INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
ROORKEE

No. Acd./3812 /UG-15 Dated: November 16 , 2018

NOTIFICATION

Subject: Modified structure and syllabi of M.Tech. (Communication Systems)

The Senate in its 75th meeting held on 01.10.2018 approved the modified Structure and Syllabi of courses of M.Tech. (Communication Systems) of the Department of Electronics and Communication Engineering.

The approved structure and syllabi are enclosed herewith.

Asstt. Registrar (Curriculum)

Encl: as above

Copy to(through e-mail):-

1. Head, Electronics and Communication Engineering Department
2. All faculty
3. All Head of Departments/Centres
4. Chairman Senate & Director
5. Dean of Academic Affairs
6. Associate Deans of Academic Affairs(Curriculum/Evaluation/Admission)
7. Asstt. Registrar (Meetings)
8. Channel I/ Academic webpage of iitr.ac.in

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

M.Tech. (Communication Systems)

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1st YEAR			Semester- I (Autumn)											
1.	ECN-510	Digital Communication Laboratory	PCC	2	0	0	3	0	3	-	50	-	-	50
2.	ECN-511	Linear Algebra and Random Processes	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
3.	ECN-512	Advanced Digital Communication	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
4.	ECN-513	Multirate Digital Signal Processing	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
5.	ECN-515	Information and Coding Theory	PCC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
		Total		18	12	4	3							
Semester-II (Spring)														
1.	ECN-600	Project	PCC	2	0	0	3	0	0	-	100	-	-	-
2.	ECN-700	Seminar	SEM	2	-	-	-	-	-	-	-	-	100	-
3.		ELECTIVE - I	PEC	3 / 4	3									
4.		ELECTIVE - II	PEC	3 / 4	3									
5.		ELECTIVE - III	PEC	4	3									
6.		ELECTIVE - IV	PEC	4	3									
		Total		18- 20	12									

2nd YEAR			**Semester- I (Autumn)**											
1.	ECN-701A	Dissertation Stage–I (to be continued next semester)	DIS	12	-	-	-	-	-	-	-	-	100	-
		Total		12										
Note: Students can take 1 or 2 audit courses as advised by the supervisor, if required.														
				Semester-II (Spring)										
1.	ECN-701B	Dissertation Stage–II (contd. from III semester)	DIS	18	-	-	-	-	-	-	-	-	100	-
		Total		18										
		Total Credits		**66 - 68**										

Program Elective Courses (Communication Systems)

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1.	ECN-514	Detection and Estimation Theory	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
2.	ECN-611	Wireless Communication Systems	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
3.	ECN-612	Wireless Networks	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
4.	ECN-613	Telecommunication Networks	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
5.	ECN-614	Adaptive Signal Processing Techniques	PEC	4	3	0	2	3	0	10-15	10-20	20-30	40-50	-
6.	ECN-615	Advanced Coding Theory	PEC	4	3	0	2	3	0	10-15	10-20	20-30	40-50	-
7.	ECN-616	Speech and Audio Processing	PEC	4	3	0	2	3	0	10-15	10-20	20-30	40-50	-
8.	ECN-617	Image Processing and Computer Vision	PEC	4	3	0	2	3	0	10-15	10-20	20-30	40-50	-
9.	ECN-531	Microwave Engineering*	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
10.	ECN-539	Fiber Optic Systems*	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
11.	ECN-550	Radar Signal Processing*	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
12.	ECN-555	Microwave Imaging*	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
13.	ECN-573	Digital VLSI Circuit Design*	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-
14.	ECN-594	VLSI Digital Signal Processing*	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
15.	ECN-631	RF Receiver Design*	PEC	3	3	0	0	3	0	20-35	-	20-30	40-50	-

* Courses offered from other specialization groups of the ECE Department.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Electronics & Communication Engineering**

1. Subject Code: **ECN- 511** Course Title: **Linear Algebra and Random Processes**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE:20-30** **ETE:40-50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Autumn** 7.Subject Area**: PCC**

8. Pre-requisite**:** Nil.

9. Objective: To introduce the students to the theory and applications of linear algebra, random variables and random processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Vector spaces, subspaces, bases and dimensions, linear dependence and independence, vector products, orthogonal bases and orthogonal projections, Gram-Schmidt orthonormalizationprocedure	**10**
2.	Linear operators and Matrices: Eigen values and Eigen vectors, characteristic polynomial, diagonalization, Hermitian and unitary matrices, singular value decomposition	**10**
3.	Discrete and continuous random variables: distribution and density functions, conditional distributions and expectations, functions of random variables, moments, sequence of random variables	**10**
4.	Random process: Probabilistic structure; Mean, autocorrelation and auto-covariance functions; Strict-sense and wide-sense stationary processes; Power spectral density; LTI systems with WSS process as the input; Examples of random processes – white noise, Gaussian, Poisson and Markov Processes	**12**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	S.Axler, "Linear Algebra Done Right", 3rdEdn., Springer International Publishing.	2015
2.	G.Strang, "Linear Algebra and Its Applications", 4thEdn., Cengage Learning.	2007
3.	K.M. Hoffman and R. Kunze, "Linear Algebra", 2ndEdn.,Prentice Hall India.	2015
4.	A. Papoulis and S. Pillai, "Probability, Random Variables and Stochastic Processes", 4thEdn., McGraw Hill.	2017
5.	H. Stark and J.W. Woods, "Probability and Random Processes with Applications to Signal Processing", 3rdEdn., Pearson India.	2001
6.	A. Leon-Garcia, "Probability, Statistics and Random Processes for Electrical Engineers", 3rdEdn.,Prentice Hall India.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Electronics & Communication Engineering**

1. Subject Code: **ECN- 512** Course Title: **Advanced Digital Communication**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE:20-30** **ETE:40-50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Autumn** 7.Subject Area**: PCC**

8. Pre-requisite**:** Nil.

9. Objective: To introduce the students to the principles, techniques and applications of digital communication.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Characterization of Band-Pass signals, lowpass equivalent of bandpass signals, energy consideration, lowpass equivalent of bandpass system; Signal-space concepts, orthogonal expansion of signals	**4**
2.	Linear modulation, orthogonal and biorthogonal modulation, differential modulation, nonlinear modulation; phase modulation, quadrature amplitude modulation, continuous-phase modulation	**10**
3.	Hypothesis testing; Optimal reception in AWGN; Performance analysis; optimum detection and error probability for band-limited signaling; optimum detection and error probability for energy-limited signaling	**8**
4.	Synchronization and non-coherent communication; signal parameter estimation, carrier phase estimation, symbol timing estimation; non-coherent detection of carrier modulated signals	**6**
5.	Band-limited channels; Inter-Symbol Interference (ISI); characterization of band-limited channels, signal design for band-limited channels	**4**
6.	Channel equalization: optimum maximum-likelihood estimation, maximum-likelihood sequence estimation; linear equalization, MSE equalizer; decision feedback equalization, coefficient optimization, predictive decision feedback equalization	**10**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	U. Madhow, "Fundamentals of Digital Communication", Cambridge University Press.	2008
2.	R.G. Gallager, "Principles of Digital Communication", Cambridge University Press.	2008
3.	J.G. Proakis and M. Salehi, "Digital Communications", 5thEdn.,McGraw-Hill.	2008
4.	S. Hykin, "An Introduction to Analog & Digital Communication", 4thEdn., Wiley	2012
5.	B. Ekman, "Handbook of Digital Communication", NY Research Press	2015

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Electronics & Communication Engineering**

1. Subject Code: **ECN- 513** Course Title: **Multirate Digital Signal Processing**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE:20-30** **ETE:40-50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Autumn** 7.Subject Area**: PCC**

8. Pre-requisite**:** Digital Signal Processing.

9. Objective: To introduce the students to the principles, techniques and applications of digital signal processing, specifically multi-rate signal processing.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Review of DSP concepts: Discrete-time Fourier transform (DTFT), discrete Fourier transform (DFT), and fast Fourier transform (FFT); Karhunen-Loeve transform (KLT), discrete cosine transform (DCT); Digital filter structures, FIR, IIR and their implementation	**8**
2.	Fundamentals of multirate systems: Sampling and resampling in time and frequency domains, interpolation (up-sampling), down-sampling, arbitrary sample-rate conversion, Multistage implementation of sampling rate conversion; Sampling rate conversion of bandpass signals	**10**
3.	Multirate processing using Filter-banks: Noble identities; Type-1 and Type-2 polyphase representations, poly-phase filter structures, Uniform DFT filter bank, Half-band filters, Quadrature mirror filters and variations thereof	**10**
4.	Wavelet transform and its relation to multirate filter banks, Relating dyadic MRA to filter banks, two-band filter bank design for dyadic wavelets; Examples of application of wavelet transform, Orthogonal and biorthogonal wavelets; Sub-band coding	**10**
5.	Applications of multirate systems: Audio signal processing; Image signal processing; Base-band signal processing	**4**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	J.G. Proakis, "Digital Signal Processing: Principles, Algorithms and Applications", 4thEdn., Pearson.	2007
2.	A.V. Oppenheimand R.W. Schafer, "Discrete-Time Signal Processing", 3rdEdn., Pearson.	2009
3.	P.P. Vaidyanathan, "Multirate Systems And Filter Banks", Prentice Hall.	1992
4.	F.J. Harris, "Multirate Signal Processing for Communication Systems: Current Practice and Next Generation Techniques", 2ndEdn.,Prentice Hall.	2009
5.	V.M. Gadre and A.S. Abhvankar, "Multiresolution and Multirate Signal Processing – Introduction, Principles and Applications", Mc-Graw Hill.	2017

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Electronics & Communication Engineering**

1. Subject Code: **ECN- 514** Course Title: **Detection and Estimation Theory**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE:20-30** **ETE:40-50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Spring** 7.Subject Area**: PEC**

8. Pre-requisite**:** Nil

9. Objective: To acquaint the students of Communication Engineering with the knowledge of how to use the tools of probability and signal processing to estimate signals and parameters and detect events from data.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to detection and estimation problem in signal processing and communication	**2**
2.	Estimation in signal processing; Sufficient statistic, Bias; Minimum variance unbiased estimator; Cramer-Rao lower bound; Best linear unbiased estimator; Maximum likelihood estimation (MLE)	**9**
3.	Bayesian Estimation – Minimum mean square-error (MMSE) estimators, Maximum a-posteriori (MAP) estimators; Linear MMSE estimation, Linear estimation of signals, Weiner filtering; Kalman filtering – Kalman estimation and tracking	**9**
4.	Detection theory in signal processing; Hypothesis test – Bayesian, Minimax Neyman-Pearson and composite hypothesis testing; Receiver operating characteristics	**8**
5.	Detection of deterministic signals with known parameters in Gaussian noise, Matched filters; Detection of random signals with known characteristics, Estimator-correlator; Detection of deterministic signals with unknown parameters, Bayesian approach and generalized likelihood ratio test (GLRT); Detection of random signals with unknown parameters; Expectation maximization; Hidden Markov Model (HMM)	**12**

6.	Applications of detection and estimation in signal processing and communication – biomedicine, communications, radar, sonar, etc	**2**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	S.M. Kay, "Fundamentals of Statistical Signal Processing – Estimation Theory (vol. 1)", Prentice Hall.	2009
2.	S.M. Kay, "Fundamentals of Statistical Signal Processing – Detection Theory (vol. 2)", Prentice Hall.	2009
3.	H.L. Van Trees, "Detection, Estimation and Modulation Theory", Part I, Wiley Interscience.	2013
4.	H. Vincent Poor, "An Introduction to Signal Detection and Estimation", 2nd Edn., Springer.	1998
5.	K.S. Shanmugan and A.M. Breipohl, "Random Signals: Detection, Estimation and Data Analysis", Wiley.	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Electronics & Communication Engineering**

1. Subject Code: **ECN- 515** Course Title: **Information and Coding Theory**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE:20-30** **ETE:40-50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Autumn** 7.Subject Area**: PCC**

8. Pre-requisite**:** Nil.

9. Objective: To acquaint the students of Communication Engineering with the knowledge of information theory, source coding for data compression and channel coding for error detection and correction.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to probability, uncertainty and information, entropy; Joint and conditional entropies, Mutual information	**3**
2.	Source coding theorems, Kraft-McMillan inequality, prefix code, variable and fixed length codes; Discrete memoryless channels, Binary symmetric channels (BSC), Capacity of a discrete channel; Channel coding theorem; Entropy for sources with memory, Markov sources	**10**
3.	Information measures for continuous random variables – Extensions of the discrete measures to the continuous case; Differential entropy, Entropy power, Mutual information, Distortion; Rate distortion function; Capacity for waveform channel, channel capacity theorem, Bandwidth efficiency, Shannon's Limit	**9**
4.	Source coding – Introduction to data compression, lossless and lossy compression, entropy coding; Huffman code, Shannon-Fano code, Arithmetic code, Run-length code, Lempel-Ziv code	**10**
5.	Channel coding – Error correcting codes, minimum distance principles, error detection and correction capabilities; Linear block code, Single parity check code, repetition code, Hamming code; Binary cyclic code; Convolutional code	**10**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	T.M. Cover and J.A. Thomas, "Elements of Information Theory", 2nd Edn., Wiley Interscience.	2006
2.	R. Bose, "Information Theory, Coding and Cryptography", Tata McGraw-Hill.	2008
3.	K. Sayood, "Introduction to Data Compression", 5th Edn.,Morgan Kaufmann.	2017
4.	S. Roman, "Coding and Information Theory", Springer.	1992
5.	R.E. Blahut, "Principles and Practice of Information Theory", Addison-Wesley Publishing Company.	1987

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Electronics & Communication Engineering**

1. Subject Code: **ECN- 611** Course Title: **Wireless Communication Systems**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE:20-30** **ETE:40-50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Spring** 7.Subject Area**: PEC**

8. Pre-requisite**:** Advanced Digital Communication, Information and Coding Theory.

9. Objective: To acquaint the students with the concepts and the issues involved in the design of wireless communication systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Wireless channels: Physical modeling, input/output model, time and frequency coherence, statistical channel models	**4**
2.	Point-to-point communication: Detection in a Rayleigh fading channel, diversity techniques, channel uncertainty	**6**
3.	Cellular systems: Multiple access and interference management,narrow-band and wide-band systems	**6**
4.	Capacity of wireless channels, MIMO capacity, multiuser capacity, Uplink/Downlink AWGN and fading channels, multiuser diversity, opportunistic communication, relay communication	**12**
5.	OFDM and its application to wireless communication: Subcarrier mapping, synchronization, PAPR reduction techniques	**6**
6.	4G and 5G technology: System key components, different layers of OSI model, relay technology, applications and challenges	**8**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	D. Tse and P. Viswanath, “Fundamentals of Wireless Communication”, Cambridge University Press.	2005
2.	Y. Li and G.L. Stuber, “Orthogonal Frequency Division Multiplexing for Wireless Communications”, Springer.	2006
3.	Y.S. Cho, J. Kim, W.Y. Yang and C.G. Kang, “MIMO-OFDM Wireless Communications with MATLAB”.	2010
4.	“5G Mobile and Wireless Communications Technology”, A. Osseiran, J.F. Monserrat and P. Marsch (eds.), Cambridge University Press.	2016
5.	A. Goldsmith, “Wireless Communications”, Cambridge University Press.	2012

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Electronics & Communication Engineering**

1. Subject Code: **ECN- 612** Course Title: **Wireless Networks**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE:20-30** **ETE:40-50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Spring** 7.Subject Area**: PEC**

8. Pre-requisite**:** Nil.

9. Objective: To acquaint the students with the concepts and the issues involved in the design of wireless networks.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Wireless network topologies, infrastructure and ad-hoc networks, different generations of wireless networks; The cellular concept and design fundamentals, coverage and capacity expansion techniques	**5**
2.	Fixed assignment and random access; Capacity and performance of FDMA, TDMA, DS/CDMA and FH/CDMA; WCDMA and OFDMA; Access techniques for WLAN, Bluetooth and mobile data networks; Quality of service enabled wireless access, access methods for integrated services	**8**
3.	Location and handoff management, classification of handoffs and handoff algorithms, mobile IP; Power control, and techniques of power control, power saving mechanisms, energy efficient designs; Security in wireless networks	**8**
4.	GSM: Reference architecture, registration, call establishment, handoff mechanisms, communication in the infrastructure, GPRS; IS-95: Reference architecture, physical layer, radio resource and mobility management; IMT 2000: Physical layer, handoff, power control; Introduction to cordless systems and wireless local loop technologies	**7**
5.	Reference and layered architecture of IEEE 802.11 WLANs, physical layer alternatives, MAC scheme and frame format, handoff and power management; Protocol architecture, physical and MAC layer of Hiperlan-1 and Hiperlan-2; IP telephony using WLANs	**5**

6.	Wireless home networking; HomeRF; Bluetooth: Protocol stack, physical and MAC layer	**5**
7.	Broadband wireless access and IEEE 802.16; Next generation broadband wireless networks and navigational services	**4**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Books / Authors**	**Year of Publication**
1.	K. Pahalvan and P. Krishnamurthy, "Principles of Wireless Networks: A Unified Approach", Pearson Education.	2002
2.	W. Stallings, "Wireless Communications and Networking", 2nd Edn.,Pearson Education.	2009
3.	T.S. Rappaport, "Wireless Communications: Principles and Practice", 2nd Edn., Pearson Education.	2002
4.	R. Prasadand L. Munoz, "WLANs and WPANs: Towards 4G Wireless", Artech House.	2003
5.	S. Haykinand M. Moher, "Modern Wireless Communication", Pearson Education.	2005
6.	R. Pandya, "Mobile and Personal Communication Systems and Services", Prentice-Hall of India.	2000
7.	M. Guizani, H.-H. Chen and C. Wang, "The Future of Wireless Networks: Architectures, Protocols, and Services", CRC Press.	2015

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Electronics & Communication Engineering**

1. Subject Code: **ECN- 613** Course Title: **Telecommunication Networks**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35** **PRS: 0** **MTE:20-30** **ETE:40-50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Spring** 7.Subject Area**: PEC**

8. Pre-requisite**:** Nil.

9. Objective: To provide an in-depth study of communication networks with emphasis on development of analytical tools and quantitative performance evaluation.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction tocommunication networks**,** network topologies, internetworking, circuit and packet switching; Layered architecture and protocols, OSI reference model and functions of various layers, overview of TCP / IP, ISDN and SS – 7 protocol architectures	**3**
2.	Brief characterization of communication channels and fundamental limits in digital transmission; Line codes and modems; Transmission media and transmission impairments; Synchronous and asynchronous time division multiplexing, SONET and SDH	**3**
3.	Error detection: Parity check, polynomial representation, cyclic redundancy checks and their capabilities; Error control: Stop and wait, go - back n and selective repeat ARQ strategies, correctness and throughput analysis; Framing and optimum frame size; HDLC and LAPB protocols, throughput analysis of HDLC	**6**
4.	Introduction to queuing models, modeling of arrivals, inter-arrival times and service times, Poisson process; Little's theorem, proof and examples; Continuous–time discrete event process and Markov chain, Birth-Death process; Analysis and applications of M/M/1, M/M/m, M/M/m/m, M/M/m/K and M/M/∞ queues; M/G/1 queue, vacation, reservation, polling, and priority; G/G/1 queue; Network of queues, Kleinrock's independence assumption, Burke's and Jackson's theorems	**15**

5.	Classification and performance measures of MAC protocols; Pure-ALOHA and slotted-ALOHA, Markov chain modeling, stability, BEB and other stabilization techniques; Splitting algorithms; Non-persistent, 1-persistent and p-persistent CSMA, performance evaluation; CSMA/CD and CSMA/CA; Polling, reservation and token ring protocols; Overview of IEEE 802 standards and frame structures of 802.3 and 802.5	**8**
6.	Main issues in routing, virtual circuit and datagram routing; Classification of routing algorithms; Shortest path algorithms: Bellman-Ford, Dijkstra and Floyd-Warshall; Distributed asynchronous Bellman-Ford algorithm	**4**
7.	Objectives and means of flow and congestion control, End-to-end and node by node windows, performance analysis and simplified queuing models; Rate control schemes: Time window, modeling and performance of leaky bucket algorithm	**3**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Books / Authors**	**Year of Publication**
1.	D. Bertsekasand R. Gallager, "Data Networks", 2nd Edn., Prentice-Hall of India.	1992
2.	A. Kumar, D. Manjunathand J. Kuri, "Communication Networking: An Analytical Approach", Morgan Kaufmann.	2004
3.	M. Schwartz, "Telecommunication Networks: Protocols, Modeling and Analysis", Pearson Education.	1987
4.	W. Stallings, "Data and Computer Communication", 8th Edn., Pearson Education.	2007
5.	J. Walrand, "Communication Networks", 2nd Edn., McGraw-Hill.	2009
6.	L. Kleinrock, "Queuing Systems: Theory", 2nd Edn., Wiley Blackwell.	2008
7.	T.N. Saadawi, "Fundamentals of Telecommunication Networks", Wiley.	2015

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Electronics & Communication Engineering**

1. Subject Code: **ECN- 614** Course Title: **Adaptive Signal Processing Techniques**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS:10-15** **PRS: 10-20** **MTE:20-30** **ETE:40-50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Spring** 7.Subject Area**: PEC**

8. Pre-requisite**:** Digital Signal Processing.

9. Objective: To acquaint the students with the concepts, algorithms and applications of adaptive signal processing in digital communication systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Definitions, assumptions and requirements of adaptive signal processing applicable to different application examples; Linear filter structures; Adaptive beamforming	**4**
2.	Optimum linear combiner and Wiener-Hopf equations, orthogonality principle, minimum mean square error and error performance surface; Multiple linear regression model; Linearly constrained minimum-variance filter	**6**
3.	Forward and backward prediction error filters; Levinson—Durbin algorithm; Properties of prediction-error filters; Autoregressive modeling of a stationary stochastic process; All-pole, all-pass lattice filter	**8**
4.	Steepest-descent algorithm and its stability; Principles of stochastic gradient descent, LMS algorithm and its variants	**4**
5.	Least Squares method, its efficient implementation: Minimum sum of error squares, normal equations and linear least-squares filters, Singular valuedecomposition, cyclic Jacobi, Householder methods	**8**
6.	RLS adaptive filtering algorithms;Exponentially weighted RLS algorithm; Kalman filter and its variants; Square-root adaptive filters, adaptive beamforming	**8**

7.	Implementation examples: Adaptive modeling and system identification, inverse adaptive modeling, equalization and deconvolution, adaptive control systems, adaptive interference cancellation.	**4**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Books / Authors**	**Year of Publication**
1.	S. Haykin, "Adaptive Filter Theory", 4th Edn., Pearson Education.	2014
2.	B. Widrowand S.D. Stearns, "Adaptive Signal Processing", 1st Edn., Pearson Education.	1985
3.	D.G. Manolakis, V.K. Ingleand M.S. Kogon, "Statistical and Adaptive Signal Processing", Artech House.	2005
4.	H. Sayed Ali, "Fundamentals of Adaptive Filtering", Wiley-Interscience, IEEE Press.	2003
5.	P.S.R. Diniz, "Adaptive Filtering: Algorithms and Practical Implementation", 3rd Edn., Springer.	2008
6.	H. Sayeed Ali, "Adaptive Filters", 1st Edn., John Wiley & Sons.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Electronics & Communication Engineering**

1. Subject Code: **ECN- 615** Course Title: **Advanced Coding Theory**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS:10-15** **PRS: 10-20** **MTE:20-30** **ETE:40-50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Spring** 7.Subject Area**: PEC**

8. Pre-requisite**:** Information and Coding Theory.

9. Objective: To provide an in-depth study of the design of good forward error correction codes and their efficient decoding.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to coding for reliable information transmission and storage; Shannon's channel coding theorem, minimum distance principles, error detection and correction capabilities revisited.	**2**
2.	Introduction to Algebra – Groups, Fields; Binary field arithmetic; Galois Field, construction and properties of GF (2^m); Vector spaces.	**7**
3.	Linear Block Codes – encoding, syndrome and error detection; Systematic and non-systematic codes; Standard array and syndrome decoding; Probability of undetected error over binary symmetric channel; Some important linear block codes – Hamming, Reed-Muller and Golay codes.	**6**
4.	Cyclic Codes – Polynomial and matrix description of cyclic codes; encoding of cyclic codes; syndrome computation and error detection; Meggitt decoder, decoding of cyclic Hamming code, Error trapping decoding; Golay, Shortened and Quasi-cyclic codes.	**8**
5.	Binary primitive BCH codes, Berlekamp's iterative algorithm for BCH decoding; Non-binary BCH codes, Reed-Solomon (R-S) codes, decoding of R-S codes by Berlekamp's algorithm, Frequency domain representation and decoding of R-S codes.	**8**

6.	Convolutional Codes – generator sequences and matrix description of feedforward convolutional encoder; Systematic encoders; Transform domain representation; Equivalent encoder realizations in Controller canonical form, Observer canonical form and feedback encoder form; Finite state machine model and Trellis representation of an encoder, Viterbi decoding, Soft-output Viterbi Algorithm (SOVA) and BCJR algorithm.	**8**
7.	Introduction to Turbo and LDPC codes; Iterative decoding of Turbo codes; Trellis coded modulation; Block coded modulation; Automatic Repeat Request (ARQ) strategies.	**3**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Books / Authors**	**Year of Publication**
1.	S. Lin, and D.J. Costello Jr., "Error Control Coding", 2nd Edn., Pearson.	2004
2.	R.E. Blahut, "Algebraic Codes for Data Transmission", 2nd Edn., Cambridge University Press.	2003
3.	W.C. Huffman and V. Pless, "Fundamentals of Error Correcting Codes", Cambridge University Press.	2003
4.	T.K. Moon, "Error Correction Coding: Mathematical Methods and Algorithms", Wiley Interscience.	2005
5.	J. Bierbrauer, "Introduction to Coding Theory", 2nd Edn., CRC Press.	2016

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Electronics & Communication Engineering**

1. Subject Code: **ECN- 616** Course Title: **Speech and Audio Processing**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS:10-15** **PRS: 10-20** **MTE:20-30** **ETE:40-50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Spring** 7.Subject Area**: PEC**

8. Pre-requisite**:** Digital Signal Processing.

9. Objective: To acquaint the students with the concepts in speech and audio processing, and their applications in communication systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Digital speech processing and its applications, production and classification of speech sounds, lossless tube models, digital models for speech signals; Analysis and synthesis of pole-zero speech models, Levinson recursion, lattice synthesis filter.	**7**
2.	Time dependent processing of speech, pitch period estimation, frequency domain pitch estimation; Discrete-time short-time Fourier transform and its application, phase vocoder, channel vocoder.	**6**
3.	Homomorphic speech processing, waveform coders, hybrid coders and vector quantization of speech; Model based coding: Linear predictive, RELP, MELP, CELP; Speech synthesis.	**9**
4.	Principles of speech recognition, spectral distance measures, dynamic time warping, word recognition using phoneme units, hidden Markov models and word recognition, speech recognition systems, speaker recognition.	**7**
5.	Ear physiology, psychoacoustics, perception model and auditory system as filter bank; Filter bank design and modified discrete cosine transform algorithm for audio compression in MP3 and AAC coders; Standards for high-fidelity audio coding.	**7**

6.	Tree-structured filter banks, multi-complementary filter banks; Properties of wavelets and scaling functions, wavelet transform; Filter banks and wavelets, applications of wavelet signal processing in audio and speech coding.	**6**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Books / Authors**	**Year of Publication**
1.	L.R. Rabinerand R.W. Schafer, "Digital Processing of Speech Signals", Pearson Education.	2006
2.	T.F. Quatieri, "Discrete-Time Speech Signal Processing: Principles and Practice", Pearson Education.	2002
3.	S. Furui, "Digital Speech Processing, Synthesis and Recognition", 2nd Edn., CRC Press.	2000
4.	A. Spanias, T. Painterand A. Venkatraman, "Audio Signal Processing and Coding", John Wiley & Sons.	2007
5.	B. Goldand N. Morgan, "Speech and Audio Signal Processing", John Wiley & Sons.	2002
6.	A.R. Jayan, "Speech and audio Signal Processing", Prentice-Hall India.	2016

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Electronics & Communication Engineering**

1. Subject Code: **ECN- 617** Course Title: **Image Processing and Computer Vision**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS:10-15** **PRS: 10-20** **MTE:20-30** **ETE:40-50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Spring** 7.Subject Area**: PEC**

8. Pre-requisite**:** Digital Image Processing.

9. Objective: To acquaint the students with the advanced concepts of digital image processing and computer vision.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Digital image fundamentals: Simple image model; Sampling and quantization; Imaging geometry, perspective projection, digital geometry; Photometric model in image formation; Brightness, adaptation and contrast; Perception of color, color models.	**6**
2.	Image processing techniques: Image enhancement; Image restoration; Image registration; Image compression methods – transform coding, block truncation coding, vector quantization; Morphological image processing.	**12**
3.	Detection and matching of points, patches, lines and edges, Hough transform; Segmentation: active contours, split and merge, normalized cuts, graph cuts and energy-based methods; Dense motion estimation using optical flow; Stereo correspondence; 3-D reconstruction.	**8**
4.	Feature extraction, representation and description of objects in images: Chain codes, polygonal approximations, boundary segments, skeletons, statistical moments, texture, Fourier descriptors, pattern spectrum.	**6**

5.	Object recognition – decision theoretic, structural and neural network methods; Bayes' classifier, linear discriminant functions, supervised and unsupervised learning, clustering; Multi-layer perceptron, self-organizing feature map and deep learning; Applications of object recognition in object detection, context and scene understanding, biometric applications.	**10**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Books / Authors**	**Year of Publication**
1.	R.C. Gonzalez and R.E. Woods, "Digital image Processing", 3rd Edn., Prentice-Hall.	2008
2.	A.K. Jain, "Fundamentals of Digital Image Processing", Pearson Education, India.	2015
3.	R. Szeliski, "Computer Vision: Algorithms and Applications", Springer.	2010
4.	R.O. Duda, P.E. Hartand D.G. Stork, "Pattern Classification", 2rd Edn., Wiley India.	2009
5.	B. Chandaand D. Dutta Majumder, "Digital Image Processing and Analysis", Prentice-Hall.	2007