Punyashlok Ahilyadevi Holkar Solapur University, Solapur

पुण्यश्लोक अहिल्यादेवी होळकर
सोलापूर विद्यापीठ
।। विद्यया संपन्नता ।।

NAAC Accredited-2015
'B' Grade (CGPA 2.62)

Name of the Faculty: Science & Technology

CHOICE BASED CREDIT SYSTEM

Syllabus: BIO-MEDICAL ENGINEERING

Name of the Course: B.E.- IV (Sem. VII & VIII)

(Syllabus to be implemented from w.e.f. June 2019)

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

FACULTY OF ENGINEERING & TECHNOLOGY

Bio-Medical Engineering

Programme Educational Objectives and Outcomes

A. Program Educational Objectives (PEOs)

Graduate will –

1. To prepare our students for skilled and ethical service to their communities by creating a free and open learning environment that enhance their intellectual growth
2. To engage our students to work in collaborative projects, corporate and academic communities in effective manner.
3. To create innovative technologies for the improvement of health care sectors and contribute positively to the needs of society.

B. Program Outcomes

Engineering Graduate will be able to –

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

C. Program Specific Outcomes (PSOs)

1. Apply advanced science and engineering to solve the problems at the interface of engineering and healthcare.
2. Demonstrate understanding of the principles and working of the hardware and software aspects of biomedical systems.
3. Use professional and ethical practices, strategies and tactics for the development, operation and maintenance of biomedical technologies.
4. Provide effective and efficient real time solutions using acquired knowledge in various domains

PUNYASHLOK AHILYADEVI HOLKAR SOLAPUR UNIVERSITY, SOLAPUR

Faculty of Engineering & Technology (Revised from 2016-17)

Credit System structure of B.E. Biomedical Engineering

W.E.F. 2019-20 (CBCS) - Semester I

Course Code	*Theory Course Name*	*Hrs./week*			*Credits*	*Examination Scheme*			
		L	*T*	*P*		*ISE*	*ESE*	*ICA*	*Total*
BM411	**Rehabilitation Engineering**	4	-	-	4	30	70	25	125
BM412	**Medical Informatics**	4	-	-	4	30	70	25	125
BM413	**Medical Instrumentation-III**	4	-	-	4	30	70	25	125
BM414	**Principles of Image processing**	4	-	-	4	30	70	25	125
BM415	**Elective –I**	4	-	-	4	30	70	25	125
Sub Total		**20**	**-**	**-**	**20**	**150**	**350**	**125**	**625**
Course Code	*Laboratory Course Name*								
							ESE		
							POE	*OE*	
BM413	**Medical Instrumentation-III**	-	-	2	1	-	-	25	-	25
BM414	**Principles of Image processing**	-	-	2	1	-	50	-	-	50
BM416	**Seminar and Project Stage - I**	-	-	4	2	-	-	-	50	50
Sub Total		-	-	08	4	-	75		50	125
Grand Total		**20**	**-**	**08**	**24**	**150**	**425**		**175**	**750**

Abbreviations: L- Lectures, P –Practical, T- Tutorial, **ISE**- In Semester Exam,
ESE - End Semester Exam, **ICA**- Internal Continuous Assessment,
ESE - University Examination (Theory &/ POE &/Oral examination)

PUNYASHLOK AHILYADEVI HOLKAR SOLAPUR UNIVERSITY, SOLAPUR

-Faculty of Engineering & Technology (Revised from 2016-17)

Credit System structure of B.E. Biomedical Engineering

W.E.F. 2019-20 (CBCS) - Semester II

Course Code	*Theory Course Name*	*Hrs./week*			*Credits*	*Examination Scheme*			
		L	*T*	*P*		*ISE*	*ESE*	*ICA*	*Total*
BM421	**Medical Imaging – II**	4	-	-	4	30	70	25	125
BM422	**Biomedical Microsystems**	4	-	-	4	30	70	25	125
BM423	**Tissue Engineering**	4	-	-	4	30	70	25	125
BM424	**Elective -II**	4	-	-	4	30	70	25	125
Sub Total		**16**	**-**	**-**	**16**	**120**	**280**	**100**	**500**
Course Code	*Laboratory Course Name*								
							ESE		
							POE	*OE*	
BM421	**Medical Imaging – II**	-	-	2	1	-	-	50	-	50
BM425	**Final Project stage (II)**	-	-	8	4	-	100	-	100	200
Sub Total		**16**	**-**	**10**	**5**	**-**	**150**		**100**	**250**
Grand Total		**16**	**-**	**10**	**21**	**120**	**430**		**200**	**750**

Abbreviations: L- Lectures, P –Practical, T- Tutorial, **ISE**- In Semester Exam,
ESE - End Semester Exam, **ICA**- Internal Continuous Assessment,
ESE - University Examination (Theory &/ POE &/Oral examination)

- **Note** –

1) Batch size for the practical /tutorial shall be of 15 students. On forming the batches, if the strength of remaining student exceeds 7, then a new batch shall be formed.

2) Project group for B.E.(Biomedical) Part I and Part II shall not be of more than **three** students.

3) ICA assessment shall be a continuous process based on student's performance in – class tests, assignments, homework, subject seminars, quizzes, laboratory books and their interaction and attendance for theory and lab sessions as applicable

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

B.E. (Bio-medical Engineering) Semester-I
BM411 REHABILITATION ENGINEERING

Teaching Scheme	**Examination Scheme**
Lectures – 4 Hours/week**,** 4 Credits	**ESE -** 70 Marks
	ISE - 30 Marks
	ICA - 25 Marks

Course Objectives:

1. Define rehabilitation and explain the composition of rehabilitation team.
2. Discuss the engineering principles of rehabilitation engineering.
3. Apply engineering skills in the development of prosthetic and orthotic devices.
4. Evaluate the orthopedic design and applications.
5. Apply the principles of engineering in the development of mobility aids for physically Handicap
6. Describe therapeutic exercise techniques, Orthopedic Prosthetics, Orthotics

Course Outcomes:

1. Study the principles of rehabilitation.
2. Know new rehabilitation concepts for future development and applications.
3. Learn therapeutic Exercise Techniques.
4. Understand orthopedic prosthetics and orthotics in rehabilitation.

SECTION I

Unit I : Introduction To Rehabilitation & Rehabilitation Team: **10 Hrs**

What is Rehabilitation, Epidemiology of Rehabilitation, Health, Levels of Prevention, and Preventive Rehabilitation, Diagnosis of Disability, Functional Diagnosis, Importance of Psychiatry in Functional diagnosis, Impairment disability handicap, Primary & secondary Disabilities, Rehabilitation team-Classification of members, The Role of Psychiatrist, Occupational therapist, Physical therapist, Recreation therapist, Prosthetics - Orthotics, Speech pathologist, Rehabilitation nurse, Social worker, Corrective therapist, Psychologist, Music therapist, Dance therapist & Biomedical engineer.

Unit II: Principles Of Rehabilitation: 10 Hrs

Introduction, The Human Component, Principles of Assistive Technology Assessment, Principles of Rehabilitation Engineering- Key Engineering Principles, Key Ergonomic Principles - Practice of Rehabilitation and Assistive Technology.

Unit III: Therapeutic Exercise Technique: 9 Hrs

Co-ordination exercises, Frenkels exercises, Gait analyses-Pathological Gaits, Gait Training, Relaxation exercises-Methods for training Relaxation, Strengthening exercises-Strength training, Types of Contraction, Mobilisation exercises, Endurance exercises.

SECTION II

Unit IV: Principles In Management Of Communication: 9 Hrs

Impairment-introduction to communication, Aphasia, Types of aphasia, Treatment of aphasic patient, Augmentative communication-general form of communication, types of visual aids, Hearing aids, Types of conventional hearing aid, Writing aids.

Unit V : Orthotic & Prosthetic Devices: 10 Hrs

General orthotics, Classification of orthotics-functional & regional, General principles of Orthosis, Calipers- FO, AFO, KAFO, HKAFO. Prosthetic devices**:** Hand and arm replacement, Body powered prosthetics, Myoelectric controlled prosthetics and externally powered limb prosthetics.

Internal Continuous Assessment (ICA):

ICA shall consist of minimum eight Assignments on above Syllabus.

TEXT BOOKS:

1. Dr. S. Sunder, Rehabilitation Medicine-, 3 rdEdition, Jaypee Medical Publications, New Delhi. 2010 (Units I, III, IV & V)
2. Joseph D. Bronzino, The Biomedical Engineering Handbook, Third Edition: Three Volume Set, CRC Press, 2006 (Units II & V).

REFERENCES:

1. Rory A Cooper, An Introduction to Rehabilitation Engineering, Taylor & Francis, CRC press, 2006.
2. Susan B O'Sullivan, Thomas J Schmitz, Physical Rehabilitation. 5 th Edition, Davis publications, 2007.

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

B.E. (Bio-medical Engineering) Semester-I

BM412 MEDICAL INFORMATICS

Teaching Scheme	**Examination Scheme**
Lectures – 4 Hours/week**,** 4 Credits	**ESE -** 70 Marks
	ISE - 30 Marks
	ICA - 25 Marks

Course Objectives:

1. Discuss the Medical Informatics.
2. Apply management skills hospital.
3. Evaluate the Patient Records.
4. Apply Management Information System

Course Outcomes:

1. Study the Hospital Management.
2. Know Telecommunication Based Systems
3. Learn Surgical Simulation how to carry out
4. Understand Management Information System

SECTION I

Unit I: Medical Informatics **7 Hrs**

Aim and scope, salient feature, Introduction, history, definition of medical informatics, Bio-informatics, online learning, introduction to health informatics, prospectus of medicalinformatics.

Unit II: Hospital Management And Information Science: **7 Hrs**

Introduction, HMIS: need, Benefits, capabilities, development, and functional areas. Modules forming HMIS, HMIS and Internet, Pre-requisites for HMIS, PACS, why HMIS fails, health information system, disaster management plans, advantages of HMIS.

Unit III: Hospital Management And Information Systems: **10 Hrs**

Central Registration Module, OPD / Consultant Clinic / Policlinic Module, Indoor Ward Module, Patient Care Module, Procedure Module, Diet Planning Module, MLC Register Module, Pathology Laboratory Module, Blood Bank Module, Operation Theatre Module, Medical Stores Module, Pharmacy Module, Inventory Module, Radiology Module, Medical Records Index Module, Administration Module, Personal Registration Module, Employee Information Module, Financial modules, Health & Family Welfare, Medical Examination, Account Billing, Medical Research, Communication, General Information.

Unit IV: Knowledge Based And Expert Systems & Patient Records: **7Hrs**

AI, expert systems, materials and methods, applications of ES, Introduction to computer based patient record, development tools, intranet, CPR in radiology, legal security and private issues, application service providers.

SECTION II

Unit V: Computer Assisted Medical Education & Surgery: 7 Hrs

CAME, Education software, Tele-education, Tele-mentoring, CAPE, patient counseling software. Limitation of conventional surgery, computer assisted surgery (CAS), 3D navigation system, intra-operative imaging for 3D navigation system, merits and demerits of CAS.

Unit VI: Surgical Simulation And Virtual Environment: 6 Hrs

Need, technology, volume image data file, human resources, interface and applications. Virtual environment (VE), technology, applications of VE, advantages of simulators and after effects of VE participation.

Unit VII: Telecommunication Based Systems: 6 Hrs

Telemedicine, need of telemedicine, technology materials and methods, internet, applications of telemedicine, reliability and cost analysis, tele-surgery, robotic surgery, needs for tele-surgery, advantages and disadvantages, technology materials and methods, applications.

Internal Continuous Assessment (ICA):

ICA shall consist of minimum eight Assignments on above Syllabus.

TEXTBOOK:

1 .Medical Informatics: A Primer - by Mohan Bansal, 1st Print, Tata McGraw Hill, Publications, 2003.

REFERENCE BOOKS:

1. Medical Informatics: Computer applications in health care and biomedicine by E.H.Shortliffe, G. Wiederhold, L.E.Perreault and L.M.Fagan, 2nd Edition, Springer Verlag, 2000
2. Handbook of Medical Informatics by J.H.VanBemmel, Stanford University Press/ Springer, 2000.

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

B.E. (Bio-medical Engineering) Semester-I

BM413 MEDICAL INSTRUMENTATION-III

Teaching Scheme	**Examination Scheme**
Lectures – 4 Hours/week**,** 4 Credits	**ESE -** 70 Marks
Practical - 2 Hours/week,1 Credit	**ISE -** 30 Marks
	ICA - 25 Marks
	OE - 25 Marks

Course Objective:

1. To understand the basic principle, working and design of various automated diagnostic equipments.
2. To develop skills enabling Biomedical Engineers to serve Hospitals, National and International Industries and Government Agencies.
3. To develop core competency in the field of Biomedical Engineering to gain technical expertise in biology and medicine for effective contribution in the development and improvement of health care solutions.
4. To study various medical instrumentation systems, drug delivery systems and health management systems.

Course Outcome:

1. Demonstrate the principles of electronics used in designing various diagnostic equipment.
2. Have in-depth knowledge about different streams in Biomedical Engineering with greater emphasis on health care equipments and the advanced technologies such as Telemedicine, Telemetry, Medical Imaging, etc.
3. Exhibit competency in suggesting, designing and offering the apt, reliable and optimum solution after understanding customer's requirement completely.
4. Demonstrate ability of correlating theoretical concepts with their practical implementation while performing laboratory exercises and project work.
5. Provide a better technical support with exposure to the hospitals and health care industry.
6. Use modern methodologies, multi-disciplinary skill set and knowledge while working on real time projects that demand convergence of engineering, science and technology.

SECTION- I

Unit I :Physiotherapy, Electrotherapy and Radiation Therapy Equipment's 10 Hrs

Basic principle, working and technical specifications of Shortwave Diathermy, Ultrasonic therapy unit, Infrared and UV lamps, Nerve and Muscle Stimulator, Radiation and Physical therapy Units.

Unit II Surgical Instruments: 7 Hrs

Surgical Diathermy machine, electrodes used with surgical diathermy, safety aspects in electronic surgical units, surgical diathermy analyzers.

Unit III: Cardiac Pacemakers: **7 Hrs**

Modes of operation, leads and electrodes. Power supply sources. External and Implantable Pacemaker, Performance aspects of Implantable Pacemaker.

SECTION- II

Unit IV: Cardiac Defibrillators: **06 Hrs**

DC defibrillator, Modes of operation and electrodes, Performance aspects of dc-defibrillator, defibrillator analyzers. Implantable defibrillator and defibrillator analyzer.

Unit V:Hemodialysis Machine: **04 Hrs**

Basic principle of Dialysis. Different types of dialyzer membrane, Portable type.

Unit VI: Laser Applications in Biomedical Engineering: **08 Hrs**

Laser Classifications, Types of Lasers, Medical Applications, Laser Delivery Systems

Unit VII: Heart rate variability measurement and applications: **02 Hrs**

Internal Continuous Assessment (ICA):

ICA shall be based minimum Ten Experiments on above Syllabus.

Text Books:

1. Handbook of Biomedical Instrumentation: R S. Khandpur. (PH Pub)
2. Medical Instrumentation, Application and Design: J G. Webster. (John Wiley)
3. Introduction to Biomedical Equipment Technology: Carr –Brown. (PH Pub)

Reference:

1. Encyclopedia of Medical Devices and Instrumentation: J G. Webster. Vol I,II,III,IV (PH Pub)
2. Various Instruments Manuals.

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

B.E. (Bio-medical Engineering) Semester-I

BM414 PRINCIPLES OF IMAGE PROCESSING

Teaching Scheme	**Examination Scheme**
Lectures – 4 Hours/week**,** 4 Credits	**ESE -** 70 Marks
Practical - 2 Hours/week,1 Credit	**ISE -** 30 Marks
	ICA - 25 Marks
	POE - 50 Marks

Course Objectives:

1. To understand the basics of Image Processing
2. To learn image enhancement in spatial & frequency domain
3. To study the image segmentation & compression

Course Outcomes:

1. Define the general terminology of digital image processing.
2. Identify the need for image transforms and their types both in spatial and frequency domain.
3. Identify different types of image degradation and apply restoration techniques.
4. Describe image compression models and learn image compression techniques.
5. Explain and apply various methodologies for image segmentation.
6. Implement image processing and analysis algorithms.

SECTION I

Unit I: Introduction **8Hrs**

Background, Examples of fields that use DIP, Fundamental steps in Digital Image Processing (DIP), Components of DIP system, Image sensing and acquisition, A simple image formation model, Image sampling and quantization. Basic relationship between pixels, Colour image processing fundamentals and models.

Unit II: Image Enhancement in Spatial Domain **9Hrs**

Background, Point processing – Image negatives, Log transformations, Power law transformations, Contrast stretching, Intensity level slicing, Bit plane slicing, Histogram processing – Histogram equalization, Histogram matching (specification),Arithmetic/Logic operations – Image subtraction, Image averaging. Fundamentals of spatial filtering, Smoothing spatial filters, Sharpening spatial filters

Unit III: Image Enhancement In Frequency Domain **8Hrs**

Background, 2D-Discrete Fourier Transform and its Inverse, Basic properties of the 2D-Discrete Fourier Transform, Basics of filtering in the frequency domain. Image smoothing using frequency domain filters – Ideal low pass filters, Butterworth low pass filters, Gaussian low pass filters; Image sharpening using frequency domain filters – Ideal high pass filters, Butterworth High pass filters, Gaussian high pass filters, Homomorphic filtering.

SECTION II

Unit IV: Image Segmentation **7Hrs**

Fundamentals, Point detection, Line detection, Edge models, Edge detection, Candy edge detector. Thresholding, Region based segmentation.

Unit V: Image Compression **7Hrs**

Fundamentals of Image compression models, Lossless Compression- RLE, Huffman, LZW, Arithmetic coding techniques Lossy Compression- IGS coding, Transform coding, JPEG, Predictive Coding.

Unit VI: Representation and Description **7Hrs**

Morphology-dilation, Erosion, open, close, Hit and miss, Boundary extraction, region filling, skeletonization, Feature extraction, Moments

Internal Continuous Assessment (ICA):

ICA shall be based minimum Eight Experiments on above Syllabus.

Text Books:

1. Digital Image Processing - Rafael. C. Gonzalez and Richard. E. Woods, Third Edition, Pearson Education, 2008.

Reference Books:

1. Fundamentals of Digital Image Processing - Anil K. Jain, 5th Indian Print, PHI, 2002.
2. Digital Image Processing and Computer Vision - Milan Sonka, India Edition, Cengage Learning.

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

B.E. (Bio-medical Engineering) Semester-I

BM415A MEDICAL RADIATION SAFETY ENGINEERING

(ELECTIVE –I)

Teaching Scheme	**Examination Scheme**
Lectures – 4 Hours/week**,** 4 Credits	**ESE -** 70 Marks
	ISE - 30 Marks
	ICA - 25 Marks

Course Objectives:

To impart sufficient information on the various precautionary and safety measures for radiation protection in medicine.

Course Outcomes:

1.To provide an insight to the basics of radiation physics.
2.To enable them understand the guidelines of radiation protection and radiation detectors.
3.To provide information on safety measures related to UV, laser and nuclear medicine

SECTION I

Unit I: Introduction To RF And Microwave Radiation (9 hours)

Sources of radio frequency radiation- Effects of radio frequency radiation Development of standards for human safety- Calculation of RF field quantities- RF radiation measuring instruments and methods.

Unit II: Radiation Detection And Measurement (9 hours)

Fundamentals of radiation detection- Conducting radiation measurements and surveys- Gas detectors- Designing to reduce radiation hazards- Radio frequency radiation safety management and training-Scintillation detectors- Statistics of counting- minimum detectable activity- Quality assurance of radiation counters.

Unit III: Radiation Safety In Nuclear Medicine And Radiotherapy (9 hours)

Design and description of NM department- Radiation protection in nuclear industry- Guidelines for radiation protection- Molecular medicine and radiation safety program-procedures for safe operation of radiation equipment- Radiation protection in external beam radiotherapy- Radiation protection in brachytherapy Radioactive wastes.

SECTION II

Unit IV: Laser And Ultraviolet Radiation Safety (9 hours)

Classification of UV radiation -Sources of UV- Biological effects of UV- Hazards associated with UV radiation- UV control measures - Safety management of UV- Classifications of LASER and its radiation hazards- control measures Emergencies and incident procedures.

Unit V: Monitoring And Internal Dosimetry (9 hours)

Monitoring methods-personal radiation monitoring- Records of personal dosimetry- ICRP method- MIRD method- Internal doses from radiopharmaceuticals- Bioassay of radio activity Hazard and risk in radiation protection- radiological incidents and emergencies- Regulation to radiation protection.

Internal Continuous Assessment (ICA):

ICA shall consist of minimum eight Assignments on above Syllabus.

TEXTBOOKS/ REFERENCES

1.Jamie V, Trapp, Thomas Kron, ―An introduction to radiation protection in medicine‖, crc press Taylor &Francis group, 2008.

2.Alan Martin, Samuel Harbison, Karen Beach, Peter Cole, Hodder Arnold, ―An Introduction to radiation protection‖, 6th edition 2012.

3.Max Hlombardi, ―Radiation safety in nuclear medicine‖, CRC Press Taylor & Francis group, 2nd edition, 2007.

4.ArunaKaushik, Anupammondal, Dwarakanath B.S, Tripathi R P, ―Radiation protection manual‖, INMAS, DRDO, 2010.

5.Ronald kitchen, ―RF and microwave radiation safety‖, Newness publishers, 2edition,2001.

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

B.E. (Bio-medical Engineering) Semester-I

BM415B LASERS AND OPTICAL FIBERS IN MEDICINE

(ELECTIVE –I)

Teaching Scheme	**Examination Scheme**
Lectures – 4 Hours/week**,** 4 Credits	**ESE -** 70 Marks
	ISE - 30 Marks
	ICA - 25 Marks

Course Objectives: To Study About:

1. The optical properties of the tissues and the interactions of light with tissues.
2. The instrumentation and components in Medical Optics.
3. The Medical Lasers and their applications
4. The optical diagnostic applications
5. The emerging optical diagnostic and therapeutic techniques
6.

Course Outcomes: At The End Of The Course, The Students Should Be Able To:

1. Demonstrate knowledge of the fundamentals of optical properties of tissues
2. Analyze the components of instrumentation in Medical Photonics and Configurations
3. Describe surgical applications of lasers.
4. Describe photonics and its diagnostic applications.
5. Investigate emerging techniques in medical optics

SECTION I

Unit I: Optical Properties Of The Tissues **9 Hrs**

Fundamental Properties of light - Refraction, Reflection, Laws (Snell's law and Fresnel law) Scattering, Absorption, Light transport inside the tissue, Tissue properties, Laser Characteristics as applied to medicine and biology, Laser tissue Interactions – Photo chemical, Photo thermal and Photo mechanical interactions, Fluorescence, Speckles, Photo ablative processes.

Unit II: Instrumentation In Photonics **9 Hrs**

Instrumentation for absorption, Scattering and emission measurements, Excitation light sources –high pressure arc lamps, LEDs, Lasers, Optical filters – Prism and Monochromators, Polarizers, Optical detectors – Single Channel and Multichannel detectors, Time resolved and phase resolved detection methods, Optical fibers – Total Internal Reflection.

SECTION II

Unit III: Surgical Therapeutic Applications Of Lasers **9 Hrs**

Lasers in ophthalmology, Dermatology, Dentistry, Urology, Otolaryngology, Tissue welding and Soldering.

Unit IV: Non Thermal Diagnostic Applications **9 Hrs**

Optical coherence tomography, Elastography, Laser Induced Fluorescence (LIF)-Imaging, FLIM Raman Spectroscopy and Imaging, FLIM – Holographic and Speckle applications of lasers in biology and medicine.

Unit V: Diagnostic And Therapeutic Techniques 9 Hrs

Near field imaging of biological structures, In vitro clinical diagnostics, Phototherapy, Photodynamic therapy (PDT) - Principles and mechanisms - Oncological and non-oncological applications of PDT - Biostimulation effect – applications - Laser Safety Procedures.

Internal Continuous Assessment (ICA):

ICA shall consist of minimum eight Assignments on above Syllabus.

TEXT BOOKS:

1. Tuan Vo Dirh, ―Biomedical Photonics – Handbook‖, CRC Press, Bocaraton, 2014.
2. Paras N. Prasad, ―Introduction to Biophotonics‖, A. John Wiley and Sons, Inc. Publications, 2003
3. Lasers and Optical Fibers in Medicine – AbrahimCatzir Academic press 1998
4 Optical Fiber Communication by Gerd Keiser

REFERENCES:

1. MarkolfH.Niemz, ―Laser-Tissue Interaction Fundamentals and Applications‖, Springer, 2007
2. G.David Baxter ―Therapeutic Lasers – Theory and practice‖, Churchill Livingstone publications Edition- 2001.
3. Leon Goldman, M.D., &R.James Rockwell, Jr., ―Lasers in Medicine‖, Gordon and Breach, Science Publishers Inc., 1975.
4.Therapeutic Lasers – G David Baxter – Churchill Living stone publications
5. Medical Laser and their safe use – David H Shiny Stiffen and L Trokel Springer Publications
6. Element of Fiber optics – S. L. Wymer Regents PHI
7. Lasers in Urologic Surgery – Joseph A.Smith,Jr, Barry S.Stein, Ralph C.BensonJr, Mosby Pub
8. Laser Fundamentals-William T.Silfvast, Cambridge University Press
9. Lasers in Medicine, Volume-1,Hans K. Koebner, John Wiley & Sons
10.. Lasers in Medicine - by Ronal W. Waynant, CRC Press, 2002.

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

B.E. (Bio-medical Engineering) Semester-I
BM415C NEURAL NETWORK AND AI IN BIOMEDICAL ENGINEERING (ELECTIVE –I)

Teaching Scheme	**Examination Scheme**
Lectures – 4 Hours/week**,** 4 Credits	**ESE -** 70 Marks
	ISE - 30 Marks
	ICA - 25 Marks

Course Objective:

1. To understand the basic principle and working design of biomedical systems.
2. To study artificial intelligence in biomedical engineering

Course Outcome:

1. Understand the Pattern Recognition and Mata data
2. Apply Artificial Intelligence in Biomedical System

SECTION I

Unit I: **04 Hrs.**

Overview: Early Biomedical Systems, Medical and Biological Data. Neural Network: Introduction, Human Brain, Benefits of Neural Networks, Models of a Neuron, Neural Networks viewed as Directed Graph, Feedback.

Unit II: **06 Hrs.**

Classes of Neural Networks: Basic Network Properties, Classification Models, Association Models, Optimization Models, Self-Organization models, Radial Basis Functions.(Text 1: Chapter 2)Classification Networks and Learning: Network Structure, Feature Selection, Types of Learning

Unit III: **10 Hrs.**

Supervised Learning: Decision Surfaces, Two Category Separation, Linearly Separable Sets, Non Linearly Separable Sets, Multiple Category Classification Problems, Relationship to Neural Networks Models, Comparison of Methods, Applications Unsupervised Learning: Clustering, Kohonen Networks and Competitive Learning, Hebbian Learning, Adaptive Resonance Theory, Applications. Design Issues: Introduction, Input Data Types.

SECTION II

Unit IV: **10 Hrs.**

Foundations of Computer-Assisted Decision Making: Motivation, Data Bases and Medical Records, Mathematical Modeling and Simulation, Pattern Recognition, Bayesian Analysis, Decision Theory, Symbolic Reasoning Techniques .Knowledge Representation: Production Rules, Frames, Data Bases, Predicate Calculus and Semantic Nets, Temporal Data Representation.

Unit V: **10 Hrs.**

Knowledge Acquisition: Expert Input, Learned Knowledge, Meta Knowledge, Knowledge Based Maintenance. Reasoning Methodologies: Problem Representation, Blind Searching, Ordered Search ,AND/OR Trees, Searching Game Trees, Searching Graph, Rule Based Searching ,Higher Level Reasoning Methodologies.

Internal Continuous Assessment (ICA):

ICA shall consist of minimum eight Assignments on above Syllabus.

Text Books:

1. "Neural Networks and Artificial Intelligence for Biomedical Engineering", Donna L. Hudson, Maurice E. Cohen, IEEE Press, 2000.
2. "Neural Networks: A Comprehensive Foundation", Simon Haykin, 2nd Edition, Prentice Hall International.

Reference Books:

1. "Artificial Neural Networks", Robert J. Schalkoff, Tata McGraw Hill, 1997.
2. "Introduction Artificial Neural System", Jacek M. Zurada, Jaico Publication House, 2004.
3. "Neural Networks: A Classroom Approach, Sathish Kumar, Tata McGraw Hill, 2004.
4. "Artificial Intelligence: A Modern Approach", Stuart Russell, Peter Norvig, 2nd Edition,

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

B.E. (Bio-medical Engineering) Semester-II

BM421 MEDICAL IMAGING - II

Teaching Scheme	**Examination Scheme**
Lectures – 4 Hours/week**,** 4 Credits	**ESE -** 70 Marks
Practical - 2 Hours/week, 1 Credit	**ISE -** 30 Marks
	ICA - 25 Marks
	OE - 50 Marks

Course Objective:

1. To familiarize the learners with the various Imaging techniques in medicine operating principles and quality control aspects of various imaging modalities.
2. To keep the learners abreast with the technological developments in the field of Medical Imaging

Course Outcomes:

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

SECTION- I

Unit I: Computed Tomography (**9 Hrs**)

Principle of Computed tomography: Scanner configurations/generations, CT system: Scanning unit (gantry), detectors, data acquisition system, spiral CT, scanner parameters, CT Number tomography.

Unit II: Reconstruction techniques **(9 Hrs)**

Radon Transform, Filtered Back projection, Fourier Reconstruction Technique, Iterative reconstruction Technique, Image quality and artifacts, Clinical applications of CT

Unit III: Magnetic Resonance Spectroscopy (MRS) **(6 Hrs)**

Basic Principle of MRS and localization techniques, Chemical Shift Imaging, Single-voxel and Multivoxel MRS, Water Suppression techniques

SECTION-II

Unit IV: MDCT Magnetic Resonance Imaging **(10 Hrs)**

Multi-detector computed tomography, Flat panel detectors, CT-Angiography

Physics of MRI, Relaxation Parameters and Spin Echoes, Magnetic Field Gradients, Slice selection and Frequency Encoding, Pulse sequences

Unit V: Hardware: Magnets, Gradient systems, RF coils. **(8 Hrs)**
Safety Considerations/Biological Effects of MRI , Basics of Electrical Impedance Tomography

Unit VI: Fourier Reconstruction techniques and applications (6 Hrs)
Image contrast, Resolution and Factors affecting signal-to-noise, Hybrid Imaging modalities and its clinical application

Internal Continuous Assessment (ICA):
ICA shall consist of minimum Eight Experiments on above Syllabus.

Text Books

1. Christensen's Physics of Diagnostic Radiology, Lipimcott William, (willkins Publication)
2. Medical Imaging Physics William R. Hendee (Wiley-Liss Publication)

References

1. Biomedical Technology and Devices Handbook by James Moore George Zouridakis (CRC Press)
2. Biomedical Engineering Handbook by Bronzino (CRC Press)
3. Physics of Diagnostic Imaging –Dowsett

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

B.E. (Bio-medical Engineering) Semester-II
BM422 BIOMEDICAL MICROSYSTEMS

Teaching Scheme
Lectures – 4 Hours/week**,** 4 Credits

Examination Scheme
ESE - 70 Marks
ISE - 30 Marks
ICA - 25 Marks

Course Objective:
1. To understand various fabrication technology for MEMS devices.
2. To apply the knowledge of MEMS in Biomedical field.
3. To understand recent advancements in Biomedical Engineering for a successful career in the area of nanotechnology.

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

SECTION-I

Unit I: Overview Of Mems & Microsystem (4 Hrs)

MEMS & Micro systems - typical MEMS & Micro system products. Introduction to the world of microsystems. Description of the design and fabrication of microsystems. Integration of fabrication processes.

Unit II: Materials For Mems And Micro Systems (3 Hrs)
Introduction- Substrates and Wafers, Active Substrate Materials – silicon as a substrate Material, Silicon Compounds, Polymers- photo resists and Packaging Materials.

Unit III: Microsystems Fabrication Processes (8 Hrs)
Photolithography, Photo resist, Mask design, Additive Processes - deposition, Subtractive Processes - etching, Modifying – doping, annealing, curing .Thin Film Deposition: Spin-on Films, Physical Vapor Deposition (PVD), Chemical Vapor Deposition (CVD)

Unit IV: Micro machining And Micro-Molding Techniques (7 Hrs)
Bulk Micromachining, Surface Micromachining, High Aspect-Ratio Processes (LIGA), Polymer Micro/Nano Fabrication Rigid Mold: Micro contact Printing, Imprinting or hot embossing, Injection molding, Cast Molding (Replica Molding),Flexible Mold: Soft lithography

SECTION II

Unit V: Nano lithography And Nano patterning (02 Hrs)

Unit VI: Micro Total Analysis Systems (µTAS) (07 Hrs)
Components, Micro Fluidies and Fluid control components (channels, pumps, valves),µ-TAS: sample handling – (Micro actuators examples – micro valves, micro pumps, micro motors, Micro mixers, Micro activation methods), µ-TAS: separation components,µ-TAS: detection

Unit VII: Micro/ Nano Biosensors And Cell Chips (10 Hrs)
Classification of physical sensors, Integrated, Intelligent, or Smart sensors, Biosensing Principles and sensing methods, biosensors arrays and implantable devices, Cell handling and characterization systems, systems for biotechnology and PCR, polynucleotide arrays and genetic screening, microsurgical tools and microneedles

Unit VIII: Drug Delivery Microsystem Packaging (03 Hrs)
Micro Systems Packaging (Types) – Essential Packaging Technologies (Types)

Internal Continuous Assessment (ICA):
ICA shall consist of minimum eight Assignments on above Syllabus.

Text Books:

1. Marc Madou, "Fundamentals of Microfabrication" by, CRC Press, 1997.Gregory Kovacs.
2. "Micromachined Transducers Sourcebook" WCB McGraw-Hill, Boston, 1998.
3. Steven S. Saliterman, " Fundamentals of BioMEMS and Medical Microdevices", (SPIE Press Monograph Vol. PM153 by Wiley Interscience

Reference Books:

1. A. Manz and H. Becker, Eds. Microsystem Technology in Chemistry and Life Sciences Spronger-Verlag, New York, 1999. ISBN: 3-540-65555-7
2. Stephen D. Senturia, "Microsystem Design" by, Kluwer Academic Publishers, 2001.
3. M.-H. Bao, "Micromechanical Transducers: Pressure sensors, accelrometers, and gyroscopes" by Elsevier, New York, 2000.

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

B.E. (Bio-medical Engineering) Semester-II

BM423 TISSUE ENGINEERING

Teaching Scheme	**Examination Scheme**
Lectures – 4 Hours/week**,** 4 Credits	**ESE -** 70 Marks
	ISE - 30 Marks
	ICA - 25 Marks

Course Objective:

1. To Study the basics of Tissue Engineering
2. To Understand the Biology of Cell and Tissue Architecture

Course Outcome:

1. Understand the various tissue structures

SECTION-I

Unit I: Tissue Engineering (6 Hrs)

Introduction, basic principles and considerations, reconstruction of connective tissue, reconstruction of epithelial and endothelial tissue, bioreactor design in tissue engineering.

Unit II: Fluid Shear Stress Effects On Cellular Function (7 Hrs)

Introduction, devices and methodologies for in-vitro experiments, shear stress – mediated cell endothelium interactions, shear stress effects on gene regulation, mechanism of shear stress - induced gene regulation, gene therapy, and tissue engineering in vascular biology.

Unit III: Biology Of Stem Cell (4 Hrs)

Introduction, embryonic stem cell, control of stem cell development, adult stem cell, ageing of stem cell, other types of stem cells.

Unit IV: Cell Motility And Tissue Architecture (6 Hrs)

Introduction, directed motile responses in-vivo, engineering directed motile response in-vitro. Importance of Stromal Cells: Tissue composition and stromal cells, stromer cells as feeder layers, support of cultured cells using cell lines, stereotypic culture vs. monolayer culture.

Unit V: Tissue Engineering Of Bone Marrow (4 Hrs)

Biology of hematopoiesis, application of reconstituted ex-vivo hematopoiesis, history of hematopoietic cell culture development, challenges for scale- up, recapitulation.

SECTION –II

Unit VI: Tissue Engineering Of Liver (3 Hrs)

Background, hepatocyte transplantation systems, conclusions.

Unit VII: Tissue Engineering In Nervous System (4 Hrs)

Delivery of neuroactive molecules to the nervous system, tissue reconstruction nerve regeneration, in-vitro neural circuits and biosensors, conclusions.

Unit VIII: Tissue Engineering Of Skeletal Muscle (5 Hrs)
Introduction, skeletal muscle structure, skeletal muscle function, injury and repair of skeletal muscle, reconstructive surgery of skeletal muscle, myoblast transfer and gene therapy.

Unit IX: Tissue Engineering Of Cartilage (3 Hrs)
Scope, cell based approaches to cartilage tissue engineering, cell polymer bioreactor system, summary and future directions.

Unit X: Tissue Engineering Of Kidney (4 Hrs)
Introduction, fundamentals of kidney functions, tissue engineering formulation based upon fundamentals, clinical and economical implications.

Internal Continuous Assessment (ICA):
ICA shall consist of minimum eight Assignments on above Syllabus.

TEXT BOOKS:

1. The Biomedical Engineering Handbook- Volume II (2nd Edition) - by Joseph D. Bronzino, CRC/IEEE Press, 2000.
2. Biomechanics: Motion, Flow, Stress and Growth – by Y. C. Fung, Springer, Publications, 1990.

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

B.E. (Bio-medical Engineering) Semester-II

BM424A BIOMETRIC SYSTEMS

(ELECTIVE –II)

Teaching Scheme	**Examination Scheme**
Lectures – 4 Hours/week**,** 4 Credits	**ESE -** 70 Marks
	ISE - 30 Marks
	ICA - 25 Marks

Course Objectives:

1.To Understand the basics of Biometrics
2.To Understand the Algorithms to recognize the Biometric systems

Course Outcomes:

1.Explain the general principles of designing biometric-based systems.
2.Analyze various biometric systems, their characteristics and performance.
3.Discuss the online identification biometric techniques.
4.Recognize some of the personal privacy and security implications of biometrics based identification technology.
5.Analyze the privacy and security issues of biometrics.
6.Develop simple model of biometric system.

SECTION I

Unit I: Introduction to Biometrics **10 Hrs.**

Introduction, Identification Methods, Biometrics, Biometrics Technology Overview, Biometrics technologies: A Comparison, Automatic Identification, Research Issues – Acquisition, Representation, Feature Extraction, Matching, Search, Organization and Scalability, Privacy, Novel Applications.

Unit II: Finger Print Verification **8 Hrs**

Matching – Verification and Identification, Feature type, Image Processing and Verification, System Issues, Recognition Rate, Multi-modal Biometrics **Face Recognition:** Introduction, Approaches, The SHOSLIF.

Unit III Hand Geometry Base Verification **10Hrs**

Introduction, System Operation, Implementation Issues ,Applications .**Recognizing By Iris Patterns:** Introduction, Iris Patterns – Complex Phenotypic Features, Statistical Recognition Principle, Decidability of Iris Based personal Identification, Identification versus Verification, Stability of Iris Pattern Overtime

SECTION II

Unit IV: Retina Identification **9Hrs**

Retina/Choroid as Human Descriptor, Background, Technology, Eye Signature, RI Camera, Signal Acquisition and Computing Subsystem, System Operation, Performance. **Key stroke**

Dynamics Based Authentication: Introduction, Types of Security Attacks, Predicting Human Characteristics, Applications of Keystroke Dynamics using Interkey Times and Hold Times as Features.

Unit V Multimodal Biometrics **9Hrs**

Introduction, Decision Fusion, Experimental Results.

Biometrics: Identifying Law & Policy Concerns: Introduction, Definition and Advantages, Biometric Applications, Context of Biometrics, Privacy Concerns, Biometrics as Privacy's Foe Criticisms, Biometric Centralization vs. Biometric Balkanization.

Internal Continuous Assessment (ICA):

ICA shall consist of minimum eight Assignments on above Syllabus.

Text Books:

1."Biometrics, Personal Identification in Networked Society", Anil Jain, Ruud Bolle, Sharath Pankanti, Kluwer Academic Publishers, 2002

Reference Books:

1."Biometrics -Identity verification in a networked World", Samir Nanavathi, Michel Thieme, and Raj Nanavathi, Wiley Eastern, 2002.
2."Implementing Biometric Security", John Chirillo and Scott Blaul, Wiley Eastern Publications, 2005.
3."Biometrics for Network Security", John Berger, Prentice Hall, 2004.

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B.E. (Bio-medical Engineering) Semester-II

BM424B VIRTUAL INSTRUMENTATION DESIGN FOR MEDICAL SYSTEMS

(ELECTIVE –II)

Teaching Scheme	**Examination Scheme**
Lectures – 4 Hours/week**,** 4 Credits	**ESE -** 70 Marks
	ISE - 30 Marks
	ICA - 25 Marks

Course Objectives:

To impart adequate knowledge on Virtual Instrumentation for acquisition and analysis of signals in medical system

Course outcomes:

1.Learner will be able to educate about the Basic concepts of VI
2.Learner will be able to make them understand the programming concepts of VI.
3.Learner will be able to provide an insight to various Common Instrument Interface.
4.Learner will be able to enable them to implement VI in medical systems
5.Learner will be able to impart knowledge on various analysis tools

SECTION I

Unit I: Introduction To Virtual Instrumentation (VI) 08 Hrs.

Virtual instrumentation (VI): Evolution, Definition, Architecture- Conventional-, and Distributed- VI, Comparison of VI with traditional Instruments, Need of VI, advantages, block diagram, data flow techniques, graphical programming, Comparison between graphical programming and conventional programming, VI in engineering process.

Unit II: Programming Modes In VI 08 Hrs.

VI: front panel, Block diagram, LABVIEW Environment: Startup-, Shortcut-, and Pull down menu, Palletes, Control structures: FOR loop, WHILE loop, Shift Registers, feedback nodes, Selection Structures: Case and sequence structures, Formulae nodes, Arrays, Clusters, Waveform Chart and graph, XY Graph, Strings, Tables, File I/O functions.

Unit III: Hardware Aspects Of VI System 08 Hrs.

Digital I/O Techniques: pull-up and pull down resistors, TTL to solid state Relays, Voltage dividers, data acquisition in LABVIEW, hardware installation and configuration, Data acquisition (DAQ): Components, Accessories, Hardware, and Software.

SECTION II

Unit IV: Common Instrument Interface 08 Hrs.

Current loop:4-20mA,60mA, RS232, RS422, RS485, General purpose interface bus(GIPB) Virtual Instrument Software Architecture (VISA), Universal serial port bus(USB), Peripheral computer interface (PCl), VME extensions for instrumentation (VXI), PCI extensions for Instrumentation (PXI), Personal Computer Memory Card International Association (PCMCIA), Signal conditioning extension for instrumentation (SCXI).

Unit V: Analysis Tools And Applications Of VI **08 Hrs.**

Fourier transform, Power spectrum, Correlation, Windowing, filtering, Oscilloscope, Waveform generator, Multi-channel data acquisition using LABVIEW, ECG acquisition for long term monitoring of heart rate using VI

Internal Continuous Assessment (ICA):

ICA shall consist of minimum eight Assignments on above Syllabus.

TEXTBOOKS

1. Gary Jonson, "Labview Graphical Programming", Second Edition, McGraw Hill, New York, Fourth edition 2006.
2. Lisa K wells & Jeffrey Travis, "Labview for everyone", Prentice Hall Inc, New Jersey, First edition 1997.

REFERENCES

1. Gupta S J, Gu.pta P, "PC interfacing for Data Acquisition & Process Control", Instrument Society of America, Second Edition, 1994.
2 Technical Manuals for DAS Modules of Advantech and National Instruments.

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B.E. (Bio-medical Engineering) Semester-II
BM424C BIOMECHANICS PROSTHESIS AND ORTHOSIS
(ELECTIVE –II)

Teaching Scheme	**Examination Scheme**
Lectures – 4 Hours/week**,** 4 Credits	**ESE -** 70 Marks
	ISE - 30 Marks
	ICA - 25 Marks

Course Objectives:
1. To recall the general characteristics, mechanical properties of bone and tissues.
2. To analyze the forces at joints for various static and dynamic human activities; analyze the stresses and strains in biological tissues.
3. To understand principles used in designing orthoses and prostheses.
4. To study different materials used for orthoses and prosthesis.
5. To understand the fabrication of prostheses and orthoses.

Course Outcome:
1. Understand the definition of biomechanics, prostheses orthoses and its classification and design principles.
2. Develop a better understanding of how mechanical principles influence human motion during everyday life.

SECTION-I

Unit I: Force system: Classification of force system. Equilibrium of force system. **02 Hrs**

Unit II: Tissue Biomechanics: 12 Hrs

Direct shear, bending and torque actions and the corresponding stresses and strains in biological tissues. Stress relaxation and creep. Bone structure & composition, Mechanical properties of bone, Fracture mechanism & crack propagation in bones.Soft connective (skin, tendon, ligaments, etc.) covering structure function, and physiological factors.

Unit III: Movement Biomechanics: 06 Hrs

Study of joints and movements. Anatomical levers, Gait Analysis.

SECTION-II

Unit IV: Joint analysis: 06 Hrs

Instrumentation for gait analysis: Measurement devices-footswitches, instrumented walkway, Motion analysis- interrupted light photography, film/video, Selspot, Goniometers.

Unit V: Principles in designing orthoses and prostheses: 06 Hrs

Principles of three point pressure, total contact, partial weight bearing.

Unit VI: Classification in prosthetics and orthotics: 06 Hrs

Lower Extremity orthoses and prostheses, Upper Extremity orthoses and prostheses. Spinal orthoses.

Internal Continuous Assessment (ICA):
ICA shall consist of minimum eight Assignments on above Syllabus.

Text books:

1. Basic Biomechanics- Susan J. Hall, MC Graw Hill.
2. Basics of Biomechanics" by Dr. Ajay Bahl and others
3. Basic Biomechanics of the Musculoskeletal System,M. Nordin, V.Frankel
4. Human Limbs and their substitutes – Atlas, C. V. Mosby
5. American Atlas of Orthopedics: Prosthetics, C. V. Mosby.
6. American Atlas of Orthopedics: Orthotics, C. V. Mosby
7. Biomechanics - Prof Ghista (Private Publication UAE)
8. Biomechanics – By White and Puyator (Private Publication UAE)

Reference Books:

1.Introductory Biomechanics: from cells to tissues by Ethier and Simmons
2.Biomechanics: Mechanical properties of living tissues by Y. C. Fung