Panel of Examiners recommended by BoS to Bio Medical and Robotic Engineering Programme for the academic year 2023-2024.

Internal Members:

1. Dr. Ananthapadmanabha T, Director, Mysore University School of Engineering Manasagangotri, Mysuru-6.
2. Dr. Pradeep T. M, Assistant Professor, Dept. of B M & R E, Mysore University School of Engineering Manasagangotri, Mysuru-6.
3. Dr. Suma A. P, Assistant Professor, Dept. of B M & R E, Mysore University School of Engineering Manasagangotri, Mysuru-6.
4. Mr. Bharath Bhargav B, Assistant Professor, Dept. of B M & R E, Mysore University School of Engineering Manasagangotri, Mysuru-6.
5. Mr. Rakesh M, Assistant Professor, Dept. of B M & R E, Mysore University School of Engineering Manasagangotri, Mysuru-6.
6. Mr. Nithin S. K, Assistant Professor, Dept. of B M & R E, Mysore University School of Engineering Manasagangotri, Mysuru-6.
7. Dr, Vishwanath G, Assistant Professor, Dept. of B M & R E, Mysore University School of Engineering Manasagangotri, Mysuru-6.

External Members:

1. Dr. M. Mahadeva Prasad, Professor, Dept. of Studies in Electronics, P G Centre, University of Mysore, Hemagangotri, Hassan-573226.
2. Dr. Mallikarjun S Holi, Professor, Dept. of Electronics and Instrumentation Engineering, University BDT College of Engineering, Davanagere.
3. Dr. Chandrashekar M Patil, Professor, Vidhyavardhka College of Engineering, Gokulam III Stage, Mysuru-2
4. Dr. Bindu A. Thomas, Professor, Dept. of E & C Engineering, Vidyavikas Institute of Engineering and Technology, Bannur Road, Alanahally Post, Mysuru-28
5. Dr. M. S. Mallikarjuna Swamy, Associate Professor, Dept. of Instrumentation Technology, S J College of Engineering, JSS Science and Technology University, Mysuru-6.
6. Dr. Ravichandra Kulkarani, Associate Professor, Dept. of Electronics Communication Engineering, Maharaja Institute of Technology, Belawadi, Srirangapatna-571477.
7. Dr. S. Parmeshwar, Associate Professor, Dept. of Electronic & Communication Engineering, The National Institute of Engineering, Manandavadi Road, Mysuru-8.
8. Prof. B. R. Narendra Babu, Professor, Dept. of Mechanical Engineering, Vidyavikas Institute of Engineering and Technology, Bannur Road, Alanahally Post, Mysuru-28
9. Prof. Vinay K. B., Professor, Dept. of Mechanical Engineering, Vidhyavardhka College of Engineering, Gokulam III Stage, Mysuru-2
10. Dr. Anand Srivatsa, Associate Professor, Dept. of E & C Engineering, The National Institute of Engineering, Manandavadi Road, Mysuru-8.
11. Dr. Basavaraj M S, Chief Medical Officer, University of Mysore, Mysuru-05.

12. Dr. Anjanappa C, Associate Professor, Dept. of E & C Engineering, The National Institute of Engineering, Manandavadi Road, Mysuru-8.
13. Dr. Chidanandappa R, Associate Professor, Dept. of E & E Engineering, The National Institute of Engineering, Manandavadi Road, Mysuru-8.
14. Dr. Likit Kumar M V, Associate Professor, Dept. of E & E Engineering, The National Institute of Engineering, Manandavadi Road, Mysuru-8.
15. Dr. Ravi K S, Associate Professor, Dept. of Mechanical Engineering, Vidhyavardhka College of Engineering, Gokulam III Stage, Mysuru-2
16. Dr. Lokesh M, Assistant Professor, Dept. of E & E Engineering, NIE Institute of Technology, Koorgalli Village, Hootagalli Industrial Area, Next to BEML, Mysuru – 570018
17. Dr. Mohan N, Assistant Professor, Dept. of E & E Engineering, S J College of Engineering, JSS Science and Technology University, Mysuru-6.
18. Dr. Satish K R, Assistant Professor, Dept. of E & E Engineering, ATME College of Engineering, Mysuru.
19. Dr. Naveen Prakash, Professor, Dept. of Mechanical, Vidhyavardhka College of Engineering, Gokulam III Stage, Mysuru-2

MYSORE UNIVERSITY SCHOOL OF ENGINEERING

Manasagangotri campus, Mysuru 570006

(Approved by AICTE, New Delhi)

AMENDMENTS TO REGULATIONS 2023-24

	Existing	Proposed
1	1.0	No changes
2	2.0	No changes
3	3.0	No changes
4	4.0	No changes
5	5.7 A student shall be eligible to obtain an Undergraduate degree with Honors/Minors, if He /she earns minimum additional 18 credits, as specified by the university from time to time regarding the earning of additional credits.	5.7 A student shall be eligible to obtain an Undergraduate degree with Honors/Minors, if He /she earns minimum additional 18 credits with **CGPA 7.0 upto VI sem**, as specified by the university from time to time regarding the earning of additional credits.
	5.7 **B.E (Honors) Degree** (Page no. 5) (b) has earned additional 18 or more credits through online courses approved by university.	5.7 **B.E (Honors) Degree** (Page no. 5) (b) has earned additional 18 or more credits in same discipline (Branch) through online/**offline** courses approved by university.
	B.E with minor Degree (Page no. 5) (b) has earned additional 18 or more credits through university approved online courses list submitted by the Board of studies.	**B.E with minor Degree** (Page no. 5) (b) has earned additional 18 or more credits from another department through university approved online/offline courses (as per AICTE Annual process Handbook) list submitted by the Board of studies.
6	6.0	No changes
7	7.0	No changes
8	8.0	No changes
9	9.0	No changes
10	10.0	No changes
11	11.0	No changes
12	12.0	No changes
13	13.0	No changes
14	14.0	No changes
15	15.0	No changes
16	16.0	No changes
17	17.0	No changes

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	-	2	03	50	50	100	4
2	PCC	21BR62	Python for System Programming	BM & RE	BM & RE	3		-	03	50	50	100	3
3	PCC	21BR63	IoT and Smart Sensors	BM & RE	BM & RE	3	-	-	03	50	50	100	3
4	PEC	21BR64X	Professional Elective -2	BM & RE	BM & RE	3	-	-	03	50	50	100	3
5	OEC	21BR65X	Open Elective –B	Any Dept.	Any Dept.	3	-	-	03	50	50	100	3
6	HSMC	21BR66	Research Methodology and Intellectual Property Rights	BM & RE	BM & RE	-	-	-	03	50	50	100	3
7	PCC	21BRL67	Python for System Programming Lab	BM & RE	BM & RE	-	-	4	03	50	50	100	2
8	MP	21BRMP68	Mini Project	BM & RE	BM & RE	0	0	4	NA	50	-	50	1
Total						**15**	**04**	**10**	**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	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	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
- Design 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	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	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

(PEC-I)

Pattern Recognition (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	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.

(PEC-II)

Communication Systems (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	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.

(PEC-III)

Hospital Desing, Planning, and Management (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	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.

(PEC-IV)

Embedded System Design (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	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

(OEC-I)

Introduction to Biomedical Transducers and 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	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.

(OEC-II)

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	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.

(OEC-II)

Hospital Management ([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	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 Theater, 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,

(OEC-III)

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	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.

Programming in MATLAB (21BRL57)

Semester V			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	00
L:T:P	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	-	**CIE Marks**	50
No. of Tutorial hours/week	-	**SEE Marks**	50
Total No. of Lecture hours	-	**Exam Hours**	03
L:T:P	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	50	**Exam Hours**	03
L:T:P	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	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	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)

(PEC-I)

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	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.

(PEC-II)

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	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.

(PEC-III)

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	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.

(PEC-IV)

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	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	**08 Hours**

	a notified body.	
Module 4	**Standards and Regulations Background:** Standards: What are 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.	**08 Hours**
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)

(OEC-I)

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	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.

(OEC-II)

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	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	**08 Hours**

	LEAP Application: Episodic Sampling, Conclusion and Next Generation Platforms.	
Module 5	**Wearable Electronic Systems**: Applications to Medical 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.	**08 Hours**

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

(OEC-III)

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	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

(OEC-IV)

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	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:

3. "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.
4. Andrew N Sloss, "ARM System Developer's guide", Elsevier Publications, 2016
5. Shibu K V, "Introduction to Embedded Systems", Tata McGraw Hill Education Private Limited, 2nd Edition.

Reference Books:

3. James K Peckol, "Embedded systems- A contemporary design tool", John Wiley, 2008.
4. Yifeng Zhu, "Embedded Systems with Arm Cortex-M Microcontrollers in Assembly Language and C", 2nd Ed., Man Press LLC ©, 2015.
5. K V K K Prasad, "Embedded real time systems", Dreamtech publications, 2003.
6. 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	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	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	-	**Exam Hours**	03
L:T:P	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]

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

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: 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 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)
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(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	-	2	03	50	50	100	4
2	PCC	21BR62	Python for System Programming	BM & RE	BM & RE	3		-	03	50	50	100	3
3	PCC	21BR63	IoT and Smart Sensors	BM & RE	BM & RE	3	-	-	03	50	50	100	3
4	PEC	21BR64X	Professional Elective -2	BM & RE	BM & RE	3	-	-	03	50	50	100	3
5	OEC	21BR65X	Open Elective –B	Any Dept.	Any Dept.	3	-	-	03	50	50	100	3
6	HSMC	21BR66	Research Methodology and Intellectual Property Rights	BM & RE	BM & RE	-	-	-	03	50	50	100	3
7	PCC	21BRL67	Python for System Programming Lab	BM & RE	BM & RE	-	-	4	03	50	50	100	2
8	MP	21BRMP68	Mini Project	BM & RE	BM & RE	0	0	4	NA	50	-	50	1
Total						**15**	**04**	**10**	**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	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	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
- Design 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	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	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

(PEC-I)

Pattern Recognition (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	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.

(PEC-II)

Communication Systems (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	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.

(PEC-III)

Hospital Desing, Planning, and Management (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	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.

(PEC-IV)

Embedded System Design (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	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

(OEC-I)

Introduction to Biomedical Transducers and 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	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.

(OEC-II)

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	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.

(OEC-II)

Hospital Management ([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	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 Theater, 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,

(OEC-III)

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	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.

Programming in MATLAB (21BRL57)

Semester V			
No. of Teaching hour/Week	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	00
L:T:P	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	-	**CIE Marks**	50
No. of Tutorial hours/week	-	**SEE Marks**	50
Total No. of Lecture hours	-	**Exam Hours**	03
L:T:P	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	50	**Exam Hours**	03
L:T:P	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	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	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)

(PEC-I)

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	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.

(PEC-II)

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	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.

(PEC-III)

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	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.

(PEC-IV)

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	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	**08 Hours**

	a notified body.	
Module 4	**Standards and Regulations Background:** Standards: What are 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.	**08 Hours**
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)

(OEC-I)

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	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.

(OEC-II)

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	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	**08 Hours**

	LEAP Application: Episodic Sampling, Conclusion and Next Generation Platforms.	
Module 5	**Wearable Electronic Systems**: Applications to Medical 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.	**08 Hours**

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

(OEC-III)

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	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

(OEC-IV)

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	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:

3. "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.
4. Andrew N Sloss, "ARM System Developer's guide", Elsevier Publications, 2016
5. Shibu K V, "Introduction to Embedded Systems", Tata McGraw Hill Education Private Limited, 2nd Edition.

Reference Books:

3. James K Peckol, "Embedded systems- A contemporary design tool", John Wiley, 2008.
4. Yifeng Zhu, "Embedded Systems with Arm Cortex-M Microcontrollers in Assembly Language and C", 2nd Ed., Man Press LLC ©, 2015.
5. K V K K Prasad, "Embedded real time systems", Dreamtech publications, 2003.
6. 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	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	3	**CIE Marks**	50
No. of Tutorial hours/week	0	**SEE Marks**	50
Total No. of Lecture hours	-	**Exam Hours**	03
L:T:P	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.