Savitribai Phule Pune University
(Formerly University of Pune)

Board of Studies, Department of Technology
Electronics & Electrical (EE) Technology

Curriculum Structure for M.Tech Program
In
Scientific Instrumentation and Medical Devices & Diagnostics

Sr. No.	Subject Code	Subject Name	Credits	Teaching Scheme (Theory)	Teaching Scheme (Lab)
Semester (I)					
1	MMaths	Mathematics for Technology	3	√	
2	SIMDC2	Biomedical Instrumentation and Embedded Systems	3	√	
3	SIMDC3	Advanced Biomedical Signal Processing	3	√	
4	SIMDC4	Analytical Instrumentation	3	√	
5	SIMDE*	Elective-1	3	√	
6	SIMDLP1	Lab Practice - 1	3		√
7	SIMDSM1	Seminar - 1	1		√
Semester (II)					
8	SIMDC5	Biomedical Microsystems	3	√	
9	SIMDC6	Biomedical Image Processing and Computer Vision	3	√	
10	SIMDC7	Advanced Control Systems	3	√	
11	SIMDC8	Bioinformatics	3	√	
12	SIMDE*	Elective-2	3	√	
13	SIMDLP2	Lab Practice - 2	3		√
14	SIMDSM2	Seminar - 2	1		√
Semester (III)					
15	SMDAT	Statistical Methods and Data Analysis Techniques	3	√	
16	SIMDDS	Elective 3 /DS(Directed Study)	3	√	
17	SIMDIntProj	Interim Project	10		√

Semester (IV)					
18	SIMDFinProj	Final Project (Dissertation Submission)	16		√
		TOTAL CREDITS	70		

List of Electives

Sr. No	Subject Code	Subject Title
1.	SIMDE01	Data Science in Biomedical Engineering
2.	SIMDE02	IoT in Health Care
3.	SIMDE03	Biosensors
4.	SIMDE04	Robotics in Medicine
5.	SIMDE05	Medical Imaging Systems
6.	SIMDE06	Rehabilitation Engineering
7.	SIMDE07	Radiological Physics
8.	SIMDE08	Nuclear Medicine
9.	SIMDE09	Nanotechnology in Biomedical Applications
10	SIMDE10	Diagnostic and Therapeutic Instruments
11	SIMDE11	Machine Learning
12	SIMDE12	Artificial Intelligence
13	SIMDE13	Instrumentation and Communication Protocols
14	SIMDE14	Multiresolution Analysis
15	SIMDE15	Statistical Signal Analysis and Stochastic Processes
16	SIMDE16	Statistical Natural Language Processing
17	SIMDE17	Big Data Mining and Analysis

18	SIMDE18	Cloud Computing
19	SIMDE19	Deep Learning
20	SIMDE20	Materials Engineering
21	SIMDE21	Mathematical Modelling and Analysis
22	SIMDE22	Optimization Techniques
23	SIMDE23	Biomechanics
24	SIMDE24	Biostatistics
25	SIMDE25	Finite Element Analysis in Biomedical Engineering

MMaths- Mathematics for Technology

Unit 1: Numerical differentiation I:

Partial differential equation Laplace and Poisson's equation-solution, method of characteristics for solution of initial boundary value problems, relaxation method

Unit 2: Numerical differentiation II:

Finite Difference, Gaussian elimination and Gauss, Jordan methods, matrix inversion, Gauss Seidel method –Newton- Raphson method

Unit 3: Statistics and Probability:

Moments, Skewness and Kurtosis, Probability, conditional probability, various theoretical distributions like binomial, normal, log-normal, Poisson, gamma distribution, Pearson type I, II & II distribution test of significance, Gumbel distribution, testing of hypotheses – Large sample tests for mean and proportion, Chi-square test, errors, types of errors.

Unit 4: Regression and Correlation:

Regression and correlation – rank correlation – multiple and partial correlation – analysis of variance-one way and two way classifications – experimental design – Latin square design

Unit 5: Transforms:

Laplace Transformer: LT of standard function, inversions and their application in civil engg. Fourier Transformer: Fourier integral, Fourier transform and their application in civil engg.

Unit 6: Matrix method and Finite element:

Matrix method analysis (Stiffness) co ordinate calculation for different types of structure. Finite element method basics (1D and 2D) co ordinate calculations.

Reference Books:

1. Higher Engineering Mathematics by B. S. Grewal (Khanna Publication, Delhi).
2. Venkatraman, M.K., Numerical Methods in Science and Engineering, National Publisher Company.
3. Numerical Methods by Krishna Raju
4. Shanthakumar M.S., Numerical Methods & Analysis
5. Gupta, S.C. and Kapur, V.K., "Fundamentals of Mathematical Statistics ", Sultan Chand & Sons, New Delhi, 1999.

SIMDC2- Biomedical Instrumentation and Embedded Systems

Categories and Characteristics of Transducer, Signal conditioning units. Origin of Biopotential, half-cell potential, polarization effects. Different types of electrode and its equivalent circuits. Differential amplifier. Bioamplifier – Characteristics - Instrumentation amplifier - active filter. Isolation Amplifier, Chopper amplifier, Carrier Amplifier. Multichannel data acquisition system, various types of recorders. ECG, EEG, EMG, PCG, EOG, ERG lead system, block diagram and recording methods, typical waveform, frequency spectrum, abnormal waveform, artifacts and its removal, Design of Bioamplifier. Introduction to Wearable Technology in healthcare - Design challenges, smart wearable sensors, smart wearable textiles. Respiration rate, Pulse rate, Temperature, Blood Pressure, Pulse oximetry, Respiratory volume measurement, BMR measurement, Plethysmography technique, Detection of various physiological parameters using impedance technique. Manual and Automatic Counting of RBC, WBC and Platelets. pH, pCO2, pO2 and electrophoresis, colorimeter, spectrophotometer, flame photometer, auto analyser.
Biosensors-Ion Selective Field Effect Transistor (ISFET), Immunologically sensitive FET (IMFET). Blood glucose sensors - Continuous glucose monitoring and closed loop systems. Concepts & types of Memory, Cache Memory, mapping techniques, replacement policies. Packaging, Circuit Boards, Interconnection and Signal Integrity. General Purpose Processor, System On chip, Embedded Computer Organization. ARM architecture, ARM Microcontrollers and Processor Cores, Instructions and Data handling, interfacing with Memory, Interrupts, Timers, ARM Bus. I/O Devices, Controllers. Parallel, Multiplexed, Tristate, and Open-Drain Buses, Bus Protocols. Operating System Concepts, Processes, Deadlocks, Memory Management, Input/Output, Files, Security, Shell. Multiprocessor communication. Arduino Integrated Development Programming.

Reference Books:

1. L.A Geddes and L.E.Baker, Principles of Applied Biomedical Instrumentation, John Wiley and Sons
2. John G.Webster, Medical Instrumentation Application and Design, 4th Edition, John Wiley and Sons, New York, 2009.
3. Khandpur R.S, Handbook of Biomedical Instrumentation, Tata McGraw Hill, New Delhi, 3rd Edition, 2014.
4. S. Salivahanan, “Digital circuits and Design”, Vikas Publishing House.
5. Andrew Sloss, Dominic Symes, Chris Wright, ARM system developer’s guide: designing and optimizing system software, Morgan Kaufmann.

SIMDC3- Advanced Biomedical Signal Processing

Characteristics of some dynamic biomedical signals, Noises- random, structured and physiological noises. Filters- IIR and FIR filters. Spectrum – power spectral density function, cross-spectral density and coherence function, cepstrum and homomorphic filtering. Estimation of mean of finite time signals.

Bilinear transformation, Linear prediction & optimum linear filters stationary random process, forward-backward filters linear prediction, solution of normal equation. Time series analysis in biomedical signals like EEG, ECG.

Multirate DSP, Sampling rate conversion, polyphase filters, multistage decimator & interpolator, QMF, digital filter banks, Adaptive filters & spectral estimation for biosignals. Minimum mean square criterion, LMS algorithm, Recursive least square algorithm, DFT in spectral estimation.

Introduction to wavelets, application to image processing, design of phase shifters & other applications. Time frequency a nd Multivariate Analysis. Analysis of phonocardiogram signals, Analysis of EEG signals, Speech enhancement for hearing aids

Biosignal and Medical image formats - Medical data storage and retrieval techniques – Steganography - Medical Standards – HL7 – DICOM - IRMA - LOINC - ICD10 – HIPPA - IEEE 1073 – IEC standards - Medical standard organizations

Reference Books:

1. Willis J.Tompkins, Biomedical Digital Signal Processing, Prentice Hall of India, New Delhi, 2006.
2. Rangaraj M. Rangayyan, Biomedical Signal Analysis – A case study approach, Wiley, 2 nd Edition, 2009.
3. J.G.Proakis and D.G.Manolakis Digital signal processing: Principles, algorithm and applications, Macmillan publishing.
4. Salivahanan, Vallavaraj & Gnanpriya Digital signal processing:: Tata Mcgraw Hill

SIMDC4- Analytical Instrumentation

Introduction to chemical analysis, Classical and Instrumental methods, Classification of Instrumental techniques, important considerations in evaluating an instrumental method. Absorption methods: Spectrometric UV, VIS, Laws of photometry, IR spectrometry, correlation of IR spectra with molecular structure. Atomic absorption spectrometry, Emission methods. Flame, AC/DC arc, spark, plasma excitation sources. Spectrofluroscence and phosphorescence spectrometer, Raman spectrometer. Mass spectrometer, Ionisation methods, mass analysers, mass detectors, FTMS. Chromatography, Gas chromatography, Liquid chromatography. X-ray and Nuclear methods, x-ray absorption, fluorescence and diffractometric techniques, electron microscope and microprobe, ESCA and Auger techniques, nuclear radiation detectors. NMR spectroscopy, chemical shift, spin-spin coupling, types of NMR. Electroanalytical methods, potentiometry, voltammetry, coulometry techniques. Analysis of phonocardiogram signals, Analysis of EEG signals, Speech enhancement for hearing aids

Reference Books:

1. Willard, Merritt, Dean and Settle, "Instrumental Methods of Analysis", CBS publishers.
2. Galen W. Ewing, "Instrumental Methods of Chemical Analysis", McGraw- Hill.
3. John G.Webster, Medical Instrumentation Application and Design, 4th Edition, John Wiley and Sons, New York, 2009.

SIMDC5- Biomedical Microsystems

Introduction to miniaturization and materials , Block diagram of MEMS and BIOMEMS, comparison, examples, Clean room: definition, classification, air flow system ,Safety in handling hazardous materials in clean room, Scaling Laws in Miniaturization, Substrates and Wafers: CZ process, wafer types Materials: Properties and applications of single crystal silicon, SiO_2, Si_3N_4, SiC, Polysilicon, GaAs, Glass, Al, Gold, PMMA, PDMS, SU8, Conducting polymers.

Wafer cleaning processes: RCA, Piranha , PVD: definition, Types: Evaporation (Thermal and E-beam) and Sputtering (DC and RF), applicable materials, advantages, disadvantages .CVD: definition, reaction steps, types: APCVD, LPCVD, PECVD, and HWCVD, applicable materials, advantages, disadvantages ,Oxidation: Thermal,Polymers coating techniques: spinning, spraying and electrodeposition ,Doping: definition, Types: Ion implantation and Diffusion, advantages, disadvantages ,Etching: Types: Dry etching (RIE, DRIE) and wet etching (isotropic and anisotropic), advantages, disadvantages, specific etchants Photolithography: Definition, steps, light sources (UV, DUV, and EUV), positive and negative photoresist, mask, different projection systems, X-ray lithography: Synchrotron radiation, X-ray mask, Nanolithography: EBL, Surface characterization techniques: AFM, SEM, TEM, Ellipsometer, Profilometer Bulk micromachining: definition, advantages and disadvantages Examples: pressure sensor, dissolved wafer process, CO_2 sensor, Surface micromachining: definition, advantages and disadvantages Examples: pressure sensor, cantilever Non polysilicon surface micromachining: SOI fabrication,LIGA: definition, process steps, examples, advantages and disadvantages, Molding techniques: Injection, compression, hot embossing,Soft lithography: Definition, SAMs, Types: Micro contact Printing, Micro molding techniques: replica molding, microtransfer molding, micromolding in capillaries and solvent-assisted micromolding. Micro/ Nano Biosensors and drug delivery Devices. Microsystem Packaging, Comparison between IC and MEMS packaging.

Reference Books:

1. MEMS & MICROSYSTEMS Design and Manufacture‖, Tai-Ran Hsu, TATA McgrawHILL.
2. Fundamentals of BioMEMS and Medical Microdevices, Steven S. Saliterman, (SPIE Press Monograph) by Wiley Interscience.
3. Introduction to Microfabrication, Sami FranssilaJohn Wiley & Sons Ltd, ISBN 0-470- 85106-6.

SIMDC6- Biomedical Image Processing and Computer Vision

Image perception, MTF of the visual system, Image fidelity criteria, Image model, Image sampling and quantization – two dimensional sampling theory, Image quantization, Optimum mean square quantizer, Image transforms – 2D-DFT and other transforms. Image Enhancement operations, Geometric transformations and correction. Mathematical preliminaries and basic reconstruction methods, Image reconstruction in CT scanners, MRI, fMRI, Ultrasound imaging. 3D Ultrasound imaging, Nuclear Medical Imaging modalities – SPECT, PET, Molecular Imaging. Image segmentation, Active contour models and Level sets for medical image segmentation, Image representation and analysis, Feature Extraction and Representation-Statistical, Shape, Texture features. Statistical and Neural Network based image classification. Image Registration: Rigid body transformation – Affine transformation, Principal axes registration, Iterative principal axes registration, Feature based registration, Elastic deformation based registration, Registration of Images from Different modalities, Evaluation of Registration Methods. Image visualization: 2-D display methods, 3-D display methods, surface and volume based 3-D display methods – Surface Visualization and Volume visualization, 3-D Echocardiography, 3D+time Echocardiography, virtual reality based interactive visualization. Medical Imaging, Nuclear Imaging. Hybrid Imaging.

Case Study: Breast cancer detection/ Brain Tumor Detection/ Fingerprint identification

Reference Books:

1. Rafael C.Gonzalez and Richard E.Woods, Digital Image Processing, Pearson Education, 2018.
2. Anil K Jain, Fundamentals of Digital Image Processing, 1st Edition, Pearson Education India, 2015.
3. Geoff Dougherty, Digital Image Processing for Medical Applications, 1 st Edition, Cambridge University Press, 2010.

SIMDC7- Advanced Control Systems

Review of Process Control basics, Control objective and benefits, Control system elements. Mathematical Modeling and dynamic performance analysis process for control, models from fundamental laws, empirical model identification, dynamic performance analysis of first order, second order, multi-capacity processes, Effect of Zeros and time delay. Multivariable Process control, Cascade control, Ratio control, feedback-feedforward control, override control, selective control, modeling of multivariable process, Design of Multivariable controllers. Model Based control: Feedback-feedforward, delay compensation, Internal Model controller (IMC). Model forms, DMC, SISO unconstrained DMC Problem, controller tuning, Statistical Process Control (SPC), Case study: Design of Fuzzy-Logic, Neural Network based controller.

Example of multivariable control systems, differential operator and transfer matrix, state-space models, system solution. Controllability, observability, state estimation pole allocation, stability and reproducibility, minimal realization of multivariable control systems. Decoupling and model matching control, extension of classical theory to multivariable control systems. Optimal Control System, Pontryagin's minimum principle, application to discrete and continuous systems. Hamilton - Jacoby equation. Relation between the minimum principle and dynamic programming. Linear regular problem. Quadratic performance criterion. Minimum time problems, Bang Bang Control, singular solutions.

Reference Books:

1. Manfreo Clynes and John H. Milsum, Biomedical Engineering System, McGraw Hill and Co, New York.
2. Michael C.K. Khoo, Physiological Control System - Analysis, Simulation and Estimation, Prentice Hall of India, New Delhi.
3. N. K. Sinha, "Multivariable Control", Marcel Dekker Inc.
4. C. T. Chen, "Linear System Theory and Design", Oxford

SIMDC8- Bioinformatics

Need for Bioinformatics Technologies – Overview of Bioinformatics Technologies – Structural Bioinformatics – Data Format and Processing – Secondary Resources and Applications – Role of Structural Bioinformatics – Biological Data Integration System. Sequence Analysis, NGS,Graph Theory Gene Ontology.

Historical overview, Information Theory and Central Dogma of Molecular Biology, Bioinformatics Applications, Features and Classification Schema of Biological Databases, Protein Structure Classification Databases

Sequence Visualization, Structure visualization, Rendering Tools, Statistical Concepts, Micro arrays, Imperfect Data, Quantifying Randomness, Data Analysis, Tool selection for Statistical Analysis, Statistics of Alignment, Statistical Classification of Biological data.

Methods & Technology Overview, Infrastructure, Pattern Recognition & Discovery, Text Mining & Tools, Sequence alignment-Concept of alignment, Scoring matrices, PAM, BLOSUM, Alignment of pairs of sequences, alignment algorithms.

Introduction, Heuristic Methods for Sequence Alignment, Working with FASTA, Working with BLAST, FASTA & BLAST Algorithms & Comparison, Introduction to Phylogenetic, Prediction algorithms for Genes and Phylogenetic

Methods for Protein Modeling, Homology or Comparative modeling, Model refinement and Evaluation, Tools for Modeling and Simulation, Drug Discovery Process, Structural Bioinformatics in Drug Discovery, Simulation and Statistical Protocols of Markov Chain and Hidden Markov Model

Recent and Future trends in Bioinformatics.

Reference Books:

1. S.C.Rastogi, N.Mendiratta, P.Rastogi 'Bioinformatics-Methods & Application Genomics, Proteomics and Drug Discovery', Third Edition, Prentice Hall of India.
2. Bryan Bergeron, 'Bioinformatics Computing', Pearson Education.
3. Zhumur Ghosh, BibekanandMallick, 'Bioinformatics Principles and Applications', Oxford University Press 2008.
4. G. Alterovitz, M. F. Ramoni, "Systems Bioinformatics: An Engineering Case-Based Approach", Artech House, 2007

ELECTIVES

Data Science in Biomedical Engineering

Introduction to Data Science, Evolution of Data Science – Data Science Roles – Stages in a Data Science Project – Applications of Data Science in various fields – Data Security Issues, Scope of Data Science, Steps of Data Science Process: Data collection, Pre- processing, Data Collection Strategies – Data Pre-Processing Overview – Data Cleaning – Data Integration and Transformation – Data Reduction – Data Discretization. Training and testing. Use cases in various domain such Image, Natural Language, Audio and Video. Introduction to Artificial Intelligence, The Foundations of AI, AI Technique, Production system characteristics, Production systems: 8-puzzle problem. Searching: Uniformed search strategies – Breadth first search, depth firstsearch.

Introduction to data mining and Machine Learning. Basics of Python Programming, Problem solving using python.

Python Programming for Electronic Health record, clinical data processing, Conventional Machine Learning application in Biophysical Modelling, Clinical Predictions, Neural Networks, Convolution Neural Networks, Recurrent Neural Networks applied to Biomedical imaging, physiological signals, Generative models for generating drug molecules. Deep Learning in medical diagnostics. Big Data Analysis for the big volume medical data.

Reference Books:

1. Rachel Schutt, Cathy O'Neil, "Doing Data Science: Straight Talk from the Frontiline" by Schroff/O'Reilly, 2013
2. Eric Seigel, "Predictive Analytics: The Power to Predict who Will Click, Buy, Lie, or Die", 1st Edition, by Wiley, 2013.
3. David Dietrich, Barry Heller, Beibei Yang, “Data Science and Big data Analytics”, EMC 2013
4. John W. Foreman, "Data Smart: Using data Science to Transform Information into Insight" by John Wiley & Sons, 2013.

IoT in Health Care

IOT: An Introduction Introduction to Embedded Systems-an overview, features. Networked Embedded Systemtypes and overview, wireless communication standards-zigbee, Bluetooth & Wi-Fi. OSI & TCP/IP model in a nutshell. Introduction to the Internet and understand how internet works. Introduction to Smart Objects or Things. IOT- understand what IOT is and discuss its application in health-care systems-Patient Monitoring & diagnostics, Home healthcare & Personal care & Fitness. UNIT- II IOT Hardware Platform& Sensor Interface :Introduction to CC3100 Wi-Fi BoosterPack: overview & features. Introduction to CC3100 SDK: understand the important APIs. Getting Started with Energia Wi-Fi libraries. Sensor interface:Temperature sensor, pressure sensor, Light sensor, IR sensor. UNIT -III Client-Server Communication Paradigm Basic Client-Server communication model, Network Sockets, Ports, and Examples of client server communication, Energia client & server class APIs. UNIT- IV Embedded Web-Server & IOT Cloud Services Embedded web server: Basic introduction, its importance and role in IOT. Design of a simple embedded web server: understand the HTTP & HTML basics Overview of different IOT Cloud Services. UNIT- V Application Design & Case Study Case Study1: Wireless Patient Monitor system Case Study2: Wearable Fitness & Activity Monitor Application Design: Design of IOT based pulse oximeter, block diagram, concepts of analog front end, signal process and Wi-Fi integration.

Reference Books:

1. Getting Started with Internet of Things- CunoPfister, 2011
2. Interconnecting Smart Objects with IP- J. P Vasseur, Adam Dunkels, 2010

Biosensors

Biosensor Transducers- Electrochemical transducers (amperometric- potentiometric, conductimetric) Semiconductor transducers, Optical transducers ,Thermal transducers, Piezoelectric and acoustic-wave transducers-Limitations & problems to be addressed-An Overview of Performance and Applications.

Catalytic biosensors, mono-enzyme electrodes-bi-enzyme electrodes-enzyme sequence electrodes and enzyme competition electrodes,Affinity-based biosensors- Inhibition- based biosensors-Cell-based biosensors-Biochips and biosensor arrays- Problems and limitations.

Enzymes- Oligonucleotides and Nucleic Acids - Lipids (Langmuir-Blodgett bilayers, Phospholipids, Liposomes) Membrane receptors and transporters; Microbial metabolism,Tissue and organelles (animal and plant tissue) Cell culture, Immunoreceptors, Chemoreceptors- Limitations.

Bio recognition elements and transduction technology - Biosensors for diabetes applications - Glucose as diabetes biomarker - Biosensors for glucose measuring - Biomarker & Biosensors for cardiovascular diseases applications - Biomarker & Biosensors for cancer applications

Reference Books:

1. Jacob Kline, Handbook of Bio Medical Engineering, Academic press Inc., Sandiego, Oxford University Press, 2004.
2. Smart Biosensor Technology, G. K. Knoff, A. S. Bassi, CRC Press, 2006
3. Optical Biosensors. Present & Future. Editors: F. Ligler, C. Rowe Taitt, Elsevier,2002
4. Biosensors for Health, Environment and Biosecurity, Edited by Prof. Pier Andrea Serra, Intech 2011.

Robotics in Medicine

Introduction Automation and Robots, Classification, Application, Specification, Notations. Direct Kinematics Dot and cross products, Coordinate frames, Rotations, Homogeneous coordinates Link coordination arm equation, (Five- axis robot, Four-axis robot, Six-axis robot). Inverse Kinematics General properties of solutions tool configuration Five axis robots, Three-Four axis, Six axis robot(Inverse Kinematics). Workspace analysis and trajectory planning work envelope and examples, workspace fixtures, Pick and place operations, Continuous path motion, Interpolated motion, Straight-line motion. Robot Vision Image representation, Template matching, Polyhedral objects, Shane analysis, Segmentation (Thresholding, region labeling, Shrink operators, Swell operators, Euler numbers, Perspective transformation, Structured illumination, Camera calibration). Task Planning Task level programming, Uncertainty, Configuration, Space, Gross motion, Planning, Grasp Planning, Fine-motion planning, Simulation of planar motion, Source and Goal scenes, Task Planner simulation. Applications in Biomedical Engineering Application in rehabilitation, Clinical and Surgery.
Wearable Robots: Wearable Robot technology, Sensors, Actuators, Portable Energy Storage, Human–robot cognitive interaction (cHRI), Human–robot physical interaction (pHRI), Wearable Robotic Communication

Reference Books:

1. Fundamentals of Robotics-Analysis and control, Robert Schilling, Prentice Hall of India.
2. Robotics, Fu,Gonzales and Lee, McGraw Hill
3. Introduction to Robotics, J.J,Craig,Pearson Education
4. Nagrath and Mittal, “Robotics and Control”, Tata McGraw Hill, First edition, 2003

Medical Imaging Systems

X Rays and Computed Tomography- Principle and production of X – Rays, Selection of anodes, heel pattern, Scattered Radiation, Porter-Bucky systems, Digital Radiography, principles of Angiography and Fluoroscopic Techniques, Image Intensifiers, digital subtraction angiography, mammography, dental X-ray units. Computerised Axial Tomography, Principle, Detectors, image reconstruction, Spiral CT, 3D Imaging.

Alpha, Beta, Gamma Emission, different types of Radiation Detectors, G.M. & Proportional Counters, Pulse Height Analyzers, Isotopic, Scanners, Principle of PET and SPECT.

Magnetic Resonance Imaging- Principle of MRI, Relaxation processes and their measurements, Pulse sequencing and MR image acquisition, MRI instrumentation, Magnets, gradient coils, Imaging Different Sections of the Body, Tissue Characterization, MR Spectroscopy, Functional MRI.

Diagnostic Ultrasound- Ultrasonic waves - Beam characteristics –- attenuation of ultrasound - Specific acoustic impedance - reflection at body interfaces-Coupling medium- Interaction ultrasound with tissues -A scan B scan and M mode-real time scanners Image clarity - Resolution –axial and lateral resolution - Artifacts-Pulse echo imaging- Obsterics abdominal investigations Echo cardiograph (UCG) – The Doppler Effect-Doppler Shift- continuous wave Doppler system-pulsed wave Doppler systems - duplex scanning - display devices for ultrasonic imaging.

Thermography and Optical Imaging- Physics of thermography - infrared detectors –thermographic equipments - quantitative medical thermography - pyroelectric video camera - applications of thermography - Fluorescence Imaging –Fluorescence Life-time Imaging –OCT- Electrical impedance tomography (EIT) – Electrical Source Imaging (ESI) – Magnetic Source Imaging (MSI).

Reference Books:

1. Medical Physics: Imaging, Jean A. Pope, Heinemann Publishers, 2012
2. The Essential Physics for Medical Imaging–2 nd Edition–Jerrold T Bushberg, Lippincott Williams & Wilkins 2002.
3. Essentials of Nuclear Medicine Imaging. F A Mettler,MJ Guibertau,Saunders, 2005.

Rehabilitation Engineering

Introduction to Rehabilitation Engineering- Definition - Impairments, disabilities and handicaps, Primary and secondary disabilities, Activities of daily living, Appropriate Technology, Residual function. Rehabilitation. Rehabilitation teammembers and their function. Epidemiology of Rehabilitation, Health, Levels of Prevention, Preventive Rehabilitation. Rehabilitation care –Need for proper delivery of rehabilitation care, Community based rehabilitation and its aspects.

Orthotics and Prosthetics in rehabilitation.

Auditory and Speech assist devices- hearing aids, DSP in hearing aids, cochlear implants, tinnitus, voice speech synthesizer, speech trainer, brain plasticity.

Visual impairments and visual aids, tacticle devices for visually challenged.

Rehabilitation Medicine- Architectural design features for motor and visual disability for day-to-day life. Physiological aspects of Function recovery, Psychological aspects of Rehabilitation therapy, Legal aspects of rehabilitation – Disability evaluation, provision available in education, job and in day-to-day life. Virtual reality and multimedia applications.

Reference Books:

1. Rory A Cooper, An Introduction to Rehabilitation Engineering, CRC Press, 1 st Edition, 2006
2. Joseph D.Bronzino, The Biomedical Engineering Handbook, Four Volume Set, 4th Edition: CRC Press, 2015.
3. Albert M Cook and Webster J G, Therapeutic Medical Devices, Application and Design, Prentice Hall New York 1982.

Radiological Physics

Structure of matter - atom - nucleus -atomic mass and energy units, distribution of orbital electrons - atomic energy levels -nuclear forces -nuclear energy levels, particle radiation -Electro-magnetic radiation Binding energy, General properties of alpha, beta and gamma rays. Laws of equilibrium, modes of radioactive decay - nuclear isomerism -nuclear reactions, natural and artificial radioactivity - reactor and cyclotron produced isotopes , fission products.

Interaction of electromagnetic radiation with matter, Thomson scattering, Rayleigh scattering, Compton scattering, Photoelectric absorption, Pair production – Interaction of light (electrons and positrons) and heavy charged particles with matter–specific ionization – Cerenkov radiation- mass-energy- attenuation and absorption coefficient - Bethe-Block formalism for energy loss by heavy charged particles, mass-collision – Bragg peak, mass-radioactive stopping power, range and path length of charged particles - Interaction of neutron with matter.

Introduction -exposure-Roentgen - photon fluence and energy fluence -KERMA-Kerma and absorbed dose -CEMA -Absorbed dose - Radiation Dose Equivalent - stopping power - relationship between the dosimetric quantities - stopping power ratio.

Principles of Radiation detection – properties of dosimeters - Theory of gas filled detectors – Ion chamber dosimetry systems - free air ion chamber – parallel plate chamber - ionization chamber – proportional chamber - GM counter– thimble chambers working and different applications – film dosimetery- Luminescence dosimetry - TLD - OSLD - semiconductor dosimetry – Gel dosimetry – radiographic and radiochromic films – scintillation detections.

Radiation Monitoring Instruments. Radiation Generating Equipments like

Reference Books:

1. E.B.Podgorsak, Radiation Physics for Medical Physicists, 3rd Edition, Springer, 2016.
2. F.M.Khan, The Physics of Radiation Therapy, Fifth Edition, Lippincott Williams and Wilkins, U.S.A.,2015.
3. H. E. Johns, J. R. Cunningham, The Physics of Radiology, Charles C. Thomas, New York, 2002

Nuclear Medicine

Basic Physics of Nuclear Medicine - Atom- Nuclear structure- Nuclear nomenclature- Nuclear stability curve, Radioactivity, Specific activity, Effective half-life -Radioactive decay, Types of equilibrium. Historical developments of radionuclide -Production of radionuclides- Radionuclide generators, Toxicity of radionuclides, Radiopharmaceuticals-Ideal characteristics- Mechanism of localization of radiopharmaceuticals, radionuclides and radiopharmaceuticals.

Instrumentation for nuclear medicines- Single head- Dual head scanner/Camera- PET ,Detectors- Gas filled, scintillation& semiconductor - Properties, Design ,Principle –Construction, working-Annihilation coincidence detection-Attenuation correction- Acquisition, SPECT, Processing, Reconstruction techniques, Attenuation correction, Filters, Algorithm, SUV calculation, Display, comparison between black and white & color.

Quality control of equipments in nuclear medicine, calibration, calibration sources.

Clinical radio isotopes/Radiopharmaceuticals, In vivo non-imaging and imaging procedures- In vitro techniques,RIA- Thyroid uptakes ,procedures, calculation, measurement. Few imaging procedures – Bone scan, Thyroid scan, Liver scan, Pre and Post instructions, Absorbed dose, equivalent dose, effective dose, limitations.

Therapeutic application of radionuclides and radiopharmaceuticals.

Reference Books:

1. Marie Claire. Cantone, Christoph. Hoeschen, Radiation Physics for Nuclear Medicine, Springer, 2010.
2. Nuclear Medicine Physics, A Hand Book for Teachers and Students, D.L.Bailey, J.L.Humm., A.Todd-Pokropek, A.VanAswegen, IAEA, 2014
3. Essential Nuclear Medicine Physics, Rachel A Powsner and Edward R Powsner, 2nd Edition, Blackwell publishing, 2006.

Nanotechnology in Biomedical Applications

Photolithography - Deposition, and Selective Etching - Thin Film Growth and Deposition- Diffusion and Dopants - Atomic Layer Epitaxy - Soft Lithography. Self- assembled organized systems: Dendrimers, Liposomes, Vesicles, Supramolecular Complexes, Langmuir Blodgett films. Atomic Force Microscopy (AFM).

Micro fluidic Processes: Fundamentals of Laminar Fluids Micro fluidic Processes: The Role of Micro-Scale Fluid Dynamics in Bio-MEMS Neuro MEMS - Microelectrodes and Neuronal Interfaces, Micro stereolithography.

Molecular Engineering and Quantum Dots, Nanoscale Structures as Biological Tags and as Functional Interfaces with Biological Systems.

Nanoparticles and Microorganisms, Nano-materials in Bone Substitutes and Dentistry, Nanoparticles in Food and Cosmetic applications, Drug delivery and its applications.

Biochips and analytical devices, Biosensors Nanomedicine, Nanobiosensor, Nanofluidics, Nanocrystals in Biological Detection, Electro-chemical DNA Sensors, Integrated Nanoliter Systems. Clean rooms practice and environmental issues; Applications.

Reference Books:

1. Michael Koch, Alan Evans, Arthur Brunnschweiler, Micro fluidic Technology and Applications (Micro technologies and Microsystems Series) , CRC Press; London, 2001.
2. Niemeyor, christober M. Mirkin, Nanobiotechnology: concepts, applications and perspectives, Kluwer publications , USA, 2004.
3. Gabriel A. Silva, Nanotechnology for biology and medicine, Springer, 2012.

Diagnostic and Therapeutic Instruments

Biopotential- Cell Potential-Half-cell potential, Electrodes-types of electrodes, Signal Conditioning circuits. Characteristics of Amplifiers, Differential Amplifiers, Filters, Isolation Amplifier, Design concepts. ECG, EEG, EMG, PCG, EOG, lead system and recording methods, typical waveform, frequency spectrum, abnormal waveforms. Evoked response.

Non- Electrical Parameter Measurement- Measurements of Respiration Rate, Temperature, Pulse rate, Blood pressure Measurements Direct, Indirect. Blood flow Measurements – In vitro, In vivo, Gas flow measurements. Lung volume measurement and capacity measurement.

Pace makers - different types, batteries for pace makers, Design Concept. DC defibrillators, synchronous and synchronous types, patient monitoring system, principles of bio telemetry.

Heart Lung Machine-Condition to be satisfied by the H/L System. Different types of Oxygenators, Pumps, Pulsatile and Continuous Types, Monitoring Process. Hemodialyser Indication and Principle of Hemodialysis, Membrane, Dialysate, Different types of hemodialysers, Monitoring Systems, Wearable Artificial Kidney, Implanting Type. Respiratory aids- Types of Ventilators – Pressure, Volume, and Time controlled.

Diathermy, Stimulators and Patient care.

Reference Books:

1. L.A Geddes and L.E.Baker, Principles of Applied Biomedical Instrumentation, 3rd Edition, John Wiley and Sons, Reprint 2008.
2. John G.Webster, Medical Instrumentation Application and Design, 4th Edition, John Wiley and Sons, New York, 2009.
3. Khandpur R.S, Handbook of Biomedical Instrumentation, Tata McGraw Hill, New Delhi, 3rd Edition, 2014.
4. Joseph J. Carr and John M. Brown, Introduction to Biomedical equipment technology, Pearson Education, 4th Edition, 2014.

SIMDE11- Machine Learning

Designing a Learning System, Perspectives and Issues in machine learning, Decision Tree learning, Appropriate problems for decision tree Learning, Basic Decision tree learning algorithms, Issues in Decision tree learning, Estimating Hypothesis accuracy, Comparing learning algorithms, Analytical Learning: Inductive and Analytical learning problems, Explanation based learning of search control knowledge

Introduction to Regular Expression and Finite Automata, Follow Automata, Conversion of DFA to RE using vertical and horizontal chopping, Multi-node loop, Reducing NFAs by invariant equivalences, Finite automata on infinite words and trees, Finite automata and monadic second order (MSO) logic on words and trees, Decidability of MSO theory of various infinite graphs, Application of Regular expression in Natural Language processing, Finding pattern in DNA and protein sequence, grep in Unix, Regular expression in Scheduling of process, Regular expression in perl, Context free grammar and Parsing, Application of context free grammar in Markup language and XML.

Reference Books:

1. Tom M. Mitchell, Machine Learning, Tata McGraw Hill (1997).
2. Nils J. Nilsson, Introduction to Machine Learning, Online available at http://ai.stanford.edu/~nilsson/mlbook.html.
3. E. Hopcroft and J.D. Ullman, Introduction to Automata Theory, Narosa (2002).
4. Stephen Marsland, Machine Learning and Pattern Recognition, Chapmanand and Hall/CRC (2009).
5. John Levine, Tony Mason, Doug Brown, Lex and Yacc, O'REILLY (1992).
6. E. Hopcroft and J.D. Ullman," Introduction to Automata Theory, Languages of Computations", Addison-Wesley (2006).
7. Alfred V. Aho, Ravi Sethi, Jeffrey D. Ullman Compilers: Principles, Techniques, and Tools, Dorling Kingsley (2008) 2nd ed.

SIMDE12- Artificial Intelligence

Introduction-Definition, What is A.I.? Foundation of A.I., History , intelligent Agents, Agent Architecture, A.I. Application(E Commerce & Medicine), A.I. Representation, Properties of internal representation Futures of A.I. Production System. and issue in Design of search Programs, Logic Programming – Introduction logic, Logic Programming, Forward and Backward reasoning, Forward and backward chaining rules, Heuristic search techniques- Heuristic search, Hill Climbing, Best first search, mean and end analysis, Constraint Satisfaction, A* and AO* Algorithm, Game Playing- Minmax search procedure, Alpha beta cutoffs, waiting for quiescence, Secondary search, Knowledge Representation –Basic of Knowledge representation Paradigms, Prepositional Logic, Inference Rules in Prepositional Logic, Knowledge representation using Predicate logic: Predicate Calculus, Predicate and arguments, ISA hierarchy Frame Notation, Resolution, Natural Dedication, Knowledge representation using non monotonic logic: TMS(Truth Maintenance system), Statistical and probabilistic reasoning ,fuzzy logic, structure knowledge representation ,semantic net ,Frames, Script, Conceptual dependency, Learning – What is Learning? Types of Learning (Rote, Direct instruction Analogy, Induction, Deduction), Planning- Block world, Strips, Implementation using goal stack, Non Linear planning with goal stacks, Hierarchical planning, least commitment strategy.

Reference Books:

1. Eiaine Rich and Kerin Knight: Artificial Intelligence
2. Eugene, Charniak, Drew Mcdermott: Introduction to artificial intelligence.
3. Kishen Mehrotra , Sanjay Rawika , K Mohan : Artificial Neural Network.
4. Herbert A Simon,The Sciences of the Artificial, MITPRESS, 3rd Edition (2nd Printing), 1995.
5. Ivan Bratko: Prolog Programming For Artificial Intelligence, 2nd Edition Addison Wesley ,1990
6. Stuart Russell & peter Nerving: Artificial Intelligence : A Modern Approach, Prentice Hall ,2nd Edition

SIMDE13- Instrumentation Communication Protocols

Networks in process automation, flow requirements, Hierarchical communication model, Data Communication, OSI reference model, Industry Network, Recent networks. Communication Protocols, Network Classification, Device Networks, Control Networks, Enterprise Networking, Network selection. Proprietary and open networks, Architectures, Building blocks, Industry open protocols (RS-232C, RS- 422, RS-485), Ethernet, Modbus, Modbus Plus, Data Highway Plus, Advantages and Limitations. Fieldbus, Trends, Hardware selection, Fieldbus design, Installation, Documentation, Advantages and limitations. HART, Design, Installation, calibration, commissioning, Application in Hazardous and Non-Hazardous area. Foundation Fieldbus & Profibus, Design, Calibration, Commissioning, Applications. Wireless Protocols, WPAN, Wi-Fi, Bluetooth, ZigBee, Z-wave.

Reference Books:

1. B.G. Liptak, “Process Software and Digital Networks”, CRC Press.
2. Romilly Bowden , “HART Communications Protocol ‘, Fisher-Rosemount.

SIMDE14- Multiresolution Analysis

Discrete Fourier transform, , sub band coding and multiresolution analysis, wavelet transform, Discrete wavelet transform, Introduction to time frequency analysis; the how, what and why about wavelets, wavelet functions: Harr scaling functions, Harr wavelet function, orthogonality & normalization, wavelet compression. Background of Image processing: digitized image & its properties, basic concepts, image digitization, brightness adaption and discrimination, colour representation, statistical background, Image representation, Image formats. Image enhancement by point operations, spatial frequency & Fourier frequency methods, colour image processing, image segmentation & representation. Introduction to time frequency analysis Different families of wavelets, Vector space Continuous time bases and wavelets, multiresolution analyisis,, mathematical preliminaries, windowed Fourier transform, short-time Fourier transform, properties of continuous wavelet transform; Idea of multiresolution, Harr as a basis for L2 (R), Wavelet packet analysis Harr wavelet packets, application to signal and image compression, Transform coding, DTWT for image compression, Audio compression, Edge detection and object isolation, Image fusion, Scaling functions as signaling pulses, Multi tone modulation, image enhancement, feature extraction.

Reference Books:

1. Insight into wavelets (from theory to practice by K P Soman, K I Ramchandran PHI publication (2nd edition)
2. Wavelet transform –introduction to theory & application By Rao & Bopardikar Pearson Publication
3. Fundamentals of Electronic Image Processing by Arthur R. Weeks, Jr., Prentice – Hall, India. .
4. Wavelet Analysis –by Springer Publication
5. Ten lectures on wavelets –by Daubechies I (CBMS-NSF, SIAM, 1982)
6. Data compression book by Nelson BPB Publication
7. Data Compression book by Khalid Sayood Morgan Kaufmann Publishers

SIMDE15- Statistical Signal Analysis and Stochastic Processes

Signals and Systems: System theory, stochastic process and their representation, Gauss – Markov models, likelihood and efficiency. Detection theory: Hypothesis testing, Decision criterion, multiple measurements, multiple and composite hypothesis system, CFAR detection. Detection of signals in noise: detection of known signals in white noise, co- relation receiver, Maximum SNR criterion Estimation theory: Estimation of parameters, random and non-random, Bayer's estimates, properties of estimators, linear mean square estimation. Estimation of waveform: Linear MMSE estimation of waveform, estimation of stationary process, Weiner filters, estimation of non- stationary process, Kalman filters. Relation between Weiner filters and Kalman filters, non-linear estimation. Application to RADAR signal processing, estimation of range Detection of object, it's size etc. Linear prediction and optimum linear filters: Forward and backward linear prediction, properties of linear prediction error filters, AR lattice and ARMA lattice ladder filters, Weiner filters for filtering and prediction.

Reference Books:

1. Srinath, Rajeskaran, Introduction to statistical signal processing with application, PHI- Pearson Publication
2. John Proakis, Digital Signal Processing. PHI Pearson Publication
3. Papoulis, Probability Theory and Random Variables, PHI
4. Henry Stark and John Woods, Probability and Random Processes with Applications to Signal Processing, Pearson Education

SIMDE16- Statistical Natural Language Processing

Morphology and Speech Processing- Introduction –Regular Expressions and Automata- Non-Deterministic FSAs.Tranducers – English Morphology – Finite-State Morphological Parsing - Porter Stemmer – Tokenization-Detection and Correction of Spelling Errors. N-grams – Perplexity - Smoothing - Interpolation - Backoff Part-ofSpeech Tagging – English Word Classes - Tagsets - Rule-Based - HMM - Transformation-Based Tagging - Evaluation and Error Analysis. Hidden Markov and Maximum Entropy Models.

Phonetics – Articulatory Phonetics - Phonological Categories - Acoustic Phonetics and Signals - Speech Synthesis – Text Normalization – Phonetic and Acoustic Analysis - DiphoneWaveformsynthesis – Evaluation- Automatic Speech Recognition –Architecture - Hidden Markov Model to Speech - MFCC vectors - Acoustic Likelihood Computation - Evaluation. Triphones – Discriminative Training - Modeling Variation. Computational Phonology-Finite-State Phonology – Computational Optimality Theory - Syllabification - Learning Phonology and Morphology.

Syntax Ananlysis- Formal Grammars of English – Constituency - Context-Free Grammars –Grammar Rules Treebanks - Finite-State and Context-Free Grammars - Dependency Grammars. Syntactic Parsing – Parsing as Search - Ambiguity - Dynamic Programming Parsing Methods –CKY-Earley and Chart Parsing- Partial Parsing-Evaluation. Statistical Parsing – Probabilistic Context-Free Grammars – Probabilistic CKY Parsing of PCFGs –Probabilistic Lexicalized CFGs – Collins Parser Language and Complexity -The Chomsky Hierarchy -The Pumping Lemma

Semantics- Representation of Meaning – Desirable Properties - Computational Semantics -Word Senses - Relations Between Senses – WorldNet - Event Participants- Proposition Bank - Frame Net – Metaphor. Computational Lexical Semantics – Word Sense Disambiguation- Supervised Word Sense Disambiguation - Dictionary and Thesaurus Methods- Word Similarity - Minimally Supervised WSD - Hyponymy and Other Word Relations - Semantic Role Labeling - Unsupervised Sense Disambiguation. Computational Discourse - Discourse Segmentation - Unsupervised Discourse - Segmentation - Text Coherence - Reference Resolution –Phenomena– Features and algorithms - Pronominal Anaphora Resolution.

Applications of NLP.

Reference Books:

1. Jurafsky and Martin, “Speech and Language Processing”, Pearson Prentice Hall, Second Edition, 2008
2. .Stevan Bird, “Natural Language Processing with Python”, Shroff, 2009
3. James Allen, “Natural Language Understanding”, Addison Wesley, Second Edition, 2007
4. NitinIndurkhya, Fred J. Damerau, “Handbook of Natural Language Processing”, (Chapman& Hall/CRC Machine Learning & Pattern Recognition), Second Edition, 2010.

SIMDE17- Big Data Mining and Analysis

Introduction to Statistical modeling – Machine Learning – Computational approaches to modeling – Summarization – Feature Extraction – Statistical Limits on Data Mining – Distributed File Systems– Map-reduce – Algorithms using Map Reduce – Efficiency of Cluster Computing Techniques.
Nearest Neighbor Search – Shingling of Documents – Similarity preserving summaries – Locality sensitive hashing for documents – Distance Measures – Theory of Locality Sensitive Functions – LSH Families – Methods for High Degree of Similarities. Stream Data Model – Sampling Data in the Stream – Filtering Streams – Counting Distance Elements in a Stream – Estimating Moments – Counting Ones in Window – Decaying Windows. Page Rank –Efficient Computation – Topic Sensitive Page Rank – Link Spam – Market Basket Model – Apriori algorithm – Handling Larger Datasets in Main Memory – Limited Pass Algorithm Counting Frequent Item sets. Introduction to Clustering Techniques – Hierarchical Clustering –Algorithms – K-Means – CURE – Clustering in Non – Euclidean Spaces – Streams and Parallelism – Case Study: Advertising on the Web – Recommendation Systems.

Reference Books:

1. Jure Leskovec, AnandRajaraman, Jeffrey David Ullman, “Mining of Massive Datasets”, Cambridge University Press, Second Edition, 2014.
2. Jiawei Han, MichelineKamber, Jian Pei, “Data Mining Concepts and Techniques”, Morgan Kaufman Publications, Third Edition, 2011.
3. Ian H.Witten, Eibe Frank “Data Mining – Practical Machine Learning Tools and Techniques”, Morgan Kaufman Publications, Third Edition, 2011.
4. David Hand, HeikkiMannila and Padhraic Smyth, “Principles of Data Mining”, MIT Press,2001.

SIMDE18- Cloud Computing

Introduction- Historical Development – Cloud Computing Architecture – The Cloud Reference Model – Cloud Characteristics –Cloud Deployment Models: Public, Private, Community, Hybrid Clouds- Cloud Delivery Models: IaaS, PaaS, SaaS – Open Source Private Cloud Software: Eucalyptus, Open Nebula, Open Stack. Data Center Technology – Virtualization – Characteristics of Virtualized Environments - Taxonomy of Virtualization Techniques – Virtualization and Cloud Computing –Pros and Cons of Virtualization – Implementation Levels of Virtualization – Tools and Mechanisms: Xen, VMWare, Microsoft Hyper-V, KVM, Virtual Box. Cloud Infrastructure Mechanism: Cloud Storage, Cloud Usage Monitor, Resource Replication – Specialized Cloud Mechanism: Load Balancer, SLA Monitor, Pay-per-use Monitor, Audit Monitor, Failover System, Hypervisor, Resource Cluster, Multi Device Broker, State Management Database – Cloud Management Mechanism: Remote Administration System, Resource Management System, SLA Management System, Billing Management System. Apache Hadoop – HadoopMap Reduce –Hadoop Distributed File System- Hadoop I/ODeveloping a MapReduce Application MapReduce Types and Formats – MapReduce Features– Hadoop Cluster Setup –Administering Hadoop.

Basic Terms and Concepts – Threat Agents – Cloud Security Threats –Cloud Security Mechanism: Encryption, Hashing, Digital Signature, Public Key Infrastructure, Identity and Access Management, Single Sign-on, Cloud Based Security Groups, Hardened Virtual Server Images.

Reference Books:

1. RajkumarBuyya, Christian Vecchiola, S. ThamaraiSelvi, “Mastering Cloud Computing”, Tata McGraw-Hill, 2013
2. ArshdeepBahga, Vijay Madisetti, “Cloud Computing: A Hands-On Approach”, Universities Press(India) Private Limited, 2014.
3. James E Smith and Ravi Nair, “Virtual Machines”, Elsevier, 2005
4. John Rittinghouse& James Ransome, “Cloud Computing, Implementation,Management and Strategy”, CRC Press, 2010.

SIMDE19- Deep Learning

Basics of Neural Network, Introduction to deep learning- Feed Forward Neural Networks – Gradient Descent – Back Propagation Algorithm – Vanishing Gradient problem – Mitigation – RelU Heuristics for Avoiding Bad Local Minima – Heuristics for Faster Training – Nestors Accelerated Gradient Descent – Regularization – Dropout. CNN Architectures – Convolution – Pooling Layers – Transfer Learning – Image Classification using Transfer Learning. LSTM, GRU, Encoder/Decoder Architectures – Autoencoders – Standard- Sparse – Denoising – Contractive- Variational Autoencoders – Adversarial Generative Networks – Autoencoder and DBM.
Applications of Deep learning in case study.

Reference Books:

1. Ian Good Fellow, Yoshua Bengio, Aaron Courville, “Deep Learning”, MIT Press, 2017
2. Francois Chollet, “Deep Learning with Python”, Manning Publications, 2018
3. Phil Kim, “Matlab Deep Learning: With Machine Learning, Neural Networks and Artificial Intelligence”, Apress , 2017.
4. Navin Kumar Manaswi, “Deep Learning with Applications Using Python”, Apress, 2018

SIMDE20- Materials Engineering

Basics of material science – atomic structure, types of defects, microstructure, physical & mechanical properties, temperature and strain rate effects, characterization of materials
Effect of manufacturing (casting, forging, rolling, extrusion) and fabrication (welding) processes on material microstructure, properties and generation of residual stress, Heat Treatment of Nonferrous alloys, Heat Treatment of Tool steels

Overview of production methods, semiconducting nanostructures, carbon nanotubes, buckyballs, nanowires, semiconducting nanoparticles, metallic nanostructures, organic nanomaterials, nanometals
Introduction to corrosion and wear, stress corrosion cracking, surface cleaning and coating methods (viz. Chemical Vapor Deposition (CVD), Physical Vapor Deposition (PVD), Ion Implantation, conducting polymers) and its applications to mechanical engineering, strengthening mechanisms, shot peening, shot blasting
Polymers, ceramics, composites, conducting polymers, shape memory alloys, nano materials, Orthodental materials, Bio material, Prosthetic materials, super conducting materials, sports materials
Transition behavior of material, stages of fatigue, damage estimation, methods of fatigue life estimation – stress life approach, strain life approach, cycle counting methods, critical plane approaches, Integration of Damage Differential (IDD) criteria, Smith Watson Topper (SWT) criteria, Dong criteria, elementary fracture mechanics, residual strength analysis.

Reference Books:

1. R. A. Higgins, Engineering Metallurgy, Viva Books Pvt. Ltd.
2. H. Lawrence, Van Vlack, Elements of Material Science and Engineering, Addison-Wesley Publishing Company
3. William F. Smith, Principles of Material Science and Engineering, McGraw-Hill Book Co.
4. R. B. Gupta, Material Science, Satya Publications, New Delhi.
5. William D. Callister, Jr., Material Science and Engineering An Introduction, John Wiley and Sons Inc.
6. E. A. Brandes and G. B. Brook, Smithells Metals Reference Book, Butterworth Heinemann.
7. Donald L. Wise, Biomaterials and Bioengineering Handbook, Marcel Dekker Inc.
8. Philippe Boch and Jean-Claude Niepce, Ceramic materials
9. Donald Askeland and Pradeep Phule, The science and engineering of materials

SIMDE21- Mathematical Modelling and Analysis

System, environment and variables, the state of a system, mathematical models of continuous line linear lumped parameter time invariant systems, discrete time systems, linear approximation of non-linear systems, topological models of system, block diagram representation, signal flow graph, Mason's rule

The principles of conservation and continuity, physical laws, mechanical systems, electrical and electro mechanical systems, fluid systems, thermal systems, biomedical systems.
The linear graph approach, linear graph terminology, formulation of system equations, systems with multi terminal components,linear graph models: skeletal structures, mass transfer processes
Discrete signal models, discrete time-convolution, response of linear discrete time systems, continuous (analogue) signal models, continuous time convolution, response of linear continuous time state equation - discrete time systems, computation of state transition matrix by canonical transformation, computation of state transition matrix by technique based on Caley-Hamilton theorem, the solution of state equation-continuous time systems
Numerical method for solution of continuous time state, ordinary differential equations: explicit and implicit techniques, adaptive step size control, adaptive RK method, numerical methods for partial differential equations
Application of Laplace transforms to differential equations, stability in s domain, linear system, Laplace transform analysis of causal periodic input to linear systems, relationship of the Z transform to the Fourier and Laplace transforms
Fourier spectra of power signals, Fourier transform of periodic functions- Fourier series, Fourier analysis of sampled signals, modulation, discrete Fourier transforms
The inverse Z-transform, Z-transform analysis of linear discrete time systems, nature of response of linear discrete-time systems, computation system, de-convolution
Multi resolution analysis and construction of wavelets, representation of functions by wavelets, the characterization of MRA wavelets
Introduction to simulation: digital and analogue simulation, analytic and Monte Carlo simulation, stochastic and deterministic simulation, random and pseudo random number generation, designing a simulation experiment, simulating basic stochastic models, simulator technology, applications

Reference Books:

1. Nicola Bellomo & Luigi Preziosi, Modeling Mathematical Methods & Scientific Computations, 1995, CRC Press.
2. I.J. Nagarath & M. Gopal, Systems Modeling & Analysis, Tata McGraw Hill, New Delhi.
3. Jan Willen Polderman, Jan C. Willems, Introduction to Mathematical Systems Theory-Abehavioural approach, 1998, Springer.
4. J.L. Shearer, A.T. Murphy, H.H. Richardson, Introduction to System Dynamics, 1971,Addison & Wesley.
5. T.H. Glisson, Introduction to System Analysis, 1987, McGraw Hill.

SIMDE22- Optimization Techniques

Basic Concepts, Functions of one variable, Unconstrained Functions of N Variables, Constrained Functions of N Variables: Linear Programming, Sequential Unconstrained Minimization Techniques,DirectMethods, Approximation Techniques,Duality
Discrete Variable Optimization and Multi-Objective Optimization, Structural Optimization, General Design Applications and Multidiscipline Design Optimization, Optimization Software
Sizing, Shape and Topology/ Topography Optimization, Design Sensitivity Analysis

Optimization by ANN and GA techniques

Optimization of Systems for specific application like acoustics, laminated composite materials etc.

Reference Books:

1. Raphael Haftka and Zafer Gurdal, Elements of Structural Optimization, Kluwer Academic Publishers
2. Jasbir Arora, Optimization of Structural and Mechanical Systems, World Scientific
3. Garret N Vanderplaats, Numerical optimization techniques for engineering design, Vanderplaats Research and Development, Inc

SIMDE23- Biomechanics

Introduction to bio-mechanics, relation between mechanics and Medicine, Newton's laws, stress, strain, shear rate, viscosity, visco elasticity, non-Newtonian viscosity, soft tissue mechanics, mechanical properties of soft biological tissues. Anthropometry.

Flow properties of blood, effect of shear rate, hematocrit, temperature and protein Content of blood, rheology of blood and micro vessels, dynamics of circulatory system, turbulence flow around prosthetic heart valves.

Orthopedic biomechanics, mechanical properties of bones, stress induced bone growth, kinematics and kinetics of joints, lubrication of joints, gait analysis, spatio-temporal parameters of gait. Analysis of force in orthopedic implants.

Skeletal muscles servo mechanism, Cardio vascular control mechanism, respiratory control mechanism, Finite element analysis in Biomechanics.

Experimental and Analytical method of analysis, Clinical evaluation, Head Injury tolerance, rotational injury, spine injury – Accident reconstruction, Analysis of impact, skid analysis – Damage analysis.

Reference Books:

1. Susan J.Hall, Basics Bio Mechanics 4 th Edition, McGraw-Hill Publishing Co, 2002
2. Subrata pal, Text book of Biomechanics, Viva education private limited, 2009.
3. C.R Ethier and C.A.Simmons , Biomechanics from cells to organisms, Cambridge University Press, 2007.

SIMDE24- Biostatistics

Introduction to probability, likelihood & odds, distribution variability. Statistical parameters p-values, computation and level chi square test and distribution. Regression, correction use of regression, multiple regression. Interpreting life tables clinical trails, epidemical reading and interpreting of epidemical studies, application in community health. META analysis for research activities, purpose and reading of META analysis, kind of data used for META analysis.

Reference Books:

1. Joseph A. Ingelfinger, Frederick Mosteller, Lawrence A. Thibodeau, James H. Ware Biostatistics in Clinical Medicine (third edition), Singapore, 1994.
2. Raymond Hampton, John Havel, " Introductory Biological Statistics", 4th edition

SIMDE25- Finite Element Analysis for Biomedical Engineering

Mathematical Modeling of field problems in Engineering – Governing Equations – Discrete and continuous models – Boundary, Initial and Eigen Value problems – Variational Formulation of Boundary Value Problems – Ritz Technique –Natural and Essential Boundary conditions - Basic concepts of the Finite Element Method. One Dimensional Second Order Equations – Discretization – element types- Linear and Higher order Elements – Derivation of Shape functions and Stiffness matrices and force vectors - Assembly of Matrices - solution of problems from solid and bio mechanics- Structural, stress, and strain analysis of the human body and/or artifical implants.

Fourth Order Beam Equation –Transverse deflections - Natural frequencies of beams and Longitudinal vibration. Second Order 2D Equations involving Scalar Variable – Variational formulation –Finite Element formulation – Triangular elements – Shape functions and element matrices and vectors. Application to Field Problems in Bio mechanics - Quadrilateral elements.

Higher Order Elements. Natural co-ordinate systems – Isoparametric elements – Shape functions for isoparametric elements – One, two and three dimensions – Serendipity elements – Numerical integration and application to plane stress problems transformation in and coordinates-Jacobian of transformation-order of convergence- numerical integration –example problems-shape functions in natural coordinates-rectangular elements- Lagrange familySerendipity family- rectangular prisms- tetrahedral elements.

Introduction to elasticity equations – stress strain relations – plane problems of elasticity – element equations Plane stress, plane strain and axisymmetric problems – stress-strain-time or constitutive equations for soft connective tissue components Modelling and force analysis of musculoskeletal systems– Stress calculations - Plate and shell elements – Introduction to flow problems- solution of problems in fluid mechanics- numerical examples -plates and shells.

Introduction to Non-linear problems - some solution methods- computational proceduresimple material nonlinearity, stress stiffening, contact interfaces- problems of gaps and contact- geometric non-linearity-modeling considerations- Impact analysis. Mechanical properties of biological and commonly used biomedical engineering materials - Critical reviews of finite element analysis in biomechanical research.

Reference Books:

1. Seshu. P., Textbook of Finite Element Analysis Prentice Hall of India, 2003
2. J.N. Reddy, Finite Element Method, Tata McGraw Hill, 2003.
3. S.S. Rao, The Finite Element Method in Engineering —Butter worth heinemann, 2001

SMDAT- Statistical Methods for Data Analysis Techniques

Basics of Summarizing data:
Average, Arithmetic mean, weighted Areithmetic mean, merits and demerits of arithmetic mean, median, mode, merits and demerits of mode and median, relationship between mean, median and mode, Measures of Dispersion, Range, mean deviation, semi-interquartile range, 10-90 percentile range, standard deviation, variance, moments, moments of grouped data, relations between moments, skewness, Kurtosis.

Elementary sampling:
Definitions of Probability, Probability distributions, Mahematical Expectations, sampling from a normal distribution, sampling from a Binomial distribution, sampling from a Pisson distribution, measures of central tendency, Fitting Theoretical Distributions to Sample Frequency Distributions, Confidence level estimates

Noise Removal an Outlier Detection:
Introduction, Outlier identification methods, statistical methods : Tukey's Method, Z-score, Modified Z-score, Interquartile range with Log-normal distribution, Cook's Distance. Proximity based Models, Criteria for Outlier Detection, Case study.

Regression and correlation:
scatter plot, Linear Regression, Pearson Product moment correlation coefficient, Spearman's rank order correlation coefficient, Multiple Regression, Chi-square goodness of fit test, chi-sqare test for independence, distribution of chi-square, problems with large samples, problems with small samples

Hypothesis Tests:
Statement of the null and alternative hypothesis, choosing the test of significance, describing the sample and derivation of the p-value, test of statistical significance of the result, Reporing results error types in hypothesis testing, Rejecting the null hypothesis, Failing to reject the null hypothesis.
The t- distribution, One sample t- test for mean, F- test for equality of more than two means. The sampling distributions of sample percentages, z- test for a binomial percentage.
Analysis of Variance : One way classification, methods of obtaining variations, Mathematical model of analysis of variance, Expected value of variations, Distributions of variations, Analysis-of variance tables.

Reference Books:

1. George Argyrous, Statistics for Research, Third Edition, Sage Publications (2011).
2. Murray R Speigel, Larry J Stephens, Statistics, Sixth Edition, McGraw Hill Education (2017).
3. R.E. Walpole, R. H. Myers, S. L. Meyers, K. E. Ye, Probability and Statistics for Engineers and Scientists, Pearson Education India, *9th* edition (*2013)*
4. V.K. Rohatgi, A. K. Md. E. Saleh, An Introduction to Probability and Statistics, Wiley Student Edition, (2018)