Course Structure
of
M.Tech (2 year), M.Tech + PhD
Dual Degree
in
Biomedical Engineering
and
Syllabi of Courses

Proposed Course Structure for M.Tech. (2 year), M.Tech. + Ph.D. Dual Degree in Biomedical Engineering from AY 2023-2024

Scope of the Program:

The M.Tech. program in Biomedical Engineering is designed for providing students with outstanding and higher fundamental education coupled with applied research to pursue their career in Biomedical Engineering. These students will be an asset to biomedical research industries/institutions and teaching organizations with outstanding technical expertise in interdisciplinary domains. The structure of this program is to give a holistic perspective and to provide a blend of industry and research-orientated courses encompassing all important facets of Biomedical Engineering. High quality, engaging career-based postgraduate education, rigorous fundamental-applied curriculum, and contemporary delivery in terms of teaching, assignments, term projects, and conducting labs. High quality applied and translational research will result in excellent advanced research training, connecting deeply with industry, in turn enhancing the quality of research.

Minimum Educational Qualification (MEQ) (For Indian applicants):

1. Four-year Bachelor's degree or MSc or five-year integrated degree (with the first division as defined by the awarding Institute/University) in Biomedical Engineering/Biotechnology/Life Sciences/Instrumentation Engineering/ Electrical Engineering/ Mechanical Engineering/ Engineering Sciences
2. Two-year M.Sc. or five-year integrated degree (with the first division as defined by the awarding Institute/University) in Biotechnology/ Life Sciences/ Physics/ Chemistry.
3. MBBS (Medicine) /BDS (dental).

Minimum Educational Qualification (MEQ) (For International applicants): Four-year Bachelor's degree or five-year integrated degree (with the first division as defined by the awarding Institute/University) in Biomedical Engineering/ Instrumentation Engineering/ Electrical Engineering/ Mechanical Engineering/ Engineering Sciences/ Biotechnology/ Life Sciences/ Physics/ Chemistry.

Qualifying Examination (QE):

(a) International applicants: Valid GRE and TOEFL or IELTS score

(b) Indian applicants: Valid GATE qualification in qualifying degrees.

Categories of Admission:

(a) International applicants: (i) International self-financed **(ISF)** students; (ii) International students sponsored by non-government organizations or by a reputed industry **(ISW)**; (iii) International students sponsored by foreign government or its organizations or through mutual collaborative programs of India with other countries **(GSW)**

(b) Indian applicants: Teaching Assistantship **(TA)**; (ii) Highly motivated sponsored candidate **(SW)** on full-time basis from highly reputed R and D organizations such as DRDO, ISRO, BHEL, C-DAC, ADE, ADA, etc. and highly reputed Industries; (iii) Defense Forces **(DF)**: Candidates sponsored by the Defense Forces; (iv) Regular Institute Staff **(IS)** of IIT Indore on part-time basis only.

Candidates of SW, DF and IS categories will not be provided any scholarship.

Selection Criteria: Admission would be based on GATE score, personal interview and/or the written examination.

Duration of the Program: Two years full-time.
Total Intake: 10 (TA).

Scholarship (only for TA category Indian students): As per MoE norms.

Course Structure for two-year Full-time M.Tech (Biomedical Engineering) Program

1st Year: Semester-I

Course code	Course Title	Contact Hours (L-T-P)	Credits
BSE 614*	General Physiology	2-1-0	3
BSE 6XX	Biomaterials and Nano-biotechnology	2-1-0	3
BSE 6XX	Bioelectronics and Biomedical Sensors	2-1-0	3
BSE 6XX	Tissue Engineering and Regenerative Medicine	2-1-0	3
BSE 6XX	Experimental Techniques Laboratory-1	0-0-4	2
ZZ XXX	Elective-I	2-1-0	3
Total minimum credits earned during the semester			**17**
Additional course (as per the requirement basis)			
HS 641*	English Communication Skills	2-0-2	PP/NP

1st Year: Semester-II

Course code	Course Title	Contact Hours (L-T-P)	Credits
BSE 6XX	Biomedical Instrumentation	2-1-0	3
BSE 6XX	Mechanobiology and Electrophysiology	2-1-0	3
BSE 624*	Bioprocess Engineering and Technology	2-0-4	4
BSE 698/798	PG Seminar Course	0-2-0	2
ZZ XXX	Elective-II	2-1-0	3
ZZ XXX	Elective-III	2-1-0	3
Total minimum credits earned during the semester			**18**

2nd Year: Semester–III

Course code	Course Title	Contact Hours (L-T-P)	Credits
BSE XXX	M.Tech. Research Project (Stage–I)	0-0-36	18
Total minimum credits to be earned during the semester			**18**

2nd Year: Semester–IV

Course code	Course Title	Contact Hours (L-T-P)	Credits
BSE XXX	M.Tech. Research Project (Stage–II)	0-0-36	18
Total minimum credits to be earned during the semester			18
Total minimum credits to be earned during the program			**71**

** Already existing course*

Courses for Elective I-II[@]

Course code	Course Title	Contact Hours (L-T-P)	Credits
BSE 628*	Genomics and Proteomics	2-1-0	3
BSE 604/404*	Biomedical Imaging	2-1-0	3
BSE 625*	Emerging Technologies	2-1-0	3
BSE 605*	Molecular Biophysics	2-1-0	3
BSE 608*	Advanced Drug Delivery Systems	2-1-0	3
BSE 702*	Applied Genetic Engineering	2-1-0	3
BSE 618*	Bioinformatics	2-0-2	3
BSE 617*	Biomolecular Modeling	2-1-0	3
BSE 631*	Bio-entrepreneurship, IPR, Biosafety and Bioethics	2-1-0	3
BSE 606*	Molecular Virology and Viral Pathogenesis	2-1-0	3
BSE 6XX	Biomedical Microsystems	2-1-0	3
BSE 6XX	Biofabrication	2-1-0	3

* *Already existing course*

[@]In addition to this course list, a student can also opt from the PG courses being offered by the other disciplines**.**

NOTE: 1. Request for conversion from M.Tech to M.Tech + PhD dual degree will be considered after evaluating the research potential of the promising and motivating PG students at the end of the **third semester of their program.** The confirmation to PhD program in FA category will be subject to successfully qualifying CSIR/UGC-JRF or equivalent fellowship.

2. If the student opts for Dual Degree Programme but cannot complete the requirements of a PhD, an **exit option** with the M.Tech degree can be earned at the end of the final semester of the normal M.Tech programme by getting the M.Tech research project examined in the standard manner as per the requirements for the award of an M.Tech degree.

3. The enhancement in the scholarship, if any, from MTech to PhD will be from the beginning of the fifth semester or from the date on which all requirements for the award of MTech degree are fulfilled, whichever is later**.**

1.	Course Code	**BSE 6XX**
2.	Title of the Course	**Biomaterials and Bio-nanotechnology**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Course Category	Core
5.	Name of the Concerned Department	Biosciences and Biomedical Engineering
6.	Pre–requisite, if any	Nil
7.	Scope of the course (Objective)	To develop understanding of nano-materials and biomaterials for applications in biomedical engineering
8.	Course outcomes	● Knowledge of fundamental principles of biomaterial science and bionanotechnology ● Multidisciplinary approach to biomaterial design and properties
9.	Course Syllabus	Introduction: Cellular nanostructures, Multilayer Thin Film: Polyelectrolyte multilayers Colloidal nanostructures, characterization, Therapeutic and diagnostic nano-carriers like solid lipid nanoparticles, biopolymeric nanoparticles, carbon nanotubes, polymeric nanofibers, quantum dots, magnetic nanoparticles and gold nanostructures Stimuli responsive materials, in situ gels, nanocomposites, self-assembly to form coated colloids and smart capsules. Biomaterials classification, Cell-Material Interactions, Protein Adsorption, Implant rejection, inflammation and foreign body response, Implant Infection Testing of biomaterials - Biocompatibility, Biodegradation, Mechanical properties. Tissue engineering, regenerative biomaterials, diagnostic and biomedical devices applications of biomaterials
10.	Suggested Books	Text Books: 1. Ratner B D, Hoffmann A S, Schoen F J, Lemons J E. Biomaterials science: An introduction to materials in medicine, 3rd Edition, Academic Press, 2013, | ISBN: 9780080470368] 2. David S. Goodsell, Bio-nanotechnology: Lessons from Nature; Wiley-Liss, 2004 [ISBN: 978-0-471-41719-4] 3. Neelina H. Malsch, Biomedical Nanotechnology, CRC Press, 2005, [ISBN: 9780824725792] 4. Challa Kumar, Nanotechnologies for the Life Sciences, Vol 2, Biological and pharmaceutical nanomaterials; Wiley-VCH, 2006, [ISBN: 978-3-527-33114-7] Reference Books: 5. Basu B, Katti D and Kumar A. Advanced Biomaterials: Fundamentals, Processing and Applications, Wiley, 2009, ISBN: 978-0470193402. 6. Gero Decher, Joseph B. Schlenoff, Multilayer Thin Films;Sequential Assembly of Nanocomposite Materials Wiley-VCH Verlag GmbH, 2012, [ISBN: 9783527316489]

1.	Course Code	**BSE 6XX**
2.	Title of the course	**Mechanobiology and Electrophysiology**
3.	Course category	**Core**
4.	Credit Structure	L-T-P-Credits 2-1-0-3
5.	Name of the Concerned Department	Biosciences and Biomedical Engineering
6.	Pre–requisite, if any	None
7.	Scope of the course	The course will focus on how mechanical forces influence cell behavior through physical and biochemical mechanisms. The objective includes integrating engineering and cell biology to solve biomedical problems.
8.	Course outcomes	After completing this course, students should be able to • Propose mechanical tests for the characterization of biological tissues and fluids • Develop physical models of living systems • Specify the role of mechanics in a particular physiological or pathological process
9.	Course Syllabus	**Mechanobiology**: Introduction to mechanobiology, Cell architecture, Extracellular matrix, Cellular interactions with biomaterials, Mechanics of receptor binding, Arterial wall stress/strain analysis, Fluid mechanobiology, Mechanosensors, Mechanotransduction - whole cell and nanoscale analysis, Mechanical regulation of cell fate, Cytoskeletal dynamics and mechanics, Viscoelasticity, Mechanical testing of cells, Cellular forces, Microelectromechanical systems (MEMS) tools. **Electrophysiology**: Introduction to electrophysiology, Current-voltage curves for voltage-gated ion channels, Goldman equation. Input resistance: theory, measurement, inferencing. Applications to skeletal and smooth muscle. Extensions of cable theory, Electrical models of neurotransmission in neurons, skeletal muscle and smooth muscle. Modeling of synaptic potentials, Special properties of syncytial tissues, Ca dynamics: components of Ca flux. Computational modeling.
10.	Suggested Books	Text Book 1. Rawlinson, S. C. F. Mechanobiology: Exploitation for Medical Benefit, Wiley-Blackwell, 1st Ed., 2017 | ISBN-13: 978-1118966143. 2. Rettinger, J., Schwarz, W. Electrophysiology: Basics, Modern Approaches and Applications, Springer International Publishing AG, 1st Ed., 2016 | ISBN-13:978-3319300115. Reference Book 3. Chien, S., Engler, A. J., Wang, P. Y. Molecular and Cellular Mechanobiology, Springer-Verlag New York Inc, 1st Ed., 2016 | ISBN-13: 978-1493981663. 4. Steinberg, J. S., Mittal, S. Electrophysiology: The Basics, Lippincott Williams and Wilkins, 2nd Ed., 2017 | ISBN-13: 978-1496340016.

1.	Course Code	**BSE 6XX**
2.	Title of the Course	**Bioelectronics and Biomedical Sensors**
3.	Course Category	**Core**
4.	Credit Structure	L-T-P-Credits 2-1-0-3
5.	Name of the Concerned Department	Biosciences and Biomedical Engineering
6.	Pre–requisite, if any	Nil
7.	Course Objective	To know about different bioelectronic devices and their mechanisms towards mode of analyte detection
8.	Course Outcomes	• Students will demonstrate knowledge and concepts which are competitive for application in bioelectronics • Students will demonstrate an ability to analyze, formulate and solve problems related to Bioelectronics devices and system design
9..	Course Syllabus	**Introduction:** Bioelectronics, Bioelectronics sensor, Systems biology and synthetic biology, review of Kirchoff's laws **Electrodes, Sensors and transducers**: sensor/actuators, transducers-resistance temperature detector, linear variable differential transformer, strain gauge, piezo electric transducers. **Bio-potential electrodes**: electrode-electrolyte interface, polarization, polarizable and nonpolarizable electrodes, electrode behavior and circuit models, body surface recording electrodes, internal electrodes, micro and macro electrode. **Bio-electric amplifier**: basic requirements for biological amplifiers, various types of bio amplifiers and their applications **Biosensors**: Introduction to biosensors and classification. Transduction mechanisms and recognition layers. Sensor characteristics: linearity, repeatability, hysteresis, drift; **Sensors for measurement of chemicals:** potentiometric, ion selective electrodes; Amperometric, optical biosensors, immunosensors. **Sensors for physical measurands:** mechanical (micro-cantilever, piezoelectric etc.), Thermal sensors. strain, force, pressure, acceleration, flow, volume, measurands temperature and biopotentials. Analytical modelling of biosensors.
10.	Suggested Books	**Text book** 1. D. D. Reddy, O. M. Hussain, D. V. R. S. Gopal, D. M. Rao, K. S. Sastry, Biosensors and Bioelectronics, I. K. International Publishing House Pvt. Ltd, 2012 | ISBN-13: 978-9382332190. 2. R.S. Marks, C. R. Lowe, D. C. Cullen, H. H. Weetall, I. Karube, Handbook of biosensors and biochips, John Wiley, 2007 [ISBN: 978-0-470-01905-4] **Reference book** 3. Tran Minh Canh, Biosensors, Chapman and Hall, London 1993, [ISBN: 978-0-412-48190-1] 4. D. G. Buerk, Biosensors: theory and applications Lancaster: Technomic Publications, 1993, [ISBN: 9780877629757] 5. Albert Szent-Györgyi, Bioelectronics: A Study in Cellular Regulations, Defense, and Cancer, Academic Press, 2014 | ISBN-13: 978-1483247267

1.	**Course Code**	**BSE 6XX**
2.	**Title of the Course**	**Tissue Engineering and Regenerative Medicine**
3.	**Course Category**	**Core**
4.	Credit Structure	L-T-P-Credits 2-1-0-3
5.	Name of the Concerned Department	Biosciences and Biomedical Engineering
6.	Pre–requisite, if any	Nil
7.	Scope of the Course	This course is designed to teach the basics and the details of tissue engineering and regenerative medicine. This course will also introduce the students with an overall strategic approach to solve the clinical problems.
8.	Course Outcomes	● Develop skills and knowledge in tissue engineering and regenerative medicine ● Identify challenges and formulate tissue engineering solutions for unmet clinical needs
9.	Course Syllabus	Introduction: History and scope of tissue engineering, basis for cell growth and differentiation, molecular biology of the cell, Cell-extracellular matrix (ECM) interactions, morphogenesis and tissue engineering Engineering functional tissues in vitro, bioreactor design for tissue engineering, regulation of cell behavior by ECM proteins and growth factors, mechanobiology, tissue development and organ engineering, *In vivo* synthesis of tissues and organs Biomaterials in tissue engineering – cell interaction with polymers, polymer scaffold fabrication, biodegradable polymers, 3D scaffold design, role of host immune response in tissue engineering and regenerative medicine Stem cells in tissue engineering, gene therapy, Applications in Cardiovascular, Hepatic, Musculoskeletal, Neural, Ophthalmic, Dental and Maxillofacial tissue engineering
10.	Suggested Books	**Text Books:** 1. Robert Lanza, Robert Langer, Joseph Vacanti, Principles of Tissue Engineering, (4th Edition), Academic Press, Boston, [ISBN-10: 0123983584 | ISBN-13: 978-0123983589] **Reference Books:** 2. Robert Lanza (Editor), Anthony Atala (Editor), Essentials of Stem Cell Biology, (3rd Edition), Academic Press, Boston. [ISBN-10: 0124095038 | ISBN-13: 978-0124095038] 3. David Warburton, Stem Cells, Tissue Engineering and Regenerative Medicine, World Scientific, 2015. [ISBN: 978-9814612777

1.	Course Code	**BSE 6XX**
2.	Title of the Course	**Experimental Techniques Laboratory**
3.	Course category	**Core**
4.	Credit Structure	L-T-P-Credits 0-0-4-2
5.	Name of the Concerned Department	Biosciences and Biomedical Engineering
6.	Pre–requisite, if any	Nil
7.	Course Objective	To gain hands on experience of different experimental methods used in different domains of biomedical engineering area.
8.	Course outcomes	At the end of the course, students will have practical experience on techniques and instrumentation in biomedical engineering domain
9.	Course Syllabus	1. Fabrication of Nanoparticles, Microspheres, and Liposomes, morphological characterization, Drug/molecule encapsulation efficiency measurement, and release testing 2. Imaging of biological specimen (cells, bacteria, etc.) using fluorescence staining and unstaining methods, physical parameter extraction from images. 3. Computer-aided design (CAD) using SolidWorks software, extrusion 3D bioprinting and prototyping: 3-D printed biomaterial scaffold development and evaluation 4. Tensile, compression, and flexure testing of biomaterials 5. Enzyme encapsulation and activity assay 6. Cell culture evaluation of nanoparticles for uptake and compatibility. 7. Protein and Nucleic Acid sequence analysis using web servers 8. Computer-aided drug design targeting a receptor protein 9. Nucleic acid based detection using polymerase chain reaction. 10. Biomedical Sensors development and characterization
10.	Suggested References	1. Sambrook J and Russell D, Molecular Cloning: A Laboratory Manual. CHSL Press, 2001, ISBN: 978-0879695767 2. Walsh G.: Proteins: Biochemistry and Biotechnology. Wiley India Pvt Ltd, 2011, ISBN: 978-8126530274

1.	Course Code	**BSE 6XX**
2.	Title of the Course	**PG Seminar Course**
3.	Credit Structure	L-T-P-Credits 0-2-0-2
4.	Name of the Concerned Department	Biosciences and Biomedical Engineering
5.	Pre–requisite, if any	Nil
6	Course Objective	To develop confidence and presentation skills of the student
7.	Course Syllabus	In this course a PG student has to present seminar/presentation or a series of presentations on a topic(s) chosen by him/her in consultation with his/her PG Thesis Supervisor/ Faculty Advisor. The frequency of seminar/presentation will be decided by the Course Coordinator.
8.	Suggested Books	Books and research publications in various relevant journals/conference proceeding, etc.

1.	Course Code	**BSE 6XX**
2.	Title of the Course	**Biomedical Instrumentation**
	Course Category	**Core**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Biosciences and Biomedical Engineering
5.	Pre–requisite, if any	Nil
6	Course Objective	This course is designed to provide an overview of the clinically used biomedical Instrumentation for disease diagnosis and treatment.
	Course outcomes	After completing this course students will a) be introduced with different biomedical instruments and their applications b) learn the different signal acquisition modalities in biomedical instruments and will learn their mechanism/science
7.	Course Syllabus	Cell resting potential and action potentials, Origin of bioelectric potentials – frequency and amplitude characteristics, for biomedical applications such as Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG), etc. Electrodes and transducers. Electrode-electrolyte interface, Electrode–skin interface, Types of electrodes, Polarizable and non-polarizable electrodes. Principles of diagnostic and therapeutic Equipment: Blood pressure monitors, Pulse Oximeter, pH meter, Pacemakers, Defibrillator, Nerve and muscle stimulators, Dialysis machines, Nebulizer, inhalator, Aspirator, Humidifier, Ventilator and spirometry, etc. Medical imaging techniques: Diagnostic radiology – X-ray radiography, Computed Tomography (CT), Physics of radioactivity and its application in nuclear imaging. Single photon emission (SPECT), Positron emission tomography (PET). Principle of NMR and its biomedical application, Magnetic resonance imaging (MRI). Physics of Ultrasound waves, Doppler effect, Ultrasonography.
8.	Suggested Books	**Text book:** 1. R S Khandpur, “Handbook of Biomedical Instrumentation”, 3rd ed., Tata McGraw Hill Publishing Company Limited, 2014, ISBN (13): 978-93-392-0543-0 **Reference books:** 2. J G Webster, “Medical Instrumentation: Application and Design”, 4th ed. John Wiley & Sons, 2015, ISBN: 978-8126553792 3. W R Hendee, E R Ritenour, “Medical Imaging Physics”, 1st Ed, Wiley-Liss, 2002, ISBN: 9780471382263 4. C Guy, D ffytche, An Introduction to The Principles of Medical Imaging, Imperial College Press, 2008, ISBN: 9781860945021

1.	Course Code	**BSE 6XX**
2.	Title of the Course	**Biofabrication**
	Course Category	**Elective**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Biosciences and Biomedical Engineering
5.	Pre–requisite, if any	Nil
6	Course Objective	This course will provide an overview of biofabrication methods as applicable for tissue engineering and regenerative medicine
	Course Outcomes	● Students will know various biofabrication methods with a special emphasis on 3D Bioprinting ● Demonstration and hands-on-training for select biofabrication methods
7.	Course Syllabus	Biofabrication history and definition, scaffold free biofabrication, organic and inorganic materials, hydrogels, synthetic and natural extracellular matrix (ECM), surface functionalization, topography and porous scaffolds for biofabrication Conventional scaffold fabrication methods - electrospinning, phase separation, gas foaming, freeze drying, etc. 3D Bioprinting essentials of cell and protein viability, software for design of 3D print construct, Bioinks - polymers, hydrogels and ECM derived, Types of Bioprinters - extrusion, droplet and laser-assisted, Applications of 3D Bioprinting, Organ Printing
8.	Suggested Books	**Text Books:** 1. Aurelien Forget. Biofabrication, Berlin, Boston: De Gruyter, 2023. [ISBN - 9781501515736] 2. Ibrahim T. Ozbolat. 3D Bioprinting: Fundamentals, Principles and Applications, 2016, Academic Press, Boston, [ISBN: 9780128030301] **Reference Books:** 3. Anthony Atala (Author), James J Yoo (Author), Essentials of 3D Biofabrication and Translation, (First edition), Academic Press, Boston. [ISBN-10: 0128009721 | ISBN-13: 978-0128009727] 4. Gabor Forgacs, Wei Sun (Eds). Biofabrication: Micro- and Nano-fabrication, Printing, Patterning and Assemblies, 2013, Elsevier [ISBN: 978-1-4557-2852-7]

1.	Course Code	**BSE 6XX**
2.	Title of the Course	**Biomedical Microsystems**
3.	Course category	**Elective**
4.	Credit Structure	L-T-P-Credits 2-1-0-3
5.	Name of the Concerned Department	Biosciences and Biomedical Engineering
6..	Pre–requisite, if any	Nil
7.	Course Objective	To develop an understanding of different types, working, and functions of different biomedical instruments.
8.	Course outcomes	• Enable learning on concepts of miniaturization of biomedical devices • Design and evaluation of fluid flow in microfluidic devices
9.	Course Syllabus	Introduction; Photolithography; Crystallography, Mask Design Wet, and Dry Etching, Thin Film Deposition and Growth Electroplating, Molding, LIGA, Bonding and Sacrificial Processes, Polymer Processing, and Rapid Prototyping, Micro Total Analysis Systems (μ-TAS): Fluid Control Components, Sample Handling, Separation Components, Detection, Cell Handling, and Characterization Systems Miniature Biosensors, Biosensor Arrays and Implantable MEMS Devices, Neural Interfaces, Microsurgical Tools, Microneedles, Drug Delivery, Miniature Bioreactors, and Microsystems for Tissue Engineering BioMEMS: Evolution, Applications, Traditional MEMS, Polymeric materials for MEMS, Microfluidic microsystems, Packaging of Microfluidic and Optical Systems, Nanotechnology, Metrology, Built-in safety features for medical instruments.
10.	Suggested Books	**Text Books:** 1. Marc J. Madou, Fundamentals of Microfabrication: The Science of Miniaturization, Second Edition, CRC Press; 2nd edition, 2002 [ISBN: 9780849308260] 2. Ellis Meng, Biomedical Microsystems 1st Edition, CRC Press, 2010, [ISBN-13: 978-1420051223] **Reference Books:** 1. Swarup Bhunia *et. al.*, Implantable Biomedical Microsystems: Design Principles and Applications, 1st Edition, Elsevier, 2015, [ISBN: 9780323262088] 2. R.S. Khandpur, Handbook of Biomedical Instrumentation, McGraw Hill Education Pvt. Ltd. 3rd Edition, 2014, [ISBN: 9789339205430] 3. J.G. Webster (Ed.): Medical Instrumentation - Application and Design; Houghton Mifflin Co., Boston, 1992, [ISBN: 978-0471676003]