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(Accredited by NAAC)

GU/Acad –PG/BoS -NEP/2023/85/4 Date:29.05.2023

Ref: GU/Acad –PG/BoS -NEP/2022/339/9 dated 20.08.22

CIRCULAR

In supersession to the above referred Circular, the updated approved Syllabus with revised Course Codes of the **Master of Science in Electronics** Programme is enclosed.

The Dean/ Vice-Deans of the School of Physical and Applied Sciences are requested to take note of the above and bring the contents of the Circular to the notice of all concerned**.**

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2023.05.29 17:11:40 +05'30'

(Ashwin Lawande)
Assistant Registrar – Academic-PG

To,

1. The Dean, School of Physical and Applied Sciences, Goa University.
2. The Vice-Deans, School of Physical and Applied Sciences, Goa University.

Copy to:

1. The Chairperson, Board of Studies in Electronics.
2. The Programme Director, M. Sc. Electronics, Goa University.
3. The Controller of Examinations, Goa University.
4. The Assistant Registrar, PG Examinations, Goa University.
5. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

Goa University

M.Sc. Electronics Programme Course Syllabus as per NEP 2020

Semester	Course Code	Course Title	Theory/ Lab	Course Credits	Contact Hours
Semester I	**Discipline Specific Core Courses (DSCC)**				
	ELE-500	Micro Electronics and VLSI Design	Theory	4	60
	ELE-501	Instrumentation & Control Theory	Theory	4	60
	ELE-502	Advanced Digital Communication System	Theory	4	60
	ELE-503	Electronics Practical I	Lab	4	120
	Discipline Specific Elective Courses (DSEC)				
	ELE-521	Numerical Computation and Algorithms	Theory	4	60
	ELE-522	EDA Tools	Theory	4	60
Semester II	**Discipline Specific Core Courses (DSCC)**				
	ELE-504	Embedded System Design	Theory	4	60
	ELE-505	Real Time Operating System	Theory	4	60
	ELE-506	Digital System Design	Theory	4	60
	ELE-507	Electronics Practical II	Lab	4	120
	Discipline Specific Elective Courses (DSEC)				
	ELE-523	Internet of Things	Theory	4	60
	ELE-524	Switching and Routing	Theory	4	60
Semester III	**Research Specific Elective Courses (RSEC)**				
	ELE-600	Signals and Systems	Theory	4	60
	ELE-601	Artificial Intelligence and Applications	Theory	4	60
	ELE-602	Robotics	Theory	4	60
	Elective Generic Course (EGC)				
	ELE- 621	Laser System Engineering	Theory	4	60
	ELE- 622	Data Science and Machine Learning	Theory	4	60
	ELE- 623	Electric Vehicle Technology	Theory	4	60
	ELE- 624	Biomedical Instrumentation	Theory	4	60
Semester IV	**Research Specific Elective Courses (RSEC)**				
	ELE-603	Optical Communication Systems	Theory	4	60
	ELE-604	Digital Image Processing	Theory	4	60
	ELE-605	Neuromorphic Computing	Theory	4	60
	Discipline Specific Dissertation (DSD)				
	ELE-625	Project	Dissertation	16	480

Semester I

Course Code: ELE-500
Course Title: Micro Electronics and VLSI Design
Number of Credits: 04 **Total Hours: 60** **Total Marks: 100**
Effective from AY: 2022-23

Prerequisites for the course		
Should have graduate level knowledge in analog and digital electronics		
Objectives of Course		
This course is intended to: ● Introduce to the VLSI Technology, various fabrications processes involved in IC design , ● Analysis of Electronics circuits, Design examples of VLSI circuits, Circuit Optimization techniques ● Advance circuits designs: Memory, Registers, Synchronous circuits etc.		
Course Content		
Unit I	An overview of VLSI, Modern CMOS Technology	**4 Hours**
Unit II	Silicon Logic, Logic design with MOSFET.	**6 Hours**
Unit III	Physical structure of CMOS Integrated circuits	**6Hours**
Unit IV	Fabrication Technologies of CMOS Integrated Circuits	**7 Hours**
Unit V	Elements of Physical Design	**4 Hours**
Unit VI	Electrical characteristics of MOSFETS	**6 Hours**
Unit VII	Electronic analysis of CMOS Logic gates	**6 Hours**
UNIT VIII	Advanced Techniques in CMOS Logic Circuits	**6 Hours**
UNIT IX	System specifications using HDL, General VLSI	**5 Hours**

	components	
UNIT X	Memories and Programmable Logic	**10 Hours**

Pedagogy

Lectures/Experiential Learning

Course Outcome

Students will,

- Design fundamental gates and customize them for specific electrical and electronics application,
- Understand the fabrications processes involved in VLSI technology,
- Write the Hardware descriptive form of circuits, Synchronize the combinational and sequential circuits, design a static and dynamic memory cell,
- Understand the Programmable logics building blocks

References/Readings

1. Introduction to VLSI Circuits and Systems, John P. Uyemura, WILLEY.
2. Principles of CMOS VLSI Design, N.H.E. W. & Eshahiraghian, Addison Wesley
3. Modern VLSI Design System on Silicon, Pearson Education Asia. By W. Wolf.
4. VLSI Technology, S.M. Sze, McGraw -Hill (1995). 5.Basic VLSI Design, Douglas Pucknell, K. Eshraghian, Prentice Hall India.

Course Code: ELE-501
Course Title: Instrumentation & Control Theory
Number of Credits: 04 **Total Hours: 60** **Total Marks: 100**
Effective from AY: 2022-23

Prerequisites for the course		
knowledge of analog and digital electronics, Basics of differential equations.		
Objectives of Course		
This course is intended to: ● Introduce principles of transduction and actuator. ● Explain the important parameters used in instrument characterization, Types of error committed by a user and how to deal with them. ● Describe various standards followed for accurate measurement. ● Explain the techniques used to convert analog data into digital domain and its analysis and storage. ● Understand instruments such as Oscilloscope, spectrum analyzers, wave analyzers, Lock in amplifiers depth. ● Fundamentals of control theory and working of PID controller tuned for a given application.		
Course Content		
Unit I	**Introduction**	**8 Hours**
Basic Concepts of measurements, Calibrations and standards, Transducers: Types and parameters, Sensors - Displacement, Strain, Vibration, Pressure, Flow, Temperature, Force and Torque		
Unit II	**Signal Conditioning**	**8 Hours**
Introduction, Amplification, Simple ended amplifier, Instrumentation amplifier, Types of Filters		
Unit III	**Sampling**	**8 Hours**
Fundamental concepts, Anti-aliasing, Multiplexers, Sample and Hold, Track and Hold.		
Unit IV	**Computer Interfaces**	**08 Hours**
Serial (RS-232), Parallel, GPIB (IEEE-488), Universal Serial Bus (USB) and Variants, Bluetooth		
Unit V	**Display Devices**	**10 Hours**
Review of LED, LCD, Plasma display devices, segmental and dot matrix displays, MEMS display		
Unit VI	**General Purpose Test Equipments**	**08 Hours**

CRO, Digital storage oscilloscope, Digital voltmeter, Wave Analyser, Spectrum analysis, Lock-in-amplifiers, Pulse generators and waveform generators		
Unit VII	**Control System**	**10 Hours**
Types of control system - open loop, closed loop, linear, non-linear, continuous, discrete, frequency and time response, open loop motor control, Principles of PD, PI, PID		
Pedagogy		
Lectures/Experiential Learning		
Course Outcome		
students will: ● Explain measurement parameters, calibrations and standards in electronic instrumentation. ● Comprehend the significance of signal conditioning and sampling theorem. ● Gain the knowledge of various computer interfaces, and understand the construction, working principle of different display devices and general-purpose equipments used in signal analysis. ● Explain the working principle of different types of control systems.		
References/Readings		
1. H. S. Kalsi, 'Electronic Instrumentation', Tata MacGrow-Hill 2.Joseph J. Carr, 'Elements of Electronic Instrumentation and Measurement', Prentice Hall India. 3.Albert Helfnick and William Cooper, 'Modern Electronic Instrumentation and Measurement Techniques', Prentice Hall India. 4.Robert Northrop, 'Introduction to Instrumentation and Measurements', CRC Press		

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Course Code: ELE-502
Course Title: ADVANCED DIGITALCOMMUNICATION SYSTEMS
Number of Credits: 04 Total Hours: 60 Total Marks: 100
Effective from AY: 2022-23

Prerequisites for the course		
Graduate level understanding in basics of Electronic Communications		
Objectives of Course		
This course is intended to: ● Introduce to students with basics of wireless systems – concepts, theory. ● Covers various modulation techniques, to enable the student to synthesize and ● analyse wireless and mobile cellular communication systems over a stochastic fading channel ● Mitigation and diversity techniques		
Course Content		
Unit I	**Introduction to Mobile and Cellular Communication Systems:**	**5 Hours**
Definitions, impact of Mobile and Cellular Radio Communication Historical overview. Fundamental of Radio Mobile and Cellular Practices Radio mobile links and cells, Frequency re-use, Principles of Cellular Com. Mobile Telephone Switching Subsystem, The mobile frequency spectrum, Hand-off, Cochannel and adjacent channel interference limitations, Near-far problem, Power Control.		
Unit II	**Mobile Communication Channel including antennas**	**10 Hours**
The mobile wireless propagation channel, Notions on antennas especially the near and far field concept, Line of Sight (LOS) propagation, Multipath fading , outdoor and Indoor Propagation, Flat and selective fading, Special antennas for base stations and headsets, Deterministic, Empirical and Statistical Methods for propagation link computations.		
Unit III	**Overview of Mobile and Cellular Radio Communication Modulation and Detection Techniques:**	**15 Hours**
Analog modulations and detection: AM, FM, PM, ACSB, Hybrid and Digital modulation: PCM, ASK, FSK, QPSK, QAM, MSK, etc, Coherent and noncoherent detection, C/N, S/N, Eb/No and BER relations, Probability concepts, Mobile Radio links parameters.		
Unit IV	**Overview of Multiple Accesses Techniques**	**12 Hours**
Simplex, Duplex TDD and Time Division Duplex, Time division multiple access (TDMA) FDMA and OFDM, Code Division multiple access (CDMA), Hybrid multiple access, Management of voice, Data and Video (Multimedia) information.		
Unit V	**Modern Digital Radio Systems**	**10 Hours**
standards, proposals and comparisons GSM (Europe and all over the world) - TDMA, IS-54 (U.S.A.)- TDMA, IS-95 (U.S.A., Korea) CDMA-, PHS (Japan) - TDMA, Frequency Hopping (FH) (U.S.A.) - CDMA, PCS, PCS Cordless telephone 2nd generation (CT-2), Cellular digital packet data (CDPD), and Wireless LAN, New standard trends Edge, 3rd and 4th generation beginning, LTE,		
Unit VI	**Mitigation Techniques for Mobile System**	**4 Hours**
Overview of Natural and manmade external noise sources, Radiation hazards effects from		

base stations, Mobile and portable equipments.		
Unit VII	**Diversity Techniques for Mobile Radio Systems**	**4 Hours**
Dispersive channels, Space diversity, Frequency diversity, Equalizer techniques		
Pedagogy		
Lectures/Experiential Learning		
Course Outcome		
Students will ● understand the design, specifications and the performances of various wireless communication systems ● Apply the cellular concepts to evaluate the signal reception performance in a cellular network. ● Apply the traffic analysis to design cellular network with given quality of service constraints. ● Determine the appropriate model of wireless fading channel based on the system parameters and the property of the wireless medium. ● Analyze and design receiver and transmitter diversity techniques.		
References/Readings		
1. Steele, R., Hanzo, L., "Mobile Radio Communication" 3rd Edition Wiley 2005. 2. Rappaport, T.S., "Wireless Communications: Principles And Practice, 2/E,Pearson 3. Wireless Communications (WIRELESS COMMUNICATIONS, 2ND ED, Molisch A F),Wiley		

Course Code: ELE-503
Course Title: ELECTRONICS PRACTICALS – I
Number of Credits: 04 **Total Hours: 60** **Total Marks: 100**
Effective from AY: 2022-23

Prerequisites for the course

Should have studied graduate level basic level electronic subject. It is assumed that students have a working knowledge of passive and active components and digital circuits.

Objectives of Course

This course is intended to:

- Give the hands-on experience to design the basic digital and analog circuits
- Simulate the various digital modulation techniques and data correction and detection used in general communication system.
- Expose students to design digital circuits using microwind.
- Implement numerical algorithm.

Course Content

Practical Title	**120 Hours**

Unit I

1. Design of counters for digital clock (using Microwind s/w)
2. Multiplexer and Demultiplexer (using Microwind s/w)
3. Encoder and Decoder (using Microwind s/w)
4. 2nd order Butter-worth Notch Filter (p-Spice)
5. Buffer design using SPICE (p-Spice)
6. Memory design using 6T cell

Unit II

7. Design of variable voltage supply @ 2 Amps.
8. Design of Function Generator.
9. Design of Power Amplifier 10 Watts.
10. Design of Stepper driver using Monoshot & 555 Timer.
11. Design of S/C circuit for Strain gauge /Glucose strip @ 3.3V.
12. Design of 4-bit UP-DOWN Counter.

Unit III

13. Implementation of MSK modulation and demodulation.
14. ASK, FSK, QPSK modulation & demodulation.
15. QPSK, modulation & demodulation
16. DS-CDMA simulation.
17. Channel Coding methods. a. Convolution b. Block code
18. Error detection and correction Algorithm
    a. CRC
    b. Hamming code

Unit IV

19. Numerical Programming 1 (Trapezoid method)
20. Numerical Programming 2 (Bisection method)
21. Numerical Programming 3 (Runge Kutta method)
22. Numerical Programming 4 (Newton Raphson method)
23. Numerical Programming 5 (Regula falsi method)
24. Numerical Programming 6 (Secant method)

Pedagogy

Presentations /assignments/Experiential learning

Course Outcome

The Students will :

- learn the basics of a communication system for modulation, data coding , error coding channel coding methods.
- Design signal conditioning and VLSI circuits for various applications.

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Course Code: ELE-521
Course Title: Numerical Computation and Algorithms
Number of Credits: 04 **Total Hours: 60** **Total Marks: 100**
Effective from AY: 2022-23

Prerequisites for the course		
Students should have a knowledge of programming		
Objectives of Course		
The course is intended to, ● **Develop the basic understanding of numerical computation and algorithm.** ● **Develop skills to implement algorithms to solve mathematical problems on the computer and Data Bases.**		
Course Content		
Unit I	**Computer Programming**	**8 Hours**
Introduction to Algorithms, Elements of Computer Programming language, Basics of algorithm design, general model, Dynamic programming model, principle of optimality, backtracking models.		
Unit II	**Data Structures**	**12 Hours**
Introduction to Data Structures, Vectors and Lists, Stack, Queue, Binary Trees, Graphs, Hashing.		
Unit III	**Theory of Numerical programming**	**25 Hours**
Numerical Integration: Theory of numerical errors, Trapezoidal & Simpsons rule, Romberg method, Improper integrals; Numerical Solution of linear equations: Gauss-Jordon elimination and Lu decomposition; Numerical Solutions of nonlinear equations: Bracketting, bisection, Secant & Regula falsi method, Newton Raphson method; Numerical Solutions to Ordinary differential equations: Runge-Kutta method, Modified midpoint method, Richardson extrapolation.		
Unit IV	**Database**	**15 Hours**
Basic Concepts, Relational Data Model, Database Design, DBMS storage structures and access methods, Query Processing, Transaction Processing, Security & Integrity, Distributed Databases, Client Server Computing		
Pedagogy		

lectures/ Experiential Learning

Course Outcome

The students will:

- Use numerical methods for solving a problem, locate and use good mathematical software to achieve the required accuracy for a particular application, get the accuracy you need from the computer, assess the reliability of the numerical results.
- Solve a linear system of equations using an appropriate numerical method.
- Use data structures like Lists, Stack, Queue, Binary Trees.

References/Readings

1. Data structures using C and C++ by Yedidyah Langsam, Moshe J Augenstein, Aaron M Tenenbaum, Prentice Hall of India, 1995

2. Data Abstraction and Problem solving in Java by Frank M Carrano, Janet J Prichard ,Addison-Wesley, 2001

3. Numerical Recipes in C, William H. Press, Brain P. Flannery, William T. Vetterling, Saul A. Teulosky, Cambridge University Press, 1990.

4. Numerical Mathematical Analysis, J. B. Scarborough, Oxford and IBM Publishing Company (1979).

5. Numerical Recipes in C: The Art of Scientific Computing by William H Press, Brian P Flannery, Saul A Teukolsky - Mathematics – 1992.

6. Fundamentals of Database Systems, 4th Edition by R Elmasri, S Navathe Addison-Wesley, 2003

Course Code: ELE-522
Course Title: EDA Tools
Number of Credits: 04 **Total Hours: 60** **Total Marks: 100**
Effective from AY: 2022-23

Prerequisites for the course
Should have studied Digital Communication Systems
Objectives of Course
This course is intended to: ● Familiarize the students with industry oriented EDA tools. ● Teach Quartus, ISE compilations and programming and its use for design and analysis. ● Enable the student to extract various design parameters from simulation results.
Course Content (minimum 10 to be studied/implemented)
Study of JTAG, Modelsim Syntax study. 1. Study of Phases of Quartus compilations. 2. Study of phases of ISE compilations 3. Testing logic using ChipScope-I. 4. Testing logic using ChipScope-II 5. Parallel implementation of CRC. 6. Serial implementation of CRC. 7. FIFO implementation 8. Pulse stretcher 9. Test bench using Modelsim-I 10. Test bench using Modelsim-I 11. Test bench using Modelsim-I 12. Test bench using Modelsim-I
Pedagogy
Lectures/FLIPPED CLASSROOM/Experiential Learning
Course Outcome
The students will, ● Perform compilation using Quartus and ISE software. ● Analyse logic using Chipscope-I and II. ● Develop the Test benches using Modelsim-I
References/Readings

1. Design through Verilog HDL By T. R> Padmanabhan &
Sundari. IEEE press, Wiley Interscience.
2. http://www.xilinx.com/itp/xilinx7/help/iseguide/html/ise
_fpga_design_flow_overview.htm
3. Hands on experience on altera development board by
J.S.Parab,etal: Springer Netherland 2018(ISBN 978-81-
322-3769-3)

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SEMESTER II

Course Code: ELE-504
Course Title: EMBEDDED SYSTEMS DESIGNS
Number of Credits: 04 **Total Hours: 60** **Total Marks: 100**
Effective from AY: 2022-23
Prerequisites for the course

Should have studied microprocessor and C programming at graduate level		
Objectives of Course		
This course is intended to: • Introduce with Architectures of Microcontroller and its programming with Interfacing various Interfaces is discussed in depth in this paper. • Programming in assembly as well as in C for 8/16/32 bit controller		
Course Content		
Unit I	**Introduction to Controller Architecture**	**5 Hours**
Computer Architecture, RISC/CISC and Princeton Architectures		
Unit II	**Embedded system**	**5**
Definition, Basic Block, Designing of System, Applications		
Unit III	8-bit Micro controllers	**20**
Introduction to various 8-Bit microcontroller, 8051 features, Architecture , Memory organization, Instruction set, Interrupts, Timer/counter, LED, Switches, ADC, DAC, LCD Interfacing, Programming in Assembly and C,		
Unit IV	**16 bit microcontroller**	**15**
PIC controller Introduction, Architecture, Instruction set, Peripheral interfaces: LED, LCD, Serial RS232,Programming in C		
Unit V	**32-bit Microcontroller**	**15**
ARM architecture, THUMB/ARM instruction, ARM Exception Handling, Timers/Counters, UART, SPI, PWM, WDT, Input Capture, Output Compare Modes, I2C , Instruction set, Programming in Assembly and C.		
Pedagogy		
Lectures/Experiential Learning		
Course Outcome		
The students will: ● Students will learn the architecture of 8051,PIC and ARM . ● students will write an assembly and C program for 8051,PIC and ARM . ● students will write an assembly and C program for ● Students will be able to develop their own embedded platform using 8051, PIC and ARM		
References/Readings		
1. Jivan Parab etal., Exploring C for microcontroller (Springer 2007)		

2. Lipovski G. J. Single and multiple Chip Microcontroller interfacing. Prentice Hall, USA 1998.
3. Beginning Android 4 Application Development
4. Professional Android 4 Application Development
Learning Android Game Programming : A Hands-On Guide to Building Your First Android Game 1st Edition

5 .Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stefan Avesand,StamatisKarnouskos, David Boyle, **"**From Machine-to-Machine to theInternet of Things: Introduction to a New Age of Intelligence**",** 1st
Edition, Academic Press, 2014.

6. Bernd Scholz-Reiter, Florian Michahelles, "Architecting the Internet ofThings", ISBN 978-3-642-19156-5 e-ISBN 978-3-642-19157-2,
Springer

7. Vijay Madisetti and ArshdeepBahga, **"**Internet of Things (A Hands-onApproach)**",** 1st Edition, VPT, 2014.

Course Code: ELE- 505
Course Title: Real Time Operating System
Number of Credits: 04 **Total Hours: 60** **Total Marks: 100**
Effective from AY: 2022-23

Prerequisites for the course		
Should have studied microprocessor and C programming at graduate level		
Objectives of Course		
This course is intended to: ● To focus on concept of highlighting the various methods of improvising speed of computing machine through the operating system organization and various entity managements. ● To analyse the small embedded system developments through the Real Time Operating Systems for task management efficiency. ● Porting RTOS on embedded platform		
Course Content		
Unit I	**Introduction to Computer Organization and Architecture**	**6 Hours**
hardware vs. software -the virtual machine concept, the concept of von Neumann architecture, hardware components and functions, trends in hardware development, system configurations and classifications.		
Unit II	**Process Description and Control:**	**6**
Processes, process states, processor modes, context switching, CPU scheduling algorithms, threads		
Unit III	Concurrency Control:	**6**
Concurrent processes, critical section problem and solutions, mutual exclusion solution requirements, semaphores and monitors.		
Unit IV	**Deadlocks:**	**6**
Characterization, detection and recovery, avoidance, prevention		
Unit V	**Inter Process Communication**	**7**
classical IPC problems and solutions, IPC techniques.		
Unit VI	The Input/Output and File Subsystem:	**7**
I/O devices, controllers and channels, bus structures, 1/0 techniques (programmed, interrupt-driven and DMA), I/O subsystem layers. Concepts of files and directories, issues and techniques for efficient storage and access of data. I/O and file system support for graphics, multimedia, databases, transaction processing and networking.		
Unit VII	**The Memory Subsystem**	**7**
Memory types and hierarchy, module level Organization, cache memory. Memory partitioning, swapping, paging, segmentation, virtual memory.		
Unit VIII	**The Central Processing Unit**	**7**
CPU components, register sets, instruction cycles, addressing modes, instruction sets, the concept of micro-programming, Basics of RISC approach, pipelined and super-scalar approaches, vector processors and parallel processors, hardware support for the OS.		
Unit IX	**µCOS case study**	**8**

Pedagogy
Lectures/Experiential Learning
Course Outcome
The Student Will: ● Generalize the understanding of the computing machine and various entities associated with the enhancement of the efficiency. ● Handle the operating system management process, memory, I/O, Secondary Disk and organizations of various. ● Handle any operating system for process and task managements if follows the documentations of the same.
References/Readings
1.Operating system principles, 3rd Edition,by Willian Stallings –PHI(1998) 2. Operating system concepts by Silberchatz and Galvin - Addision wesley 3. Operating system by Tanaumbuam, PHI New Delhi

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Course Code: ELE-506
Course Title: Digital System Design
Number of Credits: 04 **Total Hours: 60** **Total Marks: 100**
Effective from AY: 2022-23

Prerequisites for the course		
Should have studied digital electronics at the graduate level		
Objectives of Course		
This course is intended to, ● Teach principles of combination and sequential logic design ● Develop implementation skills using hardware description languages. ● Teach and familiarize with industry technologies such as Memory, CPLDS, FPGA.		
Course Content		
Unit I	**Introduction**	**6 Hours**
About Digital Design, Analog versus Digital, Electronic Aspects of Digital Design, PLD's, ASIC, Digital Design level. Digital Concept and Number System: General Positional number system conversions, Operation, BCD, Gray Code,Character Codes, Codes for Actions, Conditions, and States nCubes and Distance, Codes for Detecting and Correcting Errors, Error-Detecting Codes, Error-Correcting and Multiple Error-Detecting Codes, Hamming Codes, CRC Codes, Two Dimensional Codes, Checksum Codes, m-out-of-n Codes, Codes for Serial Data Transmission and Storage, Parallel and Serial Data, Serial Line Codes		
Unit II	**Combinational Logic Design Principles**	**4 Hours**
Switching Algebra, Combinational-Circuit Analysis, Combinational-Circuit Synthesis, and Timing Hazards.		
Unit III	**Hardware Description Languages**	**4 Hours**
HDL-Based Digital Design, The VHDL Hardware Description Language, The Verilog Hardware Description Language		
Unit IV	**Combinational Logic Design Practices**	**4 Hours**
Documentation Standards, Circuit Timing, Combinational PLDs, Decoders, Encoders, Three-State Devices , Multiplexers, Exclusive-OR Gates and Parity Circuits , Comparators, Adders, Subtractors, and ALUs , Combinational Multipliers, Exclusive-OR Gates and Parity Circuits , Comparators, Adders, Subtractors, and ALUs , Combinational Multipliers.		
Unit V	**Sequential Logic Design Principles & Practices**	**12 Hours**

Bistable Elements, Latches and Flip-Flops, Clocked Synchronous State-Machine Analysis, Clocked Synchronous State-Machine Design, Designing State Machines Using State Diagrams, State-Machine Synthesis Using Transition Lists, Another State-Machine Design Example, Decomposing State Machines, Feedback Sequential-Circuit Analysis, Feedback Sequential-Circuit Design, Features ,Sequential-Circuit Design with VHDL , Sequential- Circuit Design with Verilog, Sequential-Circuit Documentation Standards , Latches and Flip-Flops ,Sequential PLDs , Counters, Shift Registers, Iterative versus Sequential Circuits , Synchronous Design Methodology , Impediments to Synchronous Design , Synchronizer Failure and Metastability		
Unit VI	**Memory, CPLDS**	**10 Hours**
Read-Only Memory, Read/Write Memory, Static RAM, Dynamic RAM, Complex Programmable Logic Device		
Unit VII	**Field Programmale Gate Array**	**10 Hours**
Introduction, FPGA Architectures, Configuration: SRAM-Based FPGAs and Antifuse Permanently Programmed FPGAs, Chip I/O, Circuit Design of FPGA Fabrics, Architecture of FPGA Fabrics, FPGA Soft-core Processor Development flow.		
VIII	**Neural Networks on FPGA**	**10 Hours**
Introduction, Designing a Neuron, Activation functions, Design of layers, Training and validations, Hardware verification, Case study using PYNQ/VITIS AI framework.		
Pedagogy		
lectures/ Experiential Learning		
Course Outcome		
The student will, ● Understand principles of combination and sequential logic design ● Leverage Hardware description languages for realization of combinational and sequential designs ● Understand the architecture of field programmable gate array.		
References/Readings		

1. Digital Design Principles and Practices, by John F. Wakerly, Prentice Hall's Fourth Edition.
2. Digital System Design using VHDL: Charles. H.Roth ; PWS (1998)
3. Scott Hauck and Andre DeHon , Reconfigurable Computing, Morgan Kaufmann, 2008
4. Srinivas Devadas, Abhijit Ghosh, and Kurt Keutzer, “Logic Synthesis,” McGraw-Hill, USA, 1994.
5. Neil Weste and K. Eshragian,”Principles of CMOS VLSI Design: A System Perspective,2nd edition, Pearson Education, 2000.
6. Kevin Skahill, “VHDL for Programmable Logic,” Pearson Education, 2000. M.N.O. Sadiku, Elements of Electromagnetics 2nd Edition) , Oxford University press, 1995.

Course Code: ELE-507
Course Title: ELECTRONICS PRACTICALS – II
Number of Credits: 04 **Total Hours: 120** **Total Marks: 100**
Effective from AY: 2022-23

Prerequisites for the course

Should have studied microcontrollers, embedded system, OS and EDA tools

Objectives of Course

This course is intended to,

- Develop skills in handling controllers like 89C51/52, PIC and ARM controller derivatives .
- Input Output operation, Various communication interfaces, data acquisition, task management and Robotic applications.
- Cover experiments using LabVIEW with MyRIO and NI ELVIS Platform

Course Content

Practical Title	**120 Hours**

Unit I

1. 7-segment Interfacing to ATMEL 89C52 (BCD counter)
2. Display Temperature using ATMEL 89C52 on LCD
3. Obstacle Avoidance using 89V52 based Robot
4. Serial Transmission and reception PIC16F877
5. Configuring On – chip ADC PIC16F877
6. Hex Keypad Interfaced to ARM controller & display on LCD

Unit II

7. Switching of LED using µ - COS
8. Switching of LED using RTX
9. Switching of LED using FPGA
10. KEY pad and ADC interfacing using RTOS
11. Shell programming – Web Application.
12. Shell programming – System Management

Unit III

13. VHDL implementation for the Multiplexer & Demultiplexer
14. VHDL Implementation for Encoder & Decoder
15. VHDL implementation for the Counter.
16. LCD and 7 -segment Interfacing using DE2 board
17. UART Interface using DE2 board
18. Echo & Reverberation implementation on speedy33 kit(lab view)

Unit IV

19. Automated Street lighting
20. Smart Irrigation System
21. Home Automation
22. Smart water monitoring system

23. Surveillance System
24. Smart Parking System

Unit V

25. Switch basic setup
26. Virtual LAN
27. Spanning tree protocol
28. Routing
29. DHCP (Dynamic Host Configuration Protocol)
30. Switch stacking

Pedagogy

Presentations /Experiential Learning/laboratory design and implementation

Course Outcome

The Students will be,

- Able to analyze the architectures of any controller.
- Designs application using embedded system using tasks for real time applications.
- Handle any computing machine using shell script for computing and management.
- Develop and design some applications based on SPEEDY 33 using LABView , NI ELVIS , MYRio, Altera DE2 Board.
- Develop an android app.

References/Readings

1. Digital Design Principles and Practices, by John F. Wakerly, Prentice Hall's Fourth Edition. Lipovski G. J. Single and multiple Chip Microcontroller interfacing. Prentice Hall, USA 1998.
2. Beginning Android 4 Application Development
3. Professional Android 4 Application Development
4. Learning Android Game Programming : A Hands-On Guide to Building Your First Android Game 1st Edition

Course Code: ELE-523
Course Title: Internet of Things
Number of Credits: 04 **Total Hours: 60** **Total Marks: 100**
Effective from AY: 2022-23

Prerequisites for the course

Students should know the basic knowledge about passive electrical and electronics components, and programming

Objectives of Course

This course is intended to:

- Introduce the fundamentals of Internet of Things and its building blocks along with their characteristics.
- understand the protocols and standards designed for IoT and the current research on it.
- know the other associated technologies like cloud and fog computing in the domain of IoT.
- provide the recent application domains of IoT in everyday life.

Course Content

Unit I	**Introduction**	**05 Hours**
Evolution, Addressing strategies, Sensing and Actuation -Type, Characteristics, Processing topologies and types		
Unit II	**IOT Networking**	**10 Hours**
Basics of Networking, Networking Components, Connectivity Protocol: 6LoWPAN and RFID, Data Protocol – MQTT, SMQTT, CoAP, XMPP and AMQP, Communication protocols – IEEE 802.15.4, Zigbee, HART & Wireless HART, NFC, Bluetooth, Z-wave and ISA 100.11A		
Unit III	**Sensing Network**	**15 Hours**
Wireless Sensor Networks, Sensor nodes, Sensor web, Node Behavior in WSNs, Applications of WSNs, Coverage of WSNs, Stationary and Mobile Wireless Sensor Network, UAV Network, Flying Ad Hoc Network, Interoperability		
Unit IV	**Software Defined Networking**	**10 Hours**
Basic concept, SDN architecture, SDN in IOT, Software Defined WSN, SDN for Mobile Networking		
Unit V	**Cloud and Fog Computing**	**10 Hours**
Cloud Computing: Fundamentals, Components & Characteristics, Architecture, Service Models, Cloud types, Service Management & Security and Sensor Cloud, Fog Computing: Fog nodes, Architecture, Fog Computing in IOT and Application		

Unit VI	IOT case studies and Future Trends	05 Hours
Smart Cities and Smart Homes, Connected Vehicles, Smart Grid, Industrial IOT, Agriculture, Healthcare, Paradigms, Challenges and the future.		
Unit VII	**Hands-on**	**05 Hours**
Integration of sensors and actuators with Ardunio, Introduction to Python programming, Introduction to Raspberry Pi, Implementation of IOT with Raspberry Pi		

Pedagogy

Lectures/Experiential Learning

Course Outcome

On completion of the course, students will be able to:

1. Explain the of IOT enabling components, such as sensors, connectivity protocols, and communication protocols.
2. Describe the IOT architecture and its component details.
3. Explain the associated technologies including cloud computing, fog computing and its applications.
4. Gain practical knowledge about the integration of sensor and actuators, coding structure, and implementation of IOT in various applications.

References/Readings

1. S. Misra, A. Mukherjee, and A. Roy, 'Introduction to IoT', Cambridge University Press.
2. S. Misra, C. Roy, and A. Mukherjee, 'Introduction to Industrial Internet of Things and Industry 4.0', CRC Press.
3. Pethuru Raj and Anupama C. Raman, 'The Internet of Things: Enabling Technologies', Platforms, and Use Cases", CRC Press.
4. Arshdeep Bahga and Vijay Madisetti, 'Internet of Things: A Hands-on Approach', Universities Press.

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Course Code: ELE-524
Course Title: Switching and Routing
Number of Credits: 04 **Total Hours: 60** **Total Marks: 100**
Effective from AY: 2022-23

Prerequisites for the course		
Students should know the basic knowledge about network, basic terminologies and security at graduate level		
Objectives of Course		
This course is intended to: ● Introduce the student to the broader understanding of computer networks ● Cover Extensive learning in switching and routing technologies. ● Comprehensive understanding in LAN switching environment.		
Course Content		
Unit I	**Computer Networking**	**05 Hours**
Introduction, Network Components, Network types: LAN, PAN, MAN & WAN, Connection type: Point-to-point & Point-to-multipoint, Physical Topology: Star, Mesh, Bus and Ring, Data Communication		
Unit II	**Network Models**	**10 Hours**
OSI Model, TCP/IP Model, OSI and TCP/IP model comparison, Critique of OSI and TCP/IP model, Internet and Internet Architecture		
Unit III	**IP Addressing and Subnets**	**15 Hours**
IP Addressing: Composition, Types & Classes, Private and Public IP addresses, Subnetting, Variable Length Subnet Masks (VLSM), Troubleshooting IP addressing		
Unit IV	**Switching and Spanning Tree Protocol**	**15 Hours**
Switching and Switches, Switch Operation, Virtual Local Area Network (VLAN) and VLAN Trunding Protocol (VTP), Spanning Tree Protocol (STP), Switch Stacking, Network Address Translation (NAT)		
Unit V	**Routing**	**10 Hours**
IP Routing, Types, Classes of Routing, Distance Vector Routing Protocol (DVRP), Routing Information Protocol (RIP)		
Unit VI	**Network Security**	**05 Hours**
Cryptography, Digital Signatures, Communication Security, Web Security, Virtual Private Network (VPN),		
Pedagogy		

Lectures/Experiential Learning

Course Outcome

The students will:

- Explain in detail the concepts of Computer networking, OSI and TCP/IP model architecture along with the comparison.
- Gain the knowledge about the Switching and Routing
- Understand the basic device configuration and troubleshooting.
- Explain the Network security principles and its applications

References/Readings

1. Andrew S.Tanenbaum, 'Computer Networks', 3rd Edition, Prentice Hall.
2. James F. Kurose and Keith W. Ross, 'Computer Networking: A Top-Down Approach', 7th Edition, Pearson Education.
3. D-Link Certified, DCS Switching Training Guide.
4. D-Link Certified, DCS Switching Lab Manual
5. Cisco Certified Network Associate Training Guide

Semester III

Course Code: ELE-600

Course Title: Signals and Systems

Number of Credits: 04 **Total Hours: 60** **Total Marks: 100**

Effective from AY: 2022-23

Prerequisites for the course		
Should have the basic knowledge of Integration, Differentiation, Complex Numbers		
Objectives of Course		
This course is intended to: • Develop understanding about signals, systems and their classification. • Provide with necessary tools and techniques to analyse electrical networks and systems to develop expertise in time-domain and frequency domain approaches. • Discusses different types of Filters and its design.		
Course Content		
Unit I	**Signals and Signal Processing**	**05 Hours**
Characterization and Classification of Signals, Typical Signal Processing Operations.		
Unit II	**Discrete Time Signal and Systems**	**08 Hours**
Discrete-Time Signals, Sequence Representation, Sampling Process, Simple Interconnection Schemes, Correlation of Signals, Random Signal.		
Unit III	**Discrete Transform**	**17 Hours**
Fourier series, Continuous and Discrete-time Fourier Transform, Laplace Transform, Energy Density Spectrum, Phase and Group Delays. Digital Processing of Continuous Time Signals - Sampling of Continuous Time Signal, Low-pass & Band-pass Signal, Anti-Aliasing Filter design, Sample-and-Hold (S/H), Analog to Digital, Digital to Analog Convertors, Effects of S/H, Short-Time Fourier Transform, Wavelet Transform		
Unit IV	**Digital Filter Structure**	**08 Hours**
Block Diagram Representation, FIR, IIR filter, Allpass Filter, Tunable IIR Digital Filter, Digital Sin-Cosine Generator, Computational Complexity.		
Unit V	**FIR Digital Filter Design**	**10 Hours**
Preliminary Considerations, FIR Filter Design Based on Windowed Fourier Series, Design of Minimum Phase FIR Filters.		
Unit VI	**DSP Algorithm Implementation**	**08 Hours**
Computability Equation Describing Filter Structure, Verification, Computation of Discrete Fourier Transform (DFT), FFT, DFT & Inverse-DFT using MATAB, Number Representation, Handling Overflow, Tunable Digital Filters.		
Unit VII	**Application of Digital Signal Processing**	**04 Hours**
Dual-Tone Multi-Frequency Signal Detection, Musical Sound Processing, Signal Compression, Transmultiplexers		
Case Studies		
1. Implementation of Filters – Ensemble Average filter, Exponential weighted running system, Median Filter. 2. Implementation of aliasing effect and interpolation 3. Implementation of DFT and FFT algorithms 4. Design Oscillator system - Lorentz and Gaussian oscillator system 5. Design Transfer function and convolution		

Pedagogy
lectures/ Experiential Learning
Course Outcome
Students will be able to: 1. Explain classification of signals and signal processing operations. 2. Understand the discrete time signals and its discrete time Fourier transform representation. 3. Learn different structural representation of FIR and IIR digital filters.
References/Readings
1. Sanjit K Mitra, 'Digital Signal Processing: A computer Based Approach, 3rd Edition, Tata MacGraw-Hill, 2011 2. Johnny R. Johnson, Introduction To Digital Signal Processing, Prentice Hall, 1989. 3. John G. Proakis, Dimitris G. Manolakis, Digital Signal Processing, 4th Edition, Pearson Education, 2007. 4. Simon Haykin, Van Veen, Signals and Systems, 2nd Edition, Wiley, 2007 5. Richard G. Lyons, 'Understanding Digital Signal Processing', Pearson, 2022 6. S. Palani, 'Signals and Systems', Springer International Publishing, 2021

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Course Code: ELE-601
Course Title: Artificial Intelligence and Applications
Number of Credits: 04 **Total Hours: 60** **Total Marks: 100**
Effective from AY: 2022-23

Prerequisites for the course		
Should have knowledge of basic electronics and programming.		
Objectives of Course		
This course is intended to: • Introduce the foundation concepts in the field of artificial intelligence. • Become familiar with basic principles of AI toward problem solving • Know approaches of inference, perception, uncertain knowledge, and reasoning Prepares a student to take a variety of focused, advanced courses in various subfields of AI.		
Course Content		
Unit I	**Introduction**	**08 Hours**
History, Philosophy of AI, Definitions, Introduction to: • AI System Hardware CPU, RAM, GPU, Interconnects, Storage, Network Controller; • AI Accelerators GPUs; • System Software Operating System, Virtualization, Cloud.		
Unit II	**Containers, IDE & Schedulers**	**08 Hours**
Introduction to Containers and IDE; Scheduling and Resource Management Introduction to schedulers and orchestration tools; DeepOps: Deep-dive into Kubernetes with the deployment of various AI-based services.		
Unit III	**Problem-solving by search**	**12 Hours**
Introduction to unguided and guided search; State Space Search: Depth First Search, Breadth First Search, Depth First Iterative Deepening Heuristic Search: Best First Search, Hill Climbing, Solution Space, TSP, Escaping Local Optima, Stochastic Local Search		
Unit IV	**Knowledge Representation and Reasoning**	**10 Hours**
Knowledge Representation (KR) Introduction, Knowledge Progression, KR model, category: typology map, type, relationship, framework, mapping, forward & backward representation, KR system requirements; KR schemes; KR issues; KR using predicate logic, KR using Rules Reasoning: Definitions Reasoning, formal logic, and informal logic, uncertainty, monotonic logic, non-monotonic Logic; Methods of reasoning and examples – deductive, inductive, abductive, analogy; Sources of uncertainty; Approaches to reasoning – symbolic, statistical		

and fuzzy; Symbolic Reasoning, Statistical Reasoning

Unit V	**Learning System & Neural Networks**	**12 Hours**

Definition, learning agents, components of the learning system; Rote Learning, Learning from examples; Explanation-based learning, Clustering, Reinforcement Learning
Introduction to NN, ANN, CNN, ML, Deep Learning: Model, architecture, Learning Methods

Unit VI	**Applications of AI**	**10 Hours**

Game playing, Computer Vision, Expert Systems, agricultural and soil management applications, Cognitive Science, Finance, meteorology, Health care.

Case Studies:

1. Implementation of CNN for databases available in the public domain.
2. Development of your own deep network.
3. Image processing of the data collected using UAV/drone
4. Solving health care/ meteorology problem using AI algorithm.

Pedagogy

Lectures/Experiential Learning

Course Outcome

Students will:

- Gain knowledge of the basic concepts of Artificial Intelligence.
- Learn problem-solving, knowledge representation, and reasoning approaches.
- Able to deal with all the concepts and problems using NN, ANN, CNN, ML, and deep learning.
- Able to apply the knowledge and will generate automated systems (Applications) using AI.

References/Readings

1. Deepak Khemani, 'A First Course in Artificial Intelligence', McGraw Hill Education (India), 1st ED, 2014.
2. Stuart J. Russell and Peter Norvig, 'Artificial Intelligence', Pearson, 3rd ED, 2016
3. George F Lugar, Artificial Intelligence: Structure and strategies for complex, Problem Solving, 6th ED, 2021.
4. Wolfgang Ertel, Nathanael T. Black, Introduction to Artificial Intelligence Nils J Nilsson, Springer,2018

5. Principles of Artificial Intelligence, Illustrated Reprint Edition, Springer Heidelberg, 2014.
6. Alexander Jung Machine, 'Learning: The Basics (Machine Learning: Foundations, Methodologies, and Applications)', Springer, 2022
7. Cherry Bhargava, Pardeep Kumar Sharma, 'Artificial Intelligence. Fundamentals and Applications', CRC Press, 2022

Course Code: ELE-602
Course Title: Robotics

Number of Credits: 04 **Total Hours: 60** **Total Marks: 100**
Effective from AY: 2022-23

Prerequisites for the course		
Should have knowledge of Basic electronics hardware, Mathematics, and programming.		
Objectives of Course		
This course is intended to: ● Introduce robotics and the key elements and constituents of a robot; science and technology in robots; ROS. ● Understand and explain the various elements of the robotic system. ● Study all necessary kinematics and various analysis techniques. ● Understand the robot dynamics and control theory. ● Give exposure to futuristic robotic technologies.		
Course Content		
Unit I	**Introduction**	**10 Hours**
Introduction- Brief history, types, classification and usage, growth; Robot applications- Manufacturing industry, defense, rehabilitation, medical, etc.; Laws of Robotics; Introduction to ROS		
Unit II	**Elements of robots**	**12 Hours**
Links, joints, actuators, and sensors; Position and orientation of a rigid body, Homogeneous transformations; Representation of joints, link representation using D-H parameters, Examples of D-H parameters, and link transforms; Different kinds of actuators – stepper, DC servo and brushless motors, model of a DC servo motor; Types of transmissions; Purpose of sensors, internal and external sensors, common sensors – encoders, tachometers, strain gauge-based force-torque sensors, proximity, and distance measuring sensors, and vision sensors.		
Unit III	**Kinematics**	**07 Hours**
Direct and Inverse Kinematics; Kinematics of serial robots: Direct and inverse kinematics problems, Inverse kinematics of constrained and redundant robots, Tractrix-based approach for fixed and free robots and multi-body systems; Kinematics of parallel robots: direct and inverse kinematics problems, Mobility, Stewart-		

Gough platform, Degrees-of- freedom of parallel mechanisms and manipulators, Active and passive joints.		
Unit IV	**Velocity and static analysis**	**05 Hours**
Linear and angular velocity of links, Manipulator Jacobians for serial and parallel manipulators; Statics of serial and parallel manipulators, Statics and force transformation matrix of a GoughStewart platform, Singularity and Statics analysis.		
Unit V	**Robot Dynamics & Controls**	**10 Hours**
Robot dynamics equation; General procedure for dynamics equation forming and introduction to control; Actuator dynamics and PD, PID control for robots; Trajectory tracking control; Lyapunovs theorems; Neural network control design		
Unit VI	**Robotics Applications**	**09 Hours**
Introduction, development, and working of: UAV, Drone, Humanoid Robots & Underwater robot		
Unit VII	**Futuristic Robots**	**07 Hours**
Introductions to MEMS (micro-electro-mechanical systems), Introduction to Cognitive Robotics and Human-Robot Interaction, Robots in Space & Defense applications		
Case Studies:		
1. Development of obstacle avoidance and line following robot. 2. Implementation of ROS. 3. Simulation of robotic trajectories. 4. Drone-based image analysis.		
Pedagogy		
Lectures/Experiential Learning		
Course Outcome		

Students will:

- Gain knowledge of the basic concepts in robotics, ROS, key elements, and constituents of the robotic system.
- Learn the kinematics of serial and parallel robots and will be able to perform various analyses.
- Understand the various robotic dynamics and control designs.
- Able to understand and develop robotic systems.
- Have an update on the latest robotic research & technologies.

References/Readings

1. Ghosal, A., 'Robotics: Fundamental Concepts and Analysis', Oxford University Press, 9th reprint, 2013
2. Robert J Schilling, 'Fundamentals of Robotics', Prentice Hall India, 1st ED, 2003
3. John J Craig, 'Introduction to Robotics', Prentice Hall International, 3rd ED, 2005
4. Jitendra R. Raol, Ramakalyan Ayyagari, 'Control Systems: Classical, Modern, and AI-Based Approaches', CRC Press, 1st ED, 2019
5. Gao, Yang, 'Space Robotics and Autonomous Systems', Institution of Engineering & Technology, 2021
6. Lentin Joseph, Aleena Johny, 'Robot Operating System (ROS) for Absolute Beginners', 2nd ED, 2022

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Course Code: ELE-621
Course Title: Laser System Engineering
Number of Credits: 04 **Total Hours: 60** **Total Marks: 100**
Effective from AY: 2022-23

Prerequisites for the course		
Graduate level knowledge in Electronics/Physics		
Objectives of Course		
This course is intended to: ● Teach the difference between ordinary light and light emitted by a laser device. ● Introduce the method used for excitation of laser devices. ● Explain the theory behind generation of stimulated emissions. ● Cover various application of lasers in medical, civil and defence areas.		
Course Content		
Unit I	**Optical Resonators**	**12 Hours**
Energies in resonator, Febry-Perot Etalon , Febry-Perot Etalon as Optical Spectrum Analyzer, Mode Stability Criteria , Resonance Frequency of Optical Resonator,Unstable Resonator		
Unit II	**Interaction of Radiation with Atomic System**	**10 Hours**
Spontaneous transmission between Atomic layer, Homogenous and In-Homogeneous broadening , Line shape functions, Stimulated transmission , Absorption and amplification , gain saturation in Homogenous media .		
Unit III	**Theory of Laser Oscillator**	**10 Hours**
Febry Perot Laser , Three and Four Level Laser , Power in Laser Oscillator, Optimum Light coupling , Multimode Laser Oscillator and Mode Locking Methods of Mode locking , Pulse length Measurements , Q-Switching , methods of Q-Switching .		
Unit IV	**Laser Systems**	**8 Hours**
Pumping and laser Efficiency, Ruby Laser, Flash Pumping ,Nd-YAG Laser , Nd Glass Laser , Threshold for CW and Pulse operation , HeNe Laser , CO2 Laser , Ar-Ion Laser , Excimer Laser , Dye Laser.		
Unit V	**Non –Linear Optics**	**6 Hours**

Origins of Non-Linear Polarization, relation between induced Polarization		
Unit VI	**Interaction of Light and Sound**	**7 Hours**
Scattering of Light by Sound, RamanNath and Bragg diffraction , Diffraction of light by Sound , Intensity modulation.		
Unit VII	**Applications of Lasers**	**7 Hours**
Lidar, Laser cutting and welding, lunar laser ranging, Optical Network, optical tweezers, microscopy, Laser Leveling, Surface Defects scanning, bar code scanner		
	Case Studies	
1. Understanding the diffraction of Laser Light using grating 2. Comparison of resolving power of Prism and Grating. 3. Focusing of Laser Light. 4. Collimation of Laser Light.		
Pedagogy		
lectures/ tutorials/assignments/presentation		
Course Outcome		
The student will, ● have sufficient knowledge of lasers for applications involving medical treatment as well as defence needs. ● have a full knowledge of classification of lasers and its usage. ● Have knowledge to handle high power industrial lasers.		
References/Readings		
1. A. Yariv, “Optical Electronics”, 4th Edition by, HRW publication, 1991. 2. A. Ghatak and K. Tyagarajan, “Optical Electronics”, by Cambridge University Press, 1989 . 3. William T. Silfvast, “Laser fundamentals”, 2nd Edition, Cambridge University Press, 2008 4. K.Thyagarajan, and Ajoy Ghatak, Lasers: Fundamentals and Applications (Graduate Texts in Physics), Springer publication, 2012. 5. L. Tarasov, “Laser Physics and application” , Mir Publication, 1987		

Course Code: ELE-622
Course Title: Data Science and Machine Learning
Number of Credits: 04 **Total Hours: 60** **Total Marks: 100**
Effective from AY: 2022-23

Prerequisites for the course		
Should have the basic knowledge of linear algebra and Python programming language.		
Objectives of Course		
This course is intended to: • Introduce the mathematical foundations required for Data Science and Machine learning. • Introduce the statistical and probabilistic concepts. • Learn the data analysis and processing. • To study different machine learning and deep learning techniques.		
Course Content		
Unit I	**Introduction**	**05 Hours**
Introduction to Data Science, Data Science Process, Fundamentals of linear algebra		
Unit II	**Foundations of Data Science**	**08 Hours**
Python for Data Science- Programming basics, libraries – Numpy, SciPy, Scikit-Learn, Tensor flow, Keras, Py-tourch, Pandas, Matplotlib, Seaborn. Statistical concepts – Descriptive and Inferential Statistics, Probability		
Unit III	**Data Visualization, Exploration and Manipulation**	**12 Hours**
Types of Data, Visualization, Exploratory Data Analysis, Data Cleansing, Data Manipulation, Feature Extraction and Feature Selection		
Unit IV	**Regression and Classification**	**10 Hours**
Linear Regression, Logistic Regression, Multivariate Regression, Support Vector Machine, Decision Tree, Random Forest, Naive Bayes, Regularization, Goodness of fit		
Unit V	**Machine Learning**	**15 Hours**
Machine Learning Process Flow, Overfitting and under fitting, Bias-Variance, Types of machine learning, Dimensionality Reduction-Principal Component Analysis, K-Nearest Neighbour, Clustering- K-means		
Unit VI	**Deep Learning**	**10 Hours**
Neural Networks, Convolutional Neural Networks, Transfer Learning, Reinforcement learning, Recurrent Neural Networks		
case studies		
1. Implement data cleansing and manipulation operations 2. Implement Support Vector Machine algorithm for multiclass classification 3. Implement clustering algorithm 4. Demonstrate the overfitting and under fitting conditions 5. Face recognition using deep convolutional neural network and using transfer learning.		
Pedagogy		
lectures/ Experiential Learning		
Course Outcome		
The students will: 1. Understand the fundamental concepts of data science and machine learning. 2. Perform data processing technique using python.		

3. Explain and implement the machine learning methods.

References/Readings

1. Trevor Hastie, Robert Tibshirani, Jerome Friedman, 'The Elements of Statistical Learning - Data Mining, Inference, and Prediction', Springer New York, 2013
2. Joel Grus, 'Data Science from Scratch - First Principles with Python', 2nd Edition, O'Reilly Media, 2019.
3. Cathy O'Neil and Rachel Schutt, 'Doing Data Science - Straight Talk From The Frontline', O'Reilly. 2013.
4. Laura Igual, Santi Seguí, Eloi Puertas, Petia Radeva, Oriol Pujol, Sergio Escalera, Francesc Dantí, Lluís Garrido, 'Introduction to Data Science - A Python Approach to Concepts, Techniques and Applications', Springer International Publishing, 2017
5. Samir Madhavan, 'Mastering Python for Data Science', Packt Publishing, 2015
6. Ian Goodfellow, Yoshua Bengio, Aaron Courville, 'Deep Learning', MIT Press, 2016
7. Zhi-Hua Zhou, 'Machine Learning', Springer Nature Singapore, 2021

Course Code: ELE-623
Course Title: Electric Vehicle Technology
Number of Credits: 04 **Total Hours: 60** **Total Marks: 100**
Effective from AY: 2022-23

Prerequisites for the course		
Should have graduate level knowledge in Basic Electrical and Electronics		
Objectives of Course		
This course is intended to: • Introduce Hybrid & Electric Vehicle • Cover various types of Electric Drives and energy • Modelling and Characteristics of EV/HEV Powertrains Components • Matlab Simulink modeling of Electric Vehicle		
Course Content		
Unit I	**Introduction to Hybrid Electric Vehicle**	**5 Hours**
Review of Conventional Vehicle, Introduction to Hybrid Electric Vehicles, Types of EVs, Hybrid Electric Drive-train, Tractive effort in normal driving		
Unit II	**Electric Drives**	**10 Hours**
Energy consumption Concept of Hybrid Electric Drive Trains, Architecture of Hybrid Electric Drive Trains, Series Hybrid Electric Drive Trains, Parallel hybrid electric drive trains, Electric Propulsion unit, Configuration and control of DC Motor drives, BLDC, Induction Motor drives, Permanent Magnet Motor drives, switched reluctance motor		
Unit III	**Energy Storage**	**8 Hours**
Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles:- Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system, Design of Hybrid Electric Vehicle and Plug-in Electric Vehicle		
Unit IV	**Energy Management System**	**8 Hours**
Energy Management Strategies, Automotive networking and communication, EV charging standards, V2G, G2V, V2B, V2H		
Unit V	**Mobility and Connectors**	**8 Hours**
Connected Mobility and Autonomous Mobility- case study E-mobility Indian Roadmap Perspective. Policy: EVs in infrastructure system, integration of EVs in smart grid, social dimensions of EVs. Connectors- Types of EV charging connector, North American EV Plug Standards, DC Fast Charge EV Plug Standards in North America, CCS (Combined Charging System), CHAdeMO, Tesla, European EV Plug Standards		
Unit VI	**Modelling of Vehicle Performance Parameter**	**7 Hours**
Modelling Vehicle Acceleration - Acceleration performance parameters, modeling the acceleration of an electric scooter, modeling the acceleration of a small car.		
Unit VII	**Modelling of Battery Electric Vehicles**	**7 Hours**
Electric Vehicle Modelling - Tractive Effort, Rolling resistance force, Aerodynamic drag, Hill climbing force, Acceleration force, Total tractive effort, Modelling Electric Vehicle Range - Driving cycles, Range modelling of battery electric vehicles, Constant velocity range modelling, Range modelling of fuel cell vehicles, Range modelling of hybrid electric vehicles		
UNIT VIII	**Drivetrain Characteristics**	**7 Hours**
Modelling and Characteristics of EV/HEV Powertrains Components- ICE Performance		

Characteristics, Electric Motor Performance Characteristics - Battery Performance Characteristics-Transmission and Drivetrain Characteristics-Regenerative Braking Characteristics-Driving Cycles Modelling and Analysis of Electric and Hybrid Electric Vehicles Propulsion and Braking - Longitudinal Dynamics Equation of Motion - Vehicle Propulsion Modelling and Analysis - Vehicle Braking Modelling and Analysis

Case studies

1. Explore Electric Powertrain Architectures
2.Tune Regenerative Braking Algorithms
3.Modify Suspension Design
4.Optimize Vehicle-Level Performance
5.Model Inverters, Traction Motors, and Develop Motor Control Software
6. Model Batteries and Develop Battery management System(BMS)

Pedagogy

Lectures/Experiential Learning

Course Outcome

Students will,

- To understand about basics of hybrid electric vehicle
- To understand about drives and control.
- Select battery, battery indication system for EV applications
- Design battery charger for an EV
- Modelling of Electric Vehicle in MATLAB

References/Readings

1. Emadi, A. (Ed.), Miller, J., Ehsani, M., Boca Raton, "Vehicular Electric Power Systems" CRC Press, 2003
2. Husain, I. Boca Raton ,"Electric and Hybrid Vehicles" , CRC Press, 2010.
3. Larminie, James, and John Lowry, "Electric Vehicle Technology Explained" John Wiley and Sons, 2012
4. Tariq Muneer and Irene IllescasGarcía, ,"The automobile, In Electric Vehicles: Prospects and Challenges" , Elsevier, 2017
5. Sheldon S. Williamson ,"Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles" , Springer, 2013
6. Amir Khajepour, Saber Fallah and Avesta Goodarzi, "Electric and Hybrid Vehicles Technologies, Modelling and Control: A Mechatronic Approach" John Wiley & Sons Ltd, 2014.
7. Antoni Szumanowski, "Hybrid Electric Power Train Engineering and Technology: Modelling, Control, and Simulation" IGI Global, 2013.

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Course Code: ELE-624
Course Title: Biomedical Instrumentation
Number of Credits: 04 **Total Hours: 60** **Total Marks: 100**
Effective from AY: 2022-23

Prerequisites for the course

Graduate level knowledge in analog and digital electronics.

Objectives of Course

This course is intended to: ·

- Introduce fundamentals of biomedical instrumentation and measurements
- Introduce concepts of biotelemetry and non-invasive diagnostic imaging
- Cover noise reduction technique in electronics systems

Course Content

Unit I	**Introduction to biomedical instrumentation**	**10 Hours**
Components of Man-Measurement system, Physiological system of body, problems encountered in measuring a living System, Basic transducer principle, Source of Bioelectric Potential, Skin contact Impedance, Electrodes: ECG, EEG, EMG, Microelectrodes.		
Unit II	**Noise reduction technique in electronics systems**	**10 Hours**
Introduction, cabling, grounding, balancing and filtering, shielding, contact protection, Intrinsic Noise Source, Active device Noise, and Electrostatic discharge.		
Unit III	**Cardiovascular measurements.**	**8 Hours**
Heart and cardiovascular system, characteristics of blood flow, Electrocardiography, measurement for Blood Pressure, ,photo-plethysmography,FunctionalNIR for brain oxygenation.		
Unit IV	**Non-invasive diagnostic imaging**	**8 Hours**
X-Ray, CT, MRI, fMRI, PET and SPECT, ULTRASOUND, Optical Tomography		
Unit V	**Biotelemetry**	**10 Hours**
Introduction to Biotelemetry, Physiological parameters Adaptable to Biotelemetry, The components of Biotelemetry System, Implantable Units, and Applications of telemetry in-Patient care.		

Unit VI	**Instrumentation for clinical laboratory**	**6 Hours**
The Blood, Test for Blood cells, chemical Tests, Automation of chemical Test		
Unit VII	**Applications in biomedical field**	**8 Hours**
Wearable devices: activity trackers, hearing aid, Electromyogram band. Laser applications in biomedical fields: Ophthalmology, dermatology, urology, Photoacoustic Tomography.		

Case Studies

1. ECG wave analysis using simulator
2. Signal condition for EMG
3. Signal condition for photoplethysmography
4. Implementation of noise reduction techniques

Pedagogy

lectures/ Experiential Learning

Course Outcome

The student will:

- Understand Fundamentals of medical instrumentation, Bioelectric potential, electrodes
- Understand concepts of biotelemetry
- Understand application of laser in biomedical field
- Implement Noise reduction technique in electronics systems

References/Readings

1. Leslie Cromwell, Fred J. Weibell, and Erich A. Pfeiffer, “Biomedical instrumentation and Measurements” Prentice Hall India, 2011.
2. R .S, Khandpur, “Handbook of Biomedical instrumentation”, Tata Mc GRAW Hill, 2014.
3. Henry W. Ott, “Noise reduction Technique in Electronic systems” , Wiley & sons, 1998.
4. Paul Suetens, “Fundamentals Of Medical Imaging”, 3rd Edition, Cambridge University Press, 2017.

SEMESTER IV

Course Code: ELE-603
Course Title: Optical Communication Systems
Number of Credits: 04 **Total Hours: 60** **Total Marks: 100**
Effective from AY: 2022-23

Prerequisites for the course

Should have knowledge of Electro statics and electromagnetics. Also, a basic understanding of analog and digital communication is preferable.

Objectives of Course

This course is intended to:

- Highlight the importance of optical communication over existing copper cable and microwave communication.
- Elaborate on electromagnetic spectrum usage for various applications, from telephone to satellite communication.
- Create a strong theoretical base to understand the difference between the ray theory and wave theory approach for the passage of signals in optical fibers.
- Discuss the estimation of Noise in optical detection in detail.
- Emphasizes the industrial needs in cabling technique and type of cable used.
- Discuss different techniques of optical fiber manufacturing and their characteristic

Course Content

Unit I	**Light Propagation in Optical Fiber**	**14 Hours**
Introduction & Evolution of Fiber optics system; Geometric picture, Pulse spread due to material dispersion, loss mechanism, Theory of Optical waveguides, methods of waveguides analyses, modes in steps and graded index fiber, new types of optical fibers		
Unit II	**Fiber Optics Technology**	**08 Hours**
Fiber materials & fiber fabrication, cable design, coupling, splicing and connectors, splicing methods, connectors, fiber measurements. Signal Degradation: Attenuation, Losses, Distortion, Pulse broadening.		
Unit III	**Optical Sources & Power Launching**	**08 Hours**
LED and LDs, development of Laser diodes structures, transmitter circuits, Coupling efficiency of the source to fiber. Source to fiber power launching, fiber joints, splicing.		
Unit IV	**Optical detectors**	**09 Hours**
Photoconductive detector: biasing circuit, Commercial photoconductor, Heterodyne Detection, p-n junction & its Equivalent circuit.		

Photodiode: Geometry of p-i-n, Frequency Response of Photodiodes/N ratio, Schottky photodiode. Avalanche diode: Construction, S/R ratio, minimum detection of power. Noise in detectors		
Unit V	**Receiver sensitivity and BER**	**05 Hours**
Receiver design & configuration, Receiver operations, Error sources, Receiver noise		
Unit VI	**Communication System design**	**08 Hours**
System requirement, System design, Link analyses, Power budgeting, Line coding (NRZ, RZ, Block codes),		
Unit VII	**Advance System**	**08 Hours**
TDM, Undersea fiber optics communication system, fibers in a telephone network, WDM, DWDM, OAE techniques, LAN topologies & fail safe fiber optics nodes.		

Case Studies

1. To compute Numerical aperture of a fiber.
2. Launching light in single mode fiber.
3. Computing losses in fiber link.
4. Analysing fiber networks.

Pedagogy

Lectures/Experiential Learning

Course Outcome

Students will:

- Have some knowledge of designing a point-to-point optical link for a given situation.
- Able to choose the right type of components for designing an optical network.
- Able to monitor signal losses during signal transmission.

References/Readings

1. Gerd Keiser , 'Optical Fiber Communication', MGH, 5th ED, 2017
2. A. Selvarajan and et al, 'Optical Fiber Communication', TMH, 1st ED, 2002
3. A. Yariv, 'Optical Electronics', HRW publication, 4th ED, 1991
4. P. Chakrabarti, ' Optical fiber Communication' MGH, 2015
5. Reinhold Noé, 'Essentials of Modern Optical Fiber Communication', Springer, 2nd ED, 2016
6. Govind P. Agrawal, 'Fiber-Optic Communication Systems', Wiley, 5th ED, 2021

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Course Code: ELE-604
Course Title: Digital Image Processing
Number of Credits: 04 **Total Hours: 60** **Total Marks: 100**
Effective from AY: 2022-23

Prerequisites for the course		
Concepts of Digital Signal Processing		
Objectives of Course		
• Learn fundamentals of digital image processing. • To study image processing techniques such as image enhancement, reconstruction, segmentation, morphing and representation		
Course Content		
Unit I	**Introduction**	**10 Hours**
Digital image fundamentals, Sampling and quantization, Pixel relationship, Imaging geometry, Image transforms		
Unit II	**Image Enhancement**	**10 Hours**
Spatial domain- Gray level transformations, Histogram processing, Smoothing and sharpening Spatial filtering. Frequency domain- Fourier Transform, Smoothing and sharpening, Highpass and lowpass filters		
Unit III	**Image Restoration and Segmentation**	**10 Hours**
Image Restoration - Degradation/Restoration process, Noise model, Restoration approach, Inverse filtering, Weiner filtering. Segmentation - Detection of discontinuities, Edge linking and boundary detection, Region based segmentation		
Unit IV	**Color Depth and Image Processing Across Spectrum**	**10 Hours**
Color Image Processing - Color models, Color transformations, Smoothing and sharpening, Segmentation. Depth Imaging processing – RGBD image processing, filling holes. Image Processing across spectra- Multi-spectral imaging, Hyperspectral Imaging, Image feature extraction, fusion.		
Unit V	**Morphological Image Processing and Image Compression**	**10 Hours**
Morphological Image Processing – Dilation and Erosion, Hit or Miss transform, Morphological algorithms. Image Compression – Lossy and Lossless compression, Image compression standards.		
Unit VI	**Object Representation, Description and Recognition**	**10 Hours**
Representation, Boundary descriptors, Regional descriptor, Patterns and Pattern classes, Matching		
Case studies		
1. Image enhancement in spatial and frequency domain 2. Implementing degradation and restoration of image 3. Implement feature extraction algorithms 4. Object detection from the image 5. Spatio-spectral image fusion		
Pedagogy		
Lectures/ Experiential Learning		
Course Outcome		

The Students will:

1. Understand the fundamentals of digital image processing.
2. Operate on images using the techniques such as smoothing, sharpening and enhancement.
3. Explain the concept of image restoration, segmentation and Morphological image processing algorithms.
4. Explain object representation along with the pattern matching.

References/Readings

1. Rafael C Gonzalez and Richard E Woods, 'Digital Image Processing', 4th Edition, Pearson, 2018
2. Anil K Jain, 'Fundamentals of Digital Image Processing', Prentice Hall India Learning Private Limited, 1994
3. William K Pratt, 'Digital Image Processing', 4th Edition, A Wiley-Interscience Publication, 2006
4. Edward R. Dougherty, 'Digital Image Processing Methods', CRC Press, 2020
5. Kumar Navulur, 'Multispectral Image Analysis Using the Object-Oriented Paradigm', CRC Press, 2020
6. Paul L. Rosin, Yu-Kun Lai, Ling Shao, Yonghuai Liu, 'RGB-D Image Analysis and Processing', Springer International Publishing, 2020
7. D. Sundararajan, 'Digital Image Processing - A Signal Processing and Algorithmic Approach', Springer Nature Singapore, 2017

Course Code: ELE-605
Course Title: Neuromorphic Computing
Number of Credits: 04 **Total Hours: 60** **Total Marks: 100**
Effective from AY: 2022-23

Prerequisites for the course		
Graduate level knowledge in analog and digital electronics. Preferable to have exposure to programming.		
Objectives of Course		
This course is intended to: ● Introduce Neuromorphic computing and spiking neural networks (SNN). ● Introduce operational principles and learning models for Artificial Neural Networks and Spiking Neural Networks ● Cover various Neuromorphic computing architectures		
Course Content		
Unit I	**Introduction**	**7 Hours**

Basics of brain-inspired computing and history of neural computing, Comparison of neuromorphic and conventional computing, Basics of linear algebra and probability theory needed for modelling of neural networks.		
Unit II	**Shallow neural networks**	**17 Hours**
Deep learning techniques using convolutional neural networks(AlexNet, VGG, Inception Net, GoogLeNet, and ResNet), Python programming preliminaries and Software development tools for Deep Neural Net (DNN), Shallow neural networks – Perceptron, Hopfield network, Boltzmann machine, Recurrent neural network, and Kohonen's self-organizing map		
Unit III	**Operational principles and learning models**	**17 Hours**
Operational principles and learning models for Artificial Neural Networks and Spiking Neural Networks(SNN) such as spike timing dependent plasticity (STDP), Q-learning, actor-critic reinforcement learning, supervised learning, and back-propagation algorithms.		
Unit IV	**Neuromorphic computing architectures**	**11 Hours**
Neuromorphic computing architectures- Loihi, TrueNorth, Neurogrid, Brainchip and SpiNNaker, Commercial hardware acceleration platforms such as NVDIA's graphics processing unit (GPU), Google's tensor processing unit (TPU), and Intel's vision processing unit (VPU) and FPGA accelerators.		
Unit V	**Applications and Emerging technologies**	**8 Hours**
Application-specific VLSI chips capable of STDP learning, actor/critic reinforcement learning, and Q-learning, Emerging technologies in neuromorphic circuits such as memristors, spin transfer torque devices, and photonic devices.		
Case Studies		
1. Setup of python environment for implementation of Spiking neural network(SNN) 2. Implementation of SNN for Image classification 3. Implementation of SNN for pattern recognition. 4. Handwritten digit recognition Using STDP		
Pedagogy		
lectures/ Experiential Learning		
Course Outcome		

Students will,

- Apply concepts of neuromorphic computing in research as well as industry in various applications such as computer vision, speech processing, pattern recognition etc.
- The student will be able to pursue research in development of neruromorphic hardware.

References/Readings

1. Nan Zheng and Pinaki Mazumder, “Learning in Energy-Efficient Neuromorphic Computing: Algorithm and Architecture Co-Design”, John Wiley & Sons, USA, 2019.
2. Aaron C. Courville, Ian Goodfellow, and Yoshua Bengio, “ Deep Learning”, MIT Press, 2015.
3. Pinaki Mazumder, Yalcin Yilmaz, Idongesit Ebong, “Neuromorphic Circuits for Nanoscale Devices”, River Publishing, 2019.

Course Code: ELE-625
Course Title: Project
Number of Credits: 16 **Total Hours: 480** **Total Marks: 400**
Number of Credits: 04 **Total Hours: 60** **Total Marks: 100**
Effective from AY: 2022-23

Prerequisites for the course
Understanding of Electronics in the area such as Embedded programming, Machine learning, Signals & System, IoT, Robotics.
Objectives of Course
This course is intended to: ● Course train students to develops conceptual design and implementation. ● Hands on experience in H/W and S/W integration. ● Train students to plan and execute the projects and tasks. ● Train students to work in groups ● Hands on exposure to work of Technology development
Methodology
The Project course will commence at beginning of the I st /III rd semester. If student wishes to take up project in industry/Academic institution/organization, such projects can be taken over six-month period in such case the student has to complete 4(four) credit RSOC course prior to II nd /IV th semester. Such student will have to associated with the mentor from industry/Academic institution/organization who will liaison with local supervisor from parent institution. This course is basically to apply the knowledge they have acquired during the course of study and apply them for designing a gadget/interface/module required for an electronic industry/Research & Academic Institutions. The progress of the project is monitored by the local supervisor/guide/discipline members over the period of a month for the I st /III rd semester and fortnightly for II nd /IV th semester for internal evaluation. There will be final evaluation of the projects. The scheme of evaluation will be decided by the school discipline members.
Pedagogy

Presentation /Experiential Learning/Practical implementation
Course Outcome
Students will: ● The student will be exposed to the different kinds of working environments in electronic industries. ● Should able to understand product development cycle, team work, research survey, technical writing.

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