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# UNIVERSITY OF MYSORE

Estd. 1916

**VishwavidyanilayaKaryasoudha**
**Crawford Hall, Mysuru- 570 005**

No.AC2(S)/54/2024-25

Dated: 15.07.2024

## Notification

**Sub:-**Syllabus and Scheme of Examinations of Biomedical and Robotic Engineering MUSE programme (VII & VIII Semester) from the Academic year 2024-25.

**Ref:-**1. Decision of Board of Studies in Biomedical and Robotic Engineering MUSE meeting held on 16-05-2024.
2. Decision of the Faculty of School of Engineering meeting held on 14-06-2024.
3. Decision of the Academic Council meeting held on 28-06-2024.

*****

The Board of Studies in Biomedical and Robotic Engineering MUSE which met on 16-05-2024 has resolved to recommend & approved the Syllabus and Scheme of examinations of Biomedical and Robotic Engineering MUSE (CS & D) programme (VII & VIII Semester) with effect from the Academic year 2024-25.

The Faculty of School of Engineering and Academic Council at their meetings held on 14-06-2024 and 28-06-2024 respectively has also approved the above said Syllabus and Scheme of examinations, hence it is hereby notified.

The Syllabus and Scheme of Examinations content may be downloaded from the University Website i.e., www.uni-mysore.ac.in.

**Registrar**

Registrar
University of Mysore
Mysore

**To;**

1. The Registrar (Evaluation), University of Mysore, Mysuru.
2. The Chairman, BOS/DOS in Biomedical and Robotic Engineering MUSE Manasagangothri, Mysore.
3. The Dean, Faculty of Engineering, DOS in MGM.
4. The Deputy Registrar/Assistant Registrar/Superintendent, Administrative Branch and Examination Branch, University of Mysore, Mysuru.
5. The PA to Vice-Chancellor/ Registrar/ Registrar (Evaluation), University of Mysore, Mysuru.
6. Office Copy.

# Biomedical DSP (21BR71)

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

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

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

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

**Text Books:**

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

**Reference Books:**

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

**Assessment Details (both CIE and SEE)**

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

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

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

**Question Paper Pattern (SEE):**

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

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

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

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

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

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

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

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

**Reference Books:**


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


**Assessment Details (both CIE and SEE)**

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

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

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

**Question Paper Pattern (SEE):**

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

# Professional Elective-3

## Scientific and Analytical Instrumentation (21BR731)

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

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

**Course outcomes:**

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

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

**Text Books:**

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

**Reference Books:**

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

**Assessment Details (both CIE and SEE)**

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

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

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

**Question Paper Pattern (SEE):**

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

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

# Database Management System in Health Care (21BR732)

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

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

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

**Course outcomes:**

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

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

**Text Books:**


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


**Reference Books:**


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


**Assessment Details (both CIE and SEE)**

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

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

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

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

**Question Paper Pattern (SEE):**

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

# Medical Imaging System (21BR733)

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

| Modules | Course Content | Teaching Hours |
|---|---|---|
| **Module 1** | **X-Ray Imaging:** Fundamentals of X-ray – Electromagnetic radiation, Interactions between X-rays and matter, Intensity of X-ray beam, Attenuation, Generation and Detection of X-rays – X-ray generation, X-ray generators, Filters, Beam restrictors and grids, Intensifying screens, fluorescent screens, and image intensifiers, X-ray detectors, Biological effects of ionizing radiation.<br>**X-Ray Diagnostic Methods:** Conventional X-ray radiography, Fluoroscopy, Angiography, Mammography and Xeroradiography. | **08 Hours** |
| **Module 2** | **Ultrasound Imaging:** Fundamentals of acoustic propagation - Characteristic impedance, Intensity, Reflection and refraction, Attenuation, Doppler effect. Generation and detection of Ultrasound- Piezoelectric effect, Ultrasonic transducers, Axial and Lateral resolution, Focusing, Arrays.<br>**Ultrasonic Diagnostic Methods:** Pulse echo systems- Amplitude mode (A-mode), Brightness mode (B-mode), Motion mode (M-mode), Doppler methods, Duplex imaging, Tissue characterization, Colour Doppler flow imaging. | **08 Hours** |
| **Module 3** | **Radionuclide Imaging:** Introduction, Fundamentals of Radioactivity – Nuclear particles, Nuclear activity and half-life, Units of measuring nuclear activity, Specific activity, Interaction of nuclear particles and matter, Attenuation of Gamma radiation, Radionuclides, Generation & Detection of Nuclear Emission – Radionuclide generators, nuclear radiation detectors, Collimators, Diagnostic methods using radiation detector probes –Thyroid function test, Renal function test, Blood volume measurement, Radionuclide imaging systems- Rectilinear scanner, Scintillation camera, SPECT, PET. | **08 Hours** |
| **Module 4** | **Basics of Magnetic Resonance Imaging:** Fundamentals of nuclear magnetic resonance- Angular momentum, magnetic dipole moment, magnetization, Larmor frequency, Free induction decay (FID), Fourier spectrum of the NMR signal, Spin density, Relaxation times, Pulse sequences.<br>**MRI System & Imaging Methods:** Introduction, Magnet, | **08 Hours** |

| | | |
|---|---|---|
| | NMR Coil/Probe, Transmitter, Receiver, Data acquisition. Imaging Methods- Introduction, slice selection, frequency encoding, phase encoding, Spin-Echo imaging- Gradient echo imaging, Characteristics of MRI images- Spatial resolution, image contrast. Biological effects of magnetic fields- Static magnetic fields, Radio-frequency fields, Gradient magnetic fields, Imaging safety, Functional MRI (brief introduction only). | |
| **Module 5** | **Thermal Imaging:** Medical thermography, Physics of thermography, Infrared detectors, Thermographic equipment, Quantitative medical thermography, Pyroelectric vidicon camera, Thermal camera based on IR sensor with digital focal plane array.<br>**Advances in Medical Imaging:** Image guided intervention- Introduction, Stereotactic neurosurgery, Stereotactic neurosurgery based on digital image volumes- image acquisition, planning and transfer, Intraoperative Imaging- Intraoperative diagnostic imaging, transfer by matching preoperative with intraoperative images, augmented reality. | **08 Hours** |

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

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

**Text Books:**


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


**Reference Books:**


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


**Assessment Details (both CIE and SEE)**

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

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

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

**Question Paper Pattern (SEE):**

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

# Biomaterials and Artificial Organs (21BR734)

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

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

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

**Course outcomes:**

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

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

**Text Books:**


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


**Reference Books:**


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


**Assessment Details (both CIE and SEE)**

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

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

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

**Question Paper Pattern (SEE):**

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

# Professional Elective-4

## Bio-MEMS (21BR741)

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

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

**Course outcomes:**

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

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

**Textbook:**

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

**Reference Books:**

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

**Assessment Details (both CIE and SEE)**

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

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

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

**Question Paper Pattern (SEE):**

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

# Computer Communication Networks in Healthcare (21BR742)

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

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

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

**Course outcomes:**

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

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

**Textbook:**

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

**Reference Books:**

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

**Assessment Details (both CIE and SEE)**

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

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

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

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

**Question Paper Pattern (SEE):**

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

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

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

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

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

**Course outcomes:**

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

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

**Text Books:**


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


**Reference Books:**


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


**MOOC Courses:**

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

**Assessment Details (both CIE and SEE)**

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

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

**Question Paper Pattern (SEE):**

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

# Medical Robots (21BR744)

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

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

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

**Course outcomes:**

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

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

**Text Books:**


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


**Reference Books:**


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

**Assessment Details (both CIE and SEE)**

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

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

**Question Paper Pattern (SEE):**

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

# Biomedical DSP Lab (21BRL75)

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

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

**Course outcomes:**

After Studying this course, students will be able to:

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

# ABILITY ENHANCEMENT COURSE III (21AEC77)

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

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

**Course outcomes:**

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

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

**Text Books:**


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

**Reference Books:**


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

# MYSORE UNIVERSITY SCHOOL OF ENGINEERING

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

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

### VII-SEMESTER

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

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

**Professional Elective-3**

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

**Professional Elective-4**

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

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

**CIE procedure for Project Work Phase - 1:**

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

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

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

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

# MYSORE UNIVERSITY SCHOOL OF ENGINEERING

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

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

### VIII-SEMESTER

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

**Note:** INT: Internship

**Project Work CIE procedure for Project Work Phase - 2:**

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

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

**SEE for Project Work Phase - 2:**

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

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

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

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

**Panel of Examiners recommended by BoS to Biomedical 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. M. Mahadeva Prasad, Professor, Dept. of Studies in Electronics, P G Centre, University of Mysore, Hemagangotri, Hassan-573226.
3. Dr. Pradeep T. M, Assistant Professor, Dept. of B M & R E, Mysore University School of Engineering Manasagangotri, Mysuru-6.
4. Dr. Suma A. P, Assistant Professor, Dept. of B M & R E, Mysore University School of Engineering Manasagangotri, Mysuru-6.
5. Mr. Bharath Bhargav B, Assistant Professor, Dept. of B M & R E, Mysore University School of Engineering Manasagangotri, Mysuru-6.
6. Dr. Rakesh M, Assistant Professor, Dept. of B M & R E, Mysore University School of Engineering Manasagangotri, Mysuru-6.
7. Dr. Nithin S. K, Assistant Professor, Dept. of B M & R E, Mysore University School of Engineering Manasagangotri, Mysuru-6.
8. Dr.Vishwanath G, Assistant Professor, Dept. of B M & R E, Mysore University School of Engineering Manasagangotri, Mysuru-6.
9. Dr. Basavaraj M S, Chief Medical Officer, University of Mysore, Mysuru-05.

**External Members:**

1. Dr. Mallikarjun S Holi, Professor, Dept. of Electronics and Instrumentation Engineering, University BDT College of Engineering, Davanagere.
2. Dr. Chandrashekar M Patil, Professor, Vidhyavardhka College of Engineering, Gokulam III Stage, Mysuru-2
3. Dr. Bindu A. Thomas, Professor, Dept. of E & C Engineering, Vidyavikas Institute of Engineering and Technology, Bannur Road, Alanahally Post, Mysuru-28
4. Dr. M. S. Mallikarjuna Swamy, Associate Professor, Dept. of Instrumentation Technology, S J College of Engineering, JSS Science and Technology University, Mysuru-6.
5. Dr. Ravichandra Kulkarani, Associate Professor, Dept. of Electronics Communication Engineering, Maharaja Institute of Technology, Belawadi, Srirangapatna-571477.
6. Dr. G. Shivakumar, Professor, Dept. of Electronics & Instrumentation Engineering, MCE, Hassan-573202.
7. Dr. S. Parmeshwar, Associate Professor, Dept. of Electronic & Communication Engineering, The National Institute of Engineering, Manandavadi Road, Mysuru-8.
8. Dr. B. R. Narendra Babu, Professor, Dept. of Mechanical Engineering, Vidyavikas Institute of Engineering and Technology, Bannur Road, Alanahally Post, Mysuru-28
9. Dr. 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. Shailaja R, Associate Professor, Dept. of Instrumentation Technology, S J College of Engineering, JSS Science and Technology University, Mysuru-6.
12. Dr. K. Umarani, Associate Professor, Dept. of Instrumentation Technology, S J College of Engineering, JSS Science and Technology University, Mysuru-6.
13. Dr. Anjanappa C, Associate Professor, Dept. of E & C Engineering, The National Institute of Engineering, Manandavadi Road, Mysuru-8.
14. Dr. Chidanandappa R, Associate Professor, Dept. of E & E Engineering, The National Institute of Engineering, Manandavadi Road, Mysuru-8.
15. Dr. Likit Kumar M V, Associate Professor, Dept. of E & E Engineering, The National Institute of Engineering, Manandavadi Road, Mysuru-8.
16. Dr. Ravi K S, Associate Professor, Dept. of Mechanical Engineering, Vidhyavardhka College of Engineering, Gokulam III Stage, Mysuru-2
17. Dr. Lokesh M, Assistant Professor, Dept. of E & E Engineering, NIE Institute of Technology, Koorgalli Village, Hootagalli Industrial Area, Next to BEML, Mysuru – 570018
18. Dr. Mohan N, Assistant Professor, Dept. of E & E Engineering, S J College of Engineering, JSS Science and Technology University, Mysuru-6.
19. Dr. Satish K R, Assistant Professor, Dept. of E & E Engineering, ATME College of Engineering, Mysuru.
20. Dr. Naveen Prakash, Professor, Dept. of Mechanical, Vidhyavardhka College of Engineering, Gokulam III Stage, Mysuru-2
21. Dr. Nanda S, Assistant Professor, Department of Electronics & Instrumentation Engineering, Sri Jayachamarajendra College of Engineering, JSS Science & Technology University, Mysuru-570006
22. Dr. N Sheela, Assistant Professor, Department of Electronics & Instrumentation Engineering, Sri Jayachamarajendra College of Engineering, JSS Science & Technology University, Mysuru-570006
23. Mrs. P. Rajeshwari, Assistant Professor, Department of Electronics & Instrumentation Engineering, Sri Jayachamarajendra College of Engineering, JSS Science & Technology University, Mysuru-570006
24. Dr. S Rathnakara, Assistant Professor, Department of Electronics & Instrumentation Engineering, Sri Jayachamarajendra College of Engineering, JSS Science & Technology University, Mysuru-570006