Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

Syllabus for B. Tech in Biomedical Engineering

(Applicable from the academic session 2018-2019)

SEMESTER-VI

Name of the Course	**BIOMEDICAL DIGITAL SIGNAL PROCESSING**
Course Code: PC-BME601	**Semester: Sixth**
L-T-P-C: 3-0-0-3	**Contact: 3 hrs/week**
Objectives:	
1	Toimpartknowledgeabout filtercharacteristicsandtodesignvariousdigital filters.
2	To develop competency for transforming discrete signals and systemsfromtimedomainto frequency domain.
3	To build the required base fordevelopingalgorithms forsignalprocessingsystems.
4	To understand the fundamental techniques and applications of digital signal processing for biomedical signals.
5	Toprovideanin-depthknowledgeabout thebasicconceptsof waveletand speechanalysis.
Pre-Requisite: Signals & Systems in Biomedical Engineering (PCBME301), Digital Electronics & Integrated Circuits (ESEC401), Biomedical Instrumentation (PCBME402)	

M#	Content	Hrs
1	**Introduction:** Concept of discrete-time signal, basic idea of sampling and reconstruction of signal, sampling theorem, simple signal conversion systems, frequency domain representation, spectral analysis, cepstral analysis, linear filtering, adaptive filters-general structure, LMS adaptive filter, noise cancellation, feature extraction and pattern recognition.	7
2	**Digital Filters Realizations:**Characteristics of practical frequency selective filters, analog filter approximations-Butterworth and Chebychev filters, design of IIR filters from analog filters (LPF, HPF, BPF, BRF)- impulse invariance method, bilinear transformation, spectral transformation, characteristics of FIR filters, symmetric and anti-symmetric FIR filters, design of FIR filters using windowing techniques-rectangular, Hamming and Hanning window, comparison of FIR and IIR filters.	12
3	**Cardiological&ElectromuscularSignal Processing:**ECG signal processing, P-wave detection, QRS complex detection, rhythm analysis, arrhythmia detection algorithms, automated ECG analysis, ECG pattern recognition, analysis of heart rate variability, EMG signal processing, rectification and averaging.	8
4	**Neurological Signal Processing:**EEG signals processing, EEG analysis-time frequency domain method, linear prediction theory and autoregressive (AR) method, detection of spikes and spindles, detection of alpha, beta and gamma waves, least squares and polynomial modeling-Markov model and Markov chain, dynamics of sleep-wake transition, hypnogram model parameters, analysis of evoked potential.	8
5	**Data Compression & Wavelet:** Data reduction algorithms-TP, AZTEC, and CORTES, special example to ECG signal, introduction to wavelets, time frequency representation, discrete wavelet transform, pyramid algorithm, speech analysis.	5

COURSE OUTCOMES

At the end of the course, students should able to:

1. Apply DFT for the analysis of digital signals and systems.
2. Implement algorithms based on discrete time signals.
3. Applyappropriatesignalprocessingtechniquesinanalyzingvariousbio-signals.
4. Design IIR and FIR filters for bio-signal processing.
5. Explain and employ sampling and quantization procedures for digitally recording physiological data.
6. Develop measurement systems for bio-signals and its signal conditioning circuits.

Text/Reference Books:

1. D.C.Reddy,"Biomedicalsignalprocessing-PrinciplesandTechnique",TataMcGraw-Hill.
2. WillsJ.Tompkins, "Biomedicaldigitalsignalprocessing",PHIPvt.Ltd.
3. L.R.Rabiner,B.Gold,"TheoryandapplicationofDigitalSignalProcessing".
4. S.K.Mitra,"DigitalSignalProcessing:Acomputerbasedapproach",TMH.
5. J.G.Prokis, D.G.Manolakis, "DigitalSignalProcessing:Principles,AlgorithmandApplications",PHI/PearsonEducation.
6. S.Salivahanan et al, "Digital Signal Processing",TMH.
7. Oppenheim, RonaldWSchafer,"DigitalSignalProcessing",PrenticeHallIndia.
8. AndreasAntonion,"DigitalFiltersAnalysis&Design",PrenticeHallIndia.
9. RRabiner, B. Gold,"Theory&ApplicationofDigitalSignalprocessing",PHI.

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(Applicable from the academic session 2018-2019)

Name of the Course	**BIOMATERIALS & TISSUE ENGINEERING**
Course Code: PC-BME602	**Semester: Sixth**
L-T-P-C: 3-1-0-4	**Contact: 4 hrs/week**

Objectives:	
1	Tostudythephysicalandmechanicalpropertiesofdifferent types of biomaterials and various factorsthatinfluencefailure of implants.
2	To learn the significance of biocompatibility and acquaint with different toxicological screening tests and methods for sterilization of implantable biomaterials.
3	To understand the principles of tissue engineering andclinicalrequirementfortissueengineeringsystems.
4	To know about scaffold, biomimetic scaffold preparation and its application in engineered tissue.

Pre-Requisite: Engineering Physiology & Anatomy (PCBME301), Biophysics & Bio-chemistry (PCBME303), Basic Knowledge on Material Science and Mechanics

M #	**Content**	**Hrs**
1	**Characterization & Properties of Biomaterials:** Introduction to biomaterials, criteria for biomaterials, classification of biomaterials, selection and performance of biomaterials, biological responses, surface and physical properties, mechanical properties-stress strain behavior and hardness, mechanical failures, electrical, optical and magnetic properties.	6
2	**Metallic & Ceramic Biomaterials:** Metallic biomaterials: stainless steels, Co-Cr alloys and Ti alloys, properties of metal: corrosion and cracking, applications of metallic biomaterials, definition of bioceramics, non-absorbable materials: alumina, carbons and zirconia, biodegradable ceramics: calcium phosphate and aluminum-calcium-phosphate (ALCAP) ceramics, bioactive ceramics: glass ceramics and hydroxyapatite, applications of bioceramics.	10
3	**Polymeric&CompositeBiomaterials:**Polymericbiomaterials:polyethylene(PE),polypropylene(PP), polyvinylchloride (PVC), polyamide (Nylon), polytetrafluoroethylene (PTFE), plolymethylmetacrylate (PMMA), polyetherether ketone (PEEK), silicone rubber and hydrogels, biodegradable polymers, applications of polymers in medical field, definition of composites, properties and types of composites, composite theory of fiber reinforcement, polymers filled with osteogenic fillers, medical applications.	10
4	**Biocompatibility & Sterilization of Biomaterials:** Introduction to biocompatibility, blood compatibility and tissue compatibility, toxicity screening tests of biomaterials: systemic toxicity, haemolysis, cytotoxicity and special tests, sterilization of implantable biomaterials, sterilization techniques: autoclaving, ETO and gamma radiation, effects of sterilization on material properties.	8
5	**Introduction to Tissue Engineering:** Definition, current scope of development, engineering wound healing and sequence of events, cells as therapeutic agents, different cell types, cell differentiation and cell migration, extracellular matrix (ECM), cell-matrix and cell-	10

	cellinteractions,cellsignalingmolecules,growth factors, cell surface markers, cell separation, cell culture and storage, cell lines, fundamental of stem cell tissue engineering, inflammatoryandimmunesresponsestotissueengineereddevices, tissueengineeringapplications.	
6	**Biomimetic Scaffolds &Tissue Engineering Case Studies**Naturalscaffoldmaterials, syntheticbiomaterialscaffolds, scaffoldfabrication andtailoring, cell substrates, cell incorporation,growth factor delivery, oxygentransport,diffusion,Michaelis-Mentenkinetics, tissue morphogenesisandangiogenesis, bioreactors and cryopreservation, skin tissue engineering, vascular graft, liver tissue engineering, bone, muscle and nerve regeneration.	8

COURSE OUTCOMES

At the end of the course, students should able to:

1. Classify and select biomaterials for hard and soft tissue replacement.
2. Characterize the complex host tissue-implant interaction and explain the probable causes of implant failure.
3. Analyze the design ofvarious implants andimprove the functionality.
4. Evaluate the biocompatibility and toxicological screening of biomaterials.
5. Explain the significance, current status and future potential of tissue engineering.
6. Demonstrate the design, fabrication and biomaterials selection criteria for tissue engineering scaffolds.

Text/Reference Books:

1. JBPark,"Biomaterials-ScienceandEngineering",PlenumPress,1984.
2. SujataV. Bhat, "Biomaterials", Narosa Publishing House,2002.
3. BronzinoJD,"TheBiomedicalEngineeringHandbook",2nded.Vol-II,CRCPress
4. Jonathan Black, "Biological Performance of materials", MarcelDecker, 1981
5. C.P.Sharma,M.Szycher, "Blood compatible materials and devices", Tech.Pub.Co. Ltd.,1991.
6. Piskin, A.S.Hoffmann,"PolymericBiomaterials", MartinusNijhoffPublishers.
7. BuddyD.Ratner,AllanS. Hoffman,"BiomaterialSciences-Introduction toMaterials inMedicine"
8. FrederickH.Silver,"Biomaterials,MedicaldevicesandTissueEngineering",Chapman&Hall
9. Bernhard O. Palsson, Sangeeta N. Bhatia,"Tissue Engineering", Pearson Prentice Hall Bioengineering.
10. Cato T. Laurencin, Lakshmi S. Nair, "Nanotechnology and Tissue engineering - The Scaffold", CRC Press.

Name of the Course	**BIOMECHANICS & IMPLANTS**
Course Code: PC-BME603	**Semester: Sixth**
L-T-P-C: 3-0-0-3	**Contact: 3 hrs/week**
Objectives:	
1	To understand thefundamentals ofmechanicsand itsapplicationin human system.
2	To knowtheflowpropertiesofblood, various propertiesofhardand soft tissues.
3	Tostudythedeformability,strength,viscoelasticityofboneandflexibletissues,modesofloadin gand failure.
4	To learnthe mechanics of orthopedic implants and joint replacement, artificial heart valve, mechanicalpropertiesofcardiovascular system, etc.
Pre-Requisite: Physics-1 (PH201),Engineering Mechanics& Fluid Mechanics (ME201), Engineering Physiology & Anatomy (PCBME302).	

M #	**Content**	**Hrs**
1	**Introduction to Engineering Mechanics:** Free-body diagrams and equilibrium, trusses and frames, virtual work, kinematics and dynamics of particles and of rigid bodies in plane motion, impulse and momentum (linear and angular) energy formulations, collisions.	6
2	**Hard Tissues Mechanics:** Definition of stress and strain,deformation mechanics, bone and its composition, mechanical and electrical properties of bones, cortical and cancellous bones, viscoelasticity, MaxwellandVoightmodels-anisotropy,fatigue analysis, biomechanicsoffracturehealing,electrical stimulation for bone healing, external and internal fixation, intramedullary nails, plates, screws.	10
3	**Biomechanics of Joints &Locomotion:** Skeletal joints,forces and stresses in human joints, types of joints, biomechanical analysis of joints, kinetics and kinematics of joints, human locomotion, gait analysis and goniometry, ergonomics, foot pressure measurements.	6
4	**Soft Tissues &Bio-Fluid Mechanics:** Structure and functions of soft tissues, materials properties and modeling of soft tissues-cartilage, tendon and ligament, muscle-Hodgkin-Huxley Model, flowproperties of blood, dynamics of fluid flow in the in the intact human cardiovascular system-modeling and experimental approaches, pulse wave velocities in arteries, measurement of in-vivo elasticity of blood vessels.	10
5	**Implants&Prostheses:**Generalconceptsofimplants,classificationofimplants, basic considerationsand limitations, body response to implants, dental implants, ear and eye implants, prostheses: total hip joint, knee joint, shoulder joint, small joints, cardiovascular implants: prosthetic heart valves, biological & mechanical valves, differentheart valve prosthesis.	8

COURSE OUTCOMES

At the end of the course, students should able to:

1. Apply knowledge of biomechanics to analyze the properties of biofluid, hard and soft tissues and identifythe appropriate modeltodemonstrate mechanical behavior.

2. Analyze the biomechanicsofdifferenthumanjoints and alsoforcesfor variousstatic anddynamic human activities.
3. Demonstrate adetailed understandingofthe design requirements ofmedical implants based on the human anatomyand biologicalresponsesto biomaterials.
4. Interpretandexplainthemodeofoperationofdifferentartificial implantsanditsmedicalapplications.
5. Interprettechnicallytothequestsofbiomechanicalteam and formulatedesignspecification.
6. Perform a systematic qualitative biomechanical analysis of human movement activities or skills in sport, exercise, rehabilitation, work, and daily living.

Text/Reference Books:

1. Alexander R Mc Neill, "Biomechanics", Chapman and Hall,1975
2. D.Dawson, V.Wright, "Introduction to Biomechanics of joints and jointreplacement"
3. D N Ghista, "Biomechanics of Medical Devices", Macel Dekker,1982
4. D.O.Cooney,"BiomedicalEngineeringPrinciples",MacelDekker,INC,Newyork
5. A.Z.Tohen, C.T.Thomas,"ManualofMechanicalOrthopaedics".
6. D.N.Ghista, Roaf, "Orthopaedic Mechanics", AcademicPress
7. V.C.Mow, W.C.Hayes, "Basic Orthopedic Biomechanics", Lippincott, Ravenpublishers.

Name of the Course	**ADVANCED MEDICAL IMAGING TECHNIQUES**
Course Code: PC-BME604	**Semester: Sixth**
L-T-P-C: 3-0-0-3	**Contact: 3 hrs/week**
Objectives:	
1	Toimparttheversatileadvancedimagingtechniques andrelated modalities in healthcare system.
2	To develop acomprehensive understandingofthe functionalityand specific applications ofadvanced medical imaging systems.
3	Tounderstandthefundamentalprincipleandworkingof the advancedmedicalimagingsystemsinvolvedinthediagnosisofhealthcare.
4	To know the advanced instruments and latest techniques used for visualizing various sections of the body.
Pre-Requisite: Engineering Physiology & Anatomy (PCBME302), Biophysics & Biochemistry (PCBME303), Biomedical Instrumentation (PCBME402), Medical Imaging Techniques (PCBME502)	

M#	**Content**	**Hrs**
1	**Computed Tomography:** Introduction,principles of computed tomography, CT generations, scanning system, detectors in CT, data acquisition system and processing, storing and viewing system, gantry geometry, different information from gantry, Hounsfield and CT numbers, image reconstruction techniques: back projection, iterative and analytical methods, image quality and artifacts, Dose in CT, Spiral CT,multi-slice CT, 3D imaging and its application.	10
2	**Magnetic Resonance Imaging System**: Introduction, fundamentals of magnetic resonance, interaction of nuclei with static magnetic field and radio frequency wave, rotation and precession, induction of magnetic resonance signals, bulk magnetization, relaxation process-T1 and T2, gradient pulse, slice selection, phase encoding, frequency encoding, data acquisition and image reconstruction. MRI instrumentation: system magnet, gradient magnetic field coils, radio frequency coils (transmitter & receiver) and shim coils, diagnostic utility and clinical MRI, functional MRI (fMRI), magnetic resonance angiography (MRA), magnetic resonance spectroscopy (MRS), diffusion MRI, bio-effects and safety levels.	12
3	**Nuclear Medical Imaging System**: Introduction to emission tomography, physics of radioisotope imaging, compton cameras for nuclear imaging, radio nuclides for imaging, nuclear decay and energy emissions, brief of radionuclide production, pulse height analyzer, uptake monitoring equipment, gamma camera principles, rectilinear scanners, single-photon emission computed tomography (SPECT), positron emission tomography(PET), scintigraphy, dual isotope imaging.	10
4	**Advanced Imaging Applications**: Clinical aspects of PET/CT and SPECT/CT, optical coherence tomography (OCT), perfusion CT, cone beam CT for radiotherapy, 3D-CRT, IMRT, IGRT, cyber knife, gamma knife, functional brain imaging, bone marrow scanning, CSF imaging, thyroid and parathyroid imaging, liver and spleen imaging, Cath Lab imaging system.	8

COURSE OUTCOMES

At the end of the course, students should able to:

1. Explain the underlying physics and mode of operation of CT, MRI and SPECT-PET system.
2. Demonstrate the advanced imaging instruments and apply mathematical methods forimage reconstruction.
3. Justify the utility of advanced imaging system and explain the principles of working.
4. Analyzeandinterpretthe images forclinical purposes.
5. Compare and interpret the techniques used for visualizing various sections of the body.
6. Planandminimizetherisksandhealthhazards.

Text/Reference Books:

1. Carr & Brown, "Introduction to Biomedical Equipment Technology" Pearson Education, Asia.
2. R. S. Khandpur, "Handbook of Bio-Medical Instrumentation", Tata McGraw Hill.
3. J.Webster, "Bioinstrumentation", Wiley & Sons
4. Dowsett, Kenny & Johnston, "The Physics of Diagnostic Imaging", Chapman & Hall Medical, Madras/London.
5. Brown, Smallwood, Barber, Lawford& Hose, "Medical Physics and Biomedical Engineering", Institute of Physics Publishing, Bristol.
6. Massey & Meredith, "Fundamental Physics of Radiology", John Wright & Sons.
7. S. Webb, "The Physics of Medical Imaging", Ada m Hilger, Bristol.
8. Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, "Biomedical Instrumentation and Measurements", Prentice-Hall of India, 2nd Edition, 1997.
9. Wolfgang Drexler James G.Fijimoto "Optical coherence tomography technology and applications", Springer, First edition, 2008
10. P Raghunathan, "Magnetic Resonance Imaging & Spectroscopy in Medicine- Concept and Techniques" Orient Longman Pvt. Ltd., 2006.

Name of the Course	**ARTIFICIAL ORGANS & REHABILITATION ENGINEERING**
Course Code: PE-BME601	**Semester: Sixth**
L-T-P-C: 3-0-0-3	**Contact: 3 hrs/week**
Objectives:	
1	To give abasic ideaof theartificialorgansthatcan aida human to live anormal life.
2	To acquaint the studentwith modern artificial organs, devices and methods used to partially support or completely replace pathological organs.
3	Tolearnthebasicconceptsofrehabilitationengineeringandtounderstandthe importanceofbiomedicalengineeringinrehabilitation.
4	To gainknowledgeoftherecent developmentsinthefieldofrehabilitationengineering and get aware of how a helpcan be rendered to adifferently-abled person.
Pre-Requisite: Engineering Physiology & Anatomy (PCBME302), Biomaterials & Biomechanics, Biomedical Instrumentation (PCBME402).	

M #	**Content**	**Hrs**
1	**IntroductiontoArtificialOrgans:**Needofartificialorgans,designconsideratio nandevaluationprocess, problem associated with extra-corporeal devices,circulatory assist devices-IABP, cardiac catheterization, stents, CVP and SWAN catheters, artificialheart and engineering design,artificial blood-haemoglobin solutions and perfluorocarbon emulsions, liversupportsystem,artificialpancreas,artificialskin.	8
2	**Artificial Kidney:** Brief of kidney filtration, basic methods of artificial waste removal, hemodialysis, equation for artificial kidney, middle molecule hypothesis, artificial kidney machine (block diagram), hemodialyzers: flat plate, coil and hollow fiber, analysis of mass transfer in dialyzers (cross current flow), regeneration of dialysate, membrane configuration, wearable artificial kidney machine, electrical safety and maintenance.	8
3	**Artificial Heart-Lung Machine:** Brief of lungs gaseous exchange, artificial heart-lung devices, oxygenators: bubble, film oxygenators and membrane oxygenators, gas flow rate and area for membrane oxygenators.	4
4	**Introduction to Rehabilitation Engineering:** Impairments, disabilities and handicaps, measurement and assessment,engineering concepts in sensory and motor rehabilitation, rehabs for locomotion, visual and speech rehabilitation, spinal rehabilitation, rehabilitation in sports, robots in rehabilitation, role of biomedical engineering in rehabilitation.	6
5	**Orthotic & Prosthetic Devices:** Anatomy of upper and lower extremities,types of amputation, orthotic and prosthetic materials,artificial limb and hands, intelligent prosthetics, externally powered and controlled orthotics and prosthetics, FES system-restoration of standing and walking, hybrid assistive system, myoelectric hand and arm prostheses, MARCUS intelligent hand prostheses.	8
6	**Hearing & Mobility Aids:** Engineering concept in communication disorders, common tests-audiograms, air conduction, bone conduction andmasking, hearingaids-	6

	principles,types,drawbacksintheconventionalunit,DSPbasedhearingaids, mobility aids-crutches, wheelchairs, laser cane, ultrasound torch andguide.	

COURSE OUTCOMES

At the end of the course, students should able to:

1. Explain the structure and role of artificial organs and rehabilitation devices for sustaining functions.
2. Describe the expected functionalities of an artificial organ,orthotics and prosthesis.
3. Test and apply different types of hearing and mobility aids for the benefit of the society.
4. Identify available technology and recognize the user needs and benefits.
5. Prioritize in technological innovations for longer, healthier and more productive lives.
6. Design and develop various aids for physically challenged.

Text/Reference Books:

1. Bronzino. Joseph, "Hand book of biomedicalengineering".
2. R.S.Khandpur, "Hand book of biomedicalinstrumentation".
3. Erie.D.Blom, Howard.B.Rotham, "ArtificialOrgans".
4. David O. Cooney, "Biomedical Engineering Principles"Vol-II, Marcel DekkerInc.
5. Robbinson C.J., Rehabilitation Engineering. CRC press1995
6. BallabioE.etal, "Rehabilitation Engineering". IOS press1993.
7. Dr. S.Sundar, "Rehabilitation Medicine". Jaypee Medical Pub., NewDelhi.
8. KopffW.J,"ArtificialOrgans",JohnWiley andsons,NewYork,1976(UnitII).

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(Applicable from the academic session 2018-2019)

Name of the Course	**LASER & FIBER OPTICS IN MEDICINE**
Course Code: PE-BME602	**Semester: Sixth**
L-T-P-C: 3-0-0-3	**Contact: 3 hrs/week**
Objectives:	
1	To understand the fundamentals of different types of laser, its operations and applications in medical field.
2	Tostudyabouttheprinciplesandapplicationsoflaserandfiberopticsinmedicalfield especially in diagnosis and therapy.
Pre-Requisite: Physics-1 (PH201),Engineering Physiology & Anatomy (PCBME302),	

M#	Content	Hrs
1	**LASER Fundamentals:** Characteristics of lasers, spontaneous and stimulated emission, Einstein's co-efficient, population inversion, three level and four level lasers, properties of laser, laser modes, resonator configuration, cavity damping, types of lasers: gas lasers, solid lasers, liquid lasers and semiconductor lasers.	8
2	**Lasers in Surgery:** Surgical instrumentation of CO_2, Ruby, Nd-YAG, He-Ne, argon ion, Q-switched operations, continuous wave, quasi-continuous, surgical applications: removal of tumors of vocal cards ,brain surgery, plastic surgery, gynaecology and oncology.	8
3	**Laser Specific Applications:** Lasers in tissue welding, lasers in dermatology, lasers in ophthalmology, laser photocoagulations, laser in dentistry, laser flow cytometry, laser transillumination and diaphanography, speckle intereferometry, holography, application safety with biomedical Lasers.	8
4	**Optical Fibers Fundamentals:** Principles of light propagation through a fiber, different types of fibers and their properties, fiber characteristic, transmission of signal in SI and GI fibers, attenuation in optical fibers, connectors and splicers, fiber termination, optical sources, optical detectors.	8
5	**Optical Fiber Bundles & Applications**: Introduction and construction details of optical fibers, non-ordered fiber optic bundles for light guides-fundamentals and principles, ordered fiber-optic bundles for imaging devices-fundamentals and principles, fiberscopes and endoscopes-fundamentals, fiber optic imaging systems-advances, optical fiber in communication.	8

COURSE OUTCOMES

At the end of the course, students should able to:

1. Explain the principle of laser action and the characteristics of laser.
2. Recognize and classify various types of laser and its mode of operation.
3. Relate various applications of lasers in medical field and apply appropriately.
4. Demonstratethe basic concepts ofopticalfibersandtheirproperties.
5. Illustrate theconstruction, working principleand selection criteria ofopticalfibercables.
6. Propose and integrate lasers and optical fibers for diagnostic, therapeutic and imaging purposes.

Text/Reference Books:

1. Leon Goldman, " The Biomedical laser Technology and ClinicalApplications " Springer-Verlar

2. Leon Goldman, " Lasers in Medicine",Springer-Verlac
3. E.D.R.Pratesi, Sacchi, "Lasers in photomedicine and photo biology",Springer-Verlay
4. BashtM.L.Wel, "Laserapplicationsinmedicineandbiology",VolI,II,III,PlenumPress(1971&1974).
5. Nandini K. Jog, "Electronics in medicine and biomedical instrumentation",PHI
6. J.U.Wilson, Hawkes J.F.B., "Opto Electronics: An Introduction", Prentice Hall Int.1983
7. H.C.Allen,"AnIntroductiontoopticalfibers",McGrawHill, NewYork,1983.

Name of the Course	**IOT & ARTIFICIAL INTELLIGENCE**
Course Code: PE-BME603	**Semester: Sixth**
L-T-P-C: 3-0-0-3	**Contact: 3 hrs/week**
Objectives:	
1	To understand IoT architectures and application areas of IoT.
2	To learn about various IOT-related protocols.
3	To build simple IoT systems using Arduino and Raspberry Pi.
4	To provide a strong foundation of fundamental concepts in Artificial Intelligence (AI).
5	To provide a basic exposition to the goals and methods of Artificial Intelligence.
Pre-Requisite: Basic Knowledge on Mathematics, Science and, Computer programming	

M #	**Content**	**Hrs**
1	**Fundamentals of IoT:** Evolution of Internet of Things, enablingtechnologies,IoTarchitectures:oneM2M,IoTWorld Forum(IoTWF) and alternative IoT models, simplified IoT architecture and core IoT functional stack, fog, edge and cloud in IoT, functional blocks of an IoT ecosystem, sensors, actuators, smart objects and connecting smart objects.	9
2	**IoT Protocols:** IoT access technologies: physical and MAC layers, topology and security ofIEEE802.15.4,802.15.4g,802.15.4e,1901.2a,802.11ah and LoRaWAN, network layer: IP versions, constrained nodes and constrained networks, optimizing IP forIoT:from6LoWPAN to6Lo, routing overlow power and lossy networks, application transport methods: supervisory control and data acquisition, application layer protocols: CoAP and MQTT.	9
3	**Design & Development:** Design methodology, embedded computing logic, system on chips, IoT system building blocks, developing on the Arduinos, Raspberry Pi, mobile phone and tablet, laser cutting, 3D printing, CNC milling.	8
4	**Introduction to AI:** Definition of Artificial Intelligence, history and applications, components of AI structures, strategies for state space search, data driven and goal driven search, depth first and breadth first search, DFS with iterative deepening, heuristic search- best first search, A* algorithm, constraint satisfaction.	6
5	**Knowledge Representation in AI:** Knowledge representation - propositional calculus, predicate calculus, theorem proving by resolution, answer extraction, AI representational schemes- semantic nets, conceptual dependency, scripts, frames.	8

COURSE OUTCOMES

At the end of the course, students should able to:

1. Explain the concept of IoT and application areas of IoT.
2. Analyze various protocols for IoT.
3. Design a PoC of an IoT system using Rasperry Pi/Arduino
4. Apply IoT in industrial and commercial automation and real world design constraints.
5. Demonstrate fundamental understanding of AI and its foundations.
6. Apply basic principles of AI for problem solving, inference, perception and knowledge representation.

Text/Reference Books:

1. George FLuger,"ArtificialIntelligence-StructuresandStrategiesforComplexProblemSolving",4/e,2002,PearsonEducation.
2. ArshdeepBahga,VijayMadisetti, "Internet ofThings-Ahands-onapproach",Universities Press,2015
3. OlivierHersent,DavidBoswarthick,OmarElloumi,"TheInternetofThings-Keyapplicationsand Protocols",Wiley,2012(for Unit2).
4. JanHoller,VlasiosTsiatsis,CatherineMulligan,Stamatis,Karnouskos,StefanAvesand.
5. DavidBoyle,"FromMachine-to-Machine to the InternetofThings-Introduction to aNew Age ofIntelligence", Elsevier,2014.
6. Dieter Uckelmann, MarkHarrison,Michahelles, Florian (Eds), "Architecting the InternetofThings", Springer,2011.
7. StuartRussel,PeterNorvig, "ArtificialIntelligence:AModernApproach",3rdEdition, PearsonEducation,
8. ElaineRich,KevinKnightandShivashankarBNair,"ArtificialIntelligence" 3rdEdition,Tata McGraw Hill,2008.

Name of the Course	**OBJECT ORIENTED PROGRAMMING**
Course Code: OE-CS601	**Semester: Sixth**
L-T-P-C: 3-0-0-3	**Contact: 3 hrs/week**
Objectives:	
1	To understand object oriented programming concepts and basic characteristics programming.
2	To develop an object oriented programming application with threads and generics classes.
3	To know the principles of packages, inheritance and interfaces.
4	To design and build simple graphical user interfaces.
Pre-Requisite: Basic knowledge of algorithm and Procedural Programming Language	

M#	**Content**	**Hrs**
1	Abstract data types and their specification, How to implement an ADT, Concrete state space, Concrete invariant, Abstraction function, Implementing operations, illustrated by the Text example.	8
2	Basic concepts of Object Oriented Programming using Java / C++/ Python	6
3	Features of objectoriented programming, Encapsulation, Object identity, Polymorphism.	8
4	Inheritance in OO design, Design patterns, Introduction and classification, Theiterator pattern.	6
5	Model-view-controller pattern, Commands as methods and as objects, Implementing OO language features, Memory management.	6
6	Generic types and collections-GUIs, Graphical programming with Scale and Swing, The software development process.	6

COURSE OUTCOMES

At the end of the course, students should able to:

1. Differentiate between proceduraloriented programmingand object orientedprogramming.
2. Specify simple abstract data types and design implementations, using abstraction functions to documentthem.
3. Recognize features of object-oriented design such as encapsulation, polymorphism, inheritance, and composition of systems based on objectidentity.
4. Design applications with an event-driven graphical userinterface.
5. Design, write and apply straightforward programs using the knowledge of object orientedprogramming.
6. Analyze the complex problems and provide awareness of the need for a professional approach to design and the importance of good documentation to the finished programs.

Text/Reference Books:

1. Rambaugh, James Michael, Blaha, "Object Oriented Modelling and Design", PHI.
2. Ali Bahrami, "Object Oriented System Development", McGraw Hill.
3. Patrick Naughton, Herbert Schildt, "The complete reference-Java2", TMH.

4. R.K Das, "Core Java For Beginners", Vikas Publishing.
5. Deitel and Deitel, "Java How to Program", Pearson.
6. Ivor Horton's Beginning Java 2 SDK - Wrox
7. E. Balagurusamy, "Programming With Java: A Primer", TMH.
8. Barbara Liskov, "Program Development in Java", Addison-Wesley,2001.
9. E.Balaguruswamy, "ObjectOrientedProgrammingwithC++",6thEd, 2013 TMH.
10. R.S.Salaria, Khanna, "ObjectOrientedProgrammingwithC++",Publishing House,NewDelhi.
11. Brian Jones, David Beazley, "Python Cookbook: Recipes for Mastering Python 3", 3rd Edition, O'Reilly.
12. Paul Barry, Head-First Python: A Brain-Friendly Guide", 2ndEdition, O'Reilly.
13. Dusty Phillips, "Python 3 Object-Oriented Programming", 3rdEdition,Packt.

Name of the Course	**COMPUTER NETWORK**
Course Code: OE-CS602	**Semester: Sixth**
L-T-P-C: 3-0-0-3	**Contact: 3 hrs/week**
Objectives:	
1	To develop an understanding of the fundamental concepts of computer networking.
2	To familiarize the student with the basic taxonomy and terminology of the computer networking area.
3	To introduce about advanced networking concepts, preparing the student for entry in advanced courses in computer networking.
4	To gain expertise in some specific areas of networking such as the design and maintenance of individual networks.
Pre-Requisite: Communication Engineering, Basic Knowledge of Computer Organization	

M#	Content	Hrs
1	**Data communication Components:** Representation of data and its flow networks, various connection topology, protocols and standards, OSI model, transmission media, LAN: wired LAN, wireless LANs, connecting LAN and virtual LAN, techniques for bandwidth utilization: multiplexing-frequency division, time division and wave division, concepts on spreadspectrum.	6
2	**Data Link Layer & Medium Access Sub Layer:** Error detection and error correction-fundamentals, block coding, Hamming Distance, CRC; flow control and error control protocols-stop and wait, go back- N ARQ, selective repeat ARQ, sliding window, piggybacking, random access, multiple access protocols - pure ALOHA, slotted ALOHA, CSMA/CD,CDMA/CA	12
3	**Network Layer:** Switching, logical addressing-IPV4,IPV6; address mapping -ARP, RARP, BOOTP and DHCP-delivery, forwarding and unicast routingprotocols.	8
4	**Transport Layer:** Process toprocess communication, user datagram protocol (UDP), transmission control protocol (TCP), SCTP congestion control; quality ofservice, QoS improving techniques: leaky bucket and token bucketalgorithm.	8
5	**Application Layer:** Domain name space (DNS), DDNS, TELNET, EMAIL, File transfer protocol (FTP), WWW, HTTP, SNMP, bluetooth, firewalls, basic concepts of cryptography.	6

COURSE OUTCOMES

At the end of the course, students should able to:

1. Explain the functions of the different layer of the OSI protocol.
2. Draw the functional block diagram for different networks and describe the function of each block.
3. Design and implement small scale networks for a given specifications.
4. Develop network programing for a given TCP/IP related problems.
5. Configure application layer protocols using open source available software and tools.
6. Describe, analyze and evaluate varioustechnical, administrative and social aspects of specific computer network protocols.

Text/Reference Books:

1. Behrouz A. Forouzan, "Data Communication and Networking", 4thEd, McGraw Hill.
2. William Stallings, "Data and Computer Communication", 8thEd, Pearson Prentice Hall India.
3. Andrew S. Tanenbaum, "Computer Networks", 8th Ed, Pearson New International.
4. Douglas Comer, "Internetworking with TCP/IP", Volume 1, 6thEd, PHI.
5. W. Richard Stevens, Addison-Wesley, "TCP/IP Illustrated", Volume 1, United States of America.
6. BhavneetSidhu, "An Integrated Approach to Computer Networks", Khanna Publishing House

Name of the Course	**SOFTWARE ENGINEERING**
Course Code: OE-CS603	**Semester: Sixth**
L-T-P-C: 3-0-0-3	**Contact: 3 hrs/week**
Objectives:	
1	To learn the fundaments of software engineering principles and practices, including project management.
2	To provide the idea of decomposing the given problem into analysis, design, implementation, testing and maintenance phases.
3	To provide an idea of using various process models in the software industry according to given circumstances.
4	To gain the knowledge of how analysis, design, implementation, testing and maintenance processes are conducted in a software project.
Pre-Requisite: Basic Programming Skills, Basic Management Concepts	

M#	**Content**	**Hrs**
1	**Overviewof System Analysis &Design:**Business system concept, system developmentlife cycle, waterfall model, spiralmodel, feasibilityanalysis, technical feasibility, cost-benefitanalysis, COCOMO model.	10
2	**System Design**: Context diagramand DFD, problem partitioning, top-down andbottom-up design, decision tree,decision tableand structuredenglish, functionalvs. object orientedapproach.	5
3	**Coding&Documentation**: Structured programming, OO programming,information hiding, reuse,system documentation, testing, levels of testing,integration testing, test casespecification,reliabilityassessment, validation andverification metrics, monitoring andControl.	11
4	**SoftwareProject Management**: Projectscheduling, staffing, software configuration management, qualityassurance, project monitoring.	6
5	**Static &Dynamic Models:** Brief ofmodeling, UMLdiagrams:class diagram,interaction diagram:collaboration diagram,sequence diagram, state chart diagram, activity diagram, implementationdiagram.	8

COURSE OUTCOMES

At the end of the course, students should able to:

1. Identify, formulate and solve software engineering problems, including the specification, design, implementation, and testing of software systems.
2. Analyze and specify software requirements through a productive working relationship with various stakeholders of a software development project.
3. Elicit professional, ethical and social responsibility of a software engineer.
4. Participate in design, development, deployment and maintenance of a medium scale software development project.
5. Use unified modeling language in software specification documents.
6. Evaluate the impact of potential solutions to software engineering problems in a global society, using the knowledge of contemporary issues and emerging software engineering trends, models, tools, and techniques.

Text/Reference Books:

1. Pressman, "Software Engineering: A practitioner's approach", TMH.
2. PankajJalote, "Software Engineering", Wiley-India.
3. N.S. Gill, "Software Engineering", Khanna Publishing House.
4. Rajib Mall, "Software Engineering", PHI.
5. Agarwal and Agarwal, "Software Engineering", PHI.
6. Sommerville, "Software Engineering", Pearson.
7. Martin L. Shooman, "Software Engineering", TMH.

Name of the Course	**BIOMEDICAL DIGITAL SIGNAL PROCESSING ABORATORY**
Course Code: PC-BME691	**Semester: Sixth**
L-T-P-C: 0-0-2-1	**Contact: 2 hrs/week**
Objectives:	
1	To introduce the basic principles, methods, and applications of digital signal processing.
2	To explore DSP algorithmic, computational, and programming aspects.
3	To learn programming of DSP hardware for real-time signal processing applications
4	To familiarize with biomedical signals conditioning using FIR and IIR filters and to plot and observe the nature of these signals.

LIST OF EXPERIMENTS:

1. Computation of convolution
2. Computation of correlation
3. Auto-correlation, cross correlation techniques of biosignal
4. Design and application of digital IIR filter
5. Design and application of digital FIR filter
6. Frequency domain description of signal-DFT
7. FFT and IEFT computation of ECG signal
8. Design of 50 Hz adaptive filter
9. Power spectral density of any sequence
10. Estimation of power spectral density
11. Reduction of ECG signal
12. Wavelet transform
13. A mini project based on biosignal processing

COURSE OUTCOMES

At the end of the course, students should able to:

1. Perform basic signal processing operations and implement various DSP systems.
2. Design and implement digital filters for biosignal processing.
3. Program the digital signal processing algorithm using software.
4. Analyze biosignals and perform computation depending on the application.

Name of the Course	**BIOMATERIALS & BIOMECHANICS LABORATORY**
Course Code: PC-BME692	**Semester: Sixth**
L-T-P-C: 0-0-2-1	**Contact: 2 hrs/week**

Objectives:	
1	To study mechanical properties of biomaterials using destructive and non-destructive method.
2	To provide hands-on experience in characterization of biomaterials for medical applications.
3	To study forces, momentum, torque, stresses and strains in biological tissues for a given loading conditions and material properties.

LIST OF EXPERIMENTS:

1. Mechanical characterization of metallic biomaterials
2. Mechanical characterization of polymeric biomaterials
3. Hardness testing of biomaterials
4. Surface roughness measurement of biomaterials
5. Estimation of haemocompatibility of biomaterials by hemolysis studies
6. Ultrasonic characterization of biomaterials-NDE
7. Biomechanical arm muscle analysis
8. Determination of moment of inertia of human limb using dynamometer.
9. Determination of moment of inertia of human bone using compound pendulum method
10. Dynamic measurements using force plate
11. Measurement of torque required to tap and screwing in jaw bone
12. Stress-strain analysis of hip prosthesis

COURSE OUTCOMES

At the end of the course, students should able to:

1. Measure and evaluate the mechanical characteristics and compatibility properties of biomaterials and implants.
2. Perform dynamics analysis and interpret force and momentum for a recorded motion.
3. Analyze and interpret the forces at a skeletal joint for various static and dynamic human activities.
4. Evaluate the stresses and strains in biological tissues for a given the loading conditions and material properties.

Name of the Course	**OBJECT ORIENTED PROGRAMMING LABORATORY**
Course Code: OE-CS691	**Semester: Sixth**
L-T-P-C: 0-0-2-1	**Contact: 2 hrs/week**
Objectives:	
1	To gain the basic knowledge on object oriented concepts and applications using object oriented programming concepts.
2	To understand the principles and practice of object oriented analysis and design in the construction of robust, maintainable programs which satisfy theirrequirements.
3	To provide hands-on experience to students in implementing object oriented programming concepts.

LIST OF EXPERIMENTS:

1. Assignments on class,constructor, overloading,inheritance,overriding
2. Assignments on wrapperclass, arrays
3. Assignments on developinginterfaces-multiple inheritance,extendinginterfaces
4. Assignments on creatingandaccessingpackages
5. Assignments on multithreaded programming

Any experiment specially designed by the college
(Detailed instructions for Laboratory Manual to be followed for further guidance)
Note:Use Java / C++ / Pythonforprogramming

COURSE OUTCOMES

At the end of the course, students should able to:

1. Writes, compile, test and execute straightforward programs using the knowledge of object oriented programming.
2. Implement features of object oriented programming to solve real world problems.
3. Apply the major object-oriented concepts to implement object oriented programs.
4. Design, develop and troubleshoot software based on object oriented programming methodologies.

Name of the Course	**COMPUTER NETWORK LABORATORY**
Course Code: OE-CS692	**Semester: Sixth**
L-T-P-C: 0-0-2-1	**Contact: 2 hrs/week**
Objectives:	
1	To understand different transmission media and design cables for establishing a network.
2	To understand the basic concepts of network and application layer protocol design; including client/server models, peer to peer models.
3	To learn the major software and hardware technologies used on computer networks and device sharing on network.

LIST OF EXPERIMENTS:

1. NIC Installation & Configuration (Windows/Linux)
2. Understanding IP address, subnet etc
   Familiarization with
   - Networking cables (CAT5, UTP)
   - Connectors (RJ45, T-connector)
   - Hubs, Switches.
3. TCP/UDP Socket Programming
   - Simple, TCP based, UDP based
   - Multicast & Broadcast Sockets
   - Implementation of a Prototype Multithreaded Server
4. Implementation of
   - Data Link Layer Flow Control Mechanism (Stop & Wait, Sliding Window)
   - Data Link Layer Error Detection Mechanism (Cyclic Redundancy Check)
   - Data Link Layer Error Control Mechanism (Selective Repeat, Go Back N)
5. Server Setup/Configuration: FTP, TelNet, NFS, DNS, Firewall

Any experiment specially designed by the college
(Detailed instructions for Laboratory Manual to be followed for further guidance)

COURSE OUTCOMES

At the end of the course, students should able to:

1. Identify and use various networking components and commands.
2. Install a network system consists of various computers using NIC, networking cables, connector, hubs and switches.
3. Implement networking in software using various socket programming and various networking protocols.
4. Anticipate software and hardware technologies used on computer networks andimplements device sharing on network.

Name of the Course	**SOFTWARE ENGINEERING LABORATORY**
Course Code: OE-CS693	**Semester: Sixth**
L-T-P-C: 0-0-2-1	**Contact: 2 hrs/week**
Objectives:	
1	To understand the phases of software projects and practice the activities of each phase.
2	To acquire the generic software development skill through various stages of software life cycle.
3	To provide project-rich learning experiences for success in a rapidly evolving computing field.
4	To acquainted with modern software methodologies and take part in part in project management.

LIST OF EXPERIMENTS:

Using project management software - MS Project

Exercises using CASE tool for software engineering practice.

These are few sample projects but not limited to:

Project 1:

Hospital Management System: It provides relevant information across the hospital.

Inputs: • Hospital information (name, address, branch, department, facilities) • Employee information (name, employee id, address, contact details) • Doctor Information (name, employee id, address, contact details, specialization, degrees) • Patient information (name, id, address, age, payment, others)

Output: • Patient details • Patients list • Receipt generation • Report generation.

Project 2:

Railway Reservation System: This project is to take up this to develop a reservation system.

Functions: • Availability check • Booking ticket • Canceling Ticket.

Output: • Results on availability for a given date with capacity • Booking confirmation • Cancellation of an existing booking.

Project 3:

Social Networking: We are living in the age of Social Networking like Facebook, LinkedIn, Google + etc. Operations: • User can register into the application with their name, email id and password. • Registered user may be able to login into the application. • There should be options to get the basic information like date of birth, address, phone no, education, upload his/her picture, professional information, hobby etc. • After login, user should be able to see their profile information, etc.

Project 4:

Airline Management System: It helps the users to book flights without visiting offline booking counters. In such a system, a passenger should be able to view the availability of flights' details, as per their requirement. They can book the flights online and can also cancel the reservation. • To view the available flight details, passenger has to give source, destination, and date and time. • After confirmation of reservation request, passenger can see the status.

COURSE OUTCOMES

At the end of the course, students should able to:

1. Apply modern software methodologies to the needs of the dynamic global computing-based society.
2. Ensure the quality of software through software development with various protocol based environment.
3. Convert the requirements model into the design model and demonstrate use of software and user interface design principles.
4. Generate team and organizational leadership in computing project settings and application of computing-based solutions to societal and organizational problems.

Name of the Course	**GROUP DISCUSSION & SEMINAR**
Course Code: HM-HU681	**Semester: Sixth**
L-T-P-C: 0-1-2-2	**Contact: 2 hrs/week**
Objectives:	
1	To introduce different models and topics in terms of skills, content mastery, attitudes, or values.
2	To learn to control the conversation through listening attentively and then having the perseverance to mould it towards his/her own direction.
3	To know the latest happenings in their field and explore an appreciation of the self in relation to its larger diverse social and academic contexts.

GUIDELINES:

- Seminar topics must relate to the current trend in technology depending on the studentsinterest in the field of medical electronics.
- Carry out an elaborate literaturesurvey on the related field referring standard international journals/conferences.
- Make an oral presentation and also submit a technical report.

COURSE OUTCOMES

At the end of the course, students should able to:

1. Improveoral,written and technical communicationskills.
2. Communicatewith other health professionalsin arespectful andresponsible manner.
3. Participate in any interactive session andsucceedincompetitiveexaminations.
4. Formulate strategies for audience-centricvisual presentations with concreteprofessionalobjectives.

Special Remarks:

The above mentioned outcomes are not limited. Institute may redefine course outcomes based on their Program Educational Objectives (PEOs).