SRI SATHYA SAI INSTITUTE OF HIGHER LEARNING

(Deemed to be University)

Syllabus for M.Tech. (Optoelectronics & Communications)

(WITH EFFECT FROM A.Y. 2022-23)

Prasanthi Nilayam – 515 134

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REGISTRAR
Sri Sathya Sai Institute of Higher Learning
(Deemed to be University)
Vidyagiri, Prasanthi Nilayam
Sri Sathya Sai District, A.P. - 515 134
India

Applicable from Academic Year 2022-2023 onwards

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17-10-2022

M.Tech. Program Objective

The Master of Technology program is envisioned to train the students to make a transition from science to technology. The program aims at producing engineers who are technically skilled and can convert their fundamental knowledge to enabling technologies. Critical thinking, problem solving skills, IT skills, and effective communication and leadership skills form part of the overall training given under this program. The program aims at preparing the students to become Industry ready and compete efficiently in the corporate world.

In essence, the objectives of the program are:

1. To prepare graduates who will be successful professionals in industry, government, academia, research, entrepreneurial pursuit and consulting firms.
2. To prepare graduates who will contribute to society as educated, expressive, ethical and responsible citizens with proven expertise.
3. To prepare graduates who will achieve peer-recognition through demonstration of good analytical, research, design and implementation skills.
4. To prepare graduates who will, through clarity and unity in thought word and deed, also pursue higher goals of life and not succumb to the stress and pressures of corporate life.

Program Specific Objective and Outcome of M.Tech. (OEC) Program

The M.Tech. program in Optoelectronics and Communications is unique in its content, bridging the gap between academia and industry.

Specific objectives of the program and the curriculum.

The program aims to:

1. Prepare students for a smooth and easy entry into the corporate world.
2. Equip students with a strong foundation in understanding the physics and technology of modern networking and communication systems
3. Provide hands-on training through adequate lab courses in the areas of optoelectronics, broadband communications and networking.
4. Provide electives, soft skill training, Industrial visits and Industry live projects to specialize and learn advanced concepts in a particular area and become self-sufficient to enter industry.

Specific Outcomes of the M.Tech. (OEC) Program

On completion of the program the students will gain the following:

1. A strong foundation in the physics and technology of modern networking and communication systems.
2. The ability to design, construct and use optoelectronic devices for sensor applications.
3. Hands-on experience with optical fibers and fiber based components.
4. The skill to build and analyze computer networks.
5. Proficiency in Optical Networking technologies.
6. The ability to understand the impact of engineering solutions in a contemporary, global, economic, environmental, and societal context for sustainable development.
7. The ability to function professionally with ethical responsibility and positive attitude.

Finally, healthy teacher-student interactions, coupled with extensive insights and inputs from alumni, all through the program, ensure that students develop into individually competent, collectively compatible and socially responsible citizens.

Sri Sathya Sai Institute of Higher Learning

DEPARTMENT OF PHYSICS

SCHEME OF INSTRUCTION AND EVALUATION FOR
M.Tech. (Optoelectronics and Communications)

(WITH EFFECT FROM 2022-23)

Paper Code	Title of the Paper	Credits	Hours	Modes of Evaluation	Types of Papers	Maximum Marks
SEMESTER – I:						
MTOC-101	Optoelectronics and Optoelectronic Sensors	3	3	IE2	T	100
MTOC-102	Digital Communication Systems	3	3	IE2	T	100
MTOC-103	Broadband Communication Networks	3	3	IE2	T	100
MTOC-104	Elective-I	3	3	IE2	T	100
MTOC-105	Optoelectronics Lab	3	6	I	P	100
MTOC-106	Fiber Optic Components Lab	3	6	I	P	100
MTOC-107	Algorithm Development Lab	3	6	I	P	100
MTOC-108	Semester End Viva voce	1	-	E1	SEV	50
MTOC-109	Seminar-I	1	-	I	-	50
MAWR-100	Awareness Course-I: Fundamentals of Indian Culture	1	1	I	T	50
		24 credits	**31**			**850 marks**
SEMESTER – II:						
MTOC-201	Optical Communication Systems	3	3	IE2	T	100
MTOC-202	Optical Networks	3	3	IE2	T	100
MTOC-203	Elective-II	3	3	IE2	T	100
MTOC-204	Elective-III	3	3	IE2	T	100
MTOC 205	Entrepreneurship and Innovation**	1	3	I	P	50
MTOC-206	Network Lab	3	6	I	P	100
MTOC-207	Automation Lab	3	6	I	P	100
MTOC-208	Mini Project **	2	4	I	MP	50
MAWR-200	Awareness Course-II: Sources of Values	1	1	I	T	50
		22 credits	**32**			**750 marks**
SEMESTER – III:						
MTOC-301	Elective-IV	3	3	IE2	T	100
MTOC-302	Elective-V	3	3	IE2	T	100
MTOC-303	Network Security Lab	3	6	I	P	50
MTOC-304	Seminar-II	1	-	I	-	50
MTOC-401	Project Interim Review	-	20	I	PW	50**
MAWR-300	Awareness Course-III: Work Culture, Ethics and Values	1	1	I	T	50
		11 credits	**33**			**400 marks**
SEMESTER – IV:						
MTOC-401	Project	18	32	E2	PW	250***
MAWR-400	Awareness Course-IV: SSSIHL'S Core Values and Philosophy	1	1			50
		19 credits	**33**			**300 marks**
	TOTAL	**76 Credits**	**129 hours**			**2300 marks**

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Applicable from Academic Year 2022-2023 onwards

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Modes of Evaluation

Indicator	Legend
IE1	CIE and ESE ; ESE single evaluation
IE2	CIE and ESE ; ESE double evaluation
I	Continuous Internal Evaluation (CIE) only Note: 'I' does not connote 'Internal Examiner'
E	End Semester Examination (ESE) only Note: 'E' does not connote 'External Examiner'
E1	ESE single evaluation
E2	ESE double evaluation

Types of Papers

Indicator	Legend
T	Theory
P	Practical
SEV	Viva voce
PW	Project Work
D	Dissertation
MP	Mini Project

Continuous Internal Evaluation (CIE) & End Semester Examination (ESE)

PS: Please refer to guidelines for 'Modes of Evaluation for various types of papers', and Viva voce nomenclature & scope and constitution of the Viva-voce Boards.

** The Project Work topic would be finalized by the end of the second semester, and the Project Work starts thereafter, continues in the third semester and gets completed in the fourth semester.

*** Total marks for the Project Work would be 300 marks, which would include 50 marks for the review of the Preliminary Report submitted by the student at the end of the third semester (please see **) + 100 marks for the Project Viva-Voce conducted at the end of the 4th semester + 150 marks for the double evaluation of the Project Report at the end of the fourth semester.

++ The evaluation of the mini project is completely internal with a maximum of 50 marks.

This course is offered by Department of Management and Commerce (DMC). The applicable syllabus is adopted from the MBA program as decided by DMC from time to time

Elective Courses

All electives are three credit courses. A student will be allowed to take any of the electives in the following categories of electives. He can take the guidance of course coordinator/ HOD for choosing the best possible elective. The HOD / course coordinators will take the final decision to offer the electives.

PROGRAM ELECTIVES

Stream I: Optoelectronics

PE-OPT-1: Principles of Photonics
PE-OPT-2: Optical Instrumentation
PE-OPT-3: Integrated Optics
PE-OPT-4: Biomedical Optics and Biophotonics

Stream II: Networking and Communications

PE-NC-1: IoT and Sensor Networks
PE-NC-2: Network Security
PE-NC-3: Wireless Communication Networks
PE-NC-4: AL & ML in Cyber Security

Stream III: Very Large Scale Integration (VLSI) Technology

PE-VLSI-1: Principles of VLSI
PE-VLSI-2: VLSI Design &Test
PE-VLSI-3: FPGA Based Design
PE-VLSI-4: Embedded Systems and RTOS
PE-VLSI-5: ASIC Design
PE-VLSI-6: Digital Logic Design

Stream IV: Robotic Technologies

PE-ROB-1: Embedded Signal Processing
PE-ROB-2: Adaptive Signal Processing
PE-ROB-3: Image Processing and Computer Vision
PE-ROB-4: Robotic Instrumentation and Sensors
PE-ROB-5: Robot Programming
PE-ROB-6: Fundamentals of AI for Robotics

OPEN ELECTIVES:

OE-1: Introduction to Virtualization Technologies
OE-2: Software Engineering
OE-3: Microfluidics: Devices and Applications
OE-4: Biomedical Signal Processing
OE-5: Data Structures and Algorithms
OE-6: Computer Organization and Architecture
OE-7: Basics of Managing a Business

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SYLLABUS FOR CORE PAPERS

MTOC-101 Optoelectronics and Optoelectronic sensors 3 Cr

Course Objectives:

- To make the students understand different aspects of optical devices and sensors and the fundamentals of light interaction with semiconductor materials and vice-versa.
- To enable students to understand the working principle of the optoelectronic sensors/devices like LED, LASER diode, photodiodes, photovoltaic cells, FBG, gyroscope, LIDAR, microfluidic/optofluidic chips.

Course Outcomes:

1. Development and application of optoelectronic systems.
2. Selection of the appropriate optical fiber sensors for industrial application
3. PN junction diode working in homo junction and heterojunctions, working of LED
4. Basic laser operation, advantage of heterostucture laser diodes
5. Photodiode types and their respective advantages like PIN diode and APD's & basic operation
6. Working principle of FBG, gyroscope, LIDAR, LVD and Integrated optical sensors

Syllabus:

Semiconductor Science (review): Semiconductors and Energy Bands, Band gap Diagrams, pn junctions; Science and engineering of light emitting diodes. 6 hrs

Stimulated Emission Devices (review): Laser Diodes, Fabry-Perot and distributed-feedback lasers; vertical-cavity surface-emitting lasers. 4 hrs.

Photodetectors:pn junction, photodiode science and operation, avalanche and heterojunction photodiodes, phototransistors. 4 hrs

Photovoltaic Devices: Solar energy spectrum, device principles, I-V characteristics, equivalent circuit, temperature effects, materials, devices, and efficiencies. 4 hrs

Polarization and Modulation of light: Polarization, propagation in anisotropic media, birefringent devices, optical activity, electro-optic effects, integrated optical modulators, acousto-optic modulators, magneto-optic modulators. 5 hrs

Sensors based on Guided waves sensing (review): Fundamentals of waveguiding, waveguide sensors basic working principle. Optical Fiber Sensors: Principle and applications of FBG based, Distributed Fiber optic Sensors and Fiber gyroscope sensors. 6 hrs

Sensors based on Free Space monitoring: Principle of Laser Doppler velocimetry: forward and backward scattering geometries; Principle of LIDAR applications in remote sensing and Environmental pollution monitoring. 5 hrs

Sensors Based on Integrated optics / on chip sensing: Surface Plasmon Resonance: Theory and Applications in Sensors and Biosensors; Integrated optic waveguide based sensors: Overview of fabrication techniques of integrated optic waveguides; Femtosecond laser based fabrication of optical waveguides and microfluidic channels; Sensors based on integrated optic MZI, microfluidic/optofluidic Lab on chip based sensors; 8 hrs

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References:

1. S. O. Kasap, Optoelectronics and Photonics: Principles and Practices, 2nd ed., Pearson Education, 2012.
2. S. L. Chuang, Physics of Photonic Devices, 2nd ed., New York: Wiley, 2009.
3. Saleh and Teich, Fundamentals of Photonics, 2nd ed. Wiley Interscience 2007.
4. An Introduction to Optoelectronic Sensors. Edited by: Giancarlo C Righini (CNR, Italy), Antonella Tajani (CNR, Italy), AntonelloCutolo (University of Sannio, Italy).
5. Optical Fiber Communications, 4th edition, GerdKeiser,Tata McGraw-Hill,2009.
6. Femtosecond Laser Micromachining: Photonic and Microfluidic Devices in Transparent Materials, Edited by: Roberto Osellame, Giulio Cerullo, Roberta Ramponi; Springer 2012.

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MTOC-102 Digital Communication Systems 3 Cr

Course Objectives:
Understanding the fundamentals of all aspects of digital communications from the information source to the receiver, including various types of source / channel coding and multiple access schemes.

Course Outcomes:
1. Get an understanding and fair working knowledge of the various components of a typical digital communication system from the source to the receiver and their role in the overall scheme.
2. Calculate the BER for a given system and solve problems related to system design.
3. Appreciate the need for different systems, using different Baseband and Bandpass modulation techniques and also be able to assess the performance using measurables like BER, eye diagrams and Eb/No ratio and constellation diagrams as well as solve problems related to these.
4. Understand multiple access techniques and spread spectrum techniques, as well as solve problems related to these.
5. Knowledge of basic information theory concepts and simple source coding, channel coding schemes including Huffman compact codes, linear block and cyclic codes.
6. Estimate the capacity and fundamental limits of capacity of a given communication channel.

Syllabus:

Signals and Spectra:

Introduction to communication systems, classifications and overview. Signals: classification, correlation and components,Fourier series to Fourier transforms and their properties, LTI systems, Ideal filters, Impulse response. Review of probability in the context of digital communications, Review of random variables, mean and variance, Gaussian, Rayleigh, Rician, Binomial and Poisson distributions, Random Process: Ergodic and WSS processes, autocorrelation and PSD. 9 hrs

Baseband Modulation: Formatting Analog Information, Sources of Corruption: quantization noise, channel noise. PCM waveforms (Line codes): bipolar and unipolar NRZ, RZ, and variants. Power spectral Density of line codes. DPCM and Delta modulation. Detection of Binary Signals in Gaussian Noise, Maximum likelihood receiver: Matched filter and correlation receiver. 10 hrs

Bandpass Modulation and Demodulation/Detection: Signal Space representation, Coherent and incoherent detection of PSK, DPSK, FSK, MPSK, MFSK, and APK along with their Bit error performance. QPSK and QAM. 7 hrs

Multiple Access and Spread-Spectrum Techniques: Allocation of the Communications Resource. Overview and comparison of TDMA, FDMA, Multiple Access Communications System and Architecture. Spread-Spectrum Overview, Pseudo noise Sequences, Direct-

Sequence Spread-Spectrum Systems, Frequency Hopping Systems, Synchronization, and Jamming Considerations. 8 hrs

Coding: Entropy, information rate, Coding to increase average information per bit, Huffman Coding, Shannon's theorem for Capacity of Gaussian Channel, Bandwidth- S/N tradeoff, Discrete Memoryless channel capacity. Channel coding:Linear Block codes, cyclic codes and their error correction/detection properties, Cyclic Redundancy Check, Coding strength.

8 hrs

References

1. Bernard Sklar, and Fred Harris,'Digital Communications: fundamentals and applications', Third Edition, (Kindle edition) (Communications Engineering & Emerging Technology Series from Ted Rappaport), 2021.

2. B. P. Lathi, Zhi Ding, and Hari M. Gupta, "Modern Digital and Analog Communication Systems", 4thed., Oxford University Press, (South Asia Edition), 2017.

3. Simon Haykin, "Communication Systems", 4th ed., John Wiley, 2006.

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MTOC-103 Broadband Communication Networks 3 Cr

Course Objectives:

- To learn the basics of Broadband Communication Networks in Wireline and Wireless domains.
- This fundamental course teaches the principles of layered architecture of broadband networks and their functional significance.
- Exposes the latest trends in network technology like the Software Defined Networks (SDN) and Network Function Virtualization (NFV).
- Designed to emphasize the principles of broadband communications including mobile broadband, Wimax, cable broadband.
- Acquaints the student about Green telecom and the broadband communication architecture of National Knowledge Networks (NKN) and National Optical Fiber Networks of our Nation.

Course Outcomes:

1. It makes the student familiar with the components required to build different types of Networks and protocols.
2. Students will understand QoS parameters required for broadband services
3. Understand the impact of Broadband on Society.
4. Exposure to the technologies used in Networks both in wireline and wireless domains.

Syllabus:

Overview of Network models: Layered architecture, brief overview of main principles of Application, Transport, Network& Data link layers functionalities. Protocols involved in each layer. 10 hrs

Classification networks, Congestion and congestion control mechanisms, Types of broadband communication systems 6 hrs

Trends in Network technologies - Software defined networks (SDN) and Network Function Virtualization (NFV); Green Networking and Communications -Energy Efficiency and Management in Wireless Networks. Cellular Networks; 4 hrs

Wireless Broadband networks:
Review of Cellular Communications, Interference, Frequency reuse. Cell splitting. Evolution of mobile technology, Wireless backhaul, Requirement for wireless backhaul 4 hrs

3G Mobile technology, Spectrum requirements for 3G, 802.11 WLAN protocols, Blue Tooth overview, pico& scatter net; Introduction to 4G & LTE technology, spectrum requirements, technologies used, LTE deployment status, LTE Advanced. Wimax, technologies, comparison with WiFi. 8 hrs

Broadband Communication Network architecture: QOS parametrs for services; Cable Broadband: DOCSIS, usage of cable broadband services National Optical Fiber Networks (NOFN) & National Knowledge Networks (NKN) 6 hrs

Advances in Broadband Communication Networks:
Green Telecom & carbon credit policy for telecom industry. Spectrum usage for 5G communication systems, smart connected cities for holistic services, Metrics for Broadband Networks. 4 hrs

Applicable from Academic Year 2022-2023 onwards

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References:

1. William Stallings, "ISDN and Broadband ISDN with ATM frame relay" Ed 4, Pearson Education, 2017.
2. Jim Kurose and Keith Ross, "Computer Networks: A top down Approach", 8th Ed., 2018.
3. H. Taub and D. L. Schilling, "Principals of Communication Systems", 4th Ed., McGraw Hill Education, 2017.
4. William Stalling, "Wireless Communication & Networks", Ed 2, Pearson, 2009
5. R. J. Bud Bates, "Broadband Telecommunications Handbook" Ed 2, McGraw Hill, 2002.
6. BA Frrouuzen, "Data communication & Networking", 5th Ed., McGraw Hill, 2017.

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MTOC-105 Optoelectronics Lab 3 Cr

Course Objectives:

To give 'hands-on' experience in the use of Digital sampling oscilloscopes (DSO), Photodetectors (PD), LEDs, Laser diodes (LD), optical power meters under various conditions. To give 'hands-on' experience in interfacing microcontroller/PC to drive stepper motors, read and configure optical sensors, as well as be able to do optical alignment / design of some basic optical instruments. They will also get 'hands-on' experience with basic aspects of digital communication including noise, sampling, modulation, and encoding. This course supplements the MTOC 101 theory course.

Course Outcomes:

On completion of this course the students should

1. Be able to efficiently and confidently use a DSO for different applications.
2. Be able to design PD /LED /LD biasing circuits for sensing / communication applications
3. Interface a stepper motor to ARDUINO/SCILAB/Some other application
4. Optically align components of an optical system and do software driven electronic interfacing for a given application.
5. Understand basics of digital ASK/PSK/FSK / QPSK modulation schemes
6. Understand basics of digital spread spectrum modulation schemes

Syllabus: The students should perform **at least Nine** out of the following

1. Use a DSO and understand the role of various common instrument settings, as well as analyze the Spectrum of a signal using FFT with different window functions.
2. Study the Voltage Vs Current characteristics as well as spectral bandwidth of a LED Vs a Laser Diode and be able to modulate their output.
3. Study the various characteristics (including responsivity, and bandwidth) of a photodetector under the photovoltaic and photoconductive modes of operation.
4. Interface a bipolar / Unipolar Stepper motor to a microcontroller and drive it in FULL STEP, HALF STEP, MICROSTEP modes
5. Learn to interface a microcontroller (eg. ARDUINO) to the personal Computer (PC) using some open source software (e.g. SCILAB / Python)
6. Study basic aspects of digital Sampling using simulations
7. Study basics of digital ASK/PSK/FSK using simulations
8. Study basics of QPSK using simulations
9. Study basics of digital Direct Sequence Spread Spectrum using simulations
10. Study basics of digital spread spectrum Frequency Hopping using simulations
11. Perform optical alignment using optical and opto-mechanical components on a vibration isolation table
12. Design a complete optical instrument (e.g. Spectrometer / power meter / wave meter) including the necessary electronic interface and GUI front end software on a PC.

References

1. https://www.scientechworld.com/analog-communication
2. http://www.falconindia.biz/Tech_Edu.html
3. https://www.mathworks.com/matlabcentral/fileexchange/ Dhananjay Kadlag. Communication Practicals Using Matlab.

Applicable from Academic Year 2022-2023 onwards

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MTOC-106 Fiber Optics Components Lab 3 Cr

Course Objectives:

Provide practical and complete hands on training in basics of Fiber optics and fiber based components.

Course Outcomes:

1. Skill of preparing the ends of an optical fiber and efficiently launch light into an optical fiber
2. Ability to analyze the Modal patterns of a SMF and MMF outputs
3. Practical knowledge of measuring basic characteristics of an optical fiber
4. Ability to use fiber based components and analyse their characteristics.
5. Ability to design and build a simple fiber optic communication channel.

Syllabus:

1. Basic Fiber cutting and polishing and launching light
2. Measurement of attenuation & Bend induced losses
3. Measurement of Mode field diameter.
4. Measurement of Numerical aperture;
5. Characterization of a 2x2 optical fiber coupler
6. Study the working of an optical isolator.
7. Study of working of inline fiber polarizing elements.
8. Setup a simple optical communication system.

References:

1. Ghatak A and Tyagarajan K, "Introduction to Fiber optics", Cambridge University Press, 1998.
2. Thyagarajan K and Ghatak A., Fiber Optic Essentials, Wiley Interscience, 2007.
3. Keiser, Gerd: Optical Fiber Communications, 4th Ed., McGraw Hill (2009).

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MTOC-107 Algorithm Development Lab 3 Cr

Course Objectives:
This course is designed to make the student equipped with programming languages like C and C++ to solve real time problems effectively by the selection of appropriate techniques for the task.

Course Outcomes:
At the end of the course, the students will be able to get an understanding of a given computational problem, identify and abstract the programming task involved.

1. Approach the programming tasks using techniques learnt and writing pseudo-codes.
2. Choosing the right data representation formats based on the requirements of the problem.
3. Select the right algorithmic paradigm (such as greedy, dynamic programming, divide and Conquer etc.).
4. Identify suitable numerical techniques and apply them to write programs
5. Real time implementation of concepts on hardware engines.

Experiments:

1. Familiarization with tools:
    a. Matlab/Octave
    b. VisualStudio development environment
    c. Using GCC with makefiles
2. Programming frequently used operations:
    a. Matrix operations
    b. Handling arrays
    c. Using recursions
3. Using data structures effectively:
    a. Heaps
    b. Queues
    c. Trees
    d. Graphs
4. Modelling problems using state machines.
5. Introduction to algorithms:
    a. Sorting algorithms
    b. Greedy algorithms
    c. String matching algorithms
    d. Graph based algorithms
6. Understanding how to use libraries – introduction to openCV image processing library.
7. Programming mini project

References

1. Goodrich, M.T., Tamassia, R. and Mount, D.M., "Data structures and algorithms in C++", John Wiley & Sons2011.
2. Karumanchi, N., Data structures and algorithms made easy: data structure and algorithmic puzzles, Careermonk Publications, 2016.
3. Patterson, David A.., Hennessy, John L.. Computer Organization and Design MIPS Edition: The Hardware/Software Interface. Netherlands: Elsevier Science, 2014.

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MTOC-201 Optical Communication Systems 3 Cr

Course Objectives:

1. Understanding all the fundamentals aspects of the state of the art optical communication systems.
2. Assess the design of an optical communication link in terms of the choice of source, fiber, optical amplifier, detector modulation / demodulation scheme.

Course Outcomes:

1. Given a customer specific demand the student would be able to choose the various components (Source, Fiber and Detector) and design and optimize an entire link, perform a power and rise time budget analysis,
2. Assess the need for optical amplifiers and solve problems related to use of optical amplifiers and OSNR.
3. Assess the effect of various nonlinear optical effects and solve problems related to the same.
4. Assess the power penalties due to various sources of imperfections that degrade the SNR/OSNR.
5. Predict the BER performance of a given optical link. Asses the need for coherent/incoherent optical detection and choose the right modulation scheme for a specific demand
6. Analyze CNR in analog optical communication links for single/ multichannel AM FM/ SCM

Syllabus:

Optical Receiver operation: Overview of optical fiber communications, digital receiver performance, Q factor and BER relationship, high, low and trans impedance preamplifier, raised cosine filter 4 hrs

Digital links: Direct detection, Coherent detection; Homodyne, Heterodyne detection with ASK, PSK, FSK based SNR calculations, Phase and Polarization Diversity Receiver, Link Design choices, Power and Rise time budget. 10 hrs

Transceivers: 40 GBit and 100 GBit transceiver technology, Construction and working of transcievers for 40G and 100G 2 hrs

Mitigation of transmission impairments: Modal Noise, Mode Partition Noise, chirping, reflection noise. 4 hrs

Analog Links: RIN and CNR calculations, Multichannel AM and Composite beat stacking, FM, Subcarrier multiplexing; 5 hrs

Optical amplifiers: EDFA: Architectures, ASE, noise figure, and OSNR, inline amplifiers, Preamplifier. SOA, and Raman Amplifiers; 6 hrs

Nonlinear effects: Nonlinear optical effects in fibers, Effective length and effective area, SPM, FWM, SRS, Soliton, Dispersion compensation and Dispersion Management; 9 hrs

Performance Measurement and Monitoring: OTDR, Eye pattern analysis; 2 hrs

References:

1. Gerd Keiser, Optical fiber Communications, 5th Edition, McGraw Hill Education (India), 2017.
2. John M Senior and M Y Jamro, Optical fiber Communications, 3rd Ed. Pearson Education, 2010.
3. G.P. Aggarwal, Fiber Optic Communication systems, 5th Ed., Wiley, 2021.
4. http://www.fiber-optic-transceiver-module.com/category/fiber-optic-transceivers/40-100g-transceivers
5. http://www.lightwaveonline.com/articles/print/volume-29/issue-6/feature/challenges-and-key-technologies-for-coherent-metro-100g-transceivers.html
6. http://cubeoptics.hubersuhner.com/en/Solutions

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MTOC-202: Optical Networks 3 Cr

Course Objectives:

Provide a thorough understanding of the fundamental principles of Optical networks covering network architecture, network design, protection schemes along with details of OTN and PON.

Course Outcomes:

1. Know different types of optical network architectures and their applications.
2. Knowledge of different wavelength routing networks.
3. Understand principles of passive optical networks (PON) and Optical Transport Networks.
4. Basic knowledge of Elastic Optical Network.
5. Familiarity with different types of protection schemes and network management functionalities.
6. Design optical networks with right choices of components.

Syllabus:

Overview of Optical Networks: Telecommunications Networks, Circuit and Packet Switching; Demand for Optical Networks; Optical Layer, evolution and basics of Optical Networks. 4 hrs

Optical Networks: Architecture: SONET basics; Optical Layer and client layers: SONET, OTN, GFP, Gigabit Ethernet and Carrier Transport, IP/MPLS; Network components: WDM, OLT, OADM/ROADM, OXC 10 hrs

Passive Optical Networks: Evolution of PON, types of PON, usage of PON in commercial deployments, advantages of PON over traditional broadband systems 6 hrs

Optical Networks: Design: Client models, Routing and traffic grooming, Traffic models; Optimization algorithms and methods – routing algorithms examples 6 hrs

Elastic Optical Networks: Basics of EONs, Flexigrid or Gridless transmission, Basic architecture of flexible optical components. 5 hrs

Network Reliability and Protection: Standard protection and restoration, rings, mesh topologies; SONET/SDH, Next Generation SONET, Fast reroute; Resilient Packet Rings; Generalizations: Quality of protection, protecting path segments 7 hrs

Network Control and Management: Basic network management functions, Optical layer services and interfacing; OTN, Performance and fault management, optical supervisory channel, Basics of Software defined optical transport 4 hrs

References:

1. Rajiv Ramaswami: "Optical Networks: A Practical Perspective" 3rd ed., Morgan Kaufman/Elsevier, 2010
2. Prat, Joseph (Ed): "Next-Generation FTTH Passive Optical Networks: Research Towards Unlimited Bandwidth Access":, Springer, 2008.
3. Jane M Simmons, Optical Network Design and Planning, 2nd Ed., Springer, 2014.
4. CasimerDeCusatis, "Handbook of Fiber Optics Data Communication: A practical guide to Optical Networking", III Ed, Elsevier Academic Press, 2008.
5. Gilbert Held, "Deploying Optical Networking Components", McGraw Hill, 2001.
6. Biswanath Mukherjee, "Optical WDM Networks", Springer, 2006

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MTOC-205 Entrepreneurship and Innovation 3 Cr

(Offered by Dept. of Management and Commerce under MBAG-201: Entrepreneurship and Innovation)

(1 credit, 3 hours, Practical)

Course Objective:

This is a course where students through interactions with entrepreneurs, case studies, classroom interactions, cross functional teams, group discussions, learn about transforming creative ideas into commercially viable business models / businesses.

Course Outcome

At the end of the course the student would be able to apply above concepts in his profession, whether in the role of owner of a business, intrapreneur, an innovative manager or as a social entrepreneur.

Contents

1. Entrepreneur and Entrepreneurship 6 hrs

Traits of most innovative entrepreneurs. Challenges and opportunities of entrepreneurship, Identifying and evaluating opportunities, Developing effective business plan, Sources of capital for entrepreneurship, Making the pitch, Business incubators, Social entrepreneurship, Intrapreneurship

2. Innovation 3 hrs

Creativity and innovation in an entrepreneurial organization, Role of creative Thinking, Elements of innovation, Forms of innovation, Challenges of innovation, Creating culture of innovation.

3. Case Studies 9 hrs

4. Interactions with entrepreneurs 6 hrs

5. Group activity developing and presenting business model/business case for an entrepreneurial idea. 15 hrs

Evaluation Assignments

Text Book:

1. D.F. Kuratko, T.V. Rao., Entrepreneurship A south-Asian Perspective, ISBN-10:8131517160, ISBN-13:978-8131517161 Cengage Learning, 2012.

Suggested Readings

1. Peter F. Drucker, Peter Ferdinand Drucker, Innovation and Entrepreneurship: Practice and Principles, Publisher Routedge, 2007 ISBN 0750685085 ,9780750685085.
2. New Venture Creation – Entrepreneurship for the 21 centuries by Jeffery Timmons and Stephen Spinelli (McGraw Hill, edition 2009) ISBN-13:978-0-07-067738-9 ISBN -10:0-07-067738-7

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MTOC-206 **Network Lab** **3 Cr**

Course Objectives:
To get an understanding of building of various types of Networks that are deployed in a real situation. Exposure to building a Local Area Networks (LAN) is given, using the hardware and widely used networking software. The concepts involved in networking protocols and analyzing the traffic is given.

Lab Course Outcomes:
1. To get acquainted with building of different types of network architectures using standard software like CISCO Packet tracer, GNS3 etc. Configuring of the of routers and switches in a LAN environment is given. Hands on experience of few CISCO hardware routers is given.
2. To build optical network systems and simulate the study of various parameters that influence the data rate performance.
3. To capture a network data stream and observe and filter the packets belonging to various protocols and the analysis of data rate are also given.

Experiments:
1. Study of Routing Information (RIP) &OSPF (Open Shortest Path First) protocols using CISCO packet tracer software.
2. Configuring the CISCO hardware routers by assigning IP addresses and sub-netting.
3. Understanding and design of Internet of things by constructing sensor networks
4. Study of routing protocols using GNS3 software for routers from different manufacturers
5. Analysis of packets using WIRESHARK software
6. DWDM fiber communication Systems and the study of the dispersion on the data rate of transmission
7. Group Velocity Dispersion (GVD) on Gaussian pulse propagation
8. HTTP, TCP Protocol filtering & Study of DNS packets

References:

1. https://www.netacad.com/courses/packet-tracer
2. https://docs.gns3.com/docs/
3. https://www.wireshark.org/
4. www.cisco.com

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MTOC-207 Automation Lab 3 Cr

Course Objectives:

This course introduces core programming basics—including data types, control structures, algorithm development, and program design with functions via the Python programming language. The course discusses the fundamental principles of Object-Oriented Programming, as well as in-depth data and information processing techniques. Students will solve problems, explore real-world software development challenges, and create practical and contemporary applications.

Course Outcomes:

1. Ability to work on real time problems and apply python as a tool for seamless data traffic and management.
2. Ability to work on different types of real time data and incorporate in a way for faster and efficient processing.

Syllabus:

Specific topic coverage includes:

1. Algorithms and Information Processing
2. Control Structures
3. Boolean logic and Numeric Data Types
4. Strings, Text Files, Lists, and Dictionaries
5. Procedural Abstraction in Function Definitions
6. Objects and Classes
7. Graphics and Image Processing
8. Graphic User Interfaces (GUI)
9. Events and Event-driven Programming
10. Networks and Client/Server Programming: Multithreading, Networks, and Client/Server Programming; introduction to HTML, interacting with remote HTML server, running html-based queries, downloading pages; CGI programming, programming a CGI form.

References

1. Omondi, Amos., Marvin, Ryan., Ng'ang'a, Mark. Python Fundamentals: A Practical Guide for Learning Python, Complete with Real-world Projects for You to Explore. United Kingdom: Packt Publishing, 2018.
2. Ratan, A., Practical Network Automation: Leverage the power of Python and Ansible to optimize your network. Packt Publishing Ltd., 2017.
3. Sarker, M.F. and Washington, S., Learning Python Network Programming. Packt Publishing Ltd., 2015.

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Sri Sathya Sai Institute of Higher Learning (Deemed to be University) PRASANTHI NILAYAM India

MTOC-303 **Network Security Lab** **3 Cr**

Course Objectives:

This course introduces the students to work on real time problems like data mining, metadata extraction etc. By the end of this course, a student will be able to apply his theoretical knowledge of concepts like networking protocols, analyzing data traffic in practical applications.

Course Outcomes:

At the end of the course, the students will be able to

1. Write client and server programs using UDP and TCP protocols using Python.
2. Perform Socket Programming.
3. Use existing softwares for analyzing network traffic and implement the same using dkpt and scapy packages.
4. Extract Metadata and practical applications on internet today like web scrapping and data mining.

Syllabus:

Introduction and Basics: Networking Terminologies, Installing Third Party Libraries, Interpreted and Interactive Python, Basics of Sockets, Socket Methods, Working with TCP Sockets, Working with UDP Sockets, Handling Received Data, Blocking & Non-Blocking Socket, Securing Sockets

Network Analysis: Building a Port Scanner, Integrating Port Scanner with Nmap, Input from Command Line, Banner Grabbing, Introduction to Wireshark, Using Wireshark Analyzing Network Traffic, Introduction to scapy.

Practical Applications: Extracting MetaData from PDF Files, pyGeoIP Module, Web Scraping, Example of Web Scraping, Understanding API's, Facebook Graph API, Mining Facebook Data, Mechanize Library, Changing User Agent.

References:

1. Ratan, A., *Practical Network Automation: Leverage the power of Python and Ansible to optimize your network*. Packt Publishing Ltd., 2017.

2. Sarker, M.F. and Washington, S., Learning Python Network Programming. Packt Publishing Ltd., 2015.

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SYLLABUS FOR ELECTIVES

PROGRAM ELECTIVES (PE)

Stream I: Optoelectronics

Stream Objectives:
The objective of the courses in this stream is to give exposure to fundamentals of Optoelectronics and Integrated optics system design considerations using principles of geometrical and physical optics, Fourier optics, waveguide optics, nonlinear optics, photodetectors and light sources. The stream consists of 4 electives:

Stream Outcomes:

Students who take 2 or more electives from this stream should at the end,

- be able to assess /design/ evaluate bulk optics system and integrated optical systems
- Incorporate knowledge of geometrical and physical optics, Fourier optics, waveguide optics, nonlinear optics, photodetectors and light sources.
- Become competent optical engineers, with 'hands-on' knowledge along with sound theoretical foundations.
- Ability to apply their knowledge in the domain of medical imaging and diagnosis and build photonics based sensor.

PE-OPT-1: Principles of Photonics

Course Objective: To provide fundamental principles of optics covering topics on geometrical and wave optics.

Course Outcome: The student will be able to solve problems that require recalling / understanding / Analyzing / designing photonic systems based on basic theoretical and practical aspects of

1. Lenses and mirrors
2. Interference and Diffraction of light
3. Dispersion of light
4. Polarisation of light
5. Fourier Optics
6. Gaussian laser beams
7. AOM and EOM

Syllabus:

Introduction to Photonics:

Geometrical Optics: lenses, mirrors and applications, ABCD matrix methods for lenses/mirrors 6 hrs

Wave Optics: Wave equations and Electromagnetic waves; Energy flow and absorption; Superposition of Waves and Interference: Two-beam interference, Multi-beam interference, Fabry-Perot interferometer, Group/phase velocity and dispersion - pulses in optical fibers 10 hrs

Diffraction and Imaging: Fraunhoffer diffraction, Diffraction grating, Fresnel diffraction (concepts only), Resolution and Abbe limit - implications in imaging; Basic image formation; Far-field diffraction as Fourier transform; Application of Fourier optics to processing optical images 10 hrs

Polarization: Jones vectors and Jones matrices, Fresnel equations, Evanescent waves, Birefringence, Polarization components and devices 6 hrs

Selected photonic devices: 3 and 4 level Laser basics, operation, Characteristics of laser beams, Gaussian Beams and ABDC matrix, Acousto-optic modulation; Electro-optic modulation 10 hrs

References:

1. T.P. Pearsall, Photonics Essentials: An introduction with experiments, McGraw Hill, 2002.
2. E. Hecht, Optics,4th ed., Pearson Education 2002.
3. R. Menzel, Photonics, Springer, 2001.
4. R.S. Quimby, Photonics and Lasers-An Introduction, Wiley-Interscience, 2006.

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PE-OPT-2: Optical Instrumentation

Course Objective: To teach the operating principles of various optical instruments right from simple magnifiers to high level medical systems, metrology instruments and imaging / night vision systems.

Course Outcome: The student will be able to solve problems that require recalling / understanding / Analyzing / designing optical systems based on basic theoretical and practical aspects of

1. Microscopic imaging
2. Projection Systems
3. IR Thermal Imaging and night vision
4. Interferometric metrology
5. Optical material selection
6. Thermal effects

Syllabus:

Radiometry: basic concepts; Visual Systems: magnifiers and eyepieces;	5 hrs
Projection Systems: profile projectors	4 hrs
IR and Medical Systems: thermal imaging instruments	5 hrs
Metrology Instruments: interferometric instruments, online optical sensing of temperature and flow	9 hrs
Unique features of the infrared region - materials, effect of temperature on optical properties and athermalization methods	9 hrs
Optical design and material selection, tolerances, Reflective and transmitive infrared zoom systems, Night vision equipment; Applications in industry and defence	10 hrs

References:

1. Malcara, D., Geometrical and Instrumental Optics,Academic Press, London, 2000.
2. Mann Allen, Infrared Optics and Zoom Lenses,SPIE, 2002.
3. R. Kingslake, Applied Optics and Optical Engineering, Vol. 4 and 5, Academic, 2002.
4. Michael Vollmer, Infrared Thermal Imaging: Fundamentals, Research and Applications,Wiley, 2010.

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PE-OPT-3: Integrated Optics

Course Objective: To provide deeper understanding of integrated optics in its varied forms by covering topics on design, optimization, fabrication and characterization of integrated components like waveguides, couplers, lenses, integrated sensors, etc.

Course Outcome: At the end of this course the students will be able to

1. Solve simple problems based on total internal reflection / refraction
2. Solve problems based on TE / TM modes in planar waveguides
3. Choose and evaluate the fabrication methods for making integrated waveguides.
4. Choose and evaluate methods of coupling light into integrated devices.
5. Theoretically design and optimize the parameters for integrated optical sensors.

Syllabus:

Integrated optics introduction and overview: Advantages of Integrated Optics, Comparison of Optical Fibers with Other Interconnectors, Comparison of Optical Integrated Circuits with Electrical Integrated Circuits. Hybrid versus Monolithic Approach; 4 hrs

Review of Geometrical optics and Electromagnetism: Reflection, refraction. Review of Maxwell's equations, propagating wave equation. 4 hrs

Optical waveguide modes: Review of optical modes TE, TM modes; Modes in planar waveguide, Analytical and theoretical description of modes in three layer planar waveguide structure 7 hrs

Waveguide fabrication techniques: Deposition techniques, Channel waveguide fabrication, femtosecond laser micromachining of waveguides in transparent glasses; 7 hrs

Coupling techniques: prism couplers, grating couplers; Couple mode theory of synchronous coupling, applications of directional couplers; 6 hrs

Losses in optical waveguides: Scattering losses, surface scattering losses, radiation losses in planar straight waveguides and curved channel waveguides. Propagation losses waveguides fabricated by femtosecond laser; 8 hrs

Integrated optical sensors and devices: Femtosecond laser fabrication -Planar Splitters (Y) splitter; 3D splitters; MZI based RI sensors. 6 hrs

References:

1. R.G. Hunsperger, Integrated Optics: Theory and Technology, Sixth Edition, Springer Verlag, 2009.
2. Roberto Osellame, Giulio Cerullo, Roberta Ramponi (*Editors*), Femtosecond laser micromachining, First Edition, Springer, 2012.
3. B.E.A. Saleh and M.C. Teich, Fundamentals of Photonics, Second Edition, John Wiley & Sons, Inc., 2007.
4. R.G. Hunsperger, Ed., Marcel Dekker, Photonic Devices & Systems, 1994, ISBN 0-8247-9243-2
5. Ivan P. Kaminow and Tingye Li, "Optical Fiber Telecommunications IVA: Components" Academic Press 2002.

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PE-OPT-4: Biomedical Optics and Biophotonics

Objective: To learn the fundamentals of interaction of light with biological tissues; understand different optical techniques useful in medical diagnosis and therapy.

Outcomes: At the end of the course the students will

1. Have knowledge of the basic scattering mechanisms in biological tissues and laser tissue interaction.
2. Understand the basics of selected spectroscopic method and be able to choose the right spectroscopic method for biomedical applications.
3. Know the differences between various 2D / 3D optical imaging methods, and their limitations, as well as be able to select the right method for a given application.
4. Basic knowledge of optical tweezers, laser surgery and photodynamic therapy.
5. Understand the working, and analyze selected optical biosensors.

Syllabus:

Introduction: Light-Matter interactions, Rayleigh and Mie scattering; Optical Properties of Biological Tissues; Basics of Biotechnology & Cancer Biology; 6 hrs

Spectroscopy: Fluorescence(FRET) & Up-conversion spectroscopy; Raman: SERS & CARS; Flow-cytometry; 9 hrs

Imaging: Confocal, Nonlinear & Multiphoton Microscopy/imaging, Super-resolution: NSOM technique, Adaptive optics for biomedical imaging. Tomography: OCT , Doppler OCT, Diffuse Optical OCT , Photo-acoustic tomography; 10 hrs

Optical manipulation of biological materials: Optical tweezers, Laser dissection & surgery, Neural excitation , Photodynamic therapy 7 hrs

Applications: Optical biosensors: Glucose sensing, Optical diagnostics, Wireless/capsule Endoscopy. 10 hrs

References:

1. Valery V. Tuchin, "Handbook of Photonics for Biomedical Science", CRC Press, Taylor & Francis Group, 2010.
2. Paras N. Prasad, Introduction to Biophotonics, Wiley & Sons (2003).

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Stream II: Networking and Communications

Stream Objectives:
The electives under this stream cater to the aspects of networking and communications. There are 4 electives under this stream. The objective of this stream is

- to enable student to become competent in the field of computer and telecommunication networks.
- Have a working knowledge of the networking aspects, security requirements, TRAI regulations, signal processing requirements in communications, etc.
- Become conversant with current day technologies related to wireless communications.
- Learn the nuances of IoT and sensor networks.

Stream Outcomes:

Students who take 2 or more electives from this stream would have the following outcomes:

- Become competent network engineers,
- Have practical knowledge of data communications and networking,
- sufficiently equipped with the understanding of latest trends in networking industries
- Ability to take up design, development and testing related jobs.
- Have complete knowledge of sensor networks and protocols related to IoT.

PE-NC-1: IoT and Sensor Networks

Course Objectives:

The Internet is evolving to connect people to physical things and also physical things to other physical things all in real time. It has become the buzzword, Internet of Things (IoT). The course enables student to understand the basics of Internet of things and protocols. It also exposes him the required sensor technology concepts for realizing the IOT in practice. Students will learn about the middleware for Internet of Things. To understand the concepts of Web of Things.

Course Outcomes:

1. It exposes the student to understand the principles of sensor technology and IOT.
2. Students will know the description of the hardware required to design and build an IOT system.
3. The interfacing software and the intricacies in the development of complex systems.
4. The problem solving abilities in dealing with engineering issues.

Syllabus:

Internet of Things (IOT) - 8 hrs

Elements of an IoT ecosystem, Trends and implications, Security Issues. IOT Communication Model, Protocols, M2M and WSN protocols, SCADA and RFID protocols, IEEE802.15.4– BACNet Protocol– Zigbee– Network layer – APS layer

Application of IoT: 5 hrs

Home, Cities, Environment, Energy, Retail, Logistics, Agriculture, Industry, Health, Life style, M2M Machine to Machine, Difference between IoT and M2M. Industry 4.0 concepts – cyber physical system, Security aspects in IoT

IOT Supporting sensor hardware 8 hrs

Introduction to sensors and sensor network, Wireless, RFID, Sensors, IoT supported Hardware platforms (Any two hardware can be handled) Raspberry pi, Arduino and Intel Galileo boards, Beaglebone, ARM Cortex Processors

Communication in IOT 7 hrs

Interface protocol , Serial, SPI, I2C, 6LoWPAN, 802.11wifi, 802.15 Bluetooth, 802.15.4 Zigbee, RTLS, GPS, CoAp Constrained application protocol, RPL routing protocol for lossy networks.

IOT Software development 6 hrs

Linux, Networking configurations in Linux, Accessing Hardware Device Files interactions, Python. packages: JSON, XML etc

IoT Physical Servers and Cloud Offerings 4 hrs

Introduction to Cloud Storage Models and Communication APIs, PHP and MySQL for data processing ,WAMP, Python Web Application Framework , Designing a RESTful Web API, MQTT, Amazon Web Services for IoT (Any three topics can be covered)

Application Development for mobile Platforms 4 hrs

Overview of Android, IOS App Development tools, CSS and jQuery for UI Designing, recent Trends

References:

1. Arshdeep Bahga, Vijay Madisetti, Internet of Things: A hands-on Approach, University Press, 2015.
2. Adrian McEwen Hakim Cassimally, Designing the Internet of Things,Wiley,2018.
3. Claire Rowland, Elizabeth Goodman, Martin Charlier, Ann Light, Algred Lui, Designing Connected Products: UX for the consumer internet of things, O Reilly,(1stedition), 2015.
4. Honbo Zhou, "The Internet of Things in the Cloud: A Middleware Perspective", CRC Press, 2012.
5. Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), "Architecting the Internet of Things", Springer, 2011.
6. David Easley and Jon Kleinberg, "Networks, Crowds, and Markets: Reasoning About a Highly Connected World", Cambridge University Press, 2010.

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PE-NC-2: Network Security

Course Objective: This course covers the concepts related to network security. Security attacks and their types, encryption and decryption methods, protocols and other higher order security related concepts are covered.

Course Outcomes:

1. Knowledge of different types of security attacks
2. Exposure to perform encryption and decryption of messages.
3. Knowledge of transport level security aspects like HTTPS, SSL, etc.
4. Fundamental ideas on security for wireless networks and exposure TRAI Regulations.

Introduction: Computer Security Concepts, Security Attacks, Security Services, Security Mechanisms 2 hrs

Symmetric Encryption: Principles, Symmetric Block Encryption Algorithms, Random and Pseudorandom Numbers, Stream Ciphers and RC4, Cipher Block Modes of Operation 6 hrs

Message Authentication and Hash Functions: Approaches to Message Authentication, Secure Hash Functions, Message Authentication Codes 4 hrs

Public key Cryptography: Principles, Public-Key Cryptography Algorithms, Digital Signatures 4 hrs

Key Distribution and User Authentication: Kerberos, X.509 Certificates, Public-Key Infrastructure 4 hrs

Network Access Control: Network Access Control, Extensible Authentication Protocol, Cloud Security: Cloud Security Risks and Countermeasures, Data Protection in the Cloud, Cloud Security as a Service 6 hrs

Transport-Level Security: Web Security Considerations, Secure Sockets Layer (SSL), Transport Layer Security (TLS), HTTPS, Secure Shell (SSH) 6 hrs

Wireless Network Security: Wireless Security, IEEE 802.11 Wireless LAN Overview, IEEE 802.11i Wireless LAN Security 5 hrs

IP Security: IP Security Overview, IP Security Policy, Encapsulating Security Payload, Combining Security Associations; functions of TRAI 3 hrs

References:

1. Network Security Essentials: Applications and Standards by William Stallings, 5th Ed, Pearson Education Inc., 2014. (Key book)
2. Cryptography and Network Security Principles and Practice, 7th Ed, William Stallings, Prentice Hall. 2017.
3. Introduction to Computer and Network Security: Navigating Shades of Gray by Richard R. Brooks, 1st edition, 2013.
4. Network Security: Private Communication in a Public World by Charlie Kaufman, Radia Perlman, Mike Speciner, 2 nd edition, 2002.

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PE-NC-3: Wireless Communication Networks

Course Objectives:

The course is designed to emphasize the principles of Wireless Communication Networks. It introduces the basics of cellular communication concepts, including the path loss models. It gives an overview of the evolution of generations of mobile communications from 2G to 5G. It exposes the student to the concepts of WiMax. It also gives the fundamentals of AdHoc and Wireless Sensor Networks.

Course Outcomes:

At the end of this course, students will demonstrate the ability to:

1. Understand cellular concept in mobile communication in terms of frequency reuse, interference, system capacity, handoff techniques.
2. Principles of multiple-access techniques for mobile communications e.g. FDMA, TDMA, CDMA. Identify the radio propagation issues
3. Explore higher generation cellular standards and technologies 4G, 5G.
4. Basics of WiMax technology.
5. Fundamentals of Ad Hoc and Wireless sensor technologies and their application areas.

Syllabus:

Cellular Communication Fundamentals: system design, Frequency reuse, cell splitting, handover concepts, Co channel and adjacent channel interference, interference reduction techniques and methods to improve cell coverage, Frequency management and channel assignment. 12 hrs

Mobile Radio Propagation: Large Scale Path Loss, Free Space Propagation Model, Reflection, Diffraction, Scattering. An overview of Link Budget Design using Path Loss Models. Fast and Slow fading. 6 hrs

Over view of Higher Generation Cellular Standards: GSM subsystems, Mobility Management, Multiple Access Technologies: Comparison of TDMA, FDMA and CDMA technologies. 2.5 G Standards: General Packet Radio Service (GPRS), EDGE, CDMA 2000, IMT 2000 vision, 3 G standard: WCDMA, evolved EDGE, motivation for 4G and 5G networks. LTE (Long Term Evolution) Drivers for 5G, Roadmap and Vision, 5G Enabler technologies. 802.11 IEEE standards. 12 hrs

Wireless Broadband (Wimax): Mobile Wimax, technologies used in WiMax, advantages and disadvantages of WiMax and WiFi. 3 hrs

Adhoc Wireless Networks: cellular Ad Hoc wireless networks, Issues involved, MAC scheme, Routing, Multi casting, QoS, Energy management. Applications 6 hrs

Wireless Sensor Networks (WSN): Layered & Clustered Architecture, Data gathering & dissemination, MAC Protocols, Applications. Introduction to Hybrid Wireless Architectures 4 hrs

References:

1. V.K.Garg, J.E.Wilkes, "Principle and Application of GSM", Pearson Education, 5th edition, (2016).
2. V.K.Garg, "IS-95 CDMA & CDMA 2000", Pearson Education, 4th edition, 2009.
3. T.S.Rappaport, "Wireless Communications Principles and Practice", 2nd edition, PHI (2016)

4. William C.Y.Lee, "Mobile Cellular Telecommunications Analog and Digital Systems", 2nd edition, TMH. (2014)
5. Asha Mehrotra, "A GSM system Engineering" Artech House Publishers Bosten, London (2015)
6. C.Siva Ram Murthy and B.S.Manoj, Ad hoc wireless Networks- Architecture & protocols by Pearson Educaion (2014)

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PE-NC-4: AI and ML in Cyber Security

Course Objectives

1. An overview of different AI and Machine Learning models in Cyber Security
2. Using Machine Learning for effective security
3. Various attacks on ML model
4. Machine Learning and Privacy

Course Outcome

1. Understand the concepts in Machine Learning
2. Learn various AI and Machine learning models for cyber security
3. Ability to apply AI and machine learning models in cyber security issues

Syllabus

Introduction: Role of AI in Cyber Security and Security Framework: Artificial Intelligence in Cyber Security, Challenges and Promises, Security Threats of Artificial Intelligence, Use-Cases: Artificial Intelligence Email Observing, Programming in Python and Basics of manipulation of Data. 18 Hrs

Machine Learning in Security: Introduction to Machine Learning, Applications of Machine Learning in Cyber Security Domain, Machine Learning: tasks and Approaches, Anomaly Detection, Privacy Preserving Nearest Neighbour Search, Machine Learning Applied to Intrusion Detection, Online Learning Methods for Detecting Malicious Executables 12 Hrs

Deep Learning in Security: Introduction to deep learning, Cyber Security Mechanisms Using Deep Learning Algorithms, Applying deep learning in various use cases, Network Cyber threat Detection 10 Hrs

Artificial Intelligence in Cyber Security: Model Stealing & Watermarking, Network Traffic Analysis, Malware Analysis 6 Hrs

References

1. Tom Mitchell. Machine Learning. McGraw Hill, 1997.
2. Gupta, Brij B., and Quan Z. Sheng, eds. Machine learning for computer and cyber security: principle, algorithms, and practices. CRC Press, 2019.
3. Artificial Intelligence and Data Mining Approaches in Security Frameworks Editor(s):N Bhargava, R. Bhargava, P. S. Rathore, Rashmi Agrawal, 2021,
4. Tsai, Jeffrey JP, and S. Yu Philip, eds. Machine learning in cyber trust: security, privacy, and reliability. Springer Science & Business Media, 2009.
5. Machine Learning: A Probabilistic Perspective, Kevin P Murphy, MIT Press.
6. Christopher M. Bishop. Pattern Recognition and Machine Learning. Springer 2006.

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Stream III: VLSI Technology

Stream Objectives:
This stream is designed to give additional edge to the students of this M.Tech. program by way of specializing in VLSI technology. With basic knowledge of optoelectronics, fiber optics and communications learnt from the core papers, the students can opt to pursue this stream to be able to go over to semiconductor industry. The stream consists of the 6 electives:

Stream Outcomes:

Students who take 2 or more electives from this stream would be familiar with the principles and practical aspects of VLSI and would be competent enough to pursue career in semiconductor industries in design, development and testing of semiconductor integrated circuits.

PE-VLSI-1: Principles of VLSI

Course Objective: To teach basic principles of VLSI with introduction to CMOS theory, IC design and characteristics and implementation strategies.

Course Outcome:

1. Knowledge of MOSFET characteristics.
2. Ability to design combinational logic circuits using CMOS.
3. Estimate path delays, cost, power dissipation in CMOS circuits.
4. Knowledge of semiconductor industry standards.

MOSFET & CMOS Inverter : MOS transistor theory – Ideal I-V & C-V characteristics – Non-ideal effects – DC transfer characteristics of CMOS inverter – Dynamic characteristics of CMOS inverter; 4 hrs

IC Manufacturing Process : Manufacturing steps of CMOS ICs – Simplified process flows – Layout design rules – Trends in process technology – IC packaging; 4 hrs

Designing Combinational Logic Circuits : Static CMOS design (complementary CMOS, Ratioed Logic, Pass-Transistor Logic) – Dynamic CMOS design (basic principles, speed / power dissipation, cascading dynamic gates) – Physical design of gates – Stick diagrams; 10 hrs

Circuit Characterization : Circuit characterization & performance estimates – Delay estimates – Logical effort & transistor sizing – Power estimates – Interconnect – Design Margins – Reliability; 3 hrs

Designing Sequential Logic Circuits : Sequencing static circuits – Design of latches & flip-flops – Max-delay & min-delay constraints – Clock skew; 7 hrs

Arithmetic Building Blocks & Memory Array Subsystems : Datapaths in digital processor architectures – Adder/Subtractor, Multiplier, Shifter, Comparator, Counter, Division - Memory core (Static RAM, Dynamic RAM, Read only memory) 8 hrs

Implementation Strategies for Digital ICs & Design Economics : Custom circuit designs – Semicustom design flows – Standard cells – Compiles cells – Prediffused arrays – Prewired arrays – FPGAs – Cost estimates – Datasheets 6 hrs

References:

1. Neil H.E. Weste, David Harris &Ayan Banerjee, "CMOS VLSI DESIGN – A Circuits and Systems Perspective" 4[th]Ed, Pearson Education / Dorling Kindersley (India) Pvt Ltd, 2010.
2. Jan M. Rabaey, AnanthChandrakasan&Borivoje Nikolic, "Digital Integrated Circuits – A Design Perspective" 2[nd] Ed, PHI Learning Pvt. Ltd, 2014.

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PE-VLSI-2: VLSI Design & Test

Course Objective: To teach design aspects using VHDL and verification techniques.

Course Outcome:

1. Ability to design digital logic circuits using VHDL;
2. knowledge of design verification process.
3. Knowledge of Logic testing methods and memory testing models.

Syllabus:

Verilog HDL : Overview of digital design with Verilog – Hierarchical modeling concepts – Basic Verilog concepts – Data types – Modules and ports – Gate level modeling – Data flow modeling – Behavioral modeling – Test benches – Logic synthesis with Verilog; 6 hrs

Logic Design with Behavioral Models : Behavioral models of combinational logic – Cyclic behavioral models of Flip-flops and Latches – Multiplexers, encoders, decoders – Algorithmic state machines – design of counters, shift registers, register files – Datapath controllers; 6 hrs

Synthesis of Combinational and Sequential Logic : Introduction to synthesis – Synthesis of combinational logic – Synthesis of sequential logic with latches, explicit state machines and register logic – Synthesis of implicit state machines, registers; 4 hrs

Design Verification : Functional verification – Verification techniques - Post-synthesis design validation – Static timing analysis – Timing specifications; 3 hrs

VLSI Testing & DFT : Concepts of VLSI testing – Challenges in VLSI testing – Fault models – Levels of abstraction in VLSI testing - Testability analysis – DFT basics – Scan cell designs – Scan architectures – Scan design rules – Scan design flow; 8 hrs

Logic Testing : Circuit defects and faults – Fault detection and testing – ATPG for combinational logic – Fault coverage and defect levels – Test generation for sequential logic – Fault collapsing – Fault simulations – Logic BIST; 8 hrs

Memory Testing : RAM functional fault models (Dynamic faults, Functional test patterns and algorithms, March tests, Word oriented memory) – Memory Built In Self-Test; 7 hrs

References:

1. Michael D. Ciletti, "Advanced Digital Design with the Verilog HDL", PHI Learning Pvt Ltd, 2013.
2. Samir Palnitkar, "Verilog HDL – A Guide to Digital Design and Synthesis" 2nd Ed, Dorling Kindersley (India) Pvt Ltd / Pearson Education, 2013.
3. Laung-Terng Wang, Cheng-Wen Wu, Xiaoqing Wen, "VLSI Test Principles and Architectures", Reed Elsevier India Pvt Ltd (Elsevier), 2011.

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PE-VLSI-3: FPGA Based Design

Course Objective:
This is a specialized course on FPGA based systems and their architecture.

Course Outcomes:
1. Knowledge of FPGA based systems.
2. Ability to design combinational and sequential logics.
3. Knowledge of FPGA architecture.

Syllabus:

FPGA-Based Systems : Digital design and FPGA based system design – Techniques – Hierarchical design – Design abstraction – Methodologies 6 hrs

FPGA Fabrics : FPGA architectures – SRAM-Based FPGAs – Permanently programmed FPGAs – Chip IO – Circuit design of FPGA fabrics – Architecture of FPGA fabrics 8 hrs

Combinational Logic : The logic design process – Modeling with HDLs – Combinational delay, fanout, path delay – Power and energy optimization – Arithmetic logic – Logic implementation of FPGAs; 8 hrs

Sequential Logic : Sequential machine design process – Sequential design styles – Rules for clocking – Performance analysis – Power optimization; 8 hrs

Architecture : Behavioral design – Datapath-controller architecture – Design processes – Design standards – Design verification; 6 hrs

Large-scale Systems : Busses – Protocols and specifications – Logic design for busses – Microprocessor and system busses 6 hrs

Reference:

1. Wayne Wolf, "FPGA-Based System Design", Dorling Kindersley (India) Pvt. Ltd / Pearson Education Inc, 2009.
2. Giovanni De Micheli, "Synthesis and Optimization of Digital Circuits", Tata McGrawHill, 2003.
3. ZviKohavi, "Switching and Finite Automata Theory", Tata McGraw Hill, thirdedition, 2000.
4. Alan B.Marcovitz, "Intro. To Logic Design", TMH, second edition, 2002.

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PE-VLSI-4: Embedded Systems and RTOS

Course Objectives:

1. Develop an understanding of the technologies behind the embedded computing systems.
2. To introduce students to the design issues of embedded systems.
3. Enable students to analyze and develop software programs for embedded systems

Course Outcomes:

1. Understand hardware and software design requirements of embedded systems.
2. Analyze the embedded systems' specification and develop software programs.
3. Evaluate the requirements of programming Embedded Systems, related software architectures and tool chain for Embedded Systems.

Syllabus:

Introduction to Embedded system: Advanced architectures, and Processor Memory organization: Introduction to Embedded systems: Embedded system definition, components, Embedded hardware units and devices in a system, Design Metrics used in the embedded system designs. Processor organization, instruction-level parallelism, ARM and SHARC architecture examples, embedded memories, Memory maps & Hierarchy, Selection of processor and memory devices; 10 Hrs

I/O Devices, Communication Buses & Distributed networked Embedded architectures: Serial communication Devices and Protocols: - Synchronous, Isosynchronous and Asynchronous communication, UART and SPI. Serial Bus Communication Protocols: I2C Bus, CAN, USB standards. Introduction to wireless system protocols: IrDA, Bluetooth, IEEE 802.11 and Zigbee; 8 Hrs

Device Drivers & Interrupts handling: Device access using both programmed I/O and Interrupts, Hardware and Software Interrupts, Interrupt Servicing mechanism, Service threads, Context switching, Interrupt latency and deadline. Direct Memory Access (DMA) driven I/O, Device driver programming; 8 Hrs

Real Time operating systems: Processes, Tasks and Threads, Synchronization using inter-process communication; Multiple processes and threads, Task and Thread states, Inter-process communication and synchronization, Semaphores, Queues and Mailboxes, Remote procedure call functions. Basic functions of OS and RTOS: - Services, Process management, Timer and Event functions, Memory management, ISR in RTOS environment and Handling of interrupts, RTOS Task-Scheduling models, Security issues; 8 Hrs

Real Time Operating System Programming: Real-time operating systems, µC/OS-II, Introduction to : Unix-based RTOS and Real-time Linux Operating systems. 8 Hrs

References:

1. Raj Kamal, Embedded Systems – Architecture, Programming and Design, 3rd Edition, McGraw Hill, 2017.
2. Daniele Lacamera, "Embedded Systems Architecture", Ingram Short Title, 2018.
3. Tammy Noergaard, Embedded Systems Architecture, Comprehensive Guide for Engineers and Programmers, , Ed II, Newnes Publishing, 2013.
4. Yifeng Zhu, Embedded systems with ARM Cortex-M microcontrollers in Assembly language and C, E-Man Press LLC, 2015.

PE-VLSI-5: ASIC Design

Course Objectives: This course introduces ASIC design, programmable ASIC logic cells, ASIC interconnects and ASIC design software.

Course Outcomes: Students will have knowledge of ASIC design, use of ASIC design software and simulation using VHDL.

INTRODUCTION TO ASICS, CMOS LOGIC AND ASIC LIBRARY DESIGN

Types of ASICs - Design flow - CMOS transistors CMOS Design rules - Combinational Logic Cell - Sequential logic cell -Data path logic cell – Transistors as Resistors -Transistor Parasitic Capacitance- Logical effort - Library cell design - Library architecture; 10 hrs

PROGRAMMABLE ASICS, PROGRAMMABLE ASIC LOGIC CELLS AND PROGRAMMABLE ASIC I/O CELLS

Anti fuse - static RAM - EPROM and EEPROM technology - PREP benchmarks - Actel ACT - Xilinx LCA - Altera FLEX - Altera MAX DC & AC inputs and outputs - Clock & Power inputs - Xilinx I/O blocks. 8 hrs

PROGRAMMABLE ASIC INTERCONNECT, PROGRAMMABLE ASIC DESIGN SOFTWARE AND LOW LEVEL DESIGN ENTRY

Actel ACT -Xilinx LCA - Xilinx EPLD - Altera MAX 5000 and 7000 - Altera MAX 9000 - Altera FLEX - Design systems - Logic Synthesis - Half gate ASIC -Schematic entry - Low level design language - PLA tools - EDIF- CFI design representation. 10 hrs

LOGIC SYNTHESIS, SIMULATION AND TESTING

Verilog and logic synthesis -VHDL and logic synthesis - types of simulation -boundary scan test - fault simulation - automatic test pattern generation; 6 hrs

ASIC CONSTRUCTION, FLOOR PLANNING, PLACEMENT AND ROUTING:

System partition - FPGA partitioning - partitioning methods - floor planning - placement - physical design flow - global routing - detailed routing - special routing – circuit; 8 hrs

References:

1. Lionel Bening and Harry D. Foster, Principles of Verifiable RTL Design Second Edition - A Functional Coding Style Supporting Verification Processes in Verilog, 2nd ed., Springer, 2001.
2. Michael Smith, Application Specific Integrated Circuits (ASIC),Addison Wesley, 1997.

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PE-VLSI-6: Digital Logic Design

Course Objectives:

This course introduces students to the basic concepts of digital systems, including analysis and design. Both combinational and sequential logic will be covered. Students will gain experience with several levels of digital systems, from simple logic circuits to programmable logic devices and hardware description language.

Course Outcomes:

Students completing this course will be able to:

1. Represent and manipulate decimal numbers in different coding systems
2. Express and simplify logic expressions using the theorems of Boolean algebra and Karnaugh maps.
3. Find the minimal sum-of-products (SOP) and product-of-sums (POS) expressions, and create a corresponding circuit from AND, OR, NAND, and NOR gates.
4. Analyze and design combinational and sequential digital systems
5. Calculate the propagation delays through a circuit and draw a timing diagram.
6. Design and simulate digital circuits using Hardware Description Language (HDL).

Syllabus:

Number Systems, Combinational Logic Modules and Logic Families: Definition and specification; Truth table; Basic logic operation and logic gates, Decoders, encoders, multiplexers, demultiplexers and their applications; Parity circuits and comparators; Arithmetic modules- adders, subtractors, Propagation Delay; 4 hrs

Basic postulates and fundamental theorems of Boolean algebra; Standard representation of logic functions - SOP and POS forms; Simplification of switching functions - K-map; 4 hrs
Introduction to different logic families; Operational characteristics of BJT in saturation and cut-off regions; Operational characteristics of MOSFET as switch; TTL inverter - circuit description and operation; 4 hrs

CMOS inverter - circuit description and operation; Structure and operations of TTL and CMOS gates; Electrical characteristics of logic gates – logic levels and noise margins, fan-out, propagation delay; 6 hrs

Sequential Circuits: Definition of state machines, state machine as a sequential controller; Basic sequential circuits- latches and flip-flops: SR-latch, D-latch, D flip-flop, JK flip- flop, T flip-flop; Timing hazards and races; Analysis of state machines using D flip- flops and JK flip-flops 6 hrs
Design of state machines - state table, state assignment, transition/excitation table, excitation maps and equations, logic realization Sequential circuits and timing - Setup and hold times, Basics of static timing analysis, Setup and Hold time analysis. 8 hrs

System Design with Verilog HDL:.Introduction, Data types, Operators, Gate Level Modeling, Behavioral Modeling, Parameterized Modules, Synthesis using Verilog. Introduction to test-benches and testing of Registers, counters, sequential machines; 6 hrs

Logic design with Programmable Devices:, Verilog coding of digital design elements and building blocks, Synthesis, Place and Route; 4 hrs

References:

1. M. Morris Mano. Digital Design (5th. ed.). Prentice Hall PTR, USA.
2. Frank Vahid. Digital Design with RTL Design, VHDL, and Verilog, Second Edition.
3. David A Patterson and John L Hennessy. Computer Organiztion and Design: The Hardware and Software Interface, 5th Edition.

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Stream IV: Robotic Technologies

Stream Objectives:

This stream is designed to give additional edge to the students of this M.Tech. program by specializing in robotic technologies. With the basic knowledge acquired from core papers and from optoelectronic sensors, the student can apply these concepts to build engineering designs which involve mixed signal processing and control.

Stream Outcomes:

Students who take 2 or more electives from this stream would be familiar with fundementals of signals and images acquired from sensors. The students will be able to process them, apply these techniques to design robotic systems and program them.

PE-ROB-1: Embedded Signal Processing

Course Objectives:
This course covers the techniques of modern Digital Signal Processing that are fundamental to a wide variety of application areas. Special emphasis is laid on the architectures and design techniques for digital filters.

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

1. Design FIR and IIR filters by hand to meet specific magnitude and phase requirements.
2. Perform Z and inverse Z transforms using the definitions, Tables of Standard Transforms and Properties, and Partial Fraction Expansion.
3. Determine if a system is linear, time-invariant, causal, and memory less, determine asymptotic, marginal and BIBO stability of systems given in frequency domain.
4. Design and implement digital filters
5. Use computers to create, analyze and process signals, and to simulate and analyze systems sound and image synthesis and analysis

Syllabus:
Discrete time signals and Systems & Z-transforms: Discrete time systems, Linear time invariant systems and properties, Frequency Domain Representation of discrete time signals and systems, discrete time Fourier transform and properties, Z transform Definition, properties and Inverse z-transform 9 hrs

Discrete Fourier Transform & Fast Fourier Transform: Representation of Periodic sequences by Discrete Fourier series; Fourier transform of periodic signals; Sampling Fourier transform; Fourier representation of finite duration sequences by Discrete Fourier transform (DFT), properties of DFT, Linear convolution using the DFT (Overlap save and Overlap add methods), Computation of Discrete Fourier Transform (FFT): The Goertzel Algorithm, Decimation-in-Time FFT algorithm, Decimation-in-Frequency Algorithms 8 hrs

Introduction to Time-Frequency Analysis: Fundamentals of multi-rate systems: basic multi-rate operations (interpolation and decimation), Polyphase representation, Applications of multi-rate systems, Introduction to Short Time Fourier Transform (STFT) and limitations, Introduction to Wavelet transforms and relation to multi-rate filter banks. 8 hrs

Study of DSP Architectures: Basic Building blocks of DSP systems: ALU, Multipliers, Dividers, MAC, Barrel shifter, DSP processor architecture, Implementation considerations, finite word length effects 4 hrs

Digital Filters: Introduction, Specifications of practical filters. FIR Filters: Symmetric and anti-symmetric FIR filters, Design of linear phase FIR filter using Windows / optimization techniques. Design of Linear phase FIR Filters.FIR filters for harmonic elimination. IIR Filters: Design from Analog filters – Design by Approximation of Derivatives, Impulse Invariance and Bilinear Transfomation. IIR filters for extraction of fundamental frequency. 7 hrs

Digital Filters Realizations: Structures for the realization of Discrete time system – Structures for FIR systems – direct form structures, cascade form structures, frequency sampling structures, Lattice structures. Structures for IIR systems – Direct form structures, Cascade form structures, Parallel form structures and Analysis of Finite Word Length Effect and limit cycle oscillations in recursive systems. 7 hrs

References:

1. Discrete-Time Signal Processing, Alan V. Oppenheim and Ronald W. Schafer, Ed III, Pearson, 2010.
2. Digital Signal Processing - S. Salivahanan, Ed IV, McGraw Hill, 2019.
3. Multirate systems and Filter Banks by P.P.Vaidyanathan
4. Digital Signal Processing (with MATLAB), Sanjay Sharma, S. K. Kataria& Sons, Ed 5, 2010.
5. Digital Signal Processor Architecture, Programming and Application, by B.Venkataramani and M.Bhaskar, TMH 2002.

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Deepa.S

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PE-ROB-2: Adaptive Signal Processing

Course Objectives:

Adaptive signal processing concerns with processing of signals where the processing parameters are adjusted continuously to suit time varying signal environmental conditions. The study of adaptive signal processing involves development of various adaptation algorithms and assessing them in terms of convergence rate, computational complexity, robustness against noisy data, hardware complexity, numerical stability etc. This course demonstrates the design of an important class of adaptive filters. The students opting for this elective should have undergone PE-NC-3 as a prerequisite for this course.

Course Outcomes:

The student will be able to:

1. Explain the importance of signal processing in a non-stationary environment.
2. Explain the role and importance of adaptive signal processing in communications signal processing
3. List and apply the various mathematical models to adaptive signal processing.
4. Understand the problem of finding the minimum error criteria.
5. Use computer based simulation tools to understand the theoretical concepts of adaptive signal processing in various communication applications.

Syllabus:

Introduction to Adaptive Filters: 4 hrs

1. Adaptive filter structures, issues and examples.
2. Applications of adaptive filters:
   a. Channel equalization, active noise control
   b. Echo cancellation, beamforming.

Discrete time stochastic processes: 8 hrs

1. Re-visiting probability and random variables.
2. Discrete time random processes.
3. Power spectral density - properties.
4. Autocorrelation and covariance structures of discrete time random processes.
5. Eigen-analysis of autocorrelation matrices.

Wiener filter, search methods and the LMS algorithm: 8 hrs

1. Wiener FIR filter (real case).
2. Steepest descent search and the LMS algorithm.
3. Extension of optimal filtering to complex valued input.
4. The Complex LMS algorithm.

Multi Rate Analysis and DWT: 10 hrs

1. Need for Scaling function.
2. Multi Resolution Analysis, Two Channel Filter Banks, Perfect Reconstruction Condition.
3. Relationship between Filter Banks and Wavelet Basis.
4. DWT, Structure of DWT Filter Banks.
5. Daubechies Wavelet Function, Applications of DWT.

6. Application of Multirate signal processing: Subband Coding of Speech Signals, Quadrature Mirror Filters, Transmultiplexers, Over Sampling A/D and D/A Conversion

Introduction to Modern Spectral Analysis & Estimation: 12 hrs

1. Spectrum Estimation: Introduction, Correlogram method, Periodogram Computation via FFT, properties of Periodogram method such as bias analysis, window design considerations
2. Parametric Methods for line Spectra: Models of sinusoidal Signals in Noise, Non-linear least squares method. High Order Yule Walker method, Min – Norm Method, ESPRIT Method, Forward – Backward Estimation

References

1. S. Haykin, Adaptive Filter Theory, Pearson Education, V Ed., 2013.
2. MilicLjiljana, Multirate Filtering for Digital Signal Processing: MATLAB Applications, Information Science Reference (IGI Global), 2009.
3. S. M. Kay, Modern Spectral Estimation: Theory and Application, Prentice Hall, 1999.

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PE-ROB-3: Image Processing and Computer Vision

Course Objectives:

1. To study the image fundamentals and mathematical transforms necessary for image processing.
2. To study the image enhancement and compression techniques
3. Fundamentals of Computer Vision and Machine Learning in Image Processing

Course Outcomes:

1. Review the fundamental concepts of a digital image processing system.
2. Analyze images in the frequency domain using various transforms.
3. Evaluate the techniques for image enhancement and image restoration.
4. Understanding various compression techniques.

Syllabus:

Fundamental Steps in Digital Image Processing - Components of an Image Processing System-Digital Image Fundamentals Image Sampling and Quantization-Representing Digital Images - Spatial an Gray-Level Resolution, Image Enhancement in the Spatial Domain. Power-Law Transformations, Histogram Equilization, Laplatian Filters, Image Enhancement in the Frequency Domain. 8 hrs

Color Image Processing Color Fundamentals -Color Models -The RG13 Color Model - The CMY and CMYK Color Models -The HSI Color Model – Pseudocolor Image Processing. 5 hrs

Image Compression Fundamentals - Variable-Length Coding, Lossless and Lossy Compression, Predictive Coding. Image Compression Standards – Jpeg- Mpeg-1 &2 standards- 6 hrs

Image Segmentation- Boundary Detection, Thresholding, Region-Based Segmentation - Segmentation by Morphological Watersheds; 5 hrs

Image Descriptors and Features: Texture Descriptors, Colour Features, Edges/Boundaries. Object Boundary and Shape Representations. Interest or Corner Point Detectors, Histogram of Oriented Gradients, Scale Invariant Feature Transform, Speeded up Robust Features, Saliency. 8 Hrs

Fundamentals of Machine Learning: Linear Regression, Basic Concepts of Decision Functions, Elementary Statistical Decision Theory, Parameter Estimation, Clustering for Knowledge Representation, Dimension Reduction, Linear Discriminant Analysis. 6 hrs

Applications of Computer Vision: Artificial Neural Network for Pattern Classification, Convolutional Neural Networks, Autoencoders. Gesture Recognition, Motion Estimation and Object Tracking, Programming Assignments. 4 hrs

References:

1. Digital Image Processing by Rafael. C. Gonazalez & Richard E. Woods. IInd Edn, Pearson Education, 2002.
2. Fundamentals of Digital Image Processing by Anil. K. Jain, Eastern Economy Edn, Prentice Hall of India 1997.
3. Forsyth & Ponce, "Computer Vision-A Modern Approach", Pearson Education.
4. M.K. Bhuyan , " Computer Vision and Image Processing: Fundamentals and Applications", CRC Press, USA, ISBN 9780815370840 - CAT# K338147.
5. Richard Szeliski, "Computer Vision- Algorithms & Applications", Springer.

PE-ROB-4: Robotic Instrumentation and Sensors

Course Objectives: To introduce the concepts of Robotic system, its components and instrumentation and control related to robotics

Course Outcomes:

1. To be able to represent a system using a transfer function and perfirm measurement and calibration
2. To understand and appreciate different error analysis techniques
3. To evaluate a problem and apply the right transducer and sensor for the application

Syllabus

Measurement and Characteristics: Elements of a Measurement System; Classification of Instruments; Static Performance Parameters; Loading and Impedance Matching; Errors and Uncertainties in Measurement; Process and Standards of Calibration; Dynamic Characteristics- Transfer Function Representation of a Measurement System, Impulse and Step Responses of First and Second Order Systems, Frequency Response of First and Second Order Systems; 10 hrs

Error Analysis: Types of errors, Methods of error analysis, uncertainty analysis, statistical analysis, Gaussian error distribution, chi- square test, correlation coefficient , students T – test, method of least square , curve fitting, graphical analysis. Electrical Measurement: DC measurements, DC voltmeter, Ammeter ohmmeter, digital type voltmeter, Ammeter ohmmeter, AC measurement, Ammeter, ohmmeter; 10 hrs

Transducers: Principles and classification of transducers, guidelines for selection and application of transducers, basic requirements of transducers. Different types of transducers. Display Devices and Recorders: Telemetry & Remote sensing, GIS (Geographical information System), various display devices and Recorder, CRO (basic block diagram, deflection sensitivity, application: voltage, current, frequency and phase angle measurement). Digital R-L-C meters, digital frequency Meter and Universal Counter. 12 hrs

Sensors: Classification, characteristics and calibration of different sensors, position sensors, motion sensors, force sensors, torque sensors, strain gauge sensors, pressure flow sensors, temperature sensors, smart sensors, tactile and proximity sensors, opto-electrical sensor, Principles and structures of modern micro sensors. 10 hrs

Text Books:

1. D.V.S. Murthy, "Transducers and Instrumentation", PHI 2003.
2. Albert D Helfrick and William D Cooper, "Modern Electronic Instrumentation and Measurement Techniques" 2004, PHI.
3. Nakra and Chaudhry, "Instrumentation, Measurement and Analysis", Tata McGraw-Hill.

Reference Books:

1. C.S. Rangan, G.R. Sarma, and V.S.V. Mani, "Instrumentation Devices and Systems", Tata McGraw-Hill
2. S.K. Singh, "Industrial Instrumentation and Control" Tata Mcgrow-Hill (Third Edition).
3. K. Krishnaswamy and S. Vijaychitra, "Industrial Instrumentation", New Age International Publishers, Second Edition.
4. Doeblin and Ernest, "Measurement Systems Application and Design", Tata McGraw-Hill 2004.

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PE-ROB-5: Robot Programming

Course Objectives

The course is designed to provide candidates with the skills needed to program an industrial articulated robotic arm after understanding its anatomy and components.

Course Outcomes:

1. Demonstrate basic skills of programming ROS nodes
2. Describe and apply basics of robot and environment modelling for simulations
3. Demonstrate understanding of RTOS concepts and intraprocess communication
4. Demonstrate an ability of developing interface and control of robotic systems using ROS

Syllabus

Basics Of Robot Programming: Robot programming-Introduction-Types- Flex Pendant-Lead through programming, Coordinate systems of Robot, Robot controller- major components, functions-Wrist Mechanism-Interpolation-Interlock commands-Operating mode of robot, Jogging Types, Robot specifications- Motion commands, end effectors and sensors commands. 8 hrs

VAL Language: Robot Languages-Classifications, Structures- VAL language commands-motion control, hand control, program control, pick and place applications, palletizing applications using VAL, Robot welding application using VAL program-WAIT, SIGNAL and DELAY command for communications using simple applications. 9 hrs

RAPID LANGUAGE RAPID: language basic commands- Motion Instructions-Pick and place operation using Industrial robot- manual mode, automatic mode, subroutine command based programming. 8 hrs

Practical Study of Virtual Robot: Robot cycle time analysis-Multiple robot and machine Interference-Process chart problems-Virtual robotics, Robot studio online software-Introduction, Jogging, components, work planning, program modules, input and output signals-Singularities. Collision detection-Repeatability measurement of robot-Robot economics. 9 hrs

VAL-II and AML: VAL-II programming-basic commands, applications- Simple problem using conditional statements- pick and place applications-Production rate calculations using robot. AML Language-General description, elements and functions, Statements, constants and variables-Program control statements- Operating systems, Motion, Sensor commands-Data processing. 8 hrs

Books and References:

1. Deb. S. R. "Robotics Technology and Flexible Automation", Tata McGraw Hill publishing company limited, 1994
2. Mikell. P. Groover, "Industrial Robotics Technology", Programming and Applications, McGraw Hill Co, 1995.
3. Klafter. R.D, Chmielewski.T.A and Noggin's, "Robot Engineering : An Integrated Approach", Prentice Hall of India Pvt. Ltd.,1994.
4. Fu .K. S, Gonzalez .R. C. & Lee .C.S.G, "Robotics Control, Sensing, Vision and Intelligence", McGraw Hill Book co, 1987.

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PE-ROB-6: Fundamentals of AI for Robotics

Course Objectives

This course will teach basic methods in Artificial Intelligence, including probabilistic inference, planning and search, localization, tracking and control, all with a focus on robotics.

Course Outcomes

1. Describe human intelligence and AI and explain how intelligent system work.
2. Apply basics of Fuzzy logic and neural networks.
3. Apply concepts like Kalman Filters and particle filters in Robotic Design
4. Demonstrate and Illustrate functionalities of Robots and Robotics.

Syllabus

Localization: Localization, Total Probability, Uniform Distribution, Probability After Sense, Normalize Distribution, P_{hit} and P_{miss}, Sum of Probabilities, Sense Function, Exact Motion, Move Function, Bayes Rule, Theorem of Total Probability; 6 hrs

Kalman Filters: Gaussian Intro, Variance Comparison, Maximize Gaussian, Measurement and Motion, Parameter Update, New Mean Variance, Gaussian Motion, Kalman Filter Code, Kalman Prediction, Kalman Filter Design, Kalman Matrices; 8 hrs

Particle Filters: Slate Space, Belief Modality, Particle Filters, Using Robot Class, Robot World, Robot Particles; 4 hrs

Search: Motion Planning, Compute Cost, Optimal Path, First Search Program, Expansion Grid, Dynamic Programming, Computing Value, Optimal Policy; 6 hrs

PID Control: Robot Motion, Smoothing Algorithm, Path Smoothing, Zero Data Weight, PID Control, Proportional Control, Implement P Controller, Oscillations, PID Controller, Systematic Bias, PID Implementation, Parameter Optimization; 8 hrs

SLAM (Simultaneous Localization and Mapping): Localization, Planning, Segmented Ste, Fun with Parameters, SLAM, Graph SLAM, mplementing Constraints, Adding Landmarks, Matrix Modification, Untouched Fields, Landmark Position, Confident Measurements, Implementing SLAM. 10 hrs

Books

1. Sebastian Thrun, Dieter Fox, Wolfram Burgard, "Probabilistic Robotics", MIT Press
2. Russell Stuart, Norvig Peter, "Artificial Intelligence Modern Approach", Pearson Education series in AI, 3rd Edition, 2010.

References:

1. Grisetti, Giorgio, et al. "A tutorial on graph-based SLAM." Intelligent Transportation Systems Magazine, IEEE 2.4 (2010): 31-43.
2. Thrun, Sebastian. "Robotic mapping: A survey." Exploring artificial intelligence in the new millennium (2002): 1-35.
3. Durrant-Whyte, Hugh, and Tim Bailey. "Simultaneous localization and mapping: part I." Robotics & Automation Magazine, IEEE 13.2 (2006): 99-110.
4. Bailey, Tim, and Hugh Durrant-Whyte. "Simultaneous localization and mapping (SLAM): Part II." IEEE Robotics & Automation Magazine 13.3 (2006): 108-117.

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OPEN ELECTIVES (OE)

OE-1: Introduction to Virtualization Technologies

Course Objectives:

The purpose of this course to introduce students to the fundamentals of Virtualization technologies

Course Outcomes:

1. Gain understanding of Virtualization techniques,
2. Appreciate differences in hardware and software virtualization,
3. Work with Intel VT-x and AMD-V instructions and data structures for multi-processor and multi-core systems;
4. Understand memory virtualization and management.

Syllabus:

Introduction: Virtualization approaches, its uses and monetization, Processor virtualization theory – trap and emulate, Virtualization techniques – para virtualization, full virtualization, ring aliasing and binary translation. 6 hrs

Hardware Technology: Intel VT-x instructions, operating modes, processor data structures, MSRs, multi-processor and multi-core systems working with Intel VT-x. AMD-V instructions and data structures. Virtualization of Interrupts – handling and performance. SMP guests and performance. Security features. Hardware and software virtualization differences. 12 hrs

Resource Virtualization: Memory virtualization and management – Intel extended page tables and AMD nested page tables. Device virtualization. Virtualized NICs. PCI Express IOV, Intel VT-d and AMD IOMMU solutions. 12 hrs

Case Study: VMWare, Microsoft, XEN, LXC, KVM; 12 hrs

References:

1. Sean Campbell, Michael Jeronimo, Applied Virtualization Technology - Usage Models for IT Professionals and Software Developers, Intel Press, 2006.
2. Tom Clark, Storage Virtualization: Technologies for Simplifying Data Storage and Management, Addison-Wesley Professional (2005).
3. Chris Wolf, Erick M. Halter, Virtualization: From the Desktop to the Enterprise, Apress, 2008.

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OE-2: Software Engineering

Course Objectives:
The purpose of this course to introduce students to the conceptualization, design, testing and comparison of application specific software.

Course Outcomes:

1. Correctly create a model of the structure and behavior of a software system.
2. Design and implement, in a programming language, an executable solution to a given problem using common software principles and best practices.
3. Apply appropriate software testing techniques and evaluate the quality of a software product at module, integration, and system granularity levels.
4. Select and adapt suitable elements from among conventional and evolving software development life-cycle processes and apply the resulting process to a software project.

Syllabus:

Introduction: The Problem Domain, S/W Engineering Challenges, S/W Engineering Approach. Software Processes: Software Process, Desired Characteristics, Development Process Models, Other Software Processes. 5 hrs

Software Requirements Analysis and Specification: Software Requirements, Problem Analysis, Requirements Specification, Functional Specification with Use Cases, Validation, metrics 7 hrs

Planning a software project: Planning Process, Effort Estimation, Project Scheduling and Staffing, Software Configuration Management Plan, Quality Plan, Risk Management, Project Monitoring Plan 8 hrs

Function oriented design: Design Principles, Module Level Concepts, Design Notation and Specification, Structured Design Methodology, Verification, Metrics 7 hrs

Object oriented design: OO Analysis and Design, OO Concepts, Design Concepts, UML Design Methodology, Metrics. Detailed design: Detailed Design, PDL, Verification, Metrics. 8 hrs

Coding &Testing: Programming Principles and Guidelines, Coding Process, Refactoring, Verification, Metrics, Testing fundamentals, Black-box Testing, White-box Testing, Testing Process, Defect Analysis and Prevention 7 hrs

References:

1. Pankaj Jalote, An Integrated Approach to Software Engineering, 3rd Ed., Narosa Publishing House, 2005.

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OE-3: Microfluidics: Devices and Applications

Course Objectives:
The purpose of this course is to introduce students to the basics of microfluidics and their state-of-the-art applications.

Course Outcomes:
1. Understand the relative merits of various types of microfluidics technologies and be able to choose the right technology based on the application.
2. Understand the basic physics, of microfluidic devices and solve problems, with specific reference to opto-fluidic devices.
3. Have basic knowledge of soft lithography, femtosecond laser micromachining and related printing technologies, and also be able to choose the best suited method for a specific microfluidic device fabrication.
4. Be able to design a microfluidic sensor for a specific application related to bio-medical / chemical sensing

Syllabus:

Introduction and General overview of Applications: Microfluidics classification; Glass, Polymer and Paper based microfluidics their advantages and limitations 9 hrs

Basic principles in microfluidics: General principles of microfluidic flow, Design principles for microfluidic devices. 9 hrs

Device fabrication: Soft lithography, femtosecond laser processing, printing technologies 12 hrs

Optofluidic Device Applications: Biological, chemical and optical sensing applications, point-of-care diagnostics and drug discovery 12 hrs

References:

1. Patric Tabeling, Introduction to Microfluidics, Oxford University Press,2005.
2. Frank A. Gomez (Editor), Biological Applications of Microfluidics, Wiley,2008.
3. Roberto Osellame, Giulio Cerullo, Roberta Ramponi (Ed), Femtosecond laser micromachining, I Ed., Springer, 2012.
4. Sang-Joon John Lee, Narayan Sundararajan, Microfabrication for Microfluidics, Artech House, 2010.
5. Trung Nguyen and Stev, Fundamentals and Applications of Micro- fluidics,2nd Ed. Artech House; 2006.

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OE-4: Biomedical Signal Processing

Course Objectives:

1. To understand the basic signals in the field of biomedical.
2. To study origins and characteristics of some of the most commonly used biomedical signals, including ECG, EEG, evoked potentials, and EMG.
3. To understand Sources and characteristics of noise and artifacts in bio signals.
4. To understand use of bio signals in diagnosis, patient monitoring and physiological investigation

Course Outcomes:

1. Understand the model a biomedical system.
2. Understand various methods of acquiring bio signals.
3. Understand various sources of bio signal distortions and the remedial techniques.
4. Understand and Analyze ECG signal with characteristic feature points.
5. Understand and Analyze EEG signals and related signal processing methods.
6. Understand and Analyze EMG signals and related signal processing methods.
7. Have an understanding of diagnosing bio-signals and classifying them.

Syllabus:

Introduction: Characteristic of medical data, medical instrument, microprocessor-based medical instrument. Genesis and significance of bio electric potentials, fundamentals of ECG, EOG, EMG and their monitoring /measurement 8 hrs

Digital filtering for Biomedical Signals: Finite Impulse Response filters: - smoothing filters, Notch filters, Derivatives, window design, Frequency sampling and minimax design. Infinite impulse response filters: - simple one-pole example, integrators, Two-pole filters, IIR digital filters for ECG analysis. Integer filters: - Low-pass, high-pass, Bandpass and band-reject integer filters, Integer filters for ECG analysis. Adaptive filters: - Principal noise canceler model, 60Hz adaptive canceling using a sine wave model, AR, ARMA models. 12 hrs

ECG – Pre-processing, measurements of amplitude and time intervals, classification, QRS detection, ST segment analysis, Base line wander removal, waveform recognition, morphological studies and rhythm analysis, automated diagnosis based on decision theory ECT compression 8 hrs

EEG: Evoked responses, Epilepsy detection, Spike detection, Hjorth parameters, averaging techniques, removal of artifacts by averaging and adaptive algorithms 7 hrs

EMG- Wave pattern studies, bio feedback, Zero crossings, Integrated EMG, Time Frequency methods and Wavelets in Biomedical signal processing. 7 hrs

References:

1. N. Vyas & S. Khalid, "Biomedical Signal Processing", University Science Press, 2012.
2. Willis J Tompkins, ED, "Biomedical Digital Signal Processing", Prentice-Hall of India, 1996.
3. Willis J. Tompkins, "Biomedical Digital Signal Processing: C-Language examples and Laboratory Experiments for the IBM PC", PHI, 1998.

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OE-5: Data Structures and Algorithms

Course Objectives:

1. To provide the knowledge of basic data structures and their implementations.
2. To understand importance of data structures in context of writing efficient programs.
3. To develop skills to apply appropriate data structures in problem solving

Course Outcomes:

1. Assess how the choice of data structures and algorithm design methods impacts the performance of programs.
2. Choose the appropriate data structure and algorithm design method for a specified application.
3. Write programs using object-oriented design principles.
4. Solve problems using data structures such as linear lists, stacks, queues, hash tables, binary trees, heaps, tournament trees, binary search trees, and graphs and writing programs for these solutions.
5. Solve problems using algorithm design methods such as the greedy method, divide and conquer, dynamic programming, backtracking, and branch and bound and writing programs for these solutions.

Syllabus:

Models of Computation; representations of algorithms; the concept of problem size; performance of algorithms: space and time complexity measures, asymptotics, worst case and average case analyses, lower and upper bounds. 8 hrs

Operations on data; elementary Data structures: linked lists, arrays, matrices, stacks, queues, binary trees, trees, heaps; tree traversals; linear search and binary search; priority queues: lists and heaps. 10 hrs

Sorting algorithms: insertion-sort, bubble-sort, selection sort, shellsort, quicksort, mergesort, heapsort; Analysis of sorting algorithms; lower bound for sorting; selection. 10 hrs

Search Trees: binary search trees, (a,b)-trees, red-black trees, AVL trees, splay trees, B-trees. 5 hrs

Graphs: representations, depth first search, breadth first search, connectivity. 4 hrs

Hashing: separate chaining, linear probing, quadratic probing. The disjoint-set union-find data structure (without the amortized analysis). Strings, suffix arrays, tries. 5 hrs

References:

1. M. A. Weiss, Data Structures and Algorithm Analysis in C++, 4th Edition, Pearson, 2014.
2. T. H. Cormen, C. F. Leiserson, R. L. Rivest, C. Stein, Introduction to Algorithms, 3rd Edition, MIT Press, Prentice Hall of India, 2009.
3. Brass, Peter. Advanced Data Structures. Cambridge University Press, 2008.

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OE-6: Computer Organization and Architecture

Course Objectives:
The purpose of this course to introduce students to the structure and components of a computer, design of memory hierarchy and I/O

Course Outcomes:
1. Understand the structure, function and characteristics of computer systems.
2. Understand the design of the various functional units and components of computers.
3. Identify the elements of modern instructions sets and their impact on processor design.
4. Explain the function of each element of a memory hierarchy
5. Identify and compare different methods for computer I/O.

Syllabus
Arithmetic algorithms: Overview of basic digital building blocks; truth tables; basic structure of a digital computer; Number representation: Integer - unsigned, signed (sign magnitude, 1's complement, 2's complement); Characters - ASCII coding, other coding schemes; Real numbers - fixed and floating point, IEEE754 representation. Basic building blocks for the ALU: Adder, Subtractor, Shifter, Multiplication and division circuits 8 hrs

Hardware description language: Introduction to some HDL (Verilog, VHDL, BSV). Digital Design using HDLs 8 hrs

CPU: CPU Sub-block: Datapath - ALU, Registers, Instructions, Execution of Instructions; CPU buses; Control path - microprogramming, hardwired logic; External interface. Advanced Concepts: Pipelining; Introduction to Advanced Processors (multiprocessors and multi-cores). Examples of some well-known processors 10 hrs

Memory: Memory Sub-block: Memory organization; Technologies - ROM, RAM, EPROM, Flash, etc., Virtual Memories. Cache: Cache algorithms, Cache Hierarchy, Cache coherence protocols. Advanced concepts: Performance, Interleaving, On chip vs Off chip Memories/Caches 8 hrs

I/O and Peripherals: I/O Sub-block: I/O techniques - interrupts, polling, DMA; Synchronous vs. Asynchronous I/O; Controllers. Peripherals: Keyboard, Mouse, Monitors, Disk drives, etc. 8 hrs

References:

1. Computer Organization and Design: The Hardware/Software Interface, David A Patterson, John L. Hennessy, 4th Edition, Morgan Kaufmann, 2009
2. Computer Architecture and Organization by William Stallings, PHI Pvt. Ltd., Eastern Economy Edition, Sixth Edition, 2003
3. Structured Computer Organization by Andrew S Tanenbaum, PHI/Pearson, 4th Edition

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OE-7: Basics of Managing a Business

Course Objectives

To acquaint Post Graduate students of diverse programs (who are not MBA), with the basic concepts of managing a business. Introduce the students to business challenges in the modern context. Practical sharing of real-world examples would introduce students of sciences, mathematics, arts, or other subjects, to the context of the business world, and introduce them to an entrepreneurial mindset.

Course Outcomes

At the end of the course, the students would be able to explain and apply basic concepts of managing a business including Marketing, Finance and Human Resource Management.

Syllabus

Strategic Marketing: Introduction to Marketing, Analysing Consumer markets, Identifying Market Segments, Targeting & Positioning. Developing Marketing Strategies & Plan - SWOT analysis. 7 P's strategies Product, Price, Place, Promotion, People, Process, Planet. Competitive Advantage. Digital Marketing and Communication. Brand and developing a strong brand 12 hrs

Financial Management & Accounting: Introduction basics of financial statements - P&L statement, Balance sheet, and Cash-flow. Ratio analysis. Cost Volume Profit Analysis. Discounted Cash Flow, Time value of money, Internal Rate of Return 10 hrs

Human Resource Management & Organizational Development: Nature, Scope, Context, and Challenges of HRM. Importance of leadership and Change management in business 6 hrs

Basics of Business strategy: Introduction to strategy: Identification of Opportunities & Threats, Porter's 5 forces analysis. Distinctive Competencies, Competitive Advantage, and Profitability 7 hrs

Operations: Introduction, Competitive advantage through operations, Effectiveness (Quality management) and Efficiency of processes, Basics of supply chain management and inventory management 7 hrs

Text Books

1. Philip Kotler, Kevin Lane Keller -- *Marketing Management*, Pearson India. 15th edition, ISBN 978-93-325-5718-5
2. Essentials of Corporate Finance, Ross, Westerfield, and Jordon; McGraw Hill, 9e, 2017
3. K. Aswathappa- *Human Resource Management - Text and Cases* - 7th Edition, Publisher: McGraw Hill Education; May 2013, ISBN-10: 1259026825, ISBN-13: 978-1259026829.
4. Hongren, Charles T, Cost accounting: a managerial emphasis, Pearson 15e, 2016
5. Charles L. Hill, and Gareth R. Jones -- *Strategic Management-An Integrated Approach* Cengage; 9 edition (2012). ISBN: 978-8131518373.
6. Refer to material distributed in the class.

Reference books

1. Al Ries, Jack Trout, *Positioning: The Battle for Your Mind.* McGraw Hill Education; 70th edition, ISBN: 978-0070533752.
2. Seth Godin, *All Marketers Tell Stories: The Underground Classic That Explains How Marketing Really Works--and Why Authenticity Is the Best Marketing of All.* Penguin USA; Reprint edition (2012).ISBN-13: 978-1591845331
3. Philip Kotler, *Marketing 4.0: Moving from Traditional to Digital.* Wiley (2017). ISBN: 978-8126566938
4. *Purple Cow: Transform Your Business by Being Remarkable.* Seth Godin. Penguin UK; Latest Edition edition (2005). ISBN: 978-0141016405
5. W. Chan Kim and Renée Mauborgne, *Blue Ocean Strategy: How to Create Uncontested Market Space and Make the Competition Irrelevant.* Harvard Business Press; 1 edition (2015), ISBN: 978-1625274496
6. HBR articles: 'Marketing Myopia' (Theodore Levitt); 'Core Competence of the Corporation' (CK Prahalad, Gary Hammel, HBR May-June 1990); Marketing is Everything (Regis McKenna, HBR Jan-Feb 1991), 'What is Strategy' (Michael E. Porter HBR Nov-Dec 1996). 'Analysing Consumer Perceptions' (Robert J. Dolan HBR Dec 2001). "Marketing Success through Differentiation—of Anything" (Theodore Levitt).

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