B.Tech. (EBME) Scheme 2021-22

Course Code	Course Title	Teaching Schedule			Hours	Credits
Semester - 1						**17.5**
Semester - 2						**20.5**
Semester - 3						**22.5**
Semester - 4						**19.5**
Semester - 5						**23**
		L	**T**	**P**		
OE-I	Open Elective - I	3	0	0	3	3
HSMC302-T	Fundamentals of Management for Engineers	2	0	0	2	2
PCC-EBME301-T	Biomedical Instrumentation - II	3	0	0	3	3
PCC-EBME303-T	Microprocessors & Microcontrollers	3	0	0	3	3
PCC-EBME305-T	Medical Imaging Technology	3	0	0	3	3
ESC-EBME307-T	Biomaterials	3	0	0	3	3
PCC-EBME309-T	Control System Engineering	3	0	0	3	3
PCC-EBME301-P	Biomedical Instrumentation - II Lab	0	0	2	2	1
PCC-EBME303-P	Microprocessors & Microcontrollers Lab	0	0	2	2	1
INT-EBME321-P	Industrial Training Presentation - I	0	0	2	2	1
Semester - 6						**22**
OE-II	Open Elective - II	3	0	0	3	3
HSMC301-T	Economics for Engineers	2	0	0	2	2
PEC-I	Professional Elective - I	3	0	0	3	3
PCC-EBME302-T	Communication Engineering	3	0	0	3	3
PCC-EBME304-T	Medical Devices	3	0	0	3	3
PCC-EBME306-T	Rehabilitation & Assistive Technology	3	0	0	3	3
PCC-EBME308-T	Laser & Fibre Optics in Medicine	3	0	0	3	3
PCC-EBME302-P	Communication Engineering Lab	0	0	2	2	1
PCC-EBME304-P	Medical Devices Lab	0	0	2	2	1
MC-EBME310-T	Entrepreneurship	3	0	0	3	0

Note:

At the end of the VI semester, each student will have to undergo Practical Training - II of 4 to 6 weeks duration during summer vacations in an industry/research institute which will be evaluated in 7th semester.

OE-I	**Open Elective - I**
OE-EBME391-T	Medical Imaging Technology

OE-II	**Open Elective - II**
OE-EBME392-T	Medical Devices

PEC-I	**Professional Elective - I**
PEC-EBME351-T	Biomedical Ethics & Device Regulations
PEC-EBME352-T	Artificial Organs & Tissue Engineering
PEC-EBME353-T	Biosensors
PEC-EBME354-T	Biomedical Waste Management
PEC-EBME355-T	Nanotechnology For Healthcare Applications

SEMESTER-5

Semester - 5

		L	T	P		
OE-I	Open Elective - I	3	0	0	3	3
HSMC302-T	Fundamentals of Management for Engineers	2	0	0	2	2
PCC-EBME301-T	Biomedical Instrumentation - II	3	0	0	3	3
PCC-EBME303-T	Microprocessors & Microcontrollers	3	0	0	3	3
PCC-EBME305-T	Medical Imaging Technology	3	0	0	3	3
ESC-EBME307-T	Biomaterials	3	0	0	3	3
PCC-EBME309-T	Control System Engineering	3	0	0	3	3
PCC-EBME301-P	Biomedical Instrumentation - II Lab	0	0	2	2	1
PCC-EBME303-P	Microprocessors & Microcontrollers Lab	0	0	2	2	1
INT-EBME321-P	Industrial Training Presentation - I	0	0	2	2	1

OE-I	**Open Elective - I**
OE-EBME391-T	Medical Imaging Technology

OPEN ELECTIVE – I

MEDICAL IMAGING TECHNOLOGY

Course Code: OE-EBME391-T Course Credits: 3 Mode: Lecture (L) and Tutorial (T) Type: Compulsory Contact Hours: 3 hours (L) + 00 hours (T) per week. Examination Duration: 03 hours.	**Course Assessment Methods; Max. Marks: 100 (Internal: 30; External: 70)** Three minor tests, each of 20 marks, will be conducted. The third minor will be conducted in open book mode by the Course Coordinator. No date sheet will be issued for the third minor at the level of the Departments. For the purpose of internal assessment, the average of the highest marks obtained by a student in any two minor examinations will be considered. All the minor examination question papers will be prepared and evaluated by following the Outcome Based Education framework. Class Performance will be measured through the percentage of lectures attended (4 marks) Assignments (4 marks) and class performance (2 marks). The end-semester examination will be of 70 marks. For the end-semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. All questions carry equal marks

Prerequisite: Basic knowledge and understanding of human anatomy & imaging principles.

Sr. No.	Course outcomes At the end of the course students will be able to:	RBT Level
CO-1	To understand the principle & working of various imaging equipment for diagnosis	LOTS: Ll (Remember)
CO-2	Understanding the interaction of ionizing radiation with tissue and principles of radiation protection.	LOTS: L2 (Understand)
CO-3	To apply the knowledge of clinical applications of various medical imaging equipment.	LOTS: L3 (Apply)
CO-4	To analyze the concept of doppler effect for medical applications.	HOTS: L4 (Analyze)

Unit-I

Imaging with Ionizing Radiation: Interactions of Radiation with tissue, Production of X Rays, X-ray equipment, Radiation protection, Scattered radiation, Clinical applications, X-Ray Image intensifier, Angiography.
Computerized Tomography: Construction, function and operation of a CT Scanner, Clinical applications. Single Photon Emission, Computed Tomography (SPECT), Positron Emission Tomography (PET).

Unit-II

Magnetic Resonance Imaging: Physics of MRI/NMR, T_1 and T_2 relaxation time, MRI pulse sequences, Instrumentation of MRI, MRI slice selection and encoding, Functional MRI (f-MRI), MRI clinical applications, Fluid flow imaging, Chemical-shift and Spectroscopic imaging.

Unit-III

Ultrasound Imaging: Propagation of ultrasound waves in fluids, solids and tissue. Doppler Effect, Ultrasound transducers and instrumentation, Modes of ultrasonic imaging, Clinical applications.

Unit-IV

Thermal imaging& other techniques: Medical thermography - equipment & applications. Fluoroscopy, Endoscopy-surgery navigation, Role of nanoparticles in medical imaging.

Text Books:

1. Steve Webb, “The Physics of Medical Imaging”, Taylor & Francis, New York, 2010.
2. William R Hendee, Russell Ritenour E, “Medical Imaging Physics” John Wiley, New York, 2002.

3. Paul Suetens, "Fundamentals of Medical Imaging", Cambridge University Press, 2002.

Reference Books:

1. Joie P Jones, Manbir Singh and Cho Z.H., “Foundations of Medical Imaging”, John Wiley, 1993.
2. Mark A Brown, Richard C Semelka**,** “MRI: Basic Principles and Applications”, John Wiley, Third Edition, 2003
3. Atam Dhawan, **“**Medical Image Analysis”, John Wiley, 2003

BIOMEDICAL INSTRUMENTATION-II

Course Code: PCC-EBME-301-T Course Credits: 3 Mode: Lecture (L) and Tutorial (T) Type: Compulsory Contact Hours: 3 hours (L) + 00 hours (T) per week. Examination Duration: 03 hours.	**Course Assessment Methods; Max. Marks: 100 (Internal: 30; External: 70)** Three minor tests, each of 20 marks, will be conducted. The third minor will be conducted in open book mode by the Course Coordinator. No date sheet will be issued for the third minor at the level of the Departments. For the purpose of internal assessment, the average of the highest marks obtained by a student in any two minor examinations will be considered. All the minor examination question papers will be prepared and evaluated by following the Outcome Based Education framework. Class Performance will be measured through the percentage of lectures attended (4 marks) Assignments (4 marks) and class performance (2 marks). The end-semester examination will be of 70 marks. For the end-semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. All questions carry equal marks

Prerequisite: Study of the course PCC—EBME 206-T Biomedical Instrumentation-II

Sr. No.	Course outcomes At the end of the course students will be able to:	RBT Level
CO-1	Define & outline the general concepts and terminologies related to medical instrumentation; and explain and illustrate important functions of the human body and of man-made medical systems	LOTS:L1 & L2 (Remember and understand)
CO-2	To understand the Pulmonary analyzers, electrotherapy equipment's and Instruments dealing with kidney and bones:	LOTS:L2 (Remember and understand)
CO-3	To understand the Sensory instrumentation and Special equipment's like Endoscopy	LOTS: L3 (Apply and analyze)
CO-4	Measurement of various physiological parameters and maintenance of medical instrumentations.	HOTS: L4 & L5 (Analyze&Evaluate)
CO-5	Able to apply and design medical instrumentation for various medical applications.	HOTS:L5(Create)

Unit I

Pulmonary analyzers and aid equipments: Regulation of Breathing - Pulmonary gas flow measurements – Pulmonary volume measurements - Respiratory gas analyzers – Nitrogen Gas Analyzer, Oxygen Analyzer - Humidifier, Nebulizer –Ventilators - IPPB Unit – Anaesthesia machine.

Unit-II

Physiotherapy and electrotherapy equipment's: Tissue response -Short ware diathermy - Microwave diathermy - Ultrasonic therapy Unit - Electrotherapy - FES, TENS - Bladder stimulator - Lithotripter system - Extra corporeal Shock wave therapy.

Unit-III

Instruments dealing with kidney and bones: Regulation of Water and Electrolyte Balance – Artificial Kidney – Hemo dialysis - Crafts for dialysis - Peritoneal dialysis - Dialyzers – different types - BMD Measurements – SXA – DXA - Quantitative ultrasound bone densitometer.

Unit-IV

Sensory instrumentation: Mechanism of Hearing, Sound Conduction System - Basic Audiometer, Pure toneaudiometer, Audiometer system Bekesy – Hearing Aids – Ophthalmoscope– Tonometer - Measurement of Basal Skin response and Galvanic skin response - Instruments for testing Motor responses - Experimental Analysis of Behaviour – Biofeedback Instrumentation.

Special equipment's: Endoscopy – Laparoscopy – Cryogenic Equipment - Automated drug delivery system – Components of drug infusion system – Implantable infusion systems.

REFERENCE BOOKS:

1. Geoddes L.A and Baker L.E, “Principles of Applied Biomedical Instrumentation”, John Wiley.
2. Khandpur R.S, “Hand-book of Biomedical Instrumentation”, Tata McGraw Hill, India.
3. Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, “Biomedical Instrumentation and Measurement”, Prentice-Hall India.
3. Carr Brown, “Introduction to Biomedical Equipment Technology” Pearson Education Publications.
4. John G. Marcel Dekkar “Medical Instrumentation: Applications and Design” by Webster Publishers.

MICROPROCESSORS& MICROCONTROLLERS

Course Code: PCC-EBME303-T Course Credits: 3 Mode: Lecture (L) and Tutorial (T) Type: Compulsory Contact Hours: 3 hours (L) + 00 hours (T) per week. Examination Duration: 03 hours.	**Course Assessment Methods; Max. Marks: 100 (Internal: 30; External: 70)** Three minor tests, each of 20 marks, will be conducted. The third minor will be conducted in open book mode by the Course Coordinator. No date sheet will be issued for the third minor at the level of the Departments. For the purpose of internal assessment, the average of the highest marks obtained by a student in any two minor examinations will be considered. All the minor examination question papers will be prepared and evaluated by following the Outcome Based Education framework. Class Performance will be measured through the percentage of lectures attended (4 marks) Assignments (4 marks) and class performance (2 marks). The end-semester examination will be of 70 marks. For the end-semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. All questions carry equal marks

Prerequisite: Basic knowledge of Physics, Electronics, and engineering mathematics.

Sr. No.	Course outcomes At the end of the course students will be able to:	RBT Level
CO-1	The objective of this course is to providecomprehension of microprocessor structure: CPU, memory and input/output peripherals.	LOTS: Ll (Remember)
CO-2	To understand & to know how to use sets of instructions and machine language.	LOTS: L2 (Understand)
CO-3	To develop a capacity to analyze systems architecture based on microprocessors.	LOTS: L3 (Apply)
CO-4	To develop a capacity to use hardware description languages.	HOTS: L4 (Analyse)

Unit-I

8085 MICROPROCESSORS: Introduction to microprocessor, 8085 microprocessors: Architecture, Instruction set, Interrupt structure and Assembly language programming.

Unit-II

8086 MICROPROCESSORS: Architecture, block diagram of 8086, details of sub-blocks such as EU, BIU; memory segmentation and physical address computations, program relocation, addressing modes, instruction formats, pin diagram and description of various signals.

Unit-III

I/O CONTROLLERS: Features, Organization and operating modes of 8155 Multi-function device, programmable peripheral interface, 8237 Programming DMA Controller. 8259 Programmable interrupt controller, Programmable interval timer chips.

Unit-IV

MICROCONTROLLER: Introduction, classification based on- Architecture, instruction set & memory.

8051 MICROCONTROLLERS: Introduction, block diagram, pin description & special features.

TEXT BOOK:

1. Microprocessor Architecture, Programming & Applications with 8085: Ramesh S Gaonkar; Wiley Eastern Ltd. 6 edition, 2012.
2. The Intel Microprocessors 8086- Pentium processor: Brey; PHI, 8 edition, 2008.

REFERENCE BOOKS:

1. Microprocessors and interfacing: Hall; TMH, 2005
2. The 8088 & 8086 Microprocessors-Programming, interfacing, Hardware & Applications: Triebel& Singh; PHI, 4 edition, 2007.

3. Microcomputer systems: the 8086/8088 Family: architecture, Programming & Design: Yu-Chang Liu & Glenn A Gibson; PHI, 2 edition, 2015
4. Advanced Micrprocessors and Interfacing: Badri Ram; TMH, 2017.

MEDICAL IMAGING TECHNOLOGY

Course Code: PCC-EBME305-T Course Credits: 3 Mode: Lecture (L) and Tutorial (T) Type: Compulsory Contact Hours: 3 hours (L) + 00 hours (T) per week. Examination Duration: 03 hours.	**Course Assessment Methods; Max. Marks: 100 (Internal: 30; External: 70)** Three minor tests, each of 20 marks, will be conducted. The third minor will be conducted in open book mode by the Course Coordinator. No date sheet will be issued for the third minor at the level of the Departments. For the purpose of internal assessment, the average of the highest marks obtained by a student in any two minor examinations will be considered. All the minor examination question papers will be prepared and evaluated by following the Outcome Based Education framework. Class Performance will be measured through the percentage of lectures attended (4 marks) Assignments (4 marks) and class performance (2 marks). The end-semester examination will be of 70 marks. For the end-semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. All questions carry equal marks

Prerequisite: Basic knowledge and understanding of human anatomy & imaging principles.

Sr. No.	Course outcomes At the end of the course students will be able to:	RBT Level
CO-1	To understand the principle & working of various imaging equipment for diagnosis	LOTS: Ll (Remember)
CO-2	Understanding the interaction of ionizing radiation with tissue and principles of radiation protection.	LOTS: L2 (Understand)
CO-3	To apply the knowledge of clinical applications of various medical imaging equipment.	LOTS: L3 (Apply)
CO-4	To analyze the concept of doppler effect for medical applications.	HOTS: L4 (Analyze)

Unit-I

Imaging with Ionizing Radiation: Interactions of Radiation with tissue, Production of X Rays, X-ray equipment, Radiation protection, Scattered radiation, Clinical applications, X-Ray Image intensifier, Angiography.
Computerized Tomography: Construction, function and operation of a CT Scanner, Clinical applications. Single Photon Emission, Computed Tomography (SPECT), Positron Emission Tomography (PET).

Unit-II

Magnetic Resonance Imaging: Physics of MRI/NMR, T_1 and T_2 relaxation time, MRI pulse sequences, Instrumentation of MRI, MRI slice selection and encoding, Functional MRI (f-MRI), MRI clinical applications, Fluid flow imaging, Chemical-shift and Spectroscopic imaging.

Unit-III

Ultrasound Imaging: Propagation of ultrasound waves in fluids, solids and tissue. Doppler Effect, Ultrasound transducers and instrumentation, Modes of ultrasonic imaging, Clinical applications.

Unit-IV

Thermal imaging& other techniques: Medical thermography - equipment & applications. Fluoroscopy, Endoscopy-surgery navigation, Role of nanoparticles in medical imaging.

Text Books:

1. Steve Webb, “The Physics of Medical Imaging”, Taylor & Francis, New York, 2010.
2. William R Hendee, Russell Ritenour E, “Medical Imaging Physics” John Wiley, New York, 2002.
3. Paul Suetens, "Fundamentals of Medical Imaging", Cambridge University Press, 2002.

Reference Books:

1. Joie P Jones, Manbir Singh and Cho Z.H., “Foundations of Medical Imaging”, John Wiley, 1993.
2. Mark A Brown, Richard C Semelka**,** “MRI: Basic Principles and Applications”, John Wiley, Third Edition, 2003
3. Atam Dhawan, **“**Medical Image Analysis”, John Wiley, 2003

BIOMATERIALS

Course Code: ESC-EBME307-T Course Credits: 3 Mode: Lecture (L) and Tutorial (T) Type: Compulsory Contact Hours: 3 hours (L) + 00 hours (T) per week. Examination Duration: 03 hours.	**Course Assessment Methods; Max. Marks: 100 (Internal: 30; External: 70)** Three minor tests, each of 20 marks, will be conducted. The third minor will be conducted in open book mode by the Course Coordinator. No date sheet will be issued for the third minor at the level of the Departments. For the purpose of internal assessment, the average of the highest marks obtained by a student in any two minor examinations will be considered. All the minor examination question papers will be prepared and evaluated by following the Outcome Based Education framework. Class Performance will be measured through the percentage of lectures attended (4 marks) Assignments (4 marks) and class performance (2 marks). The end-semester examination will be of 70 marks. For the end-semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. All questions carry equal marks

Prerequisite: Basic knowledge of Materials Science and Engineering Concepts.

Sr. No.	Course outcomes At the end of the course students will be able to:	RBT Level
CO-1	To understand the fundamental principles of biomaterials and their contribution to medical device's development and performance.	LOTS: Ll (Remember)
CO-2	Understanding the long-term performance of biomaterials.	LOTS: L2 (Understand)
CO-3	Selection of materials for device design and construction	LOTS: L3 (Apply)
CO-4	To analyze the concept of biocompatibility and methods for biomaterials testing.	HOTS: L4 (Analyze)

Unit-I

Introduction of Different types of Biomaterials: Definition and classification of biomaterials (Polymers, Plastics, Metallic and ceramic biomaterials), properties of biomaterials (Biocompatibility, functionality, carcinogenicity etc.), carbon and polymers materials, adsorbable and porous biomaterials with examples, biological responses, Surface chemistry of biomaterials, thermal and chemical properties, mechanical properties.

Unit-II

Metallic and Ceramic biomaterials: Properties and uses of Stainless steel, Co-based alloys, Ti and Ti-based alloys, Host tissue reaction with biomaterials and its corrosion behavior. Hard tissue replacement implant: Orthopedic implants- types of orthopedic function devices, Dentals implants, Soft tissue replacement implants: Percutaneous and skin implants, Definition of bio ceramics, Common types of bio ceramic, bone cement.

Unit-III

Polymeric Implant Materials: Classification, thermal properties, factors influencing polymer properties, polymer compatibility, polymer degradation, Biodegradable polymers for medical purposes, Biopolymer in controlled release systems, Synthetic polymer for membranes and their biological application, tissue adhesives, Viscoelastic behaviour: creep-recovery, stress relaxation, strain rate sensitivity. Polymeric Biomaterials: Polythene, polypropylene, silicones rubber, hydrogels.

Unit-IV

Biocompatibility &toxicological screening of biomaterials: Concept of biocompatibility, blood compatibility and tissue compatibility. Toxicity test: acute and chronic toxicity studies, sensitization, carcinogenicity, mutagenicity. Testing of biomaterials and Implants**:** In vitro testing (Mechanical testing): tensile, compression, wears, fatigue, corrosion studies and fracture toughness; In-vivo testing (animals): biological performance of implants, standards of implant materials.

Text Book:

1. Buddy D. Ratner, et al, "Biomaterial Science: An introduction to material in Medicine", Academic Press, San Diego, 3rd Edition, 2013.

2. Sujata V. Bhat, “Biomaterials”, Narosa Publishing House, 2nd Edition, 2010.

Reference Books:

1. Joon B. Park & Joseph D. Bronzino, “Biomaterials – Principles and Applications”, CRC Press, London, 2013.
2. J. B. Park & R. S. Lakes, “Biomaterials: An Introduction” Springer, 3rd Edition, 2007.

CONTROL SYSTEM ENGINEERING

Course Code: PCC-EBME309-T Course Credits: 3 Mode: Lecture (L) and Tutorial (T) Type: Compulsory Contact Hours: 3 hours (L) + 00 hours (T) per week. Examination Duration: 03 hours.	**Course Assessment Methods; Max. Marks: 100 (Internal: 30; External: 70)** Three minor tests, each of 20 marks, will be conducted. The third minor will be conducted in open book mode by the Course Coordinator. No date sheet will be issued for the third minor at the level of the Departments. For the purpose of internal assessment, the average of the highest marks obtained by a student in any two minor examinations will be considered. All the minor examination question papers will be prepared and evaluated by following the Outcome Based Education framework. Class Performance will be measured through the percentage of lectures attended (4 marks) Assignments (4 marks) and class performance (2 marks). The end-semester examination will be of 70 marks. For the end-semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. All questions carry equal marks

Prerequisite: Basic knowledge of Physics, Electronics, and engineering mathematics.

Sr. No.	Course outcomes At the end of the course students will be able to:	RBT Level
CO-1	Acquire an understanding about the models & their classifications.	LOTS: Ll (Remember)
CO-2	Able to design mathematical models of different systems.	LOTS: L2 (Understand)
CO-3	Gain knowledge on stability & its judging criteria.	LOTS: L3 (Apply)
CO-4	Understand the various ways to analyze these systems in frequency domain.	HOTS: L4 (Analyse)
CO-5	Contrast different types of digital circuits and their designing methods.	HOTS: L5 (Evaluate)

Unit-I

SYSTEMS BASICS: System model, types of models, examples of systems and their inputs and outputs, controller, servomechanism, regulating system, linear time-invariant (LTI) system, time-varying system, causal system, open loop control system, closed loop control system, continuous time and Discrete time systems. Effects of feedback on sensitivity (to parameter variations), stability, external disturbance (noise), overall gain. non-linear control systems.

Unit-II

MATHEMATICAL MODELLING: Block diagram algebra, signal flow graphs: Mason's gain formula & its application, characteristic equation.

TIME DOMAIN ANALYSIS: Time response of first order systems to various standard inputs, time response of 2nd order system to step input, relationship between location of roots of characteristics equation. Steady state error and error constants.

Unit-III

STABILITY: Concept of stability, pole zero configuration and stability, necessary and sufficient conditions for stability, Hurwitz stability criterion, Routh stability criterion and relative stability.
Root locus concept, development of root loci for various systems, stability considerations.

Unit-IV

FREQUENCY DOMAIN ANALYSIS: Relationship between frequency response and time-response for 2nd order system, polar, Nyquist, Bode plots, stability, Gain-marginand Phase Margin, relative stability, frequency response specifications.
SYSTEM MECHANISM: Pupil control system, skeletal muscle servomechanism, Respiratory models and controls, cardiovascular control systems, visual fixation system,oculomotor system. Sugar level control mechanism endocrine control mechanism.

TEXT BOOK:

1. Control System Engineering: I.J.Nagrath&M.Gopal; New Age, 2017
2. Automatic Control Systems: B.C.Kuo, PHI. 9 Edition, 2014

REFERENCE BOOKS:

1. Ross and Wilson-Anatomy and physiology in Health and illness. 12 Edition, 2014
2. Modern Control Engg: K.Ogata; PHI. 2010
3. Control Systems - Principles & Design: MadanGopal; Tata McGraw Hill. 4 Edition, 2012
4. Modern Control EngineeringR.C.Dorl& Bishop; Addison-Wesley, 12 Edition, 2012

BIOMEDICAL INSTRUMENTATION – II LAB

Course Code: PCC-EBME-301-P Course Credits: 1 Type: Compulsory Contact Hours: 2 hours/week Mode: Practical session	**Course Assessment Methods (Internal: 50; External: 50)**Internal continuous assessment of 50 marks on the basis of class performance and attendance in practical classes. There will be a continuous process for laboratory course evaluation. Two internal examinations (each of 50 marks) for the laboratory courses (Minor Laboratory Evaluations: MLE I and MLE Il) will be conducted the week before or after the internal examinations for the theory courses. The overall internal marks will be calculated as the average of the two minor laboratory course evaluations. The course coordinator will conduct these minor evaluations in the slots assigned to them as per their timetable. The marks for MLE I and MLE Il must be submitted within a week of the conduct of these laboratory course evaluations. For the end-semester practical examination, the assessment will be done out of 50 marks by an external examiner appointed by the Controller of Examination along with the internal examiner, preferably the lab course coordinator, appointed by the Chairperson of the Department.

Prerequisite: Basic knowledge of Physics & Electronics.

Sr. No.	Course Outcomes At the end of the semester, students will be able to:	RBT Level
CO-1	Examine and identify the various blocks and specifications of biomedical equipments.	LOTS: L3 (Apply)
CO-2	Analyze, evaluate and calibrate the various medical equipments.	HOTS: L4 & L5 (Analyze&Evaluate)
CO-3	Measurement of various physiological and medical parameters and design of circuits for measurements.	HOTS: L6(Create)
CO-4	Create written records for the given experiments with problem definition, solution, observations and conclusions.	HOTS: L4(Create)
CO-5	Demonstrate ethical practices while performing lab experiments individually or in groups.	LOTS: L3 (Apply)

LIST OF EXPERIMENTS:

1. To demonstrate various bioelectrodes and their properties.
2. Operating, Maintenance and calibration of Muscle Stimulator
3. Operating, Maintenance and calibration of Ultrasound Therapy
4. Operating, Maintenance and calibration of different Sensory equipment's.
5. Measurement of various pulmonary parameters.
6. Measurement of Galvanic skin response.
6. Study and demonstration of Endoscopes

Note: At least five experiments are to be performed by the students from the above topics. The course coordinator may also design and set experiments in addition to above topics as per the scope and requirement of the syllabus.

MICROPROCESSORS& MICROCONTROLLERS LAB

Course Code: PCC-EBME303-P Course Credits: 1 Type: Compulsory Contact Hours: 2 hours/week Mode: Practical session	**Course Assessment Methods (Internal: 50; External: 50)**Internal continuous assessment of 50 marks on the basis of class performance and attendance in practical classes. There will be a continuous process for laboratory course evaluation. Two internal examinations (each of 50 marks) for the laboratory courses (Minor Laboratory Evaluations: MLE I and MLE Il) will be conducted the week before or after the internal examinations for the theory courses. The overall internal marks will be calculated as the average of the two minor laboratory course evaluations. The course coordinator will conduct these minor evaluations in the slots assigned to them as per their timetable. The marks for MLE I and MLE Il must be submitted within a week of the conduct of these laboratory course evaluations. For the end-semester practical examination, the assessment will be done out of 50 marks by an external examiner appointed by the Controller of Examination along with the internal examiner, preferably the lab course coordinator, appointed by the Chairperson of the Department.

Prerequisite: Basic knowledge of Physics & Electronics.

Sr. No.	Course Outcomes At the end of the semester, students will be able to:	RBT Level
CO-1	Able to perform basic design procedure used in designing the microprocessors embedded circuits	LOTS: L3 (Apply)
CO-2	Understand the importance and functionality of microprocessors.	HOTS: L4 & L5 (Analyze & Evaluate)
CO-3	Understand the assembly language programming for microprocessors.	HOTS: L6 (Create)
CO-4	Able to execute & learn the various mathematical operative programs.	HOTS: L6 (Create)

LIST OF EXPERIMENTS:

1. Study of 8085 Microprocessor kit.
2. Write a program using 8085 and verify for:
    a. Addition of two 8-bit numbers.
    b. Addition of two 8-bit numbers (with carry).
3. Write a program using 8085 and verify for:
    a. 8-bit subtraction (display borrow)
    b. 16-bit subtraction (display borrow)
4. Write a program using 8085 for multiplication of two 8- bit numbers by repeated addition method. Check for minimum number of additions and test for typical data.
5. Write a program using 8085 for multiplication of two 8- bit numbers by bit rotation method and verify.
6. Write a program using 8085 for division of two 8- bit numbers by repeated subtraction method and test for typical data.
7. Write a program using 8085 for dividing two 8- bit numbers by bit rotation method and test for typical data.
8. Study of 8086 microprocessor kit.
9. Write a program using 8086 for division of a defined double word (stored in a data segment) by another double
10. Write a program using 8086 for finding the square root of a given number and verify.
11. Write a program for finding square of a number using look-up table and verify.

Note: At-least seven experiments are to be performed by students from the above list. The course coordinator may also design and set experiments in addition to the above list/topic as per the scope and requirement of syllabus.

TEXT BOOK:

1. Microprocessor Architecture, Programming & Applications with 8085: Ramesh S Gaonkar; Wiley Eastern Ltd. 6 edition, 2012.
2. The Intel Microprocessors 8086- Pentium processor: Brey; PHI, 8 edition, 2008.

SEMESTER-6

Semester - 6

OE-II	Open Elective - II	3	0	0	3	3
HSMC301-T	Economics for Engineers	2	0	0	2	2
PEC-I	Professional Elective - I	3	0	0	3	3
PCC-EBME302-T	Communication Engineering	3	0	0	3	3
PCC-EBME304-T	Medical Devices	3	0	0	3	3
PCC-EBME306-T	Rehabilitation & Assistive Technology	3	0	0	3	3
PCC-EBME308-T	Laser & Fibre Optics in Medicine	3	0	0	3	3
PCC-EBME302-P	Communication Engineering Lab	0	0	2	2	1
PCC-EBME304-P	Medical Devices Lab	0	0	2	2	1
MC-EBME310-T	Entrepreneurship	3	0	0	3	0

Note:

At the end of the VI semester, each student will have to undergo Practical Training - II of 4 to 6 weeks duration during summer vacations in an industry/research institute which will be evaluated in 7th semester.

OE-II	**Open Elective - II**
OE-EBME392-T	Medical Devices

PEC-I	**Professional Elective - I**
PEC-EBME351-T	Biomedical Ethics & Device Regulations
PEC-EBME352-T	Artificial Organs & Tissue Engineering
PEC-EBME353-T	Biosensors
PEC-EBME354-T	Biomedical Waste Management
PEC-EBME355-T	Nanotechnology For Healthcare Applications

OPEN ELECTIVE – II

MEDICAL DEVICES

Course Code: OE-EBME 392-T Course Credits: 3 Mode: Lecture (L) and Tutorial (T) Type: Compulsory Contact Hours: 3 hours (L) + 00 hours (T) per week. Examination Duration: 03 hours.	**Course Assessment Methods; Max. Marks: 100 (Internal: 30; External: 70)** Three minor tests, each of 20 marks, will be conducted. The third minor will be conducted in open book mode by the Course Coordinator. No date sheet will be issued for the third minor at the level of the Departments. For the purpose of internal assessment, the average of the highest marks obtained by a student in any two minor examinations will be considered. All the minor examination question papers will be prepared and evaluated by following the Outcome Based Education framework. Class Performance will be measured through the percentage of lectures attended (4 marks) Assignments (4 marks) and class performance (2 marks). The end-semester examination will be of 70 marks. For the end-semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. All questions carry equal marks

Prerequisite: Basic knowledge of fundamentals of physiological measurements and instrumentation system.

Sr. No.	Course outcomes At the end of the course students will be able to:	RBT Level
CO-1	Describe the components and working of various medical devices.	LOTS: Ll (Remember)
CO-2	Describe the applications of various medical devices.	LOTS: L2 (Understand)
CO-3	Maintain and troubleshoot the various medical devices	LOTS: L3 (Apply)
CO-4	Stimulation among the learners for futuristic research, design and development of medical devices	HOTS: L4 (Analyze)

Unit-I

Dialysis: Renal Function, Hemodialysis, Peritoneal Dialysis, Dialyzers, Membranes for Hemodialysis, Hemodialysis Machine

Heart Lung Machine: Need and Block Diagram, Oxygenators, Blood Pumps, Traps and filters, Heat Exchangers.

Anesthesia Machine: Need for Anesthesia, construction and working of Anesthesia Machine, Capnography

Unit-II

Ventilators: Mechanics of Respiration, Artificial Ventilation, Types of Ventilators, Ventilator Terms, Classification of Ventilators, Pressure-Volume-Flow Diagrams, Modern Ventilators, High Frequency Ventilators, Humidifiers, Nebulizers and Aspirators

Lithotriptors: The Stone Disease Problem, The Shock Wave, The First Lithotriptor Machine, Modern Lithotriptor Systems, Laser Lithotripsy

Unit-III

Coronary Care Devices: Artificial Heart Valves, Requirements for the Design of Artificial Heart valves, Various Types and Replacement of Heart Valves; Coronary Stents, Types of Stents, Angiography, Balloon Angioplasty

Endoscopes: Principles and description of electronic and optical assembly, Types of Endoscopes, Fiber optic endoscope, Laparoscope, Cystoscope.

Unit-IV

Intraocular Lens: Materials for Intraocular Lens, Types of Intraocular Lens

Prosthetic Devices: Limb prosthesis and its components, Interface between the residual limb and prosthesis, dental Prosthesis

Automated Drug Delivery Systems: Infusion Pumps, Components of Drug Infusion Systems, Implantable Infusion System, Closed-Loop Control in Infusion Systems, Examples of Typical Infusion Pumps, Insulin Pumps

Books Recommended:

1. R.S. Khandpur, “Handbook of Biomedical Instrumentation”, McGraw Hill Education (India) Pvt. Ltd., 2015.
2. John G. Webster, “Medical Instrumentation Application & Design”, Wiley, 2011.
3. Shakti Chatterjee &Aubert Miller, “Biomedical Instrumentation Systems”, Delmer Cengage Learning, 1St Ed, 2010.
4. Joseph J. Carr and John M. Brown, Introduction to Biomedical Equipment Technology”, Pearson Education, Inc., 2007.

COMMUNICATION ENGINEERING

Course Code: PCC-EBME302-T Course Credits: 3 Mode: Lecture (L) and Tutorial (T) Type: Compulsory Contact Hours: 3 hours (L) + 00 hours (T) per week. Examination Duration: 03 hours.	**Course Assessment Methods; Max. Marks: 100 (Internal: 30; External: 70)** Three minor tests, each of 20 marks, will be conducted. The third minor will be conducted in open book mode by the Course Coordinator. No date sheet will be issued for the third minor at the level of the Departments. For the purpose of internal assessment, the average of the highest marks obtained by a student in any two minor examinations will be considered. All the minor examination question papers will be prepared and evaluated by following the Outcome Based Education framework. Class Performance will be measured through the percentage of lectures attended (4 marks) Assignments (4 marks) and class performance (2 marks). The end-semester examination will be of 70 marks. For the end-semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. All questions carry equal marks

Prerequisite: Basic knowledge of Electronics, Physics, and Engineering mathematics and its concepts.

Sr. No.	Course Outcomes At the end of the semester, students will be able to:	RBT Level
CO-1	Acquire a basic knowledge in information & its transmission.	LOTS: (Remember)
CO-2	To develop an ability to understand the basics of amplitude modulation & its features.	LOTS:L2 (Understand)
CO-3	To develop an understanding & Observation about the frequency modulation & its features.	LOTS: L3 (Apply)
CO-4	Understanding of various digital communication techniques.	HOTS: L4 &L5 (Analyze & Evaluate)

Unit-I

BASIC FREQUENCY THEORY: Introduction to information, messages & signals, Classification of signals. entropy of discrete systems rate of transmission redundancy. Efficiency and channel capacity.

Unit-II

AMPLITUDE MODULATION: Frequency Spectrum Power Relations, Basic requirements and description of variousmodulators, comparison, DSB, DSB-SC, SSB, VSB, Spectrum Modulators and Detectors.

Unit-III

FREQUENCY MODULATION: F.M. frequency spectrum of FM based modulation, Effect of Noise, generation of FM and demodulation.

Unit-IV

PULSE MODULATION: Sampling theorem, low pas and band pass signals, Elements of PAM, PWM, PPM, PCM and Delta Modulation, FDM, TDM.

A.M AND F.M. RADIO TRANSMITTERS AND RECEIVERS: Characteristics, block diagram, super-heterodyne receiver.

Textbook:

1. Kennedy's Electronic Communication Systems, George Kennedy, Brendan Davis, SrmPrasanna, 2011
2. Principles of Communication System:II; Taub& Schilling, 2007

REFERENCE BOOKS:

1. Modern Digital & Analog Communication System: B.P.Lathi, 2011
2. Communication System: Symon Haykin, 2013

MEDICAL DEVICES

Course Code: PCC-EBME304-T Course Credits: 3 Mode: Lecture (L) and Tutorial (T) Type: Compulsory Contact Hours: 3 hours (L) + 00 hours (T) per week. Examination Duration: 03 hours.	**Course Assessment Methods; Max. Marks: 100 (Internal: 30; External: 70)** Three minor tests, each of 20 marks, will be conducted. The third minor will be conducted in open book mode by the Course Coordinator. No date sheet will be issued for the third minor at the level of the Departments. For the purpose of internal assessment, the average of the highest marks obtained by a student in any two minor examinations will be considered. All the minor examination question papers will be prepared and evaluated by following the Outcome Based Education framework. Class Performance will be measured through the percentage of lectures attended (4 marks) Assignments (4 marks) and class performance (2 marks). The end-semester examination will be of 70 marks. For the end-semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. All questions carry equal marks

Prerequisite: Basic knowledge of fundamentals of physiological measurements and instrumentation system.

Sr. No.	Course outcomes At the end of the course students will be able to:	RBT Level
CO-1	Describe the components and working of various medical devices.	LOTS: Ll (Remember)
CO-2	Describe the applications of various medical devices.	LOTS: L2 (Understand)
CO-3	Maintain and troubleshoot the various medical devices	LOTS: L3 (Apply)
CO-4	Stimulation among the learners for futuristic research, design and development of medical devices	HOTS: L4 (Analyze)

Unit-I

Dialysis: Renal Function, Hemodialysis, Peritoneal Dialysis, Dialyzers, Membranes for Hemodialysis, Hemodialysis Machine

Heart Lung Machine: Need and Block Diagram, Oxygenators, Blood Pumps, Traps and filters, Heat Exchangers.

Anesthesia Machine: Need for Anesthesia, construction and working of Anesthesia Machine, Capnography

Unit-II

Ventilators: Mechanics of Respiration, Artificial Ventilation, Types of Ventilators, Ventilator Terms, Classification of Ventilators, Pressure-Volume-Flow Diagrams, Modern Ventilators, High Frequency Ventilators, Humidifiers, Nebulizers and Aspirators

Lithotriptors: The Stone Disease Problem, The Shock Wave, The First Lithotriptor Machine, Modern Lithotriptor Systems, Laser Lithotripsy

Unit-III

Coronary Care Devices: Artificial Heart Valves, Requirements for the Design of Artificial Heart valves, Various Types and Replacement of Heart Valves; Coronary Stents, Types of Stents, Angiography, Balloon Angioplasty

Endoscopes: Principles and description of electronic and optical assembly, Types of Endoscopes, Fiber optic endoscope, Laparoscope, Cystoscope.

Unit-IV

Intraocular Lens: Materials for Intraocular Lens, Types of Intraocular Lens

Prosthetic Devices: Limb prosthesis and its components, Interface between the residual limb and prosthesis, dental Prosthesis

Automated Drug Delivery Systems: Infusion Pumps, Components of Drug Infusion Systems, Implantable Infusion System, Closed-Loop Control in Infusion Systems, Examples of Typical Infusion Pumps, Insulin Pumps

Books Recommended:

1. R.S. Khandpur, “Handbook of Biomedical Instrumentation”, McGraw Hill Education (India) Pvt. Ltd., 2015.
2. John G. Webster, “Medical Instrumentation Application & Design”, Wiley, 2011.
3. Shakti Chatterjee &Aubert Miller, “Biomedical Instrumentation Systems”, Delmer Cengage Learning, 1St Ed, 2010.
4. Joseph J. Carr and John M. Brown, Introduction to Biomedical Equipment Technology”, Pearson Education, Inc., 2007.

REHABILITATION & ASSISTIVE TECHNOLOGY

Course Code: PCC-EBME306-T Course Credits: 3 Mode: Lecture (L) and Tutorial (T) Type: Compulsory Contact Hours: 3 hours (L) + 00 hours (T) per week. Examination Duration: 03 hours.	**Course Assessment Methods; Max. Marks: 100 (Internal: 30; External: 70)** Three minor tests, each of 20 marks, will be conducted. The third minor will be conducted in open book mode by the Course Coordinator. No date sheet will be issued for the third minor at the level of the Departments. For the purpose of internal assessment, the average of the highest marks obtained by a student in any two minor examinations will be considered. All the minor examination question papers will be prepared and evaluated by following the Outcome Based Education framework. Class Performance will be measured through the percentage of lectures attended (4 marks) Assignments (4 marks) and class performance (2 marks). The end-semester examination will be of 70 marks. For the end-semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. All questions carry equal marks

Prerequisite: Knowledge and understanding of human physiology and basic electronics.

Sr. No.	Course outcomes At the end of the course students will be able to:	RBT Level
CO-1	Understand the concept of rehabilitation for differently abled people.	LOTS: Ll (Remember)
CO-2	Understand the assistive devices & technologies for sensory augmentation and substitution	LOTS: L2 (Understand)
CO-3	Apply the knowledge of wheelchair engineering for personal transportation.	LOTS: L3 (Apply)
CO-4	Analyze the concept of prostheses and orthoses for designing of artificial limbs.	HOTS: L4 (Analyze)

Unit-I

Introduction: Rehabilitation concepts, Engineering concepts in sensory rehabilitation, motor rehabilitation, communication disorders. Sensory augmentation & substitution – visual system, auditory system, tactual system.

Unit-II

Wheel Chair Engineering: Wheeled mobility, Categories of wheel chairs, Wheel chair structure & component design, Ergonomics of wheel chair propulsion.

Unit-III

Sensory Rehabilitation: Rehabilitation of the blind – reading aids, tactile vision. Aids for the deaf- audiometry and speech therapy aids. Automatic speech synthesis & Voice recognition.

Unit-IV

Motor Rehabilitation: Orthopedic prosthetics and orthotics in Rehabilitation, Limb prostheses and orthoses for various handicapped, Spinal injury rehabilitation, Prosthetic knee, Prosthetic hand, Orthotic knee joint, FES System, Myoelectric hand and arm prostheses.

Text Books:

1. Joseph D. Bronzino, "Biomedical Engineering Handbook, Volume II", CRC Press.
2. Susan J. Garrison, "Handbook of Physical Medicine and Rehabilitation', Lippincott Williams & Wilkins, 2nd Edition.

Reference Books:

1. Manfred Clynes, John H. Milsum, "Biomedical Engineering Systems", McGraw Hill.

LASER & FIBER OPTICS IN MEDICINE

Course Code: PCC-EBME308-T Course Credits: 3 Mode: Lecture (L) and Tutorial (T) Type: Compulsory Contact Hours: 3 hours (L) + 00 hours (T) per week. Examination Duration: 03 hours.	**Course Assessment Methods; Max. Marks: 100 (Internal: 30; External: 70)** Three minor tests, each of 20 marks, will be conducted. The third minor will be conducted in open book mode by the Course Coordinator. No date sheet will be issued for the third minor at the level of the Departments. For the purpose of internal assessment, the average of the highest marks obtained by a student in any two minor examinations will be considered. All the minor examination question papers will be prepared and evaluated by following the Outcome Based Education framework. Class Performance will be measured through the percentage of lectures attended (4 marks) Assignments (4 marks) and class performance (2 marks). The end-semester examination will be of 70 marks. For the end-semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. All questions carry equal marks

Prerequisite: Knowledge and understanding of human physiology and basic electronics.

Sr. No.	Course outcomes At the end of the course students will be able to:	RBT Level
CO-1	To understand the basic concepts of optical fibers and their properties	LOTS:L1 & L2 (Remember and understand)
CO-2	To understand the basics principles construction and working of LASERS.	LOTS:L2 (Remember and understand)
CO-3	Outline the clinical applications of fiber optic Lasers systems.	LOTS: L3 (Apply and analyze)
CO-4	Able to utilize the basic engineering principles of fiber optics and lasers for developing therapeutic, diagnostic, sensing and imaging devices.	HOTS: L4 & L5 (Analyze & Evaluate)
CO-5	Stimulation among the learners for futuristic research, design and developments.	HOTS:L5(Create)

Unit I

Basics of LASER: Principle and operation of LASER, LASER materials, major types of LASER, medical LASER, basic component of LASER equipments, different types of LASER(He-Ne LASER, CO2 LASER, Nd-Yag LASER, Krypton LASER), The application of LASER in medicine, LASER Safety.

Unit-II

LASER Effects on Biological Tissue: LASER tissue interactions, thermal responses of tissues, effect of UV for Photo-biological Studies, spectroscopic diagnostics of malignant tumors and plaque, clinical applications of Low-Power LASER, Photodynamic therapy, plaque removal, lithotripsy etc.

Unit-III

Optical Fiber: Fundamentals, propagation of light in optical fibers (NA, TIR, angle of acceptance), attenuation , bending losses, scattering , absorption, dispersion, power transmission through optical fibers, power budgeting in optical, medical application of optical fibers.

Unit-IV

Laser Application in Medical Therapy: Introduction, application in general surgery, dermatology, ophthalmology, cardiovascular & chest surgery, dentistry, neuro surgery, tumor surgery, gynecologic laser, endoscopy, laparoscopy, photodynamic therapy.

Reference Books:

1. Lasers and Optical Fibers in Medicine-by Abraham Katzir, Academic Press, 1998.
2. Lasers in Medicine-by Ronal W. Waynant, CRC Press, 2002.
3. Laser and optical fibers in medicine by Katzer and Abraham (Academic press publications)
4. An Introduction to optical fibers by A. M. Cherin (McGraw Hill publications)
5. Elements of fiber optics by S. L. Wymer (Regents-Prentice Hall publications)

COMMUNICATION ENGINEERING LAB

Course Code: PCC-EBME302-P Course Credits: 1 Type: Compulsory Contact Hours: 2 hours/week Mode: Practical session	**Course Assessment Methods (Internal: 50; External: 50)** Internal continuous assessment of 50 marks on the basis of class performance and attendance in practical classes. There will be a continuous process for laboratory course evaluation. Two internal examinations (each of 50 marks) for the laboratory courses (Minor Laboratory Evaluations: MLE I and MLE Il) will be conducted the week before or after the internal examinations for the theory courses. The overall internal marks will be calculated as the average of the two minor laboratory course evaluations. The course coordinator will conduct these minor evaluations in the slots assigned to them as per their timetable. The marks for MLE I and MLE Il must be submitted within a week of the conduct of these laboratory course evaluations. For the end-semester practical examination, the assessment will be done out of 50 marks by an external examiner appointed by the Controller of Examination along with the internal examiner, preferably the lab course coordinator, appointed by the Chairperson of the Department.

Prerequisite: Basic knowledge of Physics & Electronics.

Sr. No.	Course outcomes At the end of the course students will be able to:	RBT Level
CO-1	Able to perform basic design procedure used in communication system.	LOTS: L3 (Apply)
CO-2	Understand the importance and functionality of these circuits.	HOTS: L4 & LS (Analyse & Evaluate)
CO-3	Understand the designing and working of transmitters & receivers.	HOTS: L6 (Create)
CO-4	Able to understand difference in different modulations techniques.	HOTS: L6 (Create)

LIST OF EXPERIMENTS:

01. Study of AM Modulation and Demodulation
02. Study of FM Modulation and Demodulation (Reactance modulator, Foster Seely and Ratio Detector Modulator)
03. Study of PAM, PPM, & PWM circuits
04. Study of PCM Transmitters/Receivers
05. Study of DM Transmitters/Receivers
06. Study of TDM Transmitters/Receivers
07. Study of AM Receiver Measurements (Sensitivity, Selectivity, Fidelity)
08. Study of ASK Modulation and Demodulation
09. Study of FSK Modulation and Demodulation
10. Study of ASK Modulation and Demodulation.

Note: At-least seven experiments are to be performed by students from the above list. The course coordinator may also design and set experiments in addition to the above list/topic as per the scope and requirement of syllabus.

BOOKS SUGGESTED:

1. Kennedy's Electronic Communication Systems, George Kennedy, Brendan Davis, SrmPrasanna, 2011
2. Principles of Communication System:II; Taub& Schilling, 2007

MEDICAL DEVICES LAB

Course Code: PCC-EBME304-P Course Credits: 1 Type: Compulsory Contact Hours: 2 hours/week Mode: Practical session	**Course Assessment Methods (Internal: 50; External: 50)**Internal continuous assessment of 50 marks on the basis of class performance and attendance in practical classes. There will be a continuous process for laboratory course evaluation. Two internal examinations (each of 50 marks) for the laboratory courses (Minor Laboratory Evaluations: MLE I and MLE Il) will be conducted the week before or after the internal examinations for the theory courses. The overall internal marks will be calculated as the average of the two minor laboratory course evaluations. The course coordinator will conduct these minor evaluations in the slots assigned to them as per their timetable. The marks for MLE I and MLE Il must be submitted within a week of the conduct of these laboratory course evaluations. For the end-semester practical examination, the assessment will be done out of 50 marks by an external examiner appointed by the Controller of Examination along with the internal examiner, preferably the lab course coordinator, appointed by the Chairperson of the Department.

Prerequisite: Basic knowledge of Human Physiology & Electronics.

Sr. No.	Course Outcomes At the end of the semester, students will be able to:	RBT Level
CO-1	Perform basic design procedure using components of various medical devices	LOTS: L3 (Apply)
CO-2	Demonstrate the working & applications of various medical devices	HOTS: L4 & L5 (Analyze & Evaluate)
CO-3	Maintain and troubleshoot various medical devices	HOTS: L6 (Create)
CO-4	Able to execute futuristic research, design and development of medical devices	HOTS: L6 (Create)

LIST OF SOME TOPICS FOR EXPERIMENTS:

1. Demonstration of Pace maker (extent and implantable, power source of implantable pacemaker leads and electrodes)
2. Demonstration of operation of Heart lung machine.
3. Demonstration of coronary care devices-coronary stents.
4. Operation of laser equipment
5. Various types of endoscopes
6. Various types of Intraocular lenses

Note: At least seven experiments are to be performed by the students from the above topics. The course coordinator may also design and set experiments in addition to above topics as per the scope and requirement of the syllabus.

ENTREPRENEURSHIP

Course Code: MC-EBME310-T Course Category: Mandatory Course Course Credits: 0.0 Contact Hours: 3 hours/week (L: 3; T: 0) Mode: Lectures Examination Duration: 3 hours	**Course Assessment Methods; Max. Marks: 100 (Internal: 30; External: 70)** Three minor tests, each of 20 marks, will be conducted. The third minor will be conducted in open book mode by the Course Coordinator. No date sheet will be issued for the third minor at the level of the Departments. For the purpose of internal assessment, the average of the highest marks obtained by a student in any two minor examinations will be considered. All the minor examination question papers will be prepared and evaluated by following the Outcome Based Education framework. Class Performance will be measured through the percentage of lectures attended (4 marks) Assignments (4 marks) and class performance (2 marks). The end-semester examination will be of 70 marks. For the end-semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. All questions carry equal marks

Sr. No.	Course Outcomes At the end of the semester, students will be able to:	RBT Level
CO-1	Students will be able to describe the concept of entrepreneurship, the role of entrepreneurship in economic development of the country and the scope for an entrepreneur	LOTS: L1 (Remember and understand)
CO-2	Students will be able to understand small enterprises, problems faced by small enterprises, engineering economics, product planning and development, the contents of a project report and formulation of a project report.	LOTS: L2 (Remember and understand)
CO-3	Students will be able to apply the basic steps in setup a new business.	LOTS: L3 (Apply)
CO-4	Students will be able to examine the development of a startup.	HOTS: L4 (Analyze)
CO-5	Students will be able to evaluate and analyze the depreciation, costing, economics in a startup/business.	HOTS: L5 (Evaluate)

Unit – I

Entrepreneurship: Entrepreneurship, Role of entrepreneur in Indian economy, Characteristics of all entrepreneur, Types of entrepreneurs, some myths, and realities about entrepreneurship.

Small scale Industries: Introduction, Role and scope of small-scale industries, concept of small scale and ancillary industrial undertaking, How to start a small scale industry, Steps in launching own venture, procedure for registration of small scale industries, various development agencies- their functions and role in industrial and entrepreneurship development, Infrastructure facilities available for entrepreneurship development in India.

Unit – II

Engineering Economics: Definition and concept, Importance of Economics for engineers, present value, Wealth, Goods, Wants, Value and price, capital, money, utility of consumer and producer goods.

Costing: Introduction, Elements of cost, Prime cost, Overhead, Factory cost, Total cost, Selling Price, Nature of cost, Types of Cost.

Unit III

Depreciation: Definition and concept, Causes of Depreciation, Methods of calculating depreciation.

Economic analysis of investment: Introduction, Nature of selection problem, Nature of replacement problem, Replacement of items which deteriorate, Replacement of machines whose operating cost increase with time and the value of money also changes with time.

Unit IV

Product planning and Development: Introduction, Requirement of a good product design, product development approaches, Product development process, Elements of concurrent engineering, Various controlling agencies involved their role and formalities for getting clearance before starting individual venture.

Preparation of feasibility Project Report: Tools for evaluation of techno-economic feasibility project report, Preparation of Preliminary Project Reports – Project Appraisal – Sources of Information, SWOT analysis.

Text and Reference Books:

1. Bruce R Barringer and R Duane Ireland, Entrepreneurship: Successfully Launching New Ventures, 6th ed., Pearson Edu., 2019.
2. D.F. Kuratko and T.V. Rao, Entrepreneurship: A South-Asian Perspective, Cengage Learning, 2013.
3. S. S. Khanka "Entrepreneurial Development" (4th ed.), S Chand & Company Ltd., 2012.
4. H. Nandan, Fundamental of Entrepreneurship, PHI Learning private limited, 2011
5. Mathew J Manimala, "Enterprenuership theory at cross roads: paradigms and praxis" Dream tech 2nd edition 2006.88
6. SK Mohanty, Fundamental of Entrepreneurship, PHI Learning, 2005
7. Kuratko & Hodgetts, "Enterprenuership – Theory, process and practices", Thomson learning 6th edition.
8. Hisrich R D and Peters M P, "Entrepreneurship" 5th Edition Tata McGraw-Hill, 2002
9. Dr. Vasant Desai, Management of Small Scale Enterprises, Himalaya Publishing House, 2004.
10. Rabindra N. Kanungo "Entrepreneurship and innovation", Sage Publications, New Delhi, 1998.

PROFESSIONAL ELECTIVES-I

Biomedical Ethics & Device Regulations

Course Code: EBME 351-T Course Credits: 3 Mode: Lecture (L) and Tutorial (T) Type: Compulsory Contact Hours: 3 hours (L) + 00 hours (T) per week. Examination Duration: 03 hours.	**Course Assessment Methods; Max. Marks: 100 (Internal: 30; External: 70)** Three minor tests, each of 20 marks, will be conducted. The third minor will be conducted in open book mode by the Course Coordinator. No date sheet will be issued for the third minor at the level of the Departments. For the purpose of internal assessment, the average of the highest marks obtained by a student in any two minor examinations will be considered. All the minor examination question papers will be prepared and evaluated by following the Outcome Based Education framework. Class Performance will be measured through the percentage of lectures attended (4 marks) Assignments (4 marks) and class performance (2 marks). The end-semester examination will be of 70 marks. For the end-semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. All questions carry equal marks

Prerequisite: Knowledge and understanding of basic electronics.

Sr. No.	Course outcomes At the end of the course students will be able to:	RBT Level
CO-1	Define & outline the general concepts and terminologies related to Biomedical Ethics & Device Regulation	LOTS:L1 (Remember and understand)
CO-2	Understand basics about nature and sources of medical ethics	LOTS:L2 (Remember and understand)
CO-3	Apprehend the importance of quality control for medical devices.	LOTS: L3 (Apply and analyze)
CO-4	Gain knowledge about the regulation of medical devices and learn evaluation	HOTS: L4 & L5 (Analyze & Evaluate)
CO-5	Realize and analyze the importance of maintain professional standards	HOTS:L5(Create)

Unit I

Sources of Medical Law and Ethics: Nature and sources of medical ethics, Sources of medical law. Consent, Confidentiality and Clinical Negligence: Consent to Treatment, Confidentiality and Clinical Negligence.

Unit-II

Mental Health: Types of mental health, Adults with Incapacity.

Issues: The law & ethics in relation to abortion, Reproductive Technology and Surrogacy, The law in relation to end of life issues, the ethics of end of life issues and Research.

Unit-III

Maintaining professional standards: Maintaining standards and regulation, Presenting evidence and reports, The Coroner's court, The General Medical Council, Doctors rights: Employment and other rights of doctors

Unit-IV

Device regulation: Classifications and requirements of Medical devices, Harmonized standards, CE approval , Quality Assurance and Quality Definition of quality, quality management, principles of TQM, measures for Quality Control. Safety & Testing of Medical devices patenting.

Reference Books:

1. Intervention and Reflection: Basic Issues in Medical Ethics -Ronald Munson, Cram101

2. Ethics of Health Care: An Introductory Textbook–B. M. Ashley, K. D. O'Rourke, Georgetown University Press

3. Introduction to Bio-Medical Engineering-John D. Enderle, Susan M. Blanchard, Academic Press

ARTIFICIAL ORGANS & TISSUE ENGINEERING

Course Code: PEC-EBME352-T Course Credits: 3 Mode: Lecture (L) and Tutorial (T) Type: Compulsory Contact Hours: 3 hours (L) + 00 hours (T) per week. Examination Duration: 03 hours.	**Course Assessment Methods; Max. Marks: 100 (Internal: 30; External: 70)** Three minor tests, each of 20 marks, will be conducted. The third minor will be conducted in open book mode by the Course Coordinator. No date sheet will be issued for the third minor at the level of the Departments. For the purpose of internal assessment, the average of the highest marks obtained by a student in any two minor examinations will be considered. All the minor examination question papers will be prepared and evaluated by following the Outcome Based Education framework. Class Performance will be measured through the percentage of lectures attended (4 marks) Assignments (4 marks) and class performance (2 marks). The end-semester examination will be of 70 marks. For the end-semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. All questions carry equal marks

Prerequisite: Knowledge and understanding of human anatomy & physiology.

Sr. No.	Course outcomes At the end of the course students will be able to:	RBT Level
CO-1	Understand the concept of organ replacement and substitutive medicine.	LOTS: Ll (Remember)
CO-2	Understand the engineering concerns and hemodynamic assessment of artificial organs	LOTS: L2 (Understand)
CO-3	Apply the knowledge of engineering design considerations of artificial organs for function replacement.	LOTS: L3 (Apply)
CO-4	Analyze the concept of assistive devices and support systems for vital organ replacement.	HOTS: L4 (Analyze)

Unit-I

Introduction: Substitutive medicine, outlook for organ replacement, design consideration, evaluation process.
Artificial Kidney: Renal failure, Renal transplantation, Artificial kidney, Dialyzers, Membranes for hemodialysis, Hemodialysis machine, Peritoneal dialysis equipment.

Unit-II

Artificial Heart & Circulatory Assist Devices: Engineering design of artificial heart and circulatory assist devices, Cardiac Valve Prostheses: mechanical valves, tissue valves, engineering concerns and hemodynamic assessment of prosthetic heart valves.
Artificial Lungs: Cardiopulmonary bypass (heart-lung machine), Artificial lung versus natural lung, Tracheal replacement devices, Laryngeal replacement devices, Artificial esophagus.

Unit-III

Liver Functions: Hepatic failure, Liver support systems, General replacement of liver functions.
Artificial Blood, Pancreas, Skin: Artificial oxygen carriers, Fluorocarbons, Hemoglobin for oxygen carrying plasma expanders, Hemoglobin based artificial blood. Structure and functions of pancreas, diabetes, insulin, insulin therapy, insulin administration systems. Vital functions of skin, current treatment of massive skin loss, design principles for permanent skin replacement

Unit-IV

Introduction to Tissue Engineering: Challenges in Tissue engineering, Cellular Therapies, Grafts, and Extracorporeal Bio-artificial Organs, Human Cells and Grafts as Therapeutic Agents, Mechanisms Governing Tissues, Clinical Considerations.

Text Books:

1. Joseph D. Bronzino, "Biomedical Engineering Handbook, Volume II", CRC Press, 2000.
2. L. Hench & J. Jones, "Biomaterials, Artificial Organs & Tissue Engineering", Woodhead Publishing Limited, 2005.

Reference Books:

1. Park Joon Bu, “Biomaterials Science and Engineering”, Plenum Press, 1990.

BIOSENSORS

Course Code: PEC-EBME353-T Course Credits: 3 Mode: Lecture (L) and Tutorial (T) Type: Compulsory Contact Hours: 3 hours (L) + 00 hours (T) per week. Examination Duration: 03 hours.	**Course Assessment Methods; Max. Marks: 100 (Internal: 30; External: 70)** Three minor tests, each of 20 marks, will be conducted. The third minor will be conducted in open book mode by the Course Coordinator. No date sheet will be issued for the third minor at the level of the Departments. For the purpose of internal assessment, the average of the highest marks obtained by a student in any two minor examinations will be considered. All the minor examination question papers will be prepared and evaluated by following the Outcome Based Education framework. Class Performance will be measured through the percentage of lectures attended (4 marks) Assignments (4 marks) and class performance (2 marks). The end-semester examination will be of 70 marks. For the end-semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. All questions carry equal marks

Prerequisite: Knowledge and understanding of basic electronics.

Sr. No.	Course outcomes At the end of the course students will be able to:	RBT Level
CO-1	Understanding the concept of biosensors for different applications.	LOTS: Ll (Remember)
CO-2	Understanding the design considerations of immuno-biosensors.	LOTS: L2 (Understand)
CO-3	Knowledge ofengineering concerns of fibre-optic biosensors.	LOTS: L3 (Apply)
CO-4	Understanding the concept of electrochemical biosensors.	HOTS: L4 (Analyse)

Unit-I

Biosensors: Introduction – amperometric enzyme electrodes-characteristics- enzyme activity determinations – biosensors for enzyme immunoassay – Potentiometric enzyme electrodes – electrode characteristics and performance –pH glass and ion-selective electrodes – solid-state pH and redox electrodes –gas electrodes.

Unit-II

Immuno-Biosensors: Potentiometric immune-biosensors – immobilization techniques – analytical applications. Principle and measurements of enzyme thermistor devices. Transducer – experimental techniques – types of biological element: immobilized enzymes – immobilized cells – determination of enzyme activities in solution.

Unit-III

Fiber-optic Biosensors: Introduction – sensing chemistry and materials –sensing techniques –transducer types. Transducer-based fiber optic biosensors – Optical biosensors based on competitive binding.

Unit-IV

Electrochemical Biosensors: Electron conducting redox polymer in biosensors –enzyme electrodes – specific sensor examples. Hybridization at oligonucleotide sensitive electrodes: function of oligonucleotide sensitive electrodes – hybridization efficiency and sensitivity – probe oligonucleotide structure and dynamics – hybridization conditions – hybridization kinetics.

Text Books:

1. Copper J M and Cass E G A, “Biosensors”, Second Edition, Oxford University Press, 2004.
2. Blum L J andCoulet P R, “Biosensor Principles and Applications”, Marcel Dekker Inc., 1991.

Reference Books:

1. Joseph D Bronzino, “The Biomedical Engineering Handbook”, Volume II, CRC Press, Boca Raton, Second Edition, 2000.

BIOMEDICAL WASTE MANAGEMENT

Course Code: PEC-EBME 354-T Course Credits: 3 Mode: Lecture (L) and Tutorial (T) Type: Compulsory Contact Hours: 3 hours (L) + 00 hours (T) per week. Examination Duration: 03 hours.	**Course Assessment Methods; Max. Marks: 100 (Internal: 30; External: 70)** Three minor tests, each of 20 marks, will be conducted. The third minor will be conducted in open book mode by the Course Coordinator. No date sheet will be issued for the third minor at the level of the Departments. For the purpose of internal assessment, the average of the highest marks obtained by a student in any two minor examinations will be considered. All the minor examination question papers will be prepared and evaluated by following the Outcome Based Education framework. Class Performance will be measured through the percentage of lectures attended (4 marks) Assignments (4 marks) and class performance (2 marks). The end-semester examination will be of 70 marks. For the end-semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. All questions carry equal marks

Prerequisite: Knowledge and understanding of basic electronics.

Sr. No.	Course outcomes At the end of the course students will be able to:	RBT Level
CO-1	Understanding the concept of biomedical waste & its classification.	LOTS:L1 & L2 (Remember and understand)
CO-2	Understanding the hazards of biomedical waste.	LOTS:L2 (Remember and understand)
CO-3	Design waste disposal procedures for different biowastes	LOTS: L3 (Apply and analyze)
CO-4	Categorize different biowastes based on its properties	HOTS: L4 & L5 (Analyze & Evaluate)
CO-5	Design different safety facility in hospitals and propose various regulations and safety norms	HOTS:L5(Create)

Unit I

Biomedical Waste Management: Types of wastes, major and minor sources of biomedical waste, Categories and classification of biomedical waste, hazard of biomedical waste, need for disposal of biomedical waste, waste minimization, waste segregation and labeling, waste handling and disposal.

Unit-II

Hazardous Materials: Hazardous Substance Safety, OSHA Hazard Communication Standard, DOT Hazardous Material Regulations, Healthcare Hazardous Materials, Medical Gas Systems, Respiratory Protection.

Unit-II

Facility Safety: Introduction, Facility Guidelines: Institute, Administrative Area Safety, Slip, Trip, and Fall Prevention, Safety Signs, Colors, and Marking Requirements, Tool Safety, Electrical Safety, Control of Hazardous Energy, Landscape and Ground Maintenance, Fleet and Vehicle Safety.

Unit-IV

Infection Control, Prevention and Patient Safety: Healthcare Immunizations, Centers for Disease Control and Prevention, Disinfectants, Sterilants, and Antiseptics, OSHA Bloodborne Pathogens Standard, Tuberculosis, Healthcare Opportunistic Infections

Medical Waste Patient Safety: An Organizational Function, Errors and Adverse Events, Safety Cultures, Patient-Centered Healthcare, Quality Improvement Tools and Strategies, Healthcare-Associated Infections, Medication Safety.

REFERENCES:

1. Tweedy, James T., Healthcare hazard control and safety management-CRC Press_Taylor and Francis.

2. Anantpreet Singh, Sukhjit Kaur, Biomedical Waste Disposal, Jaypee Brothers Medical Publishers (P) Ltd.
3. R.C.Goyal, Hospital Administration and Human Resource Management, PHI.
4. V.J. Landrum, Medical Waste Management and disposal, Elsevier.
5. Anantpreet Singh, Sukhjit Kaur, “Biomedical Waste Disposal”, 1st ed., Jaypee Publishers (P) Ltd, India.
6. SushmaSahai, “Bio-Medical Waste Management”, APH Publishing Corporation, India.

NANOTECHNOLOGY FOR HEALTHCARE APPLICATIONS

Course Code: EBME 355-T Course Credits: 3 Mode: Lecture (L) and Tutorial (T) Type: Compulsory Contact Hours: 3 hours (L) + 00 hours (T) per week. Examination Duration: 03 hours.	**Course Assessment Methods; Max. Marks: 100 (Internal: 30; External: 70)** Three minor tests, each of 20 marks, will be conducted. The third minor will be conducted in open book mode by the Course Coordinator. No date sheet will be issued for the third minor at the level of the Departments. For the purpose of internal assessment, the average of the highest marks obtained by a student in any two minor examinations will be considered. All the minor examination question papers will be prepared and evaluated by following the Outcome Based Education framework. Class Performance will be measured through the percentage of lectures attended (4 marks) Assignments (4 marks) and class performance (2 marks). The end-semester examination will be of 70 marks. For the end-semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. All questions carry equal marks

Prerequisite: Knowledge and understanding of basic electronics.

Sr. No.	Course outcomes At the end of the course students will be able to:	RBT Level
CO-1	Ability to understand the basics of nanotechnology, and nanomaterials and their characterization techniques	LOTS:L1 & L2 (Remember and understand)
CO-2	•Understand biomaterials and interaction of biomaterials with cells, body fluids and tissues	LOTS:L2 (Remember and understand)
CO-3	Understand how nanotechnological approaches can be used in biomedical therapies	LOTS: L3 (Apply and analyze)
CO-4	Understand the toxicological aspects of nanosized surfaces and particles	HOTS: L4 & L5 (Analyze & Evaluate)
CO-5	Stimulation among the learners to develop nanomaterials and systems for applications in biomedical engineering.	HOTS:L5(Create)

Unit-I

Nanomaterials Properties: Introduction to Nanotechnology and Nanomaterials, Nanoscale architecture, effect of nanoscale dimensions on various properties such as structural, thermal, chemical, mechanical, magnetic, optical and electronic properties.

Unit-II

Nanomaterials Fabrication and Characterization: Top- down processes, lithography, etching - bottom-up process, vapor phase deposition methods, molecular beam epitaxy, self-assembly and self-organization. Characterization methods: scanning electron microscopy, transmission electron microscopy, scanning tunneling microscopy, atomic force microscopy, Raman spectroscopy.

Unit-III

Nanodevices: Magnetic Nanoparticles, Carbon Nanotubes (CNT), Organic field effect transistor, Organic light emitting diodes. Micro and Nano Immunosensor, Bio-Barcode Assay - use of magnets, gold, DNA and antibodies.

Unit-IV

Applications in Medicine: In vivo imaging for the detection of tumors, plaque, genetic defects and other disease states. Nanorobot medical devices, Artificial scaffolds and Biosynthetic coatings, Retinal, cochlear and neural implants, PCR, DNA Profiling, Cantilever Sensors, Targeted Drug Delivery.

REFERENCES:

1. Pradeep T, “Nano: The essentials, understanding nanoscience and nanotechnology”, Tata McGraw Hill, New Delhi.
2. Chris Binns, “Introduction to nanoscience and nanotechnology,” John Wiley & Sons, New Jersey.

3. Sami Franssila, “Introduction to microfabrication”, John Wiley & Sons, UK.
4. NeelinaMalsh, “Biomedical Nanotechnology”, Taylor and Francis, CRC Press, UK.
5. Hornyak, G. Louis, Tibbals, H. F., Dutta, Joydeep. Fundamentals of Nanotechnology. CRC Press.
6. Charles P. Poole Jr., Frank J. Owens, Introduction to Nanotechnology. John Wiley & Sons.
7. David E. Reisner, Bionanotechnology: Global Prospects, CRC Press.