| COURSE CODE | COURSE NAME | L-T-P-C | YEAR OF INTRODUCTION |
|---|---|---|---|
| EC401 | INFORMATION THEORY & CODING | 4-0-0-4 | 2016 |

**Prerequisite:** EC302 Digital Communication

**Course objectives:**

- To introduce the concept of information
- To understand the limits of error free representation of information signals and the transmission of such signals over a noisy channel
- To design and analyze data compression techniques with varying efficiencies as per requirements
- To understand the concept of various theorems proposed by Shannon for efficient data compression and reliable transmission
- To give idea on different coding techniques for reliable data transmission
- To design an optimum decoder for various coding schemes used.

**Syllabus:** Concept of amount of information, Entropy, Source coding, Channel Capacity, Shannon's Limit, Rate Distortion Theory, Channel Coding, Linear Block Codes, Cyclic codes, Cryptography, Convolutional Codes, Viterbi Algorithm

**Expected outcome:**

The students will be able to

- **i.** Apply the knowledge of Shannon's source coding theorem and Channel coding theorem for designing an efficient and error free communication link.
- **ii.** Analyze various coding schemes
- **iii.** Design an optimum decoder for various coding schemes used.

**Text Books:**

1. P S Sathya Narayana, Concepts of Information Theory & Coding, Dynaram Publications, 2005
2. Simon Haykin: Digital Communication Systems, Wiley India, 2013.

**References:**


1. Bose, Information theory coding and cryptography, 3/e McGraw Hill Education India , 2016
2. D.E.R. Denning, Cryptography and Data Security, Addison Wesley, 1983.
3. J S Chitode, Information Theory and Coding, Technical Publications, Pune, 2009
4. Kelbert & Suhov, Information theory and coding by examples, Cambridge University Press, 2013
5. Shu Lin & Daniel J. Costello. Jr., Error Control Coding : Fundamentals and Applications, 2/e, Prentice Hall Inc., Englewood Cliffs, NJ,2004


**Course Plan**

| Module | Course contents | Hours | End Sem. Exam Marks |
|---|---|---|---|
| I | Introduction to Information Theory. Concept of information, units, entropy, marginal, conditional and joint entropies, relation among entropies, mutual information, information rate.<br>Source coding: Instantaneous codes, construction of instantaneous codes, Kraft's inequality, coding efficiency and redundancy | 9 | **15%** |
| II | Noiseless coding theorem , construction of basic source codes, Shannon – Fano Algorithm, Huffman coding,<br>Channel capacity – redundancy and efficiency of a channel, binary | 9 | **15%** |

| | | | |
|---|---|---|---|
| | symmetric channel (BSC), Binary erasure channel (BEC) – capacity of band limited Gaussian channels | | |
| **FIRST INTERNAL EXAM** | | | |
| **III** | Continuous Sources and Channels: Differential Entropy, Mutual information,<br>Waveform channels, Gaussian channels, Shannon – Hartley theorem, bandwidth, SNR trade off, capacity of a channel of infinite bandwidth, Shannon's limit | 9 | **15%** |
| **IV** | Introduction to rings, fields, and Galois fields. Codes for error detection and correction – parity check coding – linear block codes – error detecting and correcting capabilities – generator and parity check matrices – Standard array and syndrome decoding | 9 | **15%** |
| **SECOND INTERNAL EXAM** | | | |
| **V** | Perfect codes, Hamming codes, encoding and decoding<br>Cyclic codes, polynomial and matrix descriptions, generation of cyclic codes, decoding of cyclic codes<br>BCH codes, Construction and decoding, Reed Solomon codes | 9 | **20%** |
| VI | Convolutional Codes – encoding – time and frequency domain approaches, State Tree & Trellis diagrams – transfer function and minimum free distance – Maximum likelihood decoding of convolutional codes – The Viterbi Algorithm. Sequential decoding. | 9 | **20%** |
| **END SEMESTER EXAM** | | | |

**Question Paper**

The question paper shall consist of three parts. Part A covers modules I and II, Part B covers modules III and IV, and Part C covers modules V and VI. Each part has three questions uniformly covering the two modules and each question can have maximum four subdivisions. In each part, any two questions are to be answered. Mark patterns are as per the syllabus with 50% for theory and 50% for logical/numerical problems, derivation and proof.

| COURSE CODE | COURSE NAME | L-T-P-C | YEAR OF INTRODUCTION |
|---|---|---|---|
| EC403 | MICROWAVE & RADAR ENGINEERING | 3-0-0-3 | 2016 |

**Prerequisite:** EC303 Applied Electromagnetic Theory, EC306 Antenna & Wave Propagation

**Course objectives:**

- To introduce the various microwave sources, their principle of operation and measurement of various parameters
- To study the various microwave hybrid circuits and formulate their S matrices.
- To understand the basic concepts, types, working of radar and introduce to radar transmitters and receivers.

**Syllabus:**

Microwaves: introduction, advantages, Cavity Resonators, Microwave vacuum type amplifiers and sources, Klystron Amplifiers, Reflex Klystron Oscillators, Magnetron oscillators, Travelling Wave Tube, Microwave measurements, Microwave hybrid circuits, Directional couplers, Solid state microwave devices, Gunn diodes, Radar, MTI Radar, Radar Transmitters, Radar receivers.

**Expected outcome:**

The students will be able to understand the basics of microwave engineering and radar systems.

**Text Books:**

1. Merrill I. Skolnik, Introduction to Radar Systems, 3/e, Tata McGraw Hill, 2008.
2. Samuel Y. Liao, Microwave Devices and Circuits, 3/e, Pearson Education, 2003.

**References:**

1. Das, Microwave Engineering, 3/e, McGraw Hill Education India Education , 2014
2. David M. Pozar, Microwave Engineering,4/e, Wiley India, 2012.
3. Kulkarni M, Microwave and Radar Engineering, 4/e, Umesh Publications, 2012.
4. Rao, Microwave Engineering, 2/e, PHI, 2012.
5. Robert E. Collin, Foundation of Microwave Engineering, 2/e, Wiley India, 2012.

**Course Plan**

| Module | Course contents | Hours | End Sem. Exam Marks |
|---|---|---|---|
| I | **Microwaves:** introduction, advantages, Cavity Resonators - Rectangular and Circular wave guide resonators- Derivation of resonance frequency of Rectangular cavity. | 4 | 15% |
| | **Microwave vacuum type amplifiers and sources:** Klystron Amplifiers - Re-entrant cavities, Velocity modulation, Bunching (including analysis), Output power and beam | 4 | |
| II | **Reflex Klystron Oscillators**: Derivation of Power output, efficiency and admittance | 2 | 15% |
| | **Magnetron oscillators**: Cylindrical magnetron, Cyclotron angular frequency, Power output and efficiency. | 3 | |
| **FIRST INTERNAL EXAM** | | | |
| III | **Travelling Wave Tube**: Slow wave structures, Helix TWT, Amplification process, Derivation of convection current, axial electric field, wave modes and gain. | 4 | 15% |
| | **Microwave measurements:** Measurement of impedance, frequency and power | 2 | |

| | | | |
|---|---|---|---|
| **IV** | **Microwave hybrid circuits**: Scattering parameters, Waveguide tees- Magic tees, Hybrid rings, Corners, Bends, and Twists. Formulation of S-matrix. | 5 | **15%** |
| | **Directional couplers**: Two hole directional couplers, S-matrix of a directional coupler. Circulators and isolators. | 4 | |
| **SECOND INTERNAL EXAM** | | | |
| **V** | **Solid state microwave devices**: Microwave bipolar transistors, Physical structures, Power frequency limitations equivalent circuit. Principle of **Tunnel diodes** and tunnel | 4 | **20%** |
| | **Gunn diodes**: Different modes, Principle of operation Gunn Diode Oscillators. | 2 | |
| VI | **Radar**: The simple Radar equation. Pulse Radar, CW Radar, CW Radar with non zero IF, Equation for doppler frequency FM-CW Radar using sideband super heterodyne receiver. **MTI Radar**-Delay line canceller, MTI Radar with power amplifier & power oscillator, Non coherent MTI Radar, Pulse | 5 | **20%** |
| | **Radar Transmitters**: Radar Modulator-Block diagram, **Radar receivers**- noise figure, low noise front ends, Mixers, Radar Displays | 3 | |
| **END SEMESTER EXAM** | | | |

**Question Paper Pattern**

The question paper shall consist of three parts. Part A covers modules I and II, Part B covers modules III and IV, and Part C covers modules V and VI. Each part has three questions uniformly covering the two modules and each question can have maximum four subdivisions. In each part, any two questions are to be answered. Mark patterns are as per the syllabus with 60% for theory and 40% for logical/numerical problems, derivation and proof.

| COURSE CODE | COURSE NAME | L-T-P-C | YEAR OF INTRODUCTION |
|---|---|---|---|
| **EC405** | **OPTICAL COMMUNICATION** | **3-0-0-3** | **2016** |

**Prerequisite:** EC203 Solid State Devices, EC205 Electronic Circuits

**Course objectives:**

- To introduce the concepts of light transmission through optical fibers, optical sources and detectors.
- To compare the performance of various optical transmission schemes.
- To impart the working of optical components and the principle of operation of optical amplifiers.
- To give idea on WDM technique.

**Syllabus:** General light wave system, advantages, classification of light wave systems, fibre types, linear and non linear effects in fibres, Fibre materials, fabrication of fibres, Optical sources, LEDs and LDs Optical detectors, Optical receivers, Digital transmission systems, Optical Amplifiers, WDM concept, Introduction to free space optics, Optical Time Domain Reflectometer (OTDR).

**Expected outcome:**

The students will be able to:-

i. Know the working of optical source and detectors.
ii. Compare the performance of various optical modulation schemes.
iii. Apply the knowledge of optical amplifiers in the design of optical link.
iv. Analyse the performance of optical amplifiers.
v. Know the concept of WDM
vi. Describe the principle of FSO and LiFi.

**Text Books:**

1. Gerd Keiser, Optical Fiber Communications, 5/e, McGraw Hill, 2013.
2. Mishra and Ugale, Fibre optic Communication, Wiley, 2013.

**References:**


1. Chakrabarthi, Optical Fibre Communication, McGraw Hill, 2015.
2. Hebbar, Optical fibre communication, Elsevier, 2014
3. John M Senior- Optical communications, **3/e**, Pearson, 2009.
4. Joseph C. Palais, Fibre Optic Communications, 5/e Pearson, 2013.
5. Keiser, Optical Communication Essentials (SIE), 1/e McGraw Hill Education New Delhi, 2008.


**Course Plan**

| Module | Course contents | Hours | End Sem. Exam Marks |
|---|---|---|---|
| **I** | General light wave system, advantages, classification of light wave systems. Fibres: types and refractive index profiles, mode theory of fibres: modes in SI and GI fibres, linear and non linear effects in fibres, dispersion,<br>Group Velocity Dispersion, modal, wave guide and Polarization, Modes, Dispersion, attenuation- absorption, bending and scattering losses. | 8 | **15%** |
| **II** | Fibre materials, fabrication of fibres, photonic crystal fibre, index guiding PCF, photonic bandgap fibre, fibre cables.<br>Optical sources, LEDs and LDs, structures, characteristics, | 7 | **15%** |

| | | | |
|---|---|---|---|
| | modulators using LEDs and LDs. coupling with fibres, noise in Laser diodes, Amplified Spontaneous Emission noise, effects of Laser diode noise in fibre communications | | |
| **FIRST INTERNAL EXAM** | | | |
| **III** | Optical detectors, types and characteristics, structure and working of PIN and AP, noise in detectors, comparison of performance.<br>Optical receivers, Ideal photo receiver and quantum limit of detection. | 6 | **15%** |
| **IV** | Digital transmission systems, design of IMDD links- power and rise time budgets, coherent Systems, sensitivity of a coherent receiver, comparison with IMDD systems.<br>Introduction to soliton transmission, soliton links using optical amplifiers, GH effect, soliton-soliton interaction, amplifier gain fluctuations, and design guide lines of soliton based links. | 8 | **15%** |
| **SECOND INTERNAL EXAM** | | | |
| **V** | Optical Amplifiers ,basic concept, applications, types, doped fibre amplifiers, EDFA, basic theory, structure and working, Semiconductor laser amplifier, Raman amplifiers, TDFA, amplifier configurations, performance comparison. | 6 | **20%** |
| VI | The WDM concept, WDM standards, WDM components, couplers, splitters, Add/ Drop multiplexers, gratings, tunable filters, system performance parameters.<br>Introduction to optical networks. Introduction to free space optics, LiFi technology and VLC. Optical Time Domain Reflectometer (OTDR) – fault detection, length and refractive index measurements. | 7 | **20%** |
| **END SEMESTER EXAM** | | | |

**Question Paper Pattern**

The question paper shall consist of three parts. Part A covers modules I and II, Part B covers modules III and IV, and Part C covers modules V and VI. Each part has three questions uniformly covering the two modules and each question can have maximum four subdivisions. In each part, any two questions are to be answered. Mark patterns are as per the syllabus with 50% for theory and 50% for logical/numerical problems, derivation and proof.

| COURSE CODE | COURSE NAME | L-T-P-C | YEAR OF INTRODUCTION |
|---|---|---|---|
| **EC409** | **CONTROL SYSTEMS** | **3-0-0-3** | **2016** |

**Prerequisite:** EC202 Signals & Systems

**Course objectives:**

- To introduce the elements of control system and its modelling
- To introduce methods for analyzing the time response, the frequency response and the stability of systems.
- To design control systems with compensating techniques.
- To introduce the state variable analysis method.
- To introduce basic concepts of digital control systems.

**Syllabus:**

Control system, types and application, feedback system, mathematically modelling of control systems, block diagram representation, signal flow graph, Mason's formula, test signals, time response analysis, frequency analysis, stability concepts and analysis, state variable analysis, Observability and controllability, digital control systems , state space analysis, Jury's test

**Expected outcome:**

The Students will be able to

i. Represent mathematically a systems and deriving their transfer function model.
ii. Analyse the time response and frequency response of the systems for any input
iii. Find the stability of system
iv. Design a control system with suitable compensation techniques
v. Analyse a digital control system.

**Text Books**

1. Farid Golnaraghi, Benjamin C. Kuo, Automatic Control Systems, 9/e, Wiley India.
2. Gopal, Control Systems, 4/e, McGraw Hill Education India Education , 2012.
3. Ogata K., Discrete-time Control Systems, 2/e, Pearson Education.

**References**


1. Gopal, Digital Control and State Variable Method, 4/e, McGraw Hill Education India 2012.
2. Norman S. Nise, Control System Engineering, 5/e, Wiley India
3. Ogata K., Modern Control Engineering, Prentice Hall of India, 4/e, Pearson Education, 2002.
4. Richard C Dorf and Robert H. Bishop, Modern Control Systems, 9/e, Pearson Education, 2001.


**Course Plan**

| Module | Course contents | Hours | End Sem Exam Marks |
|---|---|---|---|
| I | Basic Components of a Control System, Applications, Open-Loop Control Systems and Closed-Loop Control Systems, Examples of control system | 1 | 15% |
| | Effects of Feedback on Overall Gain, Stability, External, disturbance or Noise | 1 | |

| | | | |
|---|---|---|---|
| | Types of Feedback Control Systems, Linear versus Nonlinear Control Systems, Time-Invariant versus Time-Varying Systems. | 1 | |
| | Overview of solving differential equations using Laplace transforms | 1 | |
| | Mathematical modelling of control systems - Electrical Systems and Mechanical systems. | 2 | |
| | Block diagram representation and reduction methods | 2 | |
| | Signal flow graph and Mason's rule formula. | 2 | |
| **II** | Standard test signals. Time response specifications. | 1 | 15% |
| | Time response of first and second order systems to unit step input, ramp inputs, time domain specifications | 2 | |
| | Steady state error and static error coefficients. | 1 | |
| | Dynamic error coefficient. | 1 | |
| **FIRST INTERNAL EXAM** | | | |
| **III** | Stability of linear control systems: methods of determining stability, Routh's Hurwitz Criterion. | 2 | 15% |
| | Root Locus Technique: Introduction, properties and its construction. | 2 | |
| | Frequency domain analysis: Frequency domain specifications, correlation between time and frequency responses. | 1 | |
| **IV** | Nyquist stability criterion: fundamentals and analysis | 2 | |
| | Relative stability: gain margin and phase margin. Stability analysis with Bode plot. | 2 | 15% |
| | Design of Control Systems: PI,PD and PID controllers | 2 | |
| | Design with phase-lead and phase-lag controllers (frequency domain approach), Lag-lead | 2 | |
| **SECOND INTERNAL EXAM** | | | |
| **V** | State variable analysis: state equation, state space representation of Continuous Time systems | 2 | 20% |
| | Transfer function from State Variable Representation, Solutions of the state equations, state transition matrix | 2 | |
| | Concepts of Controllability and Observability, Kalman's Test, Gilbert's test | 2 | |
| **VI** | Discrete Control systems fundamentals: Overview of Z transforms. State space representation for Discrete time systems. | 2 | 20% |
| | Sampled Data control systems, Sampling Theorem, Sample & Hold, Open loop & Closed loop sampled data systems. | 2 | |
| | State space analysis : Solving discrete time state space equations, pulse transfer function, Discretization of continuous time state space equations | 3 | |
| | Stability analysis of discrete time systems Jury's test | 1 | |
| **END SEMESTER EXAM** | | | |

**Question Paper Pattern**

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| COURSE CODE | COURSE NAME | L-T-P-C | YEAR OF INTRODUCTION |
|---|---|---|---|
| EC461 | MICROWAVE DEVICES AND CIRCUITS | 3-0-0-3 | 2016 |

**Prerequisite:** EC403 Microwave & Radar Engineering

**Course objectives:**

- To study microwave semiconductor devices & applications.
- To study microwave sources and amplifiers.
- To analyse microwave networks.
- To introduce microwave integrated circuits.

**Syllabus:**

Limitation of conventional solid state devices at Microwave, Gunn – effect diodes, Microwave generation and amplification, IMPATT and TRAPATT diodes, Bipolar transistors, MESFET, Microwave amplifiers and oscillators, Microwave Network Analysis, Signal flow graphs, Microwave filters, Filter design by image parameter method, Filter transformation and implementation, Introduction to MICs, Distributed and lumped elements of integrated circuits, Diode control devices

**Expected outcome:**

The Students will be able to understand with active & passive microwave devices & components used in microwave communication systems and analyse microwave networks.

**Text Books:**

1. David M. Pozar, Microwave Engineering, 4/e, Wiley India, 2012
2. Robert E. Collin, Foundation of Microwave Engineering, 2/e, Wiley India, 2012.
3. Samuel Y. Liao, Microwave Devices and Circuits, 3/e, Pearson Education, 2003.

**References:**

1. Bharathi Bhat and Shiban K. Koul: Stripline-like Transmission Lines for MIC, New Age International (P) Ltd, 1989.
2. I Kneppo, J. Fabian, et al., Microwave Integrated Circuits, BSP, India, 2006.
3. Leo Maloratsky, Passive RF and Microwave Integrated Circuits, Elsevier, 2006.

**Course Plan**

| Module | Course contents | Hours | End Sem. Exam Marks |
|---|---|---|---|
| I | Introduction, Characteristic, features of microwaves, Limitation of conventional solid state devices at Microwave. | 1 | 15% |
| | Gunn – effect diodes – Gunn effect, Ridley – Watkins-Hilsum theory, Modes of operation, Limited space – Charge accumulation (LSA) mode of Gunn diode. | 2 | |
| | Microwave generation and amplification. Structure, Operation, Power output and efficiency of IMPATT and TRAPATT diodes | 2 | |
| II | Bipolar transistors – biasing, FET – biasing, MESFET – Structure, Operation. | 4 | 15% |
| | Microwave amplifiers and oscillators – Amplifiers – Gain and stability, Single stage transistor amplifier design. | 4 | |
| | Oscillator design – One port negative resistance oscillators. | 2 | |
| **FIRST INTERNAL EXAM** | | | |

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|---|---|---|---|
| **III** | Microwave Network Analysis – Equivalent voltages and currents, Impedance and Admittance matrices, Scattering matrix, The transmission matrix. | 3 | **15%** |
| | Signal flow graphs. Impedance matching and tuning – Matching with lumped elements, Single stub tuning, Double stub tuning. Quarter wave transformer, Theory of small reflections. | 4 | |
| **IV** | Microwave filters – Periodic structures – Analysis of infinite periodic structures and terminated periodic structures,<br>Filter design by image parameter method – Constant k, m-derived and composite. Filter design by insertion loss method. Filter transformation and implementation. | 7 | **15%** |
| **SECOND INTERNAL EXAM** | | | |
| **V** | Introduction to MICSs:-Technology of hybrid MICs, monolithic MICs. Comparison of both MICs. | 4 | **20%** |
| | Planar transmission lines such as stripline, microstrip line, and slotline. | **3** | |
| VI | Distributed and lumped elements of integrated circuits - capacitors, inductors, resistors, terminations, attenuators, resonators and discontinuities. | **5** | **20%** |
| | Diode control devices – switches, attenuators, limiters. Diode phase shifter. Circulators and isolators. | **2** | |
| **END SEMESTER EXAM** | | | |

**Question Paper Pattern**

The question paper shall consist of three parts. Part A covers modules I and II, Part B covers modules III and IV, and Part C covers modules V and VI. Each part has three questions uniformly covering the two modules and each question can have maximum four subdivisions. In each part, any two questions are to be answered. Mark patterns are as per the syllabus with 70% for theory and 30% for logical/numerical problems, derivation and proof.

| COURSE CODE | COURSE NAME | L-T-P-C | YEAR OF INTRODUCTION |
|---|---|---|---|
| EC463 | SPEECH AND AUDIO SIGNAL PROCESSING | 3-0-0-3 | 2016 |

**Prerequisite:** EC301 Digital Signal Processing

**Course objectives:**

- To familiarize the basic mechanism of speech production and the basic concepts of methods for speech analysis and parametric representation of speech.
- To give an overall picture about various applications of speech processing
- To impart ideas of Perception of Sound, Psycho-acoustic analysis, Spatial Audio Perception and rendering.
- To introduce Audio Compression Schemes.

**Syllabus:** Speech production, Time domain analysis, Frequency domain analysis, Cepstral analysis, LPC analysis, Speech coding, Speech recognition, Speech enhancement, Text to speech conversion. Signal Processing Models of Audio Perception, Psycho-acoustic analysis, Spatial Audio Perception and rendering, Audio compression methods, Parametric Coding of Multi-channel audio, Transform coding of digital audio, audio quality analysis.

**Expected outcome:**

The students will be able to

i. Understand basic concepts of speech production, speech analysis, speech coding and parametric representation of speech and apply it in practical applications
ii. Develop systems for various applications of speech processing
iii. Learn Signal processing models of sound perception and application of perception models in audio signal processing.
iv. Implement audio compression algorithms and standards.

**Text Books:**

1. Douglas O'Shaughnessy, Speech Communications: Human & Machine, IEEE Press, Hardcover 2/e, 1999; ISBN: 0780334493.
2. Nelson Morgan and Ben Gold, Speech and Audio Signal Processing: Processing and Perception Speech and Music, July 1999, John Wiley & Sons, ISBN: 0471351547

**References:**

1. Donald G. Childers, Speech Processing and Synthesis Toolboxes, John Wiley & Sons, September 1999; ISBN: 0471349593
2. Rabiner and Juang, Fundamentals of Speech Recognition, Prentice Hall, 1994.
3. Rabiner and Schafer, Digital Processing of Speech Signals, Prentice Hall, 1978.
4. Thomas F. Quatieri, Discrete-Time Speech Signal Processing: Principles and Practice, Prentice Hall; ISBN: 013242942X; 1/e

**Course Plan**

| Module | Course contents | Hours | End Sem. Exam Marks |
|---|---|---|---|
| I | Speech Production: Acoustic theory of speech production. Speech Analysis: Short-Time Speech Analysis, Time domain analysis (Short time energy, short time zero crossing Rate, ACF). Parametric representation of speech: AR Model, ARMA model. LPC Analysis (LPC model, Auto correlation method). | 5 | **15%** |

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|---|---|---|---|
| **II** | Frequency domain analysis (Filter Banks, STFT, Spectrogram), Cepstral Analysis, MFCC.<br>Fundamentals of Speech recognition and Text-to-speech conversion | 8 | **15%** |
| **FIRST INTERNAL EXAM** | | | |
| **III** | Speech coding, speech enhancement, Speaker Verification, Language Identification | 7 | **15%** |
| **IV** | Signal Processing Models of Audio Perception: Basic anatomy of hearing System. Auditory Filter Banks, Psycho-acoustic analysis: Critical Band Structure, Absolute Threshold of Hearing, Simultaneous Masking, Temporal Masking, Quantization Noise Shaping, MPEG psycho-acoustic model. | 6 | **15%** |
| **SECOND INTERNAL EXAM** | | | |
| **V** | Audio compression methods: Sampling rate and bandwidth requirement for digital audio, Redundancy removal and perceptual irrelevancy removal, Transform coding of digital audio: MPEG2-AAC coding standard, MDCT and its properties, Pre-echo and pre-echo suppression, Loss less coding methods. | 7 | **20%** |
| VI | Spatial Audio Perception and rendering: The physical and psycho-acoustical basis of sound localization and space perception. Spatial audio standards.<br>Audio quality analysis: Objective analysis methods- PEAQ, Subjective analysis methods - MOS score, MUSHRA score | 6 | **20%** |
| **END SEMESTER EXAM** | | | |

**Question Paper Pattern**

The question paper shall consist of three parts. Part A covers modules I and II, Part B covers modules III and IV, and Part C covers modules V and VI. Each part has three questions uniformly covering the two modules and each question can have maximum four subdivisions. In each part, any two questions are to be answered. Mark patterns are as per the syllabus with 50% for theory and 50% for logical/numerical problems, derivation and proof.

| COURSE CODE | COURSE NAME | L-T-P-C | YEAR OF INTRODUCTION |
|---|---|---|---|
| EC465 | MEMS | 3-0-0 -3 | 2016 |

**Prerequisite : NIL**

**Course objectives:**

- To understand the operation of major classes of MEMS devices/systems
- To give the fundamentals of standard micro fabrication techniques and processes
- To understand the unique demands, environments and applications of MEMS devices

**Syllabus:**

MEMS and Microsystems applications, Review of Mechanical concepts, Actuation and Sensing techniques, Scaling laws in miniaturization, Materials for MEMS, Micro System fabrication techniques, Micro manufacturing, Micro system Packaging, Bonding techniques for MEMS, Overview of MEMS areas.

**Expected outcome:**

The student will be able to:

i. Understand the working principles of micro sensors and actuators
ii. Understand the application of scaling laws in the design of micro systems
iii. Understand the typical materials used for fabrication of micro systems
iv. Understand the principles of standard micro fabrication techniques
v. Appreciate the challenges in the design and fabrication of Micro systems

**Text Books:**

1. Chang Liu, Foundations of MEMS, Pearson 2012
2. Tai-Ran Hsu, MEMS and Microsystems Design and Manufacture, TMH, 2002

**References:**

1. Chang C Y and Sze S. M., VLSI Technology, McGraw-Hill, New York, 2000
2. Julian W Gardner, Microsensors: Principles and Applications, John Wiley & Sons, 1994
3. Mark Madou, Fundamentals of Micro fabrication, CRC Press, New York, 1997
4. Stephen D. Senturia, Microsystem design, Springer (India), 2006.
5. Thomas B. Jones, Electromechanics and MEMS, Cambridge University Press, 2001

**Course Plan**

| Module | Course content (42hrs) | Hours | End Sem. Exam Marks |
|---|---|---|---|
| I | MEMS and Microsystems: Applications – Multidisciplinary nature of MEMS – principles and examples of Micro sensors and micro actuators – micro accelerometer –comb drives - Micro grippers – micro motors, micro valves, micro pumps, Shape Memory Alloys. | 4 | 15% |
| | Review of Mechanical concepts: Stress, Strain, Modulus of Elasticity, yield strength, ultimate strength – General stress strain relations – compliance matrix. Overview of commonly used mechanical structures in MEMS - Beams, Cantilevers, Plates, Diaphragms – Typical applications | 3 | |

| | | | |
|---|---|---|---|
| **II** | Flexural beams: Types of Beams, longitudinal strain under pure bending – Deflection of beams – Spring constant of cantilever – Intrinsic stresses | 3 | **15%** |
| | Actuation and Sensing techniques : Thermal sensors and actuators, Electrostatic sensors and actuators , Piezoelectric sensors and actuators, magnetic actuators | 4 | |
| **FIRST INTERNAL EXAM** | | | |
| **III** | Scaling laws in miniaturization - scaling in geometry, scaling in rigid body dynamics, Trimmer force scaling vector, scaling in electrostatic and electromagnetic forces, scaling in electricity and fluidic dynamics, scaling in heat conducting and heat convection. | 5 | **15%** |
| **IV** | Materials for MEMS – Silicon – Silicon compounds – Silicon Nitride, Silicon Dioxide, Silicon carbide, Poly Silicon, GaAs , Silicon Piezo resistors, | 4 | |
| | Polymers in MEMS – SU-8, PMMA, PDMS, Langmuir – Blodgett Films, Micro System fabrication – Photolithography – Ion implantation- Diffusion – Oxidation – Chemicalvapour deposition – Etching | 5 | **15%** |
| **SECOND INTERNAL EXAM** | | | |
| **V** | Overview of Micro manufacturing – Bulk micro manufacturing, Surface micro machining , LIGA process –Microstereo lithography | 6 | **20%** |
| | Micro system Packaging: general considerations in packaging design – Levels of Micro system packaging | 3 | |
| **VI** | Bonding techniques for MEMS : Surface bonding , Anodic bonding , Silicon - on - Insulator , wire bonding , Sealing – Assembly of micro systems | 3 | **20%** |
| | Overview of MEMS areas : RF MEMS, BioMEMS, MOEMS, NEMS | 2 | |
| **END SEMESTER EXAM** | | | |

**Question Paper Pattern**

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| COURSE CODE | COURSE NAME | L-T-P-C | YEAR OF INTRODUCTION |
|---|---|---|---|
| **EC469** | **OPTO ELECTRONIC DEVICES** | **3-0-0-3** | **2016** |

**Prerequisite: NIL**

**Course objectives:**

- To know the physics of absorption, recombination and photoemission from semiconductors.
- To analyse different types of photo detectors based on their performance parameters.
- To discuss different LED structures with material properties and reliability aspects.
- To explain optical modulators and optical components
- To illustrate different types of lasers with distinct properties.

**Syllabus:**

Optical processes in semiconductors – LASERS- Nitride light emitters- White-light LEDs- Optical modulators - optical switching and logic devices, optical memory- Optical detection - Optoelectronic ICs - Introduction to optical components

**Expected outcome:**

The students will be able to:

i. Explain the property of absorption, recombination and photoemission in semiconductors.
ii. Illustrate different types of lasers with distinct properties.
iii. Explain different LED structures with material properties.
iv. Analyse different types of photo detectors.
v. Explain optical modulators and optical components.

**Text Books:**

1. Pallab Bhattacharya: Semiconductor Optoelectronic Devices, Pearson, 2009
2. Yariv, Photonics Optical Electronics in modern communication, 6/e ,Oxford Univ Press,2006.

**References:**

1. Alastair Buckley, Organic Light-Emitting Diodes, Woodhead, 2013.
2. B E Saleh and M C Teich, Fundamentals of Photonics:, Wiley-Interscience, 1991
3. Bandyopadhay, Optical communicatoion and networks, PHI, 2014.
4. Mynbaev, Scheiner, Fiberoptic Communication Technology, Pearson, 2001.
5. Piprek, Semiconductor Optoelectronic Devices, Elsevier, 2008.
6. Xun Li, Optoelectronic Devices Design Modelling and Simulation, Cambridge University Press, 2009

**Course Plan**

| Module | Course content (42hrs) | Hours | End Sem. Exam Marks |
|---|---|---|---|
| **I** | Optical processes in semiconductors – electron hole recombination, absorption, Franz-Keldysh effect, Stark effect, quantum confined Stark effect, deep level transitions, Auger recombination heat generation and dissipation, heat sources. | 7 | **15%** |
| **II** | Lasers – threshold condition for lasing, line broadening mechanisms, axial and transverse laser modes, heterojunction lasers, distributed feedback lasers, DBR lasers, quantum well lasers, tunneling based lasers, modulation of lasers. | 7 | **15%** |

| | | | |
|---|---|---|---|
| **FIRST INTERNAL EXAM** | | | |
| **III** | Nitride light emitters, nitride material properties, InGaN/GaN LED, structure and working, performance parameters, InGaN/GaN Laser Diode, structure and working, performance parameters.<br>White-light LEDs, generation of white light with LEDs**,** generation of white light by dichromatic sources, **,**generation of white light by trichromatic sources**,** temperature dependence of trichromatic, 7generation of white light by tetrachromatic and pentachromatic sources, white-light sources based on wavelength converters. | 9 | **15%** |
| **IV** | Optical modulators using pn junction, electro-optical modulators, acousto-optical modulators, Raman-Nath modulators, Franz-Keldysh and Stark effect modulators, quantum well electro-absorption modulators, optical switching and logic devices, optical memory. | 5 | **15%** |
| **SECOND INTERNAL EXAM** | | | |
| **V** | Optical detection – PIN, APD, modulated barrier photodiode, Schottky barrier photodiode, wavelength selective detection, micro cavity photodiodes.<br>Optoelectronic ICs, advantages, integrated transmitters and receivers, guided wave devices.<br>Working of LDR, liquid crystal display, structure, TFT display, structure, polymer LED, organic LED. | 7 | **20%** |
| VI | Introduction to optical components, directional couplers, multiplexers, attenuators, isolators, circulators, tunable filters, fixed filters, add drop multiplexers, optical cross connects, wavelength convertors, optical bistable devices. | 7 | **20%** |
| **END SEMESTER EXAM** | | | |

**Question Paper Pattern**

The question paper shall consist of three parts. Part A covers modules I and II, Part B covers modules III and IV, and Part C covers modules V and VI. Each part has three questions uniformly covering the two modules and each question can have maximum four subdivisions. In each part, any two questions are to be answered. Mark patterns are as per the syllabus with 50% for theory and 50% for logical/numerical problems, derivation and proof.

| COURSE CODE | COURSE NAME | L-T-P-C | YEAR OF INTRODUCTION |
|---|---|---|---|
| EC431 | COMMUNICATION SYSTEMS LAB (OPTICAL & MICROWAVE) | 0-0-3-1 | 2016 |

**Prerequisite:** EC403 Microwave & Radar Engineering, EC405 Optical Communication

**Course objectives:**

- To provide practical experience in design, testing, and analysis of few electronic devices and circuits used for microwave and optical communication engineering.

**List of Experiments**

**Microwave Experiments: (Minimum Six experiments are mandatory)**

1. GUNN diode characteristics.
2. Reflex Klystron Mode Characteristics.
3. VSWR and Frequency measurement.
4. Verify the relation between Guide wave length, free space wave length and cut off wave length for rectangular wave guide.
5. Measurement of E-plane and H-plane characteristics.
6. Directional Coupler Characteristics.
7. Unknown load impedance measurement using smith chart and verification using transmission line equation.
8. Measurement of dielectric constant for given solid dielectric cell.
9. Antenna Pattern Measurement.
10. Study of Vector Network Analyser

**Optical Experiments: (Minimum Six Experiments are mandatory)**

1. Measurement of Numerical Aperture of a fiber, after preparing the fiber ends.
2. Study of losses in Optical fiber
3. Setting up of Fiber optic Digital link.
4. Preparation of a Splice joint and measurement of the splice loss.
5. Power vs Current (P-I) characteristics and measure slope efficiency of Laser Diode.
6. Voltage vs Current (V-I) characteristics of Laser Diode.
7. Power vs Current (P-I) characteristics and measure slope efficiency of LED.
8. Voltage vs Current (V-I) characteristics of LED.
9. Characteristics of Photodiode and measure the responsivity.
10. Characteristics of Avalanche Photo Diode (APD) and measure the responsivity.
11. Measurement of fiber characteristics, fiber damage and splice loss/connector loss by OTDR.