ಬಿ.ಎಂ.ಎಸ್. ತಾಂತ್ರಿಕ ಮಹಾವಿದ್ಯಾಲಯ, ಬೆಂಗಳೂರು
(ಸ್ವಾಯತ್ತ ವಿದ್ಯಾ ಸಂಸ್ಥೆ)
ಬುಲ್ ಟೆಂಪಲ್ ರಸ್ತೆ, ಬೆಂಗಳೂರು – ೫೬೦ ೦೧೯

B.M.S. COLLEGE OF ENGINEERING

(Autonomous Institute, under VTU)

BANGALORE-560019

DEPARTMENT OF

MEDICAL ELECTRONICS ENGINEERING

Scheme and Syllabus for III-VIII Semester

(For the Batch 2018-2022)

B.M.S. COLLEGE OF ENGINEERING

(Autonomous College under VTU)

INSTITUTE VISION & MISSION

VISION

Promoting Prosperity of mankind by augmenting human resource capital through quality Technical Education & Training

MISSION

Accomplish excellence in the field of Technical Education through Education, Research and Service needs of society

DEPARTMENT VISION & MISSION

VISION

To promote quality education in Medical Electronics Engineering for health and well-being of humankind through teaching and research platforms.

MISSION

- **To impart knowledge and skills necessary for professional development of graduates in Medical Electronics Engineering.**
- **To provide continuous up gradation of technical education with strong academic progression.**
- **To propagate creativity, responsibility, commitment and leadership qualities and exhibit professional ethics and values.**

PROGRAMME OUTCOMES (POs)

PO1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**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.
PO4	**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.
PO5	**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.
PO6	**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.
PO7	**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.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**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.
PO11	**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 multidisciplinary environments.
PO12	**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.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO1	Investigate, Implement and demonstrate various applications of analog and digital electronic subsystems in designing and building biomedical instrumentation systems.
PSO2	Specify, architect and prototype health-care solutions by applying signal and medical image processing techniques on modern hardware and software platforms.
PSO3	Design, develop and verify processes, algorithms and computer programs for medical purposes.

SCHEME OF STUDY

III Semester Scheme

Course Code	Course Title	Type	LT:P	Credits	Hours	CIE	SEE	Total
19MA3BSEM3	Engineering Mathematics–3	BS	3:1:0	4	5	50	50	100
19ES3CCECA	Electrical Circuit Analysis	PC	3:1:0	4	5	50	50	100
19ES3CCAEC	Analog Electronic circuits	PC	3:0:1	4	5	50	50	100
19ES3CCDEC	Digital Electronic Circuits	PC	3:0:1	4	5	50	50	100
19ML3ESHPM	Human Physiology and Medical Physics	ES	3:1:0	4	5	50	50	100
19ES3GCSAM	Sensors and Measurements	PC	3:0:1	4	3	50	50	100
19HS3ICCPH	Constitution of India, Professional Ethics and Human Rights	HS	1:0:0	1	1	50	50	100
19ML3NCPYA	Physical Activity	NC	-	-	1	-	-	P/NP
Total			**19:3:3**	**25**	**30**	**350**	**350**	**700**

IV Semester Scheme

Course Code	Course Title	Type	L:T:P	Credits	Hours	CIE	SEE	Total
19MA4BSEM4	Engineering Mathematics- 4	BS	3:1:0	4	5	50	50	100
19ML4PCPCS	Physiological Control	ES	3:1:0	4	5	50	50	100
19ES4CCLIC	Linear Integrated Circuits	PC	3:0:1	4	5	50	50	100
19ES4CCMCS	Microcontrollers	PC	3:0:1	4	5	50	50	100
19ES4CCSAS	Signals & Systems	PC	3:1:0	4	5	50	50	100
19ML4PCDIN	Diagnostic Instruments	PC	3:0:0	3	3	50	50	100
19HS4ICEVS	Environmental Studies	HS	2:0:0	2	2	50	50	100
19ML4NCCLA	Cultural Activity	NC	-	-	-	-	-	-
Total			**20:3:2**	**25**	**30**	**350**	**350**	**700**

V Semester Scheme

Course Code		Course Title	Type	L:T:P	Credits	Hours	CIE	SEE	Total
19ML5PCESD		Embedded System Design with ARM	PC	3:0:1	4	5	50	50	100
19ML5PCTIE		Therapeutic Instruments and Ethics	PC	3:0:1	4	5	50	50	100
19ES5CCDSP		Digital Signal Processing	PC	3:0:1	4	5	50	50	100
19ML5PCPMI		Physics of Medical Imaging	PC	2:1:0	3	4	50	50	100
19ML5**PE**1XX	DS	C++ and Data Structures	PE	2:1:0	3	4	50	50	100
	CS	Communication Systems							
	WS	Wearable Sensors							
19ML5**PE**2XX	DV	Digital System Design using Verilog	PE	2:1:0	3	4	50	50	100
	BR	Biomechanics and Rehabilitation Engineering							
	BM	Biomaterials							
19ML5PWMP1		Mini Project–1	PW	0:0:2	2	4	50	50	100
19ES5HSIFE		Innovation for Entrepreneurship	HS	2:0:0	2	2	50	50	100
19ML5NCHVL		Human Values through Literature	NC	--	--	1	--	--	P/NP
Total				**17:3:5**	**25**	**34**	**400**	**400**	**800**

VI Semester Scheme

Course Code		Course Title	Type	L:T:P	Credits	Hours	CIE	SEE	Total
19ML6PCMIP		Medical Image Processing	PC	3:0:1	4	5	50	50	100
19ML6PCMDD		Medical Device Development	PC	3:0:1	4	5	50	50	100
19ML6PCBSP		Biomedical Signal Processing	PC	2:0:1	3	4	50	50	100
19ML6PE3XX	CD	Clinical Data Analytics	PE	2:1:0	3	4	50	50	100
	DC	Data communication in Healthcare							
	VS	VLSI & SoC design							
19ML6CE1XX	SE	Systems Engineering	PE	3:0:0	3	3	50	50	100
	BC	Brain Computer Interface							
19ML6OE1XX	ER	Ergonomics	OE	3:0:0	3	3	50	50	100
	PC	Point of Care Systems							
19ML6HSCFS		Forensics Science	HS	2:0:0	2	2	50	50	100
19ML6PWMP2		Mini Project-2	PW	0:0:2	2	4	50	50	100
19ML6SRTSR		Technical Seminar	SR	0:0:1	1	2	50	50	100
19ML6NCPDA		Personality Development, Communication and Aptitude Skill	NC	-	-	1	-	-	P/NP
Total				**18:1:6**	**25**	**33**	**450**	**450**	**900**

VII Semester Scheme

Course Code		Course Title	Type	L:T:P	Credits	Hours	CIE	SEE	Total
19ES7HSPMF		Project Management and Finance	HS	3:0:0	3	3	50	50	100
19ES7BSBFE		Biology for Engineers	BS	2:0:0	2	2	50	50	100
19ML7PCMCL		Machine Learning	PC	3:1:0	4	5	50	50	100
19ML7PCQCR		Quality control and regulatory aspects in medical devices	PC	0:0:1	1	1	50	50	100
19ML7CE2XX	BD	Biomedical Devices	CE	3:0:0	3	3	50	50	100
	IP	Advanced Image Processing							
19ML7OE2XX	IO	IoT Technologies for Healthcare	OE	3:0:0	3	3	50	50	100
	IM	Imaging Modalities							
19ML7PWMP3		Mini Project-3	PW	0:0:3	3	6	50	50	100
19ML7NCSTW		Strategies for Teamwork and Workplace Communication	NC	-	-	1	-	P/NP	-
Total				14:1:4	19	24	350	350	700

VIII Semester Scheme

Course Code		Course Title	Type	L:T:P	Credits	Hours	CIE	SEE	Total
19ES8HSIPL		IPR & Cyber Law	HS	2:0:0	2	2	50	50	100
19ML8OE3XX	PR	Pattern Recognition	OE	3:0:0	3	3	50	50	100
	BM	Biometrics							
19ML8PWMPJ		Major Project work	PW	0:0:9	9	20	50	50	100
19ML8PCISR		Internship Seminar	SR	0:0:2	2	4	50	50	100
19ML8NCMVL		MOOCs/ Virtual Lab with certification	NC	-	-	1	-	-	P/NP
Total				**5:0:11**	**16**	**30**	**200**	**200**	**400**

Course Articulation Matrix:

The Course instructor writes the course outcomes in the course design which will address the skills defined in the Program Outcomes. The COs of the courses in the curriculum and their mapping with Program Outcomes in terms of Levels is indicated in the Table next. The level of course mapping with POs considered are, 3-High correlation 2- Moderate correlation and 1- Low correlation.

The mapping strength of CO is mainly based on the percentage of marks in the Continuous Internal Evaluation (CIE) process as indicated below,

a. ***Strongly correlation****:* - If assessment covers greater than 20% marks or if CO is related to Lab component or self-study component weightage given is high as students spend more time in implementation and the activity has more importance in TLP, then the weightage taken is 3.
b. ***Moderately correlation****:* - If assessment covers greater than 10% marks and less than 20% marks or the activity defined under the particular CO has moderate contribution toward PO attainment then the weightage considered is 2
c. ***Low level correlation****:* - If assessment covers less than 10% marks or the activity defined under the particular CO has low contribution toward PO attainment then the weightage taken is 1.

The factors like the depth to which the corresponding contents are covered and its importance are duly considered. The mapping strengths are accordingly considered when a CO is mapping to another PO also.

Course and CODE	Course Outcomes	Program Outcomes												Program Specific Outcomes		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO 3
3rd semester																
19ES3GCECA	CO1:Formulate equations based on physical laws and analyze the steady state behaviour of complex electric networks	3														
	CO2: Apply the knowledge of mathematics and graph theory to the solution of complex electrical networks	3														
	CO3: Apply mathematical and analytical techniques to analyze transient behaviour of networks.		3													
	CO4: Analyze and model two port networks based on its parameters		3													
	CO5: Engage in independent study using modern tools as an individual and as a team-member to simulate the electrical circuits for the relative					3				2			3			

	comparison with theoretical values.															
	CO6: Prepare a technical document and present the same on the simulated electrical circuits										3		3			
19ES3CCAEC	CO1: Ability to define, understand and explain the structure, V-I characteristics, working and applications of analog electronic components like diodes, Bipolar Junction Transistors (BJTs) and MOSFETs	3														
	CO2: : Ability to apply the knowledge of KVL and KCL to obtain voltage /current/waveform at different points in analog electronic circuits such as diode clippers, clampers, amplifiers using BJTs and MOSFETs, current sources, current mirrors, power amplifiers.		3													
	CO3: Ability to analyse analog electronic circuits such as			3												

	diode clippers, clampers, amplifiers using BJTs and MOSFETs, current sources, current mirrors, power amplifiers, feedback amplifiers etc. to obtain voltage /current/waveform at different points for given specifications.															
	CO4: Ability to design analog electronic circuits such as diode clippers, clampers, amplifiers using BJTs and MOSFETs, current sources, current mirrors, power amplifiers, feedback amplifiers for given specifications.				2											
	CO5: Ability to conduct experiments using analog electronic components and electronic instruments to function as switch, regulator, clippers, clampers, small signal amplifiers, oscillators,					3				3	3		2			

	power amplifiers															
	CO6: Ability to implement a mini-project to implement and demonstrate the given problem using suitable analog electronic components					3				3	3		3	3		
19ES3CCDEC	CO1: Ability to understand, define and explain the fundamental concepts of Digital circuits	3														
	CO2:Ability to apply the knowledge of simplification methods to optimize a Digital circuit		3													
	CO3: Ability to analyze digital circuits and arrive at suitable conclusions			3												
	CO4: Ability to design a digital circuit for given specifications									3						
	CO5: Ability to conduct experiments using digital ICs for a given application/problem statement					3										
19ML3ESHPM	CO1: Interpret the interplay between different organ systems and how organs interact to maintain biological	3														

	equilibrium in the face of a variable and changing environment.															
	CO2: Utilize anatomical terminology to identify and analyze the physiology of and physics of human system		3													
	CO3: Analyse the impact of various diseases affecting the functioning of human organ systems.			2												
	CO4: Analyze human organ systems using mathematical models developed based on their working principles.				3											
	CO5: Assess the functioning of different organ systems in the human body.						1									
19ES3GCSAM	CO1:Apply the knowledge of science and engineering fundamentals to realize sensor based measurement systems.	2												3		
	CO2: Analyze engineering problems and performance characteristics in order to arrive at suitable techniques for		3											3		

	the measurement of non-electrical quantities using direct or complex sensors.															
	CO3: Design sensors and solutions to meet the specified measurement needs, considering the nature and properties of measured quantities.			3										3		
	CO4: Work with sensors and measurement systems both individually and in teams, document the activity and communicate the outcome to an engineering community.									3	2			2		
4th Semester																
19ML4P CPCS	CO1: Apply the knowledge of engineering and mathematics to develop models for classical and physiological control systems.	3														
	CO2: Identify and analyse the time-domain response of conventional and physiological		3													

	control systems.															
	CO3:Design and Investigate the stability of control systems using frequency analysis techniques.			3												
	CO4: Analyse the complex problems in physiological control systems through parametric and nonparametric identification methods				3											
	CO5:Implement the control theory concepts using modern tools working in a team and write reports of the same.					2				2						
	CO6: Function effectively to communicate as an individual to present the report of the implemented work in a team.										2					
19ES4CCLIC	CO1:Apply the knowledge of electronic engineering fundamentals to comprehend linear integrated circuits based systems	2												3		
	CO2:Interpret and analyze the effects of DC and AC				3									3		

	limitations of Operational Amplifiers															
	CO3:Implement linear integrated circuits in the areas of power sourcing, signal generation and conditioning, and analog communication			3										3		
	CO4:Design and develop analog sub-circuits for linear and non-linear applications			3										3		
	CO5:Experiment and document the test results of various applications of linear integrated circuits, working both independently and in teams.		2							2				3	2	
19ES4GCMCS	CO1: Understand the concepts of 8051 microcontroller architecture, assembly and embedded C programming															
	CO2: apply the learnt concepts of 8051 microcontroller to solve the problems using assembly and embedded C programming.	3														
	CO3: Identify the IDE to conduct		3			3										

	experiments															
	CO4: Debug/analyze the code in assembly and embedded C	3														
	CO5: Engage in independent study/ self-study as an individual and as a team-member to design, an open ended experiment on applications of microntrollers for medical electronics			3		3				3				2	2	2
	CO6: Prepare a technical document on the open ended experiment considering ethics, safety and sustainability of the process or product thereon						2	2	2				2			
19ES4CCSAS	CO1:Ability to define, understand, and explain various types of signals, systems, their time and frequency domain representation and their realization.															
	CO2:Ability to classify signals and systems, obtain the output for LTI systems using the time	3														

	domain and the frequency domain representation, obtain the frequency domain representation of LTI systems using various transforms.															
	CO3:Ability to analyse the given specifications for systems for causality, stability, linearity, time invariance physical realizability.		3													
	CO4:Ability to design LTI systems for the given response specifications in an efficient manner.			3												
	CO5:Ability to make an effective oral presentation or report writing on contribution of signal processing in various engineering aspects.															
19ML4PCDIN	CO1:Ability to apply knowledge of mathematics science and engineering fundamentals in designing, analysing and/or working of biomedical	3														

	circuits and instruments.															
	CO2 :Understand the health, safety, Environmental and ethical issues while Designing/working of a diagnostic equipment.		3													
	CO3:Ability to work, document and present as an individual and as a team-member to design, formulate and implement experiments using modern equipment's & tools.					3							2			
	CO4:To develop and analyse schematic models of various bio-chemical measurement systems.			2												
	CO5: Ability to understand the diagnostic equipment through case study for different diseases through references.				1											
5th Semester																
Embedded Systems Design with ARM 19ML5P	CO1:Apply the knowledge of electronics engineering, communication protocols to	3														

CESD	design embedded systems															
	CO2:Develop assembly language programs by applying knowledge of the architectural features and instructions of ARM Cortex M3		3													
	CO3:Evaluate performance of real time operating systems by applying knowledge of multitasking principles			3												
	CO4:Demonstrate understanding of ARM Cortex M3 concepts to conduct experiments using the assembly and Embedded C programming.				3	3				3						
	CO5:Develop embedded C programs to demonstrate understanding of GPIO concepts and communication protocols through interfacing peripherals with Cortex M3 microcontroller					3							3			2

19ML5PCTIE	CO1:Ability to apply knowledge of mathematics science and engineering fundamentals in designing, analysing and/or working of biomedical circuits and instruments	3														
	CO2:Understand the health, safety, Environmental and ethical issues while Designing/working of a Therauptic equipment.						3	3								
	CO3:Ability to work, document and present as an individual and as a team-member to design, formulate and implement experiments using modern equipment's & tools.											2				
	CO4:Ability to present in a group and document the findings or suggestions for the problems in the current techniques, modern tools and computing practice to improve technology in Health care instruments through				3										2	2

	hospital visits for lifelong learning.															
	CO5:Ability to understand the Therapeutic equipments through case study for different diseases through references					3										
Digital Signal Processing 19ES5CCDSP	CO1:Apply knowledge of Mathematics and Engineering to understand Sampling and Reconstruction of signals from the given samples.															
	CO2:Identify and analyse a problem and formulate the computing requirements to determine the spectrum of the given signals.	3														
	CO3:Implement the processes of FFT to reduce the computational complexity and to increase the speed.		3													
	CO4:Understand and formulate algorithms using the Multirate signal processing for sampling rate conversion in speech and			3												

	other signal analysis.															
	CO5:An ability to use current techniques and modern tools to improve the Medical data analysis and present and document the same.									2	2	2				3
19ML5PCPMI	CO1: Apply the knowledge of mathematics and science to the solutions of complex problems in medical imaging modalities.	3														
	CO2: Identify, formulate and analyse a problem in medical imaging applications to arrive at substantiated conclusions.		3													
	CO3: Analyse the biological effects of electromagnetic fields in humans for health safety issues.						3									
	CO4: Apply professional ethics and responsibilities to meet the public health safety issues for							2	2							

	sustainability through hospital visit (field survey) working in a team.															
	CO5: Comprehend the published reports for the selected imaging modality and prepare the document of the same combined with the field survey working in a team.									2						
	CO6: Function effectively to communicate as an individual to present the prepared document in a team.										2					
19ML5PE 1WS	CO1:Apply the knowledge of science, engineering and measurement fundamentals to deal with wearable sensors	3												3		
	CO2:Analyze the trade-offs in security designs and determine accountability, in order to formulate solutions using wearable sensors		3											3		
	CO3:Develop the solutions			3										3		

	for secured communicatio n in medical IoT and Implanted medical devices															
	CO4:Comprehe nd the published reports on the contribution of wearable sensors towards bettering of health care delivery, and make a presentation on a specific device/techniq ue.									2	3			2		
19ML5PE 2BM	CO1:Demonstr ate an in-depth understanding to analyze and determine the material properties critically in order to select them for the required biocompatibilit y	3														
	CO2: Analyze and account for methods to characterize interactions between materials and tissue.		2													
	CO3: To realize the important basic properties and requirements for biomaterials				2											

	and compare the mainstream biomaterials currently used for medical applications															
	CO4:Identify the suitable material and manufacturing methods for bio implant applications with considerations of health risk and economic aspects.						1									
	CO5: To understand the design and structural issues related to medical devices that are used in restoring function to load bearing tissues			1												
19ML5PWMP1	CO1 Apply the knowledge of science and medical electronics engineering to provide solutions for human-health related problems	3												3	3	3
	CO2: Analyze and identify biomedical engineering problems based on literature survey and need analysis.		3											3	3	3

	CO3: Develop solutions for relevant biomedical engineering problems with appropriate consideration of public health, safety and society.			3										3	3	3
	CO4: Design experimental techniques/ simulation models and interpret the data conclusively				3									3	3	3
	CO5:Use modern tools and resources in developing health-care solutions needing their applications					3								3	3	3
	CO6: Apply reasoning based on the contextual knowledge of the design problem statement and assess societal, health and safety issues						3									
	CO7:Demonstrate the knowledge of a sustainable solution in the context of society							3								
	CO8: Apply biomedical ethics and responsibilities								3							

	while working on project work															
	CO9: Function both individually and in diverse teams requiring multidisciplinary approaches									3						
	CO10: Comprehend, prepare effective reports and make clear presentations to an engineering community										3	3				
	CO11: Demonstrate the knowledge of project management and financial requirements of a project work											3				
	CO12: Exhibit self-reliance and life-long learning skills to align to the new trends												3			
19ES5HSIFE	CO1: Apply new ideas of design thinking, methods and ways of thinking		3													
	CO2: Able to formulate goals as an entrepreneur for a startup			3												
	CO3: Able to identify		3													

	business opportunities by performing market research and choosing target customer															
	CO4: Engage with a range of stakeholders to deliver creative and sustainable solutions to specific problems communicate effectively both orally and in writing							3			3					
	CO5: Work effectively with peers with diverse skills, experiences and be able to critically reflect on own practice									3						
6th Semester																
Medical Image Processing 19ML6PCMIP	CO1: The ability to understand concepts of digital image representation , processing, compression and objectives of biomedical image analysis and CAD.															
	CO2: The ability to apply algorithms in digital image processing for medical image enhancement restoration	3														

	segmentation and feature extraction															
	CO3: The ability to conduct experiments for medical image analysis		3			3									3	3
	CO4: Develop Graphical user interface based mathematical models to understand image enhancement and segmentation algorithms			3		3									3	3
	CO5: Engage in self-study as an individual and a team-member to design and implement an open ended experiment for medical image segmentation				3	3				3					3	3
19ML6PCMDD	CO1: Able to Identify and analyse unmet clinical need and its requirements to solve the identified need.	3	2													
	CO2: Able to Search, analyse and document clinical practice, engineering science and relevant literature in order to determine the				3	2							2	3		

	need for further research and development in a chosen clinical area.															
	CO3: Able to develop a sustainable business plan, including market overview, regulation strategies for health & safety of individuals and intellectual property (IP) strategies					3	3									
	CO4: Understand medical device design engineering and manufacturing process by avoiding common quality pitfalls in turn learning project management (PERT, Critical Path, etc).							3	3						3	
	CO5: Able to develop a virtual product of given medical device comprising of requirement analysis, Risk Analysis and management, High level design, usability analysis, verification				3					3	3	3	3			

	and validation and present the findings in a team.															
Bio-Medical Signal Processing 19ML6PCBSP	CO1: Ability to apply knowledge of mathematics, science and engineering to develop solutions for biomedical signal processing concepts.	3														
	CO2: Ability to analyze a problem and formulate appropriate solution for biomedical signal processing		3													
	CO3: An ability to design experiments in biomedical signal and analyze computer based process to meet desired needs in healthcare.			3												
	CO4: Ability to work, document and present as an individual and as a team-member to design formulate and implement experiments using modern tools.					3				3			3			

	CO5. Implement the concepts practically in groups, perform an open ended experiment/mini-project. Present and document the same.					3				3	3	3	3			
19ML6PE3 CDA	CO1: Analyze the role of biostatistics in public health or medical studies	3														
	CO2: Use descriptive tools to summarize and display data from a public health or medical studies		3													
	CO3: Identify the study designs and appropriate tests to perform hypothesis testing and interpret the outputs			3												
	CO4: Formulate and perform a descriptive and inferential analysis of a public health or other health sciences study using statistical Software and interpret the results.					3							2			3

19ML6CE 1BCI	CO1:Apply the knowledge of mathematics, science and engineering fundamentals to understand the Brain Organization, Anatomy, and Function.	3														
	CO2: Analyze and process the brain signals for artifact reduction.		3													
	CO3: To apply Machine Learning Techniques for analysing brain signals.			3												
	CO4: To demonstrate the concept of Building BCI System				3											
	CO5: Understand types of BCI, principles and its applications and ethics										2					
19ML6OE 1 ER	CO1: Apply the knowledge of mathematics, science and engineering fundamentals to improve human machine interaction.	3														
	CO2: Formulate and analyse the work environment that degrade human		3													

	machine performance															
	CO3:Design and apply reasoning by the contextual knowledge to meet the need of the users to assess health safety and legal issues						3									
	CO4: Comprehend the published reports and write reports of the case studies for ergonomically designed models working in a team.									2						
	CO5: Function effectively to communicate the prepared reports as an individual and in a team										2					
19ML6HSCFS	CO1:Apply knowledge of Engineering science to understand the basics of Forensic Science	3														
	CO2:Identify the importance of Forensic Document Examination and its scope.		2													
	CO3: Analyze the basic concepts of - Atomic and molecular spectroscopy			3												

	and instruments principles.															
	CO4: Differentiate between Ultraviolet and visible spectrophotometry				1											
	CO5: Identify the applications of modern equipments and techniques used in forensic science					1										
19ML6PWMP2	CO1: Apply the knowledge of science and medical electronics engineering to provide solutions for human-health related problems	3												3	3	3
	CO2: Analyze and identify biomedical engineering problems based on literature survey and need analysis.		3											3	3	3
	CO3: Develop solutions for relevant biomedical engineering problems with appropriate consideration of public health, safety and society.			3										3	3	3

	CO4: Design experimental techniques/ simulation models and interpret the data conclusively				3									3	3	3
	CO5:Use modern tools and resources in developing health-care solutions needing their applications					3								3	3	3
	CO6: Apply reasoning based on the contextual knowledge of the design problem statement and assess societal, health and safety issues						3									
	CO7:Demonstrate the knowledge of a sustainable solution in the context of society							3								
	CO8: Apply biomedical ethics and responsibilities while working on project work								3							
	CO9: Function both individually and in diverse teams requiring multidisciplinary approaches									3						

	CO10: Comprehend, prepare effective reports and make clear presentations to an engineering community										3	3				
	CO11: Demonstrate the knowledge of project management and financial requirements of a project work											3				
	CO12: Exhibit self-reliance and life-long learning skills to align to the new trends												3			
7th Semester																
19ES7HSPMF	CO1: Apply the Knowledge of project management principles and to implement project management methodologies required for successful project completion	3							1	2	2					
	CO2: Develop Ethical principles in project planning and execution as a team and documentation in project implementation.														2	

	CO3: Identify and Apply finance aspects for project implantation in time.											3				1
	CO4: Use modern tools to simulate their respective projects and case studies and investigate the behaviour under various operating conditions.												1			
19ES7BSBFE	CO1:Ability to apply knowledge of mathematics, science and Engineering to develop the solution using bio statistical concepts.	3														
	CO2:Ability to analyse a problem and formulate appropriate solution for bio statistical concepts application.		3													
	CO3:An ability to design and perform statistical test and interpret results			3												
	CO4: Ability to implement and demonstrate statistical analysis using modern tool usage				3	3										

	CO5; Implement the concepts practically in group perform an open ended experiment/min project and document the same.									3		3	3	3	3	3
19ML7PCMCL	CO1: Ability to apply knowledge to identify, gather information and analyse to formulate the unmet need and problem definition for project through survey				3									3		
	CO2: Ability to use appropriate tool/tools to implement and demonstrate the project.					3	3								3	
	CO3: Ability to design and develop sustainable solution/system for the biomedical applications			3					3							3
	CO4: Ability to make effective presentation of the work abiding professional ethics as an individual and a team member.					3				3	3					
	CO5: Ability to develop systems with scope for												3			

	enhancement and continue life-long learning.															
19ML7PC QCR Quality control and regulatory aspects in Medical Devices	CO1: Understand the requirements of Quality Assurance, Regulatory Compliance and Regulations of Medical Standards.		2													
	CO2: Apply and Analyse Medical Standards Requirements and Compliance.			3												
	CO3: Apply the concepts of quality assurance and control aspects for the medical device development.			3	3	3										3
	CO4: Implement medical regulatory and safety standards related to biomedical devices submission.						3	3								
	CO5: In group, study, present and submit the report on medical regulatory and									3			2			

	safety standards related to specific biomedical device															
19ML7OE2IM Imaging Modalities	CO1: Recognise the need for different imaging modalities	3														
	CO2: Compare the basic principles of various imaging modality		3													
	CO3: Analyse the biological effects of electromagnetic fields in humans for health safety issues.						3									
	CO4: Comprehend the published reports for the selected imaging modality. Prepare the document working in a team.									2						
	CO5: Function effectively to communicate the prepared document as an individual and in a team.										2					
19ML7PWMP3	CO1: Apply the knowledge of science and medical electronics engineering to provide	3												3	3	3

	solutions for human-health related problems															
	CO2: Analyze and identify biomedical engineering problems based on literature survey and need analysis.		3											3	3	3
	CO3: Develop solutions for relevant biomedical engineering problems with appropriate consideration of public health, safety and society.			3										3	3	3
	CO4: Design experimental techniques/ simulation models and interpret the data conclusively				3									3	3	3
	CO5:Use modern tools and resources in developing health-care solutions needing their applications					3								3	3	3
	CO6: Apply reasoning based on the contextual knowledge of the design problem statement and assess societal,						3									

	health and safety issues															
	CO7:Demonstrate the knowledge of a sustainable solution in the context of society							3								
	CO8: Apply biomedical ethics and responsibilities while working on project work								3							
	CO9: Function both individually and in diverse teams requiring multidisciplinary approaches									3						
	CO10: Comprehend, prepare effective reports and make clear presentations to an engineering community										3					
	CO11: Demonstrate the knowledge of project management and financial requirements of a project work											3				
	CO12: Exhibit self-reliance and life-long learning skills to align to the new trends												3			

8th Semester																
IPR & Cyber Law 19ES8HSIPL	CO1: understand and commit to professional ethics and responsibilities to obtain Intellectual property Rights like Patents, Copyright & Trademarks								3							
	CO2: Understand the impact of Patents, Copyright & Trademarks and demonstrate the knowledge of Cyber Law for the societal and environmental context.							3								
	CO3: Ability to use IPRs and Cyber Law to access societal, health, safety & Cultural issues						3									
	CO4: Ability to work in multiple teams to effectively communicate IP & Cyber Law.									3	2					
	CO4: Ability to work in multiple teams to discuss the case studies related toIPR & Cyber Law.									2				2		
	CO5: Ability to communicate effectively on										2			2		

	IPR & Cyber Law.															
Major Project 19ML8P WMPJ	CO1: Apply the knowledge of science and medical electronics engineering to provide solutions for human-health related problems	3												3	3	3
	CO2: Analyze and identify biomedical engineering problems based on literature survey and need analysis.		3											3	3	3
	CO3: Develop solutions for relevant biomedical engineering problems with appropriate consideration of public health, safety and society.			3										3	3	3
	CO4: Design experimental techniques/ simulation models and interpret the data conclusively				3									3	3	3
	CO5:Use modern tools and resources in developing health-care solutions needing their applications					3								3	3	3

	CO6: Apply reasoning based on the contextual knowledge of the design problem statement and assess societal, health and safety issues						3									
	CO7:Demonstrate the knowledge of a sustainable solution in the context of society							3								
	CO8: Apply biomedical ethics and responsibilities while working on project work								3							
	CO9: Function both individually and in diverse teams requiring multidisciplinary approaches									3						
	CO10: Comprehend, prepare effective reports and make clear presentations to an engineering community										3					
	CO11: Demonstrate the knowledge of project management and financial requirements of a project											3				

	work															
	CO12: Exhibit self-reliance and life-long learning skills to align to the new trends												3			
Internship Seminar 19ML8PCISR	CO1: engage in internship in an engineering domain, and comprehend the professional norms of the organization								3					3		
	CO2: Identify the key engineering, management, science, mathematics concepts, being transformed to a successful organization	2								3		2			2	
	CO3: identify the community that benefit from the product						2					3	3			2
	CO4: Identify and comprehend the professional norms and the model for sustainable development of the organization				3	3					3			1		
	CO5: Identify the skills/concepts from various disciplines, and able to									3						

	perform as a member of the multidisciplinary team															
	CO6 prepare the project report, three minute video and the poster of the work										3					

Program Articulation Matrix

Course and CODE	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
19ES3GCECA	3	3			3				2	3			3		
19ES3CCAEC	3	3	3	2	3				3	3		3	3		
19ES3CCDEC	3	3	3		3				3						
19ML3ESHPM	3	3	2	3		1									
19ES3GCSAM	2	3	3						3	2			3		
19ML4PCPCS	3	3	3	3	2				2	2					
19ES4CCLIC	2	2	3	3					2				3	2	
19ES4GCMCS	3	3	3		3	2	2	2				2	2	2	2
19ES4CCSAS	3	3	3						2	2	2				3
19ML4PCDIN	3	3	2	1	3							2			
19ML5PCESD	3	3	3		3				3			3			2
19ML5PCTIE	3			3	3	3	3				2			2	2
19ES5CCDSP	3	3	3						2	2	2				3
19ML5PCPMI	3	3				3	2	2	2	2					
19ML5PE1WS	3	3	3						2	3			3		
19ML5PE2BM	3	2	1	2		1									
19ML5PWMP1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
19ES5HSIFE		3	3				3		3	3					
19ML6PCMIP	3	3	3	3	3				3					3	3
19ML6PCMDD	3	2		3	3	3	3	3	3	3	3	3	3	3	
19ML6PCBSP	3	3	3		3				3	3	3	3			
19ML6PE3CD	3	3	3		3							2			3
19ML6CE1BC	3	3	3	3							2				
19ML6OE1 ER	3	3				3			2	2					
19ML6HSCFS	3	2	3	1	1										
19ML6PWMP2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
19ES7HSPMF	3							1	2	2	3	1		2	1

19ES7BSBFE	3	3	3	3	3				3	3	3	3	3	3	3
19ML7PCMCL			3	3	3	3		3	3	3		3	3	3	3
19ML7PCQCR		2	3	3	3	3	3		3			2			3
19ML7OE2IM	3	3				3			2	2					
19ML7PWMP3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
19ES8HSIPL						3	3	3	2	2			2		
19ML8PWMPJ	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
19ML8PCISR	2			3	3	2		3	3	3	3	3	1	2	2

Distribution of credits among various Curricular Components

SEM / COURSE TYPE	HS	BS	ES	PC	PE	OE	PW	SR	NC	TOTAL
I		9	11						NC1	20
II		9	11						NC2	20
III	1	4	4	16					NC3	25
IV	2	4	4	15					NC4	25
V	2			15	6		2		NC5	25
VI	2			11	6	3	2	1	NC6	25
VII	3	2		5	3	3	3		NC7	19
VIII	2					3	9	2	NC8	16
Course Total	12	28	30	62	15	9	16	3		175

COURSE TYPES:-

Humanities and Social Sciences, Management Course (HS)

Basic Science Course (BS)

Engineering Science Course (ES)

Professional Core Course (PC)

Professional Elective Course (PE)

Open Elective Course (OE)

Project/ Mini-Project (PW)

Seminar –Internship (SR)

Non-Credit Mandatory Course (NC)

III Semester Syllabus

(Common to EEE/ECE/EIE/ML/TCE)

Semester	III		
Course Title	**ENGINEERING MATHEMATICS - 3**	**Course Code**	**19MA3BSEM3**
Credits	**4**	**L-T-P**	**3:1:0**
Pre Requisites	**Basic concepts of Trigonometry, methods of differentiation, methods of integration, solution of ordinary differential equations.**		
Course Outcomes			
CO1	Apply Numerical techniques to solve problems arising in engineering.		
CO2	Demonstrate an understanding of Fourier Series, Fourier Transforms and Z- Transforms.		
CO3	Apply the concepts of calculus to functionals.		

UNIT 1	
MATRICES Introduction: Elementary row transformations, Echelon form of a matrix, rank of a matrix by elementary row transformations. Consistency of a system of linear equations and solution. Solution of a system of non-homogenous equations: Gauss elimination method, Gauss-Seidel method, LU decomposition method, eigenvalues and eigenvectors of matrices, reduction of a matrix to diagonal form.	**[9 hours]** **(7L + 2T)**
UNIT 2	
FOURIER SERIES Introduction: Dirichlet's conditions, Fourier series of periodic functions of period 2*l*, Fourier series of functions having points of discontinuity. Applications: Fourier series of typical waveforms like saw toothed waveform, triangular waveform, square waveform, half-wave rectifier, full wave rectifier and modified saw tooth waveform, exponential Fourier series, practical harmonic analysis.	**[9 hours** **(7L + 2T)**
UNIT 3	
FOURIER TRANSFORMS Infinite Fourier transform: Fourier Sine and Cosine transforms, properties, Inverse transforms. Convolution theorem, Parseval's identities.	**[9 hours]** **(6L + 3T)**
UNIT 4	
NUMERICAL METHODS Solution of algebraic and transcendental equations: Newton-Raphson method. Finite Differences and interpolation: Forward differences, backward differences. Newton- Gregory forward interpolation formula, Newton-Gregory backward interpolation formula, Lagrange's interpolation formula, Lagrange's inverse interpolation. Numerical integration: Simpson's $1/3^{rd}$ rule, Simpson's $3/8^{th}$ rule, Weddle's rule. Numerical solution of ordinary differential equations: modified Euler's method, Runge-Kutta method of fourth order.	**[10hours]** **(8L+2T)**
UNIT 5	
CALCULUS OF VARIATIONS Variation of a functional, Euler's equation, variational problems. Applications: Hanging cable problem, Brachistochrone problem. **Z -TRANSFORMS**	**[11 hours]** **(8L + 3T)**

Definition, Properties, Transforms of standard functions, Inverse transforms. Solution of difference equations using Z- transforms.		
TEXT BOOKS		
1	Higher Engineering Mathematics, B. S. Grewal, 43rd edition, 2014, Khanna Publishers.	
2	Advanced Engineering Mathematics, 4th edition, 2011, Dennis G. Zill and Cullen, Jones and Bartlett India Pvt. Ltd.	
REFERENCE BOOKS		
1	Higher Engineering Mathematics, B. V. Ramana, 2007, Tata McGraw Hill.	
2	Advanced Engineering Mathematics, Erwin Kreyszig, 10th edition Vol.1 and Vol.2, 2014, Wiley-India.	
Online course		
1	https://nptel.ac.in/courses/111103021/22 (Fourier series and Transforms, Heat and Wave Equations)	
2	https://nptel.ac.in/courses/111104025/ (Calculus of variation)	
3	https://nptel.ac.in/courses/122104018/2 (Numerical Methods)	
E-Books:		
1	https://ocw.mit.edu/courses/mechanical-engineering/2-993j-introduction-to-numerical-analysis-for-engineering-13-002j-spring-2005/lecture-notes/	
2	https://www.pdfdrive.com/calculus-of-variations-e34313748.html	

Semester	III		
Course Title	**ELECTRICAL CIRCUIT ANALYSIS**	**Course Code**	**19ES3CCECA**
Credits	4	**L-T-P-S**	**3:1:0:0**
Pre Requisites	**Basic Electrical Engineering, Engineering Mathematics- I & II**		

Course Outcomes	
CO1	Formulate equations based on physical laws and analyze the steady state behaviour of complex electric networks
CO2	Apply the knowledge of mathematics and graph theory to the solution of complex electrical networks
CO3	Apply mathematical and analytical techniques to analyze transient behaviour of networks.
CO4	Analyze and model two port networks based on its parameters
CO5	Engage in independent study using modern tools as an individual and as a team- member to simulate the electrical circuits for the relative comparison with theoretical values.
CO6	Prepare a technical document and present the same on the simulated electrical circuits

UNIT 1	
Basic Concepts: Practical sources, Source transformations, Network reduction using Star to Delta transformation, vice versa. Loop and node analysis with linearly dependent and independent sources for DC and AC circuits, Analysis of network involving concepts of super node, super mesh.	**12Hrs**
UNIT 2	
Network Topology: Graph of a network, Concept of tree and Co-tree, Incidence matrix, tie-set, tie-set schedule & cut-set, cut-set schedule, Formulation & solution of equilibrium equations, Principle of duality. Resonant Circuits: Series and parallel resonance, Frequency response of series and parallel circuits, Q factor, Bandwidth.	**10Hrs**
UNIT 3	
Network Theorems: Superposition, Reciprocity, Millman's, Thevenin's and Norton's theorems, Maximum power transfer theorem.	**10Hrs**
UNIT 4	
Transient Behavior and Initial Conditions: Behavior of circuit elements under switching condition and their representation, Evaluation of Initial and Final conditions in RL, RC and RLC circuits. Review of Laplace transforms, Waveform Synthesis, Initial and Final value theorems, Step, Ramp and Impulse responses, Convolution theorem, solution of simple R-L, R-C, R-L-C networks for AC and DC excitations using Laplace transforms.	**10Hrs**
UNIT 5	
Analysis of Two Port Network and its Parameters Definition of Z, Y, T, h parameters, Modeling, Relationship between parameters sets.	**10Hrs**

Choice: Unit-I and Unit-IV		
TEXT BOOKS		
1	Network Analysis", M.E.Vanvalkenburg, PHI/ Pearson Education, 3rd Edition. Reprint 2002.	
2	Networks and systems ", Roy Choudhury, 2nd edition, 2006 reprint, New Age International Publications.	
REFERENCE BOOKS		
1	Engineering Circuit Analysis", Hayt, Kemmerly and Durbin, TMH 6th 2002.	
2	Network analysis and Synthesis", Franklin F. Kuo, Wiley Edition.	
3	Analysis of Linear Systems", David K. Cheng, Narosa Publishing House, 11th reprint, 2002.	
4	Circuits", Bruce Carlson, Thomson learning, 2000. Reprint 2002.	
5	Network analysis and Synthesis", Anand Kumar, PHI Learning, 2019.	
Online course		
1	http://elearning.vtu.ac.in/06ES34.html	
2	https://www.coursera.org/course/circuits	

Semester	III		
Course Title	**ANALOG ELECTRONIC CIRCUITS**	**Course Code**	**19ES3CCAEC**
Credits	**4**	**L-T-P**	**3:0:1**
Pre Requisites	**Elements of Electronics Engineering**		

Course Outcomes	
CO1	define, understand and explain the structure, V-I characteristics, working and applications of analog electronic components like diodes, Bipolar Junction Transistors (BJTs) and MOSFETs
CO2	apply the knowledge of KVL and KCL to obtain voltage /current/waveform at different points in analog electronic circuits such as diode clippers, clampers, amplifiers using BJTs and MOSFETs, current sources, current mirrors, power amplifiers.
CO3	analyse analog electronic circuits such as diode clippers, clampers, amplifiers using BJTs and MOSFETs, current sources, current mirrors, power amplifiers, feedback amplifiers etc. to obtain voltage /current/waveform at different points for given specifications.
CO4	o design analog electronic circuits such as diode clippers, clampers, amplifiers using BJTs and MOSFETs, current sources, current mirrors, power amplifiers, feedback amplifiers for given specifications.
CO5	conduct experiments using analog electronic components and electronic instruments to function as switch, regulator, clippers, clampers, small signal amplifiers, oscillators, power amplifiers
CO6	formulate, design, implement, analyse, document and demonstrate an application using analog Electronic components through an open ended experiment, Document and present the same.

UNIT 1	
Diode applications: - Introduction, load line analysis, Series diode configurations, Parallel and series –parallel configurations, clippers, Clampers. **Bipolar Junction Transistor (BJTs):-** DC biasing– Introduction, operating point, voltage divider Bias configuration **BJT AC Analysis: -** Introduction, Application in the AC Domain, BJT Transistor Modeling, the r_e Transistor model, Voltage Divider Bias	**8hrs**
UNIT 2	
BJT Frequency Response :- Introduction, Logarithms, Decibels , Low frequency Response-BJT Amplifier, Miller effect Capacitance, High Frequency response – BJT Amplifier **Feedback concepts:-** Feedback connection types- Voltage series, Voltage-shunt , Current Seriesand Current Shunt Feedback. **Practical feedback Circuits**: - Voltage series, Current series feedback and voltage Shunt feedback.	**7hrs**
UNIT 3	
Power Amplifiers:-	**7 Hrs**

Introduction- Definitions and Amplifier Types, Amplifier Efficiency **Series-Fed Class A Amplifier**: DC Bias Operation, AC operation, Power Consideration, Efficiency. **Transformer coupled Class A Amplifier :** Operation of Amplifier Stage : DC load line, Quiescent operating point, AC load line , Signal Swing and Output AC power. **Class B operation:** Class B Amplifier Circuits- Transformer coupled Push- Pull Circuits, Complementary Symmetry Circuits, Amplifier Distortion. .	
UNIT 4	
MOSFETS:- Introduction ,**Device structure and physical operation** ---- Device structure, operation with no gate voltage, creating a channel for current flow, Applying a small VDs, Operation as VDs is increased, Derivation of the id – V_{DS} relationship, The P- Channel MOSFET, Complementary MOS or CMOS, operating the MOS transistor in the sub-threshold region . **Current voltage Characteristics---**Circuit symbol, id – V_{DS} characteristics, characteristics of the P-Channel MOSFET **MOSFET Circuits at DC** **The MOSFET as an amplifier and as a switch** --- Large – signal operation , Graphical derivation of the transfer characteristic, operation as a switch, operation as a linear amplifier. **Biasing in MOS amplifier circuits---**Biasing by fixing V_{GS}, Biasing by fixing V_G and connecting a resistor in the source , Biasing using a drain to gate feedback resistor, biasing using a current source.	**07hrs**
UNIT 5	
Small – signal operation and models of MOSFETs---The DC bias point, the signal current in the drain terminal ,the voltage gain, separating dc analysis and the signal analysis, small signal equivalent circuit models, the transconductance g_m, the T equivalent circuit model. **Single stage MOS amplifiers---**The basic structure, characterizing amplifiers, The CS amplifier, The CS amplifier with a source resistance. Common gate (CG) Amplifier, The common Drain or source follower Amplifier. **IC Biasing**: – **Current sources, current mirror and current steering circuits---** The basic MOSFET current source, MOS current steering circuits **Current mirror circuit with improved performance** --- The Wilson MOS mirror	**07hrs**
Choice: Unit-I and Unit-V	
TEXT BOOKS	
1 Electronic Devices and Circuit Theory-Robert L.Boylestad and Louis Nashelsky-10th edition (PEARSON EDUCATION)	
2 Microelectronic Circuits-Theory and applications by ADEL S. SEDRA and KENNETH C.SMITH FIFTH EDITION (OXFORD INTERNATIONAL STUDENT EDITION	

REFERENCE BOOKS		
1	Electronic Devices and Circuits- Millman and Halkias, TMH	
2	Electronic Devices and Circuits- David A Bell - PHI 4th edition	
Online course		
1	https: //www.mooc-list.com/ course/ electronic-systems-and-digital-electronics-uninettuno?static=true	
2	http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-012-microelectronic-devices-and-circuits-spring-2009/	
3	Introductory Analog Electronics Laboratory (Spring 2007) by MIT open courseware Reviews and Ratings	
E-Books:		
1	www.pyroelectro.com/edu/analog	
2	http://freevideolectures.com/course/3020/circuits-for-Analog-System-Design	

LABORATORY EXPERIMENT LIST

Sl. No	Title of the Experiments
1	Performance analysis of Transistor as a switch
2	Zener diode characteristics and Zener as regulator
3	Diode clipping circuits- Single/Double ended
4	Diode clamping Circuits – Positive clamping/negative clamping
5	Performance analysis BJT as RC coupled amplifier
6	Design and analysis of BJT as RC phase shift oscillator
7	Design and analysis of Crystal Oscillators
8	To obtain the characteristics of MOSFET (using Multisim/hardware)
9	To study MOSFET as an amplifier (using Multisim/hardware)
10	To study voltage series feedback amplifier using BJT(using Multisim/hardware)
11	Performance analysis of class – B Power Amplifier
12	Compare the performance of the practical circuit with the corresponding simulation

Semester	III		
Course Title	**DIGITAL ELECTRONIC CIRCUITS**	**Course Code**	**19ES3CCDEC**
Credits	**4**	**L-T-P**	**3:0:1**
Pre Requisites	**Elements of Electronics Engineering**		

Course Outcomes	
CO1	understand, define and explain the fundamental concepts of Digital circuits
CO2	apply the knowledge of simplification methods to optimize a Digital circuit
CO3	analyze digital circuits and arrive at suitable conclusions
CO4	design a digital circuit for given specifications
CO5	conduct experiments using digital ICs for a given application/problem statement

UNIT 1	
Introduction: Review of Boolean algebra, logic gates. Simplification of Boolean functions: Three Variable, Four Variable and Five Variable K – Maps, The Tabulation Method, Design with Basic gates, NAND gates and NOR gate	**7 Hrs**
UNIT 2	
Combinational Logic Circuits: Introduction, Parallel Adders (Carry Look Ahead Adder and Ripple carry adder), Decimal Adder, Code conversion, Magnitude Comparator, Decoders, Multiplexers, Read Only memories (ROM), Programmable Logic Arrays (PLAs).	**8 Hrs**
UNIT 3	
Sequential Logic Circuits: The Basic Flip-flop circuit, Clocked Flip-flops, Triggering of Flip-flops: Master Slave Flip-Flops, Edge Triggered Flip Flops, Characteristic Equations, Conversion of flip-flops, Shift Registers, Ripple Counters, Synchronous Counters	**7 Hrs**
UNIT 4	
Sequential systems: Analysis of Clocked Sequential circuits, State Reduction and Assignment, Design Procedure, Design with State Equations, Sequence detector	**7 Hrs**
UNIT 5	
Logic Families: Characteristic of Digital ICs, Transistor – Transistor Logic, Complementary MOS (CMOS) Logic, Comparison of TTL and CMOS families.	**7 Hrs**

TEXT BOOKS	
1	Digital Logic and Computer Design- M. Morris Mano, Prentice Hall – Pearson Education
2	Digital Principles and Design- Donald Givone, Tata Mc Graw Hill

REFERENCE BOOKS	
1	Fundamental of Logic Design- Charles Roth Jr., Thomas Learning
2	Digital Logic Applications and principles- John Yarbrough, Pearson Education

Online course	
1	https://nptel.ac.in/courses/108105113/
2	https://nptel.ac.in/courses/106105185/

E-Books:	
1	http://www.panstanford.com/pdf/9789814364591fm.pdf
2	https://easyengineering.net/digital-logic-and-computer-design-by-morris-mano/

3	https://www.sciencedirect.com/book/9780750645829/digital-logic-design	
4	https://easyengineering.net/fundamentals-of-digital-circuits-by-anand-kumar/	

LABORATORY EXPERIMENT LIST

	Title of the Experiment
1	Applications of IC 7483 (Adders, Subtractors and Comparators) (Unit-II)
2	Multiplexers (using Gates and IC) and their applications (Unit-II)
3	Decoders/DeMultiplexers (using Gates and IC) and their applications (Unit-II)
4	BCD to Decimal decoder using 7-segment display (Unit-II)
5	Verification of MSJK Flip-flop (using Gates and IC 7476) (Unit-III)
6	Asynchronous counters (using ICs 7476,7490,7493) (Unit-III)
7	Synchronous Counters (using ICs 7476, 74190/74192) (Unit-III)
8	Shift registers and their applications (using ICs 7476, 7495) (Unit-III)
9	Verification of few parameters of TTL (Unit-V)
10	Verification of few parameters of CMOS (Unit-V)

Semester	III		
Course Title	HUMAN PHYSIOLOGY AND MEDICAL PHYSICS	Course Code	19ML3ESHPM
Credits	4	L-T-P	3:1:0

Course Outcomes

CO1	Interpret the interplay between different organ systems and how organs interact to maintain biological equilibrium in the face of a variable and changing environment.
CO2	Utilize anatomical terminology to identify and analyze the physiology of and physics of human system
CO3	Analyse the impact of various diseases affecting the functioning of human organ systems.
CO4	Analyze human organ systems using mathematical models developed based on their working principles.
CO5	Assess the functioning of different organ systems in the human body.

UNIT 1	
Physiology and Physics of the Respiratory system: Ventilation and its mechanism: Intra Pleural Pressure, Compliance and factors affecting it. Role of chest wall, Airway resistance, Work done in Breathing, Alveolar Ventilation, Ventilation Perfusion Ration. Control of ventilation: Fick's law. Discussion on Hypoxia, High Altitude Sickness, Pulmonary Edema, Asthma, Sleep Apnea, ARDS, Lung Function Tests: Spirometry, Lung Volumes and Lung Capacities. **Fluid pressure, Fluid flow in the body:** Physics of pressure and flow of fluids, Law of Laplace, Fluids in motion, Bernoulli's equation, Pressure and flow in the body. Motion of Humans in the fluids. Human flight.	**10 Hrs.**
UNIT 2	
Physiology and Physics of the cardiovascular system: Mechanical properties of heart muscle, Electrophysiological properties of heart, Frank-Starling Mechanism, Heart as Pump, Pressure and Volume changes during a Cardiac cycle, Work done by the Heart. Mechanism of Control of Heart Rate, Conditions affecting the Heart Rate, Blood Pressure, Clinical Electrocardiography, Hypertension. Pathological conditions: Stock-Adam's Syndrome. **Blood flow and its Pressure in blood vessels** Properties of blood, Measuring flow in Blood Vessels: mechanical properties of blood, Modelling Flow of blood vessels, Pressure drops in arteries and resistive vessels, , Modelling of the Circulatory System and the Heart, Windkessel Model, Blood flow Rates and Speeds, Cardiac mechanics, Effects of exercise. Tutorials: Problems on the blood and blood vessels, cardiovascular system and human heart.	**10 Hrs.**
UNIT 3	
Physiology and Physics of Metabolism: The Cell, Functions of the Cell Membrane, Movement across the Cell Membrane: Different mechanisms. Action potentials, Homeostasis, Controls and Feedbacks. Metabolic Rate: Definition, Bomb Calorimeter, Methods of determination of Metabolic Rate: Direct and Indirect methods, Respiratory Quotient (RQ): Measurement of RQ, Roth spirometer, BMR; Factors influencing BMR,	**10 Hrs.**

Energy, Heat, Work, and Power of the Body: Conservation of Energy and Heat flow, Energy content of body fuel, Metabolic rates, loss of Body Heat, Body temperature.		
UNIT 4		
Physiology and Physics of Skeletal and Muscular System: Skeletal muscle: Contraction and relaxation, Neuromuscular junction: Receptors, transmissions. Characteristics and Properties of Skeletal muscles. Physiology of exercise: classification of exercise, different changes with exercise. Smooth muscle; properties of smooth muscle, Neuro effector junction, Electrophysiological properties.		**08 Hrs.**
UNIT 5		
Physiology and Physics of Sound, Speech and Hearing: Properties of sound: Intensity of sound waves, Transmission of sound from one medium to another, waves modes in a tube. Neuromuscular systems in voice production, systems in speech production. The Energetics of Speaking, Hearing loss, Connections to hearing Perception. Focusing and Imaging with Lenses, combinations of lenses or refractive surfaces, Imaging and detection by the Eye, the Eye as a compound Lens, Accommodation, Limitations to Visual Acuity, Aberrations in Image Formation, Quantitative Evaluation of Image Acuity, Imperfect human Vision, Correction of Vision by Eye Glasses, conduct lenses. Types of Vision Impairment, connections to Visual Perceptions.		**10 Hrs.**
TEXT BOOKS		
1	Concise Medical Physiology- by Sujit K. Chaudhuri, 5th Edition, New Central Book Agency Pvt. Ltd.	
2	Herman I.P., Physics of the Human Body, Springer Publications, 2007	
REFERENCE BOOKS		
1	Introduction to the Human Body, The Essentials of Anatomy and Physiology, 9th Edition, Tortora G.J. and Derrickson B., Wiley, USA, 2011, ISBN 0470598921.	
2	Ross & Wilson's Anatomy and Physiology in Health and Illness – by Anne Waugh and Allison Grant, 9th Edition, Churchill Livingstone Publications.	
3	Dr.R.N.Roy "Medical biophysics", Books and Allied(P) Ltd. 1st Edition,2001, Reprint 2010.	
4	B H Brown, R H Smallwood, D C Barber, P V Lawford and D R Hose "MEDICAL PHYSICS AND BIOMEDICAL ENGINEERING", Medical Science Series© IOP Publishing Ltd 1999.	
Online course		
1	https://www.kcl.ac.uk/medicine/research/divisions/imaging/departments/biomedengineering/BEngDegree/Study/Introduction-to-Anatomy- and-Physiology.aspx	
2	https://www.primalpictures.com/anatomy-physiology.aspx	
E-Books:		

1	Ross & Wilson's Anatomy and Physiology in Health and Illness – by Anne Waugh and Allison Grant, 9th Edition, Churchill Livingstone Publications.	
2	Essentials of Medical Physiology - by K. Sembulingam and Prema Sembulingam, 3rd Edition, Jaypee Publications.	

Semester	III		
Course Title	**SENSORS AND MEASUREMENTS**	**Course Code**	**19ES3GCSAM**
Credits	**4**	**L-T-P**	**3:0:1**

Course Outcomes	
CO1	Apply the knowledge of science and engineering fundamentals to realize sensor based measurement systems.
CO2	Analyse engineering problems and performance characteristics in order to arrive at suitable techniques for the measurement of non-electrical quantities using direct or complex sensors.
CO3	Design sensors and solutions to meet the specified measurement needs, considering the nature and properties of measured quantities.
CO4	Work with sensors and measurement systems both individually and in teams, document the activity and communicate the outcome to an engineering community.

UNIT 1	
Measurements: Introduction, Significance of measurements, instruments and measurement systems, Functional elements of measurement system. Performance Characteristics of measuring instruments- Static & Dynamic. Measurement Errors: Gross and systematic.	**6 hours**
UNIT 2	
Physical Principles of Sensing: Capacitance, magnetism, Induction, Resistance, Piezoelectric Effect, Hall effect, Thermoelectric effect, Sound waves, Temperature and thermal properties of materials, Heat transfer. Displacement and Level Sensors: Inductive, Magnetic and Optical, Acceleration: Accelerometers – Seismic Sensors. Force and Strain: Strain Gauge, Pressure sensors.	**8 hours**
UNIT 3	
Acoustic sensor: Resistive and Fiber-optic microphones, Humidity and Moisture sensor: Concept of Humidity, Thermal conductivity and Optical, Hygrometers, Light Detectors: Photodiode, Phototransistor, Photo resistor, Radiation Detectors: Scintillating Detectors and Ionization Detectors	**8 hours**
UNIT 4	
Temperature sensor: Pyroelectric Effect, Coupling with object, Static & Dynamic heat exchange, RTD, Thermistors, Thermocouple circuits, Optical Temperature sensor, Multi sensor arrays. [xxx].	**7 hours**
UNIT 5	
Measuring Instruments: Interface Electronic Circuits, Signal conditioners, Sensor connections, excitation circuits, Data transmission, Noise in sensors and circuits, Battery for low power sensors.	**7 hours**
CHOICE UNITS: UNIT II and UNIT III.	

TEXT BOOKS

1	Measurement Systems, Ernest O Doebelin, Dhanesh N Manik, TMH, Sixth edition	
2	Handbook of Modern Sensors: Physics, Designs, and Applications, Jacob Fraden , Springer Publications, Fifth Edition (Chapter 1,4,5,6, 8,9,10,13,15,17,19)	

REFERENCE BOOKS		
1	"Electronics & Electrical Measurements", A K Sawhney, Dhanpat Rai & sons, 9th edition	
2	"Electronic Instrumentation and Measurements", David A Bell, PHI / Pearson Education,2006	
Online course		
1	https://www.convergencetraining.com/measurement-methods-and-sensors-courses.html	
2	https://nptel.ac.in/courses/112103174/3	
E-Books:		
1	https://electronicsforu.com/resources/7-free-instrumentation-engineering-ebooks	
2	https://www.azosensors.com/book-index.aspx	
3	https://doc.xdevs.com/doc/_Metrology/introduction-to-instrumentation-and-measurements-2-edition-by-robert-b-northrop.pdf	
4	http://www.unhas.ac.id/rhiza/arsip/jurusan/TEKNIK_FISIKA_UNHAS/REFERENSI/Measurement_and_Instrumentation/Measurement_and_Instrumentation_Principles_Alan_W_Morris.pdf	
5	http://www.realtechsupport.org/UB/SR/sensors/Fraden_Sensors_2010.pdf	
6	https://automationforum.in/t/collection-of-free-instrumentation-e-books-and-pdfs/4657	

Semester	III		
Course Title	**CONSTITUTION OF INDIA, PROFESSIONAL ETHICS AND HUMAN RIGHTS**	**Course Code**	19IC3HSCPH
Credits	01	**L-T-P**	1: 0 : 0

Course Outcomes

At the end of the course, the student will have the ability to

CO1	Understand and explain the significance of Indian Constitution as the Fundamental Law of the Land.
CO2	Analyze the concepts and ideas of Human Rights.
CO3	Apply the practice of ethical responsibilities and duties to protect the welfare and safety of the public.

UNIT 1	
Introduction to Indian Constitution Historical Background of the Indian Constitution. Framing of the Indian constitution: Role of the Constituent Assembly - Preamble and Salient features of the Constitution of India, Fundamental Rights and its limitations. Fundamental Duties and their significance. Directive Principles of State Policy: Importance and its relevance. Case Studies	3 Hrs
UNIT 2	
Union Executive and State Executive The Union Executive – The President and The Vice President, The Prime Minister and The Council of Ministers. The Union Parliament – Lok Sabha & Rajya Sabha. The Supreme Court of India.State Executive – The Governors, The Chief Ministers and The Council of Ministers. The State Legislature – Legislative Assembly and Legislative Council. State High Courts.	2 Hrs.
UNIT 3	
Election Commission of India, Amendments and Emergency Provisions Election Commission of India – Powers & Functions – Electoral Process in India. Methods of Constitutional Amendments and their Limitations. Important Constitutional Amendments – 42nd, 44th, 61st,74th, 76th, 77th, 86th and 91st. Emergency Provisions. Case Studies.	02 Hrs
UNIT 4	
Special Constitutional Provisions/ Human Rights Special Constitutional Provisions for Schedule Castes, Schedule Tribes & Other Backward Classes. Women & Children. Case Studies. Human Rights/values – Meaning and Definitions, Legislative Specific Themes in Human Rights and Functions/ Roles of National Human Rights Commission of India. Human Rights (Amendment Act)2006.	2 Hrs.
UNIT 5	
Professional Ethics Scope and Aims of Engineering Ethics, Responsibilities of Engineers and impediments to responsibilities. Honesty, Integrity and Reliability; Risks – Safety and Liability in Engineering. Case Studies.	3 Hrs
TEXT BOOKS	

1	"An Introduction to Constitution of India and Professional Ethics" by Merunandan K.B. and B.R. Venkatesh, Meragu Publications, 3rd edition, 2011.	
2	"Constitution of India & Professional Ethics & Human Rights" by Phaneesh K. R., Sudha	
3	Environmental studies by – SmritiSrivastav	
4		
REFERENCE BOOKS		
1	"V.N. Shukla's Constitution of India" by Prof (Dr.) Mahendra Pal Singh (Revised), Eastern Book Company, Edition: 13th Edition, 2017, Reprint 2019.	
2	"Ethics in Engineering" by Martin, W. Mike.,Schinzinger, Roland., McGraw-Hill Education; 4th edition (February 6, 2004) .	
E-Books:		
1	https://books.google.co.in/books/about/Constitution_of_India_and_Professional_E.html?id=VcvuVt-d88QC Constitution of India and Professional Ethics, by G.B. Reddy and Mohd Suhaib, I.K. International Publishing House Pvt. Ltd., 2006.	
2	http://www.scribd.com/doc/82372282/Indian-Constitution-M-Raja-Ram-2009#scribd Indian Constitution, by M. Raja Ram, New Age International Pvt. Limited, 2009.	

Semester	III		
Course Title	Physical Activity	**Course Code**	19ML3NCPYA
Credits	NC	**L-T-P**	-

The college provides opportunity for students to associate with a large number of physical activities during the semester.
Sample activities are listed below:
• Civil Defense/ Self-defense through Karate
• NCC

• **Sports for Beginners** : Badminton/ Kho-Kho/ Chess/ Net Ball/ Football/ Table Tennis/ Handball/ Cricket/ Hockey/ Volleyball/ Kabaddi/ Basket Ball/Throw Ball

• **Sports for Regular Players**: Tennis / Athletics / Ball Badminton / Baseball / Billiards & Snookers / Body Building / Roller Skating / Rugby / Softball / Swimming / Yachting / Gymnastic / Archery / Cycling / Equestrian / Fencing / Golf / Karate / Kayaking & Canoeing / Power-lifting / Rowing / Shooting / Squash / Weight Lifting / Boxing / Wrestling / Judo

Students regularly associated with ANY one of the above activities, and certified by the concerned faculty in-charge, shall be awarded a Pass Grade in the Course.

Students who are not associated with the above affinity groups, shall participate in the events organized by the department or Sports club from outside the college:

- Walkathon • Yoga • Full/Half-Marathon

IV Semester Syllabus

Semester	IV		
Course Title	**Engineering Mathematics - 4**	**Course Code**	**19MA4BSEM4**
Credits	**04**	**L-T-P**	**3 -1- 0**
Pre Requisites	Complex numbers, multivariate calculus and basic concepts of Statistics and Probability.		

Course Outcomes

CO1	Demonstrate an understanding of concepts of statistical analysis and probability distributions.
CO2	Apply Numerical techniques to solve partial differential equations arising in engineering.
CO3	Demonstrate an understanding of analytic functions and their application to evaluate integrals.

UNIT 1	
STATISTICS AND PROBABILITY Curve fitting – Principle of least squares, fitting a straight line, fitting of a parabola, fitting of exponential curve of the form $y = ab^x$. Correlation and regression. Probability distributions: Discrete distribution - Poisson distribution. Continuous distribution- Normal distribution.	**[10 hours]** **(8L + 2T)**
UNIT 2	
JOINT PROBABILITY AND MARKOV CHAIN **Joint Probability Distributions:** Discrete random variables, Mathematical expectations, Covariance and Correlation. **Markov Chain:** Markov Chain, Probability vectors, stochastic matrices, fixed point vector, regular stochastic matrices. Higher transition probabilities, stationary distribution of regular Markov chain.	**[9 hours]** **(7L+2T)**
UNIT 3	
NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS Finite-Difference formulas to partial derivatives. Applications: Solution of one-dimensional heat equation using 2-level formula and Schmidt explicit formula and Crank-Nicolson two-level implicit formula. Solution of one-dimensional wave equation using explicit three level formula and implicit scheme.	**[9 hours]** **(7L + 2T)**
UNIT 4	
COMPLEX ANALYSIS – 1 Functions of a complex variable, limits, continuity and differentiability of a complex valued function, Analytic functions, properties of analytic functions, Cauchy-Riemann equations in Cartesian and polar form, construction of analytic functions by Milne-Thomson method. Conformal mapping: $w = z^2$ and $w = z + \frac{a^2}{z}\left(z \neq 0\right)$. Bilinear transformations.	**[10 hours]** **(7L + 3T)**
UNIT 5	
COMPLEX ANALYSIS - 2 Complex integration: Line integral, Problems on line integral, Cauchy's theorem, Cauchy's integral formula. Complex series: Taylor's, Maclaurin's and Laurent's series (without	**[10 hours]** **(7L + 3T)**

proof)-examples. Zeros, Poles and Residues, Cauchy's residue theorem (without proof)-examples.		
TEXT BOOKS		
1	Numerical Methods for Engineering, R. P. Kanale and S. C. Chapra, 6th edition, McGraw Hill, Publishers.	
2	Higher Engineering Mathematics, B. V. Ramana, 2007, Tata McGraw Hill.	
REFERENCE BOOKS		
1	Advanced Modern Engineering Mathematics, Glyn James, 3rd edition, 2004, Pearson Education.	
2	Higher Engineering Mathematics, B. S. Grewal, 43rd edition, 2013, Khanna Publishers.	
Online course		
1	https://nptel.ac.in/courses/111105090/ (Probability & statistics-Joint distribution, testing of hypothesis)	
2	https://nptel.ac.in/courses/111103070/ (Complex Analysis - Analytic functions, Mobius transformation & Residue theorem)	
3	https://nptel.ac.in/courses/111107056/ (Complex Analysis - Complex integration, conformal mapping)	
E-Books:		
1	https://www.coursera.org/learn/basic-statistics	
2	http://wiki.stat.ucla.edu/socr/index.php/Probability_and_statistics_EBook	
3	https://ocw.mit.edu/courses/mathematics/18-112-functions-of-a-complex-variable-fall-2008/lecture-notes/	
4	https://www.math.ubc.ca/~peirce/M257_316_2012_Lecture_8.pdf	

Semester	IV		
Course Title	**PHYSIOLOGICAL CONTROL SYSTEMS**	**Course Code**	**19ML4PCPCS**
Credits	04	**L-T-P**	**3:1:0**
Pre Requisites	**Linear Circuit Analysis, Engineering Mathematics I & II**		

Course Outcomes

CO1	Apply the knowledge of engineering and mathematics to develop models for classical and physiological control systems.
CO2	Identify and analyse the time-domain response of conventional and physiological control systems.
CO3	Design and Investigate the stability of control systems using frequency analysis techniques.
CO4	Analyse the complex problems in physiological control systems through parametric and nonparametric identification methods
CO5	Implement the control theory concepts using modern tools working in a team and write reports of the same.
CO6	Function effectively to communicate as an individual to present the report of the implemented work in a team.

UNIT 1	
Introduction: Examples of Control Systems, open loop vs Closed loop Systems, Mathematical Modelling of Linear Systems: Transfer functions, Mechanical Systems, Analogous Systems, Block diagram, Signal Flow graph. Difference between Engineering and Physiological Control System, Case study: Block diagram representation of the muscle stretch reflex, contributions of the muscle stretch reflex, adaptive characteristics of the muscle stretch reflex. Linear model of respiratory mechanics, linear model of muscle mechanics, lumped and distributed parameter of an unmyelinated nerve fiber, Simple Lung mechanics Neuromuscular Reflex Motion.	**9+3 hours**
UNIT 2	
Time-Domain Analysis of the Control System: Step response of first order, second order systems, response specification, steady state error and error constants. Case study: Steady State Characteristics of the Muscle Stretch Reflex Model components, Regulation of Cardiac Output, Regulation of Glucose and Insulin, Steady State Closed Loop Analysis of Cardiac Output Regulation, chemical regulation of ventilation, Response of Lung Mechanics Model,	**6+3 hours**
UNIT 3	
Stability Analysis: Concept of stability, RH criterion, applications of RH criterion with limitations. Root locus technique: Introduction to root locus concepts, Construction rules, Analysis of stability by root locus plot. Stability analysis of the pupillary reflex,	**6+2 hours**
UNIT 4	
Identification of Physiological control systems: Nonparametric and parametric identification of methods: discussion of it, Identification of closed loop systems: case studies: The starling Heart-Lung Preparation, minimal model of blood glucose regulation, respiratory control system.	**6+2 hours**

UNIT 5		
Frequency response Analysis: Bode plots, Relative stability and Frequency domain specification. Case studies; Bode plots of frequency response of the linearized lung mechanics, responses in heart rate and arterial blood pressure, frequency responses of glucose-insulin regulation model in Type-2 diabetic		**6+2 hours**
TEXT BOOKS		
1	Physiological control system- Michael. C.K .Khoo.	
2	Engineering control systems - Norman S. Nise, John WILEY & sons , fifth Edition.	
REFERENCE BOOKS		
1	Modern control Engineering- Ogata, Prentice Hall	
2	Automatic Control Systems - B.C Kuo, John Wileyand Sons.	
3	Control Engineering by Nagrath & Gopal, New Age International Publishers	
Online course		
1	www.nptel.com/IITK	
2	https://www.edx.org/course/	
3	http://nptel.ac.in/courses/108103007/	
E-Books:		
1	http://en.wikibooks.org/wiki/Control_Systems	
2	http://www.electrical4u.com/control-system-closed-loop-open-loop-control-system/#practical-examples-of-open-loop-control-system	
3	http://www.facstaff.bucknell.edu/mastascu/eControlHTML/CourseIndex.html	
4	http://en.wikibooks.org/wiki/Control_Systems	

Semester	IV		
Course Title	LINEAR INTEGRATED CIRCUITS	Course Code	19ES4CCLIC
Credits	4	L-T-P	3:0:1

Course Outcomes

CO1	Apply the knowledge of electronic engineering fundamentals to comprehend linear integrated circuits based systems
CO2	Interpret and analyze the effects of DC and AC limitations of Operational Amplifiers
CO3	Implement linear integrated circuits in the areas of power sourcing, signal generation and conditioning, and analog communication
CO4	Design and develop analog sub-circuits for linear and non-linear applications
CO5	Experiment and document the test results of various applications of linear integrated circuits, working both independently and in teams.

UNIT 1	
Operational Amplifier Characteristics: Introduction, Amplifiers in closed loop configuration, DC and AC Characteristics, Frequency compensation. **Operational Amplifier Applications:** Instrumentation Amplifier, V to I and I to V converter, Op-amp circuits using Diodes – Half wave and Full wave rectifiers, peak detector, Sample and hold circuit.	**7 Hrs**
UNIT 2	
Comparators and waveform Generators Introduction, comparator, Schmitt Trigger, Square wave generator using Astable Multivibrator, Monostable Multivibrator, Triangular wave generator. Sinusoidal oscillators - RC phase shift and Wien bridge oscillators.	**7 Hrs**
UNIT 3	
Voltage Regulators and Active Filters Introduction, RC Active Filters, First order low pass filter, second order active filter, Higher order low pass filter, High pass active filter, All pass filter-phase shift lead and lag circuit**.**	**7Hrs**
UNIT 4	
D-A and A-D converters Introduction, Analog and Digital data converter, specifications of D/A and basic DAC techniques-weighed resistor DAC, R-2R ladder DAC,A-D Converters: Specifications of A/D converter, classification of ADCs- The parallel Comparator/Flash ADC, counter type ADC, Successive Approximation Converter, single slope type ADC and Dual slope type ADC, Sigma – delta ADC	**8 Hrs**
UNIT 5	
Timers : Functional block diagram of 555, Applications - Astable and Monostable multivibrators, Ramp generator. **Phase locked loops**: Introduction, Basic principles, phase detector/comparator, voltage controlled oscillator, PLL in frequency multiplication/Division **Choice**: Unit-I and Unit-IV	**7 Hrs**

TEXT BOOKS		
1	Linear Integrated Circuits-2e-S.Salivahanan & V.S.Kanchana Bhaaskaran (Tata McGraw - Hill Publication)	
2	Linear Integrated circuits- D Roy Choudhury &shail B Jain (New Age Publication)	
REFERENCE BOOKS		
1	Opamps and Linear ICs-David A.Bell (Prentice-Hall Publications) (New age Publication)	
2	Op-Amps and Linear Integrated Circuits-Ramakanth A.Gayakwad,4th ed, PHI	
Online course		
1	https://swayam.gov.in/nd1_noc19_ee39/preview – *op amp practical applications: design, simulation and implementation by Dr. Hardik J. Pandya* , IISc Bangalore	
2	Introductory Analog Electronics Laboratory (Spring 2007) by MIT Open Courseware | Reviews and Ratings	
3	http://www.pannam.com/blog/free-resources-to-learn-electrical-engineering/	
E-Books:		
1	https://www.analog.com/en/education/education-library/tutorials/analog-electronics.html	
2	https://electronicsforu.com/resources/7-free-ebookstutorials-on-op-amp	

LABORATORY EXPERIMENTS LIST

Sl. No.	**Experiment Name**
1.	Inverting and non-inverting amplifier, voltage follower
2.	Inverting and non-inverting summing Amplifier
3.	Precision half wave and full wave rectifier
4.	Zero crossing detector and Schmitt trigger
5.	Wein bridge Oscillator
6.	First order active low pass filter
7.	First order active high pass filter
8.	IC 723 as low voltage and high voltage regulators
9.	D to A converter
10.	A to D converter
11.	555 as astable multivibrator
12.	555 as monostable multivibrator

Semester	IV		
Course Title	**MICROCONTROLLERS**	**Course Code**	**19ES4CCMCS**
Credits	**4**	**L-T-P**	**3:0:1**

Course Outcomes

CO1	Understand the concepts of 8051 microcontroller architecture, assembly and embedded C programming
CO2	apply the learnt concepts of 8051 microcontroller to solve the problems using assembly and embedded C programming.
CO3	Identify the IDE to conduct experiments
CO4	Debug/analyze the code in assembly and embedded C
CO5	Engage in independent study/ self-study as an individual and as a team- member to design, an open ended experiment on applications of microntrollers for medical electronics
CO6	Prepare a technical document on the open ended experiment considering ethics, safety and sustainability of the process or product thereon

UNIT 1	
Fundamentals of Microprocessors: Block diagram approach for Microprocessor and Microcontroller architecture, Comparison of 8-bit microcontrollers, 16-bit and 32-bit microcontrollers. Definition of embedded system and its characteristics, Role of microcontrollers in embedded Systems. Overview of the 8051 family: The 8051 Architecture Internal Block Diagram, ,address, data and control bus, working registers, SFRs, Clock and RESET circuits, Stack and Stack Pointer, Program Counter, I/O ports, Memory Structures, Memory architecture-Harvard and Princeton. Data and Program Memory, Timing diagrams and Execution Cycles, Pipelining.	**[8 hours]**
UNIT 2	
Instruction Set and Assembly Language Programming: Introduction, Instruction syntax, assembler directives, Immediate addressing, Register addressing, Direct addressing, Indirect addressing, Relative addressing, Indexed addressing, bit inherent and bit direct addressing, 8051 Instruction set - Data transfer instructions, Arithmetic instructions, Logical instructions, Branch instructions, Bit manipulation instructions, Assembly language programs	**[6 hours]**
UNIT 3	
Embedded C Programming: C Data Types, Timer and counter programming, Basics of Serial communication, Programming UART for serial communication, 8051 Interrupt programming	**[8 hours]**
UNIT 4	
Memory and I/O Interfacing: 8051 interfacing to external memory- memory address decoding, 8051 interfacing with external ROM, 8051 data memory space, accessing external data memory in 8051 C, interfacing with 8255.	**[6 hours]**
UNIT 5	
Interfacing Applications: Interfacing 8051 to LCD, Stepper motor, DC Motor, ADC and DAC, Sensor interfacing for control applications.	**[6 hours]**
TEXT BOOKS	

1	M. A.Mazidi, J. G. Mazidi and R. D. McKinlay, "The8051Microcontroller and Embedded Systems: Using Assembly and C",Pearson Education, 2007.	
2	R. S. Gaonkar, ", Microprocessor Architecture: Programming and Applications with the 8085", Penram International Publishing, 1996	
REFERENCE BOOKS		
1	K. J. Ayala, "8051 Microcontroller", Delmar Cengage Learning,2004.	
2	1. R. Kamal, "Embedded System", McGraw Hill Education,2009.	
3	D.A. Patterson and J.H. Hennessy, "Computer Organization and Design: The Hardware/Software interface", Morgan Kaufman Publishers, 2013.	
4	D. V. Hall, "Microprocessors & Interfacing", McGraw Hill Higher Education, 1991.	
Lab Experiments		
PART A: The experiments here can be implemented on a simulator using KEIL IDE.		
Assembly Language Programs to		
Data Transfer Operations		
Arithmetic, Logical Operations		
Conditional Operations		
Bit Manipulations		
Port Functioning		
Delay operations using Timers		
Embedded 'C' programs for Arithmetic, Logical, Port operations on simulator		
PART B: Interfacing of hardware modules to microcontrollers such as		
Stepper motor, Key Board, LCD, ADC, DAC, Serial Communication, Temperature sensor interface for monitoring and control		
(i) Sensing of humidity and Co2 for control applications		
(ii) The experiments may be implemented using KEIL IDE with embedded 'c' programming. The application examples may be modified on similar lines as mentioned in PARTB (vi) and (vii)		

Semester	IV		
Course Title	**SIGNALS AND SYSTEMS**	**Course Code**	**19ES4CCSAS**
Credits	**4**	**L-T-P**	**3:1:0**

Course Outcomes

CO1	define, understand, and explain various types of signals, systems, their time and frequency domain representation and their realization.
CO2	classify signals and systems, obtain the output for LTI systems using the time domain and the frequency domain representation, obtain the frequency domain representation of LTI systems using various transforms.
CO3	analyse the given specifications for systems for causality, stability, linearity, time invariance physical realizability.
CO4	design LTI systems for the given response specifications in an efficient manner.
CO5	make an effective oral presentation or report writing on contribution of signal processing in various engineering aspects.

UNIT 1	
INTRODUCTION TO SIGNALS: Definitions of a signal, elementary signals, classification of signals and basic operations on signals.	**10Hrs (8L+2T)**
UNIT 2	
INTRODUCTION TO SYSTEMS: Definitions of a system, properties of systems, systems view as Interconnections of operations, Differential and difference equation representations and block diagram representations of LTI systems.	**10 Hrs (8L+2T)**
UNIT 3	
IMPULSE RESPONSE REPRESENTATION OF LTI SYSTEMS: Introduction to impulse response representation, Convolution Sum and Convolution Integra relation with system properties, Interconnection of LTI systems (properties of convolution)	**11 Hrs (8L+3T)**
UNIT 4	
APPLICATION OF FOURIER ANALYSIS: Fourier representation for Four classes of signals, properties of Fourier transform (proof excluded), frequency response of LTI systems, soluti difference and differential equations.	**07 Hrs (5L+2T)**
UNIT 5	
APPLICATIONS OF Z-TRANSFORMS: Introduction to bilateral and unilateral Z-transforms, Properties (proof excluded), Analysis of LTI Systems: Transfer function and structures for implementin LTI system, Causality and stability, frequency response, and solution of difference equations.	**10 Hrs (7L+3T)**
Choice: Unit-I and Unit-III	

TEXT BOOKS

1	Simon Haykin and Barry Van Veen "Signals and Systems", John Wiley & Sons, 2001. Reprint 2002	
2	Alan V Oppenheim, Alan S, Willsky and A Hamid Nawab, "Signals and Systems" Pearson Education Asia / PHI, 2nd edition, 1997. Indian Reprint 2002	

REFERENCE BOOKS		
1	H. P Hsu, R. Ranjan, "Signals and Systems", Scham's outlines, TMH, 2006	
2	B. P.Lathi, "Linear Systems and Signals", Oxford University Press, 2005	
	Ganesh Rao and SatishTunga, "Signals and Systems", Sanguine Technical Publishers, 2004	
E-Books:		
1	NPTEL lecture Video on Signals and Systems by Prof. S.C.Dutta Roy,	
2	http://www.satishkashyap.com/2012/04/iit-video-lectures-on-signals-and.html	
3	NPTEL lecture Video on Signals and Systems by Prof. T.K. Basu,IIT Kharagpur	
4	http://www.nptel.ac.in/courses/108105065/	
5	NPTEL on line Course Modules–IIT Bombay –Signals and Systems	
6	http://www.cdeep.iitb.ac.in/nptel/Electrical%20&%20Comm%20Engg/Signals%20a nd%20System/TOC-M1.html	

Semester	IV		
Course Title	**DIAGNOSTIC INSTRUMENTS**	**Course Code**	**19ML4PCDIN**
Credits	**4**	**L-T-P**	**3:0:0**

Course Outcomes

CO1	apply knowledge of mathematics science and engineering fundamentals in designing, analysing and/or working of biomedical circuits and instruments.
CO2	Understand the health, safety, Environmental and ethical issues while Designing/working of a diagnostic equipment.
CO3	work, document and present as an individual and as a team-member to design, formulate and implement experiments using modern equipment's & tools.
CO4	develop and analyse schematic models of various bio- chemical measurement systems.
CO5	to understand the diagnostic equipment through case study for different diseases through references.

UNIT 1	
BIO POTENTIAL ELECTRODES: Origin of bio potential and its propagation. Electrode-electrolyte interface, electrode–skin interface, half cell potential, impedance, polarization effects of electrode – non-polarizable electrodes. Types of electrodes - surface, needle and micro electrodes and their equivalent circuits. Recording problems - measurement with two electrodes.	**8 Hrs.**
UNIT 2	
ELECTRODE CONFIGURATIONS : Bio-signals characteristics – frequency and amplitude ranges. ECG – Einthoven‟s triangle, standard 12 lead system. EEG – 10-20 electrode system, unipolar, bipolar and average mode. EMG– unipolar and bipolar mode.	**7 Hrs.**
UNIT 3	
BIO AMPLIFIER : Need for bio-amplifier - single ended bio-amplifier, differential bio-amplifier – right leg driven ECG amplifier. Band pass filtering, isolation amplifiers – transformer and optical isolation - isolated DC amplifier and AC carrier amplifier. Chopper amplifier. Power line interference.	**8 Hrs.**
UNIT 4	
MEASUREMENT OF NON-ELECTRICAL PARAMETERS: Temperature, respiration rate and pulse rate measurements. Blood Pressure: indirect methods - auscultatory method, oscillometric method, direct methods: electronic manometer, Pressure amplifiers - systolic, diastolic, mean detector circuit. Blood flow and cardiac output measurement: Indicator dilution, thermal dilution and dye dilution method, Electromagnetic and ultrasound blood flow measurement.	**8 Hrs.**
UNIT 5	
BIO-CHEMICAL MEASUREMENT: **Biochemical sensors** - pH, pO2 and pCO2, Ion selective Field effect Transistor (ISFET), Immunologically sensitive FET (IMFET), Blood glucose sensors - Blood gas analyzers, colorimeter, flame photometer, spectrophotometer, blood cell counter, auto analyzer (simplified schematic description).	**8 Hrs.**
(Units II & IV)	

TEXT BOOKS		
1	John G. Webster, "Medical Instrumentation Application and Design", John Wiley and sons, New York, 2004. (Units I, II & V)	
2	2. Khandpur R.S, "Handbook of Biomedical Instrumentation", Tata McGraw-Hill, New Delhi, 2003.	
REFERENCE BOOKS		
1	Leslie Cromwell, "Biomedical Instrumentation and measurement", Prentice hall of India, N Delhi, 2007.	
2	Myer Kutz, "Standard Handbook of Biomedical Engineering and Design", McGraw Hill Publisher, 2003. 3. Joseph J. Carr and John M. Brown, "Introduction to Biomedical Equipment Technology",	
E-Books:		
1	http://www.ebook3000.com/Introduction-to-Biomedical-Instrumentation--The-	
2	Technology-of-Patient-Care_51854.html	
3	2. Barbar**a** Christe, Introduction to Biomedical Instrumentation: The Technology of	
4	Patient Care, Cambridge University Press | 2009 | ISBN: 0521515122	
5	http://www.ebook3000.com/Introduction-to-Biomedical-Instrumentation--The-	
6	Technology-of-Patient-Care_51854.html	

Semester	IV		
Course Title	**Environmental studies**	**Course Code**	**19HS4ICEVS**
Credits	**02**	**L-T-P**	2: 0 : 0

Course Outcomes

CO1	Understand the components and impacts of human activities on environment.
CO2	Apply the environmental concepts for conservation and protection of natural resources.
CO3	Identify and establish relationship between social, economical and ethical values from environmental perspectives.

UNIT 1	
Introduction to Environment: Definition about Earth, atmosphere, hydrosphere, lithosphere and biosphere. Structure of Atmosphere: Troposphere, Stratosphere, Mesosphere, Ionosphere, Exosphere. Internal structure of the Earth: Crust, Mantle, Core. Ecosystem, types of Ecosystem: Land, Forest, Water, Desert, Marine. Effects of Human activities on Environment: Agriculture, Housing, Industries, Mining and Transportation.	6 Hrs
UNIT 2	
Natural Resources: Water resources: availability, use and consequences of over utlisation, water conflicts. Case studies :Mineral resources: Definition, types, environmental impact of mining Forest resources: Uses, effects of deforestation, remedial measures Energy resources: renewable and non-renewable, growing needs, types of energy resources: hydroelectric, wind power, fossil, solar, nuclear and bio gas. Hydrogen as an alternate future source of energy	6 Hrs
UNIT 3	
Environmental pollution Introduction, causes, effects and control measures. Water pollution, land pollution, noise pollution, air pollution and marine pollution-case studies. Environmental management: Solid waste, hazardous waste, e-waste, bio medical waste	6 Hrs
UNIT 4	
Social issues and Environment Population growth. Climatic changes: Global warming, acid rain, ozone layer depletion. Water conversation: rain water harvesting and ground water recharging. Disaster management: floods, earthquakes, landslides-case studies Environmental Protection Acts: Air, Water, land and Noise (Prevention and Control of pollution), Forest conservation, Wildlife protection.	4 Hrs

TEXT BOOKS

1.	Environmental studies by - Dr. Geethabalakrishanan (Revised Edition)	
2	Ecology by – Subramanyam (Tata McGraw Hill Publication)	
3	Environmental studies by – Dr. J.P.Sharma (Third edition)	
4	Environmental studies by – SmritiSrivastav	

REFERENCE BOOKS

1	Environmental studies by – Benny Joseph	
2	Environmental studies by – Dr. D.L.Manunath	

Online course		
1	https://www.coursera.org / course / sustain	
E-Books:		
1	NPTEL (Open Sources / power point and visuals)\	
2	Ecological studies / IITR / Open Sources	
3	Ministry of Environment and forest & wildlife	
4	MOOCS – https://www.coursera.org / course / sustain	

Course Code	**19ML4NCCLA**	**Type**	**L:T:P**	**Credits**
Course Title	**Cultural Activity**	**NC**	**-**	**-**

The college provides opportunity for students to associate with a large number of Cultural activities. Sample Affinity groups are listed below:

- Ninaad- Indian Music Team
- The Grove House- The Western Music Team
- Paramva- The Contemporary DanceTeam
- Danz Addix- The Western Dance Team
- Panache- The Fashion Team • Pravrutti- The Theatre Team
- Photography Club
- Chirantana- Kannada Sangha
- Fine Arts Club • Inksanity- The Literary Club
- Samskrithi Sambhrama – The Folk Dance Club
- VAK- The MCeeing Club
- Rotaract
- Bullz Racing
- TEDx BMSCE
- Quiz Club

Students regularly associated with ANY one of the above activities, and certified by the concerned faculty in-charge, shall be awarded a Pass Grade in the Course. Students who are not associated with the above affinity groups, shall participate in cultural events organized by the department/Organisation from outside college

V Semester Syllabus

Semester	V		
Course Title	Embedded System Design with ARM	**Course Code**	19ML5PCESD
Credits	4	**L-T-P**	3-0-1
Pre Requisites	1. Knowledge of microcontroller architecture, assembly and embedded C programming 2. Knowledge of memory and peripheral interfacing		

Course Outcomes	
CO1	Apply the knowledge of electronics engineering, communication protocols to design embedded systems
CO2	Develop assembly language programs by applying knowledge of the architectural features and instructions of ARM Cortex M3
CO3	Evaluate performance of real time operating systems by applying knowledge of multitasking principles
CO4	Demonstrate understanding of ARM Cortex M3 concepts to conduct experiments using the assembly and Embedded C programming.
CO5	Develop embedded C programs to demonstrate understanding of GPIO concepts and communication protocols through interfacing peripherals with Cortex M3 microcontroller

UNIT 1	**Hours**
Embedded System Components: Embedded Vs General computing system, Classification of Embedded systems, Major applications and purpose of ES. Core of an Embedded System including all types of processor/controller, Memory, Sensors, Actuators Communication Interface (on-board and external types), I2CBus, SPI Bus, 1-Wire Interface Bus, Parallel Interface, External Communication Interfaces- RS485,Universal serial Bus (USB), IEEE1394, Bluetooth, Wi-Fi, ZigBee, Embedded firmware, Other system components- Reset Circuit, Brown- out Circuit, Oscillator Unit, Real Time Clock(RTC), Watchdog Timer	9
UNIT 2	
ARM Cortex M3 Embedded SoC: Background of ARM and ARM architecture,Thumb-2 technology and applications of ARM, Architecture of ARM Cortex M3, Various Units in the architecture, , The Memory map, The Bus Interface, , Debugging support, General Registers, Special Registers, Operation Modes, Exceptions and Interrupts, Stack memory operations, Reset Sequence	7
UNIT 3	
ARM Cortex M3 Embedded Software Development: Assembly basics, Instruction list and description, Several Useful instructions, Memory mapping, Bit-band operations and CMSIS, Assembly and C language Programming	9
UNIT 4	
Embedded System Design Concepts: Characteristics and Quality Attributes of Embedded Systems, Operational and non-operational quality attributes, Embedded Systems-Application and Domain specific, Fundamental issues in Hardware Software Co-Design, Computational models in embedded design- DFG model, CDFG model State machine model, Concurrent Process model, Object Oriented model , Source file to object file translation.	7

UNIT 5		
RTOS based Embedded System Design - Operating System basics, Types of operating systems, Task, process and threads, Multiprocessing and multitasking, Types of multitasking, Task scheduling, Non-preemptive scheduling, priority based scheduling, Round Robin scheduling, Task Communication, Task synchronization issues – Racing and Deadlock, Task synchronization techniques-Concept of Binary and counting semaphores, choosing an RTOS.		7
TEXT BOOKS		
1	"Introduction to Embedded Systems", by Shibu K V, Tata McGraw Hill Education Private Limited, 2nd Edition.	
2	"The Definitive Guide to the ARM Cortex-M3", Joseph Yiu, 2nd Edition, Newness, (Elsevier), 2010	
REFERENCE BOOKS		
1	Embedded systems by Raj Kamal TMH, 2nd Edition.	
2	ARM System Developer's Guide by Andrew Sloss.	
3	Embedded Systems with Arm Cortex-M Microcontrollers in Assembly Language and C by Yifeng Zhu, Third Edition Paperback – 1 July 2017	
Online course		
1	https://swayam.gov.in/nd1_noc20_cs15/preview	
2	https://nptel.ac.in/courses/106/105/106105193/	
3	https://www.coursera.org/learn/introduction-embedded-systems	
E-Books:		
1	embedded-systems-textbook-rajkamal-pdf-free-download/	
2	https://www.arm.com/resources/education/books	

Semester	**V**		
Course Title	**THERAPEUTIC INSTRUMENTS AND ETHICS**	**Course Code**	**19ML5PCTIE**
Credits	4	**L-T-P**	3-0-1
Pre Requisites	Bio medical Instrumentation fundamentals		

Course Outcomes

CO 1	apply knowledge of mathematics science and engineering fundamentals in designing, analysing and/or working of biomedical circuits and instruments
CO 2	Understand the health, safety, Environmental and ethical issues while Designing/working of Therauptic equipment.
CO 3	Work, document and present as an individual and as a team-member to design, formulate and implement experiments using modern equipment's & tools.
CO4	Present in a group and document the findings or suggestions for the problems in the current techniques, modern tools and computing practice to improve technology in Health care instruments through hospital visits for lifelong learning.
CO5	understand the Therapeutic equipments through case study for different diseases through references

UNIT 1	**Hours**
CARDIAC ASSIST DEVICES: Cardiac pacemakers-Need, types and functional characteristics, AC Cardiac defibrillators, disadvantages , DC defibrillator, types- Instantaneous , Synchronized.	8
UNIT 2	
DIATHERMY : IR and UV lamp and its application. Short wave diathermy, ultrasonic diathermy, Microwave diathermy, Electro surgery machine - Current waveforms, Tissue Responses, Electro surgical current level, Hazards and safety procedures.	7
UNIT 3	8
HEMODIALYSER AND HEART LUNG MACHINE : Indication and principle of Hemodialysis, Dialysate, different types of Hemodialysis, monitoring systems, Need for heart lung machine, functioning of bubble, disc type and membrane type oxygenators, finger pump, roller pump, monitoring systems	
UNIT 4	
RESPIRATORY AIDS : Ventilator- Need, Types, Intermittent positive pressure, breathing apparatus operating sequence, electronic IPPB unit with monitoring for all respiratory parameters, Humidifier, Nebulizer, Aspirator	8
UNIT 5	
RADIATION THERAPY AND RADIATION SAFETY :Effects of ionizing radiation, Radiation therapy – Cobalt Cesium therapy, linear accelerator, betatron, cyclotron n, brachytherapy, , Radiation protection in medicine- radiate. **Patient Safety:** Electric shock hazards, Leakage currents, safety codes and analyzer. Ethical issues in the design of Biomedical Instruments.	8

TEXT BOOKS		
1	R.S.Khandpur, "Hand book of Biomedical Instrumentation, "Tata McGraw Hill, NewDelhi-1998.	
2	4. Joseph .J.Carr and John .M.Brown, "Introduction to Biomedical Equipment Technology," John Wiley&Sons Inc, New York-2002on protection principles.	
REFERENCE BOOKS		

1	1. Albert M.Cook and Webster.J.G., "Therapeutic Medical Devices", Prentice Hall Inc., New Jersey, 1982	
2	. J. G. Webster, Biomedical Instrumentation, John Wiley and Sons, Hoboken, NJ, 2004.	
Online course		
1	Online course –NPTEL	
2	Ma, Hongshen. 2.996 Biomedical Devices Design Laboratory, Fall 2007. (MIT OpenCourseWare: Massachusetts Institute of Technology), 2006. (MIT OpenCourseWare: Massachusetts Institute of Technology),http://ocw.mit.edu/courses/biological-engineering/20-010j-introduction-to-bioengineering-be-010j-spring-2006 (Accessed 26 Jul, 2014). License: Creative Commons BY-NC-SA iii)http://oyc.yale.edu/biomedical-engineering/beng-100 iv)Biomedical virtual laboratory link. http://vlab1.iitr.ac.in/	
E-Books:		
1	E-book 1http://www.ebook3000.com/Introduction-to-Biomedical-Instrumentation--The-Technology-of-Patient-Care_51854.html	
2	Barbara Christe, Introduction to Biomedical Instrumentation: The Technology of Patient Care, Cambridge University Press | 2009 | ISBN: 0521515122	

Semester	**V**		
Course Title	**DIGITAL SIGNAL PROCESSING**	**Course Code**	**19ES5CCDSP**
Credits	**04**	**L-T-P**	**3-0-1**
Pre-Requisites	**Signals and systems**		

Course Outcomes	
CO1	Apply knowledge of Mathematics and Engineering to understand Sampling and Reconstruction of signals from the given samples.
CO2	Identify and analyse a problem and formulate the computing requirements to determine the spectrum of the given signals.
CO3	Implement the processes of FFT to reduce the computational complexity and to increase the speed.
CO4	Understand and formulate algorithms using the Multirate signal processing for sampling rate conversion in speech and other signal analysis.
CO5	An ability to use current techniques and modern tools to improve the Medical data analysis and present and document the same.

UNIT 1	**8 Hours**
Introduction to DSP, Frequency-domain Sampling ,DFT , IDFT, DFT as a Linear Transformation (Matrix formulation), Properties of DFT: Periodicity, Linearity, Circular Time shifting, Circular Frequency Shifting, Circular Time Reversal, Conjugation and Conjugate Symmetry (Symmetry properties), Duality, Circular Convolution (Multiplication of two DFTs),Circular correlation, Multiplication (or Modulation) property, Parseval's Relation.	
UNIT II	**8 Hours**
Use of DFT in linear filtering, linear convolution of two finite duration sequences, overlap add and save methods. Relation between DFT and other transforms. Direct computation of DFT. Necessity for efficient computation of DFT. Radix 2 Fast Fourier Transform (FFT) algorithm for DFT computation. Decimation in time algorithm, decimation in frequency algorithms. Radix 2 FFT algorithm for computation of Inverse Discrete Fourier Transform. (IDFT).	
UNIT III	**8 Hours**
Introduction to realization of digital systems, block diagramsrepresentation, Realization of Infinite Impulse Response (IIR) systems: parallel form, cascade form. Introduction to IIR filters, Pole zero placement method for simple IIR Filters, Impulse invariant & Bilinear Transformations, Design of analog Butterworth and Chebyshev filters, Design of Digital Butterworth and Chebyshev filters.	
UNIT IV	**8 Hours**
Realization of Finite Impulse Response (FIR) systems:Direct Form, Linear Phase Form. Introduction to FIR filters, Frequency response of ideal digital low pass filter, high pass filter, Frequency sampling technique of designing FIR filters, Windowing design of FIR filters using Rectangular, Triangular & Hamming windows.	
UNIT V	**7 Hours**
Application of digital filters in noise cancellation; Limitations of Linear filters, Random noise cancellation, Adaptive filters, LMS Algorithm, Applications. Decimation by a factor D, Interpolation by a factor I, Sampling conversion by a Rational factor I/D. Introduction to Multi-rate Digital Signal Processing.	

TEXT BOOKS		
1	Digital Signal Processing, Principles, Algorithms and Applications, John G. Proakis, Dimitris K Manolakis, Pearson education/PHI, (4th Edition)	

	e-book: https://www.amazon.com/Digital-Signal-Processing-John-Proakis/dp/0131873741	
2	Digital Signal Processing, Tarun Kumar Rawat, Oxford University Press . e-book:https://www.amazon.in/Digital-Signal-Processing-Tarun-Kumar/dp/0198081936	
REFERENCE BOOKS		
1	Fundamentals of Digital Signal Processing, Lonnie Ludeman, John Wiley & Sons; Wiley International 1st Edition, 1988.	
2	Discrete-Time Signal Processing, Alan V. Oppenheim, Ronald W. Schafer, John R. Buck, Prentice-Hall Signal Processing Series, 2nd Edition, 1999	
3	Understanding Digital Signal Processing, Richard G. Lyons Prentice Hall,March 25, 2nd Edition 2004	
4	Digital Signal Processing: Fundamentals and Applications, Li Tan, Academic Press, 1st edition 2007	
5	Schaum's Outline of Digital Signal Processing, Monson Hayes, McGraw- Hill, 1st edition, 1998	
ONLINE COURSE		
1	https://nptel.ac.in/courses/117/102/117102060/	
2	https://nptel.ac.in/noc/courses/noc17/SEM1/noc17-ee05/	

LAB EXPERIMENTS : Generation of elementary signals, Study of sampling theorem, effect of under sampling leading to Aliasing effect, Study of properties of Linear time-invariant systems, Linear and Circular Convolution, Correlation ,Study of Discrete Fourier Transform (DFT) and its inverse. Study of Transform domain properties and its use, Study of Infinite Impulse Response (IIR) filter, Study of FIR filter design using window method: Lowpass and high-pass filter, Study of Adaptive filter using LMS Algorithm. Interpolation and Decimation.

Semester	V		
Course Title	PHYSICS OF MEDICAL IMAGING	Course Code	19ML5PCPMI
Credits	03	L-T-P	2-1-0
Pre-Requisites	Basic Knowledge of Physics, Anatomy and Physiology of Human Body		

Course Outcomes	
CO1	Apply the knowledge of mathematics and science to the solutions of complex problems in medical imaging modalities.
CO2	Identify, formulate and analyse a problem in medical imaging applications to arrive at substantiated conclusions.
CO3	Analyse the biological effects of electromagnetic fields in humans for health safety issues.
CO4	Apply professional ethics and responsibilities to meet the public health safety issues for sustainability through hospital visit (field survey) working in a team.
CO5	Comprehend the published reports for the selected imaging modality and prepare the document of the same combined with the field survey working in a team.
CO6	Function effectively to communicate as an individual to present the prepared document in a team.

UNIT 1	8 Hours
X-ray and CT Imaging: Physics of X-ray – Electromagnetic radiation, Interactions between X-rays and matter, Intensity of X-ray beam, Attenuation, Generation and Detection of X-rays – X-ray generation, X-ray generators, Biological effects of ionizing radiation, Conventional X-ray radiography, Fluoroscopy, Angiography, Mammography and Xeroradiography, Image subtraction Computed Tomography: Conventional tomography, Computed tomography – Projection function, Algorithms for image reconstruction, CT number, Image artefacts, Spiral CT. Recent developments, Digital radiography, Digital subtraction angiography (DSA).	
UNIT II	**8 Hours**
Ultrasound Imaging: Physics of acoustic propagation - Characteristic impedance, Intensity, Reflection and refraction, Attenuation, absorption & scattering, Doppler Effect, Generation and detection of Ultrasound-Piezoelectric effect, Ultrasonic transducers. Ultrasonic diagnostic Methods: Pulse echo systems- Amplitude mode (A-mode), Brightness mode (B-mode), Motion mode (M-mode), Constant depth mode (C-mode), Doppler methods, Biological effects of ultrasound. **Thermal Imaging:** Medical Thermography, Physics of Thermography, Infrared Detectors, Thermographic Equipment, Quantitative Medical Thermography, Pyroelectric Vidicon Camera, Thermal Camera Based on IR Sensor with Digital Focal Plane Array.	
UNIT III	**8 Hours**
Radionuclide Imaging: Introduction, Physics of Radioactivity – Nuclear particles, Nuclear activity and half-life, Units of measuring nuclear activity, Specific activity, Interaction of nuclear particles and matter, Attenuation of Gamma radiation, Radionuclides, Generation & Detection of Nuclear Emission – Radionuclide generators, nuclear radiation detectors, Collimators, diagnostic methods using radiation detector probes – Thyroid function test, Renal function test, Blood volume measurement,	

SPECT,PET, Characteristics of Radionuclide imaging, Internal radiation dosimetry and biological effects.		
UNIT IV		**8 Hours**
Physics of Nuclear Magnetic Resonance : Angular momentum, magnetic dipole moment, Magnetization, Larmor frequency, Rotating frame of reference and RF magnetic field, Free Induction decay (FID), Fourier spectrum of the NMR signal, Spin density, Relaxation times, Pulse sequences.		
UNIT V		**7 Hours**
Magnetic Resonance Imaging: Introduction, NMR Coil/Probe, Transmitter, Receiver, Data acquisition. Imaging Methods-Introduction, Characteristics of MRI images- Spatial resolution, Image contrast. Biological effects of magnetic fields- Static magnetic fields, Radio-frequency fields, Gradient magnetic fields, Imaging safety, Introduction to Functional MRI.		
TEXT BOOKS		
1	Principles of Medical Imaging by Kirk Shung, Michael B. Smith and Benjamin Tsui, Academic Press, 1992.	
2	Handbook of Biomedical Instrumentation – by R.S.Khandpur, 2nd Edition, Tata McGraw Hill, 2003.	
REFERENCE BOOKS		
1	Fundamentals of Medical Imaging by Paul Suetens, Cambridge University Press, 2002.	
2	Medical imaging signals and systems M. Links. Upper Saddle River, NJ: Pearson Prentice Hall, 2006.	
3	Foundations of Medical Imaging by Z. H. Cho, Joie P. Jones, Manbir Singh, ISBN: 978-0-471-54573-6 October 1993.	
ONLINE COURSE		
1	https://ocw.mit.edu/courses/nuclear-engineering/22-058-principles-of-medical-imaging-fall-2002/lecture-notes/	
2	https://ocw.mit.edu/courses/nuclear-engineering/22-058-principles-of-medical-imaging-fall-2002/assignments/	
E-BOOKS:		
1	https://www.academia.edu/9798762/An_Introduction_to_the_Principles_of_Medical_Imaging	
2	https://pdfs.semanticscholar.org/81be/98af292b56bd07b684933c73858094212c75.pdf	

Semester	V		
Course	C++ and Data Structures	Code: 19ML5PE1 DS	
Credits	3	**L-T-P**	2-1-0
Pre Requisites	Concepts of C- Programming		
Course outcomes : At the end of the course, the student will have the ability to:			
CO1	Identify, analyze and apply the concepts of classes, Objects and other advanced C++ Concepts.		
CO2	An Ability to understand the concept of data structures using C++.		
CO3	Can able to formulate, design, implement, analyze, demonstrate, document and present the concepts as application to modern problems implemented in groups or individual.		

UNIT 1	7 Hours
Principles of Object Oriented Programming - Basic Concepts of OOPS, OOP Languages, Pre-processors directives and header files, structure of C++ program, compiling and linking, Tokens, keywords, identifiers and constants, datatypes, symbolic constants, variables, Storage Classes, operators, manipulators, control and statement loops. **Functions in C++:** Introduction, Main function, function prototype, call by reference, return by reference, inline functions.	
UNIT 2	9 Hours
Classes and objects: Specifying a class, member functions, arrays within a class, static data members and member functions, arrays of objects, returning objects. **Constructors and Destructors -** Constructors, parameterized constructors, multiple constructors in a class, copy constructor, dynamic constructors and destructors. **Operator overloading and type conversions:** Overloading unary and binary operators, overloading using friends, rules of overloading, function overloading, friend functions.	
UNIT 3	9 Hours
Inheritance - Introduction, defining derived classes, Types of inheritance: Single, multilevel, multiple, hierarchical, hybrid. **Pointers, Virtual and Polymorphism:** Pointers, pointers to objects, this pointer, pointers to derived classes, virtual functions. **Templates :** Class templates, Function templates. **Exception handling**: Basics, Throwing and catching mechanisms, rethrowing an exception.	
UNIT 4	8 Hours
Managing console I/O operations: C++ streams, C++ stream classes, unformatted and formatted I/O operations. File operations: Introduction, classes for file stream operations, Opening and closing a file using constructors, detecting end-of-file. **Data structures** Data Representation, Introduction, Linear lists, Formula-based representation, linked representation, Indirect addressing, Arrays.	
UNIT 5	7 Hours
Stacks: The abstract data types, Derived classes, Formula-based representation, Linked representation, Applications. **Queues:** The abstract data types, Derived classes, Formula based representation, Linked representation, Applications Trees, Binary trees, Properties and representation of binary trees, Common binary tree operations, Binary tree traversal the ADT binary tree, Binary Search Trees.	

TEXT BOOKS

1	Object oriented Programming with C++, E Balaguruswamy ,TMH publications 6th edition,	
2	Data structures, Algorithms, and applications in C++, Sartaj Sahni, McGraw Hill.	

	2000.	
REFERENCE BOOKS		
1	Object oriented Programming with turbo C++**,** Robert Lafore, GALGOTIA Publicatio 2007.	
2	Data Structures using C++, D.S. Malik, India edition, CENGAGE Learning, 2003	
Online course		
1	**Object Oriented programming in C++** https://www.udemy.com/course/object-oriented-programming-in-c-q/	
2	**Data Structures and algorithms using C++** https://www.udemy.com/course/data-structures-and-algorithms-in-c-algorithms-and-ructures/?utm_source=adwords&utm_medium=udemyads&utm_campaign=DSA_Catchall_lc.INDIA&utm_content=deal4584&utm_term=_.ag_82569850245_.ad_437477497176_.kwc_.dm_.pl_.ti_dsa06594358574_.li_9062078_.pd_.&matchtype=b&gclid=EAIaIQobChMIiqW29fGB6gIVz34hQU3EAAYASAAEgKD2fD_BwE	
E-Books:		
1	C++ programming by Wikibooks upload.wikimedia.org/Wikipedia/commons/4/4b/C++_Programming2008-4-18.p	
2	Introduction to data structures and algorithms (http://nptel.ac.in/courses/106102064/	

Semester	V

Course Title	COMMUNICATION SYSTEMS	Course Code	19ML5PE1CMS
Credits	3	L-T-P	2-1-0
Pre Requisites	Basics of Signals and mathematics		

Course Outcomes	
CO 1	Ability to apply knowledge of mathematics, science and engineering to develop concepts of communication systems.
CO 2	Ability to analyze and design a problem and formulate appropriate solution for fundamentals of communication systems to biotelemetry applications
CO 3	Ability to work, document and present an individual and as a team member to design formulate and implement experiments using modern tools.

UNIT 1	8 Hours
ANALOG COMMUNICATION Introduction to Communication Systems – Modulation – Types – Need for Modulation. Theory of Amplitude Modulation – Evolution and Description of SSB Techniques – Theory of Frequency and Phase Modulation – Comparison of Analog Communication Systems (AM – FM – PM).	
UNIT 2	7 Hours
PULSE AND DATA COMMUNICATION : Pulse Communication: Pulse Amplitude Modulation (PAM) – Pulse Time Modulation (PTM) – Pulse code Modulation (PCM) – Comparison of various Pulse Communication System (PAM – PTM – PCM). Data Communication: History of Data Communication – Standards Organizations for Data Communication- Data Communication Circuits – Data Communication Codes – Data communication Hardware – serial and parallel interfaces.	
UNIT 3	8 Hours
DIGITAL COMMUNICATION: Amplitude Shift Keying (ASK) – Frequency Shift Keying (FSK)–Phase Shift Keying (PSK) – BPSK – QPSK – Quadrature Amplitude Modulation (QAM) – 8 QAM – 16 QAM – Bandwidth Efficiency– Comparison of various Digital Communication System (ASK – FSK – PSK – QAM.	
UNIT 4	8 Hours
SOURCE AND ERROR CONTROL: Entropy, Source encoding theorem, Shannon fano coding, Huffman coding, mutual information, channel capacity, Error Control Coding, linear block codes, cyclic codes – ARQ Techniques.(7hrs)	
UNIT 5	8 Hours
MULTI-USER RADIO COMMUNICATION: Global System for Mobile Communications (GSM) – Code division multiple access (CDMA) – Cellular Concept and Frequency Reuse – Channel Assignment and Handover Techniques – Overview of Multiple Access Schemes – Satellite Communication – Bluetooth. : Biotelemetry. ECG telemetry system ,Temperature telemetry system,. Multi-channel wireless telemetry system ,. Transmission of physiological signals over telephone . Telemedicine .wireless telemetry.	

TEXT BOOKS		
1	Wayne Tomasi "Advanced electronics communication systems,"6th edition Pearson education 2009,	
2	R.S.Khandpur, 'Handbook of Bio-Medical instrumentation', Tata McGraw Hill Publishing Co Ltd.	
REFERENCE BOOKS		
1	Simon Haykin, "Communication Systems", 4th Edition, John Wiley & Sons, 2004	

2	B.Sklar, "Digital Communication Fundamentals and Applications" 2nd Edition Pearson Education 2007.	
Online course		
1	https://www.mooc-list.com/tags/communication-systems?	
2	https://swayam.gov.in/nd1_noc20_ee16/preview	
E-Books:		
1	http://e4uhu.com/down/communication%20electronics/Book%204th.pdf	
2	https://www.pdfdrive.com/electronic-communication-systems-e31375051.html	

Semester	V		
Course Title	Wearable Sensors	**Course Code**	19ML5PE1WS
Credits	3	**L-T-P**	2-1-0
Pre Requisites	Basic knowledge of Sensors.		

Course Outcomes

CO1	Apply the knowledge of science, engineering and measurement fundamentals to deal with wearable sensors
CO2	Analyze the trade-offs in security designs and determine accountability, in order to formulate solutions using wearable sensors
CO3	Develop the solutions for secured communication in medical IoT and Implanted medical devices
CO4	Comprehend the published reports on the contribution of wearable sensors towards bettering of health care delivery, and make a presentation on a specific device/technique.

UNIT 1	
Introduction to Wearable sensors: Physical and Biophysical parameters, types, characteristics and principles of wearable sensors, Issues in their fabrication, Electrical properties based fabrication and other techniques, Electrochemical and Piezoelectric types of wearable sensors. Smart circuits for signal conditioning: Case-studies of PPG and Cerebral oxygenation monitoring sensors.	8Hrs
UNIT 2	
Medical IoT systems: Introduction, System processes, Secure routing, the cloud-side, System implementation. Access control and identity management: Security for IoT, Discussion – support, managing, central versus distributed, privacy preservation, Anonymous communication and accountability, Federation, Light weight solutions and edge intelligence, Transiency.	8Hrs
UNIT 3	
Wearable body sensor networks (WBSN): Generalized system architecture, Security requirements in a WBSN, Threats and attacks, Possible solutions for security and privacy in WSBN.	7Hrs
UNIT 4	
Cybersecurity for wireless implants: Implantable medical devices (IMDs) – Introduction, communication in IMDs. Ethical hacking, IMD security issues, Trade-offs in security designs, Supporting emergency access.	8Hrs
UNIT 5	
Applications of Wearable sensors: Temperature monitoring – system architecture, hardware and firmware designs, Calculations, Thermal IF based measurement. HRV based biometry – Introduction, Security requirements, Background, A wearable platform, HRV based security system for WBSNs.	8Hrs

TEXT BOOKS		
1	Subhas Chandra Mukhopadhyaay and Tarikul Islam, Wearable Sensors, IOP publishing, 2017	
REFERENCE BOOKS		
1	Edward Sazonov, Wearable Sensors: Fundamentals, Implementation and Applications, 2nd edition , Academic Press, 2020	
2	Omesh Tickoo and Ravi Iyer, Making Sense of Sensors: End-to-End Algorithms and Infrastructure Design from	

	Wearable-Devices to Data Centers, APRESS, 2017.	
Online course		
1	https://www.classcentral.com/course/medtech-digital-health-14405	
2	https://online-learning.harvard.edu/course/wearable-technologies-and-internet-things	
E-Books:		
1	https://www.intechopen.com/books/wearable-technologies/advances-in-wearable-sensing-technologies-and-their-impact-for-personalized-and-preventive-medicine	
2	https://dl.acm.org/doi/pdf/10.1155/2015/104286	

Semester	**V**		
Course Title	**Digital System Design using Verilog**	**Course Code**	**19ML5PE2DV**
Credits	**3**	**L-T-P**	**2-1-0**
Pre Requisites	Concepts of Digital Electronics		
Course Outcomes			
CO1	Apply the knowledge of HDL for modelling and functional verification of digital circuits.		
CO2	Analyze digital circuits using suitable Verilog HDL modelling.		
CO3	Design a digital circuit for complex systems using Verilog HDL and state machines.		
CO4	Program a given application/problem statement using EDA tools.		

Course Description	**Hours**
UNIT 1	**8**
Introduction to Verilog: Design Methodology-An Introduction Verilog History, System representation, Number representation and Verilog ports. Verilog Data Types: Net, Register and Constant. Verilog Operators: Logical, Arithmetic, Bitwise, Reduction, Relational, Concatenation and Conditional. Verilog Primitives.	
UNIT 2	**8**
Modeling Styles: Dataflow Modeling: Boolean Equation-Based Models of Combinational Logic, Propagation Delay and Continuous Assignments. Structural Modeling: Design of Combinational Logic, Verilog Structural Models, Module Ports, Top-Down Design and Nested Modules. Gate level modelling.	
UNIT 3	**7**
Behavioral Modeling: Behavioral Models of Flip-Flops and Latches, Comparison of Styles for Behavioral modeling, Behavioral Models of Multiplexers, Encoders, and Decoders. Test benches.	
UNIT 4	**8**
Synchronous sequential circuits: Moore and Mealy FSM, Design and implementation of sequence detector, serial adder, code converter.	
UNIT 5	**8**
Implementation Fabrics: Introduction of Programmable Logic Array (PLA), Programmable Array Logic (PAL), Programmability of PLDs.Complex PLDs (CPLDs), Field-Programmable Gate Arrays (FPGA).The Role of FPGAs in the ASIC Market, FPGA Technologies. Comparison of designn implementation using CPDs, FPGA and ASIC.	

TEXT BOOKS	
1	Samir Palnitkar, "Verilog HDL: A Guide to Digital Design & Synthesis", SunSoft Press, 2ndEdition, 2009, ISBN: 978-81-7758-918-4.

2	Stephan Brown and Zvonk Vranesic, "Fundamentals of digital logic with Verilog design", 2nd edition MGH, 2008.
REFERENCE BOOKS	
1	Roth, Charles; John, Lizy K.; Kil Lee, Byeong Digital Systems Design Using Verilog ISBN 10: 1285051076 / ISBN 13: 9781285051079.
2	M.D. Ciletti Advanced Digital Design with the Verilog HDL Published by Prentice Hall PTR -2nd Edition ISBN: 0136019285.
Online course	
1	ElectronicDesignAutomationhttp://nptel.ac.in/courses/106105083/
2	DigitalsystemdesignwithPLDsandFPGAshttp://nptel.ac.in/courses/117108040/ Fundamentals of HDL (Lecture #008)
3	https://www.youtube.com/watch?v=rdAPXzxeaxs&index=8&list=PLE3BC3EBC9CE15FB0
E-Books:	
1	http://access.ee.ntu.edu.tw/course/dsd_99second/2011_lecture/W2_HDL_Fundamentals_2011-03-02.pdf
2	http://ece.niu.edu.tw/~chu/download/fpga/verilog.pdf

Semester	V		
Course Title	Biomechanics and Rehabilitation	Course Code	19ML5PE2BR
Credit s	3	L-T-P	2-1-0
Pre Requis ites	Basics of Anatomy and Physics of flow properties		

Course Outcomes	
CO1	Ability to apply knowledge of mathematics, science and engineering to understand the fundamentals of the flow properties of the blood.
CO2	Ability to analyse the dynamics and properties of viscoelastic materials in the body.
CO3	Ability to discuss, develop and apply the principles of biomechanics to a range of Rehabilitation strategies and problem solving.

UNIT 1	**Hours**
Introduction To Biomechanics –Principles of Biomechanics, Stress ,Strain and Strain Rate, The Non viscous Fluid, Newtonian Viscous Fluid, The Hookean Elastic Solid, Viscoelasticity, Response of a Viscoelastic Body to Harmonic Excitation, Use Of Viscoelastic Models The Flow Properties of Blood-Blood rheology, the constitutive equation of blood based on viscometric data and casson's equation, Laminar flow of blood in tube, blood with viscosity described by Casson's equation.Case studies and Problems	8
UNIT 2	
Bio viscoelastic fluids: Introduction, small deformation experiments, mucus from the respiratory tract, saliva, cervical mucus and semen, synovial fluid, flow properties of synovial fluid,Bio viscoelastic solids: Introduction, some elastic materials-actin, elastin, resilin and abduction, fibers, collagen, Quasi-linear viscoelasticity of soft tissues, the concept of pseudo-elasticity.	8
UNIT 3	
Sports and Fitness Kinesiology: Muscle Action in Sport and Exercise Neural Contributions to Changes in Muscle Strength - Mechanical Properties and Performance in Skeletal Muscles - Muscle-Tendon Architecture and Athletic Performance – Eccentric Muscle Action in Sport and Exercise - Stretch–Shortening Cycle of Muscle Function -Biomechanical Foundations of Strength and Power Training Locomotion - Kinesiological view Factors Affecting Preferred Rates of Movement in Cyclic Activities - The Dynamics of Running - Resistive Forces in Swimming - Propulsive Forces in Swimming -Performance-Determining Factors in Speed Skating - Cross-Country Skiing: Technique, Equipment and Environmental Factors Affecting Performance. Gait and movement analysis.	8
UNIT 4	8
Introduction to Rehabilitation and Rehabilitation Team: What is Rehabilitation? Epidemiology of Rehabilitation, Health, Levels of Prevention, Preventive Rehabilitation, Diagnosis of Disability, Functional, Diagnosis, Importance of Physiatry in Functional Diagnosis, Impairment Disability Handicap, Primary and Secondary disabilities, Effects of Prolonged inactivity and Bed rest on body system. Rehabilitation Team: classification of members, The Role of members, The Role of Physiatrist, Occupational therapist, Recreation therapist, Prosthetist- Orthotist, speech,pathologist, Rehabilitation nurse, social worker, Corrective Therapist, Psychologist, Music therapist, Dance therapist and Biomedical Engineer.	

UNIT 5		
Therapeutic Exercise Technique: Co-ordination exercises, Freckles exercises, Gait analyses-pathological Gaits, Gait Training, Relaxation Exercises- Methods for training Relaxation, Strengthening exercises- strength training, Types of contraction, Mobilization exercises, Endurance Exercises, Principles in management of communication Impairment – introduction to communication, Aphasia, Types of Aphasia, Treatment of aphasic patient, Augmentative communication-general form of communication, types of visual aids, Hearing aids, Types of conventional hearing aid, writing aids.		7
TEXT BOOKS		
1	Biomechanics- Mechanical Properties of Living tissues -Y.C.Fung - Second Edition- Springer Verlag.	
2	Text book of Rehabilitation- S Sunder- 3rd Edition-Jaypee Brothers Medical Publishers(P) Ltd. New Delhi	
REFERENCE BOOKS		
1	Biomechanics principles and applications by Schneck and Bronzino, CRCPress, 2003	
2	Physical Rehabilitation by Susan B O'Sullivan, Thomas J Schmitz. 5th Edition	
Online course		
1	Visual3D 3D Biomechanics Adwww.c-motion.com/	
2	https://rerc-aac.psu.edu/dissemination/webcasts/	
3	https://ep.jhu.edu/programs-and-courses/585.414-rehabilitation-engineering	
E-Books:		
1	http://www.profedf.ufpr.br/rodackibiomecanica_arquivos/Books/Introduction%2 0to%20Sports%20Biomechanics.pdf	
2	http://www.profedf.ufpr.br/rodackibiomecanica_arquivos/Books/Duane%20Knud son-%20Fundamentals%20of%20Biomechanics%202ed.pdf	

Semester	**V**		
Course Title	**Biomaterials**	**Course Code**	**19ML5PE2BM**
Credits	**3**	**L-T-P**	**2-1-0**
Pre Requisites	Chemistry and Physics		

Course Outcomes

CO1	Demonstrate an in-depth understanding to analyze and determine the material properties critically in order to select them for the required biocompatibility.
CO2	To apply and account for methods to characterize interactions between materials and tissue.
CO3	To realize the important basic properties and requirements for biomaterials and compare the mainstream biomaterials currently used for medical applications.
CO4	Identify the suitable material and manufacturing methods for bio implant applications with considerations of health risk and economic aspects.
CO5	To understand the design and structural issues related to medical devices that are used in restoring function to load bearing tissues.

Course Description	**Hours**
UNIT 1	**7**
Biomaterials Science and Engineering: Multi levels of Structure and Categorization of Materials, Four Categories of Materials, Definitions of Biomaterials, Biomedical Materials and Biocompatibility. Case Study: Conducting Biocompatibility Testing for a Medical Device	
UNIT 2	**8**
Toxicity and Corrosion : Elements in the Body, Biological Roles and Toxicities of Trace Elements, Selection of Metallic Elements in Medical-Grade Alloys, Corrosion of Metals, Environment inside the Body, Minimization of Toxicity of Metal Implants, Biological Roles of Alloying Elements. Case Study: Failure of a metal-on-metal hip replacement: An unusual and severe case of corrosion, Corrosion Study of Metallic Biomaterials in Simulated Body Fluid	
UNIT 3	**8**
Mechanical Properties of Biomaterials: Role of Implant Biomaterials, Mechanical Properties of General Importance, Hardness, Elasticity: Resilience and Stretchability, Mechanical Properties Terms Used in the Medical Community, Failure, Essential Mechanical Properties of Orthopaedic Implant Biomaterials. Case Study: Orthopaedic Implant Failure.	
UNIT 4	**8**
Metallic Biomaterials in Orthopaedic Implants: Development of Metallic Biomaterials, Stainless Steels, Cobalt-Based Alloys, Titanium Alloys, Comparison. Metallic Biomaterials: Dental Materials, NiTi Shape-Memory Alloys, Other Clinically Applied Metallic Materials, New Metallic Materials: Magnesium Alloys. Case Study: Spine Implant Case Study- Titanium and Titanium Based Alloys, Biodegradable Magnesium Implants.	

UNIT 5	8
Polymeric Biomaterials: Fundamentals, Basic Concepts on Polymers, Overview of Polymeric Biomaterials, Bioinert Polymers: Polyolefin, Poly (Ethylene Terephthalate), Acrylate Polymer, Fluorocarbon Polymers, Silicone, Polyurethane, Properties and Applications of Polyurethane as Biomaterials. Case Study: Marine Origin Biopolymers for the Development of Bioresorbable Multi-layered Membranes for Guided Bone Regeneration.	
TEXT BOOKS	
1	Biomaterials: A Basic Introduction, Qizhi Chen, George Thouas, CRC Press.
REFERENCE BOOKS	
1	Ratner, B. D., Hoffman, A. S., Schoen, F. J., Lemons, J. E. (2004). Biomaterial science: an introduction to materials in medicine. (2nd ed.). New York: Academic Press.
2	Park, J. B., &Bronzino, J. D. (2003). Biomaterials: principles and applications. CRC Press.
Online course	
1	http://nptel.ac.in/courses/Biomaterials.
E-Books:	
1	http://ilkerpolatoglu.cbu.edu.tr/docs/Introduction%20to%20Materials.pdf
2	http://www.issp.ac.ru/ebooks/books/open/Biomaterials_Science_and_Engineering.pdf

Semester	V		
Course Title	Mini Project–1	Course Code	19ML5PWMP1
Credits	2	L-T-P	0-0-2
CO#	Course Outcomes:		PO# (Strength)
CO1	Apply the knowledge of science and medical electronics engineering to provide solutions for human-health related problems		PO1 (3)
CO2	Analyze and identify biomedical engineering problems based on literature survey and need analysis		PO2 (3)
CO3	Develop solutions for relevant biomedical engineering problems with appropriate consideration of public health, safety and society		PO3 (2)
CO4	Design experimental techniques/simulation models and interpret the data conclusively		PO4 (3)
CO5	Use modern tools and resources in developing health-care solutions needing their applications		PO5 (2)
CO6	Apply reasoning based on the contextual knowledge of the design problem statement and assess societal, health and safety issues		PO6 (2)
CO7	Demonstrate the knowledge of a sustainable solution in the context of society		PO7 (1)
CO8	Apply biomedical ethics and responsibilities		PO8(2)
CO9	Function both individually and in diverse teams requiring multidisciplinary approaches.		PO9 (3)
CO10	Comprehend, prepare effective reports and make clear presentations to an engineering community		PO10 (3)
CO11	Demonstrate the knowledge of project management and financial requirements of a project work		PO11 (3)
CO12	Exhibit self-reliance and life-long learning skills to align to the new trends		PO12 (2)

Guidelines for Mini Project–1 (19ML5PWMP1)
Objective: The objective of this open ended mini project is to let the students apply the knowledge of the engineering subjects into a **real- world situation/problem**.
Guidelines:
1) The mini project MUST be done in a group of 3 / 4 students.
2) Mini project can be done in the area of **biomedical engineering or any other engineering discipline.**
3) This open ended project could be based on subjects previously learnt in academics or with own interest / subjects learning currently / subjects to be learnt during implementation
4) Mini project can be a ***simulation or hardware implementation***. **(**considering current technology/situation)
5) Each group will be allotted a **Guide**. Students in that group must discuss the project

idea with Guide before finalizing it.
6) Each group will present the idea of the project and will submit 1 - 2 page(s) of an **Abstract** of the mini project work.
7) Every week, project group will report progress of the project to allotted Guide.
8) Each group will give **four presentations** according to the schedule which will be shared with students in advance.
9) **First presentation** – is introductory presentation for approving the topic. This will not carry any marks
10) Second and Third presentations will be **PROGRESS PRESENTATIONS**; will carry marks
11) Assessment of the project progress will be based on **Rubrics** which will be shared with students in advance.
12) Final presentation is about **entire mini project implementation** with demonstration; will carry marks
13) At the end of the project, all groups will submit video of the working model and technical report in the format shared.
14) Final SEE will be conducted for 50 marks.

Semester	**V**		
Course Title	**Innovation for Entrepreneurship**	**Course Code**	**19ES5HSIFE**
Credits	**2**	**L-T-P**	**2-0-0**
Pre Requisites	Chemistry and Physics		

Course Outcomes

CO1	Apply new ideas of design thinking, methods and ways of thinking
CO2	Able to formulate goals as an entrepreneur for a startup
CO3	Able to identify business opportunities by performing market research and choosing target customer
CO4	Engage with a range of stakeholders to deliver creative and sustainable solutions to specific problems communicate effectively both orally and in writing
CO5	Work effectively with peers with diverse skills, experiences and be able to critically reflect on own practice

Course Description	**Hours**
UNIT 1	**6**
Ideation and Innovation Problems and Pain Points, Ideation and Problem Solving, Design Thinking, Team importance and Leadership, Market Segmentation, Beachhead Market, Building End User Profile, Total Addressable Market (TAM) Size for the Beachhead Market, Profile the Persona, Full Lifecycle Use Case, High-Level Product Specification, Quantify the Value Proposition, Identify Your Next 10 Customers, Define Your Core, Chart Your Competitive Position.	
UNIT 2	**5**
Product Acquisition by customer Determine the Customer's Decision Making Unit (DMU), Process to Acquire a Paying Customer, Mapping sale process, Total Addressable Market Size for Follow-on Markets.	
UNIT 3	**5**
Business from Product Design a Business Model, Set your Pricing Framework, Calculate the Lifetime Value (LTV) of an Acquired Customer, Map the Sales Process to Acquire a Customer, Calculate the Cost of Customer Acquisition (COCA)	
UNIT 4	**4**
Designing, building and scaling of the product Identify key Assumptions, Test Key Assumptions, Define and build Minimum Viable Product (MVP), Test with Customer, Repeat Cycle to Reach Product Market Fit.	
UNIT 5	**6**
Startup and Entrepreneurship in India Starting company in India, IP landscape, Incubation, Government support, Taxation, Startup culture and leadership, Open innovation, Social Innovation, Entrepreneurship, entrepreneurship abroad.	

TEXT BOOKS	
1	Disciplined Entrepreneurship: 24 Steps to a Successful Startup (Wiley, 1st Edition) Bill Aulet, ISBN: 1118692284, 2013
REFERENCE BOOKS	

1	Innovator's Dilemma: When New Technologies Cause Great Firms to Fail by Christensen, Harvard Business Review Press, 2011
2	The Startup Owner's Manual: The Step-by-Step Guide for Building a great company by Steve Blank K&S Ranch Publishers, K&S Ranch, 2016
Online course	
1	https://ocw.mit.edu/courses/sloan-school-of-management/15-390-new-enterprises-spring-2013/assignments/assignment-12/ https://www.edx.org/course/entrepreneurship-101-who-customer-mitx-15-390x
E-Books:	
1	https://segera-wisuda.blogspot.in/2016/05/46-ebooks-entrepreneurship-download-free.html

Course Code	Course Title	Type	L:T:P	Credits
19ML5NCHVL	**Human Values through Literature**	**Type**	**-**	**-**

The aim of the course is to conserve values like truthfulness, kindness, honesty, law, justice, patriotism, humanism, etc. in society and eliminate negative attitudes. The course explores how Literature can be effective to inculcate human values.

At the end of the course, the student will have the ability to understand the significance of human values and responsibility in a society.
Ability to apply the knowledge of human values acquired through Indian literature in the form of a play/report.
Ability to analyze and write reports from different literary works
Method of evaluation: Students will study Indian literary works and present it as a play/report/quiz in groups of four to six students which will be evaluated by the faculty incharge as Pass/No Pass.

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VI SEMESTER

Semester	**VI**		
Course Title	**Medical Image Processing**	**Course Code**	**19ML6PCMIP**
Credits	**4**	**L-T-P**	**3-0-1**
Pre Requisites	1. Knowledge of signals and systems 2. Mathematics concepts of matrix operations.		

Course Outcomes	
CO1	understand concepts of digital image representation, processing, compression and objectives of biomedical image analysis and CAD.
CO2	apply algorithms in digital image processing for medical image enhancement restoration segmentation and feature extraction
CO3	conduct experiments for medical image analysis
CO4	Develop Graphical user interface based mathematical models to understand image enhancement and segmentation algorithms
CO5	Engage in self-study as an individual and a team-member to design and implement an open ended experiment for medical image segmentation

UNIT 1	**Hours**
Fundamentals: Introduction, Fundamental steps in DIP, Components of DIP system, A simple image formation model, Image sampling and quantization, Basic relationship between pixels, Color image processing fundamentals related with all color Models, Types of Medical Images, Objectives of Biomedical Image Analysis, Computer Aided Diagnosis, Image Quality and Information Content	8
UNIT 2	
Image Enhancement in Spatial Domain: Background, Point processing – Image negatives, Log transformations, Power law transformations, Contrast stretching, Gray level slicing, Bit plane slicing, Histogram processing– Histogram equalization, Local enhancement, Arithmetic/Logic operations – Image subtraction, Image averaging, Basics of spatial filtering, Smoothing spatial filters – Smoothing linear filters, order statistics filters Sharpening spatial filters – Foundation, The Laplacian, The Gradient.	8
UNIT 3	
Image Enhancement in Frequency Domain: Background, Basic properties of the frequency domain, Basic filtering in the frequency domain, Basic filters and their properties,Smoothing frequency domain filters – Ideal low pass filters, Butterworth lowpass filters,Gaussian lowpassfilters, Sharpening frequency domain filters – Ideal high pass filters,Butterworth highpassfilters, Gaussian highpass filters, Homomorphic filtering.	8
UNIT 4	
Removal of Artifacts: Characterization of Artifacts, Image degradation/restoration model, Examples of noise PDFs, Structured noise Physiological interference, Other types of noise and artifact, Restoration using spatial filtering – Mean filters, Geometric mean filters, Harmonic mean filters, Median filter, Max & min filters, Midpoint filter. Inverse Filtering, Minimum Mean Square Error (Wiener) Filtering, Constrained Least Squares Filtering.	8

UNIT 5		
Detection of Regions of Interest: Thresholding and Binarization, Optimal thresholding Detection of Isolated Points and Lines, Edge Detection, The Laplacian of Gaussian, Region Growing, Splitting and merging of regions. Image Representation and Description: Representation, Boundary descriptors.		7
TEXT BOOKS		
1	Digital Image Processing by Rafael C. Gonzalez & Richard E. Woods, Third Edition, Pearson Education Inc.	
2	Biomedical Image Analysis by Rangaraj M Rangayan by CRC Press 2004	
REFERENCE BOOKS		
1	Image Processing, Analysis and Machine Vision by Milan Sonka, Third edition on, The MIT Press	
2	Handbook of Medical Image Processing and Analysis, 2nd Edition, Academic Press	
Online course		
1	https://www.coursera.org/course/images.	
2	https://nptel.ac.in/courses/108/105/108105091/	
E-Books:		
1	http://ultra.sdk.free.fr/docs/DxO/Digital%20Image%20Processing%20for%20Medical%20Applications.pdf	
2	www.dcc.uchile.cl/~jsaavedr/libros/dip_gw.pdf	
3	iclass.iuea.ac.ug	

Semester	**VI**		
Course Title	**Medical Device Development**	**Course Code**	**19ML6PCMDD**
Credits	**4**	**L-T-P**	**3-0-1**
Pre Requisites	**Analog Electronics Circuits, Digital Integrated Circuits Human Physiology and Medical Physics**		
Course Outcomes			
CO1	Identify and analyse unmet clinical need and its requirements to solve the identified need.		
CO2	Search, analyse and document clinical practice, engineering science and relevant literature in order to determine the need for further research and development in a chosen clinical area.		
CO3	develop a sustainable business plan, including market overview, regulation strategies for health & safety of individuals and intellectual property (IP) strategies		
CO4	Understand medical device design engineering and manufacturing process by avoiding common quality pitfalls in turn learning project management (PERT, Critical Path, etc).		
CO5	develop a virtual product of given medical device comprising of requirement analysis, Risk Analysis and management, High level design, usability analysis, verification and validation and present the findings in a team.		

UNIT #	**Hours**
UNIT 1	**8**
MedTech Innovation: Introduction, the status of bio-innovation in India, DALY, MedTech Innovation, New medical device steps, Common Myths, Bio design process, clinical immersion, need filtration, Need Specification document, case studies, Market Segmentation, Concept Generation and Selection, Perfint Maximo Example.	
UNIT 2	8
Product Requirement: Classification of Medical Device (FDA/CE/CDSCO), Requirement Analysis: Functional, Safety, Usability, User interface, Clinical Workflow, Internal Interface, Working environment, Infrastructure, Safety, Adaptability, Availability, User training, Labelling, Operating cost, Disposable, Design Input, ISO 13485.	
UNIT 3	8
Design Engineering: Clinical Workflow, Design for Manufacturing, Design for Serviceability, FMEA, Economy of Scale, Standards in Medtech, Safety and Risk Management, Case studies.	
UNIT 4	8
Human Factor Engineering: HE75, Common UI and UA issues, Economy of Scale, Product Requirements, Design engineering, Practical Development process, Importance of verification and review, Iterative development, Design and development plan, Design Output, Design Process, Design Verification, Design Validation, Design Review, Review versus verification versus validation, Design Transfer, Functional Block Diagram, High-Level Design, Signal flow path / Signal Characteristics.	
UNIT 5	**7**
Project Management and sustainability: Activity Planning - Objectives, Defining Activities, Project Plan (Gantt Chart), Network Planning models -Critical path management (CPM), Precedence Network, Nodes, Activity network, Forward Pass, Backward Pass, Float, Critical Path and its importance	

Sustainability: Need, external push towards sustainability, hospital role, barriers, making sustainable device, examples.		
TEXT BOOKS		
1	Biodesign: The Process of Innovating Medical Technologies, by Paul Yock, Stefanos A. Zenios, and Todd J. Brinton, Cambridge University Press, 2nd edition, 2015.	
2	Inventing Medical Devices: A Perspective from India, by Jagdish Chaturvedi, Notion Press, 2017.	
REFERENCE BOOKS		
1	The Medical Device R&D Handbook, by Theodore R. Kucklick, Second Edition, CRC Press, 2012.	
Online course		
1	Pharmaceutical and Medical Device Innovations Coursera	
2	Medical Technology and Evaluation Coursera	
3	Regulatory requirements for medical devices including in vitro diagnostics in India (Version 2.0) - Course Swayam	
E-Books:		
1	http://ebiodesign.org/	
2	https://generisgp.files.wordpress.com/2016/05/ebook-medical-device-developmentbest-practices.pdf	

Semester	**VI**

Course Title	Bio-Medical Signal Processing	Course Code	19ML6PCBSP
Credits	3	L-T-P	2-0-1
Pre Requisites	Principles of Digital signal processing, basics of biomedical sensors.		

Course Outcomes	
CO1	apply knowledge of mathematics, science and engineering to develop solutions for biomedical signal processing concepts.
CO2	analyze a problem and formulate appropriate solution for biomedical signal processing
CO3	to design experiments in biomedical signal and analyze computer based process to meet desired needs in healthcare.
CO4	work, document and present as an individual and as a team-member to design formulate and implement experiments using modern tools.
CO5	Implement the concepts practically in groups, perform an open ended experiment/mini-project. Present and document the same.

UNIT 1	Hours
Adaptive filters: Principle of an adaptive filter, the steepest descent algorithm, adaptive noise canceller, cancellation of 50 Hz and power line interference in electrocardiography, applications of adaptive filters. Cancelling Donor heart Adaptive filters, high frequency noise in ECG, motion artefact in ECG, maternal interference in Foetal ECG, cancelling of maternal ECG in foetal ECG, muscle contraction interference in VAG, interference in Heart transplant electrocardiography, cancellation of ECG signal from the electrical activity of the chest muscles, cancellation of high frequency noise in Electro-surgery.	8
UNIT 2	
Data Compression Techniques: Lossy and Lossless data reduction Algorithms. ECG data compression using Turning point, AZTEC, FAN coding techniques.	7
UNIT 3	
Cardiological Signal Processing: ECG waveform analysis, ECG Parameters and their estimations: ECG QRS Detection techniques, estimation of R-R interval, estimation of ST segment inclination, Rhythm analysis, arrhythmia analysis monitoring, long term continuous ECG recording, Illustration of the Problems in an ECG signals with Case Studies.	8
UNIT 4	
Neurological signal processing: Introduction, Linear prediction theory, The Autoregressive (AR) method, Recursive estimation of AR parameters, Spectral error measure, Adaptive segmentation, EEG Transient detection and elimination in epileptic patients and its overall performance. Illustration of the Problems in an EEG signals with Case Studies.	8
UNIT 5	
Sleep EEG: Data acquisition and classification of sleep stages, The Markov model and Markov chains, Dynamics of sleep-wake transitions, Hypnogram model parameters, Event history analysis for modelling sleep. Monitoring of sleep apnoea by polysomnography.	8

TEXT BOOKS		
1	D.C.Reddy, Biomedical Signal Processing- principles and techniques, Tata McGraw-Hill, 2005	
2	Rangaraj M. Rangayyan – Biomedical Signal Analysis. IEEE Press, 2015 .	

REFERENCE BOOKS		
1	Biomedical Digital Signal Processing, Willis J.Tompkins, PHI,	
2	AkayM , Biomedical Signal Processing, Academic: Press 1994	
Online course		
1	ocw.mit.edu › Courses › Health Sciences and Technology MIT Open Course Warhttp://ocw.mit.edu	
2	www.vub.ac.be/en/study/fiches/30340/biomedical-signals-and-images	
3	www.crcpress.com › Biomedical Science › Biomedical Imaging	
4	downloads.hindawi.com/journals/special issues/129194.pdf	
E-Books:		
1	Advanced Methods of Biomedical Signal Processing edited by Sergio Cerutti, Carlo Marchesi	
2	Biological Signal Analysis By Ramaswamy Palaniappan	

Semester	**VI**		
Course Title	**Clinical Data Analytics**	**Course Code**	**19ML6PE3CD**
Credits	**3**	**L-T-P**	**2-1-0**
Pre Requisites	**Engineering Mathematics**		
Course Outcomes			
CO1	Apply the knowledge of mathematics, science and engineering fundamentals to understand the Brain Organization, Anatomy, and Function.		
CO2	Analyze and process the brain signals for artifact reduction.		
CO3	apply Machine Learning Techniques for analysing brain signals.		
CO4	demonstrate the concept of Building BCI System		
CO5	Understand types of BCI, principles and its applications and ethics		

UNIT 1	8 Hrs
Introduction to Biostatistics: Basic concepts, types of data, measurement and measurement scales, descriptive statistics, measure of central tendency, exploring data with tables and graph, measure of dispersion, bayes theorem, Probability distribution, Bernolli distribution, Binomial distribution, Poisson distribution, normal distribution, standard normal distribution, t-distribution, Central limit theorem, confidence intervals, and its significance.	
UNIT 2	8 Hrs
Epidemiological concept: Study design types, randomized control trials, observational studies, prospective/retrospective study, cohort study, case-controlled study, cross-sectional study, determining sample size, Prevalence, incidence, and power of the study.	
UNIT 3	8 Hrs
Hypothesis testing: Hypothesis, hypothesis testing, p-value, type 1, and type 2 errors, 95% confidence interval, selection of valid tests for hypothesis testing, factors to consider for valid tests.	
UNIT 4	8 Hrs
Univariate testing: Parametric testing: student's t-test, paired t-test, one way ANOVA, Non-parametric testing: Mann-Whitney test, Wilcoxon-signed rank test. Nominal- chi-square test, Fisher's exact test, Goodness-of-Fit and Contingency Tables	
UNIT 5	7 Hrs
Regression and correlation: Linear regression, scatter plot, least-square line, Pearson's correlation, spearman's correlation, Kappa coefficient. Comparing a binary outcome between groups: Risk ratio, rates ratio, odds ratio	
Software:	
Experiments and Problems for all units solved through using Standard statistical software such as R with EZR package, excel with data analysis package.	

TEXT BOOKS		
1	Biostatistics: A Foundation for Analysis in the Health Sciences, 11th Edition Wayne W. Daniel, Chad L. Cross, Wiley publishers, 2018.	
2	Biostatistics with R: An Introduction to Statistics Through Biological Data by Babak Shahbaba, Springer, 2012	
REFERENCE BOOKS		
1	Biostatistics for the Biological and Health Sciences, 2nd edition by Marc M. Triola, Mario F. Triola, Jason Roy, Pearson publishers, 2017	
	Rosner B. Fundamentals of Biostatistics, 8th ed. Cengage Learning, Boston, MA, 2016	

Online course		
1	Introduction to Applied Biostatistics: Statistics for Medical Research edX	
2	Introduction to Biostatistics - Course - Swayam	
E-Books:		
1	Biostatistics: New CD-ROM for self learning - WHO	

Semester	**VI**		
Course Title	**DATA COMMUNICATION in HEALTHCARE**	**Course Code**	**19ML6PE3DC**
Credits	**3**	**L-T-P**	**2-1-0**
Pre Requisites	**Analog and Digital communication**		
Course Outcomes			
CO 1	interpret the state of the art in network protocols, architectures and applications.		
CO 2	identify the network functional components and their interaction.		
CO 3	to analyze the importance of data communication in health care		

UNIT 1	8Hrs
Layered tasks, OSI Model, Layers in OSI model, TCP?IP Suite, Addressing, Telephone and cable networks for data transmission, Telephone networks. Overview of Health Informatics, Healthcare Data, Information and Knowledge, Healthcare Data Analysis.	
UNIT 2	7 Hrs
Datalink control: Framing, Flow and error control, Protocols, Noiseless channels and noisy channels, HDLC. Electronic Health Records, Health Information Exchange, Health Data Standards, Architectures of Information Systems, Consumer Health informatics.	
UNIT 3	8 Hrs
Static and dynamic channel allocation, multiple access protocols, LAN/MAN technology, Bus/Tree, Star and Ring topologies, The ring topology, Medium access control protocols, MAC performance, LAN/MAN standards, IEEE 802.2, 802.3, 802.4, IEEE802.5, 802.6, 802.11, and 802.16, Blue tooth.	
UNIT 4	8 Hrs
NETWORK LAYER: Unicast Routing Protocols, Multicast Routing protocols, Logical addressing, Ipv4, Ipv6 format & addressing, Delivery, Forwarding. TRANSPORT LAYER: Transport layer Process to process Delivery, UDP, TCP, SCTP, Congestion, QOS	
UNIT 5	8 Hrs
APPLICATION LAYER: Client Server Model, Domain Name Space (DNS), Electronic mail, HTTP, world wide web (www) Mobile Technology and mHealth, Online Medical Resources, Medical Information Retrieval, Disease Management and Disease Registries, Telemedicine, Medical Imaging Informatics, Bioinformatics, Public Health Informatics	

TEXT BOOKS		
1	Data Communication and Networking, B Forouzan, 4th Ed, TMH 2006	
2	Computer networks – An1. Health Informatics: Practical Guide for Healthcare and Information Technology Professionals (Sixth Edition). By Robert E. Hoyt and Ann K. Yoshihashi	
REFERENCE BOOKS		
1	Introduction to Data communication and Networking, Wayne Tomasi: Pearson education 2007	
2	Mobile Health Solutions for Biomedical Applications by Phillip Olla.	

3	Healthcare data analytics and management 1ST Edition by Nilanjan Dey, Amira S Ashour, Simon James Fong, Chinthon Bhatt.	
Online course		
1	https://freevideolectures.com/course/2278/data-communication	
2	https://freevideolectures.com/course/2278/data-communication	
E-Books:		
1	E-book 1	
2	E-book 2	

Semester	VI		
Course Title	**VLSI and SoC Design**	**Course Code**	**19ML6PE3VS**
Credits	**3**	**L-T-P**	**2-1-0**
Pre Requisites	Analog Electronics		

Course Outcomes

CO1	apply the knowledge of CMOS technology to construct basic and advanced CMOS logic circuits.
CO2	Analyze the DC characteristics of CMOS circuits.
CO3	Design of CMOS based combinational and sequential circuits for given specification.

Course Description	**Hours**
UNIT 1	**8**
Logic Design with MOSFETs: MOSFETs as Switches, Basic logic gates in CMOS, Complex logic gates in CMOS, Transmission Gate Circuits.	
UNIT 2	**7**
Physical Structure of CMOS Integrated Circuits: Integrated Circuit Layers, Interconnect Resistance and Capacitance, MOSFETs CMOS layers, Designing FET Arrays, Complex logic gates, Gate layout geometry, Euler graph.	
UNIT 3	**8**
Electronic Analysis of CMOS Logic Gates: DC Characteristics of the CMOS inverter, Inverter Switching Characteristics, Power dissipation, DC Characteristics: NAND and NOR Gates.	
UNIT 4	**8**
Motivation for SoC Design - Review of Moore's law and CMOS scaling, benefits of system-on-chip integration in terms of cost, power, and performance. Comparison between System-on-Board, System-on-Chip and System-in-Package. Typical goals in SoC design – cost reduction, power reduction, design effort reduction, performance maximization. Productivity gap issues and the ways to improve the gap – IP based design and design reuse.	
UNIT 5	**8**
System On Chip Design Process: A canonical SoC Design, SoC Design flow, waterfall vs spiral, top down vs bottom up, Specification requirement, Types of Specification, System Design Process. **Memories**: Memory Subsystem architecture, Caching.	

TEXT BOOKS

1	John P. Uyemura, "Introduction to VLSI Circuits & Systems", Wiley India Edition, 2007, ISBN: 978-81-265-0915-7.
2	Rao R. Tummala, Madhavan Swaminathan, "Introduction to system on package Miniaturization of the Entire System", McGraw-Hill, 2008.

REFERENCE BOOKS	
1	James K. Peckol, "Embedded Systems: A Contemporary Design Tool", Wiley Student Edition.
2	M.S.Suma,Poornima M,Namita Palecha,CMOS VLSI Design, New Age Internation,1st Edition 2017.
3	Michael Keating, Pierre Bricaud, "Reuse Methodology Manual for System on Chip designs", Kluwer Academic Publishers, 2nd edition 2008.
Online course	
1	ElectronicDesignAutomationhttp://nptel.ac.in/courses/VLSI Fundamentals
E-Books:	
1	http://access.ee.ntu.edu.tw/course/dsd_99second/2011_lecture/W2_HDL_Fundamentals_2011-03-02.pdf

Semester	**VI**		
Course Title	**Systems Engineering**	**Course Code**	**19ML6CE1SE**
Credits	**3**	**L-T-P**	**3-0-0**
Pre Requisites	**Basic Knowledge of multidisciplinary projects**		
Course Outcomes			
CO 1	Apply the knowledge of engineering specialization to the solution of complex engineering problems requiring multidisciplinary or systems approach.		
CO 2	Analyze health data employing advanced tools and techniques .		
CO 3	Design and formulate optimal solutions with the knowledge of elegant design characteristics, systems thinking and lean philosophy methods.		
UNIT 1			
Introduction to Systems Engineering : Definitions, Twenty-first century imperatives: Trends, Hyper connectivity and IoT, Promise and challenges. Thinking different: Introduction, 12 New types of thinking, Disciplinary Convergence – Promise and Impact, Disruptive Collaboration.			**9Hrs**
UNIT 2			
Human Performance Enhancement & Design elegance: Introduction, Trade-offs, Parameterizing, Integrated aiding-training system concept. Elegant design characteristics, solutions, designers, Smart questions, metaphors and analogies, Heuristic-enabled design, assessment.			**7Hrs**
UNIT 3			
The Healthcare Delivery system: Overview, Components, Major stakeholders, Global issues, Drivers in healthcare systems. Complexity and systems in healthcare: Taking a systems approach, Complex adaptive systems, systems thinking and dynamics.			**8Hrs**
UNIT 4			
Patient flow: Healthcare settings and Clinical workflows, Patient flow, care transitions, process mapping, queuing. Lean philosophy and methods: Drivers, Toolset for eliminating wastes, Value stream mapping, Lean implementation and thinking			**8Hrs**
UNIT 5			
Health Analytics: Data mining, data visualization, social network analysis, data envelopment analysis, multicriteria decision making, Infection control: Historical perspective, Infection control classification, checklists, The case of sepsis, Mathematical modelling of hospital infection control.			**7Hrs**
TEXT BOOKS			
1	Azad M. Madni, Transdisciplinary Systems Engineering, Springer, 2018		
2	Paul M. Griffin et al., Healthcare Systems Engineering, Wiley, 2nd edition, 2016		
REFERENCE BOOKS			
1	Alexander Kossiakoff et al., Systems engineering Principles and practice, 2nd ed, Wiley, 2011		
2	Robin Fedler et al., Systems engineering approach to medical automation, Artech house Inc, 2008		
3	Andrew P. Sage, William B. Rouse, Handbook of Systems Engineering and Management, 2nd Edition, Wiley 2009		
Online course			
1	https://www.coursera.org/learn/systems-engineering		
2	https://www.classcentral.com/course/introse-1381		
E-Books:			

1	https://www.open.edu/openlearn/science-maths-technology/computing-ict/systems-engineering-challenging-complexity/content-section-7	
2	https://research.utwente.nl/en/publications/systems-design-and-engineering-facilitating-multidisciplinary-dev	

Semester	**VI**		
Course Title	**Brain Computer Interface**	**Course Code**	**19ML6CE1BC**
Credits	**3**	**L-T-P**	**3:0:0**
Pre Requisites	Knowledge of Biomedical signals and Transducers used for the biomedical signal acquisition.		

Course Outcomes

CO1	Apply the knowledge of mathematics, science and engineering fundamentals to understand the Brain Organization, Anatomy, and Function.
CO2	Analyze and process the brain signals for artifact reduction.
CO3	apply Machine Learning Techniques for analysing brain signals.
CO4	demonstrate the concept of Building BCI System
CO5	Understand types of BCI, principles and its applications and ethics

UNIT 1	**Hours**
Basic Neuroscience : Neurons ,Action Potentials or Spikes , Spike Generation ,Adapting the Connections. Brain Organization, Anatomy and Function . Recording and Stimulating the Brain ,Invasive Techniques ,Non-invasive Techniques Multielectrode Arrays, Signal Processing ,Spike Sorting.	8
UNIT 2	
Frequency Domain Analysis :Discrete Fourier Transform ,Fast Fourier Transform, Spectral Features ,Wavelet Analysis, Time Domain Analysis ,Hjorth Parameters , Fractal Dimension Bayesian Filtering ,Kalman Filtering , Particle Filtering ,Spatial Filtering , Bipolar, Laplacian, and Common Average Referencing. Artifact Reduction Techniques : Thresholding ,Band-Stop and Notch Filtering, Linear Modelling Principal Component Analysis ,Independent Component Analysis.	8
UNIT 3	
Machine Learning: Classification Techniques , Binary Classification ,Ensemble Classification Techniques ,Multi-Class Classification , Evaluation of Classification Performance ,Regression ,Linear Regression ,Neural Networks and Backpropagation , Radial Basis Function (RBF) Networks ,Gaussian Processes	8
UNIT 4	
Building a BCI :Major Types of BCIs ,Brain Responses Useful for Building BCIs ,Imagined Motor and Cognitive Activity, Stimulus-Evoked Activity. Invasive BCIs: Two Major Paradigms in Invasive Brain-Computer Interfacing ,BCIs Based on Operant Conditioning ,BCIs for Prosthetic Arm and Hand Control, BCIs for Lower-Limb Control ,BCIs for Cursor Control ,Cognitive BCIs ,Cognitive BCIs in Humans , Establishing New Connections between Brain Regions.	8
UNIT 5	7
Applications and Ethics: Applications of BCIs ,Medical Applications ,Sensory Restoration , Rehabilitation ,Restoring Communication with Menus, Lie Detection and Applications in Law ,Monitoring Alertness ,Estimating Cognitive Load , Ethics of Brain-Computer Interfacing Medical Health, and Safety Issues: Balancing Risks versus Benefits , Informed Consent BCI Security and Privacy , Legal Issues Moral and Social Justice Issues.	
TEXT BOOKS	
1 Brain -Computer Interfacing: An Introduction by Rajesh P. N Rao, University of Washington DATE PUBLISHED: September 2013:ISBN: 9780521769419, Cambridge University Press	
2 Brain-Computer Interfaces 1: Foundations and methods Maureen Clerc, Laurent	

	Bougrain, Fabien Lotte	
REFERENCE BOOKS		
1	Brain-Computer Interfaces 2: Technology and Applications, Volume 2 Maureen Clerc, Laurent Bougrain, Fabien Lotte John Wiley & Sons, 29-Aug-2016 - Computers	

Online course/Moocs		
1	https://sccn.ucsd.edu/wiki/Introduction_To_Modern_Brain-Computer_Interface_Design	
2	https://www.udemy.com/course/brain-computer-interface/	
E-Books:		
1	Dornhege, G. (Ed.). (2007). Toward brain-computer interfacing. MIT press.	
2	"Brain-Computer Interfaces: Principles and Practice" ISBN-13: 978-0195388855.	

Semester	**VI**		
Course Title	**ERGONOMICS**	**Course Code**	**19ML6OE1ER**
Credits	**3**	**L-T-P**	**3-0-0**
Pre Requisites	-----		
Course Outcomes			
CO1	Apply the knowledge of mathematics,science and engineering fundamentals to improve human machine interaction.		
CO2	Formulate and analyse the work environment that degrade human machine performance		
CO3	Design and apply reasoning by the contextual knowledge to meet the need of the users to assess health safety and legal issues		
CO4	Comprehend the published reports and write reports of the case studies for ergonomically designed models working in a team.		
CO5	Function effectively to communicate the prepared reports as an individual and in a team		

UNIT 1	**8**
Introduction to Ergonomics: The focus of ergonomics, Ergonomics and its areas of application in the work system, A brief history of ergonomics, Modern ergonomics, Future directions for ergonomics. Anatomy, posture and body mechanics: Anatomy of the spine and pelvis related to posture, Postural stability and postural adaptation, Low back pain, Risk factors for musculoskeletal disorders in the workplace, Behavioral aspects of posture. **Anthropometric principles in workspace and equipment design:** Designing for a population of users, sources of human variability, Anthropometry and its uses in ergonomics, Principles of applied anthropometry in ergonomics, Application of anthropometry in design, Design for everyone, Anthropometry and personal space.	
UNIT 2	**8**
Static work: Design for standing and seated workers: Fundamental aspects of standing and sitting, An ergonomic approach to workstation design, Design for standing workers, Design for seated workers, Work surface design, Visual display units, Guidelines for the design of static work. **Design of repetitive tasks:** Introduction to work-related musculoskeletal disorders, Injuries to the upper body at work, Review of tissue path mechanics and WMSDs, Disorders of the neck, Carpal tunnel syndrome, Tennis elbow (epicondylitis), disorders of the shoulder, Lower limbs, Ergonomic interventions, Trends in work-related musculoskeletal disorders. Design of manual handling tasks.	
UNIT 3	**7**
Work capacity, stress and fatigue: Stress and fatigue, Muscles, structure, function and capacity, Physical work capacity, Factors affecting work capacity. Industrial applications of physiology. **Heat, cold and the design of the physical environment:** Fundamentals of human thermoregulation, measuring the thermal environment, Thermoregulatory mechanisms, Work in hot climates, work in cold climates, Skin	

temperature, Protection against extreme climates, Comfort and the indoor climate, ISO standards.		
UNIT 4		**8**
Vision, light and lighting: Vision and the eye, Measurement of light, lighting design considerations, Visual fatigue, eye strain and near work, Psychological aspects of indoor lighting. **Hearing, sound, noise and vibration:** Terminology, Measurement of sound, Ear protection, Design of the acoustic environment, Industrial noise control, Noise and communication, The auditory environment outdoors, Effects of noise on task performance, Non-auditory effects of noise on health, Noise and satisfaction, Vibration. Human information processing, skill and performance.		
UNIT 5		**8**
Displays, controls and virtual environments: Principles for the design of visual displays, Auditory displays, Design of controls, Combining displays and controls, Virtual ('synthetic') environments. Human–computer interaction, memory and language: Human-centred design processes for interactive systems, Designing information in external memory stores, Human-computer dialogues, Memory and language in everyday life. **Human–machine interaction, human error and safety:** Human error and equipment design, Mental workload in human machine interaction, Psychological aspects of human error, Characterising human–machine interaction, GOMS, Prevention of error in human–machine interaction, Accidents and safety.		
TEXT BOOKS		
1	Introduction to Ergonomics by R.S. Bridger, Taylor & Francis, 2003. eBook Published 26 June 2008.	
REFERENCE BOOKS		
1	Introduction to Human factors and ergonomics for Engineers, 2nd Edition, Marks Lehto, Steven J Landry. CRC press, Taylor and Francis group, 2013	
2	Handbook of Human Factors and Ergonomics, 4th Edition, Gavriel Salvendy, March 2012.	
3	Handbook of Human Factors and Ergonomics in Health Care and Patient Safety, Pascale Carayon, First Edition-2012, eBook Published-19 April 2016, CRC Press	
ONLINE COURSE		
1	https://www.derby.ac.uk/online/ergonomic-courses/ergonomics-human-factors-pg-cert-online/code: 7PS568	
2	https://engineering.purdue.edu/online/courses/human-factors-engineering code:IE57700	
E-BOOKS:		
1	https://moodle.ufsc.br/mod/resource/view.php?id=387317	
2	https://www.taylorfrancis.com/books/9780429104220	

Semester	**VI**		
Course Title	**Point of Care systems**	**Course Code**	**19ML6OE1PC**
Credits	**3**	**L-T-P**	**3-0-0**
Pre Requisites	**General Sensors and Biosensors**		
Course Outcomes			
CO1	Apply the knowledge of science and engineering fundamentals to comprehend immunoassays and point of care system technologies		
CO2	Reason based on the contextual knowledge related to smart POC systems for health care and management		
CO3	To engage in life-long learning, in the context of next generation of personalized and integrated healthcare for chronic diseases.		
UNIT 1			
Introduction : Overview of Point of care (POC) technologies, Enablers, Need, Target analytes for POC testing, POC Technologies, Challenges, Compliance with regulatory guidelines and requirements, Need for fully integrated bioanalytical platforms, Material safety, data security, Economic evidence, end users' perspective.			8 Hrs
UNIT 2			
Smart-phone based POC technologies for mobile healthcare: Introduction, Smartphone based techniques, POC diabetes management software and smart applications: Overview and examples.			8 Hrs
UNIT 3			
Paper based POC Immunoassays: Introduction, Formats, Types, Detection principles, Advances. Lab-on-a-chip based POC: Formats, Types.			7 Hrs
UNIT 4			
Multiplex immunoassays: Overview, Bead-based, Multiplex IAs, Paper-based techniques, Microfluidics based. Bioanalytical Parameters in Immunoassays: Introduction, Determination, Parameters, Performance parameters			8 Hrs
UNIT 5			
Future trends in POCT: Next generation of personalized and integrated healthcare for chronic diseases, Introduction, Chronic diseases- Diabetes, Depression, Obesity, Cancer, Cardiovascular diseases, Tuberculosis, Future trends.			8 Hrs
TEXT BOOKS			
1	Sandeep Kumar Vasist and John H.T. Luong, An overview of Point-of-care technologies enabling next-generation healthcare monitoring and management, Springer, 2019		
REFERENCE BOOKS			
1	Roger J. Narayan, Medical Biosensors for Point of Care (POC) Applications, Woodhead Publishing, 2017		
2	Spyridon E. Kintzios, Portable Biosensors and Point-of-Care Systems, IET Library, 2017		
Online course			
1	https://www.coursera.org/browse/health/patient-care		
2	https://www.coursera.org/learn/mobile-health-monitoring-systems		
E-Books:			

1	https://www.siemens-healthineers.com/en-us/point-of-care-testing	
2	https://gh.bmj.com/content/bmjgh/5/2/e002067.full.pdf	

Semester	VI		
Course Title	**Forensics Science**	**Course Code**	**19ML6HSCFS**
Credits	**2**	**L-T-P**	**2-0-0**
Pre Requisites	**Principles of Digital signal processing, basics of biomedical sensors.**		
Course Outcomes			
CO1	Apply knowledge of Engineering science to understand the basics of Forensic Science		
CO2	Identify the importance of Forensic Document Examination and its scope.		
CO3	Analyze the basic concepts of -Atomic and molecular spectroscopy and instruments principles.		
CO4	Differentiate between Ultraviolet and visible spectrophotometry		
CO5	Identify the applications of modern equipments and techniques used in forensic science		

UNIT 1	**Hours**
Introduction: Biometrics and Forensic Science- face, Iris & retinal imaging, speech recognition, Fingerprinting in India, What are friction ridges? Friction ridges pattern visualization techniques, Taking of finger prints from living & dead persons, preserving prints for analysis, principles of friction Ridge analysis, Classifying Fingerprints, Comparison of finger prints, Automated Fingerprint Identification System (AFIS), Identification, How long do friction ridge prints last, Elimination prints, Lip print, ear print.	5
UNIT 2	
Forensic Document Examination and its scope & importance; Classification of documents; Care, handling, preservation of documents; Observation tests and their application in handwriting examination; Preliminary examination of documents; examination of paper & inks, Process of comparison of handwriting; Principle of handwriting examination; Importance of natural variations and disguise in hand writing examination; Latest technological developments in the field of document examination with reference to office automation; Quality Assurance in document Examination.	5
UNIT 3	
Basic concepts-Atomic and molecular spectroscopy Interaction of electromagnetic radiation with matter and its consequences. fluorescence, phosphorescence. Detection of radiations: photographic detectors, thermal detectors, photoelectric detectors, PMT and semiconductor detectors. Atomic spectra, energy levels, quantum, numbers and designation of states, selection rules, qualitative discussions of atomic spectra. Elements of X-ray spectrometry-fluorescence, energy Dispersive X-ray analysis (EDX), wavelength Dispersive X-ray analysis (WDX), X-ray diffraction, Augur effect. Molecular spectra: Qualitative discussion of molecular binding, molecular orbital, types of molecular energies, qualitative discussions of rotational, vibrational and electronic spectra, spectra of polyatomic molecules, IR spectroscopy-correlation of infrared spectra with molecular structure, Fourier Transform, infrared and Raman spectroscopy, florescence and phosphorescence spectrophotometry.	6
UNIT 4	

Ultra violet and visible spectrophotometry: Types of sources and stability, wavelength selection, effect of Chemical Structure on absorption spectra, qualitative and quantitative analysis Application in forensic Atomic Emission Spectrometry (AES): Instrumentation and techniques, arc/spark emission, ICP-AES, comparison of ICP vs AAS methods, quantitative analysis, ESCA and its applications. Fluorescence and phosphorescence spectrophotometry: Types of sources, structural factors, instrumentation, Dispersive and Fourier transform spectrophotometry, (FTIR). Qualitative analysis and interpretation of IR spectra, applications.		5
UNIT 5		
State–of-the-art-equipment :– working & features of Video Spectral Comparators,VSC-6000 & VSC model I , IV, 2000 , 2000/HR, 5000, Docucenter , Poliview. Principle & working of TLC, HPLC , HPTLC, Electrophoresis , FTIR with ATR and Electrostatic Detection Apparatus. Principle & working of SEM-EXDA, Raman Spectrophotometer, GC-MS, Neutron Activation Analysis.		5
TEXT BOOKS		
1	A Beginner's Guide to Forensic Science (Paperback)by Carlson, Susan M., Pietrzyk PhD, Carly A.	
2	Chatwal G.R & Anand S. K ; Instrumental Methods of Chemical Analysis Himalaya Publ. House (2004)	
REFERENCE BOOKS		
1		
2	Guidelines for Forensic Engineering Practice Paperback – Import, 15 September 2012 by Joshua B. Kardon (Editor)AkayM , Biomedical Signal Processing, Academic: Press 1994	
Online course		
1	Courses available in Coursera or edX.	

Course Title	Mini Project–2	Course Code	19ML6PWMP2
Credits	2	L-T-P	0-0-2
CO#	Course Outcomes:		PO (Strength)
CO1	Apply the knowledge of science and medical electronics engineering to provide solutions for human-health related problems		PO1 (3)
CO2	Analyze and identify biomedical engineering problems based on literature survey and need analysis		PO2 (3)
CO3	Develop solutions for relevant biomedical engineering problems with appropriate consideration of public health, safety and society		PO3 (2)
CO4	Design experimental techniques/simulation models and interpret the data conclusively		PO4 (3)
CO5	Use modern tools and resources in developing health-care solutions needing their applications		PO5 (2)
CO6	Apply reasoning based on the contextual knowledge of the design problem statement and assess societal, health and safety issues		PO6 (2)
CO7	Demonstrate the knowledge of a sustainable solution in the context of society		PO7 (1)
CO8	Apply biomedical ethics and responsibilities		PO8(2)
CO9	Function both individually and in diverse teams requiring multidisciplinary approaches.		PO9 (3)
CO10	Comprehend, prepare effective reports and make clear presentations to an engineering community		PO10 (3)
CO11	Demonstrate the knowledge of project management and financial requirements of a project work		PO11 (3)
CO12	Exhibit self-reliance and life-long learning skills to align to the new trends		PO12 (2)

Guidelines for Mini Project–2 (19ML6PWMP2)
Objective: The objective of this open ended mini project is to let the students apply the knowledge of the engineering subjects into a **real- world situation/problem**.
Guidelines:
1) The mini project MUST be done in a group of 3 / 4 students.
2) Mini project can be done in the area of **biomedical engineering or any other engineering discipline.**
3) This open ended project could be based on subjects previously learnt in academics or with own interest / subjects learning currently / subjects to be learnt during implementation
4) Mini project can be a ***simulation or hardware implementation***. **(**considering current technology/situation)
5) Each group will be allotted a **Guide**. Students in that group must discuss the project idea with Guide before finalizing it.
6) Each group will present the idea of the project and will submit 1 - 2 page(s) of an **Abstract** of

the mini project work.
7) Every week, project group will report progress of the project to allotted Guide.
8) Each group will give **four presentations** according to the schedule which will be shared with students in advance.
9) **First presentation** – is introductory presentation for approving the topic. This will not carry any marks
10) Second and Third presentations will be **PROGRESS PRESENTATIONS**; will carry marks
11) Assessment of the project progress will be based on **Rubrics** which will be shared with students in advance.
12) Final presentation is about **entire mini project implementation** with demonstration; will carry marks
13) At the end of the project, all groups will submit video of the working model and technical report in the format shared.
14) Final SEE will be conducted for 50 marks.

Course Title	**Technical Seminar**	**Course Code**	**19ML6SRTSR**
Credits	**1**	**L-T-P**	**0-0-1**
Guidelines for Technical Seminar			
Students need to present the Latest technology and Innovations in the Biomedical Domain. They can refer to any articles published or Journals. Presentation is assessed through an oral seminar based on rubrics designed accompanied by a technical report on the topic. It is expected that this course will motivate the student to develop product through suitable projects in later semesters.			

Course Title	**Personality Development, Communication and Aptitude Skill**	**Course Code**	**19ML6NCPDA**
Credits	**Non Credit**	**L-T-P**	**0-0-0**

This courses deals with the various aspects of developing a balanced personality to be a successful and competitive team player, in the context of the Engineers beyond 2020, who are required to be more dynamic, quick and resilient.

This course will make the students to

- Comprehend that Success is relative
- Learn the of good and great engineers
- Know the requirements in the context of global engineering challenges
- Recognize the types of personality traits
- Know the tips to improve his/her personality
- Understand the kinds of aptitude tests

VII Semester Syllabus

Semester	VII		
Course Title	BIOLOGY FOR ENGINEERS	**Course Code**	19ES7BSBFE
Credits	2	**L-T-P**	2-0-0
Pre Requisites	Principles of Digital signal processing, basics of biomedical sensors.		

Course Outcomes	
CO1	understand and explain basic concepts of Biology
CO2	apply the knowledge of Biology to convey the role of basic building blocks of life
CO3	understand and analyze basics of Radiation and its effects on Human Body
CO4	Understand role of Biology in organic farming
CO5	Identify the applications of modern equipments and techniques used in forensic science

UNIT 1	**Hours**
Introduction: Why Engineers Should Study Biology?, What Is life?, The Hierarchy of Life, Evolution, Taxonomy, Interaction of Living Things with the Environment, Brief History of Life, Basic Organic Chemical Structure	5
UNIT 2	
Composition of Living Things: Carbohydrates, Lipids, Proteins, Nucleic Acids, Hybrid and Other Compounds The Cell: The Common Denominator of Living Things, Prokaryotes and Eukaryotes, The Biological Membrane, Eukaryotic Cell Structure and Function, Cell Reproduction	5
UNIT 3	
Introduction to Radiation:Where does Radiation Come from, Types of Radiation, Types of Ionizing Radiation ,X-rays for Medical Use and Generators, Types of Electromagnetic Waves, Ionization of Radiation - Property of Ionizing Radiation, Types of Radiation and Biological Effects ,Penetrating Power of Radiation, Penetrating Power of Radiation within the Body,Penetrating Power and Range of Effects on the Human Body	5
UNIT 4	
Radiation Effects on Human Body:Types of Effects, Exposure Modes and Effects, Classification of Radiation Effects, Deterministic Effects and Stochastic Effects. Mechanism of Causing Effects on Human Body: Ionization due to Radiation, Damage and Repair of DNA, DNA→Cells→Human Body, Radiation Damage to DNA, Lapse of Time after Exposure and Effects, Deterministic Effects, Radiosensitivity of Organs and Tissues, Stochastic EffectsCell phone Radiation Hazards: Introduction, Mutation	6
UNIT 5	
Organic Farming: History and Background, Requirements of Plants for Soil-Derived Nutrients: Effects of Nitrogen, Phosphorous and Potassium on Plant Growth and Quality, Symptoms of Nitrogen, Phosphorous and Potassium Deficiency in Crops	5

TEXT BOOKS		
1	Arthur T. Johnson, Biology for Engineers, Second Edition, CRC Press 2019	
2	Hand Book on " Basic Knowledge and Health Effects of Radiation" by	

	Radiation Health Management Division, Ministry of the Environment, Government of Japan and National Institutes for Quantum and Radiological Science and Technology	
3	David A. Vaccari, Peter F. Strom and James E. Alleman, Environmental Biology for Engineers and Scientists Wiley Interscience, 2006	
4	Allen V. Barker, Science and Technology of Organic Farming, CRC Press, 2010	
REFERENCE BOOKS		
1	Suraishkumar, Madhulika Dixit, Biology for Engineers and Non – Biologists, IIT Madras, Oxford University Press	
2	Naren, Anubhav E, Vinay C, Mohsen G, 'Electromagnetic Radiation Due to Cellular, Wi-Fi and Bluetooth Technologies: How Safe are we?', IEEE Access Special section on Antenna Propagation for 5G and beyond, pp42980 - 43000, January 2020	
3	Sapna E.T., India's Organic Farming Revolution, University of Iowa Press, Iowa City, 2014	
Online course		
1	E Resourse: https://letstalkscience.ca/educational-resources/backgrounders/radiation-effects-on-body	
MOOC	https://nptel.ac.in/courses/121/106/121106008/	
	Unit Choice : Unit 3 and 4	

Semester	VII		
Course Title	PROJECT MANAGEMENT AND FINANCE	**Course Code**	19ES7HSPMF
Credits	3	**L-T-P**	3-0-0
Pre Requisites	Pre-requisites: Personality development course, soft skills		

Course Outcomes	
CO1	Apply the Knowledge of project management principles and to implement project management methodologies required for successful project completion
CO2	Develop Ethical principles in project planning and execution as a team and documentation in project implementation.
CO3	Identify and Apply finance aspects for project implantation in time.
CO4	Use modern tools to simulate their respective projects and case studies and investigate the behaviour under various operating conditions.
Course Description	This course provides an insight into the basic principles of project management, including concepts, principles, and formulation of projects such as initiating, planning, executing, monitoring & controlling, and closing process groups. Introduces fundamentals from the project management knowledge areas such as integration, scope, time, cost, quality, human resources, communications, risk, procurement, and stakeholder management. Provides students with the opportunity to apply project management principles to real- world situations. It offers techniques to evaluate projects which could be successfully used for improving the quality of managerial decisions and also the importance of financial management in managing projects and programs.

UNIT 1	**Hours**
Concepts of Project Management - Project Leadership and Ethics: Introduction to project leadership, ethics in projects, Multicultural and virtual projects. Concepts of project, Categories of project, Project life cycle phases, Project management concepts, Tools and techniques for project management, The project manager, Basic education for a project manager, Roles and responsibilities of project manager, Project manager as profession, Summary.	7
UNIT 2	
Establishing the Project - Scope, Time, Cost and performance goals, Feasibility report, Financing Arrangements, Preparation of cost estimates, Finalization of project implementation schedule, Evaluation of the project profitability, Appointing a project manager, Fixing the Zero date, Summary.	8
UNIT 3	
Organizing Human Resources and Contracting - Delegation, Project manager's authority, Project organization, Accountability in Project Execution, Contracts, R's of contracting, Tendering and Selection of Contractors, Team building, Summary.	8
UNIT 4	
Organizing Systems and Procedures for Project Implementation -Working of systems, Design of Systems, Project work system design, Work breakdown structure, Project execution plan, Project procedure manual, Project control system, Planning, Scheduling and Monitoring, Monitoring contracts, Project diary, Summary.	8

UNIT 5		
Financing of Projects - Capital structure, Menu of financing, Internal accruals, Equity capital, Preference capital , Debentures (or bonds) , Methods of offering term loans , Working capital advances, Miscellaneous sources , Raising venture capital, Project financing structures, Financial closure , Financial institutions ,Summary.		8
TEXT BOOKS		
1	Project Management – S Choudhury, Tata McGRAW Hill Publishing Company Limited	
2	2. Projects- Planning, Analysis , Selection, Financing ,Implementation and Review –Dr. Prasanna Chandra McGRAW Hill Publishing Company Limited	
3	3. Project Management Institute A Guide to the Project Management Body of Knowledge PMBOK Guide (Sixth Edition), Sept 2017	
REFERENCE BOOKS		
1	Fundamentals of Project Management by Dr.Vijay Kanabar	
2	Project Management – David I Cleland – Mcgraw Hill International edition	
3	Project Management – Gopalakrishnan – Mcmillan India Ltd	
4	Project Management – harry – Maylor- Peason Publication	
E Books		
1	https://www.youtube.com/watch?v=5d16JwWwjKo	
2	NPTEL lecture on Introduction to project management by prof. Arun Kanda https://www.youtube.com/watch?v=5pwc2DYlKQU	
	Unit Choice : Unit 2 and 4	

emester	VII		
Course Title	BIOLOGY FOR ENGINEERS	**Course Code**	19ES7BSBFE
Credits	2	**L-T-P**	2-0-0
Pre Requisites	Principles of Digital signal processing, basics of biomedical sensors.		
Course Outcomes			
CO1	understand and explain basic concepts of Biology		
CO2	apply the knowledge of Biology to convey the role of basic building blocks of life		
CO3	understand and analyze basics of Radiation and its effects on Human Body		
CO4	Understand role of Biology in organic farming		
CO5	Identify the applications of modern equipments and techniques used in forensic science		

UNIT 1	**Hours**
Introduction: Why Engineers Should Study Biology?, What Is life?, The Hierarchy of Life, Evolution, Taxonomy, Interaction of Living Things with the Environment, Brief History of Life, Basic Organic Chemical Structure	5
UNIT 2	
Composition of Living Things: Carbohydrates, Lipids, Proteins, Nucleic Acids, Hybrid and Other Compounds The Cell: The Common Denominator of Living Things, Prokaryotes and Eukaryotes, The Biological Membrane, Eukaryotic Cell Structure and Function, Cell Reproduction	5
UNIT 3	
Introduction to Radiation:Where does Radiation Come from, Types of Radiation, Types of Ionizing Radiation ,X-rays for Medical Use and Generators, Types of Electromagnetic Waves, Ionization of Radiation - Property of Ionizing Radiation, Types of Radiation and Biological Effects ,Penetrating Power of Radiation, Penetrating Power of Radiation within the Body,Penetrating Power and Range of Effects on the Human Body	5
UNIT 4	
Radiation Effects on Human Body:Types of Effects, Exposure Modes and Effects, Classification of Radiation Effects, Deterministic Effects and Stochastic Effects. Mechanism of Causing Effects on Human Body: Ionization due to Radiation, Damage and Repair of DNA, DNA→Cells→Human Body, Radiation Damage to DNA, Lapse of Time after Exposure and Effects, Deterministic Effects, Radiosensitivity of Organs and Tissues, Stochastic EffectsCell phone Radiation Hazards: Introduction, Mutation	6
UNIT 5	
Organic Farming: History and Background, Requirements of Plants for Soil-Derived Nutrients: Effects of Nitrogen, Phosphorous and Potassium on Plant Growth and	5

Quality, Symptoms of Nitrogen, Phosphorous and Potassium Deficiency in Crops		
TEXT BOOKS		
1	Arthur T. Johnson, Biology for Engineers, Second Edition, CRC Press 2019	
2	Hand Book on " Basic Knowledge and Health Effects of Radiation" by Radiation Health Management Division, Ministry of the Environment, Government of Japan and National Institutes for Quantum and Radiological Science and Technology	
3	David A. Vaccari, Peter F. Strom and James E. Alleman, Environmental Biology for Engineers and Scientists Wiley Interscience, 2006	
4	Allen V. Barker, Science and Technology of Organic Farming, CRC Press, 2010	
REFERENCE BOOKS		
1	Suraishkumar, Madhulika Dixit, Biology for Engineers and Non – Biologists, IIT Madras, Oxford University Press	
2	Naren, Anubhav E, Vinay C, Mohsen G, 'Electromagnetic Radiation Due to Cellular, Wi-Fi and Bluetooth Technologies: How Safe are we?', IEEE Access Special section on Antenna Propagation for 5G and beyond, pp42980 - 43000, January 2020	
3	Sapna E.T., India's Organic Farming Revolution, University of Iowa Press, Iowa City, 2014	
Online course		
1	E Resourse: https://letstalkscience.ca/educational-resources/backgrounders/radiation-effects-on-body	
MOOC	https://nptel.ac.in/courses/121/106/121106008/	

Semester	VII		
Course Title	MACHINE LEARNING	**Course Code**	19ML7PCMCL
Credits	4	**L-T-P**	3-1-0

Course Outcomes:

CO1	Ability to apply knowledge to identify, gather information and analyse to formulate the unmet need and problem definition for project through survey
CO2	Ability to use appropriate tool/tools to implement and demonstrate the project.
CO3	Ability to design and develop sustainable solution/system for the biomedical applications
CO4	Ability to make effective presentation of the work abiding professional ethics as an individual and a team member.
CO5	Ability to develop systems with scope for enhancement and continue life-long learning.

UNIT 1	**Hours**
Introduction: Learning Problems, Designing Learning systems, Perspectives and Issues. Concept learning: Concept Learning, Version Spaces and Candidate Elimination Algorithm, Inductive bias. Decision Trees: Decision Tree learning, Representation, Algorithm, Heuristic Space Search.	8
UNIT 2	
Regression: Logistic Regression, Support Vector Machine, Kernel function and Kernel SVM Clustering: k-means, Adaptive hierarchical clustering, Gaussian mixture model.	7
UNIT 3	
Neural Networks: Neural Network Representation, Problems, Perceptron, Multilayer Networks and Back Propagation Algorithms. Genetic Algorithms: Hypothesis Space Search, Genetic Programming, Models of Evolution and Learning.	8
UNIT 4	
Bayesian Learning: Bayes Theorem, Concept Learning, Maximum Likelihood, Minimum Description Length Principle, Bayes Optimal Classifier, Gibbs Algorithm, Naïve Bayes Classifier, EM Algorithm.	8
UNIT 5	
Instant Based Learning: K-Nearest Neighbor Learning, Locally Weighted Regression, Radial Basis Functions, Case-Based Reasoning, Sequential Covering Algorithm.	7

TEXT BOOKS

1	Tom M. Mitchell, "Machine Learning", McGraw-Hill Education (INDIAN EDITION), 2013.	
2	Ethem Alpaydin, "Introduction to Machine Learning", 2nd Ed., PHI Learning Pvt. Ltd., 2013.	

REFERENCE BOOKS

1	T. Hastie, R. Tibshirani, J. H. Friedman, The Elements of Statistical Learning, Springer; 1st edition, 2001.	

Online COURSE LINK

1	1. https://www.coursera.org/learn/machine-learning.	
2	2. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-867- machine-learning-fall-2006/syllabus/#Calendar.	

	3. https://onlinecourses.nptel.ac.in/noc18_cs40/	
e-BOOK	1. Andreas C. Müller & Sarah Guido, Introduction to Machine learning with Python- A Guide for Data Scientists, Published by O'Reilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol, CA 95472.	
	2. Ethem Alpaydin, "Introduction to Machine Learning", 2nd Ed., PHI Learning Pvt. Ltd., 2013.	

Semester	VII		
Course Title	Quality Control and Regulatory aspects in Medical Devices	Course Code	19ML7PCQCR
Credits	1	L-T-P	0-0-1
At the end of the course students will have the ability to,			
CO1	Understand the requirements of Quality Assurance, Regulatory Compliance and Regulations of Medical Standards.		
CO2	Apply and Analyze Medical Standards Requirements and Compliance.		
CO3	Apply the concepts of quality assurance and control aspects for the medical device development.		
CO4	Implement medical regulatory and safety standards related to biomedical devices submission.		
CO5	In group, study, present and submit the report on medical regulatory and safety standards related to specific biomedical device.		

Course Outline:

• Quality Assurance and Regulatory Backgrounds: Quality Assurance, Regulatory Compliance, Regulations, Standards, Coping with the Increased Quality Assurance, Regulatory issues. The FDA, FDA Inspection. • ISO 9000 Standard Series, Structure of ISO 9000, Requirements and Compliance of ISO 9000. • ISO 14000 Standard Series, Structure of ISO 14000, Requirements and Compliance of 1SO 14000. • EN 46001 Standard, Structure of EN 46001, Requirements and Compliance of EN 46001. • ISO 13485 Standard, Structure of ISO 13485, Requirements and Compliance of ISO 13485..	13 hours

TEXT BOOKS		
1	1. Medical Device Quality Control and Regulatory Compliance by Richard C. Fries, Taylor & Francis Group.	
REFERENCE BOOKS		
1	1. Cost-Contained Regulatory Compliance: For the Pharmaceutical, Biologics, and Medical Device Industries by Sandy Weinberg, Wiley, Year 2011.	
E-BOOK		
	https://www.elsevier.com/books/medical-device-quality-management-systems/manz/978-0-12-814221-9	
Online Resources:		
1	https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-ge14/	
Assessment Methods	Quiz will be conducted for CIE. SEE will be a Case Study based Presentation	

Semester	VII		
Course Title	Biomedical Devices	Course Code	19ML7CE2BD
Credits	3	L-T-P	3-0-0
(Except for Medical Electronics Students) Course Outcomes:			
At the end of the course students will have ability to:			
CO1	Apply the knowledge of biomedical engineering principles in the development of modern medical devices		
CO2	Design and develop reliable solutions to solve complex design problems related to biomedical devices.		
CO3	Demonstrate knowledge and understanding of the engineering and management principles, and apply these to the development of biomedical devices, requiring multidisciplinary components.		

UNIT 1	Hours
Biomedical Devices: Physiological systems of the body – an overview, Sources of biomedical signals, Biomedical instrumentation system, Intelligent medical instrumentation systems, Interfacing biomedical signals to microprocessors, General constraints in medical device designs, Regulation of medical devices.	6
UNIT 2	
Human Factors: Introduction, Human factor process and Considerations, Anthropometry. Requirements engineering, Specifications, Software quality assurance plan. Liability, The project team,	6
UNIT 3	
Reliability of Medical devices: Basics, Effects of Medical devices, Causes of Failure, The Product design and development phase, The concept of phase: Product definition, Quality function deployment, Business proposal. Safety and Risk Management. The feasibility phase: Device classification, Overview of FDA and the approval process in India. Important medical device standards.	6
UNIT 4	
Human Factors: Introduction, Human factor process and Considerations, Anthropometry. Requirements engineering, Specifications, Software quality assurance plan. Liability, The project team,	5
UNIT 5	
The Design phase: Hardware design, Hardware risk analysis, Design and project metrics, Design for Six-sigma. Software design, Software coding, Software risk analysis, Software metrics.	4

TEXT BOOKS		
1	R.S. Khandpur, Handbook of Biomedical Instrumentation, 2nd Ed, TMH	
2	Richard C. Fries, Reliable design of Medical Devices, 3rd edition, CRC Press	
REFERENCE BOOKS		
1	The Biomedical Engineering Handbook, Third Edition - 3 Volume Set_ Biomedical	

	Engineering Fundamentals, CRC Press	
Online Resource		
1	https://www.routledge.com/Design-of-Biomedical-Devices-and-Systems-4th-edition/King-Fries-Johnson/p/book/9781138723061	
2	https://cdsco.gov.in/opencms/opencms/system/modules/CDSCO.WEB/elements/download_file_division.jsp?num_id=MzMzNg==	
3	https://nptel.ac.in/courses/127/106/127106009/	

Semester	VII		
Course Title	**Advanced Image Processing**	**Course Code**	**19ML7CE2IP**
Credits	**3**	**L-T-P**	**3-0-0**

Course Outcomes:

At the end of the course students will have ability to:

CO1	To apply knowledge of mathematics and engineering to use image transforms for image Processing.
CO2	An ability to apply region based image segmentation
CO3	An ability to apply morphological image processing algorithms
CO4	An ability to apply pattern classification methods for object detection
CO5	An ability to apply image compression techniques for storage requirements
	•**All the Unit contents will be taught and concepts will be demonstrated with reference to the Medical Images**

UNIT 1	**Hours**
Image Transforms: Matrix-based Transforms Rectangular Arrays Complex Orthonormal Basis Vectors, Biorthonormal Basis Vectors Correlation Basis Functions in the Time-Frequency Plane Basis Images Fourier-Related Transforms The Discrete hartley Transform The Discrete Cosine Transform The Discrete Sine Transform Walsh-Hadamard Transforms Slant Transform	8
UNIT 2	
Region based Image Segmentation: Region Segmentation Using Clustering and Superpixels, Region Segmentation using K-Means Clustering, Superpixel Algorithm, Specifying the Distance Measure, Region Segmentation Using Graph Cuts, Images as Graphs, Minimum Graph Cuts, Computing Minimal Graph Cuts, Graph Cut Segmentation Algorithm	8
UNIT 3	
MORPHOLOGICAL IMAGE PROCESSING: Preliminaries, Erosion and Dilation, Duality, Opening and Closing, The Hit-or-Miss Transformation, Basic Morphological Algorithms: Boundary Extraction, Hole Filling, Extraction of Connected Components, Convex Hull, Thinning, Thickening, Skeletons, Pruning, Morphological Reconstruction, Gray-Scale Morphology, Erosion and Dilation, Opening and Closing, Segmentation Using Morphological watersheds, watershed segmentation Algorithm	9
UNIT 4	
OBJECT RECOGNITION: Patterns and Pattern Classes, Recognition Based on Decision-Theoretic Methods, Matching, Optimum Statistical Classifiers, Neural Networks, Structural Methods, Matching Shape Numbers, String Matching.	7
UNIT 5	
IMAGE COMPRESSION: Introduction, coding Redundancy, Inter-pixel redundancy, image compression model , Lossy and Lossless compression, Huffman Coding, Arithmetic Coding, LZW coding, Run length coding.	7

TEXT BOOKS

1	Digital Image Processing by Rafael C. Gonzalez & Richard E. Woods, 3rd and 4th Edition. Pearson Education Inc	
2	Image Processing, Analysis and Machine-Vision by Milan Sonka, Vaclav Hlavac &	

	Roger Boyle, Second Edition	
REFERENCE BOOKS		
1	1. Digital Image Processing by S Jayakumaran, S Esakkirajan, T Veerakumar, Tata McGraw Hill Education Private Ltd	
	1. NPTELVideo Lectures	
E-Books		
1	1.http://kevinluo.net/books/book_Fundementals%20of%20Image%20Processing%20-%20Wiley-Blackwell.pdf	

Semester	VII		
Course Title	IoT Technologies for Healthcare	Course Code	19ML7OE2IO
Credits	3	L-T-P	3:0:0
Course Outcomes:			
At the end of the course students will have ability to:			
CO1	To understand the emerging applications in Internet of things for healthcare technologies.		
CO2	Infer the role of Data Analytics and Security in IoT		
CO3	Impact of IoT applications in health care.		

UNIT 1	Hours
IoT in Smart Health Care System Introduction, Classification and Categories of Wearable Devices, Communication Modes of Wearable Devices in IoT, Working Principles of Wearable Devices in IoT, Research Challenges and Open Issues	5
UNIT 2	
IoT-Based Diseases Prediction and Diagnosis System for Healthcare Materials and Methods, Dataset Types in Healthcare, Feature Extraction, Model Evaluation, Model Selection, Applications and Future Trends	5
UNIT 3	
Investigating Correlation of Tension-Type Headache and Diabetes: IoT Perspective in Health care Machine Vision, Use of Machine Intelligence in Health care, Diabetes and Headache, Big Data & Internet of Things, Experimental Study and Analysis, Future Scope and Limitations.	5
UNIT 4	
Security and Privacy Concern in IoT Health Care: IoT-Enabled Technologies and Services, Type of IoT Sensors Relates to Health Care, IoT Healthcare Framework Integrated with Cloud Computing, Different Attacks Related to IoT Health Care, Techniques Applied to Resolve the Issues of IoT. Healthcare Personal Data and Health Information Data Encryption and Decryption Techniques to Combat Security Concerns in IoT Health.	5
UNIT 5	
Applications of Internet of Things in Medical Area Medical Sector Due to IoT, Remotely Taking Care of Health, Information Over-Burden and Accuracy, Intense Consistent Glucose Checking (CGM)and Insulin Taking Devices, Associated Respiratory Inhalers, Associated Respiratory Inhalers, Digital Sensor Treatment, Prominence of IoT in Healthcare, IoT Use Cases in Healthcare, Beaming Hospitals, IoT-Related Challenges in Healthcare, Drawbacks of IoT in Healthcare.	6

TEXT BOOKS		
1	Chinmay Chakraborty , Amit Banerjee ,Maheshkumar H. Kolekar ,Lalit Garg Basabi Chakraborty, ,"Internet of Things for health care Technologies",Springer, ISSN 2197-6503,Volume 73	

Semester	VII		
Course Title	**Imaging Modalities**	**Course Code**	**19ML7OE2IM**
Credits	**3**	**L-T-P**	**3:0:0**
Course outcomes:			
At the end of the course students will have ability to:			
CO1	Recognise the need for different imaging modalities		
CO2	Compare the basic principles of various imaging modality		
CO3	Analyse the biological effects of electromagnetic fields in humans for health safety issues.		
CO4	Comprehend the published reports for the selected imaging modality. Prepare the document working in a team.		
CO5	Function effectively to communicate the prepared document as an individual and in a team.		

Unit 1: X-Rays	**Hours**
Introduction to imaging, myth busting of imaging, need of multimodality. X-Rays: Basic scientific principles of X-rays, X-ray technology, contrast, clinical applications, case study, Advanced X-ray: digital subtraction angiography (DSA), dual energy Xray absorptiometry (DXA), Orthopantomography.	8
Unit 2: Computer Tomography (CT):	8
Basic scientific principles of CT, CT Technology, Contrast, clinical applications, case study, Advanced section on CT: Back projection, maximum intensity projection reconstruction.	
Unit 3: Ultrasound	7
Basic scientific principles of ultrasound, Ultrasound technology, clinical applications, case study, Advanced section on Ultrasound: 3D reconstruction	
UNIT 4 Unit 4: Magnetic Resonance Imaging (MRI)	
Basic scientific principles of MRI - The Nuclear Spin, The MR Signal, Relaxation, Spatial Encoding, Contrast, MRI technology, Clinical Applications, case study, Advanced section on MRI: Fourier Transformation, MRI registration.	8
Unit 5: Diagnostic Nuclear Medicine	
Basic Principles of Diagnostic Nuclear Medicine, SPECT, PET, Quality Control, case study, Advanced section on Diagnostic Nuclear Medicine: PET image reconstruction, attenuation correction.	8

TEXT BOOKS		
1	Introduction to Biomedical Imaging by Andrew G. Webb Wiley-IEEE Press, Nov 2017.	
2	Guy, Chris, and Dominic Ffytche. An introduction to the principles of medical imaging. London:: Imperial College Press, 2005.	
REFERENCE BOOKS		
1	Smith, Nadine Barrie, and Andrew Webb. Introduction to medical imaging: physics, engineering and clinical applications. Cambridge university press, 2010.	
MOOCs		
1	●https://www.edx.org/course/introduction-to-biomedical-imaging ●https://www.edx.org/course/fundamentals-of-biomedical-imaging-ultrasounds-x-r https://onlinecourses.nptel.ac.in/noc20_ee40/preview	

E-Books	● Burbridge, Brent, and Evan Mah. Undergraduate diagnostic imaging fundamentals. University of Saskatchewan, 2017. (https://undergradimaging.pressbooks.com/)	
	● Maier, Andreas, Stefan Steidl, Vincent Christlein, and Joachim Hornegger, eds. "Medical imaging systems: An introductory guide.", 2018. https://link.springer.com/book/10.1007%2F978-3-319-96520-8	

Semester	VII		
Course Title	**Mini Project–3**	**Course Code**	**19ML7PWMP3**
Credits	**3**	**L-T-P**	**0-0-3**
CO#	**Course Outcomes:**		**PO# (Strength)**
CO1	Apply the knowledge of science and medical electronics engineering to provide solutions for human-health related problems		PO1 (3)
CO2	Analyze and identify biomedical engineering problems based on literature survey and need analysis		PO2 (3)
CO3	Develop solutions for relevant biomedical engineering problems with appropriate consideration of public health, safety and society		PO3 (2)
CO4	Design experimental techniques/simulation models and interpret the data conclusively		PO4 (3)
CO5	Use modern tools and resources in developing health-care solutions needing their applications		PO5 (2)
CO6	Apply reasoning based on the contextual knowledge of the design problem statement and assess societal, health and safety issues		PO6 (2)
CO7	Demonstrate the knowledge of a sustainable solution in the context of society		PO7 (1)
CO8	Apply biomedical ethics and responsibilities		PO8(2)
CO9	Function both individually and in diverse teams requiring multidisciplinary approaches.		PO9 (3)
CO10	Comprehend, prepare effective reports and make clear presentations to an engineering community		PO10 (3)
CO11	Demonstrate the knowledge of project management and financial requirements of a project work		PO11 (3)
CO12	Exhibit self-reliance and life-long learning skills to align to the new trends		PO12 (2)

Guidelines for Mini Project–3 (19ML7PWMP3)
Objective: The objective of this open ended mini project is to let the students apply the knowledge of the engineering subjects into a **real- world situation/problem**.
Guidelines:
1. The mini project MUST be done in a group of 3 / 4 students.
2. Mini project can be done in the area of **biomedical engineering or any other engineering discipline.**
3. This open ended project could be based on subjects previously learnt in academics or with own interest / subjects learning currently / subjects to be learnt during implementation
4. Mini project can be a ***simulation or hardware implementation***. **(**considering current technology/situation)
5. Each group will be allotted a **Guide**. Students in that group must discuss the project idea with Guide

before finalizing it.
6. Each group will present the idea of the project and will submit 1 - 2 page(s) of an **Abstract** of the mini project work.
7. Every week, project group will report progress of the project to allotted Guide.
8. Each group will give **four presentations** according to the schedule which will be shared with students in advance.
9. **First presentation** – is introductory presentation for approving the topic. This will not carry any marks
10. Second and Third presentations will be **PROGRESS PRESENTATIONS**; will carry marks
11. Assessment of the project progress will be based on **Rubrics** which will be shared with students in advance.
12. Final presentation is about **entire mini project implementation** with demonstration; will carry marks
13. At the end of the project, all groups will submit video of the working model and technical report in the format shared.
14. Final SEE will be conducted for 50 marks.

Semester	**VII**		
Course Title	**Strategies for Teamwork and Workplace Communication**	**Course Code**	**19ML7CSTW**
Credits	**NC**	**L-T-P**	**----**

Developing a positive company culture helps employees feel as though they belong to a team and encourages them to achieve their objectives. A team-oriented organization also fosters collaboration, which improves productivity and employee morale.

Students will be given orientation about Teamwork and Workplace Communication.
Quiz will be conducted for the assessment.

VIII Semester Syllabus

Semester	VIII		
Course Title	Intellectual Property Rights and Cyber law	Course Code	19ES8HSIPL
Credits	2	L-T-P	2:0:0
Course outcomes:			
At the end of the course students will have ability to:			
CO1	Understand and commit to professional ethics and responsibilities to obtain Intellectual property Rights like Patents, Copyright & Trademarks		
CO2	Understand the impact of Patents, Copyright & Trademarks and demonstrate the knowledge of Cyber Law for the societal and environmental context.		
CO3	Ability to use IPRs and Cyber Law to access societal, health, safety & Cultural issues		
CO4	Ability to work in multiple teams to effectively communicate IP & Cyber Law.		
CO5	Ability to work in multiple teams to discuss the case studies related toIPR & Cyber Law.		

Unit 1:	**Hours**
Basic principles of IP laws & Patents: Introduction, Concept of property, Constitutional aspects of IP, Evolution of the patent system in UK, US and India, Basis for protection, Origin and meaning of the term patent, Objective of a patent law, principles underlying the patent law in India, the legislative provisions regulating patents, Non – patentable inventions.	4
Unit 2:	
Procedure for obtaining patent: Submission of application, Filing provisional and complete specification, Examination of the application, advertisement of the acceptance, opposition, Grant and sealing of patent, Term of the patent, compulsory license. Provisional and complete specification: Definition of Specification, Kinds of specification, provisional specification, complete specification, Claims, Conditions for amendment. Rights conferred on a patentee: Patent rights, Exception and limitations, Duties of a Patentee. Transfer of patent: Forms of transfer of Patent rights, Assignment, kinds of assignment, License, kinds of license, Rights conferred on a licensee, Transmission of patent by operation of law. Infringement of patents: Construction of claims and infringement, patents held to be infringed, patents held to be not infringed.Action for Infringement: Where a suit is to be instituted, procedure followed in the suit, Onus of establishment infringement, Defence by the defendant, The Relief's, Injunction, Damages or account of profits, patent agents, patent drafting, database searching, and Case studies.	6
Unit 3:	
Copy Right: Meaning and characteristics of copy right, Indian copy right law, requirement of copy right, Illustrations copy right in literary work, Musical work, Artistic work, work of architecture, Cinematograph film, sound recording. Author and Ownership of copy right: Ownership of copy right, Contract of service, Contract for service, rights conferred by copy right, terms of copy right, license of copy right. Infringement of copy right: Acts which constitute infringement, general principle, direct and indirect evidence of copying, Acts not constituting infringements, Infringements in literary, dramatic and musical works, Remedies against infringement of copy right, Case studies Trade Marks: Introduction, Statutory authorities, procedure of registration of trademarks, rights conferred by registration of trademarks, licensing in trade mark, infringement of trade mark and action against infringement	6
UNIT 4	

Cyber Law: An introduction, Definition, why cyber law in India, Evolving cyber law practices- for corporates, privacy in Indian cyber space. Terrorism & Cyber Crime. Cyber theft and Indian telegraph act, Cyber Stalking		4
Unit 5: Diagnostic Nuclear Medicine		
Indian Cyber law: Protecting Indian children online, Spam, contempt in cyber space, Indian consumers & cyber space, E-courts of India.		4
TEXT BOOKS		
1	I Dr. T Ramakrishna, "Basic principles and acquisition of Intellectual Property Rights", CIPRA, NSLIU -2005.	
2	Dr.B.L.Wadehhra, "Intellectual Property Law Handbook", Universal Law Publishing Co. Ltd., 2002. Cyberlaw-The Indian perspective by Pavan Duggal, 2009 Edition.ntroduction to Biomedical Imaging by Andrew G. Webb Wiley-IEEE Press, Nov 2017.	
REFERENCE BOOKS		
1	Dr. T Ramakrishna, "Ownership and Enforcement of Intellectual Property Rights", CIPRA, NSLIU -2005.	
2	"Intellectual Property Law (Bare Act with short comments)", Universal Law Publishing Co. Ltd. 2007	
3	"The Trade marks Act 1999 (Bare Act with short comments)", Universal Law Publishing Co. Ltd., 2005.	
MOOCs		
1	● https://www.edx.org/course/introduction-to-biomedical-imaging ● https://www.edx.org/course/fundamentals-of-biomedical-imaging-ultrasounds-x-r https://onlinecourses.nptel.ac.in/noc20_ee40/preview	
E-Books		
1	Burbridge, Brent, and Evan Mah. Undergraduate diagnostic imaging fundamentals. University of Saskatchewan, 2017. (https://undergradimaging.pressbooks.com/)	
2	Maier, Andreas, Stefan Steidl, Vincent Christlein, and Joachim Hornegger, eds. "Medical imaging systems: An introductory guide.", 2018. https://link.springer.com/book/10.1007%2F978-3-319-96520-8	

Semester	VIII		
Course Title	PATTERN RECOGNITION	Course Code	19ML8OE3PR
Credits	3	L-T-P	3:0:0
Course outcomes:			
At the end of the course students will have ability to:			
CO1	Ability to apply knowledge of mathematics, science and engineering to understand the concepts of pattern recognition		
CO2	Ability to analyse and select a methodology of pattern recognition		
CO3	Ability to interpret pattern recognition concepts & analysis to be used in relevant application.		
CO4	Implement the concept for certain identified application, document and present the same		

UNIT1	Hrs
Introduction: Applications of pattern recognition, statistical decision theory, image processing and analysis, the internet, pointers to literature.	7
UNIT2	
Probability: Introduction, Probability of events, random variables, joint distribution & densities, moments of random variables, estimation of parameters from samples, minimizing risk estimators.	8
UNIT3	
Statistical decision making: Introduction, bayes theorem, multiple feature, conditionally independent feature, decision foundries, unequal costs of error, estimation of error rates the living one out technique characteristics curves estimating the composition of populations.	8
UNIT4	
Nonparametric decision making: introduction, histogram, kernel & window estimators, nearest neighbor classification techniques, adaptive decision foundries, adaptive.	8
Clustering: Introduction, hierarchical clustering and partitional clustering.	
UNIT5	
Artificial neural networks: Introduction, nets without hidden layers, nets with hidden layers, and the back propagation algorithm hop filed nets, an application classifying sex form facial images	8

TEXT BOOKS		
1	Pattern recognition & image analysis (chapter 1 to Chapter 6) Earl Gose, Richard Johnson Baugh & Steve Jost, PHI.	
2	Pattern Recognition Statistical structural & neural approaches, Robert J Schalkof, John Wiley, 1992.	
REFERENCE BOOKS		
1	Richard O. Duda, Peter E. Hart, and David G.Stork: Pattern Classification, 2nd Edition, Wiley-Interscience, 2001.	
2	K. Jain, R. Bolle, S. Pankanti: Biometrics: Personal Identification in Networked Society, Kluwer Academic, 1999	
MOOCs		

1	● https://www.edx.org/course/introduction-to-biomedical-imaging ● https://www.edx.org/course/fundamentals-of-biomedical-imaging-ultrasounds-x-r https://onlinecourses.nptel.ac.in/noc20_ee40/preview	
E-Books	● Burbridge, Brent, and Evan Mah. Undergraduate diagnostic imaging fundamentals. University of Saskatchewan, 2017. (https://undergradimaging.pressbooks.com/)	
	● Maier, Andreas, Stefan Steidl, Vincent Christlein, and Joachim Hornegger, eds. "Medical imaging systems: An introductory guide.", 2018. https://link.springer.com/book/10.1007%2F978-3-319-96520-8	

Semester	VIII		
Course Title	BIOMETRICS	Course Code	19ML8OE3BM
Credits	3	L-T-P	3:0:0
Course outcomes:			
At the end of the course students will have ability to:			
CO1	Ability to apply knowledge of mathematics, science and engineering to understand the concepts of Biometrics.		
CO2	Ability to analyse and select a methodology of Biometrics.		
CO3	Ability to interpret Biometric concepts & analysis to be used in relevant application.		
CO4	Implement the concept for certain identified application, document and present the same.		

Unit 1	Hours
INTRODUCTION Person Recognition, Biometric Systems, Enrolment and recognition phases, Sensor module, Feature extraction module, Database module, Matching module, Biometric Functionalities, Verification, Identification, Biometric System Errors, Performance measures, The Design Cycle of Biometric Systems, Nature of the application, Choice of biometric trait, Data collection, Choice of features and matching algorithm, Evaluation, Applications of Biometric Systems, Security and Privacy Issues.	7
Unit 2	
FINGERPRINT RECOGNITION: Introduction, Friction Ridge Pattern, Features, Formation, Fingerprint Acquisition, Sensing techniques Image quality, Feature Extraction, Ridge orientation and frequency estimation, Singularity extraction, Ridge extraction, Minutiae extraction, Matching, Alignment , Pairing minutiae, Match score generation, Latent fingerprint matching, Fingerprint individuality, Performance evaluation Fingerprint Indexing, Fingerprint Synthesis, Level 1 feature synthesis, Level 2 feature synthesis, Palm print, Palm print features Palm print recognition in forensics, Palm print recognition for access control.	8
Unit 3	
FACE RECOGNITION: Introduction, Psychology of face recognition, Facial features, Design of a face recognition system, Image Acquisition, 2D Sensors 3D Sensors, Video sequences, Face Detection, Viola-Jones face detector, Feature Extraction and Matching, Appearance-based face recognition, Model-based face recognition, Texture-based face recognition, Performance evaluation, Advanced Topics, Handling pose, illumination, and expression variations , Heterogeneous face recognition , Contents xv, Face modelling.	8
UNIT 4	
IRIS RECOGNITION:Introduction, Design of an Iris Recognition System, Image Acquisition, Iris Segmentation, Segmentation using the integro-differential operator, Segmentation using Geodesic Active Contours (GAC), Generating iris masks, Iris Normalization, Iris Encoding and Matching, Iris Quality, Quality assessment techniques, Performance Evaluation.	8

UNIT 5		
MULTIBIOMETRICS, SECURITY SYSTREMS Introduction, Ear detection, Ear recognition, Challenges in ear recognition, Gait, Feature extraction and matching, Challenges in gait recognition, Hand Geometry, Image capture, Hand segmentation, Feature Extraction, Feature matching, Challenges in hand geometry recognition, Soft Biometrics, Sources of Multiple Evidence, Acquisition and Processing Architecture, Fusion Levels, Adversary Attacks, Insider attacks, Infrastructure attacks, Attacks at the User Interface, Impersonation, Obfuscation, Spoofing, Countermeasure: spoof detection, Attacks on Biometric Processing, Attacks on the system modules, Attacks at the interconnections, Attacks on the Template Database, Countermeasure: biometric template security.		8
TEXT BOOKS		
1	Introduction to Biometrics by Anil K. Jain, Arun A. Ross, Karthik Nandakumar. Springer Publications.	
REFERENCE BOOKS		
1	Biometrics- The Ultimate Reference- John D. Woodward, Jr. Wiley Dreamtech.	
2	Personal Identification in Networked Society, Jain, A.K.; R Bolle, Ruud M.; S Pankanti, Sharath, 1st ed. 1999. 2nd printing, 2006, Springer Publications	
3	Handbook of Biometrics, Jain, Anil K.; Flynn, Patrick; Ross, Arun A, Springer, 2008.	
MOOC LINKS		
1	●https://nptel.ac.in/courses/106/104/106104119/ https://www.coursera.org/lecture/usable-security/biometric-authentication-RXVog	

Semester	VIII		
Course Title	**MAJOR PROJECT WORK**	**Course Code**	**19ML8PWMPJ**
Credits	**9**	**L-T-P**	**0-0-9**

Course Outcomes:

CO#	CO	PO# (Strength)
CO1	Apply the knowledge of science and medical electronics engineering to provide solutions for human-health related problems	PO1 (3)
CO2	Analyze and identify biomedical engineering problems based on literature survey and need analysis	PO2 (3)
CO3	Develop solutions for relevant biomedical engineering problems with appropriate consideration of public health, safety and society	PO3 (2)
CO4	Design experimental techniques/simulation models and interpret the data conclusively	PO4 (3)
CO5	Use modern tools and resources in developing health-care solutions needing their applications	PO5 (2)
CO6	Apply reasoning based on the contextual knowledge of the design problem statement and assess societal, health and safety issues	PO6 (2)
CO7	Demonstrate the knowledge of a sustainable solution in the context of society	PO7 (1)
CO8	Apply biomedical ethics and responsibilities	PO8(2)
CO9	Function both individually and in diverse teams requiring multidisciplinary approaches.	PO9 (3)
CO10	Comprehend, prepare effective reports and make clear presentations to an engineering community	PO10 (3)
CO11	Demonstrate the knowledge of project management and financial requirements of a project work	PO11 (3)
CO12	Exhibit self-reliance and life-long learning skills to align to the new trends	PO12 (2)

Rules and Regulations for UG VIII Semester Major Project work

- students Batch should not exceed 3 per group.
- Students should make a team and register the batch with the Project Coordinator.
- Student Batches are allotted with faculty as guides.
- Problem Statement needs to be preferable from Healthcare Domain.
- The Head of the Department shall form a review committee for project work for Synopsis.
- There shall be three reviews during the semester for evaluating the CIE.

Semester	VIII		
Course Title	**Internship Seminar**	**Course Code**	**19ML8DCISR**
Credits	**2**	**L-T-P**	**0-0-2**

CO#	Internship and Seminar Outcomes
CO 1	engage in internship in an engineering domain, and comprehend the professional norms of the organization
CO 2	Identify the key engineering, management, science, mathematics concepts, being transformed to a successful organization
CO 3	identify the community that benefit from the product
CO 4	Identify and comprehend the professional norms and the model for sustainable development of the organization
CO 5	Identify the skills/concepts from various disciplines, and able to perform as a member of the multidisciplinary team
CO6	prepare the project report, three minute video and the poster of the work

Rules and Regulation for Internship Seminar

- Students should perform an internship for a duration of 12 to 16 weeks.
- Internship to be performed in healthcare domain in Industries or Hospitals.
- The internships can be taken up in an industry, a government organization, a research organization or an academic institution, either in the country or outside the country
- Internship completion certificate should be produced in the report.
- An internship report should be submitted for the CIE assessment as per the rubrics of internship seminar.

Semester	VIII		
Course Title	**MOOCs/ Virtual Lab with certification**	**Course Code**	**19ML8NCMVL**
Credits	**NC**	**L-T-P**	**0**

*Students should take MOOC Courses of their choice or can do virtual lab certification program.

* Students need to submit the certificate to obtain Pass grade.