MYSORE UNIVERSITY SCHOOL OF ENGINEERING

Scheme of Teaching and Examination 2021-2022 (As per NEP-2020)
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
(Effective from the academic year 2021–2022)

B.E. in Biomedical and Robotic Engineering [BR]

III SEMESTER

Sl. No.	Course & Course Code		Course Title	Teaching Dept.	Paper Setting Board	Teaching Hours/week			Examination				Credits
						Theory/Lecture	Tutorial	Practical/ Drawing	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
						L	T	P					
1	BSC	21MAT31	Engineering Mathematics-III	Basic Science	Basic Science	2	2	0	03	50	50	100	3
2	PCC	21BR32	Analog Circuit Design	BM & RE	BM & RE	3	2	0	03	50	50	100	4
3	PCC	21BR33	Digital Circuit Design	BM & RE	BM & RE	3	2	0	03	50	50	100	4
4	PCC	21BR34	Basics of Human Anatomy and Physiology	BM & RE	BM & RE	3	0	0	03	50	50	100	3
5	PCC	21BR35	Fundamentals of Robotics	BM & RE	BM & RE	3	2	0	03	50	50	100	4
6	IPCC	21BRL36	Analog and Digital Circuit Design Lab	BM & RE	BM & RE	0	0	3	03	50	50	100	2
7	CEE	21CIV37	Environmental Studies	CEE	CEE	1	0	0	NA	50	-	50	1
8	UHV	21UHV38	Universal Human Values and Professional Ethics	Basic Science	Basic Science	1	0	0	NA	50	-	50	1
Total						**16**	**08**	**03**	**18**	**400**	**300**	**700**	**22**

Note: BSC: Basic Science Courses, PCC: Professional Core Courses, IPCC: Integrated Professional Core Courses, PEC: Professional Elective Course, OEC: Open Elective Course, CEE: Civil Environmental Engineering, MP: Mini Project, INT: Internship, AEC: Ability Enhancement Course. UHV: Universal Human Values, HSMC: Humanity, Social Science and Management Courses. NCMC: Non-credit mandatory course,

Course prescribed to lateral entry Diploma holders admitted to III semester of Engineering programs

10	NCMC	21MATDIP31	Additional Mathematics-1	Basic Science	Basic Science	2	1	0	-	50	-	50	0
11	NCMC	21KANDIP32	Technical Kannada	Basic Science	Basic Science	0	2	0	-	50	-	50	0

(a) The mandatory non – credit courses Additional Mathematics I and II prescribed for III and IV semesters respectively, to the lateral entry Diploma holders admitted to III semester of BE programs, shall attend the classes during the respective semesters to complete all the formalities of the course. In case, any student fails to register for the said course/ fails to secure the minimum 40 % of the prescribed CIE marks, he/she shall be deemed to have secured F grade. In such a case, the student has to fulfil the requirements during subsequent semester/s.
(b) These Courses shall not be considered for vertical progression, but completion of the courses shall be mandatory for the award of degree

Credit Definition:
- 1-hour lecture **(L)** per week per semester = **1 Credit**
- 2-hour tutorial **(T)** per week per semester = **1 Credit**
- 2-hour Practical/Drawing **(P)** per week per semester = **1 Credit**

- **Four-credit** courses are to be designed for **50** hours of Teaching-Learning process.
- **Three credit** courses are to be designed for **40** hours of Teaching-Learning process.
- **Two credit** courses are to be designed for **25** hours of Teaching-Learning process.
- **One credit** courses is to be designed for **15** hours of Teaching-Learning process.

AICTE Activity Points to be earned by students admitted to BE/B.Tech., day college programme (For more details refer to Chapter 6, AICTE Activity Point Programme, Model Internship Guidelines): Over and above the academic grades, every Day College regular student admitted to the 4 years Degree programme and every student entering 4 years Degree programme through lateral entry, shall earn 100 and 75 Activity Points respectively forthe award of degree through AICTE Activity Point Programme. Students transferred from other Universities to the fifth semester are required to earn 50 Activity Points from the year of entry toUoM. The Activity Points earned shall be reflected on the student's eighth semester Grade Card. The activities can be spread over the years, anytime during the semester weekends and holidays, as per the liking and convenience of the student from the year of entry to the programme. However, the minimum hours' requirement should be fulfilled. Activity Points (non-credit) do not affect SGPA/CGPA and shall not be considered for vertical progression. In case students fail to earn the prescribed activity Points, an Eighth semester Grade Card shall be issued only after earning the required activity Points. Students shall be admitted for the award of the degree only after the release of the Eighth semester Grade Card.

MYSORE UNIVERSITYSCHOOLOFENGINEERING

Scheme ofTeachingandExamination2021-2022 (As per NEP-2020)
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
(Effectivefromtheacademicyear2021–2022)

B.E. in Biomedical and Robotic Engineering[BR]

IV SEMESTER

Sl. No	Course & Course Code		Course Title	Teaching Dept.	Paper Setting Board	Teaching Hours/week			Examination				Credits
						Theory/Lecture	Tutorial	Practical/ Drawing	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
						L	T	P					
1	BSC	21MAT41	Engineering Mathematics-IV	Basic Science	Basic Science	2	2	0	03	50	50	100	3
2	PCC	21BR42	Signal Conditioning and Data Acquisition Circuits	BM & RE	BM & RE	3	2	0	03	50	50	100	4
3	PCC	21BR43	Biomedical Transducers and Instrumentation	BM & RE	BM & RE	3	0	0	03	50	50	100	3
4	IPCC	21BR44	Microcontroller and Embedded Systems	BM & RE	BM & RE	3	0	2	03	50	50	100	4
5	PCC	21BR45	Control Systems	BM & RE	BM & RE	3	2	0	03	50	50	100	4
6	IPCC	21BRL46	Signal Conditioning and Biomedical Transducers Lab	BM & RE	BM & RE	0	0	3	03	50	50	100	2
7	HSMC	21CPH47	Constitution of India, Professional Ethics and Cyber Law	Basic Science	Basic Science	1	0	0	NA	50	-	50	1
8	AEC	21AEC48	Ability Enhance Course-II	BM & RE	BM & RE	1	0	0	NA	50	-	50	1
9	INT	21INT49	Summer Internship-I	(To be carried out during the intervening vacations of IV and V semesters)					-	-	-	-	-
Total						**16**	**06**	**05**	**18**	**400**	**300**	**700**	**22**

Note: BSC: Basic Science Courses, PCC: Professional Core Courses, IPCC: Integrated Professional Core Courses, PEC: Professional Elective Course, OEC: Open Elective Course, MP: Mini Project, INT: Internship, AEC: Ability Enhancement Course. UHV: Universal Human Values, HSMC: Humanity, Social Science and Management Courses. NCMC: Non-credit mandatory course,

Summer Internship-I (21INT59): shall be carried out at industrial (State and Central Government /Non-government organizations (NGOs)/Micro, Small and Medium Enterprise (MSME)/Innovation centers/ Incubation centers. The internship can also be Rural internship. All the students admitted shall have to undergo a mandatory internship of 04 weeks during the intervening vacation of IV and V semesters. A University Viva-Voce examination (Presentation followed by Question & Answer session) shall be conducted during V semester and the prescribed credit shall be included in the V semester. The internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take up/complete the internship shallbe declared fail and shall have to complete during subsequent University examination after satisfying the internship requirements. (The faculty coordinator or mentor has to monitor the students' internship progress and interact to guide them for the successful completion of the internship.)
Summer Internship-I: SEE shall be through seminar and viva-voce.

Course prescribed to lateral entry Diploma holders admitted to III semester of Engineering programs

11	NCMC	21MATDIP41	Additional Mathematics-II	Basic Science	Basic Science	02	01	-	-	50	-	50	0
12	NCMC	21ENGDIP42	Technical English	Basic Science	Basic Science	-	2	-	-	50	-	50	0

(a) The mandatory non – credit courses Additional Mathematics I and II prescribed for III and IV semesters respectively, to the lateral entry Diploma holders admitted to III semester of BE programs, shall attend the classes during the respective semesters to complete all the formalities of the course. In case, any student fails to register for the said course/ fails to secure the minimum 40 % of the prescribed CIE marks, he/she shall be deemed to have secured F grade. In such a case, the student has to fulfil the requirements during subsequent semester/s.
(b) These Courses shall not be considered for vertical progression, but completion of the courses shall be mandatory for the award of degree

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- **Two credit** courses are to be designed for **25** hours of Teaching-Learning process.
- **One credit** courses is to be designed for **15** hours of Teaching-Learning process.

AICTE Activity Points: In case students fail to earn the prescribed activity Points, an Eighth semester Grade Card shall be issued only after earning the required activity Points. Students shall be admitted for the award of the degree only after the release of the Eighth semester Grade Card.

Engineering Mathematics-III [21MAT31]

Semester III			
No. of Teaching hour/Week	2	**CIE Marks**	50
No. of Tutorial hours/week	2	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L: T:P	2:1:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Fourier Series:** Periodic functions, Dirichlet's condition. Fourier series of periodic functions period 2π and arbitrary period. Half range Fourier series. Application of Practical harmonic analysis.	**08 Hours**
Module 2	**Fourier Transforms:** Infinite Fourier transforms, Fourier sine and cosine transforms. Inverse Fourier transforms. Problems.	**08 Hours**
Module 3	**Difference Equations and Z-Transforms:** Differenceequations, basic definition, z-transform-definition, Standard z- transforms, Damping and shifting rules, initial value and final value theorems (without proof) and problems, Inverse z-transform and applications to solve difference equations.	**08 Hours**
Module 4	**Partial Differential Equations (PDE's):** Formation of PDE's by elimination of arbitrary constants and functions. Solution of non-homogeneous PDE by direct integration. Homogeneous PDEs involving derivative withrespect to one independent variable only. Solution of Lagrange's linear PDE. Derivation of one-dimensional heat equation and wave equation. Solution of one-dimensional heat equation and wave equation by the method of separation of variables.	**08 Hours**
Module 5	**Statistical Methods:** Correlation and regression-Karl Pearson's coefficient of correlation and rank correlation-problems. Regression analysis- lines of regression –problems. **Curve Fitting:** Curve fitting by the method of least squares-fitting the curves of the form- $y = ax + b, y = ax^b and$ $y = ax^2 + bx + c.$	**08 Hours**

Course outcomes:

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

- Explain the basic concepts of Fourier Series, Fourier Transforms, Z-Transforms, Partial Differential Equations, Some concepts of statistical analysis and curve fitting.
- Apply the above concepts of the syllabus in their respective branches of engineering.
- Analyse the solutions of engineering problems using these concepts.

Text Books:

1. E. Kreyszig: Advanced Engineering Mathematics, John Wiley & Sons, 10th Ed.(Reprint), 2017.
2. B.S. Grewal: Higher Engineering Mathematics, Khanna Publishers, 44th Ed., 2017.
3. B.V.Ramana: "Higher Engineering Mathematics" 11th Edition, Tata McGraw-Hill, 2010.

Reference Books:

1. Srimanta Pal & Subobh C Bhunia: “Engineering Mathematics”, Oxford University Press, 3rd Reprint, 2016.
2. C.Ray Wylie, Louis C.Barrett : “Advanced Engineering Mathematics", 6th Edition, 2. McGrawHill Book Co., New York, 1995.
3. S.S.Sastry: “Introductory Methods of Numerical Analysis”, 11th Edition, Tata McGraw-Hill, 2010
4. N.P.Bali and Manish Goyal, “A Text Book of Engineering Mathematics”, Laxmi Publications. Latest edition, 2014.
5. Chandrika Prasad and Reena Garg “Advanced Engineering Mathematics”, Latest edition, Khanna Publishing, 2018.

Additional Mathematics-I [21MATDIP31]

Semester III			
No. of Teaching hour/Week	2	**CIE Marks**	50
No. of Tutorial hours/week	1	**SEE Marks**	-
Total No. of Lecture hours	40	**Exam Hours**	-
L: T:P	2:1:0	**Credits**	00

Modules	Course Content	Teaching Hours
Module 1	**Introduction to Complex Variables:** Definitions and properties. Modulus and amplitude of a complex number, Argand's diagram, De-Moivre's theorem (without proof). **Vector Algebra:** Scalar and vectors. Addition and subtraction and multiplication of vectors- Dot and Cross products, problems.	**08 Hours**
Module 2	**Differential Calculus**: Review of successive differentiation-illustrative examples. Maclaurin's series expansions-Illustrative examples. Partial Differentiation: Euler's theorem-problems on first order derivatives only. Total derivatives-differentiation of composite functions. Jacobians of order two-Problems.	**08 Hours**
Module 3	**Vector Differentiation**: Differentiation of vector functions. Velocity and acceleration of a particle moving on a space curve. Scalar and vector point functions. Gradient, Divergence, Curl-simple problems. Solenoidal and irrotational vector fields-Problems.	**08 Hours**
Module 4	**Numerical Methods:** Finite differences. Interpolation/ extrapolation using Newton's forward and backward difference formulae (Statements only)-problems. Solution of polynomialand transcendental equations – Newton-Raphson and Regula- Falsi methods (only formulae)-Illustrative examples. Numerical integration: Simpson's one third rule and Weddle's rule (without proof) Problems.	**08 Hours**
Module 5	**Ordinary differential equations (ODE's)**. Introduction-solutions of first order and first-degree differential equations: exact, linear differential equations. Equations reducible to exact and Bernoulli's equation.	**08 Hours**

Course outcomes:

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

- Explain the basic concepts of complex trigonometry, differential calculus and vector differentiation, Numerical methods, Ordinary Differential Equations of first order.
- Apply the above concepts of the syllabus in their respective branches of engineering.
- Analyze the solutions of engineering problems using these concepts.

Text Books:

1. S C Chapra and R P Canale, *Numerical Methods for Engineering*, 15th Edition, Tata McGraw Hill
2. Erwin Kreyszig, *Advanced Engineering Mathematics*, Latest edition, Wiley Publications.
3. B.S. Grewal, *Higher Engineering Mathematics*, Latest edition, Khanna Publishers.
4. B.V. Ramana, *Higher Engineering Mathematics*, Latest edition, Tata McGraw Hill.

Reference Books:

1. Srimanta Pal & Subodh C. Bhunia: *"Engineering Mathematics"* Oxford University Press, 3rd Reprint, 2016.
2. N.P Bali and Manish Goyal: *"A textbook of Engineering Mathematics"* Laxmi Publications, Latest edition.
3. H.K.Dass and Er. Rajnish Verma: *"Higher Engineering Mathematics"* S.Chand Publication (2014).

Analog Circuit Design [21BR32]

Semester III			
No. of Teaching Hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture Hours	40	**Exam Hours**	03
L: T:P	3:1:0	**Credits**	04

Modules	Course Content	Teaching Hours
Module 1	**BJT Biasing:** Introduction, operating point, Fixed-bias configuration, Emitter-bias configuration, Voltage-dividerbiasing, Collector feedback bias, Emitter follower configuration. Current mirror circuits, Bias stabilization.	**08 Hours**
Module 2	**AC Analysis of BJT:** Introduction, BJT modeling, r_e transistor model: Common Emitter and fixed bias configuration, Voltage-divider bias, CE Emitter-bias Configuration, Emitter follower configuration, Cascaded Systems, mention of Cascode & Darlington connection and its application. The Hybrid equivalent model, Approximate Hybrid equivalent circuit: Fixed bias configuration, Voltage-divider configuration, Hybrid π model.	**08 Hours**
Module 3	**FET Biasing:** Introduction, Fixed-bias configuration, Self-bias configuration, Voltage-divider biasing. **FET Amplifiers:** Introduction, JFET Small signal model, JFET AC equivalent circuit, Fixed- bias configuration, Self-bias configuration with by passed source resistance, Voltage-divider configuration, Source follower configuration.	**08 Hours**
Module 4	**BJT and JFET Frequency Response:** Introduction, General Frequency Considerations, Low Frequency Response of BJT Amplifier, Low Frequency Response of FET Amplifier, Miller Effect Capacitance, High frequency response of BJT Amplifier, High frequency response of FET Amplifier.	**08 Hours**
Module 5	**Power Amplifiers:** Introduction, Series Fed Class A Amplifier, Transformer-Coupled Class A Amplifier, Class B Amplifier operation. **Class B amplifier circuits:** Transformer-Coupled Push-Pull and Complementary–Symmetry circuits, Amplifier Distortion. **Feedback and Oscillator Circuits:** Feedback concepts, Feedback connection types, effects of negative feedback, Practical feedback circuits: BJT current series and FET voltage shunt feedback configurations. Oscillator operation, Barkhaunsen's criteria, RC phase oscillator using BJT.	**08 Hours**

Course outcomes:

After Studying this course, students will be able to

- Design and implement a biasing circuit for BJT and FET
- Model the BJT/FET amplifier for ac analysis
- Analyze Frequency response of BJT and FET amplifier
- Acquire the knowledge of classifications of Power amplifier and its operation
- Understand the feedback concepts and designing of oscillator circuits

Text and Reference Books:

Text Book:

Robert L Boylestad and Louis Nashelsky, Electronic Devices and Circuit Theory, 10th Edition, Pearson Prentice Hall, 2009

Reference Books:

1. David A. Bell, Electronic Devices and Circuits, 5th Edition, Oxford University Press, 2008
2. Anil K Maini, VarshaAgarwal, Electronic Devices and Circuits, Wiley, 2012.
3. Jacob Millman, Christos C. Halkias,Integrated Electronics: Analog and Digital Circuits and Systems, McGraw-Hill, 2015

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/108102112
2. https://nptel.ac.in/courses/108105158
3. http://elearning.vtu.ac.in/econtent/ECE.php#
4. http://elearning.vtu.ac.in/econtent/courses/video/ECE/06ES32.html
5. http://elearning.vtu.ac.in/econtent/courses/video/ECE/Analog_Electronics_Lab.html

Digital Circuit Design [21BR33]

Semester III			
No. of Teaching Hour/Week	3	**CIE Marks**	50
No. of Tutorial Hours/Week	2	**SEE Marks**	50
Total No. of Lecture Hours	40	**Exam Hours**	03
L: T:P	3:1:0	**Credits**	04

Modules	Course Content	Teaching Hours
Module 1	**Principles and Design of Combinational Logic:** Theorems and Properties of Boolean algebra, Boolean Functions, Definition of combinational logic, Canonical forms, Generation of switching equations from Truth Tables, Relevant Problems	**08 Hours**
Module 2	**Karnaugh Maps:** Minimum forms of switching functions, two and three variable Karnaugh maps, four variable Karnaugh maps, determination of minimum expressions using essential prime implicants, Quine-McClusky Method: determination of prime implicants. Related Problems.	**08 Hours**
Module 3	**Logic Circuit Design:** Arithmetic Operation, Combinational Circuit, Binary Adder, Binary Subtractor, Binary Parallel Adder, The Look-Ahead-Carry Binary Adders, Comparator. **Data Processing:** Introduction, Decoders: One-to-Two Line Decoder, Two-to-Four Line Decoder, Three-to-Eight Line Decoder, Encoders: Four-to-Two Line Encoder, Four-to-Two Line Priority Encoders, Multiplexers: Two-to-One Multiplexer, Four-to-One Multiplexer, Eight-to-One Multiplexer, Cascading of Multiplexer using Enable	**08 Hours**
Module 4	**Latches and Flip-Flops:** Set Reset Latch, Gated Latches, Edge-Triggered D Flip Flop 3, SR Flip Flop, J K Flip Flop, T Flip Flop, Relevant Problems.	**08 Hours**
Module 5	**Design of Sequential Circuits:** Introduction, Notations, Moore and Mealy Sequential Circuits, Analysis of Asynchronous Sequential Circuits. **Registers and Counters:** Introduction, Registers, ShiftRegisters, Ripple Counters, Synchronous counters, timing sequences, shift registers, design of Binary counters, counters for other sequences, counter design using SR and J K Flip Flops.	**08 Hours**

Course outcome:

After Studying this course, students will be able to

- Ability to apply the knowledge of mathematics and science to understand the operation of logic circuits and performance parameters.
- Ability to apply the simplification techniques/methods to optimize and implement the digital functions/circuits.
- Ability to analyze the given logic circuit based on the knowledge of digital elements
- Ability to design a combinational and sequential logic circuit for the given requirements/specifications
- Ability to understand and design the State machines with state graphs for sequential design

Text and Reference Books:

Text Books:

1. Charles H. Roth. Jr, Larry L. Kenny, "**Fundamentals of Logic Design**", 7th edition, Cengage Learning, ISBN: 978-1133628477.
2. Morris Mano , "**Digital Logic and Computer Design**", Pearson, 2016, ISBN: 9789332542525.
3. HDL Programming VHDL and Verilog by Nazeih M Botros, 2009, Dremtech Press

Reference Books:

1. Tomas Lang, Jaime H Moreno, "**Introduction to Digital System**", Milos Ercegovac, John Wiley, 2005, ISBN:978-8126522514.
2. John M Yarbrough, "**Digital Logic Applications & Design**", Cengage Delmar Learning India Pvt, 2015, ISBN: 9788131500583.

Basics of Human Anatomy and Physiology [21BR34]

Semester III			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L: T:P	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Homeostasis, Tissue, Cartilage:** Levels of structural complexity, The internal environment and homeostasis, Communication, Movement of substances within the body, Body fluids, Cell structure and functions. Tissues: Epithelial tissue (all types), Connective tissue (all types), Cartilage- Hyaline cartilage, Fibrocartilage, Elastic cartilage.	**08 Hours**
Module 2	**Cardiovascular System:** Introduction, Blood vessels- Arteries and Arterioles, Veins and Venules, Capillaries. Control of blood vessel diameter, Blood supply- internal respiration, cell nutrition. Heart- position, structure - pericardium, myocardium, endocardium, interior of the heart. Flow of blood through the heart, blood supply to heart. Conducting system of the heart, factors affecting heart rate, Cardiac cycle, cardiac output, blood pressure, control of blood pressure, pulse and factors affecting the pulse rate. Circulation of the blood- pulmonary circulation, systemic circulation-aorta (different parts of aorta & their blood supply, in brief). Summary of the main blood vessels (arteries & veins, brief explanation with flow diagram only)	**08 Hours**
Module 3	**Nervous System:** Functional Components of nervous system, Neurons: Properties of neurons, Cell bodies, Axon and Dendrites, Nerve impulse (action potential). Types of nerves, Synapse and neurotransmitters, neuromuscular junction. Central nervous system: Meninges, ventricles of the brain and CSF. Brain: Cerebrum, functions of cerebrum, functional areas of the cerebrum, Brainstem, Cerebellum, Spinal cord- grey matter, white matter, Spinal nerves (in brief list & functions only), Cranial nerves (in brief list & functions only), Autonomic nervous system (in brief)- functions and effects.	**08 Hours**
Module 4	**Respiratory System:** Organs of respiration, Nose and Nasal cavity- position, structure and functions, Pharynx - position, structure, functions. Larynx - position, structure and functions. Trachea - position, structure, functions, Bronchi, bronchioles and alveoli – structure and functions, Lungs- position, associated structure, pleura and pleural cavity. Respiration - muscles of respiration, cycle of respiration, variables affecting respiration, lung volumes and capacity. **Digestive System:** Introduction, Organs of the digestivesystem, Basic structure of the alimentary canal, Stomach - Structure, gastric juice and functions of stomach.	**08 Hours**
Module 5	**Urinary System:** Introduction, Kidneys – Gross structure of kidney, microscopic structure of kidney, Functions of kidney. **Skeletal System:** Bone - Types of bone, Bone structure, microscopic structure of bone, Functions of bone. Skull bones	**08 Hours**

	(name and position only), Sinuses, Fontanelles, Vertebral column - characteristics of typical vertebra, Different parts of vertebral column (name and position only), Features ofvertebral column, Functions of vertebral column. Bones of Thoracic cage (name and position only), Bones of shouldergirdle and upper limb (name and position only), Bones of pelvicgirdle and lower limb (name and position only). **Muscles and Joints:** Muscle tissue: Skeletal muscle, Smooth muscle, Cardiac muscle, functions of muscle tissue. Types of joint- Fibrous, Cartilaginous, Synovial, Characteristics of synovial joints, shoulder joint, Hip joint, Knee joint.	

Course outcomes:

After Studying this course, students will be able to

- Describe internal environment of human body and explain the fundamental concept of homeostasis.
- Explain the structure and functioning of various types of tissues.
- Describe the structure and explain the functioning of various nervous system, cardiovascular system, respiratory system, digestive system and musculoskeletal system.
- Demonstrate and analyze various physiological parameters in normal and abnormal conditions.

Text and Reference Books:

Text Books:

1. Ross & Wilson's Anatomy and Physiology in Health and Illness – by Anne Waugh and Allison Grant, 9th Edition, Churchill Livingstone Publications

Reference Books:

1. Concise Medical Physiology- by Sujit K. Chaudhuri, 5th Edition, New Central Book Agency Pvt. Ltd.
2. Essentials of Medical Physiology - by K. Sembulingam and Prema Sembulingam, 3rd Edition, Jaypee Publications
3. Human Physiology: From Cells to Systems – by Lauralee Sherwood, 6th Edition, Thomson India Edition, 2007.

Fundamentals of Robotics [21BR35]

Semester III			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L: T:P	3:1:0	**Credits**	04

Modules	Course Content	Teaching Hours
Module 1	**Introduction to Robotics:** Introduction to Robotics and Automation technologies, Brief history of robotics, Robot Anatomy, Four common configurations of Robot, Robot motions-Linear, Rotational, Revolving, twisting, Cylindrical, Spherical. **Degrees of Freedom of Robot,** Introduction to degrees of freedom, three degrees of freedom associated with arm and body polar Robot. Three degrees of freedom associated with robot wrist, Joint notation scheme. Work Volume, links and joints. Introduction to End Effectors-types-basic definitions and operations, Spatial Resolution, Accuracy, Repeatability, and Compliance.	**08 Hours**
Module 2	**Robot Control Systems:** Introduction to Mathematical model of spring mass damper system. The Four types of Robot controls: Limited sequence robots, Playback robots with pointto point control, playback robots with continuous path control, intelligent control. Robot controllers-On-off, proportional, integral, proportional-plus-integral, proportional-plus-derivative, proportional-plus integral plus derivative.	**08 Hours**
Module 3	**Robot ARM Kinematics:** Introduction to manipulator kinematics, Robot position representation, Forward transformation of a 2-degree of freedom Arm, Reverse Transformation of the 2-Degree of freedom Arm. **Robot ARM Dynamics:** Introduction to robot arm dynamics, understanding of Dynamics using Euler-Lagrangian-formation method. Only Introduction to Denavit–Hartenberg parameters. Simple problems on transformations.	**08 Hours**
Module 4	**Robot Sensors and Actuators: Feedbackcomponents**: Internal state sensors, external state sensors position,velocitysensors, Resolvers, Encoders.Tactile sensor, Force sensors, Joint sensing, Tactile array sensors, Proximity and range sensors, Introduction to functions of Machine vision systems only.	**08 Hours**
Module 5	**Introduction to Robot Programming:**Methods of Robot Programming-Lead through methods, Textural robot languages, Powered lead through, manual lead through. Introduction to generations of Robot Programming Languages-First Generation Languages-Second generation languages. Robot language structure block diagram. Definitions of Robot Language Elements and its functions, Robot Applications in Engineering and Specific applications in healthcare/Biomedical.-Practical demo	**08 Hours**

Course outcomes:

After studying this course, students will able to:

1. Comprehend basic concepts of robot which includes Degrees of freedom, links, joints, robot performances.
2. Develop the control aspect of robotic systems.
3. Analyze the different transformations associated with robot kinematics and robot arm dynamics, motion equations.
4. Illustrate different attributes of robot sensors and actuators.
5. To comprehend the basics/ fundamentals of Robot programming and its structure, to understand the applications of robotics in engineering and healthcare sectors.

Text and Reference Books:

Text Books:

1. Mikell P Groover, Industrial Robotics-Technology, Programming and Applications 2nd edition, Tata McGraw Hill
2. Robert J Schilling, Fundamentals of Robotics,2003.
3. Richard D.Klafter, Robotics Engg. PHI, 2003.
4. R.K.Mittal and J.Nagarath, Robotics and Control,Tata McGraw Hill, Year 1995.

Reference Books:

1. K.S.Fu, R.C.Gonzales and Lee. Robotics, McGraw Hill International, 2008.
2. Ganesh S Hegde, Industrial Robotics –Second Edition.

Analog and Digital Circuit Design Lab [21BRL36]

Semester III			
No. of Lecture hour/Week	-	**CIE Marks**	50
No. of Tutorial hours/week	-	**SEE Marks**	50
Total No. of Lecture hours	03	**Exam Hours**	03
L: T:P	0:0:2	**Credits**	02

List of Experiments

Sl No.	Course Content
1.	Study and plot the input and output characterises of CE transistor
2.	Study and plot the drain and transfer characteristics of FET
3.	Find the Efficiency and ripple factor of full-wave bridge rectifier
4.	Study the frequency response of CE amplifier with and without bypass capacitor
5.	Study the frequency response of CC amplifier and find the input and output impedances.
6.	Study of BJT based RC-Phase Shift Oscillator
Circuit Analysis using PSpice/Multisim	
7.	Analysis of voltage-divider biasing of BJT and FET.
8.	Analysis of two-stage RC-Coupled CE amplifier
9.	AC analysis of BJT with Voltage divider and Darlington configurations
10.	Analysis of frequency response of voltage divider biased single stage BJT and FET.
11.	Study of FET based Colpits and Hartley and oscillator
12.	Analysis of Series-FED Class A and Complementary Push-Pull Amplifiers

Course Outcome

After Studying this course, students will be able to

- Design and Test rectifiers circuits
- Design and Test BJT/JFET biasing circuits.
- Plot the frequency response of amplifier circuits
- Analyze the limitation in bandwidth of single stage and multi stage amplifier.
- Simulate and analyze amplifier, oscillator and power amplifier circuits using PSpice.

Digital Circuit Design Lab

Sl. No.	Course Content
List of Experiments	
1	Simplification, realization of Boolean expressions using logic gates and Universal gates.
2	Realization of half and full adders, half and full subtractor using logic gates.
3	(a) Realization of parallel adder and parallel subtractor using 7483 chip (b) Demonstration of BCD to Excess–3 code conversion and vice versa.
4	Application of the IC's – MUX–74153 for half and full adders, DEMUX – 74139 for 3 – bit binary to Gray and BCD to Excess–3 code converters.
5	Realization of 2 – bit comparator using gates and basic operational study of Priority encoder using 74147
6	Operational verification of Flip–Flops: (i) T type (ii) D type and iii) J–K Master slave.
7	Realization of 3 bit binary, and modulo N counters and display the count on seven segment display.
8	Realization of Shift left, Shift right, SIPO, SISO, PISO, PIPO register operations using 7495
9	Design and implementation of Multiplexer and De-multiplexer using logic gates
10	Design and implementation of encoder and decoder using logic gates
11	Design and implementation of 3-bit synchronous up/down counter
12	Design the Ring counters and Johnson counter.

Open ended Experiments:

1. Design and implement a circuit to synthesize clock signal of given frequency.
2. Design and implement a circuit to count event and latch it.
3. Design and implement a circuit to control traffic signal (Simple function).

Course Outcome

After Studying this course, students will be able to

- Analyzeand optimize the logic circuit for given Booleanexpressions.
- Design and Implement combinational digital circuits
- Design and Implement Sequential digital circuits
- Design and Develop a logic circuit for given problem.

Environmental Studies (21CIV37)

Semester III (Common to all branches)			
No. of Lecture hour/Week	1	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	00
Total No. of Lecture hours	16	**Exam Hours**	00
L: T:P	1:0:0	**Credits**	01

Modules	Course Content	Teaching Hours
Module 1	**Introduction:** Environment - Components of Environment **Ecosystem**: Types & Structure of Ecosystem, Balanced ecosystem Human Activities – Food, Shelter, And Economic & Social Security. **Impacts**: Impacts of Agriculture & Housing Impacts of Industry, Mining & Transportation Environmental Impact Assessment, Sustainable Development.	**03 Hours**
Module 2	**Natural Resources, Water resources –** Availability & Quality aspects, Water borne diseases & water induced diseases, Fluoride problem in drinking water Mineral resources, Forest Wealth Material Cycles – Carbon Cycle, Nitrogen Cycle & Sulphur Cycle. **Energy** – Different types of energy, Conventional sources &Non-Conventional sources of energy Solar energy, Hydro electric energy, Wind Energy, Nuclear energy, Biomass & Biogas Fossil Fuels, Hydrogen as an alternative energy.	**04 Hours**
Module 3	**Environmental Pollution** – Water Pollution, Noise pollution, Land Pollution, Public Health Aspects. **Global Environmental Issues:** Population Growth, Urbanization, Land Management, Water & Waste Water Management	**03 Hours**
Module 4	**Air Pollution & Automobile Pollution:** Definition, Effects – Global Warming, Acid rain & Ozone layer depletion, controlling measures. **Solid Waste Management**, E –Source, Segregation, Transportation, and Waste Treatment and Management &**Biomedical Waste Management** - Sources, Characteristics & Disposal methods.	**03 Hours**
Module 5	Applications of GIS & Remote Sensing and Smart Technologies in Environmental Engineering Practices. **Environmental Legislations:** Acts, Rules& Regulations, Role of government, Legal aspects, Role of Nongovernmental Organizations (NGOs), Environmental Education & Women Education.	**03 Hours**

Course outcomes:

After Studying this course, students will be able to

- Understand the principles of ecology and environmental issues that apply to air, land, and water issues on a global scale.
- Develop critical thinking and/or observation skills, and apply them to the analysis of a problem or question related to the environment.
- Demonstrate Solid Waste Management.
- Apply knowledge and technology in environmental practices
- Build inquisitiveness to protect environment through societal interventions

Text Books:

1. Benny Joseph, “Environmental Studies”, Tata McGraw – Hill Publishing Company Limited, 2005.
2. R.J.Ranjit Daniels and JagadishKrishnaswamy, “Environmental Studies”, Wiley India Private Ltd., New Delhi, 2009.
3. R Rajagopalan, “Environmental Studies – From Crisis to Cure”, Oxford University Press, 2005.
4. Aloka Debi, “Environmental Science and Engineering”, Universities Press (India) Pvt. Ltd. 2012.

Universal Human Value and Professional Ethics [21UHV39]

Semester III			
No. of Teaching hour/Week	1	**CIE Marks**	50
No. of Tutorial hours/week	-	**SEE Marks**	-
Total No. of Lecture hours	16	**Exam Hours**	-
L: T:P	1:0:0	**Credits**	01

Modules	Course Content	Teaching Hours
Module 1	**Introduction to Value Education:** Right Understanding, Relationship and Physical Facility (Holistic Development andthe Role of Education) Understanding Value Education, Self-exploration as the Process for Value Education, Continuous Happiness and Prosperity – the Basic Human Aspirations, Happiness and Prosperity – Current Scenario, Method to Fulfil the Basic Human Aspirations	**03 Hours**
Module 2	**Harmony in the Human Being:** Understanding Human being as the Co-existence of the Self and the Body, Distinguishing between the Needs of the Self and the Body, The Body as an Instrument of the Self, Understanding Harmony in the Self, Harmony of the Self with the Body, Programme to ensure self-regulation and Health	**03 Hours**
Module 3	**Harmony in the Family and Society:** Harmony in the Family – the Basic Unit of Human Interaction, 'Trust' – the Foundational Value in Relationship, 'Respect' – as the Right Evaluation, Other Feelings, Justice in Human-to-Human Relationship, Understanding Harmony in the Society, Vision for the Universal Human Order	**03 Hours**
Module 4	**Harmony in the Nature/Existence:** Understanding Harmony in the Nature, Interconnectedness, self-regulation and Mutual Fulfilment among the Four Orders of Nature, Realizing Existence as Co-existence at All Levels, The Holistic Perception of Harmony in Existence	**03 Hours**
Module 5	**Implications of the Holistic Understanding – a Look at Professional Ethics:** Natural Acceptance of Human Values, Definitiveness of (Ethical) Human Conduct, A Basis for Humanistic Education, Humanistic Constitution and Universal Human Order, Competence in Professional Ethics Holistic Technologies, Production Systems and Management Models-Typical Case Studies, Strategies for Transition towards Value-based Life and Profession	**04 Hours**

Course outcomes:

The course and further follow up is expected to positively impact common graduate attributes like:

- Holistic vision of life
- Socially responsible behaviour and Environmentally responsible work
- Ethical human conduct.

- Having Competence and Capabilities for Maintaining Health and Hygiene
- Appreciation and aspiration for excellence (merit) and gratitude for all

Textbook and Reference Books :

1. R R Gaur, R Asthana, G P Bagaria,The Textbook “A Foundation Course in Human Values and Professional Ethics”, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034- 447-1 b.
2. R R Gaur, R Asthana,The Teacher’s Manual for “A Foundation Course in Human Values and Professional Ethics”

Engineering Mathematics-IV [21MAT41]

Semester IV			
No. of Teaching hour/Week	2	**CIE Marks**	50
No. of Tutorial hours/week	2	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L: T:P	2:2:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Calculus of complex functions:** Review of function of a complex variables, limits, continuity, and differentiability. Analytic functions: Cauchy-Riemann equations in Cartesian and polar forms and consequences. **Construction of analytic functions:** Milne-Thomson method- Problems.	**08 Hours**
Module 2	**Conformal transformations:** Introduction. Discussion of transformations:$w = z^2$, $w = e^z$, $w = z + \frac{1}{z}(z \neq 0)$. Bilinear transformations- Problems. **Complex integration:** Line integral of a complex function- Cauchy's theorem and Cauchy's integral formula and problems.	**08 Hours**
Module 3	**Numerical Solutions of Ordinary Differential Equations (ODE's):** Numerical solution of ODE's of first order and first degree- Taylor's series method, Modified Euler's method. Runge -Kutta method of fourth order, Milne's predictor and corrector method (No derivations of formulae)-Problems. Numerical Solution of Second Order ODE's - Runge-Kutta method and Milne's predictor and corrector method. (No derivations of formulae).	**08 Hours**
Module 4	**Probability Distributions:** Review of basic probability theory. Random variables (discrete and continuous), probability mass/density functions. Binomial, Poisson, exponential and normal distributions- problems (No derivation for mean and standard deviation)-Illustrative examples.	**08 Hours**
Module 5	**Joint probability distribution:** Joint Probability distribution for two discrete random variables, expectation and covariance. **Sampling Theory:** Introduction to sampling distributions, standard error, Type-I and Type-II errors. Test of hypothesis for means, student's t-distribution, Chi-square distribution as a test of goodness of fit.	**08 Hours**

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

- Explain the concepts of integral calculus, higher order differential equations, Laplace transforms, Probability and Linear Algebra.
- Apply the above concepts of the syllabus in their respective branches of engineering.
- analyze the solutions of engineering problems using these concepts.

Text and Reference Books:

Text Books:

1. Erwin Kreyszig, *Advanced Engineering Mathematics*, Latest edition, Wiley Publications.
2. B.S. Grewal, *Higher Engineering Mathematics*, Latest edition, Khanna Publishers.
3. B.V. Ramana, *Higher Engineering Mathematics*, Latest edition, Tata McGraw Hill.

Reference Books:

1. Srimanta Pal & Subodh C. Bhunia: *"Engineering Mathematics"* Oxford University Press, 3rd Reprint, 2016.
2. N.P Bali and Manish Goyal: *"A textbook of Engineering Mathematics"* Laxmi Publications, Latest edition.
3. H.K.Dass and Er. Rajnish Verma: *"Higher Engineering Mathematics"* S.Chand Publication (2014).

Additional Mathematics-II [21MATDIP41]

Semester IV			
No. of Lecture hour/Week	2	**CIE Marks**	50
No. of Tutorial hours/week	1	**SEE Marks**	-
Total No. of Lecture hours	40	**Exam Hours**	-
L: T:P	2:1:0	**Credits**	00

Modules	Course Content	Teaching Hours
Module 1	**Integral Calculus**: Review of elementary integral calculus. Reduction formulae for $sin^n x, cos^n x$ (with proof) and $sin^m x cos^n x$ (without proof) and evaluation of these with standard limits-Examples. Double integrals-Simple examples. Beta and Gamma functions- Simple problems	**08 Hours**
Module 2	**Higher order ODE's:** Linear differential equations of second and higher order equations with constant coefficients. Homogeneous /non-homogeneous equations. Inverse differential operators. [Particular Integral restricted to $R(x) = e^{ax}, \sin ax / \cos ax$ for $f(D)y = R(x)$].	**08 Hours**
Module 3	**Laplace Transform:** Definition and Laplace transforms of elementary functions (statements only)-problems. Inverse Laplace Transform: Inverse Laplace transforms by method of partial fractions, Convolution theorem to find the inverse Laplace transforms. Solution of linear differential equations using Laplace transforms.	**08 Hours**
Module 4	**Introduction to Probability:** Introduction. Sample space and events. Axioms of probability. Addition and multiplication theorems. Conditional probability, Bayes's theorem, problems.	**08 Hours**
Module 5	**Linear Algebra:** Introduction - rank of matrix by elementary row operations - Echelon form. Consistency of system of linear equations - Gauss elimination method. Eigen values and Eigen vectors of a square matrix. Problems.	**08 Hours**

Course outcomes:

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

- Explain the concepts of integral calculus, Higher order differential equations, Laplace transforms, Probability and Linear Algebra.
- Apply the above concepts of the syllabus in their respective branches of engineering.
- analyze the solutions of engineering problems using these concepts.

Text and Reference Books:

Text Books:

1. Erwin Kreyszig, *Advanced Engineering Mathematics*, Latest edition, Wiley Publications.
2. B.S. Grewal, *Higher Engineering Mathematics*, Latest edition, Khanna Publishers.
3. B.V. Ramana, *Higher Engineering Mathematics*, Latest edition, Tata McGraw Hill.

4. Srimanta Pal & Subodh C. Bhunia: *"Engineering Mathematics"* Oxford University Press, 3rd Reprint, 2016.

Reference Books:

1. N.P Bali and Manish Goyal: *"A textbook of Engineering Mathematics"* Laxmi Publications, Latest edition.
2. H.K.Dass and Er. Rajnish Verma: *"Higher Engineering Mathematics"* S.Chand Publication (2014).

Signal Conditioning and Data Acquisition Circuits [21BR42]

SemesterIV			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L: T:P	3:1:0	**Credits**	04

Modules	Course Content	Teaching Hours
Module 1	**Introduction to Operational Amplifiers:** Introduction, Block schematic of an Op-amp, Power supply connections, Characteristics of an Ideal OP-AMP, Inverting Amplifier, Non-inverting Amplifier, Voltage follower, Differential Amplifier, CMRR. (Relevant problems). **Operational Amplifier Characteristics:** DC characteristics – Input bias current, Input offset current, Input offset voltage, Total output offset voltage, Thermal drift. AC characteristics – Frequency response, Slew rate, PSRR. **Basic op-amp applications:** Scale changer/Inverter. Summing amplifier: Inverting summing amplifier, Non-inverting Summing amplifier, Subtractor, Instrumentation Amplifier. (Relevant problems).	**08 Hours**
Module 2	**Operational Amplifier Applications:** V – I and I – V converter, Op-amp circuit using diodes, sample and hold circuit, Differentiator and Integrator. **Comparator and waveforms generator:** Comparator, Regenerative comparator (Schmitt Trigger), Astablemutivibrator, Monostablemultivibrator and Triangular waveform generator. Phase shift oscillator, Wien bridge oscillator. (Relevant problems).	**08 Hours**
Module 3	**Voltage Regulators:**Introduction, Series Op-amp regulator, IC voltage regulators, 723 general purpose regulators, switching regulator. **Active filters:**First and Second order LPF, First and Second orders HPF, Band Pass Filters, Band Reject filters. (Design examples).	**08 Hours**
Module 4	**555 Timer:** Description of Functional Diagram, Monostable operation, Applications of MonostableMultivibrator: Frequency Divider & Pulse Width Modulation. Astable operation, Applications of AstableMultivibrator: FSK Generator and Pulse Position Modulation. **Phase Locked Loops:** Basic Principles, Analog phase Detector/comparator, Voltage controlled oscillator.PLL applications: Frequency Multiplication/Division, Frequency translation, FM demodulation	**08 Hours**
Module 5	**Data Acquisition Systems:**Types of instrumentation systems, Components of analog data acquisition system, Digital data acquisition system. Single channel and Multi-channel data acquisition. **Data Converters:**Digital to AnalogConverters:Basic DAC techniques, Weighted Resistor DAC, R – 2R Ladder DAC, DAC 0800 (Data sheet: Features and description only).	**08 Hours**

	Analog to Digital Converters:Functional diagram of ADC, Flash ADC, Counter type ADC, Successive approximation ADC, Dual slope ADC. ADC 0809 (Data sheet: Features, specifications and description only), DAC/ADC specifications	

Course outcomes:

After Studying this course, students will be able to

1. Understand the basic principles and operation of op-amp.
2. Design and develop circuits to meet the practical applications
3. Implement and integrate the op-amp circuits in electronic gadgets.

Text and Reference Books:

Text Books:

1. D. Roy Choudhury and Shail B. Jain, "Linear Integrated Circuits", 4th edition, Reprint 2010, New Age International. (Module -1,2,3,4 & 5)
2. Ramakant A. Gayakwad, "Op - Amps and Linear Integrated Circuits", 4th edition, PHI (Module-3)
3. A K Sawhney, "A course in Electrical & Electronic Measurements & Instrumentation", DhanpatRai Publications, 19th edition, 2011.(Module-5)

Reference Books:

1. Robert. F. Coughlin & Fred. F. Driscoll, "Operational Amplifiers and Linear Integrated Circuits", PHI/Pearson, 2006
2. James M. Fiore, "Op - Amps and Linear Integrated Circuits", Thomson Learning, 2001
3. Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits", TMH, 3e, 2005.

Biomedical Transducers and Instrumentation [21BR43]

Semester IV			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L: T:P	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Measurement, Functional Elements of MeasurementSystem and Transducers:** Measurement, Significance of measurement, Instruments and measurement systems,Electronic instruments, Analog and digital modes of operation, Functions of instruments and measurement systems, Applications of measurement systems, Basic medical instrumentation system, Performance requirements of medical instrumentation systems, PC based medical instruments, General constraints in design of medical instrumentation systems. Transducers, Classifications of transducers-primary & secondary, active & passive, analog and digital transducers.	**08 Hours**
Module 2	**Bioelectric Signals and Electrodes:**Sources of Biomedical Signals, Origin of Bioelectric Signals, Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG), Electrooculogram (EOG), Electroretinogram (ERG), Recording Electrodes– Electrode-tissue interface, Electrolyte-Skininterface, polarization, skin contact impedance, motion artifacts, Silver-Silver Chloride electrodes, Electrodes for ECG, Electrodes for EEG, Electrodes of EMG, Electrical conductivity of electrode jellies and creams, microelectrodes.	**08 Hours**
Module 3	**Measurement of Displacement:** Introduction, Principles of Transduction: Variable resistance devices, Variable Inductance Transducer, Synchros and Resolvers, Variable Capacitance Transducer, Hall Effect Devices, Proximity Devices, Digital Transducer **Measurement of Strain:** Introduction, Electrical Strain Gauges, Theory of operation of resistance strain gauges, Types of Electrical Strain Gauges – Wire gauges, unbounded strain gauges, foil gauges, Semiconductor strain gauges (principle, types & list of characteristics only), Materials for strain gauges. Wheatstone bride circuit for strain gauges, Applications.	**08 Hours**
Module 4	**Measurement of Temperature**: Introduction, Resistance type temperature sensors, Platinum resistance thermometer, Thermistors (principle, types & characteristics), Thermocouples, Solid state sensors – principle and working of AD590 (characteristics and features), and LM35 (characteristics and features), Quartz thermometer, Temperature measurement by radiation methods, Optical pyrometer. **Measurement of Force**: Introduction, Force measuring sensor – Load cells – Column type devices, Proving rings, Cantilever beam,Hydraulic load cell, Electronic weighing system.	**08 Hours**
Module 5	**Flow Measurement**: Introduction, Classification of Flow Meters, Head type flow meters – Orifice meter and Venturi	**08 Hours**

	tube, Rotameter, Electromagnetic Flow Meter, Ultrasonic flow meter, Laser anemometer, Rotor torque mass flow meter. **Measurement of Pressure**: Introduction, Diaphragms, Other elastic elements, Transduction methods – potentiometric device, strain gauge transducer, variable reluctance, LVDT type, variable capacitance device (principle, schematic & working, no derivation), Piezoelectric pressure transducer, Pressure multiplexer.	

Course outcomes:

At the end of the course the student will be able to:

- Define the measurement, instrument, transducer, and explain the basic medical instrumentation system.
- Explain the principle, construction and working of transducers for the measurement of displacement and strain.
- Discuss the principle, construction and working of transducers for the measurement of temperature and force.
- Illustrate the methods for the measurement of flow and pressure.
- Use the above transducers for the measurement of physiological signals.

Text and Reference Books:

Textbooks:

1. Electrical and Electronic Measurements and Instrumentation – A. K. Sawhney, 17th Edition (Reprint 2004), Dhanpat Rai & Co. Pvt. Ltd., 2004.(Module-1).
2. Handbook of Biomedical Instrumentation- R S Khandpur, 2nd edition, Tata McGraw Hill, 2003. (Module-1 & 2)
3. Instrumentation: Devices and Systems- C. S. Rangan, G. R. Sarma, V. S. V. Mani, 2nd Edition (32nd Reprint), McGraw Hill Education (India), 2014. (Module 3, 4 & 5).

Reference Books:

1. Electronic Instrumentation and Measurements - David A Bell, 3rd Edition, Oxford University Press, 2013.
2. Transducers and Instrumentation – D.V.S.Murty, 2nd Edition, PHI, 2009.
3. Introduction to Measurements and Instrumentation - A. K. Ghosh, 2nd Edition, PHI, 2007.
4. Instrumentation Measurement and Analysis- B.C.Nakra and K.K.Choudhry, 3rd Edition, McGraw Hill Education (India) Pvt.Ltd. 2009.

Microcontroller and Embedded Systems [21BR44]

Semester IV			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L: T:P	3:0:1	**Credits**	04

Modules	Course Content	Teaching Hours
Module 1	**Microprocessors versus Microcontrollers, ARM Embedded Systems:** The RISC design philosophy, The ARM Design Philosophy, Embedded System Hardware, Embedded System Software. ARM Processor Fundamentals: Registers, Current Program Status Register, Pipeline, Exceptions, Interrupts, and the Vector Table , Core Extensions	**08 Hours**
Module 2	**Introduction to the ARM Instruction Set :** Data Processing Instructions , Programme Instructions, Software Interrupt Instructions, Program Status Register Instructions, Coprocessor Instructions, Loading Constants ARM programming using Assembly language: Writing Assembly code, Profiling and cycle counting, instruction scheduling, Register Allocation, Conditional Execution, Looping Constructs	**08 Hours**
Module 3	**Embedded System Components:** Embedded Vs General computing system, History of embedded systems, Classification of Embedded systems, Major applications areas of embedded systems, purpose of embedded systems Core of an Embedded System including all types of processor/controller, Memory, Sensors, Actuators, LED, 7 segment LED display, stepper motor, Keyboard, Push button switch, Communication Interface (onboard and external types), Embedded firmware, Other system components.	**08 Hours**
Module 4	**Embedded System Design Concepts:** Characteristics and Quality Attributes of Embedded Systems, Operational quality attributes,non-operational quality attributes, Embedded 08 Systems-Application and Domain specific, Hardware SoftwareCo-Design and Program Modelling, embedded firmware design and development.	**08 Hours**
Module 5	**RTOS and IDE for Embedded System Design:** Operating System basics, Types of operating systems, Task, process and threads (Only POSIX Threads with an example program), Thread preemption, Multiprocessing and Multitasking, Task Communication (without any program), Task synchronization issues-Racing and Deadlock, Concept of Binary and counting semaphores (Mutex example without any program), How to choose an RTOS, Integration and testing of Embedded hardware and firmware, Embedded system Development Environment-Block diagram (excluding Keil), Disassembler/decompiler, simulator, emulator and debugging techniques, target hardware debugging, boundary scan.	**08 Hours**

Course outcomes:

After Studying this course, students will be able to

- Describe the architectural features and instructions of ARM microcontroller

- Apply the knowledge gained for Programming ARM for different applications.
- Interface external devices and I/O with ARM microcontroller.
- Interpret the basic hardware components and their selection method based on the characteristics and attributes of an embedded system.
- Develop the hardware /software co-design and firmware design approaches.
- Demonstrate the need of real time operating system for embedded system applications

Text and Reference Books:

Text Books:

1. Andrew N Sloss, Dominic Symes and Chris Wright, ARM system developers guide, Elsevier, Morgan Kaufman publishers, 2008.
2. Shibu K V, "Introduction to Embedded Systems", Tata McGraw Hill Education, Private Limited, 2nd Edition.

Reference Books:

1. Raghunandan.G.H, Microcontroller (ARM) and Embedded System, Cengage learning Publication,2019
2. The Insider‟s Guide to the ARM7 Based Microcontrollers, Hitex Ltd.,1st edition, 2005.
3. Steve Furber, ARM System-on-Chip Architecture, Second Edition, Pearson, 2015.
4. Raj Kamal, Embedded System, Tata McGraw-Hill Publishers, 2nd Edition, 2008.

Microcontroller and Embedded Systems Lab

Sl. No.	Course Content
	List of Experiments
PART A: Conduct the following experiments by writing program using ARM7TDMI/LPC2148 using an evaluation board/simulator and the required software tool.	
1	Write a program to multiply two 16 bit binary numbers
2	Write a program to find the sum of first 10 integer numbers.
3	Write a program to find factorial of a number
4	Write a program to add an array of 16 bit numbers and store the 32 bit result in internal RAM
5	Write a program to find the square of a number (1 to 10) using look-up table.
6	Write a program to find the largest/smallest number in an array of 32 numbers .
7	Write a program to arrange a series of 32 bit numbers in ascending/descending order.
8	Write a program to count the number of ones and zeros in two consecutive memory locations.
PART –B Conduct the following experiments on an ARM7TDMI/LPC2148 evaluation board using evaluation version of Embedded 'C' &Keil Uvision-4 tool/compiler.	
9	Display "Hello World" message using Internal UART.
10	Interface and Control a DC Motor.
11	Interface a Stepper motor and rotate it in clockwise and anti-clockwise direction.
12	Determine Digital output for a given Analog input using Internal ADC of ARM controller.
13	Interface a DAC and generate Triangular and Square waveforms.
14	Interface a 4x4 keyboard and display the key code on an LCD.
15	Demonstrate the use of an external interrupt to toggle an LED On/Off
16	Display the Hex digits 0 to F on a 7-segment LED interface, with an appropriate delay in between.

Control Systems [21BR45]

Semester IV			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	2	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L: T:P	3:1:0	**Credits**	04

Modules	Course Content	Teaching Hours
Module 1	**Modelling of Systems and Block diagram: I**ntroduction to Control Systems, Types of Control Systems, with examples. Concept of mathematical modelling of physical systems- Mechanical, Translational (Mechanical accelerometer, systems excluded), and Rotational systems, Analogous systems based on force voltage analogy and force current analogy. Introduction to Block diagram algebra. Numerical problems on all topics. Introduction to Simulation package for practical component.	**08 Hours**
Module 2	**Signal Flow graph:** Introduction to Signal Flow graph, Mason's gain formula. Obtaining Transfer functions for the given SFG using Mason's gain formula. Time response analysis: Introduction. Standard test signals, response of first order & second order systems for unit step input. Steady state errors & Error constants. Numerical problems on all topics.	**08 Hours**
Module 3	**Concepts of stability:** The Concept of stability. Necessary conditions for stability. Hurwitz stability criterion. Routh stability criterion. Relative stability analysis using RH Criterion. The Root Locus Technique: Introduction. Root locus concepts. Construction of root loci. Stability analysis using Root locus Technique. Numerical problems on all topics.	**08 Hours**
Module 4	**Frequency domain Analysis:** Introduction to frequency domain analysis, Correlation between time & frequency response, Bode plots. Numerical problems on all topics. Polar Plot: Introduction to Polar plot and Nyquist plots, Nyquist stability criterion. Stability analysis using Polar plot. Numerical problems on all topics.	**08 Hours**
Module 5	**State space Analysis:** Concept of state, state variables and state model. State diagrams and State models for Linear continuous-time systems (Electrical systems): State space representation using Physical and Phase Variables. Derivation of transfer functions from the state model. Numerical problems on all topics.	**08 Hours**

PRACTICAL COMPONENT: Using suitable simulation software, demonstrate the operation of the following:

1. Determination of time response specification of a first order, second order and third order system taking suitable transfer functions.
2. Determination of time response specification of a second order underdamped system, for different damping factors.
3. Determination of frequency response of a second order System

4. Determination of frequency response of a lead lag compensator
5. Using suitable simulation package, plot Root locus plot for the given transfer function and analyse for stability.
6. Using suitable simulation package, plot Bode plot for the given transfer function and analyse for stability.
7. Using suitable simulation package, plot Nyquist plot for the given transfer function and analyse for stability.
8. Using suitable simulation package, obtain the time response from state model of a system.

Course outcomes:

After studying this course, students will able to:

- Apply modelling knowledge in implementation physical systems.
- Understand the reduction of block diagram &analyze using Signal flow graph.
- Comment on performance of a system by evaluating various parameters.
- Model a system by applying the concept of State Space analysis

Text and Reference Books:

Text Books:

1. I.J. Nagarath and M. Gopal, "Control Systems Engineering",5th edition,New Age International (P) Limited, Publishers,– 2012.
2. K. Ogata, "Modern Control Engineering",4thEdition, Pearson Education Asia/ PHI, 2002

Reference Books:

1. Benjamin C. Kuo, "Automatic Control Systems", 8thEdition,John Wiley India Pvt. Ltd., 2008.
2. Joseph J Distefano III et al., "Feedback and Control System", 2nd Edition Schaum's Outlines, TMH, 2007.

Signal Conditioning and Biomedical Transduers Lab [21BRL46]

Semester IV			
No. of Lecture hour/Week	-	**CIE Marks**	50
No. of Tutorial hours/week	-	**SEE Marks**	50
Total No. of Lecture hours	03	**Exam Hours**	03
L: T:P	0:0:2	**Credits**	02

Sl. No.	Course Content
1	To design and implement • Inverting Amplifier and Inverting Attenuator • Non-Inverting Amplifier and Voltage Follower
2	To realize • Full wave Precision rectifier • Voltage regulator using IC 723
3	To design and implement • Butterworth I order Low-pass filter • Butterworth II order High-pass filter
4	To design and implement • RC Phase shift oscillator • Wein Bridge oscillator
5	To realize • ZCD • Positive and Negative Voltage level detectors
6	To design and implement • AstableMultivibrator using 555 timer • Mono-stable Multivibrator using 555 timer
7	To realizeSample and Hold circuit using discrete components
8	To realizeProgrammable Gain Amplifier using Analog Mux
9	Measurement of displacement using LVDT and finding the sensitivity & resolution.
10	Characteristics of Load cell and Cantilever beam using Strain gauge: Plotting the characteristics and finding their sensitivity for Quarter, Half and Full bridge configurations.
11	Temperature measurement using RTD, Thermistor and Thermocouple: Plotting the characteristics and finding their sensitivity.
12	Temperature measurement using AD590/LM35: Plotting the characteristics and finding their sensitivity.

Course outcomes:

After studying this course, students will able to;

- Sketch circuit schematics, construct circuits on breadboards, analyze and troubleshoot circuits containing Op-amps, resistors, diodes, capacitors and independent sources.
- Memorizeand reproduce the manufacturer's data sheets of IC 555 timer, IC µa741 op-amp and data converters like IC ADC 0800 and IC DAC 0809.
- Design and evaluate analog integrated circuits like Amplifiers, Oscillators, Active filters, Precision Rectifiers and Voltage level detectors, and compare the experimental results with theoretical values.
- Demonstrate and analyze the working of Sample-Hold, Programmable gain amplifier and Analog Multiplexer circuits in data acquisition system.
- Design and evaluate different resolution data converters using discrete components and ICs.

Text and Reference Books:

1. D. Roy Choudhury and Shail B Jain, “Linear Integrated Circuits”, 4th edition, Reprint 2010, New Age International.
2. Ramakant A. Gayakwad, “Op - Amps and Linear Integrated Circuits”, 4th edition, PHI.
3. A K Sawhney, “A course in Electrical & Electronic Measurements & Instrumentation”, 19th edition, DhanpatRai Publications, 2011.
4. Robert. F. Coughlin &Fred. F. Driscoll, “Operational Amplifiers and Linear Integrated Circuits”, PHI/Pearson, 2006
5. James M. Fiore, “Op - Amps and Linear Integrated Circuits”, Thomson Learning, 2001
6. Sergio Franco, “Design with Operational Amplifiers and Analog Integrated Circuits”, TMH, 3rd edition, 2005

Constitution of India, Professional Ethics and Cyber Law [21CPH46]

Semester IV			
No. of Lecture hour/Week	1	**CIE Marks**	50
No. of Tutorial hours/week	-	**SEE Marks**	-
Total No. of Lecture hours	16	**Exam Hours**	-
L: T:P	1:0:0	**Credits**	01

Modules	Course Content	Teaching Hours
Module 1	**Introduction to Indian Constitution:** Definition of Constitution, Necessity of the Constitution, Societies before and after the Constitution adoption. Introduction to the Indian constitution, Making of the Constitution, Role of the Constituent Assembly. Preamble of Indian Constitution & Key concepts of the Preamble. Salient features of India Constitution.	**03 Hours**
Module 2	**Fundamental Rights (FR's), Directive Principles of State Policy (DPSP's) and Fundamental Duties (FD's):** Fundamental Rights and its Restriction and limitations in different Complex Situations. DPSP's and its present relevance in Indian society. Fundamental Duties and its Scope and significance in Nation building.	**03 Hours**
Module 3	**Union Executive:** Parliamentary System, Union Executive – President, Prime Minister, Union Cabinet, Parliament - LS and RS, Parliamentary Committees, Important Parliamentary Terminologies. Supreme Court of India, Judicial Reviews and Judicial Activism.	**03 Hours**
Module 4	**State Executive & Elections, Amendments and Emergency Provisions:** State Executive, Election Commission, Elections & Electoral Process. Amendment to Constitution (Why and How) and Important Constitutional Amendments till today. Emergency Provisions.	**03 Hours**
Module 5	**Professional Ethics:** Definition of Ethics & Values. Professional & Engineering Ethics. Positive and Negative aspects of Engineering Ethics. **Cyber Laws:** Salient features of the IT Act, 2000, various authorities under IT Act and their powers. ; Penalties & Offences, amendments. **Computer & Cyber Security:** (a) Types of Attacks, (b) Network Security (c) Overview of Security threats, (d) Hacking Techniques, (e) Password cracking (f) Insecure Network connections, (g) Malicious code (h) Concept of Fire wall Security	**04 Hours**

Course outcomes:

After studying this course, students will able to:

- Have constitutional knowledge and legal literacy.
- Understand Engineering and Professional ethics and responsibilities of Engineers.
- Understand cyber threats & cyber laws, acts and their powers

Textbook/Reference Books:

1. Shubham Singla, ‘Constitution of India, Professional Ethics & Human Rights’, CENGAGE Publications 2018
2. Cyber Law & Cyber Crimes By Advocate Prashant Mali; Snow White publications, Mumbai
3. Cyber Law in India by Farooq Ahmad; Pioneer Books

Ability Enhancement Course – II [21AEC47]

Semester IV			
No. of Lecture hour/Week	1	**CIE Marks**	50
No. of Tutorial hours/week	-	**SEE Marks**	-
Total No. of Lecture hours	16	**Exam Hours**	-
L: T:P	1:0:0	**Credits**	01

Modules	Course Content	Teaching Hours
Module 1	**Technical Report Writing:** Introduction to Technical writing process, Understanding of writing process, Introduction to various Technical Report writing.	**03 Hours**
Module 2	**Art of condensation and Paragraph Writing:** Introduction and importance, Types and principles of condensation. Importance of paragraph writing, Features and its construction styles.	**03 Hours**
Module 3	**Business Report Writing:** Introduction, Definition and Salient features of Business reports. Significance and types of report writing. (Formal and Informal). Resume building and Types of resumes. (samples of resumes)	**03 Hours**
Module 4	**Technical Articles and Proposals:** Nature and significance, Types of technical Articles Journal articles and conference papers. Elements of technical articles .Introduction to technical proposal writing, Purpose, importance, structure and types of technical proposals.	**04 Hours**
Module 5	**Social media posts and Blog Writing:** Ethics and practices of social media posts, Principles and fundamentals, Guiding principles for composition of articles, some common pitfalls. Maintaining common etiquette. Blogs and Blog writings strategies.	**03 Hours**

Course outcomes

At the end of the course the student will be able to:

- Effectively communicate in technical matters.
- Practice preparation of gist, abstract and notes from a technical article.
- Prepare a business proposals and reports.
- Write and respond in social media and write blogs.

Text Book/ Reference Books:

1. Sanjay Kumar and Pushpalata, 'Communication Skills', Oxford University Press. 2018.
2. M. Ashraf Rizvi, 'Effective Technical Communication', McGraw Hill, 2018.
3. Gajendra Singh Chauhan and et.al. 'Technical Communication', Cengage Publication, 2018.
4. Meenakshi Raman and Sangeeta Sharma, Technical Communication Principles and Practice, Oxford University Press, 2018.

MYSORE UNIVERSITY SCHOOL OF ENGINEERING

Scheme of Teaching and Examination 2021-2022 (As per NEP-2020)
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
(Effective from the academic year 2021–2022)

B.E. in Biomedical and Robotic Engineering [BR]

SEMESTER V

Sl. No	Course & Course Code		Course Title	Teaching Dept.	Paper Setting Board	Teaching Hours/week			Examination				Credits
						Theory lectures	Tutorial	Practical/ Drawing	Examination in Hours	CIE Marks	SEE Marks	Total Marks	
						L	T	P					
1	HSMC	21BR51	Management and Entrepreneurship	BM & RE	BM & RE	3	0	0	03	50	50	100	3
2	IPCC	21BR52	Digital Signal Processing	BM & RE	BM & RE	3	0	2	03	50	50	100	4
3	PCC	21BR53	Biomedical Instrumentation	BM & RE	BM & RE	3	0	0	03	50	50	100	3
4	IPCC	21BR54	Robot Programming	BM & RE	BM & RE	3	0	2	03	50	50	100	4
5	PEC	21BR55X	Professional Elective -1	BM & RE	BM & RE	3	0	0	03	50	50	100	3
6	OEC	21BR56X	Open Elective -A	BM & RE	BM & RE	3	0	0	03	50	50	100	3
7	AEC	21BRL57	Programming in Matlab	BM & RE	BM & RE	0	0	2	NA	50	-	50	1
8	PCC	21BRL58	Biomedical Instrumentation Lab	BM & RE	BM & RE	0	0	4	03	50	50	100	2
9	INT	21INT59	Summer Internship-I	Completed during the vacation of IV and V semesters					NA	50	-	50	1
Total						**18**	**00**	**10**	**24**	**450**	**350**	**800**	**24**

Note: HSMC: Humanity, Social Science and Management Courses, PCC: Professional Core Courses, IPCC: Integrated Professional Core Courses, PEC: Professional Elective Course, OEC: Open Elective Course, MP: Mini Project, INT: Internship, AEC: Ability Enhancement Course.

Professional Elective-1 (21BR55X)

Course Code	Course Title
21BR551	Pattern Recognition
21BR552	Communication Systems
21BR553	Hospital Design, Planning, and Management
21BR554	Embedded System Design

Open Elective-A (21BR56X)

21BR561	Fundamentals of Biomedical Transducers and Medical Instrumentation
21BR562	Biosafety and Healthcare
21BR563	Fundamentals of Robotics and its Programming
21BR564	Fundamentals of Augmented and Virtual Reality

Credit Definition:

- 1-hour lecture **(L)** per week per semester = **1 Credit**
- 2-hour tutorial **(T)** per week per semester = **1 Credit**
- 2-hour Practical/Drawing **(P)** per week per semester = **1 Credit**

- **Four-credit** courses are to be designed for **50** hours of Teaching-Learning process.
- **Three credit** courses are to be designed for **40** hours of Teaching-Learning process.
- **Two credit** courses are to be designed for **25** hours of Teaching-Learning process.
- **One credit** courses are to be designed for **15** hours of Teaching-Learning process.

Students can select any one of the open electives offered by any Department.
Selection of an open elective is not allowed provided,

- The candidate has studied the same course during the previous semesters of the programme.
- The syllabus content of open elective is similar to that of Departmental core courses or professional electives.
- A similar course, under any category, is prescribed in the higher semesters of the programme.

Registration to electives shall be documented under the guidance of Programme Coordinator/ Adviser/Mentor.

AICTE Activity Points: In case students fail to earn the prescribed activity Points, an Eighth semester Grade Card shall be issued only after earning the required activity Points. Students shall be admitted for the award of the degree only after the release of the Eighth semester Grade Card.

MYSORE UNIVERSITY SCHOOL OF ENGINEERING

Scheme of Teaching and Examination 2021-2022 (As per NEP-2020)
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
(Effective from the academic year 2021–2022)

B.E. in Biomedical and Robotic Engineering [BR]

SEMESTER VI

Sl. No	Course & Course Code		Course Title	Teaching Dept.	Paper Setting Board	Teaching Hours/week			Examination				Credits
						Theory lectures	Tutorial	Practical/ Drawing	Examination in Hours	CIE Marks	SEE Marks	Total Marks	
						L	T	P					
1	IPCC	21BR61	Digital Image Processing	BM & RE	BM & RE	3	0	2	03	50	50	100	4
2	PCC	21BR62	Python for System Programming	BM & RE	BM & RE	3	0	0	03	50	50	100	3
3	PCC	21BR63	IoT and Smart Sensors	BM & RE	BM & RE	3	0	0	03	50	50	100	3
4	PEC	21BR64X	Professional Elective -2	BM & RE	BM & RE	3	0	0	03	50	50	100	3
5	OEC	21BR65X	Open Elective –B	Any Dept.	Any Dept.	3	0	0	03	50	50	100	3
6	HSMC	21BR66	Research Methodology and Intellectual Property Rights	BM & RE	BM & RE	3	0	0	03	50	50	100	3
7	PCC	21BRL67	Python for System Programming Lab	BM & RE	BM & RE	0	0	4	03	50	50	100	2
8	MP	21BRMP68	Mini Project	BM & RE	BM & RE	0	0	2	NA	50	-	50	1
Total						**18**	**00**	**06**	**21**	**400**	**350**	**750**	**22**

Note: HSMC: Humanity, Social Science and Management Courses, PCC: Professional Core Courses, IPCC: Integrated Professional Core Courses, PEC: Professional Elective Course, OEC: Open Elective Course, MP: Mini Project, INT: Internship, AEC: Ability Enhancement Course.

Professional Elective-2 (21BR64X)

Course Code	Course Title
21BR641	Rehabilitation Engineering
21BR642	Drives and Control of Robots
21BR643	CMOS VLSI Design
21BR644	Medical Design Regulation and Safety

Open Elective-B (21BR65X)

21BR651	Fundamentals of Bio-MEMS
21BR652	Wearable Devices
21BR653	Robotic Motion Control and Path Planning
21BR654	Basics of Embedded System Design

Students can select any one of the open electives offered by any Department.
Selection of an open elective is not allowed provided,

- The candidate has studied the same course during the previous semesters of the programme.
- The syllabus content of open elective is similar to that of Departmental core courses or professional electives.
- A similar course, under any category, is prescribed in the higher semesters of the programme.

Registration to electives shall be documented under the guidance of Programme Coordinator/ Adviser/Mentor.

Mini-project work: Based on the ability/abilities of the student/s and recommendations of the mentor, a single discipline or a multidisciplinary Mini project can be assigned to an individual student or to a group having not more than 4 students.

CIE procedure for Mini project:

(i) Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two senior faculty members of the Department, one of whom shall be the Guide. The CIE marks awarded for the Mini-project work shall be based on the evaluation of project report, project presentation skill and question and answer session in the ratio 50:25:25. The marks awarded for the project report shall be the same for all the batch mates.

(ii) Interdisciplinary: Continuous Internal Evaluation shall be group wise at the college level with the participation of all the guides of the college. The CIE marks awarded for the Mini project shall be based on the evaluation of project report, project presentation skill and question and answer session in the ratio 50:25:25. The marks awarded for the project report shall be the same for all the batch mates.

Summer Internship-II: All the students admitted to III year of BE/B.Tech shall have to undergo mandatory internship of 4 weeks during the vacation of VI and VII semesters and /or VII and VIII semesters. A University examination shall be conducted during VIII semester and the prescribed credit shall be included in VIII semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take up/complete the internship shall be declared fail and shall have to complete during subsequent University examination after satisfying the internship requirements

AICTE Activity Points: In case students fail to earn the prescribed activity Points, an Eighth semester Grade Card shall be issued only after earning the required activity Points. Students shall be admitted for the award of the degree only after the release of the Eighth semester Grade Card.

Syllabus of Semester V

Management and Entrepreneurship (21BR51)

Semester V			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Management:** Introduction - Nature and characteristics of Management, Scope and Functional areas of management - Management as art or science, art or profession - Management & Administration - Roles of Management, Levels of Management, Development of Management Thought. **Planning:** Nature, importance and purpose of planning process objectives - Types of plans - Decision making, Importance of planning - steps in planning & planning premises - Hierarchy of plans.	**08 Hours**
Module 2	**Organizing and staffing:** Nature of organization Nature and purpose of organization, Principles of organization – Types of organization-Departmentation Committees-Centralization Vs Decentralization of authority and responsibility followed by Process of Selection & Recruitment **Directing:** Nature of directing Leadership styles, Motivation, Theories, Communication, and co-ordination. **Controlling: S**teps in controlling - Essentials of a sound control system - Methods of establishing control.	**08 Hours**
Module 3	**Leadership**- Leadership characteristics, Behaviour approach, Coordination, Types, Techniques of Coordination. **Controlling:** Need for Control System, Benefits of Control, Essentials of Effective Control System, Steps in Control Process **Social Responsibilities of Business:** Social Responsibility, Social Responsibilities of Business towards Different Groups, Social Audit, Business Ethics and Corporate Governance	**08 Hours**
Module 4	**Entrepreneurship:** Introduction, Evolution of the concept of Entrepreneurship, Entrepreneurship today, Types of Entrepreneurs, Intrapreneurship, Entrepreneurial competencies, Capacity Building for Entrepreneurs. **Identification of Business Opportunities:** Introduction, Mobility of Entrepreneurs, Business opportunities in India, Models for opportunity Evaluation.	**08 Hours**
Module 5	**Business Plans**: Introduction, purpose of a Business plan, contents of a Business plan, presenting a Business plan, why do some Business plan fail? Procedure for setting up an Enterprise. **Institutions supporting Business opportunities**: State, central and other level institutions and organization.	**08 Hours**

Course Outcomes:

At the end of the course the student will be able to:

- To know the fundamental concepts of Management and its functions.
- Analyze different functions to be performed by managers/Entrepreneur.
- Analyze the social responsibilities of a Business.
- Understand the Concepts of Entrepreneurship and to identify Business opportunities.
- Understand the components in developing a business plan and awareness about various sources of funding and Institutions supporting Entrepreneur.

Text Books:

1. Principles of Management, P. C. Tripathi, P.N Reddy, McGraw Hill Education, 6th Edition, 2017. ISBN- 13:978-93-5260-535-4.
2. Entrepreneurship Development Small Business Enterprises, Poornima M Charantimath, 2nd Edition, Pearson Education 2018, ISBN 978-81-317-6226-4.

Reference Books:

1. Essentials of Management: An International, Innovation and Leadership perspective, Harold Koontz, Heinz Weihrich McGraw Hill Education, 10th Edition 2016. ISBN- 978-93-392-2286-4.

Web links and Video Lectures (e-Resources):

- https://nptel.ac.in/courses/110107094
- https://nptel.ac.in/courses/110106141
- https://nptel.ac.in/courses/122106031

Digital Signal Processing (21BR52)

Semester V			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:2	**Credits**	04

Modules	Course Content	Teaching Hours
Module 1	**Introduction and Classification of signals:** Definition of signal and systems with examples, Elementary signals/Functions: Exponential, sinusoidal, step, impulse, and ramp functions. **Basic Operations on signals:** Amplitude scaling, addition, multiplication, time scaling, time-shift and time-reversal. Expression of triangular, rectangular, and other waveforms in terms of elementary signals.	**08 Hours**
Module 2	**System Classification and properties:** Linear-nonlinear, Time-variant, time-invariant, causal, noncausal, static, dynamic, stable, unstable, invertible. **Time domain representation of LTI System:** Impulse response, convolution sum. Computation of convolution sum using graphical method for unit step and unit step, unit step and exponential, exponential and exponential, unit step and rectangular, and rectangular and rectangular.	**08 Hours**
Module 3	**Discrete Fourier Transforms (DFT):** Frequency domain sampling and Reconstruction of Discrete Time Signals, The Discrete Fourier Transform, DFT as a linear transformation, **Properties of the DFT:** Periodicity, Linearity and Symmetry properties, Multiplication of two DFTs and circular convolution.	**08 Hours**
Module 4	**Fast-Fourier-Transform (FFT) algorithms:** Efficient Computation of DFT: Radix-2 DIT-FFT and DIF-FFT algorithms for the computation of DFT. **IIR Filters:** Low-pass filter specifications, IIR filter Design by Impulse Invariance and bilinear transformation techniques, Design of Digital IIR filter by Butterworth approach, Magnitude response of lowpass filters (Theoretical concept only).	**08 Hours**
Module 5	**FIR Filters:** Design of FIR Filters- Symmetric and Antisymmetric FIR filters, Design of Linear phase FIR filters by Rectangular Hamming & Hanning windows, Summary of window function characteristics.	**08 Hours**

Practical Component of DSP

Sl. No.	Digital Signal Processing using MATLAB / SCILAB/OCTAVE
1.	Program to generate discrete waveforms and basic operations on signals.
2.	Verify the Sampling theorem
3.	Program to perform Linear and Circular convolution of given sequences
4.	Program to perform Cross and Auto Correlation of given sequences
5.	Computation of N point DFT of a given sequence and to plot magnitude and phase spectrum.
6.	Verification of linearity and periodicity properties of DFT
7.	Compute the IDFT of a sequence
8.	Compute the output of an LTI system using DFT and IDFT
9.	Computation of linear convolution of sequences using DFT and IDFT.
10.	Computation of circular convolution of two given sequences using DFT and IDFT
11.	Computation of circular correlation and circular auto-correlation of given sequences using DFT and IDFT
12.	Determine the power density spectrum of the given sequence using FFT.
13.	Implementation of IIR (Butterworth) low pass filter.
14.	Implementation of IIR (Butterworth) high pass filter.
15.	Design and test FIR filter using Windowing method (Rectangular, Hamming, and Hanning windows) for the given order and cut-off frequency.

Course Outcomes:

At the end of the course the student will be able to:

- Analyse different types of signals and systems, Analyse the properties of discrete time signals & systems
- Determine response of LTI systems using time domain and DFT techniques.
- Compute DFT using FFT algorithms
- Design IIR Filters and FIR Filters

Text Books:

1. Simon Haykin and Barry Van Veen, "Signals and Systems," 2nd Edition, 2008, Wiley India. ISBN9971-51- 239-4.
2. Proakis & Manolakis, "Digital Signal Processing - Principles Algorithms & Applications", 4th Edition, Pearson education, New Delhi, 2007. ISBN: 81-317-1000-9.

Reference Books:

1. Sanjit K Mitra, "Digital Signal Processing, A Computer Based Approach", 4th Edition, McGraw Hill Education, 2013.
2. Oppenheim & Schaffer, "Discrete Time Signal Processing", PHI, 2003.
3. D Ganesh Rao and Vineeth P Gejji, "Digital Signal Processing" Cengage India Private Limited, 2017, ISBN: 9386858231.
4. V. Udayashankara, "Modern Digital Signal Processing", Third Edition, PHI 2016.

Biomedical Instrumentation (21BR53)

Semester V			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Electrocardiogram:** Action potentials in cardiac muscle, Characteristics of the normal ECG, Cardiac arrhythmias and their electrocardiographic interpretation- Abnormal sinus rhythms, Abnormal Rhythms by impulse conduction blocks, Premature contractions, Paroxysmal Tachycardia, Ventricular & Atrial Fibrillation, Atrial Flutter, Cardiac arrest. Heart sounds, Phonocardiogram, Valvular lesions (Abnormal heart sounds)	**08 Hours**
Module 2	**Catheterization Laboratory Instrumentation**: Arrhythmia monitor, Exercise stress testing, Ambulatory monitoring instruments Fetal Monitoring Instruments: Cardiotocograph, Abdominal Fetal Electrocardiogram, Fetal Phonocardiogram Oximeters: Oximetry, Ear Oximeter, Pulse Oximeter, Skin reflectance Oximeters, Intravascular Oximeter	**08 Hours**
Module 3	**Clinical methods:** Spectacles and contact lenses, Refractive surgery, Snellen's Chart, Cover – uncover test, Maddox rod test, Maddox wing test.	**08 Hours**
Module 4	**Tonometry and its types, Perimetry –** Peripheral Field Charting, Central Field Charting, Fundus Fluorescein Angiography, Electroretinography, Electro-oculography, Loupe & Lens Examination, Slit- Lamp Examination, Gonioscopy, Retinoscope- Principle, Procedure & Types, Refractometry, Keratometry- principle and types, subjective refraction, Ophthalmoscopy-Direct & Indirect.	**08 Hours**
Module 5	General considerations of Glaucoma, surgical procedures for Glaucoma,Vitreous Liquefaction, Vitreous Opacities, Vitreous Haemorrhage, Vitrectomy-types and techniques, Lasers in Ophthalmology, Cryotherapy in Ophthalmology.	**08Hours**

Course outcomes:

At the end of the course the student will be able to:

- Analyze and interpret the types of heart abnormalities.
- Describe the constructional details of equipment's used in cardiology.
- Explain the basic principles of ophthalmology instruments.
- Discuss the clinical methods and surgical procedures in ophthalmology.
- Use few of the ophthalmological instruments for diagnostic purpose.

Text Books:

1. Textbook of Medical Physiology", Guyton & Hall, 11th Edition, Reed Elsevier Pvt. Ltd., 2007.
2. "Handbook of Biomedical Instrumentation", R S Khandpur, 2nd edition, McGrawHill Education, 2013.
3. "Comprehensive Ophthalmology", A. K. Khurana, 4th Edition, New Age International Ltd., 2011.

Robot Programming (21BR54)

Semester V			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:2	**Credits**	04

Modules	Course Content	Teaching Hours
Module 1	**Introduction to Robot Programming:** Definition of Robot Programming, Robot software functions - coordinate systems, position control, other control functions, subroutines, Program Planning for Robot flow charting for robot programs with few examples.(*Reference-ABB Robot)	**08Hours**
Module 2	**Methods of Robot Programming:** Definition of Online programming and off-line programming, advantages of off-line programming, lead through methods - powered lead through, manual lead through, Teach pendant, Robot program as a path in space, defining position in space, Reasons for defining points, motion interpolation, WAIT, SIGNAL and DELAY commands, Branching capabilities and Limitations of head through methods.	**09Hours**
Module 3	**Robot Languages:** Textual ROBOT Languages, first generation and second generation languages, future generation languages, structure of a robot language -operating systems, Elements and Functions, constants, variables and other data objects, Motion commands, points in workspace, End effectors and sensor commands, computations and operations, program control and Subroutines, communications and Data processing.	**08Hours**
Module 4	**VAL II:** General description, Monitor commands, motion command, Hand Control, Configuration control, interlock commands, INPUT/OUTPUT Controls, Program Control, examples. Introduction to RAIL –General description, language features.	**07Hours**
Module 5	**AML:** General description, AML statements, Constant and variables, program control statements, motion commands, Sensor commands, Grip sensing capabilities, Data processing, examples. General objectives of Artificial intelligence.	**08Hours**

Practical Component of Robot Programming

Sl. No.	Experiments
1.	Determination of maximum and minimum position of links of robot
2.	Verification of transformation (Position and orientation) with respect to gripper and world coordinate system
3.	Estimation of accuracy, repeatability and resolution of robot.
4.	Robot programming and simulation for pick and place
5.	Robot programming and simulation for Color identification
6.	Robot programming and simulation for Shape identification
7.	Robot programming and simulation for Continuous Path operation on Cylinder
8.	Robot programming and simulation for Engineering applications (cutting, drilling)
9.	Robot programming and simulation for any industrial process (Packaging, Assembly)
10.	Robot programming and simulation for multi process.

Note: The above robot programs and simulations are executed on any of the below software.

1. Workspace-LT-Robot simulation
2. MSC-ADAMS-Dynamics simulation
3. Python programming.
4. MATLAB (additional)

Course outcomes:

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

- To know the Robot software functions and Robot flow charting.
- To evaluate various methods of programming, advantages its limitations.
- To know the robot languages, apply working principles of programming for various applications.
- To Analyse motion commands, monitor commands.
- To know statements, constant and variables of robot execution

Text Books:

1. Industrial Robotics Technology, Programming and Applications', Mikell P. Groover, Mitchell Weiss, Roger N. Nagel and Nicholas G. Odrey Mc Graw Hill Book company,1986.

Reference Books:

1. Industrial Robotics' Bernard Hodges Jaico Publishing House 1993
2. Robotics – K.S.Fu, R.C.Gonzales and Lee. McGraw Hill International, Year 2008.

Professional Elective-1 (21BR55X)

Pattern Recognition (21BR551)

Semester V			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Introduction:** Pattern recognition overview, typical pattern recognition system, patterns and feature extraction examples, classification, post processing, design cycles, training, supervised learning, Statistical decision making, Bayes theorem, continuous densities, decision regions, multiple features, conditionally independent features.	**08 Hours**
Module 2	**Bayesian classifiers:** decision boundaries, two dimensional examples, d-dimensional decision boundaries in matrix notation, examples Estimation of error rates: unequal costs of error, estimation of error rates, model based estimates, simple counting, fractional counting, characteristic curves, Confusion matrices, examples, estimating the composition of populations.	**08 Hours**
Module 3	**Nonparametric decision making**: Introduction, histograms, Kernel and Window estimators, nearest neighbor classification technique, nearest neighbor error rates, adaptive decision boundaries, algorithm, examples, adaptive discriminant functions, examples, and minimum squared error discriminate function, examples.	**08 Hours**
Module 4	**Clustering**: Introduction, Hierarchical clustering, agglomerative clustering algorithms, single linkage algorithm, complete linkage algorithm, average linkage algorithm, Wards method, examples, Partitional clustering, Forgy's algorithm, k-means algorithm, examples.	**08 Hours**
Module 5	**Artificial neural networks**: Introduction, nets without hidden layers, examples, sequential MSE algorithm, steepest descent method, examples, nets with hidden layers, examples, the back propagation algorithm, Hopfield nets, examples, storage and retrieval algorithms, Support vector machines, Risk minimization principles and the Concept of uniform Convergence, VC dimension, support vector machine algorithms.	**08Hours**

Course outcomes:

At the end of the course the student will be able to:

- To comprehend basic concepts of pattern recognition and its classification
- To analyze the different Bayesian classifiers

- To know the Nonparametric decision making and its algorithm
- To know the different clustering algorithms
- To illustrate the different algorithms of Artificial neural networks

Text Book:

1. Earl Gose, Richard Johnsonbaugh, and Steve Jost, "Pattern Recognition and Image Analysis," PHI, 2002

Reference Books:

1. Richard O Duda, Peter E Hart and David G stork, "Pattern Classification", 2nd edition, John Wiley and sons, 2001
2. Simon Haykin, "Neural Networks a comprehensive foundation", 2nd Edition, PHI, 2008.

Communication Systems (21BR552)

Semester V			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	Introduction to Analog and Digital Communication, Historical Background and Applications. **Amplitude Modulation:** Amplitude Modulation, Virtues, Limitations, and Modifications of AM, DSBSC Modulation, Costas Receiver, Single Side band Modulation, Vestigial Sideband Modulation.	**08 Hours**
Module 2	**Angle Modulation:** Basic Definitions, Properties of Angle-Modulated Waves, Relationship between PM and FM Waves, NBFM, WBFM, Transmission Bandwidth of FM Waves, Generation of FM waves, Demodulation of FM Signals.	**08 Hours**
Module 3	**Pulse Modulation:** Transition from Analog to Digital Communications: Sampling Process, PAM, Completing the Transition from Analog to Digital, Quantization Process, PCM, Delta Modulation.	**08 Hours**
Module 4	**Digital Band-Pass Modulation Techniques:** Binary Amplitude Shift Keying (BASK): Generation and Detection, Binary Phase Shift-Keying (BPSK): Generation and Detection, Quadriphase Shift Keying (QPSK): Generation and Detection, Binary Frequency Shift Keying (BFSK), Minimum-Shift Keying (MSK), Differential Phase Shift Keying(DPSK): Generation and Detection	**08 Hours**
Module 5	**Wireless Personal Area Networks (WPAN):** Network Architecture, WPAN Components, WPAN Technologies and protocols (Bluetooth & Zigbee), WPAN Applications.	**08 Hours**

Course outcomes:

At the end of the course the student will be able to:

- Explain the basics concepts of analog modulation techniques.
- Discuss the basic concepts of digital modulation techniques.
- Describe the basic concepts of digital data and pulse communication.
- Explain and analyze different digital modulation techniques.
- Describe different wireless area networks and their applications.

Text Books:

1. Simon Haykin, John Wiley & sons, "Introduction to Analog and Digital Communications"-Second Edition,2012, ISBN 978-81-265-3653-5.
2. Sunil Kumar S.Manvi, Mahabaleshwar S. Kakkasageri, "Wireless and Mobile Networks Concepts and Protocols", John Wiley & sons, 2014 Edition, ISBN 978-81-265-2069-5.

3. John G Proakis and Masoud Salehi, “Fundamentals of Communication Systems”, 2014 Edition, Pearson Education, ISBN 978-8-131-70573-5.

Reference Books:

1. Ian A Glover and Peter M Grant, “Digital Communications”, Pearson Education, Third Edition, 2010, ISBN 978-0-273-71830-7.
2. B. P. Lathi and Zhi Ding, “Modern Digital and Analog communication Systems”,
3. Oxford University Press, 4th Edition, 2010, ISBN: 978-0-198-07380-2.

Hospital Desing, Planning, and Management (21BR553)

Semester V			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Planning & Building a New Hospital:** Role of Hospital in Health Care, Hospital Planning & Design, Guiding principle in Hospital facilities & services, Functional Plans for Hospital construction, Design items, Functional program & design stage, Planning the Hospital building.	**08 Hours**
Module 2	**Effective Hospital Management:** Planning, Organization, Directing & Leading, Controlling, Financial Management. **Administrative Service:** Medical Record, Hospital Infection, Hospital Utilization Statistics, Material Management, Evaluation of Hospital services.	**08 Hours**
Module 3	**Planning & Designing Medical Services:** Out Patient service, Emergency service, Clinical laboratories, Radiology services, Radiation Therapy Department, Surgical Department, Nursing Department, Operation Theatre, CSSD Nursing services.	**08 Hours**
Module 4	**Planning & Designing Engineering Services:** Engineering Department, Maintenance management, Clinical [Biomedical] Engineering, Electrical System, Air Condition System, Water supply & sanitary system, Centralized Medical Gas System, Telecommunication System, Environmental Control, Safety & Security System, Disposal of Hospital Wastes.	**08 Hours**
Module 5	**Planning & Design of Supportive Services:** Admitting Department, Medical Record Department, Centralized Sterilization & Supply department, Pharmacy Material Management, Food service Department, Laundry & Linen Services, House Keeping & Val entry Department.	**08 Hours**

Course outcomes:

At the end of the course the student will be able to:

- Design and construct the hospital with an effective administration and financial management.
- Plan and develop an effective hospital supportive system for all types of hospital services.
- Evaluate the proper functioning and services provided by the hospitals.

Textbook:

1. Principles of Hospital Administration & Planning - by B. M.Sakharkar, Jaypee Publications, 1998.
2. Hospital Facilities, Planning & Management - by G. D. Kunders, TataMcGraw Hill, 2004.

Reference Books:

1. Hospital Administration & Management - by S. L. Goel & R. Kumar Deep, Deep Publications.
2. Applied Clinical Engineering - by Barry N. Feinberg, Prentice Hall,1984.
3. Clinical Engineering Principle & Practices - By John G. Webster &Albert M. Cook, Prentice Hall.

Embedded System Design (21BR554)

Semester V			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**8051 Microcontroller:** Microprocessor Vs Microcontroller, Embedded Systems, Embedded Microcontrollers, 8051 Architecture-Registers, Pin diagram, I/O ports functions, Internal Memory organization. External Memory (ROM & RAM) interfacing.	**08 Hours**
Module 2	**8051 Instruction Set:** Addressing Modes, Data Transfer instructions, Arithmetic instructions, Logical instructions, Branch instructions, Bit manipulation instructions. Simple Assembly language program examples (without loops) to use these instructions.	**08 Hours**
Module 3	**8051 Stack, I/O Port Interfacing and Programming:** 8051 Stack, Stack and Subroutine instructions. Assembly language program examples on subroutine and involving loops. Interfacing simple switch and LED to I/O ports to switch on/off LED with respect to switch status.	**08 Hours**
Module 4	**8051 Timers and Serial Port:** 8051 Timers and Counters – Operation and Assembly language programming to generate a pulse using Mode-1 and a square wave using Mode- 2 on a port pin. 8051 Serial Communication- Basics of Serial Data Communication, RS-232 standard, 9 pin RS232 signals, Simple Serial Port programming in Assembly and C to transmit a message and to receive data serially.	**08 Hours**
Module 5	**8051 Interrupts and Interfacing Applications:** 8051 Interrupts. 8051 Assembly language programming to generate an external interrupt using a switch, 8051 C programming to generate a square waveform on a port pin using a Timer interrupt. Interfacing 8051 to ADC-0804, DAC, LCD and Stepper motor and their 8051 Assembly language interfacing programming.	**08 Hours**

Course outcomes:

After Studying this course, students will be able to

- Explain the difference between Microprocessors & Microcontrollers, Architecture of 8051 Microcontroller, Interfacing of 8051 to external memory and Instruction set of 8051.
- Write 8051 Assembly level programs using 8051 instruction set.
- Explain the Interrupt system, operation of Timers/Counters and Serial port of 8051.
- Write 8051 Assembly language program to generate timings and waveforms using 8051 timers, to send & receive serial data using 8051 serial port and to generate an external interrupt using a switch.
- Write 8051 Assembly language programs to generate square wave on 8051 I/O port pin using interrupt and C Programme to send & receive serial data using 8051 serial port.Interface simple switches, simple LEDs, ADC 0804, LCD and Stepper Motor to 8051 using 8051 I/O ports.

Text Books:

1. "The 8051 Microcontroller and Embedded Systems – using assembly and C", Muhammad Ali Mazidi and Janice Gillespie Mazidi and Rollin D. McKinlay; PHI, 2006 / Pearson, 2006.
2. "The 8051 Microcontroller", Kenneth J. Ayala, 3rd Edition, Thomson/Cengage Learning.

Reference Books:

1. "The 8051 Microcontroller Based Embedded Systems", Manish K Patel, McGraw Hill, 2014, ISBN: 978-93-329-0125-4. Steve Furber, ARM System-on-Chip Architecture, Second Edition, Pearson, 2015.
2. "Microcontrollers: Architecture, Programming, Interfacing and System Design", Raj Kamal, Pearson Education, 2005.

OPEN ELECTIVE-A (21BR56X)

Fundamentals of Biomedical Transducers and Medical Instrumentation (21BR561)

Semester V			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Measurement, Functional Elements of Measurement System and Transducers:** Measurement, Significance of measurement, Instruments and measurement systems, Electronic instruments, Analog and digital modes of operation, Functions of instruments and measurement systems, Applications of measurement systems, Basic medical instrumentation system, Performance requirements of medical instrumentation systems, PC based medical instruments, General constraints in design of medical instrumentation systems. Transducers, Classifications of transducers-primary & secondary, active & passive, analog and digital transducers.	**08 Hours**
Module 2	**Bioelectric Signals and Electrodes:** Sources of Biomedical Signals, Origin of Bioelectric Signals, Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG), Electrooculogram (EOG), Electroretinogram (ERG), Recording Electrodes– Electrode-tissue interface, Electrolyte-Skin interface, polarization, skin contact impedance, motion artifacts, Silver-Silver Chloride electrodes, Electrodes for ECG, Electrodes for EEG, Electrodes of EMG, Electrical conductivity of electrode jellies and creams, microelectrodes.	**08 Hours**
Module 3	**Measurement of Displacement:** Introduction, Principles of Transduction: Variable resistance devices, Variable Inductance Transducer, Synchros and Resolvers, Variable Capacitance Transducer, Hall Effect Devices, Proximity Devices, Digital Transducer. **Measurement of Strain:** Introduction, Electrical Strain Gauges, Theory of operation of resistance strain gauges, Types of Electrical Strain Gauges – Wire gauges, unbounded strain gauges, foil gauges, Semiconductor strain gauges (principle, types & list of characteristics only), Materials for strain gauges.	**08 Hours**
Module 4	**Measurement of Temperature**: Introduction, Resistance type temperature sensors, Platinum resistance thermometer,Thermistors (principle, types & characteristics), Thermocouples, Solid state sensors – principle and working of AD590 (characteristics and features), and LM35 (characteristics and features), Quartz thermometer, Temperature measurement by radiation methods, Optical pyrometer.	**08 Hours**

Module 5	**Measurement of Force**: Introduction, Force measuring sensor – Load cells – Column type devices, Proving rings, Cantilever beam,Hydraulic load cell, Electronic weighing system. **Flow Measurement**: Introduction, Classification of Flow Meters, Head type flow meters – Orifice meter and Venturi tube, Rotameter, Electromagnetic Flow Meter, Ultrasonic flowmeter, Laser anemometer, Rotor torque mass flow meter.	**08 Hours**

Course outcomes:

At the end of the course the student will be able to:

- Define the measurement, instrument, transducer, and explain the basic medical instrumentation system.
- Explain the principle, construction and working of transducers for the measurement ofdisplacement and strain.
- Discuss the principle, construction and working of transducers for the measurement oftemperature and force.
- Illustrate the methods for the measurement of flow and pressure.
- Use the above transducers for the measurement of physiological signals.

Textbooks:

1. Electrical and Electronic Measurements and Instrumentation – A. K. Sawhney, 17th Edition (Reprint 2004), Dhanpat Rai & Co. Pvt. Ltd., 2004.(Module-1).
2. Handbook of Biomedical Instrumentation- R S Khandpur, 2nd edition, Tata McGraw Hill, 2003. (Module-1 & 2)
3. Instrumentation: Devices and Systems- C. S. Rangan, G. R. Sarma, V. S. V. Mani, 2nd Edition (32nd Reprint), McGraw Hill Education (India), 2014. (Module 3, 4 & 5).

Reference Books:

1. Electronic Instrumentation and Measurements - David A Bell, 3rd Edition, Oxford University Press, 2013.
2. Transducers and Instrumentation – D.V.S.Murty, 2nd Edition, PHI, 2009.
3. Introduction to Measurements and Instrumentation - A. K. Ghosh, 2nd Edition, PHI,2007.
4. Instrumentation Measurement and Analysis- B.C.Nakra and K.K.Choudhry, 3rd Edition, McGraw Hill Education (India) Pvt.Ltd. 2009.

Biosafety and Healthcare (21BR562)

Semester V			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Introduction to biosafety**: General principles, Biosafety guidelines: Microbiological risk assessment, biosafety levels 1 and 2 in basic laboratories, biosafety level 3 in containment laboratories, biosafety level 4 in maximum containment laboratory, animal facilities and biosafety, guidelines for facility commissioning and certification, biosecurity.	**08 Hours**
Module 2	**Medical laboratory safety**: Biological safety cabinets, safety equipment, Microbiological techniques: laboratory techniques, contingency plans and emergency procedures, disinfection and sterilization, transport of infectious substances.	**08 Hours**
Module 3	**Safety in hospitals**: Chemical, fire and electrical safety: Hazardous chemicals, additional laboratory hazards, Safety organization and training: biosafety personal and committee, safety for support staff, training programs, safety checklist.	**08 Hours**
Module 4	**Other safety aspects**: First aid, immunization of the staff, WHO biosafety collaborating centers, equipment safety, chemicals used and their hazards and precautions to be followed.	**08 Hours**
Module 5	**Case studies**: Biosafety in hospitals: Primary hospitals, Multispecialty hospitals, Biosafety in hospital waste disposals, rules and regulations to be followed, examples of hospitals with regard to biosafety in radiology and exposure.	**08 Hours**

Course outcomes:

At the end of the course the student will be able to:

- Assess the importance of essential biosafety related rules and regulations to be followed in healthcare.
- Comprehend the different types of safety issues in hospitals and laboratories.
- Ascertain the important safety-based issues in terms of equipment and patients in hospitals.
- Illustrate the importance of supportive safety aspects to be considered in healthcare.
- Outline the role of biosafety and their relevance in real-time with the aid of different examples.
-

Textbooks:

1. Laboratory biosafety manual, 3rd edition, World health organization, 2015.
2. Fay A Razovsky, “Handbook of patient safety compliance”, Jossey Bass publications, 2014.

Reference Books:

1. Gordon R Higson, “Medical device safety”, IOP publications, 2012.

Fundamentals of Robotics and its Programming (21BR563)

Semester V			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Introduction to Robotics:** Introduction to Robotics and Automation technologies, Brief history of robotics, Robot Anatomy, Four common configurations of Robot, Robot motions-Linear, Rotational, Revolving, twisting, Cylindrical, Spherical. **Degrees of Freedom of Robot (DOF),** Introduction to degrees of freedom, three degrees of freedom associated with arm and body polar Robot. Three degrees of freedom associated with robot wrist, Joint notation scheme. Work Volume, links and joints. Introduction to End Effectors-types-basic definitions and operations, Spatial Resolution, Accuracy, Repeatability, and Compliance.	**08 Hours**
Module 2	**Robot Control Systems:** Introduction to Mathematical model of spring mass damper system. The Four types of Robot controls: Limited sequence robots, Playback robots with point to point control, playback robots with continuous path control, intelligent control. Robot controllers-On-off, proportional, integral, proportional-plus-integral, proportional-plus-derivative, proportional-plus integral plus derivative.	**09 Hours**
Module 3	**Robot Arm Kinematics:** Introduction to manipulator kinematics, Robot position representation, Forward transformation of a 2-degree of freedom Arm, Reverse Transformation of the 2-Degree of freedom Arm. **Robot Arm Dynamics:** Introduction to robot arm dynamics, understanding of Dynamics using Euler-Lagrangian-formation method. Definition of D-H parameter.	**07 Hours**
Module 4	**Introduction to Robot Programming:** Introduction to methods of Robot Programming-Lead through methods, Textural robot languages, Powered lead through, manual lead through. Introduction to generations of Robot Programming Languages-First Generation Languages-Second generation languages. Robot language structure block diagram. Definitions of Robot Language Elements and its functions.	**07 Hours**
Module 5	**Methods of Robot Programming:** Online programming and off-line programming, advantages of off-line programming, Teach pendant, Robot program as a path in space, defining position in space, Reasons for defining points, motion interpolation, WAIT, SIGNAL and DELAY commands, Branching capabilities. Simple program on palletization, Robot Applications in Engineering and Specific applications in healthcare/Biomedical, Automotive, Defense and Service domains.	**09 Hours**

Course outcomes:

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

- Comprehend basic concepts of robot which includes Degrees of freedom, links, joints, robot performances
- Develop the control aspect of robotic systems.
- Analyze the different transformations associated with robot kinematics and robot arm dynamics, motion equations.
- To understand the Robot programming, its language and structure.
- To know methods of programming statements, constant and variables of robot execution.

Text Books:

1. Mikell P Groover, Industrial Robotics-Technology, Programming and Applications 2nd edition, Tata McGraw Hill
2. Robert J Schilling, Fundamentals of Robotics,2003.
3. Richard D.Klafter, Robotics Engg. PHI, 2003.
4. R.K.Mittal and J.Nagarath, Robotics and Control,Tata McGraw Hill, Year 1995.

Reference Books:

1. K.S.Fu, R.C.Gonzales and Lee. Robotics, McGraw Hill International, 2008.
2. Industrial Robotics' Bernard Hodges Jaico Publishing House 1993
3. S Hegde, Industrial Robotics –Second Edition.

Fundamentals of Augmented and Virtual Reality (21BR564)

Semester V			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	Introduction to Augmented Reality: Defining augmented reality, history of augmented reality, The Relationship between Augmented Reality and Other Technologies-Media, Technologies, Other Ideas Related to the Spectrum between Real and Virtual Worlds, applications of augmented reality. Concepts Related to Augmented Reality, Ingredients of an Augmented Reality Experience. AR Devices & Components: Scene Generator, Tracking system, monitoring system, display, Game Scene Devices. Optical See-through HMD.	08 Hours
Module 2	Augmented Reality Hardware: Displays – Audio Displays, Haptic Displays, Visual Displays, Other sensory displays, Visual Perception, Requirements and Characteristics, Spatial Display Model. Tracking & Sensors - Tracking, Calibration, and Registration, Characteristics of Tracking Technology, Stationary Tracking Systems, Mobile Sensors, Optical Tracking, Sensor Fusion.	08 Hours
Module 3	Introduction to Virtual Reality: Defining Virtual Reality, History of VR, Human Physiology and Perception, Key Elements of Virtual Reality Experience, Virtual Reality System, Interface to the Virtual World-Input & output- Visual, Aural & Haptic Displays, Applications of Virtual Reality. Representation of the Virtual World, Visual Representation in VR, Aural Representation in VR and Haptic Representation in VR	08 Hours
Module 4	The Geometry of Virtual Worlds &The Physiology of Human Vision: Geometric Models, Changing Position and Orientation, Axis-Angle Representations of Rotation, Viewing Transformations, Chaining the Transformations, Human Eye, eye movements & implications for VR.	08 Hours
Module 5	Motion & Tracking : Motion in Real and Virtual Worlds-Velocities and Accelerations, The Vestibular System, Physics in the Virtual World, Mismatched Motion and Vection Tracking-Tracking 2D & 3D Orientation, Tracking Position and Orientation, Tracking Attached Bodies.	08 Hours

Course outcomes:

At the end of the course the student will be able to:

- Describe how AR systems work and list the applications of AR
- Analyse the hardware requirement of AR.
- Describe how VR systems work and list the applications of VR.
- Explain the concepts of motion and tracking in VR systems.

Textbook:

1 Schmalstieg, Hollerer, "Augmented Reality: Principles & Practice," Pearson Education India, 1st Edition, 2016, ISBN-10: 9332578494
2 Steven M. LaValle, "Virtual Reality," Cambridge University Press, 2016

Reference Books:

1. Allan Fowler, "AR Game Development," A press Publications, 1st Edition, 2018, ISBN 978-1484236178
2. William R Sherman and Alan B Craig, "Understanding Virtual Reality: Interface, Application and Design," Morgan Kaufmann Publishers, San Francisco, CA, 2002
3. Alan B Craig, William R Sherman and Jeffrey, "Developing Virtual Reality Applications: Foundations of Effective Design,"Morgan Kaufmann, 2009.

Web Link and Video Recourse

- https://www.coursera.org/learn/ar
- https://www.udemy.com/share/101XPi/
- http://lavalle.pl/vr/book.html
- https://nptel.ac.in/courses/106/106/106106138/
- https://www.coursera.org/learn/introduction-virtual-reality.

Programming in MATLAB (21BRL57)

Semester V			
No. of Teaching hour/Week	0	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	00
L:T:P in Hours	0:0:2	**Credits**	01

Sl. No.	Experiments
1.	Program to understand different modes of input/output operations on numerical data and character strings
2.	Programs to define and perform different operations on vector.
3.	Programs to understand the basic operations on matrix.
4.	Program to find the roots of a quadratic equation
5.	Program to understand different arithmetic operators
6.	Program to understand different logical operations
7.	Program to understand different set operators
8.	Program to define a user-defined function and call this function in the main program to realize the task.
9.	Programs to understand basic algebra functions.
10.	Programs to create and manipulate cell arrays.
11.	Program to generate and plot and subplot 2D and 3D data
12.	Program to understand the control structures: if, if-else and switch
13.	Program to understand the loop structures: while and for
14.	Program to find the roots of a given polynomial and to construct the polynomial from the given roots of the polynomial.

Course outcomes:

At the end of the course the student will be able to:

- Understand the MATLAB environment for programming
- Able to use MATLAB as a programming tool for problem solving
- Able to write and execute main program and user-defined functions
- Able to use features of MATLAB like built-in functions and tool boxes

Continuous Internal Evaluation (CIE) Details:

- CIE marks are for 50 Marks.
- The split-up of CIE marks for record and test are in the ratio **60:40**. That is 30 marks for record and 20 marks for tests.
- Each experiment has to be evaluated for conduction with observation sheet and record write-up. Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks. Total marks scored by the students are scaled downed to 30 marks.
- Department shall conduct 02 tests for 10 marks, the first test shall be conducted after the 8th week of the semester and the second test shall be conducted after the 14th week of the semester.
- In each test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce. The Sum of scaled-down marks scored in the report write-up and marks of two tests is the total CIE marks scored by the student.

Biomedical Instrumentation Lab (21BRL58)

Semester V			
No. of Teaching hour/Week	0	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	0	**Exam Hours**	03
L:T:P in Hours	0:0:4	**Credits**	02

List of Experiments

1.	Design and Test the bio-potential amplifiers for ECG/ or EEG/ or EMG
2.	Design and Test the Notch Filter for 50 Hz and 60 Hz.
3.	Testing and analysis of the following by hardware circuit/simulation (i) DC Defibrillator (ii) Pacemaker
4.	Acquisition of ECG: (i) Single lead (iii) Three lead, and (iii) 12-Leads. Analysis of the acquired ECG in amplitude, time and frequency domain.
5.	Acquisition and analysis (time & frequency) of EEG.
6.	Acquisition and analysis of Lung Volumes and Lung Capacities using Spirometer.
7.	Quantification and assessment of hearing ability using audiometer
8.	Measurement of corneal curvature using keratometer, (ii) Measurement of Visual Acuity using Snell's Chart, and (iii) Measurement of refractive errors.
9.	Study Experiments: Baby incubator, Ventilator, Heart-lung machine, Dialysis machine, Pacemaker.

Course Outcome:

- Design and verify the different bio-amplifiers and filters
- Acquire and analyze the ECG, EEG and respiratory signals
- Analyze the visual ability and audibility using approximate instruments.
- Demonstrate the working of different diagnostic and therapeutic hospital equipment's
- Install and operate the different types of hospital instruments.

Syllabus of Semester VI

Digital Image Processing (21BR61)

Semester VI			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:2	**Credits**	04

Modules	Course Content	Teaching Hours
Module 1	**Introduction**: Background, Examples of fields that use DIP, Fundamental steps in Digital Image Processing, Components of DIP system, Image sensing and acquisition, A simple image formation model, Image sampling and quantization. Basic relationship between pixels, Colour image processing fundamentals and models.	**08 Hours**
Module 2	**Image Enhancement in Spatial Domain:** Background, Point processing – Image negatives, Log transformations, Power law transformations, Contrast stretching, Intensity level slicing, Bit plane slicing, Histogram processing – Histogram equalization, Histogram matching (specification), Arithmetic/Logic operations – Image subtraction, Image averaging. Fundamentals of spatial filtering, Smoothing spatial filters, Sharpening spatial filters.	**08 Hours**
Module 3	**Image Enhancement In Frequency Domain:** Background, 2D-Discrete Fourier Transform and its Inverse, Basic properties of the 2D-Discrete Fourier Transform, Basics of filtering in the frequency domain. Image smoothing using frequency domain filters – Ideal lowpass filters, Butterworth lowpass filters, Gaussian lowpass filters; Image sharpening using frequency domain filters – Ideal highpass filters, Butterworth highpass filters, Gaussian highpass filters, Homomorphic filtering.	**08 Hours**
Module 4	**Image Restoration:** Model of the Image degradation/restoration process, Noise models, Restoration using spatial filtering: Mean filters, Order statistic filters - Median filter, Min and Max filters, Midpoint filter. **Image Compression:** Fundamentals, Image compression models, Basic compression methods – Huffman coding, Arithmetic coding, LZW coding, Run-length coding.	**08 Hours**
Module 5	**Image Segmentation:** Fundamentals, Point detection, Line detection, Edge models, Edge detection, Canny edge detector. Thresholding, Region based segmentation.	**08 Hours**

Practical Component of DIP

Sl. No.	Experiments
1.	Display of flipped, mirror and negative of an image.
2.	Contrast stretching of a low contrast image.
3.	Compute and plot image histogram, and perform histogram equalization.
4.	Bit plane slicing of an image.
5.	Perform arithmetic operations on images
6.	Perform logical operations on images
7.	Perform image enhancement by intensity level slicing with and without image background.
8.	Implementation of FT for an image.
9.	Implementation of high pass and low pass filtering operations on an image.
10.	Implementation of image enhancement using average and weighted average filters
11.	Implementation of nonlinear spatial filtering operation on an image.
12.	Implementation of image sharpening filters and edge detection using gradient filters.
13.	Detection of dot in an image using Laplacian operator
14.	Implementation of Canny edge detection.
15.	Perform image compression by DCT.

Course outcomes:

At the end of the course the student will be able to:

- Define the general terminology of digital image processing.
- Identify the need for image transforms and their types both in spatial and frequency domain.
- Identify different types of image degradation and apply restoration techniques.
- Describe image compression models and learn image compression techniques.
- Explain and apply various methodologies for image segmentation.
- Implement image processing and analysis algorithms.

Text Books:

1. Digital Image Processing - Rafael. C. Gonzalez and Richard. E. Woods, Third Edition, Pearson Education, 2008.
2. Rafel C Gonzalez, Richard E Woods, “Digital Image Processing”, 2nd ed, Addison - Wesley Publishing Company, New Delhi, 2002.
3. William R Hendee, E. Russell Ritenour, “Medical Imaging Physics”, 4th ed., John Wiley & Sons, Inc., New York, 2002.

Reference Books:

1. Fundamentals of Digital Image Processing - Anil K. Jain, 5th Indian Print, PHI, 2002.
2. Digital Image Processing and Computer Vision - Milan Sonka, India Edition, Cengage Learning.

Python for System Programming (21BR62)

Semester VI			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Datatypes in Python:** Comments in Python How Python sees variables, datatypes, buit-in datatypes, bool datatype, literals in Python, determining the datatype of a variable. **Operators in Python:** Operators, arithmetic, operators, assignment operator, unary minus operator, relational operators, logical operators, Boolean operators, bitwise operators, membership operators, identity operators, operator precedence and associativity. **Input, Output and Control Statements:** Output statements, input statements. Control statements, if statement, A word on indentation, if-else statement, if-elif-else statement, while loop, for loop, else suite, break statement, continue statement, pass statement, assert statement, return statement. **Functions:** Math functions: floor(), ceil(), trunc(), radians(), degrees(), sin(), cos(), tan(), fmod(), log10(), exp(), gcd(), pow(), modf(), sqrt(). Difference between a function and a method, defining function, calling a function, returning results from a function, returning multiple values from a function, local and global variables. Recursive functions.	**08 Hours**
Module 2	**Strings and Characters:** Creating strings, length of a string, indexing, slicing, repeating, concatenation, removing spaces, finding substrings, counting substrings, string is immutable, replacing a string with another string, splitting and joining, changing the case, working with characters, sorting, searching, inserting a substring in a string. **Lists and Tuples:** Lists, creating lists using range() function, updating the elements of a list, concatenation, repetition, membership in lists, aliasing and cloning lists, methods to process lists, finding biggest and smallest elements, sorting, number of occurrences of an element in the list, list comprehensions, tuples, creating tuples, accessing the tuple elements, basic operations on tuples. **Dictionaries:** Operations on dictionaries, dictionary methods. **Sets:** Set datatype, union, intersection, difference, symmetric difference. **Files in Python:** Files, Types of files in python, opening a file, closing a file, reading files, writing files.	**08 Hours**
Module 3	**Working with arrays using numpy:** Creating arrays using array(), linspace(), logspace(), arange(), zeros(), ones(). Comparing arrays,	**08 Hours**

	Matrices in numpy: Getting diagonal elements, Finding maximum, minimum, sum, average, product. Sorting the matrix, transpose of a matrix, Matrix addition, multiplication, Random numbers. **Data Frame:** Creating data frame from an Excel Spreadsheet, Using pandas: displaying statistical information, performing queries on data, Knowing the index, Setting a column as index, resetting the index, sorting the index, Handling missing data.	
Module 4	**Raspberry Pi:** Block diagram and features (Raspberry Pi 3 Model B), GPIO connector, GPIO Pins. **Controlling Hardware:** Connecting LED, controlling the brightness of an LED using PWM, **Motors:** Controlling the speed and direction of a DC motor, Using unipolar stepper motor. **Display:** Alphanumeric LCD Module, OLED graphical display, Sense HAT LED Matrix Display.	**08 Hours**
Module 5	**Hardware Basics:** Interface of LEDs and switches, switch control using interrupt. using keypad, Installing Py Serial for Access to the serial port from Python, serial read and write. **Sensors:** Measuring Temperature, Measuring Light, Sense HAT (Temperature, Humidity and Pressure Measurement).	**08 Hours**

Course outcomes:

After Studying this course, students will be able to:

- Examine Python syntax and semantics and be fluent in the use of Python flow control and functions.
- Identify the methods to create and manipulate lists, tuples and dictionaries.
- Demonstrate proficiency in handling matrix and data frames.
- Illustrate the block diagram, and features of hardware controls.
- Illustrate different sensor technologies for sensing real world entities.

Text Books:

1. Dr. R. Nageswara Rao, Core Python Programming, Third edition, Dreamtech Press, 2021.
2. Simon Monk, Raspberry Pi Cook book: Software and Hardware Problems and Solutions, Second and Third edition, O'Reilly Media Inc, 2019.

Reference Books:

1. Michael Dawson, Python Programming for the Absolute Beginner, Third edition, Cengage Learning, 2010.
2. Mark Lutz, Programming Python, Fourth edition, O'Reilly Media Inc, 2010.

IoT and Smart Sensors (21BR63)

Semester VI			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Introduction to IoT**: Definition & Characteristics of IoT, Physical Design of IoT: Things in IoT, IoT Protocols, Logical Design of IoT: IoT functional blocks, IoT Communication Models, IoT Communication APIs, IoT Enabling Technologies: Wireless Sensor Networks, Cloud Computing, Bit Data Analytics, Communication Protocols, Embedded Systems.	**08 Hours**
Module 2	**IoT System Management**: Introduction, Machine-to-Machine (M2M), Difference between IoT and M2M, SDN and NFV for IoT **IoT Topologies and Types:** Data Format, Importance of processing in IoT, IoT Device Design and Selection Consideration, Processing Offloading.	**08 Hours**
Module 3	**IoT Connectivity Technologies:** IEEE802.15.4, Zigbee, RFID, Wi-Fi, Bluetooth **IoT Communication Technologies:** Constrained Node, Constrained Networks, Types of Constrained Devices, Low power and Lossy Networks, Infrastructure protocol: IPv6, 6LoWPAN, Universal plug and play (UPnP), Data protocol: MQTT, CoAP, REST, WebSocket. Identification protocol: URIs.	**08 Hours**
Module 4	**Domain Specific IoTs:** Home Automation: Smart lighting, Smart appliances, Intrusion detection, Smoke/Gas Detection, Cities: Smart parking, Smart lighting, Smart roads, Structural health monitoring, Surveillance, Emergency Response, Environment: Weather monitoring, Air pollution monitoring, Noise pollution monitoring, Forest fire detection, River flood detection, Energy: Smart grids, Renewable energy systems, prognostics, Agriculture: Smart irrigation, Green house control, Industry: Machine diagnostics and prognosis, Indoor air quality monitoring, Health and Lifestyle: Health and Fitness monitoring, Wearable Electronics.	**08 Hours**
Module 5	**Protocols and Standards for Smart Sensors:** Introduction to smart sensors, block diagram of smart sensors, CAN protocol, CAN Module, Neuron Chips, MCU Protocols, IEEE1451 working relationship: IEEE1451.1: Network Capable Application Processor, IEEE1451.2 : STIM, TEDS, TII, IEEEP1451.3, IEEEP1451.4.	**08Hours**

Course outcomes:

After Studying this course, students will be able to:

- Interpret the impact and challenges posed by IoT networks leading to new architectural models.
- Compare and contrast the deployment of smart objects and the technologies to connect them to network.
- Appraise the role of IoT protocols for efficient network communication.
- Elaborate the need for Data Analytics and Security in IoT.
- Illustrate different sensor technologies for sensing real world entities and identify the applications of IoT in Industry.

Text Books:

1. ArshdeepBahga and Vijay Madisetti, Internet of Things–A hands – on approach, Universities Press (India) Private Ltd., 2015.
2. SudipMisra, Anandarup Mukherjee, Arijit Roy, Introduction to IoT, Cambridge University Press, 2021.
3. Randy Frank, Understanding Smart Sensors, Second edition, Artech House Publications, 2000

Reference Books:

1. Francisda Costa and Byron Henderson, Rethinking the Internet of Things: A Scalable Approach to Connecting Everything, Intel Publication, 2014.

Professional Elective-2 (21BR64X)

Rehabilitation Engineering (21BR641)

Semester VI			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Introduction to Rehabilitation:** What is Rehabilitation, Medical Rehabilitation, Preventive Rehabilitation, Impairment, Disability and Handicap, Sociovocational Rehabilitation Rehabilitation Team: Classification of members, Medical, The Rehabilitation team – The medical team, Physical therapist, Occupational therapist, Prosthetist-Orthotist, Rehabilitation nurse, Speech pathologist, Psychologist and child development Specialist, Horticultural Therapist, Music therapist, Creative Movement Therapist, Dance and play Therapist, Recreational therapist, Biomedical engineer.	**08Hours**
Module 2	**Introduction to tools and assistive devices**: Tools in clinical practice, universal design, principles and benefits of universal design, examples, assistive technology, Seating biomechanics and systems, design aspects seating systems	**09Hours**
Module 3	**Wheel chair design**: manual wheelchairs, basic structural components, electric power wheelchairs, power & drive systems, control system, power-assisted wheelchairs, multifunctional wheelchair intelligent mobility aids, smart wheeled walkers, sensors, software, robotic manipulations aids, therapeutic robots	**08Hours**
Module 4	**Functional electrical stimulation** (FES): clinical considerations of FES, electrodes, clinical applications, foot drop and wrist drop, upper extreme function, spinal cord stimulation, deep brain stimulation, gait, upper limb and low limb movements, upper limb and lower limb prosthesis, biomechanical principles of orthotic devices	**07Hours**
Module 5	**Hearing assistance technologies**: Types of hearing impairment, Hearing assistance technology solutions, medical or surgical approaches to restoring function, assistive listening solutions, Visual substitutions to auditory activities, vocational, daily living, and communication aids	**08Hours**

Course outcomes:

After Studying this course, students will be able to

- Define rehabilitation and explain the composition of rehabilitation team.
- To know tools and assistive devices.

- Design of Wheel chair.
- Describe Functional electrical stimulation methods
- To know the hearing assistance technologies.

Text Books:

1. Rehabilitation Medicine – By Dr. S. Sunder, 3rd Edition, Jaypee Medical Publications, Reprint 2004.
2. Rory A Cooper, Hisaichi Ohnabe, Douglas Hobson, "An Introduction to Rehabilitation Engineering", Francis & Taylor/CRC Press, First edition, 2007.

Drives and Control of Robots (21BR642)

Semester VI			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Robot Drive Mechanism:** Objectives, motivation, open loop control, closed loop control with velocity and position feedback, Types of drive Systems. Functions of drive system. Lead Screws, Ball Screws, Chain & linkage drives, Belt drives, Gear drives, Precision gear boxes, Harmonic drives, Cyclo speed reducers.	**09 Hours**
Module 2	**Hydraulic Drives:** Introduction, Requirements, Hydraulic piston and transfer valve, hydraulic circuit incorporating control amplifier, Hydraulic fluid considerations, hydraulic actuators Rotary and linear actuators. Hydraulic components in robots.	**08 Hours**
Module 3	**Pneumatic Drives:** Introduction, Advantages, pistons-Linear Pistons, Rotary pistons, Motors-Flapper motor, Geared motor, Components used in pneumatic control. Pneumatic proportional controller, pneumatically controlled prismatic joint.	**08 Hours**
Module 4	**Electric Drives:** Introduction, Types, DC electric motor, AC electric motor, stepper motors, half step mode operation, micro step mode. Types of stepper motors, Direct drive actuator.	**07 Hours**
Module 5	**General Aspects of Robot Control and Basic Control Techniques:** Mathematical modeling of robot servos, error responses and steady state errors in robot servos, feed back and feed forward compensations, hydraulic position servo, computer Controlled servo system for robot applications, selection of robot drive systems.	**08 Hours**

Course outcomes:

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

- To know basic knowledge of different types of Drives.
- To explain the Robot Hydraulic drive mechanism, circuits and its considerations.
- To analyse the Robot Pneumatic drive mechanism and its advantages.
- To describe the importance of electrical drive systems against hydraulic and pneumatic systems.
- To inculcate the Robot control and basic control techniques.

Text Books:

1. Robotics and Image Processing an Introduction, P.A. Janaki Raman, Tata Mc Graw Hill Publishing company Ltd.,1996
2. Engineering foundation of Robotics Francis N-Nagy, Andras Siegler ,Prentice Hall Inc 1987

Reference Books:

1. Pneumatic Systems, Principles and Maintenance- SR Majumdar, 2011Edition.
2. Computer Based Industrial Control- Krishna Kant, EEE-PHI,2ndedition,2010
3. Robotics Engineering an Integrated Approach,Richard D. Klafter, Thomas.A, Chmielewski, Michael Negin, Prentice Hall of India Pvt.Ltd.,1989.
4. Industrial Robotics, Technology programming and Applications Mikell P. Groorer, Mitchell welss, Roger N. Nagel, Nicholas,G.Odrey ,Mc Graw Hill International Edition, 1896.
5. Industrial Robotics Bernard Hodges Second Edition, Jaico Publishing house,1993
6. Fundamentals of Robotics Analysis and Control Robert J. Schilling, Hall of India Pvt. Ltd 2000
7. Introduction to Robotics Mechanics and Control, John J. Craig Second Edition, Addison Wesly Industrial Robotics, Technology, Programming, and applications-MikellP. Groover. Longman Inc. ,International Student edition, 1999.

CMOS VLSI Design (21BR643)

Semester VI			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	Moore's law, speed power performance, nMOS fabrication, CMOS fabrication: n-well, p-well processes, BiCMOS, Comparison of bipolar and CMOS. Basic Electrical Properties of MOS And BiCMOS Circuits: Drain to source current versus voltage characteristics, threshold voltage, transconductance.	**08 Hours**
Module 2	**Basic Electrical Properties of MOS And BiCMOS Circuits:** nMOS inverter, Determination of pull up to pull down ratio, nMOS inverter driven through one or more pass transistors, alternative forms of pull up, CMOS inverter, BiCMOS inverters, latch up. **Basic Circuit Concepts:** Sheet resistance, area capacitance calculation, Delay unit, inverter delay, estimation of CMOS inverter delay, driving of large capacitance loads, super buffers, BiCMOS drivers.	**08 Hours**
Module 3	**MOS and BiCMOS Circuit Design Processes:** MOS layers, stick diagrams, nMOS design style, CMOS design style, design rules and layout, λ - based design. **Scaling of MOS Circuits:** scaling factors for device parameters, limitations of scaling.	**08 Hours**
Module 4	**Subsystem Design and Layout-1:** Switch logic pass transistor, Gate logic inverter, NAND gates, NOR gates, pseudo nMOS, Dynamic CMOS, example of structured design, Parity generator, Bus arbitration, multiplexers, logic function block, code converter. **Subsystem Design and Layout-2 :** Clocked sequential circuits, dynamic shift registers, bus lines, subsystem design processes, General considerations, 4-bit arithmetic processes, 4-bit shifter.	**08 Hours**
Module 5	**Design Process-Computational Elements:** Regularity, design of ALU subsystem, ALU using adders, carry look ahead adders, Multipliers, serial parallel multipliers, Braun array, Bough – Wooley multiplier. **Memory, Register and Aspects of Timing:** Three Transistor Dynamic RAM cell, Dynamic memory cell, Pseudo- Static RAM.	**08 Hours**

Course outcomes:

At the end of the course the student will be able to:

- Identify the CMOS layout levels, and the design layers used in the process sequence.
- Describe the general steps required for processing of CMOS integrated circuits.
- Design static CMOS combinational and sequential logic at the transistor level.
- Demonstrate different logic styles such as complementary CMOS logic, pass-transistor Logic, dynamic logic, etc.
- Interpret the need for testability and testing methods in VLSI.

Textbooks:

1. Basic VLSI Design -3rd Edition, Douglas A Pucknell, Kamaran Eshraghian, Prentice Hall of India publication, 2005
2. CMOS Digital Integrated Circuits, Analysis And Design, 3rd Edition, Sung – Mo (Steve) Kang, Yusuf Leblbici,Tata McGraw Hill, 2002.
3. VLSI Technology - S.M. Sze, 2nd edition Tata McGraw Hill, 2003.

Medical Design, Regulation, and Safety (21BR644)

Semester VI			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**The Medical Device as an Entity:** What is a medical device?, Defining the device, The product definition process, Overview of quality function deployment, The QFD process, The business proposal Reliability: Definition, Quality Vs Reliability, Reliability Vs Unreliability, Types of Reliability, Optimizing reliability, Reliability's effects on medical devices. Concept of Failure: Causes of Failure, Practical aspects of failure, Failure rates, Hardware failure, Software Failure, Failure due to human errors, Failures from customer's point of view. Safety and Risk Management: Medical device safety and risk management, Effectiveness/performance of medical devices, Phases in the life span of a medical device, The risk management processes, Tools for risk estimation, Participants in ensuring the safety of medical devices, The role of each participant/stakeholder, Shared responsibility for medical device safety and performance.	**08 Hours**
Module 2	**Global Harmonization Task Force (GHTF):** Objectives, Scope of the four GHTF study groups, Benefits of the GHTF, Final documents from the GHTF, Global Medical Device Nomenclature (GMDN) The Food and Drug Administration: History of device regulation, Device classification, Registration and listing, The 510 (k) Process, Declaration of conformance to a recognized standard, The PMA application, Investigational Device Exemptions (IDEs), Good Laboratory Practices (GLPs), Good Manufacturing Practices(GMPs), Human Factors, Design Control, The FDA and Software, Software classification, The FDA Inspection.	**08 Hours**
Module 3	**The European Union:** European Directives, European Standardization Bodies, European Standards Development Process, Other European Standards Considerations, Conformity Assessment and Testing, European Organization for Testing and Certification, the NVCASE Program The Medical Devices Directives: Definition of a medical device, The Medical Devices Directives process, Choosing the appropriate directive, Identifying the applicable essential requirements, Identification of corresponding harmonized standards, Essential requirements, Classification of the medical devices, identification and choice of a notified body.	**08 Hours**
Module 4	**Standards and Regulations Background:** Standards: What are	**08 Hours**

	standards? Voluntary and mandatory standards, Standards development process, Conformity assessment with standards, National and international standards systems, Identification of standards, Current trends in the use of standards in medical device regulations. The ISO 9000 Series of Standards.	
Module 5	**Software and Quality system regulation:** Software as a Technology, Domestic Software Regulations, Domestic Software Standards, International Software Regulations, International Software Standards, The Move Toward One Software Standard History of the quality system regulations, Scope, General provisions, Quality system, Design 38 controls, Document controls, Purchasing controls, Identification and traceability, Production and process controls, Acceptance activities, Non-conforming product, Corrective and preventive action	**08 Hours**

Course outcomes:

At the end of the course the student will be able to:

- Define and explain the basic concepts of medical device regulations.
- Discuss the global policies on medical device regulations.
- Analyze implications of the regulations.
- Analyze the way design concepts are imbibed in practical scenarios.

Text Books:

1. Reliable Design of Medical Devices, Second Edition by Richard Fries, CRC Press, 2006.
2. Medical Device Quality Assurance and Regulatory Compliance by Richard C Fries, CRC Press, 1998

Reference Books:

1. Medical device regulations: global overview and guiding principles By Michael Cheng, World Health Organization.
2. Product Safety in the European Union by Gábor Czitán, Attila Gutassy, Ralf Wilde, TÜV Rheinland Akadémia, 2008.

Open Elective-B (21BR65X)

Fundamentals of Bio-MEMS (21BR651)

Semester VI			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Overview of MEMS and Micro systems:** MEMS and Microsystems, Typical MEMS and Microsystem Products, Evolution of Micro-fabrication, Micro systems and Microelectronics, Multidisciplinary nature of Microsystem design and Manufacture, Microsystems and Miniaturization, Applications of Microsystem in Health-care Industry. **Bio-MEMS:** Fabrication of Bio-MEMS, Structure, The Driving Force behind Biomedical Application, Biocompatibility, Reliability consideration.	**08 Hours**
Module 2	**Microsensors:** Acoustic wave sensor, Biomedical Sensors and Biosensors, Chemical Sensors, Optical Sensors, Pressure sensors, Thermal sensors. **Microactuation:** Principal means of Microactuation, MEMS with Microactuators, Microaccelrometer, Microfluidic. **Engineering Science for Microsystem Design and Fabrication:** Ions and Ionization, The Diffusion Process, Plasma Physics, Electrochemistry, Quantum Physics.	**08 Hours**
Module 3	**Engineering Mechanics for Microsystem Design**: Static Bending of Thin plates – Circular Plates, Rectangular Plates, Square Plates with all Edges Fixed, Mechanical vibrations – General Formulation, Resonant Vibration, Design theory of Accelerometers. **Detection and Measurement Methods:** Detection Scheme– Electrochemical Detection, Chemiluminescence and Bioluminescence, Fluorescence, Molecular Beacons, Measurement Systems.	**08 Hours**
Module 4	**Materials for MEMS and Microsystems:** Substrates and wafers, Active Substrate materials, Silicon as a Substrate material – Ideal Substrate, Crystal Structure, Mechanical Properties of Silicon, Silicon Compounds, Silicon Peizoresistors, Gallium Arsenide, Quartz, Polymers, Packaging Materials. **Emerging Bio-MEMS Technology:** Minimally invasive Surgery, Cardiovascular, Diabetes, Endoscopy, Oncology, Ophthalmology, Tissue Engineering, Cell-Based Biosensors, Home land Security.	**08 Hours**
Module 5	**Microsystem Fabrication Process:** Photolithography, Ion Implantation, Diffusion, Oxidation, Chemical Vapour Deposition, Physical Vapour Deposition, Deposition By Epitaxy, Etching.	**08 Hours**

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

- Discuss MEMS with current and potential markets for types of Microsystems
- Identify the suitable material to develop a microsystem.
- Explain the principles of emerging Bio-MEMS technology.
- Apply the principles of microsensors and microactuators to design microsystem.
- llustrate micro-manufacturing techniques

Text Books:

1. "MEMS & Microsystems: Design and Manufacture", Tai-Ran Hsu, Tata McGraw-Hill, 2002
2. "Fundamentals of Bio-MEMS and Medical Microdevices", Steven S. Saliterman, Wiley Interscience, 2006.

Reference Books:

1. "Introduction to Bio-MEMS", Albert Folch, CRC Press, 2012.
2. "Bio-MEMS: Technologies and Applications", Wanjun Wang, Steven A. Soper, CRC Press, 2006.

Wearable Devices (21BR652)

Semester VI			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Introduction:** What is Wearable Systems, Need for Wearable Systems, Drawbacks of Conventional Systems for Wearable Monitoring, Applications of Wearable Systems, Recent developments – Global and Indian Scenario, Types of Wearable Systems, Components of wearable Systems, Physiological Parameters commonly monitored in wearable applications. **Smart Sensors & Vital Parameters:** Vital parameters monitored and their significances, Bio-potential signal recordings (ECG, EEG, EMG), Dry Electrodes design and fabrication methods, Smart Sensors – textile electrodes, polymer electrodes, non-contact electrodes, MEMS and Nano Electrode Arrays, Cuff-less Blood Pressure Measurement, PPG, Galvanic Skin Response (GSR), Body Temperature Measurements, Activity Monitoring for Energy Expenditure, Respiratory parameters. Sensors for Wearable Systems, Biomechanical Sensors, Physiological Sign Sensors.	**08 Hours**
Module 2	**Future Direction & E-Textiles**: Fibers and Textiles for Bio electrodes, Fibers and Textiles for Sensing, Active Fiber Electronics and Woven Logics, Fibers and Textiles for Energy Harvesting and Storage, Smart Textiles for Actuation, Textile-Based Communication Devices, Smart Fabrics and Interactive Textiles Platforms. The Commercialization of Smart Fabrics: Intelligent Textiles, Analysis of the Markets: Today and Tomorrow, Common Backbone of Applications, Present Situation and Competitors in Terms of R&D and Commercialization, Market Segmentation, Market Volumes.	**08 Hours**
Module 3	**Energy Harvesting for Self-Powered Wearable Devices:** Principles of Energy by Using Human Body Heat, Calculated Characteristics of Wearable TEGs, Human Body as a heat source for a wearable thermoelectric power supply, TEG's in wearable devices, Hybrid Thermoelectric-Photovoltaic Wearable Energy Harvesters, TEGs in Clothing, Development of New Technologies for Wearable Thermopiles.	**08 Hours**
Module 4	**Wireless Communication Technologies for Wearable Systems**: System-Level Considerations, Lower-Level Tradeoffs, Recent Applications of Wireless Technology in Wearable Health Monitoring Systems. Design of Wireless Health Platforms, system Architecture Requirements for Wireless Health Platforms, System Design, Micro LEAP: A Wireless Health Platform with Integrated Energy Accounting, Micro LEAP Application: Smart Cane, Micro LEAP Application: Episodic Sampling, Conclusion and Next Generation Platforms.	**08 Hours**
Module 5	**Wearable Electronic Systems**: Applications to Medical	**08 Hours**

	Diagnostics/Monitoring, Historical Perspective, Present and Possible Clinical Applications, Sensing Constraints and Possibilities, Discussion and Conclusion. Scenarios for the Interaction Between Personal Health Systems and Chronic Patients, The New Paradigm of Personalized Health: p-Health, The AMI Vision, Challenges of User Interaction Within the Patient-Centered Care Paradigm, Scenarios for the Application of AMI to p-Health. Wearable Systems for Disaster management, Home Health care, Astronauts, Soldiers in battle field, athletes, SIDS, Sleep Apnea Monitoring.	

Course outcomes:

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

- Identify, understand and differentiate between different wearable systems used to acquire biomedical signals.
- Incorporate the knowledge smart sensors in suitable textile material.
- Understand various energy harvesting scheme in human body.
- Choose various communication protocols for transmission of processed biomedical signals
- Design and development of smart wearable system for health monitoring.

Text Books:

1. Annalisa Bonfiglo, Danilo De Rossi, Wearable Monitoring Systems, Springer, 2011.
2. Edward Sazonov, Micheal R Neuman, Wearable Sensors: Fundamentals, Implementation and Applications, Elseiver, 2014.

Reference Books:

1. Kate Hartman, Make: Wearable Electronics: Design, Prototype and wear your own interactive garments, Maker Media
2. Elijah Hunter, Wearable Technology, Kindle Edition
3. Guang Zhong Yang, Body Sensor Networks, Springer

Robot Motion Control and Path Planning (21BR653)

Semester VI			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Introduction:** Definition, Classification, Robot Components, Degree of Freedom, Introduction to Robot locomotion: Types of locomotion, hopping robots, legged robots, wheeled robots, stability, maneuverability, controllability. Robot Characteristics- Spatial resolution, Accuracy, repeatability, compliance, Introduction robot programming and its work cell control.	**07 Hours**
Module 2	**Introduction to Robot Motion analysis :** Robots Links and joints, Joint notation scheme, Introduction to End Effectors-types-Manipulator kinematics –forward and inverse kinematics- arm equation-link coordinates- Homogeneous transformations and basics of rotation matrix and Robot dynamics and its representations. Introduction to degrees of freedom and DH parameters.	**08 Hours**
Module 3	**Robot Control Systems and Components**: Basic control concepts. The Four types of Robot controls:-Limited sequence robots, Playback robots with point to point control, playback robots with continuous path control, intelligent control. Configuration of a robot controller.	**08 Hours**
Module 4	**Robot Controllers:** Robot controllers-On-off, proportional, integral,proportional-plus-integral,proportional-plus-derivative, proportional-plus integral plus derivative, variable structure control- Impedance control. **Introduction to Trajectory Planning:** Introduction, path planning block diagram, path control modes, point to point, straight line path, curve motion.	**09Hours**
Module 5	**Robot Path Planning:** Robot workspace analysis, joint space trajectories, path and trajectory planning of a robot, Cartesian space, general considerations of joint interpolated trajectory, trajectory planning with 3^{rd} order polynomial system(4-3-4 systems). **Introduction to Robot sensors and actuators**: Internal sensor, external sensor, potentiometer, velocity sensors.	**08 Hours**

Course outcomes:

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

- To know the basic knowledge of different types of robots and its characteristics.
- Solve the forward and inverse kinematics problems of robotics with DOF.

- To analyse the robot control systems and its configurations.
- To analyze the importance of robot controllers and path-trajectory planning its modes.
- Outline the various trajectory planning algorithms and control techniques, robots sensors - actuators

Text Books:

1. Craig, J.J., Introduction to Robotics: Mechanics and Control, 2nd Edition, Addison-Wesley, Reading, MA, 1989
2. Mikell P Groover, Industrial Robotics-Technology, Programming and Applications 2nd Edition – McGraw Hill.
3. Fundamentals of Robotics – Robert J Schilling, Year 2003.

Reference Books/Publications:

1. R. Siegwart, I. R. Nourbakhsh, "*Introduction to Autonomous Mobile Robots*", The MIT Press, 2011
2. Peter Corke , Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer Tracts in Advanced Robotics, 2011.
3. Computer Based Industrial Control- Krishna Kant, EEE-PHI,2ndedition,2010
4. Fundamentals of Robotics Analysis and Control Robert J. Schilling, Hall of India Pvt. Ltd 2000
5. Melgar, E. R., Diez, C. C., Arduino and Kinect Projects: Design, Build, Blow Their Minds, 2012.
6. S. M. LaValle, "Planning Algorithms", Cambridge University Press, 2006. (Available online http://planning.cs.uiuc.edu/)
7. H. Choset, K. M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki, and S. Thrun, Principles of Robot Motion: Theory, Algorithms and Implementations, PHI Ltd

Basics of Embedded System Design (21BR654)

Semester VI			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**EMBEDDED C:** Embedded System, Programming Embedded system, Factor for selecting the Programing language, Embedded C programming Language, Embedded C vs C. **ARM-32 bit MICROCONTROLLER:** RM Design Philosophy & RISC Architecture, Programmer's Model. ARM Cortex M, Cortex M Architecture, ARM Cortex-M Internals & Debugging.	**08 Hours**
Module 2	**GPIO MANAGEMENT:** GPIO Configuration, Driving De-initialization, Interfacing IO devices and its type – LEDs, Switches, Buzzer, Seven Segment Display, LCD (4 bit, 8 bit Mode), Keypad (4*4), DC Motor, Stepper Motor, Servo motor, Relay. **INTERRUPT MANAGEMENT & UART:** NVIC Controller, Enabling Interrupt, Interrupt Priority Levels, UART Initialization, UART communication in polling Mode & in Interrupt Mode. Wireless Technologies- Bluetooth, Wi-Fi, RF.	**08 Hours**
Module 3	**TIMERS , ADC, & DAC:** Timers Basics, General Purpose Timer, SysTick Timer, ADC & DAC Basics, Initialization, DAC Peripherals & Modules. Analog Sensors and its Types(Ultrasonic Sensor, Temperature, Humidity, Soil Moisture Sensor, PIR sensor)	**08 Hours**
Module 4	**I2C & SPI:** I2C specification, Protocol configuration, I2C Peripherals. SPI Specification, Protocol configuration, it's Peripheral and Modules.	**08 Hours**
Module 5	**PWM & CAN:** RTC feature and its Module, CAN Protocols Overview, Application, Architecture, Data Transmission & Data Frames.	**08 Hours**

Course outcomes:

After Studying this course, students will be able to

- Describe the architectural features and instructions of 32 bit ARM Cortex M3 microcontroller.
- To explain Understand the basic hardware components and their selection method based on the characteristics and attributes of an Embedded System.
- To interface various Sensors, Actuators to the microcontroller.

Text Books:

1. "The 8051 Microcontroller and Embedded Systems – using assembly and C", Muhammad Ali Mazidi and Janice Gillespie Mazidi and Rollin D. McKinlay; PHI, 2006 / Pearson, 2006.
2. Andrew N Sloss, "ARM System Developer's guide", Elsevier Publications, 2016
3. Shibu K V, "Introduction to Embedded Systems", Tata McGraw Hill Education Private Limited, 2nd Edition.

Reference Books:

1. James K Peckol, "Embedded systems- A contemporary design tool", John Wiley, 2008.
2. Yifeng Zhu, "Embedded Systems with Arm Cortex-M Microcontrollers in Assembly Language and C", 2nd Ed., Man Press LLC ©, 2015.
3. K V K K Prasad, "Embedded real time systems", Dreamtech publications, 2003.
4. Rajkamal, "Embedded Systems",2nd Edition, McGraw hill Publications, 2010.

Research Methodology and Intellectual Property Rights (21BR66)

Semester VI			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P in Hours	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Research methodology:** Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, Plagiarism, Research ethics	**08Hours**
Module 2	**Results and analysis:** Importance and scientific methodology in recording results, importance of negative results, different ways of recording, industrial requirement, artifacts versus true results, types of analysis (analytical, objective, subjective), hypothesis, concept, theory, model etc.	**09Hours**
Module 3	**Technical writing:** Effective technical writing, how to write a manuscript/responses to reviewers comments, preparation of research article/ research report, Writing a Research Proposal - presentation and assessment by are view committee.	**08Hours**
Module 4	**Intellectual property rights:** Nature of Intellectual Property: Patents, Designs, Trade Mark and Copyright. Process of Patenting and Development: technological research, innovation, patenting & development. Procedure for grants of patents, Patenting under PCT.	**07Hours**
Module 5	**Patent rights and new developments in IPR:** Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR, Administration of Patent System.	**08Hours**

Course outcomes:

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

- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understand research problem formulation & Analyze research related information and Follow research ethics.
- Correlate the results of any research article with other published results. Write a review article in the field of engineering.
- Appreciate the importance of IPR and protect their intellectual property. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Text Books:

1. Ranjit Kumar, Research Methodology A step by step guide for beginners, Pearson Education, Australia, 2005.
2. Ann M.Korner, Guide to Publishing a Scientific paper, BioscriptPress2004.
3. T. Ramappa, "Intellectual Property Rights Under WTO",S.Chand,2008

Python for System Programming Lab (21BRL67)

Semester VI			
No. of Teaching hour/Week	0	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	-	**Exam Hours**	03
L:T:P in Hours	0:0:4	**Credits**	02

List of Experiments

Expt. No.	Programs
1	Check math functions. a) floor(), ceil(), trunc(), radians(), degrees(), sin(), cos(), tan(). b) fmod(), log10(), gcd(), pow(), modf().sqrt(), exp().
2	Understand Control Flow statements. a) Convert the temperature value from one unit to another. b) Display all the even/odd numbers between given two numbers c) Check whether the given number is a prime or not. d) Find the sum of all the numbers between given two numbers. e) Find whether the given number is an Armstrong number or not. f) Display first n Fibonacci numbers.
3	Implement user defined functions. a) Function to find LCM of a number. b) Function to find HCF of a number. c) Recursive function to find sum of all numbers up to a given number. d) Recursive function to find factorial of a number.
4	Check String Operations: a) len(), split(), join(), upper(), lower(), swapcase(), title(), b) Fi6nd(), index(), count(), replace(), sorted(), strip(). c) String slicing.
5	Check List and Tuple Operations. a) len(), append(), extend(), insert(), remove(). b) reverse(), clear(), sort(), sorted(), count(). c) List comprehension: Creating list, Creating Matrix, Transpose of a Matrix, Addition, Difference and Scalar multiplication of two matrices.
6	Check Dictionary and Set Operations. a) Add element, Modify element, Delete element, clear(), copy(). b) get values, get keys, get items. c) union(), intersection(), difference(), symmetrical_difference(). Understand File Handling in Python a) Read data from a file. b) Write data into a file.
7	Check Matrix operations using numpy. a) diagonal(), max(), min(), sum(), mean(), sort(), transpose() b) Arithmetic operations on matrix using arithmetic operators.

8	Handle data using pandas: Create an excel sheet and a) Display statistical information, Perform queries on data. b) Modify the index of the data, Sort the index. c) Fill missing data.
9	Interface Sense HAT to Raspberry Pi.
10	Interface stepper motor to Raspberry Pi.
11	Interface dc motor to Raspberry Pi and control its speed using PWM.
12	Interface display device to Raspberry Pi.

Course outcomes:

- To understand math function and to execute
- To have the knowledge of control statements
- To understand the user defined functions and its implementation
- To analyze the check string operations, check list and tuple operations, check dictionary and set operations and check matrix operations using numpy.
- To understand the interface of Sense HAT, stepper motor, dc motor and display device to Raspberry Pi.

Text Books:

1. Dr. R. Nageswara Rao, Core Python Programming, Third edition, Dreamtech Press, 2021.
2. Simon Monk, Raspberry Pi Cook book: Software and Hardware Problems and Solutions, Second and Third edition, O'Reilly Media Inc, 2019.

Reference Books:

1. Michael Dawson, Python Programming for the Absolute Beginner, Third edition, Cengage Learning, 2010.
2. Mark Lutz, Programming Python, Fourth edition, O'Reilly Media Inc, 2010.

MYSORE UNIVERSITY SCHOOL OF ENGINEERING

Scheme of Teaching and Examination 2021-2022 (As per NEP-2020)
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
(Effective from the academic year 2021–2022)

B.E. in Biomedical and Robotic Engineering [BR]

VII-SEMESTER

Sl No.	Course & Course Code		Course Title	Teaching Dept.	Paper Setting Board	Teaching Hours/Week			Examination				Credits
						Theory lectures	Tutorial	Practical/ Drawing	Examination in Hours	CIE Marks	SEE Marks	Total Marks	
						L	T	P					
1	PCC	21BR71	Biomedical DSP	BM & RE	BM & RE	3	0	0	03	50	50	100	3
2	PCC	21BR72	Artificial Intelligence and Machine Learning for Health Care	BM & RE	BM & RE	3	0	0	03	50	50	100	3
3	PEC	21BR73X	Professional Elective – 3	BM & RE	BM & RE	3	0	0	03	50	50	100	3
4	PEC	21BR74X	Professional Elective – 4	BM & RE	BM & RE	3	0	0	03	50	50	100	3
5	PCC	21BRL75	Biomedical DSP Lab	BM & RE	BM & RE	0	0	2	03	50	50	100	1
6	Project	21BRP76	Project Work Phase – 1	BM & RE	BM & RE	0	2	2	00	100	-	100	2
7	AEC	21AEC77	Ability Enhancement Course-III	BM & RE	BM & RE	1	0	0	NA	50	-	50	1
8	INT	21INT78	Summer Internship-II	(If not completed during the vacation of VI and VII Semesters, it has to be carried out during the intervening vacations of VII and VIII Semesters)									
Total						**13**	**02**	**04**	**15**	**400**	**250**	**650**	**16**

Note: PCC: Professional Core Courses, PEC: Professional Elective Course, INT: Internship, AEC: Ability Enhancement Course.

Professional Elective-3

Course Code	Course Title
21BR731	Scientific and Analytical Instrumentation
21BR732	Database Management System in Health Care
21BR733	Medical Imaging System
21BR734	Biomaterials and Artificial Organs

Professional Elective-4

21BR741	Bio-MEMS
21BR742	Computer Communication Network in Health Care
21BR743	Augmented and Virtual Reality Development in Health Care
21BR744	Medical Robots

Project work: Based on the ability/abilities of the student/s and recommendations of the mentor, a single discipline or a multidisciplinary project can be assigned to an individual student or to a group having not more than 4 students. In extraordinary cases, like the funded projects requiring students from different disciplines, the project student strength can be 5 or 6.

CIE procedure for Project Work Phase - 1:

(i) Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two senior faculty members of the Department, one of whom shall be the Guide. The CIE marks awarded for the project work phase -1, shall be based on the evaluation of the project work phase -1 Report (covering Literature Survey, Problem identification, Objectives and Methodology), project presentation skill and question and answer session in the ratio 50:25:25. The marks awarded for the Project report shall be the same for all the batch mates.

(ii) Interdisciplinary: Continuous Internal Evaluation shall be group wise at the college level with the participation of all guides of the college. Participation of external guide/s, if any, is desirable. The CIE marks awarded for the project work phase -1, shall be based on the evaluation of project work phase -1 Report, project presentation skill and question and answer session in the ratio 50:25:25. The marks awarded for the project report shall be the same for all the batch mates.

Internship: All the students admitted to III year of BE/B.Tech. shall have to undergo mandatory internship of 4 weeks during the vacation of VI and VII semesters and /or VII and VIII semesters. A University examination shall be conducted during VIII semester and the prescribed credit shall be included in VIII semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take up/complete the internship shall be declared fail and shall have to complete during subsequent University examination after satisfying the internship requirements

AICTE Activity Points: In case students fail to earn the prescribed activity Points, an Eighth semester Grade Card shall be issued only after earning the required activity Points. Students shall be admitted for the award of the degree only after the release of the Eighth semester Grade Card.

MYSORE UNIVERSITY SCHOOL OF ENGINEERING

Scheme of Teaching and Examination 2021-2022 (As per NEP-2020)
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
(Effective from the academic year 2021–2022)

B.E. in Biomedical and Robotic Engineering [BR]

VIII-SEMESTER

Sl. No	Course & Course Code		Course Title	Teaching Dept.	Paper Setting Board	Teaching Hours/Week			Examination				Credits
						Theory lectures	Tutorial	Practical/ Drawing	Examination in Hours	CIE Marks	SEE Marks	Total Marks	
						L	T	P					
1	Project	21BRP81	Project Work Phase-2	BM & RE	BM & RE	Two contact hours/ week for interaction between the faculty and students.			-	100	100	200	8
2	Seminar	21BRS82	Technical Seminar	BM & RE	BM & RE	One contact Hour/ week for interaction between the faculty and students.			-	100	-	100	2
3	INT	21INT83	Summer Internship-II	(Completed during the intervening vacations of VI and VII semesters and /or VII and VIII semesters)					-	100	-	100	4
Total						--	--	--	-	**300**	**100**	**400**	**14**

Note: INT: Internship

Project Work CIE procedure for Project Work Phase - 2:

(i) Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two senior faculty members of the Department, one of whom shall be the Guide. The CIE marks awarded for the project work phase -2, shall be based on the evaluation of project work phase -2 Report, project presentation skill and question and answer session in the ratio 50:25:25. The marks awarded for the project report shall be the same for all the batch mates.

(ii) Interdisciplinary: Continuous Internal Evaluation shall be group wise at the college level with the participation of all guides of the college. Participation of external guide/s, if any, is desirable. The CIE marks awarded for the project work phase -2, shall be based on the evaluation of project work phase -2 Report, project presentation skill and question and answer session in the ratio 50:25:25. The marks awarded for the project report shall be the same for all the batch mates.

SEE for Project Work Phase - 2:

(i) Single discipline: Contribution to the project and the performance of each group member shall be assessed individually in semester end examination (SEE) conducted at the department.

(ii) Interdisciplinary: Contribution to the project and the performance of each group member shall be assessed individually in semester end examination (SEE) conducted separately at the departments to which the student/s belong to.

Internship: Those, who have not pursued /completed the internship shall be declared as fail and have to complete during subsequent University examination after satisfying the internship requirements.

AICTE activity Points: In case students fail to earn the prescribed activity Points, eighth semester Grade Card shall be issued only after earning the required activity Points. Students shall be admitted for the award of degree only after the release of the Eighth semester Grade Card. Activity points of the students who have earned the prescribed AICTE activity Points shall be sent the University along with the CIE marks of 8th semester. In case of students who have not satisfied the AICTE activity Points at the end of eighth semester, the column under activity Points shall be marked NSAP (Not Satisfied Activity Points).

Biomedical DSP (21BR71)

Semester VII			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Introduction:** The nature of biomedical signals, objectives of biomedical signal analysis, difficulties encountered in biomedical signal analysis, Computer aided diagnosis. (Text book **1**) Neurological Signal processing: Brain and its potentials, Electrophysiological origin of Brain waves, EEG signal and its characteristics, EEG analysis, Linear prediction theory, Autoregressive (AR) method, Recursive Estimation of AR parameters, Spectral error measure, Adaptive segmentation. (Text book **2**)	**08 Hours**
Module 2	Basics of signal averaging, Signal averaging as a digital filter, A typical average, Software for signal averaging, Limitations of signal averaging. (Text book **3**) Data Acquisition and classification of sleep stages, The Markov model and Markov chains, Dynamics of Sleep-wave Transitions, Hypnogram Model Parameters**.** (Text book **2**)	**08 Hours**
Module 3	**Filtering for Artifacts Removal:** Time domain filters with application: Synchronized averaging, moving-average filters. Frequency domain filters with examples, removal of high frequency noise by Butterworth low pass filters, removal of low frequency noise by Butterworth high pass filter, removal of periodic artifacts by notch and comb filters. **(**Text book **1)**	**08 Hours**
Module 4	ECG Parameters and their estimation, A review of Wiener filtering problem, Principle of an adaptive filter, the steepest descent algorithm, Adoptive noise canceller, Cancellation of 60Hz Interference in ECG, Cancelling Donor heart Interference in Heart-transplant ECG, Cancellation of Electrocardiographic signals from the electrical activity of chest muscles, Cancelling of maternal ECG in Fetal ECG, Cancellation of higher frequency noise in electro-surgery. (Text book **2**)	**08 Hours**
Module 5	Direct data compression techniques, Direct ECG data compression techniques, Transformation compression techniques, other data compression techniques, Data compression techniques comparison (Text book **2**)	**08 Hours**

Course outcomes:
At the end of the course the student will be able to:

1. Discuss the origin, nature, and characteristics of biomedical signals.
2. Identify the noise and artifacts in biomedical signals and apply suitable filters to remove noise.
3. Apply the signal averaging technique.
4. Evaluate various event detection techniques for the analysis of the EEG and ECG.
5. Apply different data compression techniques on biomedical Signals.
6. Develop algorithms to process and analyze biomedical signals for better diagnosis.

Text Books:

1. Rangayyan Rangaraj, 'Biomedical signal analysis- A case study approach', Wiley Inder science (IEEE Press)-2005
2. D.C.Reddy, 'Biomedical Signal Processing- principles and techniques', Tata McGraw-Hill, , 2005
3. Willis J.Tompkins, 'Biomedical Digital Signal Processing', PHI, 2001

Reference Books:

1. Akay M, 'Biomedical Signal Processing', Academic: Press, 1994.
2. Cohen.A, 'Biomedical Signal Processing', Vol. I Time & Frequency Analysis, CRC Press, 1986.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The student has to obtain a minimum of 40% marks individually both in CIE and SEE to pass. Theory Semester End Exam (SEE) is conducted for 100 marks (3 Hours duration) and then it is reduced to 50. Based on this grading will be awarded.

Continuous Internal Evaluation (CIE): The CIE marks for theory courses shall be 50.

1. Thirty (30) marks shall be considered to evaluate students in tests. There shall be three tests generally conducted at the end of fifth, tenth and fifteenth week of each semester. Each test shall be conducted for a maximum of 50 marks and the final test marks shall be the average of three tests, proportionately reduced to a maximum of 30 marks.
2. Ten (10) marks shall be prescribed for assignments /written quizzes (one scheduled quiz and one surprise quiz). There shall be at least two assignments and two quizzes. The marks earned in these events shall be averaged to reduce to 10 marks.
3. Ten (10) marks shall be prescribed for open book tests, for self-study or to test problem solving skills. There shall be at least two events. The marks earned in these events shall be averaged to reduce to 10 marks.

Question Paper Pattern (SEE):

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks. Each full question carries 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.

- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Artificial Intelligence and Machine Learning for Health Care (21BR72)

Semester VII			
No. of Lecture hour/Week	3	**CIE Marks**	50
No. of Practical hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L: T:P	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Introduction to machine learning:** Need for Machine Learning, Machine Learning in relation to other fields, Types of Machine Learning. Challenges of Machine Learning, Machine Learning process, Machine Learning applications. **Understanding Data:** Types of data, big data analytics and types of analytics, big data analytics framework, Descriptive statistics, univariate data analysis and visualization.	**08 Hours**
Module 2	Bivariate and Multivariate data, Multivariate statistics, Essential mathematics for Multivariate data, Overview hypothesis, Feature engineering and dimensionality reduction techniques, **Basics of Learning Theory:** Introduction to learning and its types, Design of learning system, Introduction to concept learning.	**08 Hours**
Module 3	**Supervised Learning: Regression:** Introduction to linear regression, Gradient descent algorithm, Polynomial regression Regularization techniques: L1 and L2 regularization, Model evaluation: mean squared error, R-squared score. **Supervised Learning:** Classification, Introduction to logistic regression, Decision trees and random forests, Support vector machines (SVM), Evaluation metrics for classification: accuracy, precision, recall, F1-score.	**08 Hours**
Module 4	**Unsupervised Learning: Clustering:** Introduction to clustering algorithms, K-means clustering, Hierarchical clustering, Density-based clustering, Evaluation metrics for clustering: inertia, silhouette score. **Unsupervised Learning: Dimensionality Reduction:** Introduction to dimensionality reduction, Principal Component Analysis (PCA), t-SNE algorithm, Applications of dimensionality reduction	**08Hours**
Module 5	**Applications of Machine Learning in Health Care:** Image recognition, Natural Language Processing (NLP), Recommendation systems, Fraud detection, Predictive maintenance.	**08 Hours**

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

1. Build strong expertise in basics of statistics and probability.
2. Understand basics of descriptive statistics.
3. Organize data in numbers or graphs for descriptive statistical analysis.

4. Design of inferences or conclusion specific to population by taking some tests.
5. Understand concepts of model building and statistical computing techniques.

Reference Books:

1. Fan, J., Li, R., Zhang, C.-H., and Zou., Statistical Foundations of Data Science. CRC Press. 2020.
2. Ethem Alpaydin, Introduction to Machine Learning, 3rd Ed., PHI Learning Pvt. Ltd., 2014.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The student has to obtain a minimum of 40% marks individually both in CIE and SEE to pass. Theory Semester End Exam (SEE) is conducted for 100 marks (3 Hours duration) and then it is reduced to 50. Based on this grading will be awarded.

Continuous Internal Evaluation (CIE): The CIE marks for theory courses shall be 50.

1. Thirty (30) marks shall be considered to evaluate students in tests. There shall be three tests generally conducted at the end of fifth, tenth and fifteenth week of each semester. Each test shall be conducted for a maximum of 50 marks and the final test marks shall be the average of three tests, proportionately reduced to a maximum of 30 marks.
2. Ten (10) marks shall be prescribed for assignments /written quizzes (one scheduled quiz and one surprise quiz). There shall be at least two assignments and two quizzes. The marks earned in these events shall be averaged to reduce to 10 marks.
3. Ten (10) marks shall be prescribed for open book tests, for self-study or to test problem solving skills. There shall be at least two events. The marks earned in these events shall be averaged to reduce to 10 marks.

Question Paper Pattern (SEE):

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.Each full question carries 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Professional Elective-3

Scientific and Analytical Instrumentation (21BR731)

Semester VII			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Introduction to Instrumental Methods:** Terms associated with Chemical analysis, Classification of instrumental techniques, Review of important consideration in analytical methods, Basic functions of instrumentation, Fundamental Laws of photometry. (Text book **1**) **IR Spectroscopy:** Basic Components of IR Spectrophotometers, monochromators- Littrow mounting, Fourier Transform IR Spectroscopy (Text book **2**)	**08 Hours**
Module 2	**UV and Visible Spectrometry Instrumentation:** Radiation Sources, Wavelength selection: absorption filters, interference filters, Detector, Readout modules, Instruments for absorption photometry: single beam and double beam spectrophotometer. (Text book **1**)	**08 Hours**
Module 3	**Flame Emission and Atomic Absorption Spectroscopy:** Introduction, Instrumentation for flame spectrometric methods, Flame emission spectrometry, atomic absorption spectrometry, Atomic fluorescence spectrometry, Interferences associated with Flames & furnaces, applications, comparison of FES and AAS. (Text book **1**)	**08 Hours**
Module 4	**Gas Chromatography:** Chromatograph, Basics parts of a chromatograph: carrier gas supply, sample injection system, chromatographic columns: packed column & capillary column, Detectors: katharometer cell, differential flame ionization detector, electron capture detector. (Text book **2**) **HPLC Instrumentation:** Mobile phase delivery system sample introduction, separation of columns, Detectors Ultraviolet Photometers & Spectrophotometers, electrochemical detector (amperometric detector), Differential refractometer. (Text book **1**)	**08 Hours**
Module 5	**Blood analyzer:** Introduction, Blood pH measurements: electrodes for blood pH measurement, measurement of blood pCO2, pO2, Complete blood gas analyzer. (Text book **2**)	**08 Hours**

Course outcomes:

At the end of the course the student will be able to:

1. Understand the principle, construction and working of UV & IR spectroscopy.
2. Understand the principle, construction and working of Flame Emission and Atomic Absorption Spectroscopy
3. Understand the principle, construction and working of Gas & High-performance Liquid Chromatograph.
4. Understand the application of analytical techniques in medicine, Industry, etc.

Text Books:

1. H.H. Willard, L.L. Merritt, J.A. Dean, F.A. Settle, 'Instrumental Methods of Analysis', 7th edition. CBS Publishing & Distribution.
2. R.S. Khandpur, 'Handbook of Instruments' –, Tata McGraw Hill

Reference Books:

1. Braun R.D., Introduction to Instrumental Analysis, McGraw –Hill Singapore,2006.
2. Frank G. Kerry Industrial Gas Handbook: Gas Separation and Purification, Taylor and Francis group, 2007.
3. Principles of Instrumental Analysis 5th Edition – Douglas A. Skoog, F. James Holler, Timothy A. Niemen, Thomason Brooks/ Cole

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The student has to obtain a minimum of 40% marks individually both in CIE and SEE to pass. Theory Semester End Exam (SEE) is conducted for 100 marks (3 Hours duration) and then it is reduced to 50. Based on this grading will be awarded.

Continuous Internal Evaluation (CIE): The CIE marks for theory courses shall be 50.

1. Thirty (30) marks shall be considered to evaluate students in tests. There shall be three tests generally conducted at the end of fifth, tenth and fifteenth week of each semester. Each test shall be conducted for a maximum of 50 marks and the final test marks shall be the average of three tests, proportionately reduced to a maximum of 30 marks.
2. Ten (10) marks shall be prescribed for assignments /written quizzes (one scheduled quiz and one surprise quiz). There shall be at least two assignments and two quizzes. The marks earned in these events shall be averaged to reduce to 10 marks.
3. Ten (10) marks shall be prescribed for open book tests, for self-study or to test problem solving skills. There shall be at least two events. The marks earned in these events shall be averaged to reduce to 10 marks.

Question Paper Pattern (SEE):

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.Each full question carries 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

- The students will have to answer five full questions, selecting one full question from each module.

Database Management System in Health Care (21BR732)

Semester VII			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Database and Database Users:** Introduction, Characteristics of the Database Approach, Advantages of using the DBMS Approach. (**Text Book 2 :** 1.1, 1.3, 1.6) **Database System Concepts and Architecture:** Data models, Schemas, and Instances, Three–Schema Architecture and Data Independence, Database Languages and Interfaces, Classification of Database Management Systems. (**Text Book 2 :** 2.1, 2.2, 2.3, 2.6) **Patient Database:** Patient Database strategies for HIS, data acquisition, patient admission, transfer, discharge, evaluation & management. Computer based patient record, clinical decision support systems. **(Text Book 3)**	**08 Hours**
Module 2	**Overview of Database Systems:** A Historical Perspective, File Systems versus a DBMS, Describing and Storing Data in a DBMS, Queries in a DBMS, Transaction Management, Structure of a DBMS. (**Text Book 1 :** 1.2, 1.3, 1.5, 1.6, 1.7, 1.8) **Data Modeling using the Entity – Relationship (ER) Model:** Using High – Level Conceptual Data Models for Database Design, An Example Database Application; Entity Types, Entity Sets, Attributes and Keys, Relationship types, Relationship Sets, Roles and Structural Constraints, Weak Entity Types, Refining the ER Design for the COMPANY Database, ER Diagrams, Naming Conventions and Design Issues. (**Text Book 2 :** 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7)	**08 Hours**
Module 3	**Relational Algebra and Relational Calculus:** Unary Relational Operations: SELECT and PROJECT, Relational Algebra Operations from Set Theory, Binary Relational Operations: JOIN and DIVISION, Additional Relational Operations. (**Text Book 2:** 6.1, 6.2, 6.3, 6.4) **SQL – 99:** SQL Data Definition and Data Types, Specifying Constraints in SQL, Schema Change Statements in SQL, Basic Queries in SQL, More Complex SQL Queries, INSERT, DELETE and UPDATE Statements in SQL, Specifying	**08 Hours**

	Constraints as Assertions and Triggers, Views (Virtual Tables) in SQL , Additional Features of SQL. (**Text Book 2 :** 8.1, 8.2, 8.3, 8.4, 8.5, 8.6, 8.7, 8.8, 8.9)	
Module 4	**Database Design Theory and Methodology:** Informal Design Guidelines for Relation Schemas, Functional Dependencies, Normal Forms Based on Primary Keys, General Definitions of Second and Third Normal Forms, Boyce-Codd Normal Form. (**Text Book 2 :** 10.1, 10.2, 10.3, 10.4, 10.5) **Relational Database Design Algorithms and Further Dependencies:** Properties of Relational Decompositions, Algorithms for Relational Database Schema Design, Multivalued Dependencies and Fourth Normal Form, Join Dependencies and Fifth Normal Form. (**Text Book 2:** 11.1, 11.2, 11.3, 11.4)	**08 Hours**
Module 5	**Overview Of Transaction Management:** The ACID Properties, Transactions and Schedules, Concurrent Execution of Transactions, Lock-Based Concurrency Control, Performance of Locking, Transaction Support in SQL, Introduction to Crash Recovery. **(Text Book 1: Chapter 16)** **Concurrency Control:** 2PL, Serializability and Recoverability, Introduction to Lock Management, Lock Conversions, Dealing with Deadlocks, Specialized Locking Techniques, Concurrency Control without Locking. **(Text Book 1 : Chapter 17)**	**08 Hours**

Course outcomes:

At the end of the course the student will be able to:

1. Describe the basic concepts of DBMS, and DBMS architecture.
2. Describe the concept of ER model.
3. Apply the Relational operations and Structured Query Languages for RDBMS.
4. Analyze the data model based on normalization theory.
5. Discuss database transactions management and data recovery from system crash.

Text Books:

1. Raghu Ramakrishna and Johannes Gehrke, 'Database Management Systems', 3rd Edition, McGraw Hill, 2003.
2. Ramez Elmasri and ShamkantB.Navathe, 'Fundamentals of Database Systems',5thEdition, Pearson Education, 2007.
3. Joseph D, Bronzino 'The Biomedical Engineering Handbook',Volume II 2nd Edition – by., CRC/IEEE Press, 2000.

Reference Books:

1. Silberschatz, Korth and Sudharshan, 'Data base System Concepts', 4th Edition, McGraw Hill, 2002.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The student has to obtain a minimum of 40% marks individually both in CIE

and SEE to pass. Theory Semester End Exam (SEE) is conducted for 100 marks (3 Hours duration) and then it is reduced to 50. Based on this grading will be awarded.

Continuous Internal Evaluation (CIE): The CIE marks for theory courses shall be 50.

1. Thirty (30) marks shall be considered to evaluate students in tests. There shall be three tests generally conducted at the end of fifth, tenth and fifteenth week of each semester. Each test shall be conducted for a maximum of 50 marks and the final test marks shall be the average of three tests, proportionately reduced to a maximum of 30 marks.
2. Ten (10) marks shall be prescribed for assignments /written quizzes (one scheduled quiz and one surprise quiz). There shall be at least two assignments and two quizzes. The marks earned in these events shall be averaged to reduce to 10 marks.
3. Ten (10) marks shall be prescribed for open book tests, for self-study or to test problem solving skills. There shall be at least two events. The marks earned in these events shall be averaged to reduce to 10 marks.

Question Paper Pattern (SEE):

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.Each full question carries 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Medical Imaging System (21BR733)

Semester VII			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**X-Ray Imaging:** Fundamentals 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, Filters, Beam restrictors and grids, Intensifying screens, fluorescent screens, and image intensifiers, X-ray detectors, Biological effects of ionizing radiation. **X-Ray Diagnostic Methods:** Conventional X-ray radiography, Fluoroscopy, Angiography, Mammography and Xeroradiography.	**08 Hours**
Module 2	**Ultrasound Imaging:** Fundamentals of acoustic propagation - Characteristic impedance, Intensity, Reflection and refraction, Attenuation, Doppler effect. Generation and detection of Ultrasound- Piezoelectric effect, Ultrasonic transducers, Axial and Lateral resolution, Focusing, Arrays. **Ultrasonic Diagnostic Methods:** Pulse echo systems- Amplitude mode (A-mode), Brightness mode (B-mode), Motion mode (M-mode), Doppler methods, Duplex imaging, Tissue characterization, Colour Doppler flow imaging.	**08 Hours**
Module 3	**Radionuclide Imaging:** Introduction, Fundamentals 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, Radionuclide imaging systems- Rectilinear scanner, Scintillation camera, SPECT, PET.	**08 Hours**
Module 4	**Basics of Magnetic Resonance Imaging:** Fundamentals of nuclear magnetic resonance- Angular momentum, magnetic dipole moment, magnetization, Larmor frequency, Free induction decay (FID), Fourier spectrum of the NMR signal, Spin density, Relaxation times, Pulse sequences. **MRI System & Imaging Methods:** Introduction, Magnet,	**08 Hours**

	NMR Coil/Probe, Transmitter, Receiver, Data acquisition. Imaging Methods- Introduction, slice selection, frequency encoding, phase encoding, Spin-Echo imaging- Gradient echo imaging, Characteristics of MRI images- Spatial resolution, image contrast. Biological effects of magnetic fields- Static magnetic fields, Radio-frequency fields, Gradient magnetic fields, Imaging safety, Functional MRI (brief introduction only).	
Module 5	**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. **Advances in Medical Imaging:** Image guided intervention- Introduction, Stereotactic neurosurgery, Stereotactic neurosurgery based on digital image volumes- image acquisition, planning and transfer, Intraoperative Imaging- Intraoperative diagnostic imaging, transfer by matching preoperative with intraoperative images, augmented reality.	**08 Hours**

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

1. Describe the fundamentals of x-ray radiography and computed tomography, and analyze the system requirements.
2. Explain principles of ultrasound imaging and diagnostic methods and analyze the system requirements.
3. Discuss the fundamentals of radionuclide imaging, MRI, thermal imaging and analyze the system requirements.
4. Describe the concepts of image Guided Intervention and image guided surgery.
5. Design and develop prototype of simple medical imaging system.

Text Books:

1. Kirk Shung, Michael B. Smith and Banjamin Tsui, 'Principles of Medical Imaging', Academic Press, 1992.
2. R.S.Khandpur, 'Handbook of Biomedical Instrumentation', 2nd Edition, Tata McGraw Hill, 2003.
3. Paul Suetens, 'Fundamentals of Medical Imaging', Cambridge University Press, 2002.

Reference Books:

1. Steve Webb, Adam Hilger, Bristol, 'The Physics of Medical Imaging' Philadelphia Publications, 1988.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The student has to obtain a minimum of 40% marks individually both in CIE and SEE to pass. Theory Semester End Exam (SEE) is conducted for 100 marks (3 Hours duration) and then it is reduced to 50. Based on this grading will be awarded.

Continuous Internal Evaluation (CIE): The CIE marks for theory courses shall be 50.

1. Thirty (30) marks shall be considered to evaluate students in tests. There shall be three tests generally conducted at the end of fifth, tenth and fifteenth week of each semester. Each test shall be conducted for a maximum of 50 marks and the final test marks shall be the average of three tests, proportionately reduced to a maximum of 30 marks.
2. Ten (10) marks shall be prescribed for assignments /written quizzes (one scheduled quiz and one surprise quiz). There shall be at least two assignments and two quizzes. The marks earned in these events shall be averaged to reduce to 10 marks.
3. Ten (10) marks shall be prescribed for open book tests, for self-study or to test problem solving skills. There shall be at least two events. The marks earned in these events shall be averaged to reduce to 10 marks.

Question Paper Pattern (SEE):

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.Each full question carries 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Biomaterials and Artificial Organs (21BR734)

Semester VII			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Biomaterials:** Introduction to biomaterials, uses of biomaterials, biomaterials in organs & body systems, materials for use in the body, performance of biomaterials. **Metallic Biomaterials:** Introduction, Stainless steel, Cobalt-Chromium alloy, Titanium alloys, Titanium-Nickel alloys, Dental metals, Corrosion of metallic implants, Manufacturing of implants.	**08 Hours**
Module 2	**Polymeric Biomaterials:** Introduction, polymerization and basic structure, polymers used as biomaterials, sterilization, surface modifications to for improving biocompatibility. **Composite Biomaterials:** Structure, bounds on properties, anisotropy of composites, particulate composites, fibrous composites, porous materials, biocompatibility.	**08 Hours**
Module 3	**Artificial Organs:** Introduction: Substitutive medicine, outlook for organ replacement, design consideration, evaluation process. **Artificial Heart And Circulatory Assist Devices:** Engineering design, Engineering design of artificial heart and circulatory assist devices, blood interfacing implants – introduction, total artificial hearts & ventricular assist devices, vascular prostheses, Non-blood interfacing implants for soft tissues- sutures and allied augmentation devices, percutaneous and skin implants, maxillofacial implants, eye and ear implants.	**08 Hours**
Module 4	**Artificial Kidney:** Functions of the kidneys, kidney disease, renal failure, renal transplantation, artificial kidney, dialyzers, membranes for haemodialysis, haemodialysis machine, peritoneal dialysis equipment-therapy format, fluid and solute removal. **Artificial Blood:** Artificial oxygen carriers, flurocarbons, hemoglobin for oxygen carrying plasma expanders, hemoglobin based artificial blood.	**08 Hours**

Module 5	**Artificial Lungs:** Gas exchange systems, Cardiopulmonary bypass (heart-lung machine)-principle, block diagram and working, artificial lung versus natural lung. Liver functions, hepatic failure, liver support systems, general replacement of liver functions. **Artificial Pancreas:** Structure and functions of pancreas, endocrine pancreas and insulin secretion, diabetes, insulin, insulin therapy, insulin administration systems. Tracheal replacement devices, laryngeal replacement	**08 Hours**

Course outcomes:

At the end of the course the student will be able to:

1. Explain the principle and biology underlying the design of implants and artificial organs.
2. Differentiate classes of materials used in medicine.
3. Discuss the application of biomaterials in medicine.
4. Discuss concept of biocompatibility and the methods of biomaterial testing.
5. Discuss the design process in some of the prominent artificial organ

Text Books:

1. J.D.Bronzino, 'Biomedical Engineering Handbook', Volume1, 2nd Edition,CRC Press / IEEE Press, 2000.
2. R.S.Khandpur, 'Handbook of Biomedical Instrumentation', 2nd Edition,Tata McGraw Hill, 2003.

Reference Books:

1. Francisda Costa and Byron Henderson, Rethinking the Internet of Things: A Scalable Approach to Connecting Everything, Intel Publication, 2014.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The student has to obtain a minimum of 40% marks individually both in CIE and SEE to pass. Theory Semester End Exam (SEE) is conducted for 100 marks (3 Hours duration) and then it is reduced to 50. Based on this grading will be awarded.

Continuous Internal Evaluation (CIE): The CIE marks for theory courses shall be 50.

1. Thirty (30) marks shall be considered to evaluate students in tests. There shall be three tests generally conducted at the end of fifth, tenth and fifteenth week of each semester. Each test shall be conducted for a maximum of 50 marks and the final test marks shall be the average of three tests, proportionately reduced to a maximum of 30 marks.
2. Ten (10) marks shall be prescribed for assignments /written quizzes (one scheduled quiz and one surprise quiz). There shall be at least two assignments and two quizzes. The marks earned in these events shall be averaged to reduce to 10 marks.
3. Ten (10) marks shall be prescribed for open book tests, for self-study or to test problem solving skills. There shall be at least two events. The marks earned in these events shall be averaged to reduce to 10 marks.

Question Paper Pattern (SEE):

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.Each full question carries 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Professional Elective-4

Bio-MEMS (21BR741)

Semester VII			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Overview of MEMS and Micro systems:** MEMS and Microsystems, Typical MEMS and Microsystem Products, Evolution of Micro-fabrication, Micro systems and Microelectronics, Multidisciplinary nature of Microsystem design and Manufacture, Microsystems and Miniaturization, Applications of Microsystem in Health-care Industry. (**Text 1:** 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.8.1) **Bio-MEMS:** Fabrication of Bio-MEMS, Structure, The Driving Force behind Biomedical Application, Biocompatibility, Reliability consideration. (**Text 2:** 1.1, 1.1.1, 1.1.2, 1.2, 1.3, 1.4) **Microsensors:** Acoustic wave sensor, Biomedical Sensors and Biosensors, Chemical Sensors, Optical Sensors, Pressure sensors, Thermal sensors. (**Text 1:** 2.2)	**08 Hours**
Module 2	**Microactuation:** Principal means of Microactuation, MEMS with Microactuators, Microaccelrometer, Microfluidic. (**Text 1:** 2.3, 2.4, 2.5, 2.6) **Engineering Science for Microsystem Design and Fabrication:** Ions and Ionization, The Diffusion Process, Plasma Physics, Electrochemistry, Quantum Physics. (**Text 1:** 3.3, 3.6, 3.7, 3.8, 3.9)	**08 Hours**
Module 3	**Engineering Mechanics for Microsystem Design:** Static Bending of Thin plates – Circular Plates, Rectangular Plates, Square Plates with all Edges Fixed, Mechanical vibrations – General Formulation, Resonant Vibration, Design theory of Accelerometers. (**Text 1:** 4.2, 4.2.1, 4.2.2, 4.2.3, 4.3, 4.3.1, 4.3.2, 4.3.4) **Materials for MEMS and Microsystems:** Substrates and wafers, Active Substrate materials, Silicon as a Substrate material – Ideal Substrate, Crystal Structure, Mechanical Properties of Silicon, Silicon Compounds, Silicon Peizoresistors, Gallium Arsenide, Quartz, Polymers, Packaging Materials. (**Text 1:** 7.2, 7.3, 7.4.1, 7.4.3, 7.4.5, 7.5, 7.6, 7.7, 7.8, 7.10, 7.11)	**08 Hours**
Module 4	**Emerging Bio-MEMS Technology:** Minimally invasive Surgery, Cardiovascular, Diabetes, Endoscopy, Oncology, Ophthalmology, Tissue Engineering, Cell-Based Biosensors, Home land Security. (**Text 2:** 13.2, 13.4, 13.5, 13.6, 13.8, 13.9, 13.11, 13.12, 13.13)	**08 Hours**
Module 5	**Microsystem Fabrication Process:** Photolithography, Ion Implantation, Diffusion, Oxidation, Chemical Vapour Deposition, Physical Vapour Deposition, Deposition By Epitaxy, Etching, The LIGA Process. (**Text 1:** 8.2, 8.3, 8.4, 8.5, 8.6, 8.7, 8.8, 8.9, 9.4)	**08 Hours**

Course outcomes:

At the end of the course the student will be able to:

1. Discuss MEMS with current and potential markets for types of Microsystems
2. Identify the suitable material to develop a microsystem.
3. Explain the principles of emerging Bio-MEMS technology.
4. Apply the principles of microsensors and microactuators to design microsystem.
5. Illustrate micro-manufacturing techniques.

Textbook:

1. Tai-Ran Hsu "MEMS & Microsystems: Design and Manufacture", Tata McGraw-Hill, 2002.
2. Steven S. Saliterman "Fundamentals of Bio-MEMS and Medical Microdevices", Wiley Interscience, 2006.

Reference Books:

1. Albert Folch "Introduction to Bio-MEMS", CRC Press, 2012.
2. Wanjun Wang, Steven A. Soper "Bio-MEMS: Technologies and Applications", CRC Press, 2006.

Assessment Details (both CIE and SEE)

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Question Paper Pattern (SEE):

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.Each full question carries 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Computer Communication Networks in Healthcare (21BR742)

Semester VII			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Computer Networks In Health Care:** Introduction, history, impact of clinical data, information types, platforms, current technologies, identifier standards, communication (message format) standards. **Introduction To Computer Networks:** Uses of Computer Networks: Business Applications, Home Applications, Mobile Users. Network Hardware: Local Area Networks, Metropolitan Area Networks, Wide Area Networks, Wireless Networks. Network Software: Design Issues for the Layers, Connection – Oriented and Connectionless Services, Service primitives. The Relationship of Services to Protocols. Reference Models: The OSI Reference3 Model, The TCP/IP Reference Model, A Comparison of the OSI and TCP/IP Reference Models.	**08 Hours**
Module 2	**The Physical Layer:** The Theoretical Basis For Data communication: Bandwidth Limited Signals, The Maximum Data Rate of a Channel. Guided Transmission Media: Magnetic Media, Twisted Pair, Coaxial Cable, Fiber Optics. **Wireless Transmission:** The Electromagnetic Spectrum, Radio Transmission, Microwave Transmission, Infrared and Millimeter Waves, Light wave Transmission. The Public Switched Telephone Network: Structure of the Telephone System. Trunks and Multiplexing: FDM, WDM&TDM, Switching, Internet over Cable.	**08 Hours**
Module 3	**The Data Link Layer:** Data Link Layer Design Issues: Services Provided to the Network Layer, Framing, Error Control, Flow Control. Elementary Data Link Protocols: A Simplex Stop–and–Wait Protocol. Sliding Window Protocols: A One – Bit Sliding Window Protocol, A Protocol Using Go Back N, A Protocol Using Selective Repeat, HDLC –High – Level Data Link Control, The Data Link Layer in the Internet.	**08 Hours**
Module 4	**The Medium Access Control Sublayer:** Multiple Access Protocols: ALOHA, Carrier Sense Multiple Access Protocols, Wireless LAN Protocols. Ethernet: Ethernet Cabling, Manchester Encoding, The Ethernet MAC Sublayer Protocol, The Binary Exponential Backoff Algorithm, Ethernet Performance. Wireless Lans: The 802.11 Protocol Stack, The 802.11 Physical Layer, The 802.11 MAC Sublayer Protocol, The 802.11 Frame Structure, Services.	**08 Hours**
Module 5	**Blue Tooth:** Blue tooth Architecture, Bluetooth Applications. Data Link Layer SWITCHING: Local Internet Working, Repeaters, Hubs, Bridges, Switches, Routers, and Gateways, Virtual LANs.	**08 Hours**

	The Network Layer: Network Layer Design Issues: Store-and- Forward Packet Switching, Services Provided to the Transport Layer, Implementation of Connectionless Service, Implementation of Connection –Oriented Service. **Routing Algorithms:** The Optimality Principle, Shortest Path Routing, Distance Vector Routing, Link State Routing, Hierarchical Routing, Broadcast Routing. The Network layer In The Internet: The IP Protocol, IP Address Formats, IPV6 Header Format.	

Course outcomes:

At the end of the course the student will be able to:

1. Explain the different formats of data generated in clinical field or Medical field.
2. Discriminate the functionality between the layers in OSI model and TCP/IP suite.
3. Discuss the concept of physical and data link layer.
4. Distinguish the IEEE standards designed to understand the interconnectivity between different LANs.
5. Apply different algorithms to route a packet to the destination for process to process delivery.
6. Discuss the concepts of Bluetooth technology, and transport & application layer.

Textbook:

1. Joseph D. Bronzino, 'The Biomedical Engineering Handbook',Volume II 2nd Edition, CRC/IEEE Press, 2000.
2. Andrew S. Tanenbaum, 'Computer Networks' –, 4th Edition, Pearson Education / PHI, 2004.

Reference Books:

1. William Stallings, 'Data and Computer Communication', 7th Edition, Pearson Education, 2004.
2. Behrouz A Forouzan, 'Data Communications and Networking', 4th Edition, Tata McGraw Hill, 2006.
3. Kurose and Ross, 'Computer Networking, Pearson Education, 2004

Assessment Details (both CIE and SEE)

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3. Ten (10) marks shall be prescribed for open book tests, for self-study or to test problem solving skills. There shall be at least two events. The marks earned in these events shall be averaged to reduce to 10 marks.

Question Paper Pattern (SEE):

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.Each full question carries 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Augmented and Virtual Reality Development in Health Care (21BR743)

Semester VII			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Introduction to AR & VR:** Categorizing the realities – Virtual Reality, Augmented Reality & Mixed Reality, Introduction, features and application areas of Virtual Reality, Augmented Reality & Mixed Reality. Integration of VR techniques, Contents objects and scale, Gaze based Control, Handy Interactables, IDE setup with package files, concepts and features of VR, VR project example. Working with AR techniques, compatibility with the environment, system architecture, AR terminology, application areas of AR**,** Integration of AR toolkits with existing IDE's (Unity-Vuforia, Visual Studio, Netbeans, intellij IDEA, Android, iOS), connectivity of smart devices with AR.	**08 Hours**
Module 2	**VR App Development with Unity VR SDK's –** VR SDK'S and Frameworks – OpenVR SDK, StreamVR SDK, VRTK, Oculus SDK, Google VR SDK. **VR Concept Integration-** Motion Tracking, Controllers, Camera , Hardware and Software requirements. **Setting up Unity with VR-** Framework/SDK Integration with Unity, Debugging VR projects, Unity XR API's, Mobile VR Controller Tracking, Object Manipulation, Text optimizing and UI for VR	**08 Hours**
Module 3	**AR App Development with Unity AR Foundation – D**etection of surfaces, identifying feature points, track virtual objects in real world, face and object tracking. **AR Algorithms–**Briefing on SLAM Algorithm (Simu-ltaneous Localization and Mapping), understanding uncertain spatial relationship, Anatomy of SLAM, Loop detection and Loop closing. **Unity AR concepts-** Pose tracking, Environmental detection, Raycasting and physics for AR, Light estimation, Occlusion, working with ARCore and ARKit	**08 Hours**
Module 4	**ARCore**-Features of ARCore, integration with Unity/Unreal/iOS/Android Studio, augmented reality applications with ARCore. **ARToolkit**–Features of ARToolkit, setting up the environment for application development. **Vuforia-** Features of Vuforia, setting up the	**08 Hours**

	environment for application development. **Programming Languages for AR & VR applications** **C# with Unity –** OOL concepts, classes in C#, setting up visual studio or code editor for C#, 3D models compatibility with C#, C# for AR and VR.	
Module 5	**Working with VR & AR Devices** **VR Devices –** Structure and working of HTC Vive, Google Cardboard, Samsung gear VR, Oculus Quest, Samsung Odyssey+, Oculus Rift. **AR Components –** Scene Generator, Tracking system, monitoring system, display, Game scene **AR Devices –** Optical See- Through HMD, Virtual retinal systems, Monitor based systems, Projection displays, Video see-through systems. Advantages and Disadvantages of AR and VR technologies. **Use Cases for AR and VR in single application** **Trending Application Areas -** Health and Medicine, Telerobotics and Telepresence	**08 Hours**

Course outcomes:

At the end of the course the student will be able to:

1. Compare and Contrast VR and AR experiences
2. Demonstrate and develop VR apps in Unity
3. Demonstrate and develop AR apps in Unity
4. Acquire knowledge in VR and AR technologies in terms of used devices, building of the virtual environment and modalities of interaction and modeling.
5. Acquire knowledge about the application of VR and AR technologies in medicine.

Text Books:

1. Steve Aukstakalnis ' Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors for AR and VR', Addison-Wesley Professional, September 2016, ISBN:9780134094328.
2. Allan Fowler- Beginning iOS AR Game Development Developing Augmented Reality Apps with Unity and C#, 1st Edition, Apress Publications, 2018, ISBN 978-1484236178
3. William Sherif- Learning C++ by Creating Games with UE4, Packt Publishing, 2015, ISBN 978-1-78439-657-2

Reference Books:

1. Jesse Glover, Jonathan Linowes – Complete Virtual Reality and Augmented Reality Development with Unity: Leverage the power of Unity and become a pro at creating mixed reality applications. Packt publishing, 17th April 2019. ISBN -13 : 978-1838648183.
2. Jonathan Linowes, Krystian Babilinski – Augmented Reality for Developers: Build practical augmented reality applications with Unity, ARCore, ARKit, and Vuforia. Packt publishing, 9th October 2017. ISBN-13: 978-1787286436. (Text book **1**)

MOOC Courses:

https://www.coursera.org/learn/augmented-reality
https://www.coursera.org/specializations/unity-xr

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The student has to obtain a minimum of 40% marks individually both in CIE and SEE to pass. Theory Semester End Exam (SEE) is conducted for 100 marks (3 Hours duration) and then it is reduced to 50. Based on this grading will be awarded.

Continuous Internal Evaluation (CIE): The CIE marks for theory courses shall be 50.

1. Thirty (30) marks shall be considered to evaluate students in tests. There shall be three tests generally conducted at the end of fifth, tenth and fifteenth week of each semester. Each test shall be conducted for a maximum of 50 marks and the final test marks shall be the average of three tests, proportionately reduced to a maximum of 30 marks.
2. Ten (10) marks shall be prescribed for assignments /written quizzes (one scheduled quiz and one surprise quiz). There shall be at least two assignments and two quizzes. The marks earned in these events shall be averaged to reduce to 10 marks.
3. Ten (10) marks shall be prescribed for open book tests, for self-study or to test problem solving skills. There shall be at least two events. The marks earned in these events shall be averaged to reduce to 10 marks.

Question Paper Pattern (SEE):

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.Each full question carries 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Medical Robots (21BR744)

Semester VII			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	40	**Exam Hours**	03
L:T:P	3:0:0	**Credits**	03

Modules	Course Content	Teaching Hours
Module 1	**Introduction to Medical Robots:** Introduction to Bio-medical robots, Types of Medical Robots, Navigation and paradigms of Bio-Medical Robots, Forward kinematics, Inverse, Typical applications and benefits of robots in Health care sectors **Introduction to Mobile Robots:** A brief history of mobile robotics, applications and market, Recent advances in the mobile robotics for RISE (Risky Intervention and Surveillance Environment) **Textbook: 1**	**07 Hours**
Module 2	**Design of Medical Robots:** Characterization of gestures to the design of robot-design methodology- technological choices-security. **Image-Guided Interventions:** Medical Imaging Modalities: CT, US, MRI, Needling systems-Passive and active needles,-Unicyle, actuators-smart actuator such as Shape Memory Alloys, Image Guided feedback control system. **Textbook: 2**	**08 Hours**
Module 3	**Rehabilitation Robotics:** Introduction, Exoskeletons-Design concepts, Development and control- Human hand-Biomechanics, Rehabilitation for Limbs-Brain-Machine-Interfaces, Redundancy resolution, Introduction to Rehabilitation Strategies, Robotic prosthetics. **Mobile Robot locomotion:** Types of locomotion and its salient characteristics of hopping robots, legged robots, wheeled robots, stability, aerial robots, maneuverability, controllability. **Textbook: 1**	**08 Hours**
Module 4	**Current Topics in Bio-Medical Robotics:** Haptic Augmentation in Exoskeletons, Robotic Catheters for percutaneous interventions, Unsupervised learning for mapping in Bio-Robots, Reven–II Robots. Future Trends of Robotics In the Medical Field. **Mobile Robot localization and Navigation:** Introduction, the challenges of localization, localization based navigation versus programmed solutions, map representation, probabilistic map, map based localization, autonomous map building. Planning and navigation: Planning and reaction, D* algorithm obstacle avoidance. **Textbook: 1**	**09 Hours**
Module 5	**Bio-Medical robots for Surgical applications:** Introduction to Da Vinci Surgical System, The Xenex Germ-Zapping Robot, Image guided robotic systems for focal ultrasound based	**08 Hours**

	surgical applications, System concept for robotic Tele-surgical system for off-pump CABG surgery, Urologic applications, Cardiac surgery, Neuro-surgery ,General- Surgery, Gynecologic Surgery and Nano robotics. Advantages and disadvantages.	

Course outcomes:

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

1. To know the basic prime parameters of Medical and Mobile robots, its typical; applications.
2. To understand the skills and implement robotic assistant for both Minimally Invasive Surgery Image-Guided Interventions and also medical robots design parameters.
3. To know the parameters of rehabilitations, exoskeleton systems and locomotion aspects of mobile robots.
4. To know the recent developments and trends in bio medical robots and also to understand mobile robots localizations and navigations.
5. To understand the specialized robots core applications in Surgical areas, its advantages and disadvantages.

Text Books:

1. Roland Siegwart & Illah R. Nourbakhsh, “Introduction to autonomous mobile robots”, Prentice Hall of India, 2004.
2. Paula Gomes, "Medical robotics- Minimally Invasive surgery", Woodhead, 2012
3. Nagrath and Mittal, “Robotics and Control”, Tata McGraw-Hill, First edition, 2003.
4. 4.Spong and Vidhyasagar, “Robot Dynamics and Control”, John Wiley and Sons, First edition, 2008.
5. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, “Robot Modeling and Control”, Wiley Publishers, 2006
6. Fu.K.S, Gonzalez.R.C. Lee, C.S.G, “Robotics, control, sensing, Vision and Intelligence”, Tata McGraw Hill International, First edition, 2008.

Reference Books:

1. Jocelyne Troccaz, “Medical Robotics”, Wiley-ISTE, 2012.
2. VanjaBonzovic, ”Medical Robotics”, I-tech Education publishing,Austria,2008.
3. Daniel Faust, “Medical Robots”, Rosen Publishers, 2016.
4. Jacob Rosen, Blake Hannaford & Richard M Satava, “Surgical Robotics: System Applications & Visions”, Springer 2011.
5. Paula Gomes, “Medical robotics: minimally invasive surgery”, Woodhead publishing, year 2012.
6. Medical Robotics ,Winter 2019,Lecture 15,Rehabilitation (Movement Therapy) Robots Allison Okamura, Stanford University.
7. Current trend of robotics application in medical, OA Olanrewaju1, AA Faieza 2 & K Syakirah3, IOP Conf.Series: Materials Science and Engineering 46 (2013) 012041doi:10.1088/1757-899X/46/1/012041.

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- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Biomedical DSP Lab (21BRL75)

Semester VII			
No. of Teaching hour/Week	-	**CIE Marks**	50
No. of Tutorial hours/week	-	**SEE Marks**	50
Total No. of Lecture hours	-	**Exam Hours**	03
L:T:P	0:0:2	**Credits**	01

List of Experiments	
Write programs in C or Matlab or Scilab	
1.	Write a program to Compute Linear & Circular convolution, Cross & Auto correlation using ECG/EEG/EMG.
2.	Write a program to Compute DFT, FFT, Power spectrum and power spectral density of ECG/EEG/EMG.
3.	Write a program to Display Static and Moving ECG signal.
4.	Write a program to Implement 50Hz notch filter for ECG signal and display PSD.
5.	Write a program to Implement IIR filters for ECG (LPF,HPF,BPF)
6.	Write a program to Implement Low-Pass FIR filter for ECG
7.	Write a program to Implement FIR Filter using Kaiser Window.
8.	Write a program to detect QRS complex and measure the heart rate of a given ECG signal
9.	Write a program to improve the SNR using signal averaging technique
10.	Write a program to obtain the DCT & IDCT of ECG signal
11.	Write a program to down sample the given ECG signal
12.	Write a program to obtain Adaptive noise cancelling
13.	Write a program to compress the data using Turning point & FAN algorithm

Course outcomes:

After Studying this course, students will be able to:

1. Apply the signal processing techniques on biomedical signals and evaluate their performance.
2. Develop/Write signal processing algorithms for the analysis of biomedical signals

ABILITY ENHANCEMENT COURSE III (21AEC77)

Semester VII			
No. of Teaching hour/Week	1	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	--
Total No. of Lecture hours	15	**Exam Hours**	--
L:T:P	1:0:0	**Credits**	01

Modules	Course Content	Teaching Hours
Module 1	Information Design and Development- Different kinds of technical documents, Information development life cycle, Organization structures, factors affecting information and document design, Strategies for organization, Information design and writing for print and for online media.	**03 Hours**
Module 2	Technical Writing, Grammar and Editing- Technical writing process, forms of discourse, Writing drafts and revising, Collaborative writing, creating indexes, technical writing style and language.	**03 Hours**
Module 3	Basics of grammar, study of advanced grammar, editing strategies to achieve appropriate technical style. Introduction to advanced technical communication, Usability, Human factors, Managing technical communication projects, time estimation, Single sourcing, Localization.	**03 Hours**
Module 4	Communication and Technical Writing- Public speaking, Group discussion, Oral; presentation, Interviews, Graphic presentation, Presentation aids, Personality Development.	**05 Hours**
Module 5	Work culture in jobs, Personal memory, Rapid reading, Taking notes, Complex problem solving, Creativity.	**03 Hours**

Course outcomes:

At the end of the course the student will be able to:

- Design and develop the technical documents and contents.
- Write & edit technical articles without grammatical mistakes.
- Manage technical communication projects.
- Address the public and participate in group discussions.
- Work cohesively at job roles and apply problem solving strategies.

Text Books:

1. David F. Beer and David McMurrey, “Guide to writing as an Engineer”, John Willey. New York, 2004.
2. Diane Hacker, “Pocket Style Manual”, Bedford Publication, New York, 2003, ISBN 0312406843.
3. Shiv Khera, “You Can Win”, Macmillan Books, New York, 2003.

Reference Books:

1. Raman Sharma, “Technical Communications”, Oxford Publication, London, 2004.
2. Dale Jungk, “Applied Writing for Technicians”, McGraw Hill, New York, 2004. (ISBN: 07828357-4)
3. Sharma, R. and Mohan, K, “Business Correspondence and Report Writing”, TMH New Delhi 2002.
4. Xebec, “Presentation Book”, TMH New Delhi, 2000, ISBN 0402213.