and essential workload, team member responsibilities in responding to an emergency situation	8
Unit 4: POLICIES AND PROCEDURES: Physical Security Measures: alarms, building construction, cabling, communications centre, environmental controls (humidity and air conditioning), filtered power, physical access control systems (key cards, locks and alarms) Personnel Security Practices and Procedures: access authorization/verification (need to know), contractors, employee clearances, position sensitivity, security training and awareness, systems maintenance personnel, Administrative Security Procedural Controls: attribution, copyright protection and licensing , Auditing and Monitoring: conducting security reviews, effectiveness of security programs, investigation of security breaches, privacy review of accountability controls, review of audit trails and logs	8
Unit 5: Operations Security (OPSEC): OPSEC surveys/OPSEC planning	8

INFOSEC: computer security – audit, cryptography encryption (e.g., point to point, network, link), cryptography key management (to include electronic key), cryptography strength (e.g., complexity, secrecy, characteristics of the key)	
Unit 6: Case study of threat and vulnerability assessment	2

References:

1. Principles of Incident Response and Disaster Recovery, Whitman & Mattord, Course Technology ISBN: 141883663X
2. Security Risk Assessment 1st Edition John White
3. Information Security Risk Analysis Thomas R. Peltier
4. (Web Link) http://www.cnss.gov/Assets/pdf/nstissi_4011.pdf

1MCS2-13: Computer Vision

Course Name	Computer Vision
Credits	3
Pre-Requisites	Linear algebra, vector calculus, Data structures and Programming.

CONTENT	CONTACT HOURS
Unit 1: Overview: computer imaging systems, lenses, Image formation and sensing, Image analysis, pre-processing and Binary image analysis	6
Unit 2: Image Detection: Edge detection, Edge detection performance, Hough transform, corner detection	5
Unit 3: Segmentation, Morphological filtering, Fourier transform.	5
Unit 4: Image Features: Feature extraction, shape, histogram, color, spectral, texture, using CVIPtools, Feature analysis, feature vectors, distance /similarity measures, data pre processing	10
Unit 5: Pattern Analysis: Clustering: K-Means, K-Medoids, Mixture of Gaussians Classification: Discriminant Function, Supervised, Un-supervised, Semi supervised Classifiers: Bayes, KNN, ANN models; Dimensionality Reduction: PCA, LDA, ICA, and Non-parametric methods.	10
Unit 6: Recent trends in Activity Recognition, computational photography, Biometrics.	4

References:

1. Computer Vision: Algorithms and Applications by Richard Szeliski.
2. Deep Learning, by Goodfellow, Bengio, and Courville.
3. Dictionary of Computer Vision and Image Processing, by Fisher et al.
4. Computer Vision: Models, Learning, and Inference by Simon Prince
5. Computer Vision: A Modern Approach by David Forsyth and Jean Ponce
6. Recent Trends in Image and Signal Processing in Computer Vision Shruti Jain, Sudip Paul
7. Deep Learning in Computer Vision Principles and Applications Mahmoud Hassaballah, Ali Ismail Awad
8. Modern Deep Learning and Advanced Computer Vision A Perspective Approach Dr.P.S.Jagadeesh Kumar, Prof. Thomas Binford, Dr.J. Ruby, J. Lepika

1MCS2-14: Computational Intelligence

Course Name	Computational Intelligence
Credits	3
Pre-Requisites	Basic knowledge of Data structure, programming.

CONTENT	CONTACT HOURS
Unit 1: Introduction to Computational Intelligence: Computational Intelligence Paradigms, Introduction to Fuzzy logic, Fuzzy sets and membership functions, Operations on Fuzzy sets, Fuzzy relations, rules, propositions, implications and inferences, Defuzzification techniques, Fuzzy logic controller design.	7
Unit 2: Artificial neural networks: Artificial Neuron, Supervised Learning Neural Networks, Unsupervised Learning Neural Networks, Performance Issues (Supervised Learning), Performance Measures, Accuracy, Complexity, Convergence.	7
Unit 3: Evolutionary computation: Introduction to Evolutionary Computation, Genetic Algorithms: Crossover, mutation, selection, Differential evolution algorithm, Hybrid Differential Evolution Strategies, Differential Evolution for Discrete-Valued Problems**.**	7
Unit 4: Multi-objective Optimization Problem Solving: Concept of multi-objective optimization problems (MOOPs) and issues of solving them, Multi-Objective Evolutionary Algorithm (MOEA), Non-Pareto approaches to solve MOOPs, Pareto- based approaches to solve MOOPs, Some applications with MOEAs.	9
Unit 5: Applications of computational intelligent techniques: In solving single- objective and multi-objective optimization, scheduling problem, Parameter Estimation for Frequency-Modulated (FM) Sound Waves, Lennard-Jones Potential Problem, Gear Train Problem, Pressure vessel optimization problem, Welded beam design optimization problem	10

References:

1. A. P. Engelbrecht, Computational Intelligence: An Introduction, John Wiley & Sons, 2007.
2. Fuzzy Logic with Engineering Applications (3rd Edn.), Timothy J. Ross, Willey, 2010.
3. X. Yu and M. Gen, Introduction to Evolutionary Algorithms, Springer Verlag, 2010.
4. An Introduction to Genetic Algorithms, Melanie Mitchell, MIT Press, 2000.
5. Foundations of Neural Networks, Fuzzy Systems, and Knowldge Engineering, Nikola K. Kasabov, MIT Press, 1998.

1MCS2-15: Malware Analysis and Reverse Engineering

Course Name	Malware Analysis and Reverse Engineering
Credits	3
Pre-Requisites	

CONTENT	CONTACT HOURS
Unit 1: Introduction to Malware Analysis: Fundamentals of Malware Analysis (MA), Reverse Engineering Malware (REM) Methodology, Brief Overview of Malware analysis lab setup and configuration, Introduction to key MA tools and techniques, Behavioral Analysis vs. Code Analysis, Resources for Reverse-Engineering Malware (REM) Understanding Malware Threats, Malware indicators, Malware Classification, Examining Clam AV Signatures, Creating Custom Clam AV Databases, Using YARA to Detect Malware Capabilities, Creating a Controlled and Isolated Laboratory, Introduction to MA Sandboxes, Ubuntu, Zeltser'sREMnux, SANS SIFT, Sandbox Setup and Configuration New Course Form, Routing TCP/IP Connections, Capturing and Analyzing Network Traffic, Internet simulation using INetSim, Using Deep Freeze to Preserve Physical Systems, Using FOG for Cloning and Imaging Disks, Using MySQL Database to Automate FOG Tasks, Introduction to Python ,Introduction to x86 Intel assembly language, Scanners: Virus Total, Jotti, and No Virus Thanks, Analyzers: Threat Expert, CW Sandbox, Anubis, Joebox, Dynamic Analysis Tools: Process Monitor, Regshot, HandleDiff, Analysis Automation Tools: Virtual Box, VM Ware, Python , Other Analysis Tools	10
Unit 2: Malware Forensics: Using TSK for Network and Host Discoveries, Using Microsoft Offline API to Registry Discoveries, Identifying Packers using PEiD, Registry Forensics with Reg Ripper Plugins, Bypassing Poison Ivy's Locked Files, Bypassing Conficker's File System ACL Restrictions, Detecting Rogue PKI Certificates.	5
Unit 3: Malware and Kernel Debugging: Opening and Attaching to Processes, Configuration of JIT Debugger for Shellcode Analysis, Controlling Program Execution, Setting and Catching Breakpoints, Debugging with Python Scripts and Py Commands, DLL Export Enumeration, Execution, and Debugging, debugging a VMware Workstation Guest (on Windows), Debugging a Parallels Guest (on Mac OS X). Introduction to WinDbg Commands and Controls, Detecting Rootkits with WinDbg Scripts, Kernel Debugging with IDA Pro.	6
Unit 4: Memory Forensics and Volatility: Memory Dumping with MoonSols Windows Memory Toolkit, Accessing VM Memory Files Overview of Volatility, Investigating Processes in Memory Dumps, Code Injection and Extraction, Detecting and Capturing Suspicious Loaded DLLs, Finding Artifacts in Process Memory, Identifying Injected Code with Malfind and YARA.	7
Unit 5: Researching and Mapping Source Domains/Ips: Using WHOIS to Research Domains, DNS Hostname Resolution, Querying Passive DNS, Checking DNS Records, Reverse IP Search New Course Form, Creating Static Maps, Creating Interactive Maps.	7

Unit 6: Case Study: Case study of Finding Artifacts in Process Memory, Identifying Injected Code with Malfind and YARA	5

References:

1. Michael Sikorski, Andrew Honig "Practical Malware Analysis: The Hands-On Guide to Dissecting Malicious Software" publisher Williampollock.
2. Practical Malware Analysis – The Hands–On Guide to Dissecting Malicious Software by Michael Sikorski and Andrew Honig.
3. Mastering Malware Analysis: The complete malware analyst's guide to combating malicious software, APT, cybercrime, and IoT attacks 1st Edition by Alexey Kleymenov and Amr Thabet.
4. Advanced Malware Analysis by Christopher Elisan

1MCS2-16: Data Preparation and Analysis

Course Name	Data Preparation and Analysis
Credits	3
Pre-Requisites	

CONTENT	CONTACT HOURS
Unit1: Data Gathering and Preparation: Data formats, parsing and transformation, Scalability and real-time issues	10
Unit2: Data Cleaning: Consistency checking, Heterogeneous and missing data, Data Transformation and segmentation	10
Unit3: Exploratory Analysis: Descriptive and comparative statistics, Clustering and association, Hypothesis generation	10
Unit4: Visualization: Designing visualizations, Time series, Geolocated data, Correlations and connections, Hierarchies and networks, interactivity	10

References:

1. Making sense of Data: A practical Guide to Exploratory Data Analysis and Data Mining, by Glenn J. Myatt
2. Data Preparation for Data Mining (The Morgan Kaufmann Series in Data Management Systems) by Dorian Pyle
3. Principles of Data Wrangling: Practical Techniques for Data Preparation by Tye Rattenbury, Joseph M. Hellerstein, Jeffrey Heer, Sean Kandel, Connor Carreras.
4. Introduction to Data Mining by Pang-Ning Tan, Michael Steinbach.
5. Data Mining: Concepts and Techniques Jiawei Han

1MCS1-06: IoT Based Systems Design Lab

1. Calibration and accessing real-time sensors data
   (i) Accessing and observing inertial sensors' data
   (ii) Updating sensors' parameters and observing the impact
   (iii) Calibrating multi-IMU system and calibration compensation with WiFi
   (iv) Gaining familiarity with an IoT Sensor
2. Connecting smart IoT sensor with cloud (Firebase Integration with Python)
3. Firmware Modification & Compilation, USB Boot loading and Clock Budgeting
   (i) Understanding structure of Atmel Studio.
   (ii) Gaining some insight of oblu's firmware. And making minor modifications. Generating hex file (i.e. compiling the f/w) and boot loading it into oblu over USB.
   (iii) Experimenting to understand concept of clock budgeting in embedded design.
4. Getting Familiar with Raspberry Pi 3

Ref: https://karkare.github.io/cs664/

1MCS1-07: Network Simulation and Security Analysis Lab

A. Network Simulation

The students shall be exposed to simulation tools like NS3 and new platforms like SDN. All the tools are freely available. For SDN, OpenFlow is recommended platform

Suggested Exercises:

1. Simulate State Vector Routing/ Bellman Ford Algorithm on NS3.
2. Simulate a routing algorithm for WSN/MANET reported recently in the literature.
3. Create a routing table for a 4-5 node SDN with one controller.
4. Repeat the exercise for a two controller SDN network with 8-10 nodes.

B. Security Analysis

For this lab, 15 desktop systems and one server system (2 NIC) connected in LAN, with Linux and Windows on Desktop are suggested. These will be disconnected from the rest of the institute LAN. Having 15 systems will allow the lab to be used for UG programs as well. A group of 2 students (4 in case of UG) will be formed.

Each group will have access to only one system directly and will be using it to target the other systems in the LAN.

Each group will use freely available Security tools to make its system secure. Once done, each group will offer its system for attack by another group. The attacker group will need to use tools (Freeware) to find the vulnerabilities and exploit them for attacking.

each group must install, configure, and make available the following services:

- A web server – groups are encouraged to customize the page(s) with identifying information such as member names and pictures.
- An FTP server, which allows anonymous FTP access to some token files.
- An SSH server – for remote access to the machine.
- A MySQL server – the database should allow client connections from the server console and remote clients. A sample database with some data records should also be created.

The attacker group will perform the following tasks:

A. Network Based Attacks:

- The group will attempt to exploit vulnerabilities discovered on the target system.
- Once the system has been compromised, the group should create a file on the system containing the names of the group indicating the successful exploit.
- The group should immediately contact the instructor about the success of the attack, and upon confirmation should continue with the Local Attack.
- If all of the attack vectors that have been attempted were unsuccessful in compromising the system remotely, then the group should contact the lab administrator for credentials to continue with the Local Attack.

B. Local Attacks:

- The instructor will create an unprivileged account on the target client for each group.
- The group will attempt to gain root/administrator access on the target system, and leave a mark in the /root/ directory (for Linux targets) or the /Documents and Settings/Administrator/ (for Windows targets). The group should immediately contact the instructor about the success of the attack.
- A group is not allowed to disturb the target any more than is necessary, for the sake of other groups that may also be attempting to compromise the same system.

The report shall have two parts.

A. Configuration Report
    - What steps were taken to secure the system, and why they were performed?
    - Any additional software that was installed, and why. It is not required to include an itemized list of updated packages. Students just need to mention completely new software such as network diagnostic or security tools.
    - Problems encountered with their system in general and the setup steps specifically

B. Attack Report
    - A description of what attacks were attempted, and the result of each attack (for both Network and Local attacks) even if unsuccessful.
    - The location and content of the files created by the group left on the target system after each successful attack.
    - A review of how 'noisy' the attacks were. In other words, how likely would it have been that a system administrator would have noticed the attack before or after the compromise
    - If the attack(s) were unsuccessful, report on why this was so and discuss what further attacks might be tried or extended.
    - A conclusion to the overall exercise, including what the group has learned and how they might do things differently in the future. It is also encouraged to provide thoughts about how the vulnerabilities exploited might influence the setup and maintenance of the group's own machine.

Ref:

Yu, Yingbing. "Designing hands-on lab exercises in the network security course." *Journal of Computing Sciences in Colleges* 22.5 (2007): 105-110.

2MCS1-01: Data Science

Course Name	Data Science
Credits	3
Pre-Requisites	

CONTENT	CONTACT HOURS
Unit 1: Introduction to core concepts and technologies: Introduction, Terminology, data science process, data science toolkit, Types of data, Example applications.	5
Unit 2: Data collection and management: Introduction, Sources of data, Data collection and APIs, Exploring and fixing data, Data storage and management, Using multiple data sources	5
Unit 3: Data analysis: Introduction, Terminology and concepts, Introduction to statistics, Central tendencies and distributions, Variance, Distribution properties and arithmetic, Samples/CLT, Basic machine learning algorithms, Linear regression, SVM, Naive Bayes.	10
Unit 4: Data visualisation: Introduction, Types of data visualisation, Data for visualisation: Data types, Data encodings, Retinal variables, Mapping variables to encodings, Visual encodings.	10
Unit 5: Applications of Data Science: Applications of Data Science, Technologies for visualisation, Bokeh (Python)	5
Unit 6: Recent trends in various data collection and analysis techniques, various visualization techniques, application development methods of used in data science.	5

References:

1. Cathy O'Neil and Rachel Schutt. Doing Data Science, Straight Talk from The Frontline. O'Reilly.
2. Jure Leskovek, Anand Rajaraman and Jeffrey Ullman. Mining of Massive Datasets. v2.1, Cambridge University Press.
3. The Art of Data Science by Roger D. Peng and Elizabeth Matsui
4. Practical Statistics for Data Scientists — by Peter Bruce

2MCS1-02: Distributed and Parallel Algorithms

Course Name	Distributed and Parallel Algorithms
Credits	3
Pre-Requisites	

CONTENT	CONTACT HOURS
Unit 1: Introduction: Introduction of the synchronous and asynchronous distributed network models, failures, input-output and the execution of the models.	3
Unit 2: Distributed Algorithms: Leader election in a synchronous ring, Basic, Hirschberg-Sinclare, Time- Slice & Variable-Speed algorithms. Distributed algorithms in General Synchronous Networks, LubyMIS algorithm. Distributed Consensus with Link failures, Deterministic & Randomized algorithms. Distributed Consensus with Process failures, EIG algorithm for Byzantine failures, algorithms for commit problems.	9
Unit 3: Asynchronous shared memory algorithms, Lockout-free algorithms, Tournament algorithm, Bakery BurnsME algorithms. QueueME, TicketME, BufferMainME, ExecutiveME etc.	8
Unit 4: Transformations from shared memory model to network model and vice- versa. Failure Detectors.	5
Unit 5: Overview of Parallelism: Need for Parallel Processing, Models of Computation -RAM and PRAM Model, Shared Memory and Message Passing Models, Processor Organisations, PRAM Algorithm, Analysis of PRAM Algorithms, Parallel Programming Languages. PRAM Model of Parallel Computation, Parallel algorithm for Divide-and-Conquer, Sequential Subsets & Brent's theorem, Recursive Doubling, Parallel algorithms for merging and sorting, Parallel algorithm for finding diameter of a convex polygon.	8
Unit 6: PRAM Algorithms: Parallel Reduction, Prefix Sums, List Ranking, Preorder Tree Traversal, Merging Two Sorted Lists, Graph Coloring.	7

References:

1. Nancy A. Lynch, and Boaz Patt-Shamir, "Distributed Algorithms," Pearson Education, India, 2002.
2. Algorithm Design: Foundations, Analysis and Internet Examples by M.T. Goodrich & R. Tamassia; John Wiley & Sons.
3. Gerlad Tel, "Introduction to Distributed Algorithms" Cambridge University Press.
4. Michael J. Quinn, "Parallel Computing: Theory & Practice", Tata McGraw Hill Edition, Second edition, 2017.
5. Ellis Horowitz, Sartaj Sahni and Sanguthevar Rajasekaran, "Fundamentals of Computer Algorithms", University press, Second edition , 2011.
6. V Rajaraman, C Siva Ram Murthy, " Parallel computers- Architecture and Programming ", PHI learning, 2016.

2MCS2-11: Big Data Analytics

Course Name	Big Data Analytics
Credits	3
Pre-Requisites	

CONTENT	CONTACT HOURS
Unit 1: Introduction: What is big data, why big data, convergence of key trends, unstructured data, industry examples of big data, web analytics, big data and marketing, fraud and big data, risk and big data, credit risk management, big data and algorithmic trading, big data and healthcare, big data in medicine, advertising and big data, big data technologies, introduction to Hadoop, open source technologies, cloud and big data, mobile business intelligence, Crowd sourcing analytics, inter and trans firewall analytics.	7
Unit 2: Database Design: Introduction to NoSQL, aggregate data models, aggregates, key-value and document data models, relationships, graph databases, schema less databases, materialized views, distribution models, sharding, master-slave replication, peer peer replication, sharding and replication, consistency, relaxing consistency, version stamps, map-reduce, partitioning and combining, composing map-reduce calculations.	7
Unit 3: HDFS (Hadoop distributed file system): Data format, analyzing data with Hadoop, scaling out, Hadoop streaming, Hadoop pipes, design of Hadoop distributed file system (HDFS), HDFS concepts, Java interface, data flow, Hadoop I/O, data integrity, compression, serialization, Avro, file-based data structures	7
Unit 4: MapReduce: MapReduce workflows, unit tests with MR Unit, test data and local tests, anatomy of MapReduce job run, classic Map-reduce, YARN, failures in classic Map-reduce and YARN, job scheduling, shuffle and sort, task execution, MapReduce types, input formats, output formats	7
Unit 5: Data Model and Implementations: HBase, data model and implementations, HBase clients, HBase examples, praxis. Cassandra, Cassandra data model, Cassandra examples, Cassandra clients, Hadoop integration.	7
Unit 6: Overview of Pig and HiveQL: Pig, Grunt, pig data model, Pig Latin, developing and testing Pig Latin scripts. Hive, data types and file formats, HiveQL data definition, HiveQL data manipulation, HiveQL queries.	5

References:

1. Michael Minelli, Michelle Chambers, and Ambiga Dhiraj, "Big Data, Big Analytics: Emerging
2. Business Intelligence and Analytic Trends for Today's Businesses", Wiley, 2013.
3. P. J. Sadalage and M. Fowler, "NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence", Addison-Wesley Professional, 2012.
4. Tom White, "Hadoop: The Definitive Guide", Third Edition, O'Reilley, 2012.
5. Eric Sammer, "Hadoop Operations", O'Reilley, 2012.
6. E. Capriolo, D. Wampler, and J. Rutherglen, "Programming Hive", O'Reilley, 2012.
7. Lars George, "HBase: The Definitive Guide", O'Reilley, 2011.
8. Eben Hewitt, "Cassandra: The Definitive Guide", O'Reilley, 2010.
9. Alan Gates, "Programming Pig", O'Reilley, 2011.

2MCS2-12: Database Security and Access Control

Course Name	Database Security and Access Control
Credits	3
Pre-Requisites	Database Management

CONTENT	CONTACT HOURS
Unit 1: Introduction: Introduction to Access Control, Purpose and fundamentals of access control, brief history.	5
Unit 2: Access Controls: Policies of Access Control, Models of Access Control, and Mechanisms, Discretionary Access Control (DAC), Non- Discretionary Access Control, Mandatory Access Control (MAC). Capabilities and Limitations of Access Control Mechanisms: Access Control List (ACL) and Limitations, Capability List and Limitations.	6
Unit 3: Role Based Access Control (RBAC): Role-Based Access Control (RBAC) and Limitations, Core RBAC, Hierarchical RBAC, Statically Constrained RBAC, Dynamically Constrained RBAC, Limitations of RBAC. Comparing RBAC to DAC and MAC Access control policy.	6
Unit 4: Models: Biba's intrigity model, Clark-Wilson model, Domain type enforcement model, mapping the enterprise view to the system view, Role hierarchies- inheritance schemes, hierarchy structures and inheritance forms, using SoD in real system, Temporal Constraints in RBAC, MAC AND DAC. Integrating RBAC with enterprise IT infrastructures: RBAC for WFMSs, RBAC for UNIX and JAVA environments Case study: Multi line Insurance Company.	10
Unit 5: Introduction to Smart Card based Information: Smart Card based Information Security, Smart card operating system fundamentals, design and implantation principles, memory organization, smart card files, file management, atomic operation, smart card data transmission ATR, PPS Security techniques- user identification, smart card security, quality assurance and testing, smart card life cycle-5 phases, smart card terminals.	10
Unit 6: Recent Trends: Recent trends in Database security and access control mechanisms. Case study of Role-Based Access Control (RBAC) systems.	3

References:

1. Role Based Access Control: David F. Ferraiolo, D. Richard Kuhn, Ramaswamy Chandramouli.
2. http://www.smartcard.co.uk/tutorials/sct-itsc.pdf : Smart Card Tutorial.
3. Access Control Systems: Security, Identity Management and Trust Models by Messaoud Benantar
4. Database Security by Alfred Basta, Melissa Zgola.

2MCS2-13: Data Storage Technologies and Networks

Course Name	Data Storage Technologies and Networks
Credits	3
Pre-Requisites	Basic knowledge of Computer Architecture, Operating Systems, and Computer Networking is required.

CONTENT	CONTACT HOURS
Unit 1: Storage Media and Technologies: Magnetic, Optical and Semiconductor Media, Techniques for read/write Operations, Issues and Limitations.	7
Unit 2: Usage and Access: Positioning in the Memory Hierarchy, Hardware and Software Design for Access, Performance issues.	8
Unit 3: Large Storages: Hard Disks, Networked Attached Storage, Scalability issues, Networking issues.	6
Unit 4: Storage Architecture: Storage Partitioning, Storage System Design, Caching, Legacy Systems.	8
Unit 5: Storage Area Networks: Hardware and Software Components, Storage Clusters/Grids. **Storage QoS**–Performance, Reliability, and Security issues.	8
Unit 6: **Recent Trends** related to Copy data management, Erasure coding, and Software defined storage appliances.	3

References:

1. The Complete Guide to Data Storage Technologies for Network-centric Computing Paperback– Import, Mar 1998 by Computer Technology Research Corporation
2. Data Storage Networking: Real World Skills for the CompTIA Storage by Nigel Poulton
3. Security and Data Storage Aspect in Cloud Computing (Studies in Big Data) by Prachi S. Deshpande, Subhash C. Sharma, Sateesh K. Peddoju.
4. Data Deduplication for Data Optimization for Storage and Network Systems by Daehee Kim, Sejun Song, Baek-Young Choi.
5. Big Data: Storage, Sharing, and Security by Fei Hu.

2MCS2-14: Knowledge Discovery

Course Name	Knowledge Discovery
Credits	3
Prerequisites	

CONTENT	CONTACT HOURS
Unit 1: Introduction KDD and Data Mining: Data Mining and Machine Learning, Machine Learning and Statistics, Generalization as Search, Data Mining and Ethics	5
Unit 2: Knowledge Representation: Decision Tables, Decision Trees, Classification Rules, Association Rules, Rules involving Relations, Trees for Numeric Predictions, Neural Networks, Clusters	7
Unit 3: Decision Trees: Divide and Conquer, Calculating Information, Entropy, Pruning, Estimating Error Rates, The C4.5 Algorithm. **Evaluation of Learned Results**- Training and Testing, Predicting Performance, Cross-Validation.	8
Unit 4: Classification Rules: Inferring Rudimentary Rules, Covering Algorithms for Rule Construction, Probability Measure for Rule Evaluation, Association Rules, Item Sets, Rule Efficiency	8
Unit 5: Numeric Predictions: Linear Models for Classification and Numeric Predictions, Numeric Predictions with Regression Trees, Evaluating Numeric Predictions	7
Unit 6: Artificial Neural Networks: Perceptron's, Multilayer Networks, The Backpropagation Algorithm **Clustering** - Iterative Distance-based Clustering, Incremental Clustering, The EM Algorithm	5

References:

1. Data mining and knowledge discovery handbook by Maimon, oded(et al.)
2. Data Cleansing: A Prelude to knowledge Discovery
3. Knowledge Discovery and Data Mining: Challenges and Realities by Xingquan Zhu, Ian Davidson
4. Data Mining and Knowledge Discovery Handbook (Springer series in solid-state sciences) by Oded Maimon, Lior Rokach
5. Data Mining and Knowledge Discovery Technologies by David Taniar

2MCS2-15: Secure Software Design and Enterprise Computing

Course Name	Secure Software Design and Enterprise Computing
Credits	3
Pre-Requisites	Computer Programming, Software Engineering

CONTENT	CONTACT HOURS
Unit 1: Secure Software Design: Identify software vulnerabilities and perform software security analysis, Master security programming practices, Master fundamental software security design concepts, Perform security testing and quality assurance.	7
Unit 2: Enterprise Application Development: Describe the nature and scope of enterprise software applications, Design distributed N-tier software application, Research technologies available for the presentation, business and data tiers of an enterprise software application, Design and build a database using an enterprise database system, Develop components at the different tiers in an enterprise system, Design and develop a multi-tier solution to a problem using technologies used in enterprise system, Present software solution.	7
Unit 3: Enterprise Systems Administration: Design, implement and maintain a directory-based server infrastructure in a heterogeneous systems environment, Monitor server resource utilization for system reliability and availability, Install and administer network services (DNS/DHCP/Terminal Services/Clustering/Web/Email).	7
Unit 4: Manage and Troubleshoot A Network: Obtain the ability to manage and troubleshoot a network running multiple services, Understand the requirements of an enterprise network and how to go about managing them.	7
Unit 5: Insecure Exceptions and Command/SQL Injection: Handle insecure exceptions and command/SQL injection, defend web and mobile applications against attackers, software containing minimum vulnerabilities and flaws.	8
Unit 6: Case Study: Case study of DNS server, DHCP configuration and SQL injection attack.	4

References:

1. Theodor Richardson, Charles N Thies, Secure Software Design, Jones & Bartlett
2. Kenneth R. van Wyk, Mark G. Graff, Dan S. Peters, Diana L. Burley, Enterprise Software Security, Addison Wesley
3. Gary McGraw, Software Security: Building Security In, Addison-Wesley, 2006

Text Books:

1. W. Stallings, Cryptography and network security: Principles and practice, 5 th Edition, Upper Saddle River, NJ: Prentice Hall., 2011
2. C. Kaufman, r. Perlman, & M. Speciner, Network security: Private communication in a public world, 2 nd Edition, Upper Saddle River, NJ:Prentice HalL, 2002
3. C. P. Pfleeger, S. L. Pfleeger, Security in Computing, 4 th Edition, Upper Saddle River, NJ:Prentice Hall, 2007
4. M. Merkow, & J. Breithaupt, Information security: Principles and practices. Upper Saddle River, NJ:Prentice Hall, 2005

2MCS2-16: Wireless Sensor Networks

Course Name	Wireless Sensor Networks
Credits	3
Pre-Requisites	Wireless Communication

CONTENT	CONTACT HOURS
Unit 1: Introduction to Wireless Sensor Networks: Course Information, Introduction to Wireless Sensor Networks: Motivations, Applications, Performance metrics, History and Design factors. **Network Architecture:** Traditional layered stack, Cross-layer designs, Sensor Network Architecture. **Hardware Platforms:** Motes, Hardware parameters.	8
Unit 2: Medium Access Control Protocol design: Fixed Access, Random Access, WSN protocols: synchronized, duty-cycled. **Introduction to Markov Chain:** Discrete time Markov Chain definition, properties, classification and analysis. **MAC Protocol Analysis:** Asynchronous duty-cycled. X-MAC Analysis (Markov Chain).	8
Unit 3: Security: Possible attacks, countermeasures, SPINS, Static and dynamic key distribution.	6
Unit 4: Routing protocols: Introduction, MANET protocols. **Routing protocols for WSN**: Resource-aware routing, Data-centric, Geographic Routing, Broadcast, Multicast. **Opportunistic Routing Analysis**: Analysis of opportunistic routing (Markov Chain) Advanced topics in wireless sensor networks.	10
Unit 5: Advanced Topics: Localization in WSNs, Quality of Service, Data Aggregation	8

References:

1. W. Dargie and C. Poellabauer, "Fundamentals of Wireless Sensor Networks –Theory and Practice", Wiley 2010

2. KazemSohraby, Daniel Minoli and TaiebZnati, "wireless sensor networks -Technology, Protocols, and Applications", Wiley Interscience 2007

3. Takahiro Hara, Vladimir I. Zadorozhny, and Erik Buchmann, "Wireless Sensor Network Technologies for the Information Explosion Era", springer 2010

4. B. Krishnamachari, Networking Wireless Sensors, 1st Edition, Cambridge University Press, 2005

2MCS1-06: High Performance Computing Lab

The laboratory will require GPU based systems with OpenMP installed. The students be encouraged to configure the system. In the beginning, the students may undertake following preliminary exercises as below:

1. Analysis of Parallel Algorithms
2. Implementation using OpenMP
3. GPU kernel implementation for the given application.
4. Performance analysis using GPU memories.
5. Kernel reduction.
6. Profiling an application.

Once, the students are well versed with the environment, the exercises on the following may be taken. Datasets may be downloaded and used for the exercises:

1. Multiplication of Huge Matrices using CUDA
2. Sorting large data sets
3. Text Processing
4. Video Processing/ Image Analysis using CUDA

The list can be modified at the institute level depending upon the specialization of the faculty and availability of datasets.

2MCS1-07: Data Analytics Lab

The Laboratory shall have a multicore server running Hadoop or any similar platform. Alternatively, desktop with Multicore processor and 64/128GB RAM can be used to install Hadoop. R shall also be available in the Laboratory

Exercises:

A. Hadoop
   1. Install, configure and run Hadoop and HDFS
   2. Implement word count / frequency programs using MapReduce
   3. Implement an MR program that processes a weather or similar dataset. Dataset needs to be found and used.

B. R/ Python
   4. Implement Linear and logistic Regression
   5. Implement SVM / Decision tree classification techniques
   6. Implement clustering techniques
   7. Visualize data using any plotting framework
   8. Implement an application that stores big data in Hbase / MongoDB / Pig using Hadoop / R.

3MCS2-01: Business Intelligence

Course Code	
Course Name	Business Intelligence
Credits	3
Pre-Requisites	

CONTENT	CONTACT HOURS
Unit 1: Concepts with Mathematical treatment: Introduction to data, Information and knowledge, Decision Support System, Theory of Operational data and informational data, Introduction to Business Intelligence, Defining BI Cycle, BI Environment and Architecture, Identify BI opportunities, Benefits of BI. Role of Mathematical model in BI, Factors Responsible for successful BI Project, Obstacle to Business Intelligence in an Organization.	8
Unit 2: Decision Making Concepts: Concepts of Decision Making, Techniques of Decision Support System (DSS), Development of Decision Support System (DSS), Applications of DSS, Role of Business Intelligence in DSS.	6
Unit 3: Data-Warehouse: Definition, Characteristics, Types, Data Warehousing Framework, DwH 3 Tier Architecture, Alternative Architectures, Data Warehousing Integration, Data Warehousing – Development Approaches, Real-time Data Warehousing, Distributed data warehouse.	6
Unit 4: Data Pre-processing and Data Visualization: Data Analytics life cycle, Discovery, Data preparation, Pre-processing requirements, data cleaning, data integration, data reduction, data transformation, Data discretization and concept hierarchy generation, Model Planning, Model building, Communicating Results & Findings, Operationalizing, Introduction to OLAP. Real-world Applications,) Data Visualization: Definition, New Direction in Data Visualization, GIS, GIS vs GPS.	8
Unit 5: Designing and managing BI systems: Determining infrastructure requirements, planning for scalability and availability, managing and maintenance of BI systems, managing BI operations for business continuity.	6
Unit 6: BI and Data Mining Applications: Data analytics, business analytics, ERP and Business Intelligence, BI Applications in CRM, BI Applications in Marketing, BI Applications in Logistics and Production, Role of BI in Finance, BI Applications in Banking, BI Applications in Telecommunications, BI Applications in Fraud Detection, BI Applications in Retail Industry.	6

Text Books:

1. R. Sharda, D. Delen, & E. Turban, Business Intelligence and Analytics. Systems for Decision Support,10th Edition. Pearson/Prentice Hall, 2015. ISBN-13: 978-0-13-305090-5, ISBN-10: 0-13-305090.

References:

1. Introduction to business Intelligence and data warehousing, IBM, PHI.
2. Data mining concepts and techniques, Jawai Han, Michelline Kamber, Jiran Pie, Morgan Kaufmann Publishers 3rd edition.
3. Building the data Warehouse, William H Inmon, Wiley Publication 4th edition.
4. Data Mining for Business Intelligence, WILEY
5. Soumendra Mohanty, Analytics in Practice,Tata McGraw Hill Education, 2011, ISBN-13 978 0 07 0707061
6. Ken W. Collier,Agile Analytics: Avalue driven Approach to Business Intelligence and Data Warehousing, Pearson Education,2012, ISBN-13 978 8131786826
7. Donald Miner, MapReduce Design Pattern, O'Reilly, 2012, ISBN 978 9350239810
8. EMC Educational Services, Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, Wiley ISBN-13 978 1118876138
9. BoS Content: Books, Course Notes, Digital contents, Blogs developed by the BoS for bridging the gaps in the syllabus, problem solving approaches and advances in the

3MCS2-02: Block-chain Technologies

Course Name	Block-chain Technologies
Credits	3
Pre-Requisites	

CONTENT	CONTACT HOURS
Unit 1: Introduction: Overview of Block chain, Public Ledgers, Bitcoin, Smart Contracts, Block in a Block chain, Transactions, Distributed Consensus, Public vs Private Block chain, Understanding Crypto currency to Block chain, Permissioned Model of Block chain.	5
Unit 2: Overview of Security aspects of Block chain Basic Crypto Primitives: Cryptographic Hash Function, Properties of a hash function, Hash pointer and Merkle tree, Digital Signature, Public Key Cryptography, A basic cryptocurrency.	5
Unit 3: Bitcoin and Block chain: Creation of coins, Payments and double spending, Bitcoin Scripts, Bitcoin P2P Network, Transaction in Bitcoin Network, Block Mining, Block propagation and block relay. Working with Consensus in Bitcoin: Distributed consensus in open environments, Consensus in a Bitcoin network, Proof of Work (PoW) – basic introduction, Hashcash PoW, Bitcoin PoW, Attacks on PoW and the monopoly problem, Proof of Stake, Proof of Burn and Proof of Elapsed Time, The life of a Bitcoin Miner, Mining Difficulty, Mining Pool.	10
Unit 4: Understanding Block chain for Enterprises Permissioned Block chain: Permissioned model and use cases, Design issues for Permissioned block chains, Execute contracts, State machine replication, Overview of Consensus models for permissioned block chain- Distributed consensus in closed environment, Paxos, RAFT Consensus, Byzantine general problem, Byzantine fault tolerant system, Lamport-Shostak- ease BFT Algorithm, BFT over Asynchronous systems.	9
Unit 5: Enterprise application of Block chain: Cross border payments, Know Your Customer (KYC), Food Security, Mortgage over Block chain, Block chain enabled Trade, We Trade – Trade Finance Network, Supply Chain Financing, Identity on Block chain.	5
Unit 6: Block chain application development: Hyperledger Fabric- Architecture, Identities and Policies, Membership and Access Control, Channels, Transaction Validation, writing smart contract using Hyperledger Fabric, writing smart contract using Ethereum, Overview of Ripple and Corda.	6

References:

Text Books:

1. Melanie Swan, “Block Chain: Blueprint for a New Economy”, O’Reilly, 2015
2. Josh Thompsons, “Block Chain: The Block Chain for Beginners- Guide to Block chain Technology and Leveraging Block Chain Programming”
3. Daniel Drescher, “Block Chain Basics”, Apress; 1stedition, 2017
4. Anshul Kaushik, “Block Chain and Crypto Currencies”, Khanna Publishing House, Delhi.
5. Imran Bashir, “Mastering Block Chain: Distributed Ledger Technology, Decentralization and Smart Contracts Explained”, Packt Publishing
6. Ritesh Modi, “Solidity Programming Essentials: A Beginner’s Guide to Build Smart Contracts for Ethereum and Block Chain”, Packt Publishing
7. Salman Baset, Luc Desrosiers, Nitin Gaur, Petr Novotny, Anthony O’Dowd, Venkatraman Ramakrishna, “Hands-On Block Chain with Hyperledger: Building Decentralized Applications with Hyperledger Fabric and Composer”, Import, 2018.

3MCS2-03: Social Network Analysis

Course Code	
Course Name	Social Network Analysis
Credits	3
Pre-Requisites	

CONTENT	CONTACT HOURS
Unit 1: Introduction to Social Network: Analysis Steps in social network analysis: network definition, manipulation, calculation, visualization. Graph terminology. Social networks. Technological networks. Sampling and data characteristics.	6
Unit 2: Metrics Measures of Centrality: PageRank, Hubs and Authorities. Betweenness. Transitivity, Reciprocity. Structural balance. Homophily and assortativity.	5
Unit 3: Large-Scale Structure of Networks: Shortest-paths and the small-world effect. Degree distributions. Power laws and scale-free networks. Clustering coefficients. Basic graph algorithms: computing properties of nodes and dyads. Maximum flow.	5
Unit 4: Clustering Graph Partitioning: Spectral partitioning. Modularity and modularity maximization. Ego analysis Bi-partite networks Analysis of local networks. Structural holes theory. Measures of constraint. Bi-partite and affiliation networks. One-mode projections and analyses.	10
Unit 5: Exponential Random Graph Modelling Frameworks for Evaluating Results in Network Analysis: Autocorrelation, matching techniques, QAP regression, exponential random graphs, and p* models. Computational considerations. Lab: Applying ERGM analysis.	10
Unit 6: Network Evolution Actor models: Network dynamics vs behaviour dynamics. RSiena. Model creation and estimation.	4

References:

Text Books:

1. Newman, M.E.J. Networks: An Introduction. Oxford University Press. 2010.
2. Snijders, et al. Introduction to stochastic actor-based models for network dynamics. Social Networks, 2010.
3. Social Network Analysis for Startups Maksim Tsvetovat, Alexander Kouznetsov
4. Analyzing Social Networks [Borgatti, Stephen P, Everett, Martin G., Johnson, Jeffrey C.]
5. Models and Methods in Social Network Analysis (Structural Analysis in the Social Sciences) Peter J. Carrington