Biomaterials

[VIth Semester, 3rd Year]

Course Description

Offered by Department:	Credits	Status	Code
Biomedical Engineering	3-1-0, (4)	Core	BM106101BM

[Prerequisite -Nil]

Course Objectives

1. Understand common use of biomaterials as metals, ceramics and polymers and its chemical structure, properties, and morphology.
2. Understand and account for methods for categorization of biomaterials.
3. Explain methods to modify surfaces of biomaterials and choose material for desired biological response.
4. Describe interactions between biomaterials, proteins and cells.
5. Understand the interaction between biomaterial and tissue for short term and long term implantations, distinguish between reactions in blood and in tissue.
6. Explain the types of material used to replace different organs & tissues of human body.

Course Content

Unit 1 Properties of Materials

Bulk properties and Surface properties of Materials. Characterization methods of surface properties of Biomaterials Materials Used In Medicine: Metals; Polymers; Hydrogels; Bioresorbable and Biodegradable Materials.

Unit 2 Materials Used in Medicine

Fabrics; Biologically Functional Materials; Ceramics; Natural materials; Composites, thin films, grafts and coatings; Pyrolytic Carbon for long-term medical Implants; Porous materials; Nano biomaterials

Unit 3 Host Reaction to Biomaterials

Inflammation; Wound healing and the Foreign body response; Systemic toxicity and Hypersensitivity; Blood coagulation and Blood-materials Interactions; Tumorigenesis. Degradation of Materials in Biological Environment: Degradation of Polymers, Metals and Ceramics.

Unit 4 Application of Biomaterials

Cardiovascular Applications; Dental implants; Adhesives and Sealants; Opthalmologic Applications; Orthopedic Applications; Drug Delivery System; Sutures; Bioelectrodes; Biomedical Sensors and Biosensors

Course Materials

Text Books:

1. Schoen, F. J., Ratner, B. D., Hoffman, A. S., Lemons, J. E. (2004). Biomaterials Science: An Introduction to Materials in Medicine. Netherlands: Elsevier Science.
2. 2. Hench, L. L., Ethridge, E. C. (1982). Biomaterials: an interfacial approach. United Kingdom: Academic Press.

Reference Books:

Bronzino, J. D. (2000). The Biomedical Engineering Handbook. Germany: CRC Press.

Microelectronics & Integrated Circuits

[VIth Semester, 3rd Year]

Course Description

Offered by Department	Credits	Status	Code
Biomedical Engineering	3-1-0, (4)	Core	BM106102BM

[Prerequisite -Nil]

Course Objectives

1. To learn the basic building block of Op Amp and microelectronics.
2. To understand the concept of linear and nonlinear circuits using Op Amp.
3. To learn the applications of Op Amp and should be able to design Op Amp circuits

Course Content

Unit 1 Introduction to Microelectronics

IC classification: based on chip size, based on functional utility, and based on fabrication techniques; Comparison between monolithic, thick & thin film and hybrid integrated circuits; Bipolar and MOS Technology; Fabrication of active and passive components

Unit 2 Differential Amplifiers

Introduction, Characteristics, Transistorized differential amplifiers: Common mode and difference mode operation; Types; DC and AC analysis; CMRR- merits and demerits; Methods to improve CMRR: Constant current source and Current mirror

Unit 3 Operational Amplifiers

Introduction; Open loop configurations and its limitations; Practical and ideal characteristics; Realistic assumptions, Linear circuits: inverting amplifier, non-inverting amplifier, adder, subtractor, differentiator, integrator, instrumentation amplifier, log and antilog amplifier, precision rectifier, and peak detector. Nonlinear circuits: comparators, multivibrators, function generators, and voltage regulators.

Unit 4 Applications of Operational Amplifier

Sample & Hold Circuits, 555 timers: principle and working,Introduction to ADC's & DAC's. Phase Locked Loop: Principle of operation, application. Analog Multiplier: Various Types and Applications, Datasheets

Course Materials

Text Books:

1. Nashelsky, L., Boylestad, R. L. (2013). Electronic Devices and Circuit Theory. United Kingdom: Pearson Prentice Hall.
2. Franco, S. (2014). Design With Operational Amplifiers And Analog Integrated Circuits. United States: McGraw-Hill Higher Education.
3. Neamen, D. A. (2010). Microelectronics: Circuit Analysis and Design. United Kingdom: McGraw-Hill.

Reference Books:

1. Clayton, G. B. (2013). Operational Amplifiers. United Kingdom: Elsevier Science.
2. Op-Amps And Linear Integrated Circuits,3/e. (2007). India: Pearson Education.
3. Botkar, K. R. (1983). Integrated Circuits: (a Textbook for Engineering Students). India: Khanna Publishers.

Telemedicine

[VIth Semester, 3rd Year]

Course Description

Offered by Department	Credits	Status	Code
Biomedical Engineering	3-1-0, (4)	Core	BM106103BM

[Prerequisite -Nil]

Course Objectives

1. Execute formal training in areas of technology applied to healthcare including computer science and telecommunication technologies to facilitate the deployment of telemedicine.
2. Understand the basic requirements for the delivery of telemedicine services.
3. Differentiate and apply telemedicine technologies and practices in a variety of health care environments.
4. The course will also be committed as a public awareness tool to promote and advocate the use of emerging technologies to expand health care outreach and overcome geographic barriers to deliver patient care and education

Course Content

Unit 1 Fundamentals and System of Telemedicine

History and Philosophy of TM, Types and Challenges, Standards and Guidelines; TM Systems, Components of TM System, Setting up a TM Facility; TM Workstation and Interfacing Techniques; How Telehealth Services are Reshaping Healthcare; Management of Patient Healthcare Information – EMR, HER, Healthcare Data Analytics, Analytic Approaches; Patient Centered Care

Unit 2 Technology in Telemedicine System

TM Technology, Data Transmission - Images, Audio, Video, Time Series Data; DICOM; Cloud Computing, Edge Computing in TM, Types of Telecommunication Technologies, DSL, ADSL; Networking in TM, Network Topologies; Wireless Technologies – WiMAX, ZigBee etc., Evolution of Mobile Networks 1G – 5G; Mobile Health; Applications of Emerging Technologies in TM like 3D Printing, AR/ VR, Blockchain, Big Data Analytics, IoT etc., Connected Health, Digital Health.

Unit 3 Tele-home Care and Telehealth

Categories, Technologies, Requirements for Tele-home Care, Tele-home care for Chronic Disease Management; Personal Health Monitors, Point-of-Care Testing Instrument, Intelligent Biomedical Clothes, Wearable Monitors; eHealth and Cybermedicine, Internet and Telemedicine, Videoconferencing Systems and Multimedia Data Exchange.

Unit 4 Ethical, Privacy, Security, Legal, Standards and other issues

Maintaining and Sustaining a Telehealth-based Ecosystem, Tele education for Health workers, Ethical Issues, Cyber Laws, Legal Issues, TM for low resource settings, Data Protection Laws of Indian Government, ISO standards, WHO Medical Device Regulations, USFDA standards for Healthcare

Course Materials

Text Books:

1. Khandpur, R. S. (2017). Telemedicine: Technology and Applications (mHealth, TeleHealth and EHealth). India: PHI Learning.
2. Balas, V. E. (2019). Telemedicine Technologies: Big Data, Deep Learning, Robotics, Mobile and Remote Applications for Global Healthcare. United Kingdom: Elsevier Science.

Reference Books:

https://medicalfuturist.com

Sports Biomechanics

[VIth Semester, 3rd Year]

Course Description

Offered by Department	Credits	Status	Code
Biomedical Engineering	3-0-0, (3)	Program Elective	BM106201BM

[Prerequisite -Nil]

Course Objectives

1. To Make Students Understand The Basic Concepts Of Sports Biomechanics .
2. To Create Problem Solving Ability Among Students For Optimizing Action Performance In Sports Science.
3. To Encourage Students For Designing Efficient Sports Postures.

Course Content

Unit 1 Muscle Action In Sport And Exercise - Biomechanical View

Neural Contributions To Changes In Muscle Strength - Mechanical Properties And Performance In Skeletal Muscles - Muscle-Tendon Architecture And Athletic Performance - Eccentric Muscle Action In Sport And Exercise - Stretch–Shortening Cycle Of Muscle Function - Biomechanical Foundations Of Strength And Power Training .

Unit 2 Jumping And Aerial Movement

Aerial Movement - The High Jump - Jumping In Figure Skating - Springboard And Platform Diving – Determinants Of Successful Ski-Jumping Performance; Principles Of Throwing - The Flight Of Sports Projectiles – Javelin Throwing: An Approach To Performance Development - Shot Putting - Hammer Throwing: Problems And Prospects - Hitting And Kicking.

Unit 3 Injury Prevention And Rehabilitation

Mechanisms Of Musculoskeletal Injury - Musculoskeletal Loading During Landing - Sport-Related Spinal Injuries And Their Prevention - Impact Propagation And Its Effects On The Human Body - Neuromechanics Of The Initial Phase Of Eccentric Contraction-Induced Muscle Injury. Special Olympic Sports - Manual Wheelchair Propulsion, Sports After Amputation. Biomechanics Of Dance Biomechanics Of Martial Arts.

Unit 4 Biomechancis Of YOGA

Introduction, Definition Of Yoga, Origin Of The Word Yoga -Yuj', Meaning Of The Word Hatha, Stages Of Yoga, Types Of Yoga, Karma Yoga, Gnana Yoga, Bhakti Yoga, Kriya Yoga, Buddhism And Yoga, Yoga As A Universally Accepted Term. Analysis Of Yogic Postures – Standing, Sitting, Prone, Supine, Lying Prone, Inverted Postures — Nadis And Chakras — Guru And Sisya — The Effect Of Pranayama, Contribution By Patanjali, Thirumularand18
Siddhars

Course Materials

Text Books:

1. Scott, M. G. (1942). Analysis of human motion: A textbook in kinesiology. Ardent Media..
2. Roger Battlett, Taylor Bussey, M. (2002). Sports Biomechanics: Reducing Injury and Improving Performance. Routledge.
3. Hamilton, N. P. (2011). Kinesiology: Scientific basis of human motion. Brown & Benchmark.

Reference Books:

1. Hay, J. (1993). The Biomechanics of Sports Techniques, Benjamin Cummings.
2. McGinnis, Peter M (2005). Biomechanics of Sport and Exercise, Human Kinetics.
3. Clarke, David H. Clarke, Harrison H. (1984) Research Process in Physical Education, New Jersey: Prentice Hall Inc.
4. Chris Gratton and Ian Jones. (2004), Research Methods for Sports Studies, London: Routledge, Taylor & Francis Group

Biomicrofluidics

[VIth Semester, 3rd Year]

Course Description

Offered by Department	Credits	Status	Code
Biomedical Engineering	3-0-0, (3)	Program Elective	BM106202BM

[Prerequisite -Nil]

Course Objectives

1. To Make Students Understand The Basics Of Microfluidics Intervention In Biology.
2. To Create Problem Solving Ability Among Students For Analyzing Fluid Flow In Micro-Capillary Of Biological Origin
3. To Encourage Students For Designing Microfluidic Based Analytical And Diagnostic Solutions For Healthcare
Sectors.
4. To Prepare Students For Advance Level Courses In BioMEMS.

Course Content

Unit 1 Introduction To Biomicrofluidics

Introduction To Microuidics & Relevance In Biology, Fluidic Derived Mechanobiology, Pressure Driven Flows, Surface Tension Driven Flows, Modulating Surface Tension, Surface Energy Driven Flow, Centrifugal Microflow, Acoustic Streaming, Chaotic Advection, Peclet Number, Digital Microfluidics, Droplet Manipulation.

Unit 2 Fabrication Techniques Of Biomicrofluidics Chips

Silicon Microfabrication: Materials And Methods, Microfabrication Using Soft Substrate: Materials And Methods, PDMS-Based Microfluidic Chips, Design And Function Of H-Filter And T-Sensor

Unit 3 Design And Development Of Experimental Microfluidics

Experimental Flow Characterization, Microfluidics For External & Internal Flow Controls,Sensor Principle And Microflow Sensors, Microfluidic Device Based- Science Explorations, Dielectrophoresis For Particle And Cell Manipulations, Electrowetting And Droplet –Based Microfluidic, Optical Microfluidics For Molecular Diagnostics,
Microfluidic Arrays And Microchannel Enzyme Reactors

Unit 4 Clinical Applications Of Microfluidics

Mass Transport And Cellular Microfluidics, Microparticle-Based Assays, Field Flow Fractionation (FFF), Microfluidic
PCR, Microfluidic Cell Sorter, Biosensors And Bio-cantilevers, On-Chip Cellular Assay Technique, Microfluidic Technology For Monoclonal Antibody Production, SSR for cardiac engineering

Course Materials

Text Books:

1. Mitra, S. K., & Chakraborty, S. (Eds.). (2016). Microfluidics and nanofluidics handbook: fabrication, implementation, and applications. CRC press.
2. Lin, B. (Ed.). (2011). Microfluidics: technologies and applications (Vol. 304). Springer

Reference Books:

Lima, R., Imai, Y., Ishikawa, T., & Oliveira, M. S. (Eds.). (2014). Visualization and Simulation of Complex Flows in Biomedical Engineering. Springer Netherlands

Database Management System

[VIth Semester, 3rd Year]

Course Description

Offered by Department	Credits	Status	Code
Biomedical Engineering	3-0-0, (3)	Program Elective	BM106203BM

[Prerequisite -Nil]

Course Objectives

1. To learn the fundamentals of database models and to represent a database system using ER diagrams.
2. To study SQL and relational database design.
3. To understand the internal storage structures using different file and indexing techniques which will help in
physical DB design.
4. To understand the fundamental concepts of transaction processing-concurrency control techniques and recovery
procedures.
5. To have basic understanding about advance topics in DBMS

Course Content

Unit 1 Relational Languages and Database Design

Introduction to Database Systems; Introduction to the Relational Model - Structure of Relational Databases, Database Schema, Keys, 2.4 Schema Diagrams, Relational Query Languages, The Relational Algebra; Introduction to SQL – Set Operations, Null Values, Queries; Intermediate SQL; Advanced SQL; Database Design Using the E-R Model; Relational Database Design

Unit 2 Big Data Analytics

Complex Data Types; Application Development; Big Data - Motivation, Big Data Storage Systems, The MapReduce Paradigm, Beyond MapReduce: Algebraic Operations, Streaming Data, Graph Databases; Data Analytics – Overview of Analytics, Data Warehousing, Online Analytical Processing, Data Mining

Unit 3 Storage Management and Query Processing

Physical Storage Systems – Storage Interfaces, Magnetic Disks, Flash Memory, RAID, Disk-Block Access; Data Storage Structures – Architecture, File Organization; Indexing – Basic Concepts, Hash Indices, Bitmap Indices; Measures of Query Cost, Sorting, Query Operations, Query Optimization, Transaction Management

Unit 4 Advance Topics and Case Study

Parallel and Distributed Databases: Architecture, Concept, Data Storage; Blockchain Databases; Object-based Databases: Concepts, Object-Relational Features, ODMG Object Model; Object Query Language - XML Databases: XML Hierarchical Model, DTD, XML Schema, XQuery; Information Retrieval: IR Concepts, Retrieval Models, Queries in IR systems; Casestudy1 and Casestudy2.

Course Materials

Text Books:

1. Sudarshan, S., Korth, H. F., Silberschatz, A. (2020). Database System Concepts. United Kingdom: McGraw-Hill Education.
2. Navathe, S., Elmasri, R. (2016). Fundamentals of Database Systems. United Kingdom: Pearson.

Reference Books:

1. Gorman, M. M. (2014). Database Management Systems: Understanding and Applying Database Technology. United Kingdom: Elsevier Science..
2. Rahimi, S. K., Haug, F. S. (2015). Distributed Database Management Systems: A Practical Approach. Germany: Wiley.
3. Date, C. J. (2000). An introduction to database systems. United Kingdom: Addison-Wesley.

Principles of Communication

[VIth Semester, 3rd Year]

Course Description

Offered by Department	Credits	Status	Code
Biomedical Engineering	3-0-0, (3)	Program Elective	BM106204BM

[Prerequisite -Nil]

Course Objectives

1. To Make Students gain knowledge about the need and types of modulation methods.
2. Familiarize Students with analog and digital modulation systems.
3. To give students a brief history of the evolution of mobile communications throughout the world.

Course Content

Unit 1 Analog Modulation Techniques

Need for Modulation, Amplitude Modulation (AM), Amplitude Modulation Index, Modulation Index for Sinusoidal AM, Frequency spectrum for Sinusoidal AM, Generation and Detection of AM waves, Generation and Detection of DSB-SC, SSB-SC & VSB-SC, Frequency Modulation (FM) & Phase Modulation (PM), Relation between FM & PM, Spectrum of FM, Narrow band FM, Wideband FM, Phasor diagram of AM & FM, FM generation & detection, Frequency division multiplexing

Unit 2 Pulse Modulation Techniques

Sampling- Ideal sampling, Natural sampling, Flat top sampling, Sampling theorem, Signal recovery through holding, Generation and Detection of PAM, PWM and PPM, Quantization of signals, Quantization error, Electrical representation of binary digits, PCM system, DPCM, Delta modulation, Adaptive delta modulation, Time division multiplexing

Unit 3 Digital Modulation Techniques

Digital Modulation Formats, Types of Digital Modulation Techniques, Coherent & Non-coherent methods for generation & detection of Binary Amplitude Shift Keying (BASK), Binary Phase Shift Keying (BPSK), Binary Frequency Shift Keying (BFSK) & Quadrature Amplitude Shift Keying (QPSK).Elements of Information Theory: Average Information, Entropy, Information Rate. Communication Channel, Discrete and Continuous channel, Shannon-Hartley Theorem, Channel capacity

Unit 4 Introduction to Advanced Communication Techniques

Mobile communications: Evolution of Mobile Radio Communication, Different Wireless Communication Systems. Comparison of Various Wireless Communication Systems, Introduction to Modern Wireless Communication System-Second Generation(2G), Third Generation (3G) and Fourth Generation(4G). Satellite Communication: Components and block diagram of satellite communication system, satellite orbits, and satellite transponders.

Course Materials

Text Books:

1. Principles Of Communication Systems. (2008). India: McGraw-Hill Education (India) Pvt Limited..
2. Lathi, B. P. (1995). Modern Digital and Analog Communication Systems: Instructor's Edition. United Kingdom: Oxford University Press.

Reference Books:

1. Kennedy, G. (1999). Electronic Communication Systems. Germany: Gregg Division, McGraw-Hill.
2. Wireless Communications: Principles And Practice, 2/E. (2010). India: Pearson Education

Advanced Biosignal Processing

[VIth Semester, 3rd Year]

Course Description

Offered by Department	Credits	Status	Code
Biomedical Engineering	3-0-0, (3)	Open Elective	BM106301BM

[Prerequisite- BM103101BM (Signal and System)/ BM104106BM (Biomedical Signal Processing)]

Course Objectives

1 To make Students gain knowledge about advanced biomedical signal processing techniques.
2. Students should be able to implement and apply techniques for biomedical signal processing and analysis

Course Content

Unit 1 Review of Biomedical Signals and Systems

Introduction to Biomedical signals and characteristics of dynamic biomedical signals, Noises, Filters- IIR and FIR
filters, Spectrum – power spectral density function, cross-spectral density and coherence function, cepstrum and
homomorphic filtering.

Unit 2 Time-Series Analysis and Spectral Estimation

Time series analysis – Moving average and auto regressive time series model, Application in PCG signals, Non stationary analysis – fixed segmentation, adaptive segmentation and its application in EEG , PCG signals and Time
varying analysis of Heart-rate variability. Spectral estimation – Blackman Tukey, Periodogram.

Unit 3 Time-Frequency Analysis and Multivariate Analysis

Time-frequency distributions, Short-time Fourier transform, Wigner-Ville distribution, Cohen's class of distributions,
Wavelet transform, Wavelet packet decomposition, applications of wavelets, Multivariate analysis- PCA and ICA in
biomedical signal analysis

Unit 4 Biosignal Classification and Recognition

Signal classification and recognition – feature extraction from biosignals, feature selection and pattern recognition for
biosignals. Applications in biomedical signal analysis

Course Materials

Text Books:

1. Cohen, A. (1986). Biomedical Signal Processing: Volume 1 and 2. CRC Press.
2. Rangayyan, R. M. (2015). Biomedical Signal Analysis. Germany: Wiley.
3. Tompkins, W. J. (1993). Biomedical Digital Signal Processing. United Kingdom: Prentice Hall.

Reference Books:

1. Rao, R. M. (1998). Wavelet Transforms: Introduction to Theory and Applications. India: Pearson Education.

2. Biomedical Signal Processing and Control, Journal (ISSN: 1746-8094), Elsevier

Machine Learning and Deep Learning in Healthcare and Lifesciences

[6thSemester, Third Year]

Course Description

Offered by Department	Credits	Status	Code
Biomedical Engineering	3-0-0, (3)	Open Elective	BM106302BM

[Prerequisite - Nil]

Course Objectives

1. To provide a strong foundation of fundamental concepts in ML and DL
2. To provide a basic exposition of the goals and methods of ML and DL
3. Learn the methods of solving problems using ML and DL
4. To enable the student to apply these techniques in healthcare and lifesciences applications

Course Content

Unit-1 Introduction to Machine Learning

Introduction to machine learning and its applications in healthcare, Overview of healthcare data and its unique characteristics, Preprocessing and cleaning healthcare data, Feature selection and feature engineering for healthcare applications, Introduction to various machine learning algorithms used in healthcare, Evaluating and validating machine learning models in healthcare

Unit-2 Deep Learning Fundamentals

Introduction to deep learning and its applications in healthcare, Neural network architectures for healthcare applications, Convolutional Neural Networks (CNNs) for medical imaging analysis, Recurrent Neural Networks (RNNs) for time series data analysis, Transfer learning and pre-trained models in healthcare, Introduction to natural language processing (NLP) for healthcare data analysis

Unit-3 Advanced Topics in Machine Learning and Deep Learning

Ensemble learning techniques for healthcare applications, Explainable AI in healthcare and interpretability of models Time series forecasting using deep learning for healthcare applications, Generative models and their applications in healthcare, Reinforcement learning in healthcare, Ethical considerations and challenges in deploying machine learning models in healthcare

Unit-4 Hands-on Projects and Case Studies in Healthcare and Lifesciences

Implementation of machine learning and deep learning models in healthcare, Hands-on exercises using popular libraries and frameworks (e.g., TensorFlow, PyTorch), Case studies on real-world healthcare applications, Project work and group discussions

Course Materials

Required Text: Textbooks

1. "Machine Learning in Healthcare: A Comprehensive Guide" by Mark S. Davenport and Joseph V. Teran
2. "Healthcare Analytics Made Simple: Techniques for Analyzing Complex Healthcare Data" by Chantal Polsonetti
3. "Deep Learning for Medical Image Analysis" by S. Kevin Zhou, Hayit Greenspan, and Dinggang Shen
4. "Deep Learning in Healthcare: Techniques and Applications" by Faisal Mahmood and Saad Rehman

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Optional Materials: Reference Books and Links

1. "Machine Learning and Healthcare: Principles and Practice" by Halis Dokmeci and Özgür Kafali
2. "Healthcare Data Analytics and Management: A Guide for Practitioners and Researchers" by Nilmini Wickramasinghe and Rajeev K. Bali
3. "Python Machine Learning: Machine Learning and Deep Learning with Python, scikit-learn, and TensorFlow" by Sebastian Raschka and Vahid Mirjalili
4. "Deep Learning with Python" by François Chollet

Biomaterials Laboratory

[6thSemester, Third Year]

Course Description

Offered by Department	Credits	Status	Code
Biomedical Engineering	0-0-2, (1)	Core	BM106401BM

[Prerequisite - Nil]

Course Content

Experiment 1	Mechanical characterization of metallic biomaterials.
Experiment 2	Mechanical characterization of polymeric biomaterials.
Experiment 3	Surface roughness measurement of biomaterials.
Experiment 4	Stress-strain analysis of orthopedic implant.
Experiment 5	Measurement of pull-out of cortical and pedicle screws.
Experiment 6	Experimental estimation of effective elastic modulus of 3D-Printed porous biomaterials.
Experiment 7	Influence of external mechanical stress on the host tissue integration.
Experiment 8	Design and additive manufacturing of scaffold for dental application.
Experiment 9	Orthopedic Implant design and analysis subjected to different bio-materials
Experiment 10	Evaluation of Time-dependent deformation (creep) of biomaterial

Microelectronics & Integrated Circuits Laboratory

[6thSemester, Third Year]

Course Description

Offered by Department	Credits	Status	Code
Biomedical Engineering	0-0-2, (1)	Core	BM106402BM

[Prerequisite - Nil]

Course Content

Experiment 1	To design a non-inverting amplifier using op-amp (741)
Experiment 2	To design an inverting amplifier using op-amp (741).
Experiment 3	To design a summing amplifier using op-amp (741).
Experiment 4	To design a differential amplifier using op-amp (741).
Experiment 5	To design a differentiator amplifier using op-amp (741).
Experiment 6	To design an integrator amplifier using op-amp (741).
Experiment 7	To design an instrumentation amplifier using op-amp (741).
Experiment 8	To design a comparator circuit using op-amp (741).
Experiment 9	To design a zero crossing detector circuit using op-amp (741).
Experiment 10	To design a precision rectifier circuit using op-amp (741).
Experiment 11	To design a buffer circuit using op-amp (741).