SEMESTER-I
CORE SUBJECTS

08 EC 6211	**MATHEMATICS FOR COMMUNICATION ENGINEERING** *Hours/Week: Lecture – 3 hours*	**Credits – 3**

Course Objectives:

This course is intended to provide the necessary Mathematical foundation needed for the subjects to be dealt with in the program. After the completion of the course, the student should have a thorough understanding of Linear Algebra , Random Processes and their applications.

Course Outcomes:

Upon completion of the course, the student will be able to

- *Apply algebraic equations and method of solving them.*
- *Apply special functions and processes, and solve problems associated with Engineering applications*

Module I (7 hours)

Linear Algebra: Vector spaces, subspaces, Linear dependence, Basis and Dimension, Inner product spaces, Gram- Schmidt Orthogonalization Procedure

Module II (7 hours)

Linear transformations, Kernels and Images , Matrix representation of linear transformation, Change of basis, Eigen values and Eigen vectors of linear operator, Quadratic form.

Module III (12 hours)

Operations on random variables: Random Variables, Distributions and Density functions, Moments and Moment generating function, Multivariate distributions, Independent Random Variables, Marginal and Conditional distributions , Conditional Expectation, Transformation of Random Variables ,

Module IV (9 hours)

Elements of stochastic processes, Classification of general stochastic processes.

Random Processes: Markov Chains- Definition, Examples, Transition Probability Matrices of a Markov Chain, Classification of states and chains, Basic limit theorem, Limiting distribution of Markov chains.

Module V (6 hours)

Continuous Time Markov Chains: General pure Birth processes and Poisson processes, Birth and death processes, Finite state continuous time Markov chains

Module VI (13 hours)

Second Order Processes: Second Order Stochastic Processes, Linear operations and second order calculus, Stationary processes, Wide sense Stationary processes, Spectral density function, Low pass and band pass processes, White noise and white noise integrals, Linear Predictions and Filtering.

References:

1. Kenneth Hoffman and Ray Kunze, Linear Algebra, 2nd Edition, PHI.
2. Erwin Kreyszig, Introductory Functional Analysis with Applications, John Wiley & Sons.
3. Irwin Miller and Marylees Miller, John E. Freund's Mathematical Statistics, 6th Edition, PHI.
4. S. Karlin & H.M Taylor, A First Course in Stochastic Processes, 2nd edition, Academic Press, New York.
5. S. M. Ross, Introduction to Probability Models, Harcourt Asia Pvt. Ltd. and Academic Press.
6. J. Medhi, Stochastic Processes, New Age International, New Delhi.
7. A Papoulis, Probability, Random Variables and Stochastic Processes, 3rd Edition, McGraw Hill.
8. John B Thomas, An Introduction to Applied Probability and Random Processes, John Wiley & Sons.

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

End semester Examination: 60 marks

08 EC 6221	**ADVANCED DIGITAL COMMUNICATION** *Hours/Week: Lecture – 3 hours*	**Credits – 3**

Course Objectives:

This course provides a thorough understanding of the principles of Digital Communication. It addresses the issues related the recent developments in the area of Modern Communication.

Course Outcomes:

Upon completion of the course, the student will be able to

- *Analyze the issues of Digital Communication over Additive Gaussian Noise Channels, over Band limited Channels and Fading Multipath Channels*
- *Analyze the issues of digital communication over fading and band limited channels*

Module I (12 hours)

Random Process: Review of Random Process: Moment generating function, Chernoff bound, Markov's inequality, Chebyshev's inequality, Central limit Theorem, Chi square, Rayleigh and Rician distributions, Correlation, Covariance matrix, Stationary processes, wide sense stationary processes, ergodic process, cross correlation and autocorrelation functions, Gaussian process

Module II (8 hours)

Communication over Additive Gaussian Noise Channels, Characterization of Communication Signals and Systems: Signal space representation-Overview, Signal detection in Gaussian channels.

Optimum receiver in additive white Gaussian noise (AWGN) channels, Cross correlation receiver, Matched filter receiver and error probabilities.

Module III (6 hours)

Optimum Receiver for Signals with random phase in AWGN Channels, Optimum receiver for Binary Signals, Optimum receiver for M-ary Orthogonal signals, Probability of error for envelope detection of M-ary Orthogonal signals.

Module IV (7 hours)

Digital Communication over Fading Channels: Characterization of Fading Multipath Channels: Statistical Models for Fading Channels, Time Varying Channel Impulse response, Narrow band Fading Models, Wideband Fading Models, Channel Correlation Functions, Key Multi path parameters, Rayleigh and Rician Fading Channels.

Module V (7 hours)

Optimum non-coherent receiver in random amplitude, random phase channels: Performance of non-coherent receiver in random amplitude, random phase channels, Performance in Rayleigh and Rician channels, Performance of digital Modulation schemes such as BPSK, QPSK, FSK, DPSK etc over wireless Channels.

Module VI (14 hours)

Communication over band limited Channels: Optimum pulse shaping and equalization. Receiver synchronization: Frequency and phase synchronization-symbol synchronization.

References:

1. J.G. Proakis, "Digital Communication", 4TH edition, MGH.
2. Edward. A. Lee and David. G. Messerschmitt, "Digital Communication", Allied Publishers (second edition).
3. J Marvin.K.Simon, Sami. M. Hinedi and William. C. Lindsey, "Digital Communication Techniques", PHI.
4. William Feller, "An introduction to Probability Theory and its applications", Wiley.
5. Sheldon.M.Ross, "Introduction to Probability Models", Academic Press, 7th edition.

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

End semester Examination: 60 marks

08 EC 6231	**ADVANCED DIGITAL SIGNAL PROCESSING** *Hours/Week: Lecture – 3 hours*	**Credits – 3**

Course Objectives:

This is an extension of the principles of Digital Signal Processing, introduced in the undergraduate level. Upon completion of the course, the student must be able to design and implement various systems like filter banks, implement different means of spectral estimation and apply Digital Signal Processing principles to process speech and Radar signals.

Course Outcomes:

Upon completion of the course, the student will be able to

- *Design digital filters and familiar with spectral estimation*
- *Get exposure to multirate signal processing.*
- *Apply DSP to speech and radar signal processing.*

Module I (9 hours)

Review of fundamentals of the Discrete Time Systems: Design of FIR Digital filters- Window method, Park-McClellan's method. Effect of finite register length in FIR filter design.

Module II (9 hours)

Design of IIR Digital Filters- Butterworth, Chebyshev and Elliptic Approximations; Lowpass, Bandpass, Bandstop and High pass filters

Module III (9 hours)

Multirate system fundamentals: Basic multirate operations – up-sampling and down sampling, Time domain and frequency domain analysis– Identities of multirate operations– Interpolator and decimator design– Rate conversion– Polyphase representation. Multirate filter banks.

Module IV (9 hours)

Parametric and non-parametric spectral estimation: Estimation of the Autocorrelation and power spectrum of random signals: periodogram- DFT in power spectrum estimation

Module V (9 hours)

Non-parametric spectral estimation: Barlett method, Welch method, Blackman and Tukey Method-Performance characteristics-Computational requirements.

Parametric spectral estimation: Yule-Walker method for AR model parameters, Burg method, Selection of AR model order- MA and ARMA models.

Module VI (9 hours)

Application of DSP to Speech and Radar signal processing : Fourier analysis of non-stationary signals-speech and radar signals. Fourier analysis of stationary signals using Periodogram.

References:

1. A.V. Oppenheim and Schafer, Discrete Time Signal Processing, Prentice Hall.
2. John G. Proakis and D.G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, Prentice Hall.
3. L.R. Rabiner and B. Gold, Theory and Application of Digital Signal Processing, Prentice Hall.
4. J.R. Johnson, Introduction to Digital Signal Processing, Prentice Hall.
5. D. J.DeFatta, J. G. Lucas and W. S. Hodgkiss, Digital Signal Processing, J Wiley and Sons, Singapore.

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

End semester Examination: 60 marks

08 EC 6241	DESIGN OF DIGITAL SIGNAL PROCESSING SYSTEMS *Hours/Week: Lecture – 3 hours*	Credits – 3

Course Objectives:

Upon completion of this course, the student will be able to design systems using the popular Digital Signal Processor Family TMS 320 C64X.

Course Outcomes:

Upon completion of the course, the student will be able to

- *Implement real time digital filters.*
- *Apply DSP to various systems.*

Module I (14 Hours)

Introduction to a popular DSP from Texas Instruments, CPU Architecture, CPU Data Paths and Control, Timers, Interrupts, Internal Data/ Program Memory, External Memory Interface, pipelining

Module II (7 Hours)

Programming : Instruction Set and Addressing Modes ,TMS 320C64X CPU Simple programming examples using C and assembly.

Module III (7 Hours)

Typical DSP development system, support tools and files , compiler, assembler, Code composer studio, CODECs

Module IV (7 Hours)

Digital Signal Processing Applications: Filter Design , FIR & IIR Digital Filter Design, filter Design programs using MATLAB , Fourier Transform: DFT, FFT programs using MATLAB

Module V (6 Hours)

Real Time Implementation: Implementation of Real Time Digital filters using DSP ,Implementation of FFT applications using DSP , DTMF Tone Generation and Detection

Module VI (13 Hours)

DSP Application examples in CODEC : PLL ,Image processing, FSK modems, Voice detection and reverse playback, Multirate filters, PID controllers.

Current Trends in Digital Signal Processors , DSP Controllers

References:

1. Digital Signal Processing and Application with C6713 and C6416 DSK, Rulph Chassaing, Worcester Polytechnic Institute, A Wiley-Interscience Publication
2. Digital Signal Processing Implementation using the TMS320C6000 DSP Platform, 1st Edition; Naim Dahnoun
3. Digital Signal Processing - A Student Guide,1st Edition; T.J. Terrel and Lik-Kwan Shark; Macmillan Press Ltd.
4. Digital Signal Processing: A System Design Approach, 1st Edition; David J Defatta J, Lucas Joseph G & Hodkiss William S ; John Wiley
5. Digital Signal Processing-A Practical Guide for Engineers and Scientists by Steven K Smith, Newnes, An imprint of Elsevier Science

6. DSP Applications using 'C' and the TMS320C6X DSK, 1st Edition; Rulph Chassaing
7 . Digital Signal Processing Design, 1st Edition, Andrew Bateman, Warren Yates

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

End semester Examination: 60 marks

ELECTIVE I

08 EC 6251 (A)	**INFORMATION THEORY** *Hours/Week: Lecture – 3 hours*	**Credits – 3**

Course Objectives:

Gives detailed concepts in Information Theory. Upon completion of this course, the student will have a deep understanding of

- *Information and its measurement*
- *Various source coding schemes*
- *Concept of Channel capacity for both discrete and continuous channels and Shannon's theorems*
- *Rate distortion theory and its applications*

Course Outcomes:

Upon completion of the course, the student will be able to

- *Analyze the importance of entropy calculation.*
- *Design channels with different channel capacity.*
- *Analyze the rate distortion properties.*

Module I (13 hours)

Information and Sources: Zero Memory sources- Concepts of entropy-Extension of a Zero memory source-Markov information sources- Entropy calculation- Entropy of a discrete Random variable- Joint, conditional and relative entropy- Mutual Information and conditional mutual information.

Module II (7 hours)

Source Coding: Uniquely decodable codes- Instantaneous codes- Kraft's inequality – McMillan's inequality-Average length of a code- Optimal codes- Shannon codes- Fano codes-

Module III (6 hours)

Huffman Coding –Optimality of Huffman Codes-Lempel Ziv codes- Shannon's source coding theorem–Arithmetic coding.

Module IV (14 hours)

Channel Capacity**:** Properties-Data transmission over Discrete Memoryless Channels-Capacity of Binary symmetric and Binary Erasure channels-Computing channel capacity- Arimoto-Blahut algorithm- Fano's inequality- Shannon's Channel Coding Theorem

Module V (7 hours)

Continuous Sources and Channels: Information measure for Continuous sources and channels-Differential Entropy- Joint, relative and conditional differential entropy- Mutual information

Module VI (7 hours)

Waveform channels- Gaussian channels- Mutual information and Capacity calculation for

Band limited Gaussian channels- Shannon limit.

Rate Distortion Theory: Rate Distortion Function - Properties – Calculation of Rate Distortion Function for binary source Gaussian

References:

- T. Cover and Thomas, "Elements of Information Theory", John Wiley & Sons
- Robert Gallager, "Information Theory and Reliable Communication", John Wiley & Sons.
- R. J. McEliece, "The theory of information & coding", Addison Wesley Publishing Co.
- T. Bergu, "Rate Distortion Theory a Mathematical Basis for Data Compression" PH Inc.
- Special Issue on Rate Distortion Theory, IEEE Signal Processing Magazine, November 1998.

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

End semester Examination: 60 marks

08 EC 6251 (B)	**ADAPTIVE SIGNAL PROCESSING** *Hours/Week: Lecture – 3 hours*	**Credits – 3**

Course Objectives:

This course is intended to impart to the students the principles of

- *Adaptive signal processing,*
- *different algorithms used for design of Adaptive Filters,*
- *Performance evaluation of systems*
- *Modelling systems like multipath communication channel*
- *Synthesis of filters.*

Course Outcomes:

Upon completion of the course, the student will be able to

- *Analyze the convergence issues, computational complexities and optimality of different filters*
- *develop adaptive systems for various applications*

Module I (8 Hours):

Adaptive systems - definitions and characteristics - applications - properties- examples - adaptive linear combiner-input signal and weight vectors - performance function-gradient and minimum mean square error

Module II (6 Hours):

Introduction to filtering- smoothing and prediction - linear optimum filtering-orthogonality - Wiener - Hopf equation-performance surface

Module III (14 Hours):

Searching performance surface-stability and rate of convergence - learning curve-gradient search - Newton's method - method of steepest descent - comparison - gradient estimation - performance penalty - variance - excess MSE and time constants - maladjustments

Module IV (13 Hours):

LMS algorithm convergence of weight vector-LMS/Newton algorithm - properties - sequential regression algorithm - adaptive recursive filters - random-search algorithms - lattice structure - adaptive filters with orthogonal signals

Module V (7 Hours):

Applications-adaptive modelling and system identification-adaptive modelling for multipath communication channel, geophysical exploration, FIR digital filter synthesis

Module VI (6 Hours):

Inverse adaptive modelling, equalization, and deconvolution-adaptive equalization of telephone channels-adapting poles and zeros for IIR digital filter synthesis

References:

1. Bernard Widrow and Samuel D. Stearns, Adaptive Signal Processing, Pearson Education, 2005.
2. Simon Haykin, Adaptive Filter Theory, Pearson Education.
3. John R. Treichler, C. Richard Johnson, Michael G. Larimore, Theory and Design of Adaptive Filters, Prentice-Hall of India, 2002
4. S. Thomas Alexander, Adaptive Signal Processing - Theory and Application,

Springer-Verlag.
5. D. G. Manolokis, V. K. Ingle and S. M. Kogar, Statistical and Adaptive Signal Processing, Mc Graw Hill International Edition, 2000.

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

End semester Examination: 60 marks

08 EC 6251 (C)	**VLSI CIRCUITS FOR SIGNAL PROCESSING** *Hours/Week: Lecture – 3 hours*	**Credits – 3**

Course Objectives:

Provides a detailed theory of the VLSI implementation of circuits used in Signal processing. Upon completion of the course, the student will have a thorough understanding of

- *Modelling a MOS transistor at low and high frequencies*
- *Analysis and design of CMOS amplifiers, Opamps and switches*
- *Theory, application and implementation of switched capacitor circuits.*

Course Outcomes:

Upon completion of the course, the student will be able to

- *Design and analyze different configurations of CMOS Amplifier*
- *Design CMOS differential amplifier and CMOS Op-Amp.*
- *Design the Switched capacitor circuits.*

Module I (12 Hours)

Analog, Digital and Sampled analog signals and systems, Transformation methods, Design of Sampled data filters from Continuous time models. The MOS transistor, small signal equivalent, short channel effects, Low frequency and High frequency models.

Module II (7 Hours)

Analog CMOS sub circuits: MOS switch, Current sinks and sources, Current mirrors, Current and Voltage references, Bandgap references,

Module III (7Hours)

CMOS Amplifiers: Inverters, Differential amplifiers, Cascode amplifiers, Current amplifiers, Output amplifiers, High gain amplifier architectures.

Module IV (14 Hours)

CMOS Operational Amplifiers: Design of CMOS Op Amps, Stability and Compensation of Op Amps, Design of two stage Op Amps, Cascode Op Amps, High performance CMOS Op Amps.

Module V (7 Hours)

Switched Capacitor Circuits: Switched Capacitor Filters, Integrated Filters, Switched Capacitor Integrators, Stray insensitive integrators, Second order sections; cascade filter design

Module VI (7 Hours)

Switched capacitor filter design, Switched Capacitor Amplifiers and Integrators. Application of Switched Capacitor circuits in Data modems/ Digital voice transmission systems.

References :

1. Analog MOS Integrated Circuits for Signal Processing; Roubik Gregorian, Gabor C. Temes , John Wiley and Sons.
2. CMOS Analog Circuit Design; Phillip E. Allen, Douglas R. Holberg; Oxford Univesity Press

3. Analysis and Design of Analog Integrated Circuits; Gray, Hurst, Lewisand Meyer; Wiley, India.
4. Design of Analog CMOS Integrated Circuits; Behzad Razavi; Tata Mc Graw hill.

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

End semester Examination: 60 marks

08 EC 6251 (D)	**DIGITAL IMAGE PROCESSING** *Hours/Week: Lecture – 3 hours*	**Credits – 3**

Course Objectives:

Upon completion of this course, the student will have an understanding of various Monochrome and Colour Image processing methods, Image enhancement, Image segmentation, and image compression methods. The students are exposed to popular image compression standards like JPEG and JPEG 2000.

Course Outcomes:

Upon completion of the course, the student will be able to

- *Analyze various techniques for image representation*
- *Analyze the image enhancement techniques.*
- *Analyze the colour image processing and image compression*

Module I (10 Hours)

Fundamental steps in digital image processing, Components of an image processing system, Image sampling and quantization, Some basic relationships between pixels, Linear and nonlinear operations, 2D convolution- 2D FFT, 2D-wavelet, contourlet transforms.

Module II (9Hours)

Image enhancement techniques : Some basic gray level transformations, Histogram processing, Smoothing and Sharpening spatial filters, Image enhancement in frequency domain- Smoothing, and Sharpening frequency domain filters,

Module III (8 Hours)

Homomorphic filtering, Image restoration: Noise models, Restoration in the presence of noise only-spatial filtering, Estimating the degradation functions, Inverse filtering.

Module IV (9 Hours)

Colour image processing: colour models, pseudo-colour processing, image compression: image compression models, loss-less and lossy compression, JPEG and JPEG 2000

Module V (8 Hours)

Morphological image processing: dilation and erosion, opening and closing, some basic morphological algorithms.

Module VI (10 Hours)

Image segmentation: Detection of discontinuities, Edge linking and boundary detection, Thresholding, Region based segmentation, applications of digital image processing in medical, recent developments, Image fusion, pseudo colouring.

References:

1. R. C. Gonzalez and R.E. Woods - Digital Image Processing, Pearson

Education, 2006
2. K. Jain - Fundamentals of Digital Image Processing, Pearson Education, 2007
3. L. R. Rabiner and B. Gold – Theory and Application of Digital Signal Processing, Pearson Education

Internal continuous assessment: 40 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

End semester Examination: 60 marks

08 EC 6271 (P)	**SEMINAR** *Hours/Week: 2 hours*	**Credits – 2**

Course Objectives :

This course is intended for

- *Increasing the breadth of knowledge*
- *Enhancing the ability of self study*
- *Improving presentation and communication skills*
- *Augmenting the skill of Technical Report Writing.*

Students have to register for the seminar and select a topic of their interest from Communication / Signal Processing or related topics from outside the syllabus in consultation with any faculty member offering courses for the programme. A detailed write-up on the topic of the seminar is to be prepared in the prescribed format given by the Department. The seminar shall be of 30 minutes duration and a committee with the Head of the department as the chairman and two faculty members from the department as members shall evaluate the seminar based on the coverage of the topic, presentation and ability to answer the questions put forward by the committee.

Internal continuous assessment: 100 marks

08 EC 6281 (P)	**SIGNAL PROCESSING LAB** *Hours/Week: Practical 2 hours*	**Credits – 2**

Course Objectives:

This course enables the students to explore the concepts of designing and implementing various systems using DSP kits, Simulate and study various systems using MATLAB.

Course Outcomes:

Upon completion of the course, the student will be able to

- *Design and implement various filters and systems*
- *Simulate various systems using MATLAB*

Tools:

Numerical Computing Environments – GNU Octave or MATLAB or any other equivalent tool, DSP Kits.

List of Experiments:

1. Generation of waveforms and observation of the output using the graphical display utility of integrated Development Environment (IDE)
2. Generation of a sine function and sampling of generated sine waveform. Observation of the spectrum and windowing effect.
3. Implementation of linear convolution on 1D and 2D signals .
4. Implementation of circular convolution on 1D and 2D signal
5. Implementation of FIR filter(Filter coefficients may be obtained from MATLAB)
6. Implementation of FIR filter(Filter coefficients may be obtained from MATLAB)
7. Verification of FIR and IIR filters by inputting a signal from the signal generator (configure the codec in the DSP development board)
8. Implementation of simple algorithms in audio and image processing
9. Real time data exchange between MATLAB and IDE to transfer the data from computer to Development kit.
10. Assembly language programming
    i) Implementation of linear convolution
    ii) Implementation of circular convolution

Internal continuous assessment: 100 marks

Practical Records/Outputs: 40%

Regular Class Viva Voce: 20%

Final Test: 40%

08 GN 6001	**RESEARCH METHODOLOGY** *Hours/Week: Tutorial – 2 hours*	**Credits – 2**

Course Objectives

The main objective of the course is to provide a familiarization with research methodology and to induct the student into the overall research process and methodologies. This course addresses:
The scientific research process and the various steps involved formulation of research problem and research design, design of experiments, thesis preparation and presentation, research proposals, publications and ethics; Important research methods in engineering.
As a tutorial type course, this course is expected to be more learner centric and active involvement from the learners are expected which encourages self-study and group discussions. The faculty mainly performs a facilitator's role.

Syllabus:

Overview of research methodology - research process - scientific methods - research problem and design - research design process - formulation of research task, literature review and web as a source - problem solving approaches - experimental research - ex post facto research. Thesis writing - reporting and presentation - interpretation and report writing - principles of thesis writing- format of reporting, oral presentation - seminars and conferences Research proposals - research paper writing - publications and ethics - considerations in publishing, citation, plagiarism and intellectual property rights. Research methods – modelling and simulation - mathematical modeling – graphs - heuristic optimization – simulation modeling - measurement design – validity – reliability – scaling - sample design – data collection methods and data analysis

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Course Outcome:

At the end of course, the student will be able to:
Discuss research methodology concepts, research problems, research designs, thesis preparations, publications and research methods.
Analyze and evaluate research works and to formulate a research problem to pursue research
Prepare a thesis or a technical paper, and present or publish them
Apply the various research methods followed in engineering research for formulation and design of own research problems and to utilize them in their research project.

Reference Books:

1. C. R. Kothari, (2004) "*Research Methodology, Methods and Techniques"*, New Age International Publishers
2. R. Panneerselvam,(2014) *"Research Methodology"*, PHI Learning
3. K. N. Krishnaswamy, Appa Iyer Sivakumar, M. Mathirajan, (2006)) "*Management*

Research Methodology, Integration of principles", Methods and Techniques, Pearson Education
4. Deepak Chawla, Meena Sondhi,(2011) "*Research Methodology – concepts & cases"*, Vikas Publishing House
5. J.W. Bames, *"Statistical Analysis for Engineers and Scientists"*, McGraw Hill, New York
6. Schank Fr.,(2008) "*Theories of Engineering Experiments"*, Tata Mc Graw Hill Publication.
7. John W Best, James V Kahan, (2010) "*Research in Education"*, PHI Learning
8. Sinha, S. C. and Dhiman, A. K. (2002), "*Research Methodology"*, ESS Publications. (2 volumes)

COURSE PLAN

MODULE: 1

Overview of Research Methodology: Research concepts – meaning – objectives – motivation - types of research –research process – criteria for good research – problems encountered by Indian researchers - scientific method - research design process

MODULE: 2

Research Problem and Design: Formulation of research task – literature review – methods – primary and secondary sources – web as a source – browsing tools - formulation of research problems – exploration - hypothesis generation - problem solving approaches –Concepts of introduction To TRIZ-experimental research – principles – Laboratory experiment - experimental designs - ex post facto research-qualitative research

MODULE: 3

Thesis writing, reporting and presentation: significance of report writing–– principles of thesis writing- different steps in report writing Interpretation in writing – techniques of interpretation – precautions in interpretation - format of reporting - – layout and mechanics of research report -references – tables – figures – conclusions – oral presentation – preparation – making presentation – use of visual aids - effective communication - preparation for and presentation in seminars and conferences

MODULE: 4

Research proposals, publications, ethics and IPR: Research proposals - development and evaluation –research paper writing – layout of a research paper - journals in engineering – considerations in publishing –concept of impact factor– citations - open access publication - ethical issues -plagiarism – software for plagiarism checking intellectual property right- patenting case studies .

MODULE: 5

Research methods – Modelling and Simulation: Modelling and Simulation – concepts of modelling –mathematical modelling - composite modelling –modelling with – ordinary differential equations – partial differential equations – graphs-heuristics and heuristic optimization - simulation modeling

MODULE: 6

Research Methods – Measurement, sampling and Data acquisition: Measurement design – errors -validity and reliability in measurement - scaling and scale construction - sample design - sample size determination - sampling errors -data collection procedures - sources of data – data collection methods - data preparation and data analysis

Internal continuous assessment: 100 marks