M.Tech.–Communication Systems

SCHEME

First Semester

Course No.	Subject	Scheme of studies periods per week			Total Credits
		L	T	P	
CS 101	Probability and Random Process	3	-	-	3
CS 102	Optical Communication Systems	3	-	-	3
CS 103	Wireless Communication Systems	3	-	-	3
	Department Elective-1	3	-	-	3
	Department Elective-2	3	-	-	3
CS 104	Lab I (Optical Communication Laboratory)	-	-	2	1
CS 105	Lab II (Wireless Communication System)	-	-	2	1
CS 106	Seminar-1	-		2	1
CS 107	Minor Project-1 (Self Learning)	-	-	-	2
		15	-	6	20

Total Hours: 21 **Total Credits: 20**

Second Semester

Course No.	Subject	Scheme of studies periods per week			Total Credits
		L	T	P	
CS 201	Detection & Estimation Theory	3	-	-	3
CS 202	Terahertz Communication	3	-	-	3
	Department Elective-3	3	-	-	3
	Department Elective-4	3	-	-	3
	Open Elective	3	-	-	3
CS 203	Lab III (Signal Processing System Laboratory)	-	-	2	1
CS 204	Lab IV (5G Communication Laboratory)	-	-	2	1
CS 205	Seminar-II	-	-	2	1
CS 206	Minor Project-II (Self Learning)	-	-	2	2
		15	-	8	20

Total Hours: 23 **Cumulative Credits: 40**

Third Semester

Course No.	Subject	Scheme of studies periods per week			Total Credits
		L	T	P	
CS 301	Dissertation Phase –I	-	-	40	20
Total Hours: 40	Cumulative Credits: 60			Total Semester Credits	20

Fourth Semester

Course No.	Subject	Scheme of studies periods per week			Total Credits
		L	T	P	
CS 401	Dissertation Phase –II	-	-	40	20
Total Hours: 40	Cumulative Credits: 80			Total Semester Credits	20

List of Department Electives

List of Electives Departmental			
CS 501	RF Communication	CS 511	Data Compression and Cryptography
CS 502	Wireless Technologies: 5G and beyond	CS 512	Information Theory and Coding
CS 503	Microwave Communication	CS 513	Medical Image Processing and Analysis
CS 504	Advanced Digital Signal Processing	CS 514	Statistical Signal Processing
CS 505	Digital Image Processing	CS 515	Video Signal Processing
CS 506	Signal Theory	CS 516	Multirate Signal Processing
CS 507	Mobile Communication	CS 517	Computer Vision and Pattern Recognition
CS 508	Telecom Switching	CS518	Research Methodology
CS 509	Satellite Communication		NPTEL/SWAYAM Course(s)
CS 510	Optical Networks		

List of Open Electives

List of Open Electives	
CS 601	Optimization Techniques
CS 602	Neural Networks
CS 603	Fuzzy Logic
CS 604	Internet of Things (IoT)
CS 605	Applied Machine Learning and Deep Learning
CS 606	Computer Networks
CS 607	Cyber Physical Systems

CS 608 Telecom Transmission Systems
CS 609 SDN and Network Virtualization

Syllabus

FIRST SEMESTER

Name of Program	**M.Tech. (Communication Systems)**	**SemesterI**	**Year I**

Name of Course	**Probability and Random Process**
Course Code	**CS 101**
Core / Elective / Other	**Core**

Prerequisite:	
1.	Knowledge of Engineering Mathematics up to B.Tech. level
Course Outcomes:	After completion of the course, the students will be able to
CO1	Understand the basic concepts of probability and probability Modelling.
CO2	Gain knowledge about Probability and statistical distributions of random variables and correlations.
CO3	Understand the basic concepts of stochastic processes and the stationarity.
CO4	Understand the purpose of special processes
CO5	Gain knowledge about spectrum estimation and spectral density function
Description of Contents in brief:	
1.	Introduction to probability: Axiomatic definition of probability; properties of probability, conditional probability, independence, total probability, Bayes' rule; random variables: cumulative distribution function, probability mass function, probability density functions; Functions of a random variable; expectation - mean, variance and moments; characteristic and moment-generating functions; Jensen's inequality
2.	Chebyshev, Markov and Chernoff bounds; special random variables-Bernoulli, binomial, Poisson, geometric, uniform, exponential, and Gaussian; Joint distribution and density functions; Bayes' rule for continuous and mixed random variables; joint moments, conditional expectation; Covariance and correlation- independent, uncorrelated; function of two random variables; random vector- mean vector and covariance matrix; Multivariate Gaussian distribution
3.	Weak law of large numbers and central limit theorem; hypothesis testing,; Random processes: discrete and continuous time processes; probabilistic structure of a random process; mean, autocorrelation and autocovariance functions; strict-sense stationary and wide-sense stationary processes: autocorrelation and cross-correlation functions; Spectral representation of a real WSS process-power spectral density; examples of random processes: white noise and Poisson process.
List of Text Books:	
1.	A. Leon-Garcia, *Probability and Random Processes for Electrical Engineering*, 3rd edition, Pearson, 2011.
2.	H. Stark and J. W. Woods, *Probability and Random Processes with Applications to Signal Processing*, 4th edition, Pearson, 2011.
3.	A. Papoulis and S. U. Pillai, *Probability Random Variables and Stochastic Processes*, 4th edition. McGraw-Hill, 2002.

List of Reference Books:

1	D. P. Bertsekas and J. N. Tsitsiklis, *Introduction to Probability,* 2nd edition. Athena Scientific, 2008.
2.	K. L. Chung and F. AitSahlia, *Elementary Probability Theory with Stochastic Processes and an Introduction to Mathematical Finance*, 4th edition. Springer-Verlag, 2003

URLs:

1.	https://www.probabilitycourse.com/chapter10/10_1_0_basic_concepts.php

Lecture Plan (about 40-50 Lectures):

Lecture No.	Topic
1	Introduction to Probability
2	Axiomatic Definition of Probability
3	Properties of Probability
4	Conditional Probability
5	Independence
6	Total Probability
7	Bayes' Rule
8	Random Variables Overview
9	Cumulative Distribution Function
10	Probability Mass Function
11	Probability Density Functions
12	Functions of a Random Variable
13	Expectation - Mean, Variance, and Moments
14	Characteristic and Moment-Generating Functions
15	Jensen's Inequality
16	Chebyshev, Markov, and Chernoff Bounds
17	Special Random Variables Overview
18	Bernoulli, Binomial, and Poisson Random Variables
19	Geometric, Uniform, Exponential, and Gaussian RVs
20	Joint Distribution and Density Functions
21	Bayes' Rule for Continuous and Mixed RVs
22	Joint Moments
23	Conditional Expectation
24	Covariance and Correlation Overview
25	Independent and Uncorrelated Variables
26	Function of Two Random Variables
27	Random Vector Overview
28	Mean Vector and Covariance Matrix
29	Multivariate Gaussian Distribution
30	Weak Law of Large Numbers
31	Central Limit Theorem
32	Hypothesis Testing Overview
33	MMSE and Linear MMSE Estimators
34	Random Processes Overview
35	Discrete and Continuous Time Processes
36	Probabilistic Structure of a Random Process
37	Mean, Autocorrelation, and Autocovariance Functions
38	Strict-Sense and Wide-Sense Stationary Processes
39	Autocorrelation and Cross-Correlation Functions
40	Spectral Representation of a Real WSS Process
41	Examples of Random Processes: White Noise and Poisson Process

Name of Program	M.Tech. (Communication Systems)	Semester I	Year I

Name of Course	**Optical Communication**
Course Code	**CS-102**
Core / Elective / Other	**Core**

Prerequisite:

1.	Nil

Course Outcomes: After completion of the course, the students will be able to

CO1	Classify the structures of Optical and fiber modes configurations.
CO2	List channel impairments like losses, dispersion and other signal degradation factors
CO3	Design optimization of single mode fibers, refractive index profile and cut-off wavelength
CO4	Explain about various optical source materials, Laser diodes and different fibers, amplifiers, Optical Networks, WDM systems
CO5	Apply optical communication systems for various wideband applications.

Description of Contents in brief:

Introduction to vector nature of light, propagation of light, propagation of light in a cylindrical dielectric rod, Ray model, wave model. Different types of optical fibers, Modal analysis of a step index fiber. Signal degradation on optical fiber due to dispersion and attenuation. Fabrication of fibers and measurement techniques like OTDR. Optical sources - LEDs and Lasers, Photo-detectors - pin-detectors, detector responsivity, noise, optical receivers. Optical link design - BER calculation, quantum limit, power penalties. Optical switches - coupled mode analysis of directional couplers, electro-optic switches. Nonlinear effects in fiber optic links, group velocity dispersion and solution-based communication. Optical amplifiers - EDFA, Raman amplifier, WDM & DWDM systems & their Design topologies, Optical networks-

Basic networks- SONET/ SDH, wavelength routed networks, Optical Access Networks, Photonic packet switching.

List of Text Books:

1.	Fibre Optic communication, J.Keiser, McGraw-Hill, 2nd Ed.
2.	WDM Optical Networks, C. Sivaramamurthy& M. Gurusamy, PHI.

List of Reference Books:

1.	Fiber optic Communication Systems, G. Agrawal John Wiley and sons .

URLs:

1.	NIL

Lecture Plan (about 40-50 Lectures): (Tentative)

Lecture No.	Topic
1.	Overview of Optical Fiber Communication
2.	Overview of Optical Fiber Communication
3.	Basic concepts, Optical Communication systems, Modulation formats

4.	Basic concepts, Optical Communication systems, Modulation formats
5.	Nature of Light, Light polarization, Basic Optical Law & definitions, Types of Refractive Index Profiles
6.	Wave Propagation in Step index Fiber& derivation of Important parameters: NA, V- number, Cut - off wavelength etc.
7.	Wave Propagation in Step index Fiber& derivation of Important parameters: NA, V- number, Cut - off wavelength etc.
8.	Optical Fiber Modes & configurations.
9.	Types of Fibers: Single Mode & Multimode
10.	Single Mode Fibers, Mode Field diameter, Propagation Mode in Single Mode Fiber
11.	Into. to Fiber manufacturing
12.	Attenuation, Scattering & Bending losses, Absorption.
13.	Attenuation, Scattering & Bending losses, Absorption.
14.	Signal Distortion, Group Delay, and Dispersion: Intermodal & Intramodal - Material and Waveguide.
15.	Signal Distortion, Group Delay, and Dispersion: Intermodal & Intramodal - Material and Waveguide.
16.	Dispersion in Single Mode Fibers, Conventional Step Index Fiber, Refractive Index profiles.
17.	Advance Single Mode Fiber Designs & their Optimization : Dispersion Shifted, Dispersion Flattened & Dispersion Compensation
18.	Advance Single Mode Fiber Designs & their Optimization : Dispersion Shifted, Dispersion Flattened & Dispersion Compensation
19.	Basic Principles of Semiconductor, Energy bands, Intrinsic & Doped Semiconductors
20.	LEDs : Structure, Modulation Response, Light Current Characteristics etc.
21.	Laser Diode : Structure & Radiation Pattern, lasing, Efficiency, threshold conditions, Modulation, DFB lasers
22.	Laser Diode : Structure & Radiation Pattern, lasing, Efficiency, threshold conditions, Modulation, DFB lasers
23.	Optical detectors &Receivers : basic concepts
24.	p-i-n Photodiode, Avalanche Photodiode
25.	Detector Response time, , Receiver Noise, Signal to Noise Ratio, Sensitivity, Minimum Received Power
26.	Coherent Optical Fiber Communication
27.	Power coupling, Source to Fiber power efficiency, Power launching. Fiber Splicing & jointing.
28.	Digital Transmission systems, Photonic Switching
29.	Digital Transmission systems, Photonic Switching
30.	Line Coding : NRZ,RZ, Block codes, Error correction
31.	Line Coding : NRZ,RZ, Block codes, Error correction
32.	Optical Fiber Link design : Link Power budget analysis & Rise time budget
33.	Optical Fiber Link design : Link Power budget analysis & Rise time budget
34.	Intd. to Integrated Optics, Gratings, Hologram, Optical Filters

35.	Intd. to Integrated Optics, Gratings, Hologram, Optical Filters
36.	WDM Systems, DWDM, Dispersion management
37.	WDM Systems, DWDM, Dispersion management
38.	Intd. to Optical Amplifiers
39.	SOA & EDFA
40.	Examples of Typical Systems : SONET/SDH, Ring Topology, Star Architecture etc.
41.	Examples of Typical Systems : SONET/SDH, Ring Topology, Star Architecture etc.

Name of Program	M. Tech. (Communication Systems)	Semester I	Year 1
Name of Course	**Wireless Communication**		
Course Code	**CS 103**		
Core / Elective / Other	**Core**		

Prerequisite:	
1.	Basic knowledge of wireless communication
2.	Linear Algebra and Probability
Course Outcomes: After completion of the course, the students will be able to	
CO1	Understand MIMO and massive MIMO for practical applications.
CO2	Be Proficient in MIMO channel modeling, including spatial and mmWave.
CO3	Attain advanced receiver design skills for channel estimation and signal detection.
CO4	Cultivate beamforming expertise, including analog, digital, and hybrid approaches.
CO5	Develop insight into emerging wireless technologies, including index modulation, large aperture arrays, heterogeneous massive MIMO, and deep/machine learning integration.
Description of Contents in brief:	
1.	Introduction to multiple-input multiple-output (MIMO) systems and its relevance, diversity-multiplexing trade-offs, single-user and multi-user MIMO systems, Massive MIMO systems: Motivation and system model, time and frequency division duplexing, uplink and downlink transmissions, benefits and challenges, relevance for the existing wireless standards, spectral and energy efficiency
2.	Channel Models: MIMO and massive MIMO channel modeling, spatial channel models, 3GPP channel models, mm Wave channel models, Receiver designing: Channel estimation: sounding signals and estimation techniques, the issues of pilot contamination, pilot assignment techniques, estimating direction of arrivals and departures; Signal detection: linear detectors like MF, ZF, and MMSE, non-linear detectors such as ML, Sphere decoding, SIC, Neighborhood Search, and matching Pursuit algorithms, Soft decoding
3.	Beamforming: Beamforming fundamentals, Analog, Digital and Hybrid beamforming architectures, Beamforming techniques and algorithms such as phase minimization etc, quantization effects. Beam management: Beam sweeping, reference signals for beam management, Synchronization signals, beam measurement, determination and reporting
4.	Potential advancements: Index modulation for massive MIMO systems, extremely large aperture arrays, Heterogeneous massive MIMO, Holographic/RIS massive MIMO
5.	Deep/Machine Learning for Wireless Communication: Overview of DL/ML Modelling, Data set generation and acquisition, training the model. Example problems like modulation design, channel estimation, signal detection etc., intelligent massive MIMO
List of Text Books:	
1.	D. Tse and P. Viswanath, “Fundamentals of Wireless Communication”, Cambridge University Press, 2nd edition, 2005
2.	A. Goldsmith, “Wireless Communications”, Cambridge University Press, 2005

List of Reference Books:	
1.	E. Björnson, J. Hoydis and L. Sanguinetti, "Massive MIMO Networks: Spectral, Energy, and Hardware Efficiency", Foundations and Trends in Signal Processing: Vol. 11, No. 3-4, pp 154–655, (2017)
2.	T. Marzetta, E. Larsson, H. Yang, and H Ngo, "Fundamentals of Massive MIMO. Cambridge", Cambridge University Press, 2016
URLs:	
1.	Nil

Lecture Plan (about 40-50 Lectures):

Lecture No.	**Topic**
1-2	Introduction to multiple-input multiple-output (MIMO) systems
3-4	Diversity-multiplexing trade-offs, single-user and multi-user MIMO systems
5-6	Massive MIMO systems: Motivation and system model
7-8	Massive MIMO systems: Time and frequency division duplexing, uplink and downlink transmissions,
9-10	Massive MIMO systems: Benefits and challenges, relevance for the existing wireless standards, spectral and energy efficiency
11-12	MIMO and massive MIMO channel modeling, spatial channel models
13	3GPP channel models, mmWave channel models
14	Channel estimation: sounding signals and estimation techniques
15	Pilot contamination, pilot assignment techniques
16	Estimating direction of arrivals and departures
17-18	Signal detection: linear detectors MF, ZF, and MMSE,
18-20	Non-linear detectors: ML, Sphere decoding, SIC, Neighborhood Search, and matching Pursuit algorithms, Soft decoding
21	Beamforming fundamentals
22-23	Analog, Digital and Hybrid beamforming architectures,
24	Beamforming techniques and algorithms such as phase minimization etc, quantization effects.
25-28	Beam management: Beam sweeping, reference signals for beam management, Synchronization signals, beam measurement, determination and reporting
29-30	Potential advancements: Index modulation for massive MIMO systems
31-32	Extremely large aperture arrays, Heterogenous massive MIMO
33-34	Holographic/RIS massive MIMO
35-37	Overview of DL/ML Modelling, Data set generation and acquisition, training the model.
38-40	Example problems like modulation design, channel estimation, signal detection etc., intelligent massive MIMO

SECOND SEMESTER

Name of Program	**M.Tech. (Communication Systems)**	**Semester II**	**Year 1**
Name of Course	**Detection and Estimation Theory**		
Course Code	**CS 201**		
Core / Elective / Other	**Core**		

Prerequisite:	
1.	Signals and Systems
2.	Digital Communication
Course Outcomes: After completion of the course, the students will be able to	
CO1	Apply multi resolution analysis for de-noising of received signals
CO2	Design signal detectors in predefined operating conditions and known noise
CO3	Design signal estimators in predefined operating conditions and known noise
CO4	Analyze and apply theoretical knowledge to make best possible decision in unknown noise case
CO5	Adapt Artificial intelligence in the application of modern techniques to traditional ones for good estimation of signals
Description of Contents in brief:	
1.	Techniques of denoising Signals – Wavelet and Multi resolution de-noising
2.	Hypothesis Testing
3.	Detecting Signal under fully/partially known parameters
4.	Estimating signal parameters
5.	Contemporary ways of detection and estimation
List of Text Books:	
1.	Ralph D. Hippenstiel , “Detection Theory”, CRC press.
2.	H.L. Van Tree, “Detection Estimation and Modulation Theory-Part-II”, John Wiley & Sons.
List of Reference Books:	
1.	K. Sam Shanmugham and Arthur M. Breipohl, “Random Signals: Detection, Estimation and Data Analysis”, , BS Publications
URLs:	
1.	https://www.youtube.com/watch?v=SeT3TbMXQ8A

Lecture Plan (about 40-50 Lectures):	
Lecture No.	**Topic**
1	Introduction to the course
2	General strategy of detection and estimation, spaces involved.
3	Review of relevant probability theory concepts.

4	Illustrative numerical examples for enhancing understanding
5	Wavelet transform for discrete time signals
6	Multi resolution analysis of signals and de-noising
7	Illustrative numerical examples for enhancing understanding
8	Hypothesis testing : Mathematical development of Bayesian framework
9	MAP and ML detection
10	Minmax detection
11	Neyman Pearson detection
12	Multiple Hypothesis testing
13	Composite Hypothesis Testing
14	Illustrative numerical examples for enhancing understanding
15	Problem solving session
16	Receiver operating curve and performance evaluation
17	Sign detector
18	WILCOXON detector
19	Sequential detection
20	Illustrative numerical examples for enhancing understanding
21	Detection of dynamic signals in white Gaussian noise
22	Matched filter approach for detection
23	Detection of signals with random parameters
24	Illustrative numerical examples for enhancing understanding
25	Detection of signals in additive colored Gaussian noise
26	Mercers theorem
27	Karhunens-Loeve expansion
28	Introduction to estimation of signals Baye’s estimator
29	MAP, ML estimator
30	Illustrative numerical examples for enhancing understanding
31	Properties of estimators
32	Cramer Rao bound
33	Waveform estimation
34	Illustrative numerical examples for enhancing understanding
35	Spectrogram and periodogram
36	Spectral correlation and ambiguity function
37	Illustrative numerical examples for enhancing understanding
38	Random Sample consensus for parameter estimation for very low SNR
39	Machine learning based detectors and estimators
40	Concluding remarks about course

Name of Program	M. Tech. (Communication Systems)	Semester II	Year 1
Name of Course	**Terahertz Communication**		
Course Code	**CS 202**		
Core / Elective / Other	**Core**		

Prerequisite:	
1.	Basic Concepts of Communication

Course Outcomes: After completion of the course, the students will be able to	
CO1	Understand wireless fundamentals, including evolution, math representation, channels, and multi-antenna systems.
CO2	Analyze Sub-6 GHz and mmWave systems in 5G, assessing motivation, models, duplexing, and challenges
CO3	Understand Terahertz communication, differentiating from microwave, exploring propagation, power consumption, signal processing, and applications.
CO4	Master channel modeling, including MIMO, massive MIMO, spatial models, 3GPP, mmWave, and Terahertz Channel Model.
CO5	Develop baseband signal processing proficiency, covering channel estimation, pilot assignment, direction estimation, signal detection, and addressing hardware impairments.

Description of Contents in brief:	
1.	**Wireless Fundamentals**: Evolution, mathematical representation of wireless systems, channel characteristics, multi-antenna systems, multicarrier modulation schemes
2.	**Sub-6 GHz and mm-Wave Wireless Systems:** Motivation and system model, time and frequency division duplexing, uplink and downlink transmissions, benefits and challenges, relevance in 5G and beyond 5G systems, spectral and energy efficiency
3.	**THz Communication**: Motivation, differences between microwave, mm-Wave and THz communication, propagation and characteristics, power consumption, multi-antenna signal processing, applications of THz
4.	**Channel Models**: MIMO and massive MIMO channel modeling, spatial channel models, 3GPP channel models, mm-Wave channel models, THz channel model
5.	THz devices, THz transceiver technologies, mm-Wave and THz modulation, industrial and wireless communications applications of THz waves

List of Text Books:	
1.	T. Marzetta, E. Larsson, H. Yang, and H Ngo, "Fundamentals of Massive MIMO. Cambridge," Cambridge University Press, 2016.
2.	E. Björnson, J. Hoydis and L. Sanguinetti, "Massive MIMO Networks: Spectral, Energy, and Hardware Efficiency," Foundations and Trends in Signal Processing: Vol. 11, No. 3-4, pp 154–655, (2017).

List of Reference Books:	
1.	D. Tse and P. Viswanath, "Fundamentals of Wireless Communication," Cambridge University Press
2.	Saim Ghafoor, Mubashir Husain Rehmani, Alan Davy, ``Next Generation Wireless Terahertz Communication Networks'', CRC Press

URLs:	
1.	Nil

Lecture Plan (about 40-50 Lectures):

Lecture No.	Topic
1	Introduction to Wireless Fundamentals
2	Evolution of Wireless Systems
3	Mathematical Representation of Wireless Systems

4	Channel Characteristics
5	Multi-Antenna Systems
6	Multicarrier Modulation Schemes
7	Sub-6 GHz and mm-Wave Wireless Systems Overview
8	Motivation and System Model
9	Time and Frequency Division Duplexing
10	Uplink and Downlink Transmissions
11	Benefits and Challenges of Sub-6 GHz and mm-Wave
12	Relevance in 5G Systems
13	Relevance in Beyond 5G Systems
14	Spectral and Energy Efficiency
15	Introduction to THz Communication
16	Motivation for THz Communication
17	Differences Between Microwave, mm-Wave, and THz
18	Propagation and Characteristics of THz
19	Power Consumption in THz Communication
20	Multi-Antenna Signal Processing for THz
21	Applications of THz
22	Channel Models Overview
23	MIMO Channel Modeling
24	Massive MIMO Channel Modeling
25	Spatial Channel Models
26	3GPP Channel Models
27	mm-Wave Channel Models
28	THz Channel Model Overview
29	THz Devices Overview
30	THz Transceiver Technologies Overview
31	Modulation in mm-Wave and THz
32	Industrial Applications of THz Waves
33	Wireless Communications Applications of THz
34	Review and Integration of Wireless Fundamentals
35	Review of Sub-6 GHz and mm-Wave Systems
36	Review of THz Communication
37	Review of Channel Models
38	Review of THz Devices and Transceiver Technologies
39	Practical Aspects of mm-Wave and THz
40	Case Studies in Wireless Communications
41	Emerging Technologies in Wireless Communication
42	Future Directions and Trends in Wireless Technology

Department Electives

Name of Program	M.Tech. (Communication Systems)	Semester- I/II	Year I
Name of Course	**RF Communication**		
Course Code	**CS 501**		
Core / Elective / Other	**Elective**		

Prerequisite:	
1.	Electromagnetic Fields
2.	Antenna and Wave Propagation
Course Outcomes: After completion of the course, the students will be able to	
CO1	Understand the principle of operation of radio frequency devices and circuits
CO2	Explain principle of operation of various phase shifters
CO3	Analyze the performance of filters and mixers
CO4	Design planar devices and analyze its performance
CO4	Explain various RF communication systems
Description of Contents in brief:	
1.	Electromagnetic frequency spectrum with applications, network parameters, scattering matrix, S-parameter analysis of passive waveguide devices, power dividers, combiners
2.	Phase shifters, Types, Transmission line type, Reflection types phase shifters.
3.	Active and Passive Filters, LC filters, SAW filters, Crystal filters, RF detectors, and Mixers.
4.	Smith Chart, ,Planar passive devices, microstrip lines , striplines , transmission line resonators, quarter-wave transformers, Noise in RF systems, Noise figure computations, nonlinear distortion, Dynamic range.
5.	RF Communication systems , Friss formula , link budget, carrier to noise ratio, bit error rate calculations, Case studies on direct broadcasting systems, global positioning systems , WLAN, Spectrum regulations and standards
List of Text Books:	
1.	DM Pozar ,'Microwave and RF Wireless Systems', New York;Wiley,2001
2.	Principles of Electronic Communication Systems, 3 rd Ed., by Loius Frenzel
3.	David M. Pozar, "Microwave Engineering", Wiley India Limited, Fourth Edition, 2012.
List of Reference Books:	
1.	Ludwig R, Bogdanov G, RF Circuit Design, Theory and Applications, Pearson Education Inc, Second Edition, 2013.
URLs:	
1.	https://www.tutorialspoint.com/microwave_engineering/microwave_engineering_types_of_transmission_lines.htm
2.	https://www.youtube.com/watch?v=R2JYYmGeVOM

Lecture Plan (about 40-50 Lectures):	
Lecture No.	**Topic**
1.	Electromagnetic frequency spectrum with applications
2.	Network parameters, scattering matrix
3.	Problems on Scattering Parameters
4.	S-parameter analysis of passive waveguide devices
5.	Power dividers
6.	Power combiners
7.	Phase shifters , Types,
8.	Transmission line type phase shifters.
9.	Transmission line type phase shifters Continued
10.	Reflection types phase shifters
11.	Reflection types phase shifters Continued
12.	Active Filters
13.	Passive Filters
14.	LC filters,
15.	SAW filters
16.	Crystal filters.
17.	RF detectors
18.	RF detectors Continued
19.	RF Mixers
20.	Smith Chart
21.	Problems on Smith Chart,
22.	Planar passive devices, microstrip lines.
23.	Design of Mirostrip line
24.	Problems on Microstrip line
25.	Striplines and its advantages
26.	Problems on Striplines
27.	Tansmission line resonators,
28.	quarter-wave transformers,
29.	Noise in RF systems
30.	Noise figure computations
31.	Non linear distortion, Dynamic range
32.	RF Communication system
33.	Friss formula , Problems
34.	link budget, carrier to noise ratio
35.	WLAN
36.	Spectrum regulations and standards
37.	bit error rate calculations,
38.	Case studies on direct broadcasting systems
39.	Case studies Continued
40.	Globalpositioning systems

Name of Program	M. Tech. (Communication Systems)	Semester I/II	Year 1
Name of Course	**Wireless Technologies: 5G and beyond**		
Course Code	**CS 502**		
Core / Elective / Other	**Elective**		

Prerequisite:

1.	Digital Communication
2.	Wireless Communication

Course Outcomes: After completion of the course, the students will be able to

CO1	Understand and explain the channel models of 5G
CO2	Analyze MIMO antenna in 5G and its techniques.
CO3	Draw and explain 5G architecture, its components and functional criteria.
CO4	Explain about device to device (D2D) communication and standardization.
CO5	Illustrate the in-depth functioning of 5G radio access technologies.

Description of Contents in brief:

1.	5G channel modelling, Modeling requirements and scenarios, Channel modelrequirements, Propagation scenarios
2.	Introduction to Multi-antenna, Motivation, MIMO Antennas, MIMO vs. multi-antenna systems, Diversity,ransmit diversity,Space-time codes, The Alamouti scheme, Therake receiver, Spatial Multiplexing
3.	Introduction to 5G architecture, NFV and SDN, Basics about RAN architecture,High-level requirements for the 5G architecture, Functionalarchitecture and 5G flexibility, Functional split criteria, Functionalsplit alternatives, Functional optimization for specificapplications
4.	Device-to-device (D2D) communications: from 4G to 5G, D2D standardization: 4G LTE D2D, D2D in5G: research challenges, Radio resource management for mobilebroadband D2D, RRM techniques for mobile broadband D2D,5G D2D RRM concept
5.	Access design principles for multi-user communications,Orthogonal multiple-access systems, Spread spectrum multiple-access systems, Sparse code multiple access (SCMA), Network deployment types, Interferencemanagement in 5G, mobility management in 5G and heterogeneous 5G networks

List of Text Books:

1.	Afif Osseiran, Jose F. Monserrat, Patrick Marsch, "5G Mobile and Wireless Communications Technology", Cambridge University Press
2.	Erik Dahlman, Stefan Parkvall, Johan Skold, "5G NR: The Next Generation Wireless Access Technology", Elsevier

List of Reference Books:

1.	Jonathan Rodriguez, "Fundamentals of 5G Mobile Networks", Wiley

URLs:

1.	https://nptel.ac.in/courses/108/105/108105134/
2	https://www.udemy.com/course/5g-mobile-networks-modern-wireless-communication-tech2.nology/

Lecture Plan (about 40-50 Lectures):

Lecture No.	Topic
1	5G channel modelling
2	Modeling requirements
3	Modeling scenarios,

4	Channel model requirements
5	Propagation scenarios
6	Introduction to Multi-antenna
7	Motivation towards Multi-Antenna
8	MIMO Antennas
9	MIMO vs. multi-antenna systems
10	Diversity,ransmit diversity
11	Space-time codes, The Alamouti scheme,
12	Therake receiver
13	Spatial Multiplexing
14	Introduction to 5G architecture
15	NFV and SDN
16	Basics about RAN architecture
17	High-level requirements for the 5G architecture, Functionalarchitecture
18	5G flexibility, Functional split criteria
19	Functionalsplit alternatives
20	Functional optimization for specificapplications
21	Device-to-device (D2D) communications: from 4G to 5G
22	D2D standardization: 4G LTE D2D
23	D2D in5G: research challenges
24	Research challenges continued
25	Radio resource management for mobilebroadband D2D
26	RRM techniques for mobile broadband D2D
27	RRM Techniques continued
28	5G D2D RRM concept
29	Access design principles for multi-user communications
30	Orthogonal multiple-access systems
31	Spread spectrum multiple-access systems
32	Spread spectrum multiple-access systems continued
33	Sparse code multiple access (SCMA)
34	Network deployment types
35	Network deployment types
36	Interferencemanagement in 5G
37	Interface management continued
38	Mobility management in 5G
39	Heterogeneous 5G networks
40	Heterogeneous 5G networks continued

Name of Program	M.Tech. (Communication Systems)	Semester- I/II	Year I
Name of Course	**Microwave Communication**		
Course Code	**CS 503**		
Core / Elective / Other	**Elective**		

Prerequisite:	
1.	Electromagnetic Fields
2.	Microwave Engineering
3.	Antenna and Wave Propagation
Course Outcomes: After completion of the course, the students will be able to	
CO1	Recall applications of Vector calculus and matrix operations in EM fields
CO2	Analyze EM wave propagation through various types of mediums and boundary conditions
CO3	Explain various functions of a microwave transmitter and receiver
CO4	Analyze propagation of microwaves
Description of Contents in brief:	
1.	Microwave radio system: Transmitter & receivers block, FM microwave repeater, Microwave protection, microwave terminal station, repeater station.
2.	Microwave links: Block deign path characteristics, system gain, free space path logs E/N ratio.
3.	Microwave digital communication block diagram, regeneration repeater, digital modulation & demodulation at microwave frequencies
4.	Analog& digital multiplying, line codes. Local microwave distribution system.
5.	Propagation of microwave: line of sight, Non- line of sight duet propagation as Troposcatter links.
List of Text Books:	
1.	W Tomasi, “Advance Electronic Comm System.”, PHI.
2.	Roy Blake Thomsar, “Electronic Comm. Systems”. II Edition
3.	Kemealy&Dakis, “Electronic Comm.” TMH.
List of Reference Books:	
1.	Antonio Raffo Giovanni Crup “Microwave Wireless Communications”
2.	Devendra Kumar Mishra “Radio Frequency And Microwave Communication Circuits : Analysis And Design”
3.	George Kizer “Digital Microwave Communication”, Wiley
URLs:	
1.	https://nptel.ac.in/courses/108/101/108101112/
2.	https://nptel.ac.in/courses/117105130/

Lecture Plan (about 40-50 Lectures):	
Lecture No.	**Topic**
1.	Microwave radio system: Transmitter block
2.	receivers block
3.	FM microwave repeater
4.	FM microwave repeater continued
5.	Microwave protection
6.	microwave terminal station
7.	microwave terminal station continued
8.	Repeater station.
9.	Microwave links: Block design
10.	Microwave links: Block design continued
11.	path characteristics
12.	path characteristics continued
13.	system gain
14.	system gaincontinued
15.	Free space path logs E/N ratio.
16.	free space path logs E/N ratio continued
17.	Microwave digital communication block diagram
18.	Microwave digital communication block diagram continued
19.	regeneration repeater
20.	regeneration repeater continued
21.	digital modulation at microwave frequencies
22.	digital modulation at microwave frequencies continued
23.	Demodulation at microwave frequencies
24.	Demodulation at microwave frequencies continued
25.	analog & digital multiplying
26.	analog & digital multiplying continued
27.	line codes
28.	line codes continued
29.	line codes continued
30.	Local microwave distribution system
31.	Local microwave distribution system continued
32.	Local microwave distribution system continued
33.	Propagation of microwave : line of sight
34.	line of sight Continued
35.	Non- line of sight
36.	Non- line of sight continued
37.	Non- line of sight continued
38.	duet propagation as Troposcatter links
39.	duet propagation as Troposcatter links continued
40.	duet propagation as Troposcatter links continued

Name of Program	**M. Tech. (Communication Systems)**	**Semester- I/II**	**Year I**
Name of Course	**Advanced Digital Signal Processing**		
Course Code	**CS 504**		
Core / Elective / Other	**Elective**		

Prerequisite:

1.	Knowledge of Signal processing up to B.Tech. level

Course Outcomes: After completion of the course, the students will be able to

1.	Do analysis of discrete time signals
2.	Explain modern digital signal processing algorithms and applications.
3.	Obtain in-depth knowledge of use of digital systems in real time applications
4.	Apply the algorithms for wide area of recent applications.

Description of Contents in brief:

1.	Review of Discrete time signals and systems and frequency analysis of discrete time linear time invariant systems. Discrete time systems, analysis of discrete time linear invariant systems, implementation of discrete time systems, correlation of discrete time systems,ztransforms, linear time invariant systems as frequency selective filters.
2.	The Discrete Fourier transforms its properties and applications. Frequency domain sampling,properties of DFT, linear filtering methods based on DFT, Frequency analysis of signalsusing the DFT,Radix-2 decimation in time domain and decimation in frequency domainalgorithms.
3.	Design of Digital filters, Design of FIR filters, Design of IIR filters, frequency transformations Multirate digital signal processing, Decimation, interpolation, sampling rate conversion, filter design and implementation for multirate conversion, sampling rate conversion by an arbitrary factor, applications of multirate signal processing.
4.	Linear prediction and optimum linear filters, Forward and backward linear prediction, solution of the normal equations, wiener filters.
5.	Power spectrum estimation, Non-parametric and parametric methods for power spectrum estimation.

List of Text Books:

1.	Digital Signal Processing Principles, Algorithms, and Applications John G. Proakis, PrenticeHall International.Inc, 4th Edition, 2012.
2.	Theory and Application of Digital Signal Processing by Lawrence R.Rabiner and Bernard Gold.
3.	Oppenheim, Alan V. Discrete-time signal processing. Pearson Education India, 1999.

List of Reference Books:

1.	Mitra, Sanjit Kumar, and Yonghong Kuo. Digital signal processing: a computer-based approach. Vol. 2. New York: McGraw-Hill Higher Education, 2006.

URLs:

1.	Nil

Lecture Plan (about 40-50 Lectures):

Lecture No.	Topic
1	Review of Discrete time signals and systems
2	frequency analysis of discrete time linear time invariant systems

3	Discrete time systems
4	Analysis of discrete time linear invariantsystems
5	Analysis of discrete time linear invariantsystems Contd.
6	Implementation of discrete time systems
7	correlation of discrete time systems
8	Z-transforms
9	Z-transforms contd.
10	Linear time invariant systems as frequency selective filters
11	The Discrete Fourier transforms
12	The Discrete Fourier transforms Continued
13	Its properties and applications
14	Frequency domain sampling
15	Properties of DFT, linear filtering methods based on DFT
16	Frequency analysis of signalsusing the DFT,
17	Frequency analysis of signalsusing the DFT, Contd.
18	Radix-2 decimation in time domain and decimation in frequency domainalgorithms
19	Frequency domain algorithms continued
20	Design of Digital filters
21	Design of FIR filters
22	Design of FIR filters Continued
23	Design of IIR filters
24	Design of IIR filters Continued
25	frequency transformations
26	Multirate digital signal processing, Decimation, interpolation
27	Sampling rate conversion,
28	Filter design and implementation for multirate conversion
29	Sampling rate conversion by an arbitrary factor
30	Applications of multirate signal processing
31	Linear prediction filters
32	Optimum linear filters
33	Forward and backward linear prediction
34	Forward and backward linear prediction Contd.
35	Solution of the normal equations
36	Wiener filters
37	Wiener filters contd.
38	Power spectrum estimation
39	Non-parametric and parametric methods for power spectrumestimation.
40	Non-parametric and parametric methods for power spectrum estimation Continued

Name of Program	M.Tech. (Communication Systems)	Semester- I/II	YearI
Name of Course	**Digital Image Processing**		
Course Code	**CS 505**		
Core / Elective / Other	**Elective**		

Prerequisite:

1.	Digital Signal Processing
2.	Probability and Statistics

Course Outcomes: After completion of the course, the students will be able to

CO1	Analyze general terminology of digital image processing.
CO2	Examine various types of images, intensity transformations and spatial filtering
CO3	Evaluate the methodologies for image segmentation, restoration etc.
CO4	Implement image process and analysis algorithms
CO5	Apply image processing algorithms in practical applications

Description of Contents in brief:

1. **Digital Image Fundamentals:** Image Signal, Image sampling, Image quantization, Image digitization. Image resolutions: Spatial and Sampling. Types of Images, Human perception of color and color models.
2. **Spatial domain Image Processing:** Point operations: arithmetic, logical, geometric. Neighborhood operation; linear and non-linear. Image Interpolation. Enhancement and restoration in spatial domain. Image histogram, histogram equalization and matching.
3. **Transform domain Image Processing:** Preliminary Concepts, Sampling and the Fourier Transform of Sampled Functions, The Discrete Fourier Transform, Properties. Basics of Filtering in the Frequency Domain, Image Smoothing Using Lowpass, Highpass, and Bandpass Filters. Enhancement and restoration in transform domain.
4. **Image Compression:** Redundancies and their Removal Methods. Fidelity Criteria, Lossless and Lossy Image Compression Models. Entropy encoding: Huffman Coding, Arithmetic Coding, Run Length Encoding. Transform Domain Compression. JPEG and JPEG 2000 Standards.
5. **Image Segmentation:** Thresholding based segmentation, Discontinuity based Image segmentation, Image derivatives, Edge Detection, Edge linking and boundary detection, Region based image segmentation. Morphological Operations.

List of Text Books:

1.	R.C.Gonzalas and R.E.Woods, Digital Image Processing, Prentice Hall, 3rd Ed
2.	A.K.Jain, Fundamentals of Digital Image Processing, Prentice Hall.

List of Reference Books:

1.	S.Sridhar, Digital Image Processing, Oxford University Press.
2.	A.K.Jain, Fundamentals of Digital Image Processing, Prentice Hall.

URLs:

1.	Nil

Name of Program	M.Tech (Communication Systems)	Semester I/II	Year I
Name of Course	**Signal Theory**		
Course Code	**CS506**		
Core / Elective / Other	**Elective**		

Prerequisite:

1.	Analog and Digital communication
2.	Basic signal, system,
3.	Mathematical transform

Course Outcomes: After completion of the course, the students will be able to

CO1	Explain general linear models of signal and how they are related.
CO2	Apply parametric and nonparametric techniques to estimate autocorrelation, cross-correlation, and partial correlation.
CO3	Illustrate a peer-reviewed research project orally and in written form

Description of Contents in brief:

Representation of deterministic signals: Orthogonal representation of signals. Dimensionality of signal spaces. Construction of orthogonal basis functions. Time-bandwidth relationship: RMS duration and bandwidth, uncertainty relations. Random Processes: Definition and Classification, stochastic integrals, Fourier transforms of random processes, stationary and nonstationary processes, correlation functions. Special random processes (white Gaussian noise, Wiener-Levy processes, shot-noise processes, Markov processes). Optimum Filtering: Matched filters for deterministic signals in white and coloured Gaussian noise. Wiener filters for random signals in white and coloured Gaussian noise. Discrete and continuous time filters.

List of Text Books:

1.	Signals and Systems A.V. Oppenheim, A.S. Willsky and I.T. Young.
2.	Populis, “Random Variables and Random Process”.

List of Reference Books:

1.	Detection, Estimation and Modulation, H.L. Van Trees

URLs:

1.	Nil

Lecture Plan (about 40-50 Lectures):	
Lecture No.	**Topic**
1	Representation of deterministic signals
2	Discrete-Time Processing
3	Discrete-Time Systems
4	Orthogonal representation of signals
5	Signal Models
6	Signal Models Contd.
7	Practical Modeling
8	Practical Modeling Contd.
9	Autoregressive Models
10	Autoregressive Models Contd.
11	Pole-Zero Models
12	Dimensionality of signal spaces
13	Construction of orthogonal basis functions
14	Time-bandwidth relationship
15	RMS duration and bandwidth
16	uncertainty relations
17	Random Variables
18	Stochastic Signals
19	Autocorrelation
20	Random Processes
21	Definition and Classification
22	stochastic integrals
23	Fourier transforms of random processes
24	stationary and non-stationary processes
25	correlation functions
26	Windowing
27	Spectral Estimation
28	Joint Signal Analysis
29	Coherence Analysis
30	Time-Frequency Analysis
31	Special random processes -white Gaussian noise
32	Wiener-Levy processes
33	shot-noise processes
34	Markov processes
35	Optimum Filtering
36	Matched filters for deterministic signals in white and coloured Gaussian noise
37	Wiener filters for random signals in white and coloured Gaussian noise
38	Discrete and continuous time filters

39	Optimum FIR Filters
40	Linear Prediction
41	Optimum IIR Filters
42	Optimum Linear Filter Applications
43	Order-Recursive Algorithms
44	Order-Recursive Algorithms
45	Optimum Linear Filter Applications
46	Order-Recursive Algorithms
47	Order-Recursive Algorithms
48	Estimation Theory
49	Minimum-Variance Spectrum Estimation
50	Frequency Estimation

Name of Program	**M.Tech (Communication Systems)**	**Semester I/II**	**Year I**
Name of Course	**Mobile Communication**		
Course Code	**CS507**		
Core / Elective / Other	**Elective**		

Prerequisite:	
1.	Digital Communication
2.	Analog communication
3.	Wave propagation
Course Outcomes: After completion of the course, the students will be able to	
CO1	Recall different generations of mobile communication systems such as AMPS, GSM CDMA etc.
CO2	Explain about multiple access technologies used in mobile systems.
CO3	Outline the effect of fading and explain different fading models.
CO4	Illustrate different spread channel allocation techniques, performance evaluation and remedies used in mobile Communication.
Description of Contents in brief:	
1.	Cellular Concept, frequency reuse, Propagation mechanism, fading,
2.	Multiple Radio Access Protocols,
3.	Multiple Division Techniques For traffic Channel: Concept and Model for Multiple Divisions, Modulation Techniques.
4.	Traffic Channel Allocation,
5.	Handoff Parameters
6.	1^{st} G en, 2^{nd} Gen, 3^{rd} Gen, 4^{th} Gen and 5^{th} Gen Mobile systems
List of Text Books:	
1.	Dharma Prakash Agrawal and Qing-An Zeng, “Introduction to Wireless and Mobile System”.
2.	Vijay K. Garg and Joseph E. Wilkes ,“Principles and Applications of GSM”,.
3.	GottapuSasibhushana Rao, “Mobile Cellular Communication”.
List of Reference Books:	
1.	“Wireless Communications:Principles and Practice”, by T.S. Rappaport, Prentice Hall publication.
2.	“Wireless and Cellular Communications”, by William C.Y. Lee, McGRAW-HILL Publication.
URLs:	
1.	https://nptel.ac.in/courses/117/104/117104099
2.	https://swayam.gov.in/nd1_noc19_ee48/preview

Lecture Plan (about 40-50 Lectures):	
Lecture No.	**Topic**
1	Introduction to Mobile system
2	1st generation Mob System: AMPS Introduction
3	1st generation Mob System: AMPS- Architecture
4	2nd generation Mob System: GSM: Introduction
5	Network architecture of GSM
6	Radio subsystem of GSM
7	Network Subsystem of GSM
8	Network Subsystem of GSM (continued)
9	Operational Subsystem of GSM
10	Frequency Reuse
11	Introduction to Mobile Radio Propagation, Free space Propagation model
12	Types of Fading
13	Propagation mechanism-Reflection due to conductors/dielectric
14	Propagation Mechanism-Diffraction Models and scattering
15	Multipath propagation, Small scale Fading
17	Types of small scale fading-Flat/Frequency selective/fast/slow
18	Small scale fading – continued / Display of Attendance
19	Analog & Digital Mod Techniques
20	Introduction to multiple access-narrowband/wideband sys.& FDMA
21	FDMA continued
22	Multiple access tech.-TDMA & its efficiency+ Numerical problems
23	Spread spectrum technique-CDMA
24	Traffic Channel Allocation
25	Fixed channel allocation
26	Algorithms of Fixed channel allocation such as SB,
27	Algorithms of Fixed channel allocation such as SBR
28	Algorithms of Fixed channel allocation such as BA,
29	Algorithms of Fixed channel allocation such as BAR,
30	Algorithms of Fixed channel allocation such as BFA
31	Dynamic Channel Allocation
32	Algorithms of DCA-FA
33	Algorithms of DCA- LODA
34	Algorithms of DCA-RING,
35	Algorithms of DCA- MSQ
36	Hybrid channel allocation Technique
37	Comparison of FCA, DCA and HCA
38	Antenna sys in Mobile system
39	Antenna sys in Mobile system (Continued)
40	Antenna parameters
41	Antenna arrays in Mobile system
42	3rd generation Mob System: technique
43	3 G Air Interface
44	3G Spectrum, QoS,

45	3G limitations
46	4G evolution, objectives
47	4G technology
48	4G limitation
49	5G evolution and concept
50	5G technique

Name of Program	M.Tech (Communication Systems)	Semester I/II	Year I
Name of Course	**Telecom switching system**		
Course Code	**CS 508**		
Core / Elective / Other	**Elective**		

Prerequisite:

1.	Computer Communication and Networks

Course Outcomes: After completion of the course, the students will be able to

CO1	Describe different multiplexing techniques
CO2	Express the concepts of Digital Switching.
CO3	Review the performance analysis of network traffic.
CO4	Outline the ISDN architecture and Digital Loop Carrier Systems.
CO5	Analyze the Characteristics of a network.

Description of Contents in brief:

1.	Basic of Switching System, Simple Telephone Communication, Manual Switching System, Major Telecommunication Networks
2.	Digital Switching: Switching Functions, Space Division Switching, Time Division Switching, two dimensional Switching
3.	Traffic Engineering, Queuing systems: Erlang Distribution, probability of delay, Finite queue capacity, systems with a single server, Queues in tandem, delay tables and application of Delay formulae.
4.	Telephone Networks: Subscriber Loop System, Switching Hierarchy And Routing, Transmission Plan, Transmission System Numbering Plan, Charging Plan, Signaling Techniques, In-channel Signaling, Common Channel Signaling, and Cellular Mobile Telephony.
5.	Digital Subscriber Access: ISDN: ISDN Basic Rate Access Architecture, ISDN U Interface, And ISDN D Channel Protocol. High-Data-Rate Digital Subscriber Loops: Asymmetric Digital Subscriber Line, VDSL. Digital Loop Carrier Systems: Universal Digital Loop Carrier Systems, Integrated Digital Loop Carrier Systems, Cellular Mobile Telephony.

List of Text Books:

1.	ThiagarajanViswanathan&ManavBhatnagar, "Telecommunication Switching Systems andNetworks", PHI.
2.	J.E. Flood, Telecommunications Switching, Traffic and Networks, Prentice Hall, 1995

List of Reference Books:

1.	James Martin, "Telecomm. & the Computers", PHI.
2.	Network Traffic Engineering: Models and Applicationsby Andrea Baiocchi Aug 11, 2020

URLs:

1.	http://www.kopykitab.com/product/7654

Lecture Plan (about 40-50 Lectures):	
Lecture No.	**Topic**
1.	Basic of Switching System, Simple Telephone Communication
2.	Manual Switching System, Major Telecommunication Networks Strowger
3.	Rotary Dial Telephone Signaling Tones, Step by Step Switching
4.	Design Parameters, Crossbar Switching: Principal of Common Control
5.	Tutorial-1
6.	Touch Tone Dial Telephone
7.	Principals of Crossbar Switching
8.	Digital Switching: Switching Functions, , ,.
9.	Space Division Switching
10.	Time Division Switching
11.	Two dimensional Switching: STS Switching, TST Switching
12.	Digital Cross- Connect Systems
13.	Digital Switching in an Analog Environment
14.	Traffic Engineering: Queuing systems
15.	Tutorial-2
16.	Erlang Distribution, probability of delay
17.	Finite queue capacity, systems with a single server
18.	Queues in tandem, delay tables and application of Delay formulae
19.	Analysis: Traffic Characteristics: Arrival Distributions, Holding time Distribution.
20.	Loss Systems: Lost calls cleared
21.	lost calls returning, lost calls Held, lost calls cleared
22.	Tutorial-3
23.	Telephone Networks: Subscriber Loop System
24.	Switching Hierarchy And Routing
25.	Transmission Plan
26.	Transmission System
27.	Numbering Plan,
28.	Charging Plan,
29.	Signaling Techniques In-channel Signaling, Common Channel Signaling
30.	Cellular Mobile Telephony
31.	Tutorial-3
32.	Digital Subscriber Access.
33.	ISDN: ISDN Basic Rate Access Architecture
34.	ISDN U Interface, ISDN D Channel Protocol
35.	High-Data-Rate Digital Subscriber Loops
36.	Asymmetric Digital Subscriber Line,
37.	VDSL.
38.	Digital Loop Carrier Systems
39.	Universal Digital Loop Carrier Systems
40.	Integrated Digital Loop Carrier Systems
41.	Tutorial-4

Name of Program	M.Tech. (Communication Systems)	SemesterI/II	Year I
Name of Course	**Optical Networks**		
Course Code	**CS 510**		
Core / Elective / Other	**Elective**		

Prerequisite:

1.	Optical Communication

Course Outcomes: After completion of the course, the students will be able to

CO1	Summarize physical properties of optical networks
CO2	Recall protocols such as SONET / SDH in optical networks and also discuss Metropolitan-area Networks, Fiber-optic LAN architectures and their protocols.
CO3	Explain optical switching methods, networking techniques and basics of lasers and photo-detectors.
CO4	Outline optical components and design optical nodes
CO5	Design optical networks for specific applications.

Description of Contents in brief:

1.Overview of Optical Communication, Different types of optical fibers, Modal analysis of a step index fiber. Signal degradation on optical fiber due to dispersion and attenuation. WDM & DWDM systems. Optical Amplifier-EDFA

2. Interconnection networks; Networks: Introduction to computer data networks, SONET / SDH, IP-SONET-WDM, Metropolitan-Area Networks, Fiber-optic LAN architectures and protocols- ring, star and bus architectures, DQDB, FDDI; High speed busprotocols.

3. WDM Networks - Light path Topology, Broadcast and Select Networks – Topologies for Broadcast Networks, Test beds for Broadcast & Select WDM; Wavelength Routing Architecture. The optical layer, Node Designs, Routing and wavelength assignment, Switch-based Optical networks; Optical Access Network Architectures, Future Access Networks, All Optical Networks

List of Text Books:

1.	William Stalling "High Sped Networks & Internet ", 2nd edition, Pearson Education
2.	Rajiv Ramaswamy and Kumar N. Sivarajan, "Optical Networks", 2nd Edition, Morgan Kaufmann Publishers (Elsevier)

List of Reference Books:

1.	Fibre Optic communication, J. Keiser, McGraw-Hill, 5^{th} Ed.

URLs: Nil

Lecture Plan (about 40-50 Lectures): Tentative

Lecture No.	Topic
1.	Introduction to Optical Communication Technology
2.	Optical Fiber Modes & configurations.
3.	Types of Fibers : Single Mode & Multimode

4.	Single Mode Fibers, Mode Field diameter, Propagation
5.	Single Mode Fibers, Mode Field diameter, Propagation
6.	Into. to Fiber manufacturing
7.	Attenuation, Scattering & Bending losses, Absorption.
8.	Signal Distortion, Group Delay, Dispersion: Intermodal
9.	Signal Distortion, Group Delay, Dispersion: Intermodal
10.	Dispersion in Optical Fibers
11.	Dispersion in Single Mode Fibers
12.	WDM Systems, DWDM, Dispersion management
13.	WDM Systems, DWDM, Dispersion management
14.	Introduction to Optical Amplifiers, EDFA
15.	Introduction to Optical Amplifiers, EDFA
16.	Introduction to Computer Networks
17.	Various Types of Optical Networks
18.	Protocols, Architectures for Broadband Networks
19.	Protocols, Architectures for Broadband Networks
20.	Access and Hybrid Networks
21.	All optical networks. SDH
22.	All optical networks. SDH
23.	SONET
24.	Midterm
25.	Fiber-optic LAN architectures and protocols
26.	Fiber-optic LAN architectures and protocols
27.	Ring, star and bus architectures
28.	DQDB, FDDI; High speed bus protocols
29.	RATO-net, WDM networks- LAMBDA-net
30.	Coherent star, PASS-net, shuffle-net
31.	Midterm
32.	Photonic Switching
33.	Photonic Switching
34.	Switching architectures single and multistage switching
35.	Switching architectures single and multistage switching
36.	Space switching, time switching
37.	Space switching, time switching
38.	Combinations of space and time switching
39.	SEED arrays WDM Network design
40.	SEED arrays WDM Network design
41.	Lightpath Topology
42.	Optical Line Terminal
43.	Optical Add / Drop multiplexers
44.	Optical Cross connects and Wavelength conversion
45.	Optical Cross connects and Wavelength conversion

Name of Program	M.Tech. (Communication Systems)	Semester-I/II	Year I
Name of Course	**Video Signal Processing**		
Course Code	**CS 515**		
Core / Elective / Other	**Elective**		

Prerequisite:	
1.	Higher engineering mathematics
2.	Fundamental knowledge of signal processing
3.	Fourier analysis (all signal processing relates to Fourier analysis in some form or another)
Course Outcomes: After completion of the course, the students will be able to	
CO1	Explain basic principles and tools used to process videos and apply them in solving practical problems of commercial and scientific interests.
CO2	Illustrate different methods, models for video processing and motion estimation.
CO3	Apply quantitative models of image and video processing for various engineering applications and develop innovative designs for practical applications in various fields.
Description of Contents in brief:	
1.	Basics of Video, Analog Video signal, Composite video signal, Video Formation, Horizontal and vertical synchronization, Spatial and Temporal resolution
2.	Video signal standards: NTSC, SECAM, PAL, Video signal BW requirement, Digital Video Processing, Analysis and synthesis of Video Signal,Colour Signal Generation and coding, Video display, Video camera, Video Coding
3.	Motion Analysis and Motion Compensation, Motion compensated filtering, Motion Estimation techniques
4.	Optical flow methods, Block based methods, Bayesian method, Video Coding standards,
5.	Video compression standards: H2.61, MPEG 1, MPEG 2
List of Text Books:	
1.	M. Parker, s. Dhanani “Digital Video Processing for Engineers: A Foundation for Embedded Systems Design”, Newnes
2.	Vijay Madisetti “Video, Speech, and Audio Signal Processing and Associated Standards” 1st Edition CRCpress
3.	King N. Ngan, Chi W. Yap, Keng T. Tan “Video Coding for Wireless Communication Systems” CRC press
List of Reference Books:	
1.	A M Tekalp, “Digital Video Processing”, PH Publication.
2.	Y Q. Shi, H Sun,“Image and Video Compression for Multimedia Engineering”,CRC Press.
3.	J W Woods, “Multi-Dimensional, Signal, Image and Video Processing and Coding”, Academic Press.

URLs:	
1.	https://www.oreilly.com/library/view/digital-video-processing/9780133991116/
2.	https://www.crcpress.com/Image-and-Video-Compression-for-Multimedia-Engineering-Fundamentals-Algorithms/Shi-Sun/p/book/9780849373640
3.	https://www.elsevier.com/books/multidimensional-signal-image-and-video-processing-and-coding/woods/978-0-12-381420-3

Lecture Plan (about 40-50 Lectures):	
Lecture No.	**Topic**
1.	Basics of Video
2.	Analog Video signal
3.	Composite video signal
4.	Video Formation
5.	Horizontal synchronization
6.	Vertical synchronization
7.	Spatial resolution
8.	Temporal resolution
9.	Video signal standards
10.	NTSC
11.	SECAM
12.	PAL
13.	Video signal BW requirement
14.	Digital Video Processing
15.	Analysis and synthesis of Video Signal
16.	Colour Signal Generation and coding
17.	Digital Video Signals and Formats
18.	Video Compression Techniques: Entropy and Predictive coding
19.	Block Transform Coding
2.	Quantization
21.	MC and Estimation Transform Coding
22.	Video display
23.	Video camera
24.	Video Coding
25.	Motion Analysis
26.	Notation and Preliminaries: Binary Hypothesis Testing
27.	Markov Random Fields
28.	MAP Estimation and Variational Formulation
29.	Motion Detection: Hypothesis Testing with Fixed and Adaptive Threshold
30.	MAP MRF Formulation
31.	MAP Variation Formulation
32.	Experimental Comparison of Motion Detection Methods , Motion Estimation
33.	Motion Models and Estimation Criteria
34.	Search Strategies Practical Motion Estimation Algorithms

35.	Global Motion Estimation
36.	Block Matching and Phase Correlation
37.	Optical Flow via Regularization
38.	MAP Estimation of Dense Motion
39.	Motion Compensation
40.	Motion compensated filtering
41.	Motion Estimation techniques
42.	Optical flow methods
43.	Block based methods
44.	Bayesian method
45.	Video Coding standards
46.	Video compression standards: H2.61
47.	Video structure and bit-stream
48.	Scalable coding
49.	Data partitioning
50.	Comparison of MPEG-1 and MPEG-2

Name of Program	M Tech (Communication Systems)	Semester-I/II	Year I
Name of Course	**Statistical Signal Processing**		
Course Code	**CS 514**		
Core / Elective / Other	**Elective**		

Prerequisite:

1.	Probability
2.	Basic signal, system, signal analysis technique
3.	Statistical analysis techniques

Course Outcomes: After completion of the course, the students will be able to

CO1	Gain a comprehensive understanding of probability theory and random variables relevant to statistical signal processing
CO2	Master signal representation and analysis techniques, including Fourier transforms and power spectral density estimation
CO3	Develop proficiency in statistical estimation methods for parameter estimation, hypothesis testing, and confidence interval estimation
CO4	Acquire skills in designing and implementing various filtering techniques, including linear and nonlinear filters
CO5	Apply statistical signal processing principles to solve practical problems in communication systems, image processing, biomedical engineering, and radar systems

Description of Contents in brief:

1. **Probability Theory and Random Variables**: Probability distributions, Expectation and variance, Joint and conditional probabilities, Random processes,
2. **Signal Representation and Analysis**: Time-domain representation (e.g., discrete-time signals), Frequency-domain representation (e.g., Fourier transform), Power spectral density estimation, Autocorrelation and cross-correlation functions,
3. **Statistical Estimation Techniques**: Parameter estimation (e.g., maximum likelihood estimation), Hypothesis testing (e.g., likelihood ratio tests), Confidence interval estimation
4. **Filtering and Detection**: Linear filters (e.g., FIR and IIR filters), Nonlinear filters (e.g., median filters), Detection theory (e.g., Neyman-Pearson criterion),
5. **Applications of Statistical Signal Processing**: Communications (e.g., channel coding, equalization), Image and video processing (e.g., denoising, compression), Biomedical signal processing (e.g., EEG analysis, MRI reconstruction), Radar and sonar systems

List of Text Books:

1.	Statistical Digital Signal Processing and Modeling" by Monson H. Hayes
2.	Statistical Signal Processing: Detection, Estimation, and Time Series Analysis" by Louis L. Scharf
3.	Fundamentals of Statistical Signal Processing, Volume I: Estimation Theory" by Steven M. Kay

List of Reference Books:

1.	Detection, Estimation, and Modulation Theory, Part I" by Harry L. Van Trees
2.	Introduction to Random Signals and Applied Kalman Filtering: With MATLAB Exercises
3.	Digital Signal Processing: Principles, Algorithms, and Applications" by John G. Proakis and Dimitris G. Manolakis

URLs:

Name of Program	M. Tech (Communication Systems)	Semester-I/II	Year I
Name of Course	**Satellite Communication**		
Course Code	**CS 509**		
Core / Elective / Other	**Elective**		

Prerequisite:	
1.	Digital Communication
2.	Analog communication
3.	Antenna and Wave propagation
Course Outcomes: After completion of the course, the students will be able to	
CO1	Recall the principles, concepts and operation of communication satellite systems and Explain the concepts of orbital mechanism
CO2	Explain various multiple access techniques used in satellite systems
CO3	Analyze link design, rain fading and losses
CO4	Illustrate the importance of satellite transponders,
CO5	Explain working principles of transmitters, receivers and antennas
Description of Contents in brief:	
1.	Introduction, History of Satellites, Classification of Satellite Systems, Frequency Allocation, Elements of Orbital Mechanics
2.	Earth Stations: Introduction, Multiple Access Techniques: FDMA, TDMA, CDMA, Beam Switching and satellite switched TDMA, Spread Spectrum Techniques (Also called CDMA), Comparison of Multiple Access Technique
3.	RF Link Design, Types of Losses and their effect on performance
4.	Satellite Transponders: Function of Transponder, Transponder Implementation, Transmission Impairments.
5.	Transmitters, Receivers, Antennas, Tracking Systems, Terrestrial Interface
List of Text Books:	
1.	D. Roddy, “Satellite Communication”, (3/e), Mc Graw-Hill,2001.
2.	T.Pratt& C.W. Bostain , “Satellite Communication”, Willey 2000.
3.	W L. Pritchard, HG. Suyderhoud, RA. Nelson, “Satellite Communication System Engineering”.
List of Reference Books:	
1.	W Tomasi, “Advance Electronic Comm System.”, PHI.
2.	Hofmann-Wellenhof, B., Lichtenegger, H., Wasle, E., 2008. GNSS – Global Navigation Satellite Systems, Springer, Verlag Wien.
URLs:	
1.	https://nptel.ac.in/courses/117/105/117105131/
2.	https://nptel.ac.in/courses/101/105/101105077/
3.	https://swayam.gov.in/nd1_noc19_ce45/preview

Lecture Plan (about 40-50 Lectures):

Lecture No.	Topic
1.	History of satellite ,
2.	types of orbital path
3.	Types of satellite communication systems
4.	Kepler’s law

5.	Derivation of Kepler's First law
6.	Derivation of Kepler's Second law
7.	Derivation of Kepler's Third law
8.	Analysis of multiple access techniques
9.	Implementation of Analog and digital MCPC
10.	Earth station terminal block diagram of Analog MCPC
11.	Earth station terminal block diagram of digital MCPC
12.	Implementation of Analog and digital SCPC
13.	Earth station terminal block diagram of Analog SCPC
14.	Earth station terminal block diagram of digital SCPC
15.	Comparison of SCPC and MCPC techniques
16.	TDMA system and its burst and frame structure.
17.	TDMA earth station terminal
18.	Narrowband TDMA, Demand Assignment in TDMA
19.	CDMA and CDMA transmission and reception system
20.	Random access and onboard processing
21.	Performance Comparison
22.	Analysis of orbital path
23.	Orbital mechanics
24.	Orbital mechanics (continued)
25.	Analysis of orbital mechanics to derive apogee distance
26.	Analysis of orbital mechanics to derive perigee distance
27.	Eccentricity of the path
28.	Semi major axis and time period of revolution
29.	Numerical analysis of orbital path
30.	Different types of Atmospheric losses in RF link
31.	Free space loss
32.	Effects of losses on link analysis
33.	Link design requirements
34.	Link design (continued)
35.	Loss compensation techniques
36.	Basic transmission theory
37.	Received power derivation
38.	System noise temperature
39.	G/T ratio for earth stations
40.	Noise Figure and Noise Temperature
41.	Numerical analysis of Link equation
42.	Transponder system
43.	working of earth station
44.	Satellite Transmitter system
45.	Satellite Receiver system,
46.	Antennas used in Satellite system
47.	Tracking Systems
48.	Terrestrial Interface

Name of Program	M.Tech. (Communication Systems)	Semester-I/II	Year I
Name of Course	**Data Compression and Cryptography**		
Course Code	**CS 511**		
Core / Elective / Other	**Elective**		

Prerequisite:

1. Information Theory
2. Information Security
3. Network Security

Course Outcomes: After completion of the course, the students will be able to

CO1	Understand compression techniques
CO2	Explain mathematical models of compression techniques
CO3	Illustrate decompressing techniques
CO4	List various types of security attacks
CO5	Distinguish various types of encryption techniques

Description of Contents in brief:

1. **Compression Techniques:** Loss less compression, Lossy Compression, Measures of performance, Modeling and coding, Mathematical Preliminaries for Lossless compression: A brief introduction to information theory, Models: Physical models, Probability models, Markov models, composite source model, Coding: uniquely decodable codes, Prefix codes. The Huffman coding algorithm: Minimum variance Huffman codes, Adaptive Huffman coding: Update procedure, Encoding procedure, Decoding procedure. Golomb codes, Rice codes, Tunstall codes, Applications of Hoffman coding: Loss less image compression, Text compression, Audio Compression.
2. **Coding a sequence:** Generating a binary code, Comparison of Binary and Huffman coding, Applications: Bi-level image compression-The JBIG standard, JBIG2, Image compression. Dictionary Techniques: Introduction, Static Dictionary: Diagram Coding, Adaptive Dictionary. The LZ77 Approach, The LZ78 Approach, Applications: File Compression-UNIX compress, Image Compression: The Graphics Interchange Format (GIF), Compression over Modems: V.42 bits, Predictive Coding: Prediction with Partial match (ppm): The basic algorithm, The ESCAPE SYMBOL, length of context, The Exclusion Principle, The Burrows-Wheeler Transform: Movetofront coding, CALIC, JPEG-LS
3. **Introduction to the Concepts of Security:** The need for security, Security Approaches, Principles of Security, Types of Attacks. Cryptographic Techniques: Plain Text and Cipher Text, Substitution Techniques, Transposition Techniques, Encryption and Decryption, Symmetric and Asymmetric Key Cryptography, Steganography, Key Range and Key Size, Possible Types of Attacks.
4. **Cryptographic Algorithms:** Symmetric Key Cryptography Algorithm Types and Modes, An overview of Symmetric Key Cryptography, DES, International Data Encryption Algorithm (IDEA), RC5, Blowfish, AES, Differential and Linear Cryptanalysis. Module. Computer-based Asymmetric Key Cryptography: Brief History of Asymmetric Key Cryptography, An overview of Asymmetric Key Cryptography, The RSA Algorithm, Symmetric and Asymmetric Key Cryptography Together, Digital Signatures, Knapsack Algorithm, Some other Algorithms. Module.

	5. **Public Key Infrastructure:** Digital Certificates, Private Key Management, The PKIX Model, Public Key Cryptography Standards, XML, PKI and Security. Internet Security Protocols: Basic Concepts, Secure Socket Layer, SHTTP, Time Stamping Protocol, Secure Electronic Transaction, SSL versus SET, 3-D Secure Protocol, Electronic Money, E-mail Security, Wireless Application Protocol (WAP) Security, Security in GSM.
List of Text Books:	
1.	Khalid Sayood, "Introduction to Data Compression" , Morgan Kaufmann Publishers.
2.	William Stallings, "Cryptography and Network Security: Principals and Practice", Pearson Education.
3.	Behrouz A. Forouzan, "Cryptography and Network Security", TMH.
List of Reference Books:	
1	V. .K. Jain ,"Cryptography and Network Security"
2.	Bruce **"**Applied Cryptography: Protocols, Algorithms and Source Code in C 20th Edition, Kindle Edition **"**
3.	Helen F. Gaines "Cryptanalysis: A Study of Ciphers and Their Solution"
URLs:	
1.	https://nptel.ac.in/courses/106106221/
2.	https://nptel.ac.in/courses/106105162/

Name of Program	M.Tech (Communication Systems)	Semester-I/II	Year I
Name of Course	**Computer Vision and Pattern Recognition**		
Course Code	**CS517**		
Core / Elective / Other	**Elective**		

Prerequisite:

1. Digital Image Processing

Course Outcomes: After completion of the course, the students will be able to

CO1	Explain major ideas, methods and techniques of Computer Vision and image classification.
CO2	Illustrate the fundamentals and techniques of pattern recognition and detection.
CO3	Outline various issues in the design of pattern recognition and classification systems.
CO4	Select and extract the appropriate features from images of diverse application.
CO5	Apply domain specific classification models.

Description of Contents in brief:

1. **Overview of computer vision:** Image Formation and Representation: Imaging geometry, radiometry, digitization, rigid and affine transformation, Image Processing: Pixel transforms, color transforms, histogram processing, histogram equalization, filtering, convolution, Fourier transformation and its applications in sharpening, blurring and noise removal
2. **Feature detection:** edge detection, corner detection, line and curve detection, active contours, SIFT and HOG descriptors, shape context descriptors, Morphological operations, Active contours, split & merge, watershed, region splitting, region merging, graph-based segmentation, mean shift and model finding, Normalized cut.
3. **Motion representation:** the motion field of rigid objects; motion parallax; optical flow, the image brightness constancy equation, affine flow; differential techniques; feature-based techniques; regularization and robust estimation. Motion tracking: statistical filtering; iterated estimation; observability and linear systems; the Kalman filter
4. **Pattern Recognition:** Review of Probability Theory, Conditional Probability and Bayes Rule, Expectation, Correlation, Covariance, Review of Linear Algebra, Linear Transformations, Decision Theory, ROC Curves, Likelihood Ratio Test, Linear and Quadratic Discriminants, Fisher Discriminant, Template-based Recognition, Feature Extraction, Eigenvector and Multilinear Analysis, Maximum Likelihood and Bayesian Parameter Estimation, Linear Discriminant/Perceptron Learning, Optimization by Gradient Descent, Support Vector Machines, K-Nearest-Neighbor Classification, Non-parametric Classification, Density Estimation.
5. **Unsupervised Learning:** Clustering, Vector Quantization, K-means, Mixture Modeling, Expectation-Maximization, Hidden Markov Models, Viterbi Algorithm, Baum-Welch Algorithm, Linear Dynamical Systems, Kalman Filtering, Reinforcement Learning with Human Interaction, Genetic Algorithms, Combination of Multiple Classifiers "Committee Machines".

List of Text Books:

1. Pattern Classification by Duda, Hart, and Stork, 2nd edition, John Wiley Interscience, 2012.
2. Computer Vision: A Modern Approach, D.A. Forsyth and J. Ponce, Prentice-Hall, 2015.

List of Reference Books:

1.	The Elements of Statistical Learning T. Hastie et al., Springer-Verlag, 2013.
2.	Machine Learning: A probabilistic Perspective K. Murphy, MIT Press, 2012.
3.	Computer Vision, L.G. Shapiro and G. Stockman, Prentice-Hall, 2001.
4.	Artificial Intelligence: A Modern Approach, Stuart J. Russell and Peter Norvig, 3rd Edition, Pearson, 2015.
URLs:	
1.	Nil

Name of Program	**M.Tech (Communication Systems)**	**Semester- I/II**	**Year I**
Name of Course	**Information Theory & Coding**		
Course Code	**CS 512**		
Core / Elective / Other	**Elective**		

Prerequisite:	
1.	Basic exposure to linear algebra
2.	Probability theory
3.	A course in digital communications
Course Outcomes: After completion of the course, the students will be able to	
CO1	Explore maximum data rate at which data can be transmitted over a communication link and fundamental limit of data compression
CO2	Explain the error control codes such as Low Density Parity Check codes and Polar codes that have been proposed for 5G cellular communication systems.
CO3	Design of decoders for various codes.
CO4	Test MATLAB simulation circuits for various decoders.
Description of Contents in brief:	
1.	Definition of Information Measure and Entropy, extension of An Information source and Markov Source, adjoint of An information Source, Joint and Conditional Information Measure, properties of Joint and Conditional Information Measures and a Morkov Source, asymptotic properties of Entropy and Problem Solving in Entropy
2.	Block Code and its Properties, Instantaneous Code and Its Properties, Kraft-Mcmillan Equality and Compact Codes, Shannon's First Theorem, Coding Strategies and Introduction to Huffman Coding, Huffman Coding and Proof of Its Optimality, Competitive Optimality of The Shannon Code, Non-Binary Huffman Code and Other Codes, Adaptive Huffman Coding ,Shannon-Fano-Elias Coding and Introduction to Arithmetic Coding, Arithmetic Coding
3.	Introduction to Information Channels, Equivocation and Mutual Information, Properties of Different Information Channels, Reduction of Information Channels, Properties of Mutual Information and Introduction to Channel Capacity, Calculation of Channel Capacity for Different Information Channels, Shannon's SecondTheorem
4.	Differential Entropy and Evaluation of Mutual Information for Continuous Sources and Channels, Channel Capacity of A Band Limited Continuous Channel, Introduction to Rate-Distortion Theory, Definition and Properties of Rate-Distortion Functions, Calculation of Rate Distortion Functions, Computational Approach for Calculation of Rate-DistortionFunctions
5.	Introduction to Quantization, Lloyd- Max Quantizer, Companded Quantization, Variable Length Coding and Problem Solving in Quantizer Design, Vector Quantization, Transform Coding

List of Text Books:	
1.	Digital Communication by Haykins Simon Wiley Publ.
2.	Modern analog and Digital Communication system, by B.P. Lathi
3.	Error control Coding: Theory and Application, by Shu Lin and Cosstlello,PHI
List of Reference Books:	
1.	R. Bose, Information theory, coding and cryptography, McGrawHill
2.	Herbert Taub and Donald Scihiling ,"Principles of Communication Systems", McGraw Hill Publication
3.	R P Singh and S D Sapre "Communication systems", TMH
URLs:	
1.	https://nptel.ac.in/courses/117101053/
2.	https://nptel.ac.in/courses/108102117/
3.	https://nptel.ac.in/courses/117/104/117104129/

Lecture Plan (about 40-50 Lectures):

Lecture No.	**Topic**
1	Introduction to Information Theory and Coding
2	Definition of Information Measure and Entropy
3	Extension of An Information Source and Markov Source
4	Adjoint of An Information Source, Joint and Conditional Information Measure
5	Properties of Joint and Conditional Information Measures and A Morkov Source
6	Asymptotic Properties of Entropy and Problem Solving in Entropy
7	Block Code and its Properties
8	Instantaneous Code and Its Properties
9	Kraft-McMillan Equality and Compact Codes
10	Shannon's First Theorem
11	Coding Strategies and Introduction to Huffman Coding
12	Huffman Coding and Proof of Its Optamality
13	Competitive Optamality of The Shannon Code
14	Non-Binary Huffman Code and Other Codes
15	Adaptive Huffman Coding Part-I
16	Adaptive Huffman Coding Part-II
17	Shannon-Fano-Elias Coding and Introduction to Arithmetic Coding
18	Arithmetic Coding Part-I
19	Arithmetic Coding Part-II
20	Introduction to Information Channels
21	Equivocation and Mutual Information
22	Properties of Different Information Channels
23	Reduction of Information Channels
24	Properties of Mutual Information and Introduction to Channel Capacity
25	Calculation of Channel Capacity for Different Information Channels

26	Shannon's Second Theorem
27	Discussion On Error Free Communication Over Noisy Channel
28	Error Free Communication Over A Binary Symmetric Channel and Introduction to Continuous Sources and Channels
29	Differential Entropy and Evaluation of Mutual Information for Continuous Sources and Channels
30	Channel Capacity of A Band Limited Continuous Channel
31	Introduction to Rate-Distortion Theory
32	Definition and Properties of Rate-Distortion Functions
33	Calculation of Rate-Distortion Functions
34	Computational Approach for Calculation of Rate-Distortion Functions
35	Introduction to Quantization
36	Lloyd-Max Quantizer
37	Companded Quantization
38	Variable Length Coding and Problem Solving in Quantizer Design
39	Vector Quantization
40	Transform Coding

Name of Program	M.Tech (Communication Systems)	Semester I/II	year I
Name of Course	**Multirate Signal Processing**		
Course Code	**CS 516**		
Core / Elective / Other	**Elective**		

Prerequisite:

Course Outcomes: After completion of the course, the students will be able to

CO1	To apply DFT for the analysis of digital signals & systems
CO2	To design FIR filters and IIR filters, Multirate Filters
CO3	To characterize finite Word length effect on filters
CO4	To have a deep understanding on basics of digital signal processing which can be applied to communication systems

Description of Contents in brief:

1. **Overview of DSP Discrete time system:** Review of Digital filters: FIR, IIR filter, all pass filter, Design of digital filters: FIR and IIR.
2. **Introduction to multirate system:** Sample rate reduction – decimation by integer factors-sampling rate increase – interpolation by integer facto – Design of practical sampling rate converters Filter Specification- filter requirement for individual stages – Determining the number of stages and decimation factors – Sampling rate conversion using poly-phase filter structure – poly-phase implementation of interpolators, Subband coding, Types of subband coding system, Distortion in Subband coding, Nyquist filter, Interpolated filter.
3. **Multirate filter Bank:** Uniform Filter bank, DFT Filter bank, Classification filter bank: M-channel Filter bank and two-channel filter bank, Analysis of two-channel filter, aliasing cancellation condition, perfect reconstruction condition, classification of two-channel filter bank, Design of PR filter bank and NPR filter bank, computationally efficient structure for two-channel filter bank.
4. **Multichannel Filter Bank:** Classification of multichannel Filter bank: Tree structure Filter bank, modulated based filter bank, parallel filter bank, Analysis of Tree structure filter bank, Analysis for cosine modulated filter bank, Design of multichannel filter bank Application of multirate signal processing: audio signal.

List of Text Books:

1.	An Introduction to Wavelets, K. Chui, Academic Press USA.
2.	I. Daubechies, Ten Lectures on Wavelets, SIAM, 1990.

List of Reference Books:

1.	Lokenath Debnath, Wavelet Transforms and Their Applications, Birkhauser 2002.
2.	S. Mallat, A wavelet Tour of Signal Processing, Academi Press USA 2009.

URLs:

Name of Program	M.Tech(Communication Systems)	Semester I/II	Year I
Name of Course	**Medical Image Processing and Analysis**		
Course Code	**CS513**		
Core / Elective / Other	**Elective**		

Prerequisite:

1.	Digital Image Processing, Digital Signal Processing

Course Outcomes: After completion of the course, the students will be able to

CO1	Explored major medical signal modalities and their acquisition systems.
CO2	Demonstrate the various signal processing techniques of medical signals.
CO3	Classify various medical signal analysis methods.
CO4	Apply signal processing algorithms for enhancement, de-noising, compression.
CO5	Develop domain specific medical signal classification models for computer aided diagnosis.

Description of Contents in brief:

1. **Introductory Concepts:** Basic concepts of human anatomy, Modalities for Macro-scale / whole body, Mesoscopic and Microscopic range imaging, PACS, DICOM images, 3D visualization, time-lapse and GPU computing. Medical Image Formats.
2. **Introduction to medical imaging modalities:** Radiographs: Xray, Computed Tomography (CT), Magnetic Resonance Imaging, Ultrasound Images, Positron emission tomography (PET) Images, Microscopic Images: Histopathology, Cytology etc.
3. **Feature extraction:** Feature Vectors and Vector Spaces, Invariance and Robustness, Binary Object Features, Area, Centroid, Axis of Least Second Moment, Projections, Euler Number, Perimeter, Thinness Ratio, Eccentricity, Aspect Ratio, Moments, Boundary Descriptors, Chain Code, Freeman Code, and Shape Number, Fourier Descriptors, Histogram-based Features, Statistical Features, Texture Features
4. **Medical Image Processing:** Image enhancement, Image denoising, Edge Detection, Thresholding, Shape modelling, Region growing/splitting, watersheds, clustering, Texture, image statistics, Graph cuts, Image transformations.
5. **Medical Image Classification:**Supervised and unsupervised learning, Statistical classifiers, distance based classifiers, Decision tree classifier, Random Forest Classifier, CNN for image classification, Deep learning.

List of Text Books:

1. Biomedical Signal and ImageProcessing,KayvanNajarian, Robert Splinter, CRC Press,2016
2. Medical Imaging Signals and Systems, Jerry L. Prince, Jonathan Links, 4th Edition, Pearson, 2015.

List of Reference Books:

1. Biomedical Image Processing, Thomas M. Deserno, Springer Science & Business Media, 2011
2. Biomedical Signal Analysis, Rangaraj M. Rangayyan, John Wiley and Sons, 2015
3. Medical image processing, G.R. Sinha, Bhagwati Charan Patel, 1st Edition, PHI, 2014.
4. Machine Learning, SaikatDutt, Subramanian Chandramouli, Amit Kumar Das, 1st Edition, Pearson, 2018.

5.	Artificial Intelligence: A Modern Approach, Stuart J. Russell and Peter Norvig, 3rd Edition, Pearson, 2015.
URLs:	
1.	Nil

Open Elective

Name of Program	M. Tech. (Communication System)	Semester I/II	Year 1
Name of Course	**Internet of Things (IoT)**		
Course Code	**CS 604**		
Core / Elective / Other	**Elective**		

Prerequisite:	
1.	Computer Networks
Course Outcomes: After completion of the course, the students will be able to	
CO1	Understand the basic concepts, architecture and applications of IoT.
CO2	Understand the fundamentals of sensors, actuators and IoT network.
CO3	Have a brief idea of the communication protocols for the IoT networks.
CO4	Understand the data analysis for IoT networks.
CO5	Identify the application areas of the IoTs.
Description of Contents in brief:	
1.	Introduction to IoT: What is IoT, Impact of IoT, IoT Challenges. IoT network architecture & design: oneM2M, IoTWF, Core functional stack, Data management stack.
2.	'Things' in IoT: Sensors, Actuators, Smart objects, Basics of Sensor Networks.
3.	Communicating smart objects: Communication criteria, IoT access technologies- IEEE 802.15.4, IEEE 802.15.4e, IEEE 802.11ah, IEEE 1901.2a, NB-IoT. IoT Network Layer: IP as IoT network layer, 6LoWPAN, 6Lo, 6TiSCH, RPL. IoT Application Layer: IoT application transport methods, CoAP, MQTT.
4.	Data and Analytics for IoT: IoT Middleware, Data analytics for IoT, Big Data analytics tools and technology.
5.	IoT application case study: Smart City, Smart Grid, Smart Transportation, Smart Manufacturing, Smart Healthcare.
List of Text Books:	
1.	D. Hanes, G. Salgueiro, P. Grossetete, R. Barton, J. Henry; IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, 1st Edition, Pearson India Pvt. Ltd., 2018.
2.	A. Bahga, V. Madisetti; Internet of Things: A Hands-on Approach, 1st Edition, Universities Press (India) Pvt. Ltd., 2015.
List of Reference Books:	
1.	Y. Kanetkar, S. Korde; 21 Internet of Things (IOT) Experiments: Learn IoT, the programmer's way, 1st Edition, BPB Publications, 2018.
URLs:	
1.	Nil

Lecture Plan (about 40-50 Lectures):

Lecture No.	Topic
1	Introduction to IoT:
2	Impact of IoT, IoT Challenges.

3	IoT network architecture & design: oneM2M
4	IoTWF
5	Core functional stack
6	Data management stack.
7	'Things' in IoT: Sensors,.
8	Actuators
9	Smart objects
10	Basics of Sensor Networks
11	Communicating smart objects: Communication criteria.
12	IoT access technologies- IEEE 802.15.4
13	IEEE 802.15.4e
14	, IEEE 802.11ah,
15	IEEE 1901.2a, NB-IoT
16-17	IoT Network Layer: IP as IoT network layer
18	6LoWPAN
19	6Lo, 6TiSCH,
20	RPL.
21-22	IoT Application Layer: IoT application transport methods
23	CoAP, MQTT.
24	Data analytics for IoT.
25-27	, Big Data analytics tools and technology
28-30	Data and Analytics for IoT: IoT Middleware
31-32	IoT application case study: Smart City
33-35	Case Study 2: Smart Grid.
36-38	Case Study 3: Smart Transportation
39	Case Study 4: Smart Manufacturing
40	Case Study 5 Smart Healthcare

Name of Program	M. Tech Communication Systems)	Semester: I/II	Year: I

Name of Course	**Optimization Techniques**
Course Code	**CS 601**
Core / Elective / Other	**Elective**

Prerequisite:

1.	Differential Calculus.

Course Outcomes: After completion of the course, the students will be able to

CO1	Understand the basics of different optimization algorithms.
CO2	Analyse and solve various optimization problems arising from engineering areas.
CO3	Evaluate the performance of optimization techniques on standard benchmark functions
CO4	Design and formulate optimization problems from real world problems.

Description of Contents in brief:

1	**Introduction to mathematical optimization:** Objective functions, constraints, feasible region, local and global optimization, Type of optimization algorithms. One dimensional search Methods: Golden section search, Fibonacci search, Newton's linear approximation for one dimension search, Secant Method.
2	**Classical and Constrained Optimization:** Basics of set-constrained and unconstrained optimization. Lagrange Multiplier method for constrained with equality and inequality. Karush-Kuhn-Tucker (KKT) Optimality conditions. Use of KKT conditions in designing ML Models
3	**Heuristic and Nature inspired optimization techniques**: Genetic Algorithm, Particle Swarm Optimization, Differential Evaluation, Ant Colony Optimization, Grey Wolf Optimization. Multi-Objective Optimization and Pareto-front.
4	**Gradient methods of optimization:** Newton's method, Steepest Descent Method, Conjugate direction methods. Gradient Descent and Artificial Neural Networks. Convex sets and functions. Convex optimization problems
5	**Linear Programming:** Introduction to Linear Programming, Graphical Method, Simplex method, duality,Integer linear Programming, Introduction to Dynamic Programming.

List of Text Books:

1.	An Introduction to Optimization, 2nd Ed, Edwin K. P. Chong & Stanislaw H. Zak, John Wiley 2004.
2.	Practical Optimization R. Fletcher. John Wiley & Sons, 2000.
3.	S. S. Rao, Engineering Optimization: Theory and Practice, Wiley, 2008.

List of Reference Books:

1.	Algorithms for Optimization, Mykel Kochenderfer and Tim Wheeler, MIT Press, 2019.
2.	Computational Intelligence: An Introduction, Andries Engelbrecht, John Wiley & Sons, 2007.
3.	D. E. Goldberg, Genetic algorithms in Search, Optimization, and Machine Learning, Addison-Wesley Longman Publishing, 1989.
URLs:	

Name of Program	M.Tech Communication Systems)	Semester I/II	Year I

Name of Course	**Fuzzy Logic**
Course Code	**CS 603**
Core / Elective / Other	**Elective**

Prerequisite:	
1.	Elementary Set Theory
2.	Elementary Probability Theory

Course Outcomes: After completion of the course, the students will be able to	
CO1	Outline concepts of Fuzzy Set Theory and Fuzzy Logic.
CO2	Explain about Fuzzy rule base systems and performance analysis
CO3	Formulate and solve various real life problems using concepts of Fuzzy logic.

Description of Contents in brief:	
1.	Classical Set and Fuzzy set Theory, Classical and Fuzzy Relations, Fuzzification and Defuzzification
2.	Development of Membership function, Fuzzy Logic and Fuzzy Systems, Decision Making with Fuzzy Information
3.	Fuzzy Classification, Fuzzy Pattern Recognition, Fuzzy Control Systems, Miscellaneous Topics

List of Text Books:	
1.	Timothy J. Ross, Fuzzy Logic With Engineering Applications, 3rd ed. Wiley, 2010
2.	George J Klir / Bo Yuan, Fuzzy Sets and Fuzzy Logic: Theory and Applications, Pearson, 2015
3.	A.K. Bhargava, Fuzzy Set Theory Fuzzy Logic and their Applications, S.Chand and Comp, 2013

List of Reference Books:	
1.	LotfiA.Zadeh and Rafik A. Aliev, Fuzzy Logic theory and Applications, World Scientific, 2018.
2.	M.K. Hasan, Fuzzy Sets and Fuzzy Logic with Applications: Imprecision, Uncertainty and Vagueness, Scholar's Press, 2019
3.	Hans-Jurgen Zimmermann, Practical Applications of Fuzzy Technologies (The Handbooks

	of Fuzzy Sets), 2012, Springer Science
URLs:	
1.	https://www.tutorialspoint.com › fuzzy_logic
2.	https://www.guru99.com/
3.	https://www.youtube.com/watch?v=a2i-lHS-c_I

Lecture Plan (about 40-50 Lectures):

Lecture No.	Topic
1.	Introduction and historical aspects of Fuzzy set theory
2.	Classical set theory and Fuzzy set theory
3.	Fuzzy membership functions
4.	Fuzzy union, intersection and complement operations
5.	Graphical representations of Fuzzy operations
6.	Cartesian product and Fuzzy Relations
7.	Fuzzy Compositions
8.	Fuzzy equivalence Relations
9.	Value assignments for Fuzzy Relations
10.	Fuzzy Set elements and Properties
11.	Concepts of Fuzzification and Defuzzifications
13.	Methods of Defuzzification
14.	Alpha Cut for Crisp conversion
15.	Alpha Cut for Fuzzy Equivalence Relation
16.	Fuzzy Propositions
17.	Fuzzy Implications
18.	Concepts of Fuzzy Rule based Systems
19.	Mamdani Fuzzy Rule based Systems
20.	Sugeno (TSK) Fuzzy Rule based Systems
21.	Tsukamoto Fuzzy Rule based Systems
22.	Development of Fuzzy membership functions
23.	Intuition and Inference method
24.	Rank ordering and Neural network method

25.	Other methods for development of Fuzzy membership functions
26.	Fuzzy Decision Masking
27.	Fuzzy Ordering
28.	Nontransitive Ranking
29.	Preference and Consensus
30.	Multiobjective Decision Making: Concepts and Requirements
31.	Multiobjective Decision Making: Examples
32.	Multiobjective Decision Making: Practical Applications
33.	Fuzzy Bayesian Decision Making: Concepts and requirements
34.	Fuzzy Bayesian Decision Making: Examples
35.	Decision Making Under Fuzzy States
36.	Fuzzy Classification
37.	Fuzzy Clustering
38.	Fuzzy C-Means Clustering
39.	Fuzzy C-Means Clustering (Cont.)
40.	Hard C-Means and Fuzzy C-Means Algorithms
41.	Fuzzy pattern Recognition
42.	Feature Analysis
43.	Single Sample Identification
44.	Multi Feature Pattern Recognition
45.	Fuzzy Extension Principles
46.	Approximate Methods of Fuzzy Extension
47.	Fuzzy control Systems
48.	Simple Fuzzy Logic Controllers
49.	Fuzzy Logic Controllers (Cont.)
50.	Industrial Applications

Name of Program	M.Tech (Communication Systems)	Semester I/II	Year I

Name of Course	**Neural Networks**
Course Code	**CS 602**
Core / Elective / Other	**Elective**

Prerequisite:

1.	Nil

Course Outcomes: After completion of the course, the students will be able to

CO1	Develop a deep understanding of fundamental concepts in neural networks, including architecture, activation functions, and training algorithms.
CO2	Gain proficiency in implementing and training neural network models using popular frameworks such as TensorFlow or PyTorch
CO3	Explore advanced topics in neural networks, including convolutional neural networks (CNNs), recurrent neural networks (RNNs), and generative adversarial networks (GANs).
CO4	Acquire skills in applying neural networks to solve real-world problems in domains such as image recognition, natural language processing, and reinforcement learning.
CO5	Demonstrate the ability to design, analyze, and optimize neural network architectures to achieve desired performance metrics and computational efficiency

Description of Contents in brief:

1.	1. **Fundamentals of Neural Networks**: Introduction to neural networks and their applications. Neuron model: structure, activation functions, and network architecture. Single-layer perceptrons and multi-layer feedforward neural networks. Training algorithms: gradient descent, backpropagation, and optimization techniques. 2. **Advanced Neural Network Architectures**: Convolutional Neural Networks (CNNs): architecture and applications in computer vision. Recurrent Neural Networks (RNNs): architecture and applications in sequence modeling. Deep architectures: deep belief networks (DBNs), deep reinforcement learning, and autoencoders. Transfer learning and fine-tuning techniques for pre-trained models. 3. **Practical Implementation of Neural Networks**: Introduction to neural network frameworks: TensorFlow, PyTorch, Keras. Hands-on implementation of neural network models using Python. Hyperparameter tuning and regularization techniques. Debugging and troubleshooting common issues in neural network training and deployment. 4. **Applications of Neural Networks**: Image recognition and computer vision applications using CNNs. Natural language processing tasks such as sentiment analysis, named entity recognition, and machine translation using RNNs. Reinforcement learning algorithms for autonomous agents and game playing. Real-world case studies demonstrating the application of neural networks in various domains. 5. **Emerging Trends and Future Directions**: Recent advancements in neural network

	research: deep learning, attention mechanisms, and self-supervised learning. Ethical considerations and societal impacts of neural network technologies. Future directions in neural network research and applications: explainable AI, neurosymbolic AI, and neuromorphic computing. Discussion on current research challenges and opportunities for innovation in the field of neural networks.
List of Text Books:	
1.	"Neural Networks and Deep Learning: A Textbook" by Charu C. Aggarwal
2.	"Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville
3.	"Pattern Recognition and Machine Learning" by Christopher M. Bishop
List of Reference Books:	
1.	"Neural Networks: A Comprehensive Foundation" by Simon Haykin
2.	"Deep Learning for Computer Vision" by Rajalingappaa Shanmugamani
3.	"Neural Network Design" by Martin T. Hagan, Howard B. Demuth, and Mark H. Beale
URLs:	
1.	https://www.coursera.org/learn/neural-networks-deep-learning
2.	https://www.coursera.org/learn/machine-learning
3.	https://www.edx.org/learn/neural-network
Lecture Plan (about 40-50 Lectures):	
Lecture No.	**Topic**

Name of Program	M. Tech (Communication Systems)	Semester I/II	Year I
Name of Course	**Computer Networks**		
Course Code	**CS 606**		
Core / Elective / Other	**Elective**		

Prerequisite:

1.	Introduction to telephony
2.	Integrated networks
3.	Multiplexing schematics

Course Outcomes: After completion of the course, the students will be able to

CO1	Explain the networks, topologies and layers of OSI model, compare with TCP/IP model.
CO2	Classify error control and flow control techniques and types of LAN technologies.
CO3	Analyze different routing algorithms and methods to improve QOS.
CO4	Summarize the transport layer protocols and congestion controls methods.
CO5	Describe various application layer services and cryptographic techniques

Description of Contents in brief:

1.	Introduction Concepts: Goals and Applications of Networks,OSI and TCP-IP Model, Physical Layer, Transmission Media, Line coding
2	Functions of Data link layer and DLL Protocols,MAC layer protocols
3.	Network layer and routing algorithms
4.	Transport Layer: TCP and UDP, Application Layer, Other application. Overview of IEEE standards
5.	Example of Networks – Internet, Public Switched Network (PSTN), ISDN, B-ISDN and ATM Networks.

List of Text Books:

1.	Data Communication and Networking Forouzen
2.	Computer Networks A.S. Tanenbaum
3.	Data and Computer Communication W. Stallings.

List of Reference Books:

1.	Data Networks D.P. Bertsekas, R.G. Gallager
2.	ISDN and B-ISDN W. Stallings

URLs:

1.	http://www.saylor.org/courses/cs402/
2.	http://www.cs.vu.nl/~ast/
3.	https://onlinecourses.**nptel**.ac.

Lecture Plan (about 40-50 Lectures):

Lecture No.	Topic

1.	Introduction Concepts: Goals and Applications of Networks, Flow Control
2.	Network Topologies and architecture
3.	The OSI reference model
4.	Physical Layer, Transmission Media
5.	Line coding: Uni-polar, Bi-polar, RZ, NRZ, Menchester and Differential Menchester codes
6.	Switching methods Circuit, message, packet switching
7.	Functions of Data link layer
8.	Framing, Error control
9.	DLL protocol stop and wait
10.	Sliding window protocols,
11.	Tutorial-1
12.	Medium Access control (MAC) sub layer
13.	MAC protocols: ALOHA
14.	Slotted ALOHA
15.	Token bus, Token Ring,
16.	Round Robin, CSMS/CA,
17.	Bit mapped protocol, Carrier Sense Multiple Access (CSMA)
18.	Collision Avoidance, Collision Detection
19.	p-Persistent, 1-Persistent
20.	Non-Persistent spectrum sensing
21.	Ethernet frame
22.	Tutorial-2
23.	Network Layer
24.	logical addressing (i.e. IPv4 addresses and header
25.	Routing algorithms
26.	Least cost routing algorithms
27.	Dijkstra and Bellman Ford algorithms
28.	Transport Layer: TCP and UDP
29.	Application Layer, Other application.
30.	Overview of IEEE standards
31.	IEEE 802.3(LAN)
32.	IEEE 802.11a,b,g,n (WLAN)
33.	IEEE 802.15 (PAN)
34.	FDDI
35.	Tutorial-3
36.	Networking Devices: Bridge
37.	Hub, Switch, Router
38.	Gateway, Servers
39.	Example of Networks – Internet
40.	Cryptography
41.	ISDN, B-ISDN and ATM Networks
42.	Tutorial-4

Name of Program	**M. Tech (Communication Systems)**	**Semester: I/II**	**Year:** I

Name of Course	**Cyber Physical Systems**
Course Code	**CS 607**
Core / Elective / Other	**Elective**

Prerequisite:

1.	NIL

Course Outcomes: After completion of the course, the students will be able to

CO1	Understand the functional knowledge of cyber physical systems (CPS)
CO2	Analyze the physical and cyber components of real-world technical systems
CO3	Evaluate the functional units of CPS.
CO4	Design and create CPS.

Description of Contents in brief:

1	**Frameworks for cyber physical systems (CPS):** Introduction to CPS, IoT verses CPS, CPS concept map. CPS Analysis by examples, Application domain, hybrid systems verses CPS, Multi-dynamic systems. Physical, cyber, and computational components of CPS
2	**Physical Components:** Introduction to sensors and actuators, deployment, assignment and coordination, network criteria design, importance of sensors, causality, memory requirement, computational complexity. Redundant sensors, operational criteria. Test beds, case studies.
3	**Cyber Components:** Network technologies for CPS, Sensing networks and data connectivity. M2M communication, characteristics of IP and Non-IP solutions. 6LoWPAN, RPL-CoAP and HTTP-CoAP. Mobile Cloud computing-definition and types.
4	**Computational components:** (Qualitative treatment) Embedded system design and design flow of CPS. Processing units, ASIC processor, DSP, Multimedia processor, VLIW, Microcontroller and MPSoC, Reconfigurable logic.

List of Text Books:

1.	Alur, Rajeev. Principles of cyber-physical systems. MIT press, 2015.
2.	Suh, Sang C., et al., eds. *Applied cyber-physical systems*. New York, NY: Springer New York, 2014.
3.	Song, Houbing, et al., eds. *Cyber-physical systems: foundations, principles and applications*. Morgan Kaufmann, 2016.

List of Reference Books:

1.	Kravets, Alla G. *Cyber-physical systems: Industry 4.0 challenges*. Eds. Alexander A. Bolshakov, and Maxim V. Shcherbakov. Vol. 260. Manhattan, NY, USA: Springer International Publishing, 2020.
2.	Suh, Sang C., et al., eds. *Applied cyber-physical systems*. New York, NY: Springer New York, 2014.
3.	Rajkumar, Raj, Dionisio De Niz, and Mark Klein. *Cyber-physical systems*. Addison-Wesley Professional, 2016.

URLs: NIL

Lecture Plan (about 40-50 Lectures):

Lecture No.	Topic
1.	Frameworks for cyber physical systems (CPS): Introduction to CPS
2.	IoT verses CPS, CPS concept map
3.	CPS Analysis by examples
4.	Application domain examples
5.	hybrid systems verses CPS
6.	Multi-dynamic systems
7.	Physical components of CPS
8.	Cyber components of CPS
9.	Computational components of CPS
10.	Physical Components: sensors and actuators
11.	deployment, assignment and coordination of components
13.	network criteria design
14.	Design examples
15.	importance of sensors
16.	causality, memory requirement, computational complexity
17.	Redundant sensors
18.	operational criteria
19.	Test beds
20.	case studies
21.	Cyber Components: Network technologies for CPS
22.	Sensing networks and data connectivity

23.	M2M communication
24.	Characteristics of IP and Non-IP solutions
25.	6LoWPAN
26.	RPL-CoAP
27.	HTTP-CoAP
28.	Mobile Cloud computing-definition and types
29.	Computational components: (Qualitative treatment)
30.	Introduction to embedded systems
31.	Embedded system design
32.	design flow of CPS
33.	Processing units
34.	ASIC processor
35.	DSP
36.	Multimedia processor
37.	Very Long Instruction Word (VLIW)
38.	Multiprocessor systems-on-chips (MPSoCs)
39.	Reconfigurable logic
40.	Case studies

Name of Program	M. Tech. (Communication Systems)	Semester I/II	Year 1
Name of Course	**Telecom Transmission Systems**		
Course Code	**CS 608**		
Core / Elective / Other	**Open Elective**		

Prerequisite:	
1.	Knowledge of Machine Learning up to B.Tech. level

Course Outcomes: After completion of the course, the students will be able to	
CO1	Have knowledge about characteristics of Transmission
CO2	Recall basics of Microwave and Fiber Optic Links
CO3	Analyze data transmission through future networks
CO4	Gain knowledge about advances in Telephone systems
CO5	Explain the essentials of cellular communication systems

Description of Contents in brief:	

List of Text Books:	
1.	Methods of Communication :Different types of antennas & their Characteristics, Radio Frequency wave propagation, Principles of Radar , Pulsed Radar ,CW Radar
2	Review of Microwave Link and Fiber Optic Link
3	LAN, WANs, Narrowband ISDN, Broadband ISDM, ATM and Internet
4.	Telephone Systems and Application: Telephones –Telephone system- Facsimile- Cellular telephone system-Paging system –Integrated services Digital Networks (ISDN)
5	Cellular Radio: Citizen's band Radio, Cordless Telephone, Improved Mobile Telephone service (IMTS), Introduction to Advanced Mobile Phone Service (AMPS), GSM – RF channels and time slots – Voice transmission – Frequency Hopping - Subscriber ID module – GSM Privacy and Security – IS-95 CDMA PCS – Channels – Forward Channel – Reverse Channel – Voice Coding – Power Control – Hand-off and CDMA Security.

List of Text Books:	
1.	Louis.E.Frenzel, Communication Electronics – Principles and Application", 3rd Editions, Tata McGraw-Hill, 2002
2.	Wayne Tomasi,"Electronic Communication systems" 4th Edition, Pearson Education, 2001.

List of Reference Books:	
1.	Robert G. Winch, "Telecommunication Transmission Systems", 2nd Edition, Tata McGraw-Hill, 2002 (
2.	Marin Cole, "Introduction to Telecommunications –Voice, Data and Internet", Pearson Education, 2001.

URLs:	
1.	Nil

Lecture Plan (about 40-50 Lectures):	
Lecture No.	**Topic**
1	Methods of Communication :
2-3	Different types of antennas & their Characteristics,
5	Radio Frequency wave propagation,

6-7	Principles of Radar , Pulsed Radar
8	CW Radar
9-10	Review of Microwave Link
11-12	Fiber Optic Link
13-14	LAN, WANs
15-16	Narrowband ISDN, Broadband ISDM
17-18	ATM and Internet
19-20	Telephones –Telephone system- Facsimile
21-22	Cellular telephone system-
23	Paging system
24-25	Integrated services Digital Networks (ISDN)
26-27	Cellular Radio: Citizen's band Radio
28-29	,Cordless Telephone, Improved Mobile Telephone service (IMTS),
30	Introduction to Advanced Mobile Phone Service (AMPS)
31-32	)GSM – RF channels and time slots
33-34	– Voice transmission – Frequency Hopping
35-36	Subscriber ID module – GSM Privacy and Security
37-38	IS-95 CDMA PCS – Channels – Forward Channel, – Reverse Channel –
39-40	Voice Coding – Power Control – Hand-off and CDMA Security

Name of Program	M. Tech. (Communication Systems)	Semester I/II	Year 1
Name of Course	**SDN and Network Virtualization**		
Course Code	**CS 608**		
Core / Elective / Other	**Open Elective**		

Prerequisite:	
1.	Nil

Course Outcomes: After completion of the course, the students will be able to	
CO1	Explain the concepts of software defined networks
CO2	Understand emerging networking technologies for cloud infrastructure
CO3	Perform varying and complex networking tasks
CO4	Explain the importance of Network Virtualization

Description of Contents in brief:	
1	**Introduction to Software Defined Networking (SDN):** Traditional switch architecture, Autonomous and dynamic forwarding table, Technological shifts, Evolution of switches and control planes, Consideration of cost, Needs of data center and innovations, Evolution of networking technology, Forerunners of SDN, Birth of SDN technology, Open source contributions, SDN interoperability
2	**SDN Architecture and its working:** Overview of network virtualization, Fundamental characteristics of SDN, SDN operations, SDN devices, SDN Controller, SDN applications, Alternate SDN methods
3	**OpenFlow Specification**: Overview of OpenFlow, basics of OpenFlow, Various versions of OpenFlow, OpenFlow interoperability, Limitations of OpenFlow
4	**SDN in different environments**: SDN in data centers, SDN in WAN, SDN in campus networks, SDN in hospitality networks, SDN in mobile networks, SDN for service providers and carrier networks, SDN in optical networks.
5	**Network Functions Virtualizations:** Definition of NFV, Standards, OPNFV, Leading NFV Vendors, SDN Vs. NFV, In- line Network Functions, Overview of Emerging Protocol, Controller, and Application Models for SDN

List of Text Books:	
1.	Paul G., Chuck B., and Timothy C., "Software Defined Networks : A Comprehensive Approach", 2nd Edition, Morgan Kaufmann
2.	Patricia M., James A, "Software Defined Networking" , CRC Press
3	Thomas N. and Kenneth G., "*SDN : Software Defined Networks*", O'Reilly Media.

List of Reference Books:	
1.	Coker O. and Azodolmolky S., "*Software-Defined Networking with OpenFlow*", Packt publishing ltd.
2	Dijiang H., Chowdhary A., and Pisharody S., "*Software-Defined Networking and Security: From Theory to Practice*", CRC Press
3	Subramanian S. and Voruganti S., "Software-Defined Networking (SDN) with OpenStack", Packt publishing ltd.

URLs:	
1.	Nil

Lecture Plan (about 40-50 Lectures):	
Lecture No.	**Topic**
1	Traditional switch architecture
2	Autonomous and dynamic forwarding table
3	Technological shifts, Evolution of switches and control planes
4	Consideration of cost, Needs of data center and innovations
5	Evolution of networking technology
6	Forerunners of SDN
7	Birth of SDN technology
8	Open source contributions
9	SDN interoperability
10	Overview of network virtualization
11	Fundamental characteristics of SDN, SDN operations
12	SDN devices
13	SDN Controller
14	SDN applications
15	Alternate SDN methods
16	Overview of OpenFlow
17	basics of OpenFlow
18	Various versions of OpenFlow
19	OpenFlow interoperability
20	Limitations of OpenFlow
21	SDN in data centers
22	SDN in WAN
23	SDN in campus networks
24	SDN in campus networks Contd.
25	SDN in campus networks Contd.
26	SDN in hospitality networks
27	SDN in mobile networks
28	SDN in mobile networks contd.
29	SDN for service providers and carrier networks
30	SDN for service providers and carrier networks Contd.
31	SDN in optical networks
32	Definition of NFV
33	Standards, OPNFV
34	Leading NFV Vendors
35	Leading NFV Vendors Contd.
36	SDN Vs. NFV
37	In- line Network Functions
38	In- line Network Functions Contd.
39	Overview of Emerging Protocol
40	Controller and Application Models for SDN

Name of Program	M. Tech. (Communication Systems)	Semester I/II	Year 1
Name of Course	**Applied Machine Learning and Deep Learning**		
Course Code	**CS 605**		
Core / Elective / Other	**Elective**		

Prerequisite:	
1.	Basics of probability and statistical inference, and basics of machine learning (such as regression, classification, clustering).
Course Outcomes: After completion of the course, the students will be able to	
CO1	Understand the advanced Machine learning algorithms
CO2	Outline the application of advanced machine learning in the design of physical layer techniques for wireless communications
CO3	Create the application of machine learning and deep learning in network design
Description of Contents in brief:	
The objective of this course is to teach modern topics in machine learning. The course will deepen the student's knowledge of how to build computer systems that learn from experience. The course assumes basic knowledge of introductory machine learning, and a good background on probability and statistics, linear algebra, and optimization methods. We will cover modern topics such as learning theory, transfer learning, meta-learning, domain adaptation, self-adaptive learning algorithms, deep learning, Gaussian processes, and kernel methods. Students will read papers from main conferences in machine learning and will learn to identify novel ideas within the field.	
List of Text Books:	
1.	Deep Learning- Ian Goodfelllow, Yoshua Benjio, Aaron Courville, The MIT Press
2.	F. V. Jensen. "Bayesian Networks and Decision Graphs". Springer. 200
List of Reference Books:	
1.	T. J. OShea, T. Erpek, and T. C. Clancy. Deep learning based MIMO communications.
URLs:	
1.	Nil

Lecture Plan (about 40-45 Lectures):	
Lecture No.	**Topic**
1-2	Introduction to Advanced Machine Learning Meta-Learning
3-4	Self-Adaptive Learning
5-6	Semi-Supervised Learning