SYLLABUS

(With effect from 2021-22)

Bachelor Degree
In

Electronics & Communication Engineering

VII & VIII Semester

Out Come Based Education
With
Choice Based Credit System

[National Education Policy Scheme]

P.E.S. College of Engineering, Mandya - 571 401, Karnataka
[An Autonomous Institution affiliated to VTU, Belagavi,
Grant – in – Aid Institution (Government of Karnataka),
Accredited by NBA (All UG Programs), NAAC and Approved by AICTE, New Delhi]

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VISION

"PESCE shall be a leading institution imparting quality Engineering and Management education developing creative and socially responsible professionals."

MISSION

- *Provide state of the art infrastructure, motivate the faculty to be proficient in their field of specialization and adopt best teaching-learning practices.*
- *Impart engineering and managerial skills through competent and committed faculty using outcome based educational curriculum.*
- *Inculcate professional ethics, leadership qualities and entrepreneurial skills to meet the societal needs.*
- *Promote research, product development and industry-institution interaction.*

QUALITY POLICY

Highly committed in providing quality, concurrent technical education and continuously striving to meet expectations of stake holders.

CORE VALUES

***P**rofessionalism*
***E**mpathy*
***S**ynergy*
***C**ommitment*
***E**thics*

Department of Electronics and Communication Engineering

The department of Electronics and Communication Engineering was incepted in 1967 with an undergraduate program in Electronics and Communication Engineering. Initially, the program had an intake of 60 students, which increased to 120 in 2012, and further increased to 180 in 2019. Almost 200 students graduate every year, and the long journey of 50 years has seen satisfactory contributions to society, the nation, and the world. The alumni of this department have a strong global presence, making their alma mater proud in every sector they represent.

The department started its PG program in 2012 in the specializations of VLSI design and embedded systems. Equipped with well qualified and dedicated faculty, the department has a focus on VLSI design, embedded systems, and image processing. The quality of teaching and training has yielded a high growth rate of placement at various organizations. The large number of candidates pursuing research programs (M.Sc. and Ph.D.) is a true testimonial to the research potential of the department. The department is recognized as a research centre by VTU, and Mysore University offers a part-time and full-time Ph.D. Program.

Vision

The department of E & C would endeavour to create a pool of Engineers who would be extremely competent technically, ethically strong also fulfil their obligation in terms of social responsibility.

Mission

- M1: Adopt the best pedagogical methods and provide the best facility, infrastructure and an ambience conducive to imbibe technical knowledge and practicingethics.
- M2: Group and individual exercises to inculcate habit of analytical and strategic thinking to help the Students to develop creative thinking and instil team skills.
- M3: MoUs and Sponsored projects with industry and R & D organizations for collaborative learning.
- M4: Enabling and encouraging students for continuing education and moulding them for life-long learning process.

Program Educational Objectives (PEOs)

- **PEO1:** Graduates to exhibit knowledge in mathematics, engineering fundamentals applied to Electronics and Communication Engineering for professional achievement in industry, research and academia.
- **PEO2:** Graduates to identify analyse and apply engineering concepts for design of Electronics and Communication Engineering systems and demonstrate multidisciplinary expertise to handle societal needs and meet contemporary requirements.
- **PEO3:** Graduates to perform with leadership qualities, team spirit, management skills, attitude and ethics need for successful career, sustained learning and entrepreneurship.

Program Outcomes (POs)

- **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
- **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multi disciplinary settings.
- **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multi disciplinary environments.
- **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

Electronics and Communication Engineering Graduates will be able to

- **PSO1:** An ability to understand the basic concepts in Electronics and Communication Engineering and to apply them in the design and implementation of Electronics and Communication Systems.
- **PSO2:** An ability to solve complex problems in Electronics and Communication Engineering, using latest hardware and software tools, along with analytical skills to arrive at appropriate solutions.

Bachelor of Engineering (VII –Semester)											
Sl. No.	**Course Code**	**Course Title**	**Teaching Department**	**Hrs / Week**				**Credits**	**Examination Marks**		
				L	**T**	**P**	**PJ**		**CIE**	**SEE**	**Total**
1	P21EC701	Wireless and Mobile Communication	EC	3	-	-	-	3	50	50	100
2	P21EC702X	Professional Elective Course – IV	EC	3	-	-	-	3	50	50	100
3	P21EC703X	Professional Elective Course - V	EC	3	-	-	-	3	50	50	100
4	P21EC704	Computer Communication Network and IoT (Integrated)	EC	3	-	2	-	4	50	50	100
5	P21EC705	Research Methodology, Report Writing and IPR	EC	3	-	-	-	3	50	50	100
6	P21EC706	Project Work Phase – I	EC	-	-	-	3	4	100	-	100
Total								**20**	**350**	**250**	**600**

Professional Elective Course – IV (P21EC702X)	
Course Code	**Course Title**
P21EC7021	Low Power VLSI Design
P21EC7022	Cryptography and Network Security
P21EC7023	Wireless Sensor Networks
P21EC7024	Multicore architecture and Programming

Professional Elective Course – V (P21EC703X)	
Course Code	**Course Title**
P21EC7031	Satellite Communications
P21EC7032	System on Chip
P21EC7033	Advanced Wireless Technologies
P21EC7034	Biomedical Signal Processing

Bachelor of Engineering (VIII –Semester)											
Sl. No.	**Course Code**	**Course Title**	**Teaching Department**	**Hrs / Week**				**Credits**	**Examination Marks**		
				L	**T**	**P**	**PJ**		**CIE**	**SEE**	**Total**
1	P21EC801	Self-Study Course	EC	-	-	-	-	2	100	-	100
2	P21ECINT802	Research/Industry Internship- III	EC	-	-	-	-	6	50	50	100
3	P21EC803	Project Work Phase – II	EC	-	-	-	3	8	100	100	200
Total								**16**	**250**	**150**	**400**

L: Lecture	T: Tutorial	CIE: Continuous Internal Evaluation
P: Practical/ Drawing	PJ: Project	SEE: Semester End Examination

Wireless and Mobile Communication [As per Choice Based Credit System (CBCS) & OBE Scheme] SEMESTER – VII			
Course Code:	**P21EC701**	**Credits:**	**03**
Teaching Hours/Week (L:T:P):	**3 : 0 : 0**	**CIE Marks:**	**50**
Total Number of Teaching Hours:	**40**	**SEE Marks:**	**50**

Course Learning Objectives: This course will enable the students to:

- Understand the various modern wireless communication systems.
- Discuss the concept of cellular architecture and system design fundamentals to improve channel capacity.
- Describe different wireless systems and standards.
- Study the Mobile Radio Propagation
- Study the modern cellular architectures LTE, VOLTE etc.

UNIT – I	**8 Hours**

Introduction to Wireless Communication Systems and Wireless Networks: Examples of Wireless Communication Systems. Wireless local loop (WLL) and LMDS, Wireless Local Area Networks(WLANs), Bluetooth and Personal Area Networks (PANs).
Text 1:1.4, 2.3-2.5

Self-Study Component:	**1.** List out modern wireless communications networks are available to the user around the world with their services and type of technologies used.

UNIT – II	**8 Hours**

The Cellular Concept- System Design Fundamentals: Handoff strategies, Interference and system capacity, Trunking and Grade of service, Improving coverage and capacity in cellular systems.
Text 1: 3.4-3.7

Self-Study Component:	**1.** Understand the latest/recent capacity enhancement techniques in cellular system.

UNIT – III	**8 Hours**

GSM and Modulation Techniques for Mobile Radio: Global System for Mobile (GSM), Constant envelope modulation, Combined Linear and Constant Envelope Modulation Techniques, Spread Spectrum Modulation Techniques.
Text 1: 11.3 and 6.9-6.11.

Self-Study Component:	**1.** Compare and contrast CDMA with GSM mobile standards.

UNIT – IV	**8 Hours**

Mobile Radio Propagation: Large-Scale Path Loss: Introduction to Radio Wave Propagation, Free Space Propagation Model, Relating Power to Electric Field, The 3 Basic Propagation Models, Reflection, Ground Reflection, Diffraction, Okumura Model, Hata Model.
Mobile Radio Propagation: Small-Scale Fading and Multipath: Small-Scale Multipath Propagation, Impulse Response Model of a Multipath Channel.
Text 1: 4.1-4.7, 4.10.3, 4.10.4, 5.1, 5.2.

Self-Study Component:	**1.** Study the empirical models for Indoor and outdoor propagation.

UNIT – V	8 Hours

Introduction to 4G and Advanced: The Need for LTE, From UMTS to LTE, From LTE to LTE-Advanced, Carrier Aggregation, Principles of Operation, Career Aggregation, Enhanced Downlink & Uplink MIMO.

VoLTE: Introduction, Hardware Architecture of IMS, VoLTE Registration Procedure, Call Setup and Release.

LTE Advanced: Peak Data Rates of and LTE Advanced, Coverage & Capacity of an LTE Cell. Performance.

Text 2: 1.3-1.5, 19.1-19.3, 22.1-22.2, 22.5-22.6, 23.1-23.3

Self-Study Component:	**1.** Study the white papers on 5G and 6G wireless technologies in cellular systems and submit a report on recent developments in it.

Course Outcomes: On completion of this course, students are able to:

COs	Course Outcomes with *Action verbs* for the Course topics	Bloom's Taxonomy Level	Program Outcome Addressed (PO #) with BTL
CO1	**Apply** signal processing for wireless communication system to realize basic principles of wireless communication.	L2	PO1 (L2)
CO2	**Analyze** various standards and methodologies to improve the cellular capacity.	L3	PO2 (L3)
CO3	**Illustrate** fundamentals of cellular communication system to study various advanced wireless systems, standards and mobile radio propagation.	L2	PO1 (L2)
CO4	**Create** a cellular system for various parameters like capacity, interference, handoff, radio propagation etc.	L3	PO2 (L3)

Text Book(s):

1. Wireless Communications- Principles and Practice, Theodre. S. Rappaport, Pearson, 2nd Edition, 2010. ISBN-13: 9788131731864.
2. An Introduction to LTE: LTE, LTE-Advanced, SAE and 4G Mobile Communications" by Christopher Cox

Reference Book(s):

1. William. C. Y. Lee "Wireless and Cellular Communications", Mc-Graw Hill, 2005. ISBN: 978-00-714-3686-1.
2. Gary. J. Mullet"Introduction to Wireless Telecommunications Systems and Networks", Cengage Learning, 2010. ISBN-13: 978-81-315-0559-5.
3. Ozan. K. Tonguz, Giianluigi Ferrari "Ad-HOC Wireless Networks: A Communication-Theoretic Perspective", Wiley India Edition, 2009, ISBN: 9788126523047.
4. From GSM to LTE-Advanced PRO and 5G, Martin Sauter, Wireless Moves, Germany, Revised 3rd Edition.

Web and Video link(s):

1. https://onlinecourses.nptel.ac.in/noc21_ee66/preview
2. https://archive.nptel.ac.in/courses/117/104/117104099/

E-Book Resources:

1. https://books.google.co.in/books?id=G5C5ii8O_y0C&printsec=frontcover#v=onepage&q&f=false

Course Articulation Matrix (CAM)														
CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**
#1	**3**												**3**	
#2		**2**												**2**
#3	**3**												**3**	
#4		**2**												**2**
*****														

Low Power VLSI Design [As per Choice Based Credit System (CBCS) & OBE Scheme] SEMESTER – VII			
Course Code:	**P21EC7021**	**Credits:**	**03**
Teaching Hours/Week (L:T:P):	**3 : 0 : 0**	**CIE Marks:**	**50**
Total Number of Teaching Hours:	**40**	**SEE Marks:**	**50**

Course Learning Objectives: This course will enable the students:

- Provide the basic knowledge of low power VLSI design
- Understand the types of power dissipation in CMOS devices
- Discuss different techniques of power analysis and digital cell library
- Discuss the concepts of Low power Clock Distribution
- Design low power arithmetic circuits and systems
- Understand the architecture and performance management of the system

UNIT – I	8 Hours

Introduction: Needs for Low Power VLSI Chips, Charging and Discharging Capacitance, Short-circuit Current in CMOS Circuit, CMOS Leakage Current, Static Current, Basic Principles of Low Power Design, Low Power Figure of Merits.

Simulation Power Analysis: SPICE Circuit Simulation, Discrete Transistor Modeling and Analysis, Gate-level Logic Simulation, Architecture-level Analysis, Data Correlation Analysis in DSP Systems.

Text 1: 1.1-1.7, 2.1-2.6

Self-Study Component:	**1.** Study on minimizing the power consumption in Digital CMOS Circuits. **2.** Study and develop a report on Monte Carlo Simulation techniques.

UNIT – II	8 Hours

Probabilistic Power Analysis: Random Logic Signals, Probability and Frequency, Probabilistic Power Analysis Techniques, Signal Entropy.

Circuit: Transistor and Gate Sizing, Equivalent Pin Ordering, Network Restructuring and Reorganization, Special Latches and Flip- flops, Low power Digital Cell Library.

Text 1: 3.1-3.4, 4.1-4.6

Self-Study Component:	**1.** Compare various power reduction techniques for ADC circuits. **2.** Analyse the how the power loss takes place during switching activity and way to reduce that.

UNIT – III	8 Hours

Logic: Gate Reorganization, Signal Gating, Logic Encoding, State Machine Encoding, Precomputation Logic.

Special Techniques: Power Reduction in Clock Networks, CMOS Floating Node, Low Power Bus, Delay Balancing, Low Power Techniques for SRAM.

Text 1: 5.1-5.5, 6.1-6.5

Self-Study Component:	**1.** Application of Bus inverts coding for low power I/O. **2.** Study on low power techniques for DRAM.

UNIT – IV	8 Hours

Architecture and System: Power and Performance Management, Switching Activity Reduction, Parallel Architecture with Voltage Reduction, Flow Graph Transformation.

Advanced Techniques: Adiabatic Computation, Pass Transistor Logic Synthesis, Asynchronous System Basics.

Text 1:7.1-7.4, 8.1-8.3

Self-Study Component:	**1.** Understand the trade-off between power and area in low power architecture. **2.** Discuss the low power digital system based on Adiabatic Switching principle.

UNIT – V	**8 Hours**

Low–Energy Computing Using Energy Recovery Techniques: Energy Dissipation in transistor channel using an RC Model, Energy Recovery Circuit Design, Designs with Partially Reversible Logic: Designs with Reversible Logic, Simple Charge Recovery Logic Modified from Static CMOS Circuits, Adiabatic Dynamic Logic. Energy recovery SRAM Core, Another Core Organization, Energy Dissipation in Memory Core, Comparison of Two Memory Core Organizations, Design of Peripheral Circuits, Optimal Voltage Selection, Supply clock generation.
Text 2: 7.1- 7.4,

Self-Study Component:	**1.** Discuss memory allocation technique for low energy embedded software. **2.** Study on instruction level power analysis and optimization of software.

Course Outcomes: On completion of this course, students are able to:

COs	**Course Outcomes** with ***Action verbs*** for the Course topics	**Bloom's Taxonomy Level**	**Program Outcome Addressed (PO #) with BTL**
CO1	**Apply** the basic knowledge of physics and the fundamental circuit concept in understanding low power circuits and its necessities.	L3	PO1 (L3)
CO2	**Apply** suitable optimization technique for a given scenario/problem in low power VLSI Design and synthesis	L3	PO1 (L3)
CO3	**Analyze** low power VLSI circuits using different circuit technologies and design levels.	L4	PO2 (L4)
CO4	**Create** a reversible logic and partially reversible logic in low power circuits	L5	PO3 (L5)

Text Book(s):

1. Practical Low Power Digital VLSI Design, Gary K, Yeap, Kluwer Academic Publishers, ISBN – 13: 978-0792380092, 2008.
2. Low–Power CMOS VLSI Circuit Design, Kaushik Roy and Sharat C Prasad, Wiley Student edition, 2009. ISBN: 978-81-265-2023-7.

Reference Book(s):

1. Low Power Design Methodologies, Rabaey, Pedram, Kluwer Academic Publishers, ISBN – 978-1-4613-5975-3, 2009.

Web and Video link(s):

1. https://www.youtube.com/watch?v=TFOO1JAll2Y&list=PLBU5KursMXEMWAkoUPB5aqUPb3lKYqN6q

Course Articulation Matrix (CAM)													
CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**
#1	**3**												**3**	
#2	**2**												**2**	
#3		**3**												**3**
#4			**2**											
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Cryptography and Network Security [As per Choice Based Credit System (CBCS) & OBE Scheme] SEMESTER – VII			
Course Code:	**P21EC7022**	**Credits:**	**03**
Teaching Hours/Week (L:T:P):	**3 : 0 : 0**	**CIE Marks:**	**50**
Total Number of Teaching Hours:	**40**	**SEE Marks:**	**50**

Course Learning Objectives: This course will enable the students to:

- Illustrate the Cryptography, Network Security and its Principles.
- Analyze different Private and Public Key Cryptographic Algorithms.
- Demonstrate the application of Hash Functions and Message Authentication Code for different security contexts.
- Compare and contrast different security frameworks, models and architectures.
- Identify the different security issues involved in networking.
- Analyze different case study on Email Threats/Security and IP Security

UNIT - I	**8 Hours**

Classical Encryption Techniques: Symmetric Cipher Model,Substitution Techniques, Transposition Technique.

Block Ciphers and the Data Encryption Standard: Traditional Block Cipher Structure, The Data Encryption Standard.

Advanced Encryption Standard: AES Structure, AES Transformation Functions.

Text 1:3.1-3.3, 4.1-4.2, 6.2-6.3

Self-Study Component:	**1.** Design and Implement an AES-based system for a specific application, selecting appropriate key sizes, block sizes, and modes of operation to meet security and performance goals.

UNIT - II	**8 Hours**

Public-Key Cryptography and RSA: Principles of Public-Key Cryptosystems, The RSA Algorithm.

Other Public-Key Cryptosystems: Diffie-Hellman Key Exchange, Elgamal Cryptographic System, Elliptic Curve Cryptography, Pseudorandom Number Generation Based on an Asymmetric Cipher.

Text 1: 9.1-9.2, 10.1-10.2, 10.4 – 10.5.

Self-Study Component:	**1.** Discuss how Elliptic Curve Arithmetic is used in cryptographic applications, describing the properties and security benefits of elliptic curves. **2.** Analyze the basic principles and algorithms of pseudorandom number generation using block ciphers, including cipher modes and key scheduling.

UNIT - III	**8 Hours**

Cryptographic Hash Functions: Applications of Cryptographic Hash Functions, Two Simple Hash Functions, Requirements and Security.

Message Authentication Code: Message Authentication Requirements, Message Authentication Functions, Requirements for Message Authentication Codes, Security of MACs, MACs Based on Hash Functions: HMAC MACs Based on Block Ciphers: DAA and CMAC.

Digital Signatures: Digital Signatures, Elgamal Digital Signature Scheme, Schnorr Digital Signature Scheme**,** NIST Digital Signature Algorithm, Elliptic Curve Digital Signature Algorithm.

Text 1:11.1-11.3,12.1-12.6, 13.1-13.5

Self-Study Component:	**1.** Demonstrate the basic principles and constructions of hash functions based on Cipher Block Chaining (CBC), including encryption and decryption processes. **2.** Compare and contrast CCM and GCM, analyzing their security, performance, and implementation advantages and disadvantages in various applications.

UNIT - IV	**8 Hours**

Network Access Control and Cloud Security: Network Access Control, Extensible Authentication Protocol, Cloud Computing, Cloud Security Risks and Countermeasures, Data Protection in the Cloud, Cloud Security as a Service, Addressing Cloud Computing Security Concerns.
Transport-Level Security: Web Security Considerations, Transport Layer Security, HTTPS, Secure Shell (SSH).
Wireless Network Security: Wireless Security, Mobile Device Security.
Text 1:16.1-16.2, 16.4-16.8, 17.1-17.4, 18.1-18.2

Self-Study Component:	**1.** Illustrate the basic principles and components of IEEE 802.1X, including port-based access control, authentication protocols, and EAP (Extensible Authentication Protocol). **2.** Compare and contrast different Wireless LAN security protocols and implementations, analyzing their security, performance and interoperability in various network environments.

UNIT - V	**8 Hours**

Electronic Mail Security: Internet Mail Architecture, Email Formats, Email Threats and Comprehensive Email Security, S/MIME, Pretty Good Privacy.
IP Security - IP Security Overview, IP Security Policy, Encapsulating Security Payload.
Text 1: **19.1- 19.5, 20.1- 20.3**

Self-Study Component:	**1.** Analyze and Present the Case Study on Email Threats and Security: Refer the journal, Altulaihan, E., Alismail, A., Hafizur Rahman, M. M., & Ibrahim, A. A. (2023). "Email Security Issues, Tools and Techniques used in Investigation". Sustainability, 15(13), 10612. https://www.mdpi.com/2375272. **2.** Analyze and Present the Case Study on IP Security: Refer the journal, Alphy Shahrin Sadma, Md. Safiul Mujnebin. "A Case Study on IP Security" (2023). https://www.researchgate.net/publication/373832770_A_Case_Study_on_IP_Security_CSE_406_Cryptography_and_Network_Security.

Course Outcomes: On completion of this course, students are able to:

COs	**Course Outcomes** with ***Action verbs*** for the Course topics	**Bloom's Taxonomy Level**	**Program Outcome Addressed (PO #) with BTL**
CO1	**Apply** the fundamentals of communication systems to understand basic principle of cryptography and network security	L2	PO1(L2)
CO2	**Illustrate** the functionality of various private and public cryptographic algorithms	L2	PO2 (L2)
CO3	**Infer** the applicability of hash functions and Message Authentication code for **develop**ing and comparing different security contexts	L3	PO3 (L3)

CO4	**Characterize** and identify different security threats in networking applications.	L3	PO2, PO7, PO12 (L3)

Text Book(s):

1. Cryptography and Network Security: Principles and Practice, William Stallings, Pearson 7th edition, ISBN 10:1-292-15858-1 ISBN 13: 978-1-292-15858-7.

Reference Book(s):

1. Cryptography and Information Security, V. K Pachghare, PHI 2nd Edition, ISBN: 9788120350823.
2. Cryptography and Network Security, BehrouzA.Foruzan, Tata McGraw Hill, 2007 ISBN 978–0–07–287022–0.

Web and Video link(s):

1. https://nptel.ac.in/courses/106105031
2. https://onlinecourses.nptel.ac.in/noc21_cs16
3. https://www.digimat.in/nptel/courses/video/106105031
4. https://www.youtube.com/watch?v=PHsa_Ddgx6w

E-Books/Resources:

1. https://www.cs.vsb.cz/ochodkova/courses/kpb/cryptography-and-network-security_-principles-and-practice-7th-global-edition.pdf.

Course Articulation Matrix (CAM)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
# 1	3												3	
# 2		2												2
# 3			2											
# 4		2					2					2		2

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Wireless Sensor Networks [As per Choice Based Credit System (CBCS) & OBE Scheme] SEMESTER – VII			
Course Code:	**P21EC7023**	**Credits:**	**03**
Teaching Hours/Week (L:T:P):	**3 : 0 : 0**	**CIE Marks:**	**50**
Total Number of Teaching Hours:	**40**	**SEE Marks:**	**50**

Course Learning Objectives: This course will enable the students to:

- Provide an understanding of common wireless sensor node architectures.
- Discuss various applications of wireless sensor architectures.
- Provide an understanding of essential networking architecture.
- Describe current technology trends for the implementation and deployment of wireless sensor networks.
- Discuss the general issues of task-driven sensing.
- Provide an overview of few sensor node hardware platforms.

UNIT – I	**8 Hours**

Overview of Wireless Sensor Networks: The vision of Ambient Intelligence, Application examples, Types of Applications, Challenges for WSNs, why are sensor networks different? **Architectures:** Hardware components, Energy Consumption of Sensor Nodes, Operating systems and execution environments, Some example of sensor nodes.

Text 1:1.1 to 1.5, 2.1 to 2.4

Self-Study Component:	**1.** Implement a Network of N nodes using any simulation environment **2.** Illustrate the concept of Power supply of sensor nodes and design principles for WSNs

UNIT – II	**8 Hours**

Communication Protocol: Physical Layer- Introduction, Wireless Channel and Communication Fundamentals, Physical layer and transceiver design considerations in WSNs **MAC Protocols:** Fundamentals of MAC Protocols, Low Duty cycle protocols and wakeup concepts, Contention Based Protocols, Scheduled Based protocols.

Text 1:4.1 to 4.3, 5.1, to 5.4

Self-Study Component:	**1.** Implement a Network of N nodes and verify the changes in power usage using schedule-based concepts **2.** Illustrate the Fundamentals of Wireless MAC Protocols

UNIT – III	**8 Hours**

Communication Protocol: Link Layer Protocols: Fundamentals: tasks and requirements, Error Control, Framing, Link management.

Naming and Addressing: Fundamentals, Address and name management in wireless sensor networks, Assignment of MAC addresses, distributed assignment of locally unique addresses, Content-based and geographic addressing

Text 1:6.1 to 6,4, 7.1 to 7.5

Self-Study Component:	**1.** Establish communication between N nodes and demonstrate how Error Control can improve efficiency of network using any simulator **2.** Establish network of N nodes and represent address each node with an address using different addressing methods

UNIT – IV	**8 Hours**

Network Establishment and Routing: Topology Control, Motivation and Basic idea, controlling topology in flat networks, Hierarchical networks by clustering,

Routing Protocols: the many faces of forwarding and routing, Gossiping and agent- based unicast forwarding, Energy efficient unicast, Broadcast and Multicast, Geographic routing.

Security in WSN, Fundamentals, Security considerations in wireless sensor networks.
Text 1:10.1, 10.2, 10.4, 11.1 to 11.5, 14.2

Self-Study Component:	**1.** Establish communication between N nodes and illustrate efficiency achieved using Clustering using any simulator **2.** Establish network of N nodes and demonstrate unicast, broadcast and multicast routing using any simulator

UNIT – V	**8 Hours**

Sensor Network Platforms and Tools: Sensor network Hardware, Sensor network programming challenges, Node–Level software platforms–Tiny OS, nesC component implementation, nesC–concurrency and atomicity, Tiny GALS, Node– Level simulators– ns2 simulator, TOSSIM.
Advanced applications: Emerging Applications-Asset and warehouse management, Automotive, Building Monitoring, Environment Monitoring, Industrial Process Control, Military battlefield awareness, security and surveillance, Future Research directions: Secure embedded systems, Light weight Signal Processing, Networks of High Data Rate sensors, google for the physical world, closing the loops with Actuators.
Text 2:7.1 to 7.4, 8.2,8.3.1, 8.3.4, 8.3.5,8.3.6,8.3.7

Self-Study Component:	**1.** Establish network of N nodes using NS2 simulator and demonstrate data communication at different levels of network **2.** Study Future research directions in the Field of Network of High Data rate sensors

Course Outcomes: On completion of this course, students are able to:

COs	**Course Outcomes** with ***Action verbs*** for the Course topics	**Bloom's Taxonomy Level**	**Program Outcome Addressed (PO #) with BTL**
CO1	**Apply** fundamentals of Computer communication networks to understand characteristics and architecture of Wireless sensor networks	L3	PO1 (L3)
CO2	**Analyze** Communication protocols and controlling mechanisms which can enhance efficiency of Wireless sensor network	L3	PO2 (L3)
CO3	**Analyze** and compare different infrastructure establishment principles on sensor network platform	L3	PO2 (L3)
CO4	**Illustrate** and Identify the unique constraints, applications and resource fairness in context of wireless sensor networks	L3	PO6 (L3)
CO5	**Simulate** Wireless sensor network platforms using modern tools	L4	PO5 (L4)

Text Book(s):

1. Protocols and Architectures for Wireless Sensor Networks, Holger Karl and Andress Willig, John Willey, 2005. ISBN-13 978-0-470-09510-2.
2. Wireless Sensor Networks–An Information Processing Approach, Feng Zhao and Leonidas.J. Guibas, Elsevier, 2007. ISBN: 978-1-55860-914-3.

Reference Book(s):

1. Wireless Sensor Networks Technology, Protocols and Applications, Kazem Sohraby, Daniel Minoli, and Taieb Znati, John Wiley, 2007, ISBN-10: 0471743003, ISBN-13: 978-0471743002.
2. Wireless Sensor Network Designs, Anna Hac, John Wiley, 2003,

ISBN 10: 0470867361and ISBN 13: 9780470867365.

Web and Video link(s):

1. https://nptel.ac.in/courses/106/105/106105160/ (By Prof Sudip Misra, IIT Kharagpur)

E-Books/Resources:

1. https://www.google.co.in/books/edition/Protocols_and_Architectures_for_Wireless/170R-1aZsQYC?hl=en&gbpv=1&dq=%E2%80%9CProtocols+and+Architectures+for+Wireless+Sensor+Networks%E2%80%9D,Holger+Karl+and+AndressWillig,+John+Willey,+2005.+ISBN-13+978-0-470-09510-2&printsec=frontcover

Course Articulation Matrix (CAM)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
#1	2												2	
#2		3												3
#3		2												2
#4						1								
#5					1									

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Multicore Architecture and Programming
[As per Choice Based Credit System (CBCS) & OBE Scheme]
SEMESTER – VII

Course Code:	**P21EC7024**	**Credits:**	**03**
Teaching Hours/Week (L:T:P):	**3 : 0 : 0**	**CIE Marks:**	**50**
Total Number of Teaching Hours:	**40**	**SEE Marks:**	**50**

Course Learning Objectives: This course will enable the students to

- Understand the concept of multi–core architecture and system overview of threading.
- Cover fundamental concepts of parallel programming and its constructs.
- Describe in detail the concepts of threading APIs.
- Explain the different aspects of Open MP.
- Use Open MP for parallel programming

UNIT – I **8 Hours**

Introduction to Multi– core Architecture: Motivation for Concurrency in software, Parallel Computing Platforms, Parallel Computing in Microprocessors, Differentiating Multi–core Architectures from Hyper– Threading Technology, Multithreading on Single–Core versus Multi–Core Platforms Understanding Performance, Amdahl's Law, Growing Returns: Gustafson's Law.

System Overview of Threading: Defining Threads, System View of Threads, Threading above the Operating System, Threads inside the OS, Threads inside the Hardware, What Happens When a Thread Is Created, Application Programming Models and Threading.

Text 1: 2.4, 3.1to 3.5

Self-Study Component:	**1.** Undersand the concepts present in the thesis: Bulpin, James Roy. 2004. Operating System Support for Simultaneous Multithreaded Processors. PhD thesis, King's College, University of Cambridge, September.

UNIT – II **8 Hours**

Fundamental Concepts of Parallel Programming: Designing for Threads, Task Decomposition, Data Decomposition, Data Flow Decomposition, Implications of Different Decompositions, and Challenges You will Face, Parallel Programming Patterns. A Motivating Problem: Error Diffusion, Analysis of the Error Diffusion Algorithm. An Alternate Approach: Parallel Error Diffusion, Other Alternatives.

Threading and Parallel Programming Constructs: Synchronization, Critical Sections, Deadlock, Synchronization Primitives, Semaphores, Locks, Condition Variables, Messages, Flow Control–based Concepts, Fence, Barrier

Text 1: 4.1 to 4.3, 4.4 to 4.5

Self-Study Component:	**1.** Study and write a report on: Barney, Blaise. Introduction to Parallel Computing. Lawrence Livermore National Laboratory, Livermore Computing.Available at: http://www.llnl.gov/computing/tutorials/parallel_comp/.

UNIT – III **8 Hours**

Solutions to Common Parallel Programming Problems: Too Many Threads, Data Races, Deadlocks, and Live Locks, Deadlock, Heavily Contended Locks, Priority Inversion, Solutions for Heavily Contended Locks, Non–blocking Algorithms, ABA Problem, Cache Line Ping– ponging, Memory Reclamation Problem, Recommendations, Memory Issues, Bandwidth, Working in the Cache, Cache related Issues, False Sharing, Memory Consistency.

Text 1: Chapter 7

Self-Study Component:	**1.** Study and write a report on: Blumofe, Robert D., Christopher F. Joerg, Bradley C. Kuszmaul, Charles E. Leiserson, Keith H. Randall, and Yuli Zhou. 1995. Cilk: An Efficient Multithreaded Runtime System. Proceedings of the 5th ACM SIGPLAN Symposium on Principles and Practice of Parallel Programming (July):207–216.

UNIT – IV	**8 Hours**

OpenMP: A Portable Solution for Threading Challenges in Threading a Loop, Loop–carried Dependence, Data– race Conditions, Managing Shared and Private Data, Loop Scheduling and Portioning, Effective Use of Reductions, Minimizing Threading Overhead, Work–sharing Sections, Performance– oriented Programming, Using Barrier and No wait, Interleaving Single– thread and Multi– thread Execution, Data Copy–in and Copy–out, Protecting Updates of Shared Variables, OpenMP Library Functions, OpenMP Environment Variables, Compilation, Debugging, performance.

Text 1: 6.4-6.6, 9.1 to 9.6

Self-Study Component:	**1.** Understand the concepts: Hill, Mark D. 1998. Multiprocessors Should Support Simple Memory Consistency Models. IEEE Computer (August), 31(8):28–34.

UNIT – V	**8 Hours**

OpenMP Language Features: Introduction Terminology Parallel Construct Sharing the Work among Threads in an OpenMP Program Clauses to Control Parallel and Work-Sharing Constructs OpenMP Synchronization Constructs Interaction with the Execution Environment More OpenMP Clauses Advanced OpenMP Constructs .

Text 2: Chapter 4

Self-Study Component:	**1.** Understand multithreaded programming: Mattson, Tim. Nuts and Bolts of Multithreaded Programming. Santa Clara, CA: Intel Corporation. Available at: http://www.intel.com.

Course Outcomes: On completion of this course, students are able to:

COs	**Course Outcomes** with ***Action verbs*** for the Course topics	**Bloom's Taxonomy Level**	**Program Outcome Addressed (PO #) with BTL**
CO1	**Evaluate** the Multicore Hardware and Software concepts.	L2	PO1 (L2)
CO2	**Analyze** the Parallel Programming concepts with examples along with Deadlocks and Semaphores.	L3	PO1 (L3)
CO3	**Develop** the theories related to parallel programming problems and methods to overcome them.	L3	PO2 (L3)
CO4	**Describe** the various programming concepts of OpenMP with examples.	L3	PO3 (L3)

Text Book(s):

1. Multicore Programming, Increased Performance Through Software Multi–threading, Shameem Akhter and Jason Roberts, Intel Press, 2006. ISBN 0-9764832-4-6.
2. Using OpenMP, Portable Shared Memory Parallel Programming, Barbara Chapman, Gabriele Jost, Ruud van der Pas, 2008, ISBN 978-0-262-53302 MIT Press, Massachusetts Institute of Technology

Reference Book(s):

1. Principles of Parallel Programming, Calvin Lin, Lawrence Snyder, Pearson Education, 2009. ISBN-13: 978-0321487902.
2. Parallel Programming in C with MPI and OpenMP, Michael J. Quinn, Tata McGraw Hill, 2004. ISBN 13: 9780070582019.
3. Parallel Computer Architecture A Hardware / Software Approach David E, Culler, Jaswinder Pal Singh with Anoop Gupta, ISBN: 9781558603431.

Web and Video link(s):

1. Multi-Core Computer Architecture – Storage and Interconnects, NPTEL IIT Guwahati. https://www.youtube.com/playlist?list=PLwdnzlV3ogoU0TR333JyxG8T3HDg52S0h
2. Introduction to parallel Programming in Open MP https://www.youtube.com/playlist?list=PLJ5C_6qdAvBFMAko9JTyDJDIt1W48Sxm

E-Books/Resources:

1. Introduction to Computer Systems https://www.cs.cmu.edu/~fp/courses/15213-s07//schedule.html

Course Articulation Matrix (CAM)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2
#1	1												1	
#2	3												3	
#3		3												3
#4			3											

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Satellite Communications [As per Choice Based Credit System (CBCS) & OBE Scheme] SEMESTER – VII			
Course Code:	**P21EC7031**	**Credits:**	**03**
Teaching Hours/Week (L:T:P):	**3 : 0 : 0**	**CIE Marks:**	**50**
Total Number of Teaching Hours:	**40**	**SEE Marks:**	**50**

Course Learning Objectives: This course will enable the students to:

- Identify and describe the various frequency bands allocated for satellite communications and their specific uses.
- Understand the concepts of Kepler's law of planetary motion be applied to the case of geostationary satellite.
- Analyze the various satellite subsystem Components and also design trade-offs and limitations inherent in satellite system design.
- Describe different advanced satellite access methods.
- Design communication links and calculate accurate link budgets by considering various factors to ensure optimal performance of satellite communication systems.

UNIT - I	**8 Hours**

Overview of Satellite Systems: Introduction, frequency allocations for satellite services, INTELSAT.

Orbits and Launching Methods: Introduction, Kepler's first law, Kepler's second law, Kepler's third law, definitions of terms for earth orbiting satellites, orbital elements, apogee and perigee heights, orbit perturbations, effects of a non-spherical earth, atmospheric drag.

The Geostationary Orbit: Introduction, antenna look angles, the polar mount antenna, limits of visibility, near geostationary orbits, earth eclipse of satellite, sun transit outage

Text 1: 1.1 to 1.3, 2.1 to 2.8, 3.1 to 3.6, 3.7

Self-Study Component:	**1.** Study various calendar systems, universal time, Julian dates, and sidereal time.

UNIT - II	**8 Hours**

The Space Segment: Introduction, power supply, attitude control, spinning satellite stabilization, momentum wheel stabilization, station keeping, thermal control, TT&C subsystem, transponders, the wideband receiver, the input de–multiplexer, the power amplifier.

The Earth Segment: Introduction, receive–only home TV system, the outdoor unit, the indoor unit for analog (FM) TV, master antenna TV system, Community Antenna TV system.

Text 1: 7.1 to 7.7, 8.1 to 8.4

Self-Study Component:	**1.** Understand the functioning of antenna subsystems and transmit-receive earth stations.

UNIT - III	**8 Hours**

Satellite Access: Introduction, single access, pre–assigned FDMA, Demand– assigned FDMA, Spade system, bandwidth limited and power–limited TWT amplifier operation, FDMA downlink analysis, TDMA, reference burst, preamble and post amble, carrier recovery, network synchronization, Unique word detection, Traffic data, Frame efficiency and channel capacity, code–division multiple access, direct–sequence spread spectrum, the code signal c(t), acquisition and tracking, spectrum spreading and dispreading, CDMA throughput.

Text 1: 14.1 to 14.7, 14.7.1 to 14.7.7, 14.10, 14.10.1 to 14.10.5

Self-Study Component:	**1.** Study and write a report on the article "Modulation and Signal Processing for LEO-LEO Optical Inter-Satellite Links" **https://ieeexplore.ieee.org/abstract/document/10155111**

UNIT - IV	8 Hours

The Space Link: Introduction , Equivalent Isotropic Radiated power, transmission losses, free– space transmission, feeder losses, antenna misalignment losses, fixed atmospheric and ionospheric losses, the link power budget equation, system noise, antenna noise, amplifier noise temperature, amplifier in cascade, noise factor, noise temperature of absorptive networks, overall system noise temperature, carrier–to–noise ratio, the uplink, saturation flux density, input back off, the earth station HPA, Downlink, output back–off, satellite TWTA output.

Satellites in Networks: Introduction, Asynchronous transfer mode (ATM), ATM over satellite, satellite links and TCP, enhancing TCP over satellite channels using standard mechanisms (RFC–2488), requests for comments.

Text 1: 12.1 to 12.8, 15.1, 15.4, 15.5, 15.9 to 15.11

Self-Study Component:	**1.** Explore the intricacies of simulating Effective Isotropic Radiated Power (EIRP), mitigating transmission losses, and managing system noise to enhance satellite communication efficiency.

UNIT - V	8 Hours

Direct Broadcast Satellite (DBS) Television: Introduction, orbital spacing, power rating and number of transponders, frequency and polarization, transponder capacity, bit rates for digital television, MPEG compression standards, forward error correction (FEC).

Satellite Mobile and Specialized Services: Introduction, satellite mobile services, VSATs, radar sat, orbcomm.

Satellite Navigation and global positioning system: Introduction, Radio and satellite navigation, GPS position location principles, GPS receivers and codes, satellite signal acquisition, GPS navigation message.

Text 1:16.1 to 16.14, 17.1 to 17.7 & 12.1 to 12.6

Self-Study Component:	**1.** Analyze and present the application of satellites in the context of the article "A survey on satellite communication system security applications". **https://www.mdpi.com/1424-8220/24/9/2897**

Course Outcomes: On completion of this course, students are able to:

COs	Course Outcomes with *Action verbs* for the Course topics	Bloom's Taxonomy Level	Program Outcome Addressed (PO #) with BTL
CO1	**Apply** advanced mathematical concepts and communication principles to the field of satellite communications.	L3	PO1 (L3)
CO2	**Analyze** essential communication satellite systems, including design trade-offs and limitations.	L4	PO2 (L4)
CO3	**Evaluate** various multiple access techniques, benefits, and drawbacks in modern communication systems.	L3	PO3 (L3)
CO4	**Examine** specialized satellite services for various applications practicality and impact.	L3	PO2 (L3)

Text Book(s)

1. Satellite Communications, Dennis Roddy, 4th edition, Special Indian Edition 2009, Tata McGraw–Hill, ISBN 13: 978-0-07-007785-0 ISBN 10:0- 07-007785-1.
2. Satellite Communications, Timothy Pratt, Charles Bostian and Jeremy Allnutt, 2nd edition, John Wiley & Sons, 2010. ISBN: 9788126508334

Reference Book(s)

1. Satellite Communications Systems Engineering, W.L. Pitchand, H.L. Suyderhoud, R.A. Nelson, 2nd edition, Pearson education, 2007, ISBN: 9788131702420.
2. Satellite Communications, Anil K.Maini, Varsha Agrawal, 3rd edition, Wiley India Pvt.Ltd, Reprint, 2012, ISBN: 9788126520718.

Web and Video link(s):

1. NPTEL course on Satellite Communication Systems by Prof. Kalyan kumar Bandyopadhyay, IIT Kharagpur https://nptel.ac.in/courses/117/105/117105131/
2. Coursera on "Introduction to Satellite Communication" https://www.coursera.org/learn/satellite-communications#enroll

E-Books/Resources:

1. https://www.srecwarangal.ac.in/ecedownloads/IV_II%20satellite_communications_by_dennis_roddy4thedition.pdf

Course Articulation Matrix (CAM)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
# 1	3												3	
# 2		2												2
# 3			2											
# 4		2												

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System On Chip [As per Choice Based Credit System (CBCS) & OBE Scheme] SEMESTER – VII			
Course Code:	**P21EC7032**	**Credits:**	**03**
Teaching Hours/Week (L:T:P):	**3 : 0 : 0**	**CIE Marks:**	**50**
Total Number of Teaching Hours:	**40**	**SEE Marks:**	**50**

Course Learning Objectives: This course will enable the students to:

- Understand SoC architecture with processor, memory, NoC and bus models.
- Comprehend system construction with numerous components and the significance of system-level interconnections and NoC.
- Explore the trade-offs between hardware and software programmability versus performance.
- Gain knowledge hierarchy and implementation of memory organization.
- Study customization and reconfigurable technologies in SoC design along with their applications.

UNIT - I	**8 Hours**

Introduction to the systems approach: System Architecture: An Overview, Components of the System: Processors, Memories, and Interconnects Hardware and Software: Programmability, Versus Performance, Processor Architectures-Processor: A functional view, Processor: An architectural view, Memory and Addressing, SOC Memory Examples, Addressing: The architecture of Memory, Memory for SOC Operating System, System - Level Interconnection, Bus - Based Approach, Network - on - Chip Approach, An Approach for SOC Design, Requirements and Specifications, Design Iteration.

Text 1: 1.1-1.7.

Self-Study Component:	**1.** Identify the applications of SOC in today electronics industry. **2.** Prepare the report on the tools available for the SOC Design.

UNIT - II	**8 Hours**

Chip Basics: Time, Area, Power, Reliability, and Configurability-Introduction, Cycle Time, Die Area and Cost, Processor Area, Ideal and Practical Scaling, Power, Area – Time – Power Trade - Offs in Processor Design. Reliability, Configurability

Processors: Introduction, Processor Selection for SOC, Basic Concepts in Processor Architecture, Basic Concepts in Processor Microarchitecture,

Text 1: 2.1-2.7 3.1-3.4,

Self-Study Component:	**1.** Discuss the Area Estimate of Reconfigurable Devices. **2.** Prepare a report on the recent Processor used in Computers, laptop, mobiles.

UNIT – III	**8 Hours**

Processors: Basic Elements in Instruction Handling, Buffers: Minimizing Pipeline Delays.

Memory Design: System- on- Chip and Board - Based Systems- Introduction,Overview, Scratchpads and Cache Memory, Basic Notions, Cache Organization, Cache Data, Write Policies, Strategies for Line Replacement at Miss Time, Other Types of Cache, Split I - and D - Caches and the Effect of Code Density, Multilevel Caches, Virtual - to - Real Translation, SoC (On - Die) Memory Systems, Board - Based (Off - Die) Memory Systems, Simple Dram and The Memory Array.

Text 1: 3.5- 3.6, 4.1-4.15.

Self-Study Component:	**1.** Study on Models of Simple Processor.

UNIT – IV	8 Hours
Interconnect: Introduction, Overview: Interconnect Architectures, Bus: Basic Architecture, SOC Standard Buses, Analytic Bus Models, Beyond the Bus: NOC with Switch Interconnects, SOC interconnect Switches, , **Text 1: 5.1-5.6.**	
Self-Study Component:	**1.** Identify the usage of AMBA in real time. **2.** Discuss the tools available for NOC design.
UNIT – V	**8 Hours**
Customization and Configurability: Introduction, Estimating Effectiveness of Customization, SoC Customization: An Overview, Customizing Instruction Processors, Reconfigurable Technologies, Mapping Designs onto Reconfigurable Devices, Instance - Specific Design. **Application Studies:** Application Study: 3D graphics processors, image compression, video compression, MP3 audio decoding. **Text 1: 6.1-6.7,7.4, 7.5, 7.6, 7.7.1.**	
Self-Study Component:	**1.** Application Study: AES- algorithm and requirements. **2.** Identify the different algorithms used in video compression.

Course Outcomes: On completion of this course, students are able to:

COs	**Course Outcomes** with ***Action verbs*** for the Course topics	**Bloom's Taxonomy Level**	**Program Outcome Addressed (PO #) with BTL**
CO1	**Apply** the fundamentals of processors to **understand** the SoC architecture and its components	L2	PO1 (L2)
CO2	**Interpret** different trade-offs in System-on-Chip design.	L2	PO2 (L2)
CO3	**Analyze** the impact of processor architecture, memory and bus on performance of SoC.	L3	PO2 (L3)
CO4	**Discuss** the role of Configurability in SoC design.	L2	PO3 (L2)

Text Book(s):

1. Computer System Design System-On-Chip, Michael J. Flynn, Wayne Luk John Wiley & Sons, Inc., Publication, ISBN: 9781118009925, 2011.

Reference Book(s):

1. Reuse Methodology Manual for System-On-A-Chip, Michael Keating, Designs, Pierre Bricaud, 2nd edition, Kluwer Academic Publishers, ISBN: 9781461550372
2. SoC Verification-Methodology and Techniques, Prakash Rashinkar, Peter Paterson and Leena Singh, Kluwer Academic Publishers, ISBN – 8580000264227
3. On-Chip Communication Architectures: System on Chip Interconnect, Sudeep Pasricha and B Nikil B Dutt, Morgan Kaufmann, ISBN: 9780123738929

Web and Video link(s):

1. https://www.youtube.com/watch?v=_E2PS9jxkrA&list=PLZU5hLL_713ygweO3b_9KiZUJuEI7I5yK

E-Books/Resources:

1. https://www.oreilly.com/library/view/computer-system-designs/9780470643365/

Course Articulation Matrix (CAM)													
CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
# 1	3												3	
# 2		3												3
# 3		3												3
# 4			3											
*****														

Advanced Wireless Technologies [As per Choice Based Credit System (CBCS) & OBE Scheme] SEMESTER – VII			
Course Code:	**P21EC7033**	**Credits:**	**03**
Teaching Hours/Week (L:T:P):	**3 : 0 : 0**	**CIE Marks:**	**50**
Total Number of Teaching Hours:	**40**	**SEE Marks:**	**50**

Course Learning Objectives: This course will enable the students to:

- Analyse the various (4G, 5G) advanced wireless technologies.
- Describe LTE architecture, Users equipment, Communication protocols and standardization of LTE.
- Describe the basic network architectures, equipment, methodologies, specifications and topologies used by 5G wireless technologies.
- Explain the use case scenarios, design principles, performance parameters, and security, safety requirements of advanced wireless technologies.
- Analyse the working, fundamental techniques and protocols used in device to device (D2D) and machine to machine communication (M2M).
- Analyse and contrast advanced wireless technologies and wireless devices.

UNIT – I	**8 Hours**

Introduction: Architectural Review of UMTS and GSM, History of Mobile Telecommunication Systems, the Need for LTE, From UMTS to LTE, From LTE to LTE-Advanced, 3GPP Specifications for LTE.

System Architecture Evolution: High-Level Architecture of LTE, User Equipment, Evolved UMTS Terrestrial Radio Access Network.

Quality of Service, Policy and Charging: Policy and Charging Control, Policy and Charging Control Architecture, Session Management Procedures.

Text 1:1.1 to 1.6, 2.1 to 2.3, 13.1 to 13.3

Self-Study Component:	**1.** Study VoLTE Technology. **2.** Understand all the IP Multimedia Applications of LTE.

UNIT – II	**8 Hours**

Orthogonal Frequency Division Multiple Access: Principles of OFDMA, Benefits and Additional Features of OFDMA, Single Carrier Frequency Division Multiple Access.

Random Access: Transmission of Random Access Preambles on the PRACH, Non-Contention-Based Procedure, Contention-Based Procedure.

Text 1: 4.1 to 4.3, 9.1 to 9.3

Self-Study Component:	**1.** Explore the advantages of Multiple Antenna Transmission in LTE **2.** Understand the concept of Cell Acquisition Procedure in LTE

UNIT – III	**8 Hours**

Introduction to 5G Mobile and Wireless Communications Technology: Historical background, From ICT to the whole economy, Rationale of 5G: high data volume, twenty-five billion connected devices and Wide requirements, Global initiatives.

5G use cases and system concept: Use cases and requirements, 5G system concepts.

Text 2: 1.1 to 1.4, 2.1 to 2.2

Self-Study Component:	1. Hash Functions Based on Cipher Block Chaining. 2. Authenticated Encryption: CCM and GCM.

UNIT – IV		8 Hours
The 5G Architecture: Introduction, High-level requirements for the 5G architecture, Functional architecture and 5G flexibility, Physical architecture and 5G deployment. **Machine-Type Communications:** Introduction, Fundamental techniques for MTC, Massive MTC, Ultra-reliable low-latency MTC. **Text 2: 3.1 to 3.4, 4.1 to 4.4**		
Self-Study Component:	**1.** Explore new relaying techniques of 5G. **2.** Understand all the key applications of 5G.	
UNIT – V		**8 Hours**
Device-to-Device (D2D) Communication: D2D: From 4G to 5G, Radio resource management for mobile broadband D2D, Multi-hop D2D communications for proximity and emergency services, Multi-operator D2D communication. **Millimeter wave communications:** Spectrum and regulations, Channel propagation, Hardware technologies for mmW systems, Deployment scenarios. **Text 2: 5.1 to 5.4, 6.1 to 6.4**		
Self-Study Component:	**1.** Investigate various Spectrum challenges in 5G. **2.** Understand 5G spectrum landscape and its requirements.	

Course Outcomes: On completion of this course, students are able to:

COs	Course Outcomes with *Action verbs* for the Course topics	Bloom's Taxonomy Level	Program Outcome Addressed (PO #) with BTL
CO1	**Apply** knowledge of digital communication to understand modulation techniques and evolution of various wireless technologies	L2	PO1 (L2)
CO2	**Evaluate** the network architectures, equipment, methodologies, specifications and topologies used by various wireless technologies.	L2	PO2 (L2)
CO3	**Analyse** the use case scenarios, design principles, performance parameters, and security and safety requirements of advanced wireless technologies.	L3	PO3 (L3)
CO4	**Examine** the standards and protocols used for communication by LTE, 4G and 5Gtechnologies	L3	PO5 (L3)
CO5	**Inspect** and **Contrast** various advanced wireless technologies, wireless components and devices.	L3	PO4 (L3)

Text Book(s):

1. An Introduction to LTE: LTE, LTE-Advanced, SAE, VOLTE and 4G Mobile Communications, 2nd edition Christopher Cox, 20l4, ISBN: 978-1-118-81803-9.
2. 5G mobile and Wireless Communications Technology, Afif Osseiran, Ericsson, Jose F. Monserrat, Polytechnic University of Valencia, Patrick Marsch, Nokia Networks. New York: Cambridge University Press, 2016, LCCN 2015045732 |ISBN 978-1-107-13009-8

Reference Book(s):

1. LTE for UMTS: Evolution to LTE-Advanced, HarriHolma, AnttiToskala. 2nd edition, 2011, ISBN 978-0-470-66000-3.
2. Smart Device to Smart Device Communication, Shahid Mumtaz, Jonathan Rodriguez Aveiro, Springer, ISBN 978-3- 3 19-04962-5.
3. Wireless Communications and Networking, Vijay. K.Garg, Morgan Kaufman Publishers, 2014. ISBN: 978-81-312-1889-1.

Web and Video link(s):

1. Advanced 3G and 4G Wireless Mobile Communications, IIT Kanpur
   by Prof. Aditya K. Jagannatham
   https://nptel.ac.in/courses/117104099
2. 5G Wireless Technology, PPT by Vishwa
   https://www.youtube.com/watch?v=h5Lxn328zlw

E-Books/Resources:

1. An Introduction to LTE, Second Edition, Christopher Cox
   https://content.e-bookshelf.de/media/reading/L-2559658-a0ffd11f20.pdf
2. 5G Mobile and Wireless Communications Technology
   https://www.cambridge.org/core/books/5g-mobile-and-wireless-communications-technology/1FB952899CAEFCD7B05F6A334C9ECDA8

Course Articulation Matrix (CAM)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
# 1	3												3	
# 2		3												3
# 3			2											
# 4					2									
# 5				2										

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Biomedical Signal Processing [As per Choice Based Credit System (CBCS) & OBE Scheme] SEMESTER – VII			
Course Code:	**P21EC7034**	**Credits:**	**03**
Teaching Hours/Week (L:T:P):	**3 : 0 : 0**	**CIE Marks:**	**50**
Total Number of Teaching Hours:	**40**	**SEE Marks:**	**50**

Course Learning Objectives: This course will enable the students to:

Introduce students to the principles of signal processing techniques when applied specifically to biomedical signals, including: ECG, MEG, EEG, SPO2, heart rate etc.
Provide the student with a firm grounding methods and tools for extracting information from digitally acquired biomedical signals.
Understand data reduction techniques on Biomedical signals and their utility
Elaborately discuss analysis of EEG and ECG signals
Understand models related to Event related Potentials
Introduce the practical implementation of signal processing techniques to digitally acquired biomedical signals.

UNIT - I	**8 Hours**

Introduction to Biomedical Signals: The nature of biomedical signals, Examples of Biomedical Signals, Objectives of biomedical signal analysis, Difficulties encountered in biomedical signal acquisition and analysis.

Text2:1.1, 1.2.1, 1.2.2, 1.2.3, 1.2.4, 1.2.5,1.2.6, 1.2.8, 1.3, 1.4.

Self-Study Component:	1. Study of Challenges in Biomedical Signal Analysis. 2. Study of instruments and modalities for acquisition of biomedical signals of different origin. 3. Study of Computer aided diagnosis

UNIT - II	**8 Hours**

Filtering for Removal of Artifacts: Problem Statement-Artifacts in Biomedical Signals Types of noise, Illustration of the Problem with-Case Studies, Time domain filters, Frequency–Domain Filters.

Text2: 3.1-3.4

Self-Study Component:	**1.** Application of Synchronized Averaging for the detection of QRS Complex from sameECGcycles. **2.** Design of Butterworth low pass filter for the removal of high frequency noise in carotidpulse signal. **3.** ReviewofButterworthfilters,RemovalofnoiseusingButterworthfilters.

UNIT - III	**8 Hours**

Adaptive Interference/Noise Cancellation: A review of Weiner Filtering Problem, Principle of an Adaptive filter, The steepest Descent Algorithm, The Windrow – Hoff Least – Mean– square Adaptive algorithm.

Text1:6.1-6.4.

Self-Study Component:	**1.** Cancellation of maternal ECG in fetal ECG and Cancellation of High Frequency noise in Electro-surgery **2.** Study of ECG enhancement by Adaptive cancellation of Electro surgical Interference **3.** Study of Adaptive Noise Canceller.

UNIT - IV	**8 Hours**

EEG and ECG Signal Processing: EEG analysis, Linear Prediction Theory, The

Autoregressive Method, Recursive estimation of AR parameters, Special Error measure, Adaptive segmentation, ECG parameters and their Estimation.
Text1:4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 7.4.

Self-Study Component:	**1.** Study of article "Deep learning for electroencephalogram (EEG) classification tasks: A Review". **2.** Study ECG data compression using Wavelet Transform. **3.** Study of the Use of Multi – scale Analysis for Parameters Estimation of ECG waveforms.

UNIT - V | **8 Hours**

Event Detection: Illustration of the Problem With Case-Studies, Detection of Events and Waves.
Modeling Event Related Potentials: Exponential modeling, Exponential Parameter estimation, The original Prony Problem, Least Squares Prony Method, Theco variance method of Linear Prediction.
Text2:4.1-4.3.
Text1:9.1-9.5.

Self-Study Component:	**1.** Clinical application of Prony's Method and Prony's method in the presence of noise. Ref: https://www.researchgate.net/publication/329193563_Coding_Prony's_method_in_MATLAB_and_applying_it_to_biomedical_signal_filtering. **2.**

Course Outcomes: On completion of this course, students are able to:

COs	**Course Outcomes** with *Action verbs*for the Course topics	**Bloom's Taxonomy Level**	**Program Outcome Addressed (PO #) with BTL**
CO1	**Apply** the knowledge of electronics in biomedical signal acquisition and processing	L2	PO1 (L2)
CO2	**Characterize** the biomedical signals and filtering technique	L4	PO2 (L4)
CO3	**Create** different types of filters for the removal of artifacts in biomedical signals.	L6	PO3 (L6)
CO4	**Implementation of a** case based application using tools	L6	PO5, PO9 (L6)

Text Book(s):
1. Biomedical Signal Processing: Principles and Techniques–D.C Reddy Tata McGraw–Hill Publishing Company Limited–ISBN-13:978-0-07-058388-7.
2. Biomedical Signal Analysis**:** A Case – Study Approach –Rangaraj M Ragayyan John Wiley & Sons– ISBN-0-471-20811-6.

Reference Book(s):
1. Biomedical Signal Processing–Wills J Tompkins, Prentice Hall of India Pvt Ltd ISBN 10: 8120314786.
2. Digital Signal Processing: Principles, Algorithms and Applications**,** Johan G Proakis and Dimitris GMANOLAKIS-4thedition, ISBN: 9788131710005, 8131710009.
3. Digital Signal Processing: A Computer based approach, Sanjit K Mitra –2nd edition Tata McGraw Hill Publishing Company Ltd, ISBN: 9781259098581, 1259098583.

Web and Video link(s):
1. https://nptel.ac.in/courses/108/105/108105101/ (Prof Sudipta Mukhopaddhyay, IIT, Kharagpur)

2. http://www.digimat.in/nptel/courses/video/108105101/L64.html
3. http://www.infocobuild.com/education/audio-video-courses/electronics/BiomedicalSignalProcessing-IIT-Kharagpur/lecture-21.html

E-Books/Resources:

1. https://uvceee.wordpress.com/wpcontent/uploads/2016/09/digital_signal_processing_principles_algorithms_and_applications_third_edition.pdf

Course Articulation Matrix (CAM)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
# 1	3												3	
# 2		3												3
# 3			2											
# 4					1				1					

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Computer Communication Networks and IOT (Integrated) [As per Choice Based Credit System (CBCS) & OBE Scheme] SEMESTER – VII			
Course Code:	**P21EC704**	**Credits:**	**04**
Teaching Hours/Week (L:T:P):	**3 : 0 : 2**	**CIE Marks:**	**50**
Total Number of Teaching Hours:	**40**	**SEE Marks:**	**50**

Course Learning Objectives: This course will enable the students:

- Describe computer network applications, network hierarchy, TCP/IP layers functioning, their dependency and interaction.
- Compute and characterize different types of delays and error detection schemes in a computer network.
- Analyze and optimize the network delay and path for the given specifications.
- Understand the Communication and layered architectures pertaining to IoT.
- Describe LPWAN in IoT, LoRa based network architectures.

UNIT – I	**8 Hours**

Overview of The Internet, Networks , Switching, The Internet, Accessing the Internet, Hardware and Software, Protocol Layering, Scenarios, TCP/IP Protocol Suite, Standards And Administration, Internet Standards, Internet Administration, Introduction, Providing Services , Application-Layer Paradigms, Client-Server Paradigm.

Text 1: 1.1.1-1.1.5, 1.2.1-1.2.2, 1.4.1-1.4.2, 2.1.1-2.1.2, 2.2.

Self-Study Component:	**1.** Understand the issues in protocol implementation. **2.** Study the quantitative performance metrics that drive network design
Practical Topics: (2 Hours)	**1.** Implement prescribed number of nodes (a) (Point – to – point network) with duplex links between them. Set the queue size, vary the bandwidth and find the number of packets dropped (b) For data transmission with stop and wait protocol.

UNIT – II	**8 Hours**

Standard Client-Server Applications, World Wide Web and HTTP, FTP, Electronic Mail, Introduction, Transport-Layer Services, Transport-Layer Protocols, Simple Protocol, Stop and-Wait Protocol, Go-Back-N Protocol (GBN), Selective-Repeat Protocol, USER Datagram Protocol (UDP), User Datagram, UDP Services, UDP Applications.

Text 1: 2.3.1-2.3.3,

Text1: 3.1, 3.2.1 - 3.2.4, 3.3-3.3.3.

Self-Study Component:	**1.** Identify the issues that link-level protocol must address. **2.** Develop a program to simulate (i) Bit stuffing and destuffing (ii) Character stuffing and destuffing.
Practical Topics: (2 Hours)	**1.** Implement an Ethernet LAN using n nodes and set multiple traffic nodes and plot congestion window for different source / destination. **2.** Conduct an experiment to provide reliable data transfer between two nodes over an unreliable network using the Sliding Window Protocol-Selective Repeat.

UNIT – III	**8 Hours**

Introduction, Network-Layer Services, Packet Switching, Network-Layer Performance, Network-Layer Congestion, Structure of A Router, Network-Layer Protocols, IPv4 Datagram Format, IPv4 Addresses, Forwarding of IP Packets.

Text 1: 4.1.1 – 4.1.4, 4.1.5, 4.2.1 – 4.2.3.

Self-Study Component:	**1.** Discuss the mechanisms used to provide quality of service in IP. **2.** Write a program to implement CRC-CCITT polynomial.
Practical Topics: (2 Hours)	**1.** Test DSR and DSDV routing protocols over wired network and compare the performance. **2.** Implement establish a wireless network with minimum of 3 nodes and compare the operation of TCP and UDP protocols over transmission delay, throughput and packet loss.

UNIT – IV	**8 Hours**

IoT Communication: M2M and IoT, Layered Architectures, System Components
Concepts of IoT Networking: IoT Networking, Types of Networks, Devices- Sensors, Actuators and Controllers, Gateways, Security, Wireless Sensor Networks.
Physical and Link Layers: Ethernet, ITU-T G.9903, IEEE 1901.2,IEEE 802.11, IEEE 802.15.3, IEEE 802.15.4, Bluetooth Low Energy.
Text 2: 1.1-1.3, 2.1-2.5,3.2.1-3.2.3, 3.3.1-3.3.4.

Self-Study Component:	**1.** Discuss and understand IOT architecture and IOT Stack. **2.** Discuss the mechanism of Header Compression.
Practical Topics: (2 Hours)	**1.** Establishing Wired/Wireless Communication using Peripherals: a) Develop a controller system to sense a specific data and send the sensed data to the PC through communication module. **2.** GSM and Long Range Communication: a) Develop a controller system, to communicate and alert the registered mobile number using GSM module interface.

UNIT – V	**8 Hours**

Network and Transport Layers: Why IP?, IPv6, 6LoWPAN - Addresses, Header Format, Routing and Forwarding ,Header Compression, Fragmentation.
Application Layer: Architectures, Request/Response- REST Architecture, HTTP, XMPP, CoAP, SIP and RTP, OPC UA.
LPWAN Technologies: LPWAN in IoT, LoRa- Physical Layer, Link Layer, SigFox- Physical Layer, Link Layer.
Text 2: **4.1-4.3.5,5.1-5.2.6, 8.1-8.3**

Self-Study Component:	**1.** Discuss and understand the concepts of IoT Services and Resources **2.** Refer and understand any LoRa based mini project.
Practical Topics: (2 Hours)	**1.** Design a small or medium sized computer network including media types, enddevices, and interconnecting devices that meets a customer‘s specific needs. **2.** Perform configurations on routers and Ethernet switches. Simulate computer networksand analyze the simulation results. **3.** Demonstrate knowledge of programming for network communications **4.** Troubleshoot connectivity problems in a host occurring at multiple layers of the OSI model.

Course Outcomes: On completion of this course, students are able to:

COs	**Course Outcomes** with ***Action verbs*** for the Course topics	**Bloom's Taxonomy Level**	**Program Outcome Addressed (PO #) with BTL**
CO1	**Apply** basic mathematics and fundamentals of digital communication to understand concepts of computer networks.	L3	PO1 (L3)
CO2	**Analyse** and compare the various algorithms and protocols of TCP/IP	L4	PO2 (L4)
CO3	**Analyse** and characterise IoT stack and computer networks for delay, error resilience and performance.	L3	PO2 (L3)
CO4	**Implement** a protocol using suitable language and analyse the performance of of the protocol using wire shark	L5	PO3 (L5)

Text Book(s):

1. Computer Networks, A Top-Down Approach by Behrouz A. Forouzan and Firouz Mosharraf, Tata McGraw-Hill Education, 2011. ISBN 13: 9781259001567.
2. Fundamentals of IoT Communication Technologies by Rolando Herrero Springer, 2022, ISBN 978-3-030-70079-9ISBN 978-3-030-70080-5 (eBook).

Reference Book(s):

1. Computer Networks, James F. Kurose and Keith W. Ross, Pearson education, 6e. ISBN-13:9789332585492.
2. Computer Networks, Andrew S. Tanenbaum, Pearson education, 5e. ISBN-13: 9789332518742.
3. Computer and Communication Networks, Nader F Mir, Pearson education, ISBN-13: 9788131715437.

Web and Video link(s):

1. NPTEL course on "Computer Networks" by Prof. Sujoy Ghosh, IIT Kharagpur, https://nptel.ac.in/courses/106/105/106105081/
2. NPTEL course on "Computer Networks and Internet Protocol", IIT Kharagpur by Prof. Soumya Kanti Ghosh and Sandip Chakraborty https://archive.nptel.ac.in/courses/106/105/106105183//
3. NPTEL course on "Internet of Things" by Prof. SudipMisra, IIT Kharagpur https://archive.nptel.ac.in/courses/106/105/106105166/

E-Books/Resources:

1. https://www.leverege.com/ebooks/iot-intro-ebook
2. https://open.umn.edu/opentextbooks/textbooks/771

Course Articulation Matrix (CAM)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
#1	2												2	
#2		3												3
#3		3												3
#4			2											

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Project Work Phase - I

[As per Choice Based Credit System (CBCS) & OBE Scheme]

SEMESTER – VII

Course Code:	**P21EC706**	**Credits:**	**04**
Teaching Hours/Week (L:T:P:PJ):	**0 : 0 : 0 : 3**	**CIE Marks:**	**100**
Total Number of Teaching Hours:	**40**	**SEE Marks:**	**-**

Course Learning Objectives: This course will enable the students to:

- Practice acquired knowledge within the chosen area of technology for project development.
- Identify, discuss and justify the technical aspects of the chosen project with a comprehensive and systematic approach.
- Reproduce, improve and refine technical aspects for engineering projects.
- Work as an individual or in a team in development of technical projects.
- Communicate and report effectively project related activities and findings.

Course Outcomes: On completion of this course, students are able to:

COs	**Course Outcomes** with ***Action verbs*** for the Course topics	**Bloom's Taxonomy Level**	**Program Outcome Addressed (PO #) with BTL**
CO1	**Apply** the domain knowledge for addressing engineering problems related to society	L3	PO1 (L3)
CO2	**Formulate**, review literature and analyze the problem definition.	L6	PO2 (L6)
CO3	**Create** a sustainable solutions for the problem definition to meet the specified needs with consideration for public health and safety and sustainable development.	L6	PO3, PO6, PO7 (L6)
CO4	**Build** the functional units of circuits and systems for the identified problem so as to provide sustainable solution	L6	PO4(L6)

Course Articulation Matrix (CAM)

CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**
# 1	**3**												**3**	
# 2		**3**												**3**
# 3			**3**			**2**	**2**							
# 4				**3**										

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Project Work Phase - II
[As per Choice Based Credit System (CBCS) & OBE Scheme]
SEMESTER – VIII

Course Code:	**P21EC803**	**Credits:**	**08**
Teaching Hours/Week (L:T:P:PJ):	**0 : 0 : 0 : 3**	**CIE Marks:**	**100**
Total Number of Teaching Hours:	**40**	**SEE Marks:**	**100**

Course Learning Objectives: This course will enable the students to:

- Practice acquired knowledge within the chosen area of technology for project development.
- Identify, discuss and justify the technical aspects of the chosen project with a comprehensive and systematic approach.
- Reproduce, improve and refine technical aspects for engineering projects.
- Work as an individual or in a team in development of technical projects.
- Communicate and report effectively project related activities and findings.

Course Outcomes: On completion of this course, students are able to:

COs	**Course Outcomes** with ***Action verbs*** for the Course topics	**Bloom's Taxonomy Level**	**Program Outcome Addressed (PO #) with BTL**
CO1	**Apply** the research based knowledge and methods to analyze and interpret the data using modern engineering tools to provide valid conclusion.	L3	PO4, PO5 (L3)
CO2	**Adapt** the ethical principles and commit to the professional ethics when working as an individual or in a team and communicate effectively with engineering community and society.	L6	PO8, PO9, PO10 (L6)
CO3	**Motive** to manage the project and finance effectively.	L4	PO11 (L4)
CO4	**Take part in** recognizing the need for and engage in independent and lifelong learning.	L4	PO12 (L4)

Course Articulation Matrix (CAM)

CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**
#1				**3**	**3**									
#2								**3**	**2**	**2**				
#3											**2**			
#4												**3**		

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