UNIVERSITY OF MUMBAI

Bachelor of Biomedical Engineering

Third Year Engineering

Sem. VI

Revised course (Rev- 2012)

From Academic Year 2014 -15

Under

FACULTY OF TECHNOLOGY

(As per Semester Based Credit and Grading System)

Syllabus Scheme for T.E. Semester VI Biomedical Engineering

Sub Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Pract.	Tut	Theory	Pract.	Tut	Total
TEBM601	Biomedical Instrumentation –II	4	2	-	4	1	-	5
TEBM602	Biostatistics	4	-	1	4	-	1	5
TEBM603	Biological Modeling and Simulation	3	2	-	3	1	-	4
TEBM604	Microcontrollers and Embedded Systems	4	2	-	4	1	-	5
TEBM605	Medical Imaging –I	4	2	-	4	1	-	5
TEBM606	Digital Image Processing	4	2	-	4	1	-	5
	TOTAL	**23**	**10**	**1**	**23**	**5**	**1**	**29**

Sub Code	Subject Name	Examination scheme							
		Theory Marks				Term work	Pract.	Oral	Total
		Internal Assessment			End Sem exam				
		Test 1	Test 2	Avg.					
TEBM601	Biomedical Instrumentation –II	20	20	20	80	25	25	-	150
TEBM602	Biostatistics	20	20	20	80	25	-	-	125
TEBM603	Biological Modeling and Simulation	20	20	20	80	25	-	25	150
TEBM604	Microcontrollers and Embedded Systems	20	20	20	80	25	-	25	150
TEBM605	Medical Imaging –I	20	20	20	80	25	-	25	150
TEBM606	Digital Image Processing	20	20	20	80	25	50*	-	175
TOTAL				**120**	**480**	**150**	**75**	**75**	**900**

*Both Practical and Oral examination

Sub Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Pract.	Tut	Theory	Pract.	Tut	Total
TEBM601	Biomedical Instrumentation-II (abbreviated as BMI-II)	4	2	-	4	1	-	5

Sub Code	Subject Name	Examination scheme							
		Theory Marks				Term work	Pract.	Oral	Total
		Internal Assessment			End Sem exam				
		Test 1	Test 2	Avg.					
TEBM601	Biomedical Instrumentation-II	20	20	20	80	25	25	-	150

Course Objectives	The day by day rising cost of medical diagnosis has created a thrust for point of care diagnostic tools. There is well laid network of various communication channels. Students will be able to understand the basic principle of generation of various bioelectric signals, their non-invasive capture, recording, transmission and various issues involved. Further with some examples it builds the design perspective for low cost point of care devices which is the need of an hour
Course Outcomes	Students will demonstrate the principles of electronics used in designing various diagnostic equipments. Students will be able to understand the working principle and applications of various diagnostic equipments. Students who can participate and succeed in competitive exams.

Module	Contents	Time
1.	**Generation of Bioelectric Potentials:** Basic cell physiology, Nerve, Muscle, Pacemaker and Cardiac muscle	05
2.	**Biophysical signal capture, processing and recording systems (with technical specifications):** Typical medical recording system and general design consideration. Sources of noise in low level recording circuits and their removal techniques. ECG, EMG, EEG, Electrode placement and Measuring techniques for EOG, ERG and Phonocardiography. Measurement of skin resistance. **Biofeedback Technique:** EEG, EMG	13
3.	**Patient Monitoring System:** Measurement of Heart Rate, Pulse rate, Blood pressure, Temperature and Respiration rate, Apnea Detector. Electrical Safety in Biophysical Measurements. Heart rate variability measurement and applications.	10
4.	**Arrhythmia and Ambulatory Monitoring Instruments:** Cardiac Arrhythmias, waveforms and interpretation from them. Stress test measurement.	08

	Ambulatory monitoring instruments-Holter monitor **Point of care devices and their design considerations for homecare devices:** glucometer (kidney function), disposable lung function test.	
5.	**Foetal and Neonatal Monitoring System:** Cardiotocograph, Methods of monitoring of Foetal Heart rate , Incubator and Infant warmer. Non stress test monitoring.	06
6.	**Biotelemetry, Telemedicine concepts and its application**	06

Text books:

1. Handbook of Biomedical Engineering by R.S. Khandpur, PHI
2. Medical Instrumentation, Application and Design by J.G. Webster, TMH.
3. Introduction to Biomedical Equipment Technology by Carr.-Brown (Pearson Education Pub)
4. Introduction to Biomedical Engineering by J Bronzino

Reference Books:

1. Encyclopaedia of medical devices and instrumentation - J.G. Webster Vol I, II, III, IV (John Willey).
2. Principles of applied Biomedical Instrumentation by Geddes and Becker, Wiley interscience publication.
3. Principles of Biomedical Instrumentation and Measurement by Richard Aston
4. Various Instruments Manuals.
5. Various internet resources.

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the tests will be considered for final Internal Assessment.

End Semester Examination:

Question paper will comprise of 6 questions, each carrying 20 marks.
The students need to solve total 4 questions.
Question No.1 will be compulsory and based on entire syllabus.
Remaining question (Q.2 to Q.6) will be selected from all the modules.

Term Work:

Term work consists of minimum eight experiments. The distribution of the term work shall be as follows:

Laboratory work (Experiments and Journal) :15 marks
Attendance (Practical and Theory) :10 marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and completion of journal. Term work assessment must be based on the overall performance of the student.

Sub Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Pract.	Tut	Theory	Pract.	Tut	Total
TEBM602	Biostatistics (abbreviated as BST)	4	-	1	4	-	1	5

Sub Code	Subject Name	Examination scheme							
		Theory Marks				Term work	Pract.	Oral	Total
		Internal Assessment			End Sem exam				
		Test 1	Test 2	Avg.					
TEBM602	Biostatistics	20	20	20	80	25	-	-	125

Course Objectives	To cover basic concepts and theory related to statistics
Course Outcomes	Students will be able to apply statistical methods to biomedical data

Module	Contents	Time
1.	Descriptive statistics and probability Frequency distribution, Measures of central tendency, Measures of dispersion Basic probability and Bayes theorem.	04
2.	Probability and Sampling Distributions Discrete probability distributions Continuous probability distributions - Binomial, poisson and normal distributions Sampling distributions – sample mean, difference between two sample means, sample proportions, difference between two sample proportions	10
3.	Estimation t- distribution Confidence intervals for - population mean, difference between two population means, population proportion, difference between two population proportions, variance of normally distributed population, ratio of variances of two normally distributed populations Determination of sample size for estimating mean and proportions	07
4.	Hypothesis testing Hypothesis testing for – Population mean, difference between two population means, population proportions, difference between two population proportions, population variance, ratio of two population variances Type – I and II error and power of test	07
5.	Analysis of variance Completely randomized design, Randomized complete block design, repeated measures design, factorial experiment. Regression and Correlation Simple linear regression, correlation model, correlation coefficient, multiple	13

	regression, multiple correlation	
6.	Chi square distribution and analysis of frequency Chi-square distribution – properties Test of goodness of fit, independence and homogeneity	07

List of Tutorials:

1. Descriptive statistics and probability
2. Discrete probability distributions
3. Continuous probability distributions
4. Sampling distributions
5. Estimation
6. Hypothesis testing
7. Analysis of variance
8. Regression and Correlation
9. Chi square distribution and analysis of frequency

Text books:

1. Biostatistics – A foundation for analysis in health sciences by Wayne W. Daniel, Seventh edition, Wiley India
2. Fundamentals of mathematical statistics by S. C. Gupta and V. K. Kapoor, second edition, Sultan Chand Publisher
3. Probability and statistics for engineers by J. Ravichandran, Wiley /india
4. Biostatistics – How it works by Steve selvin, Pearson education
5. An Introduction to Biostatistics by Sunder Rao and J. Richard, Third Edition, Prentice Hall of India
6. Probability and Statistics by Schaum's series

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the tests will be considered for final Internal Assessment.

End Semester Examination:

Question paper will comprise of 6 questions, each carrying 20 marks.
The students need to solve total 4 questions.
Question No.1 will be compulsory and based on entire syllabus.
Remaining question (Q.2 to Q.6) will be selected from all the modules.

Term Work:

At least 08 tutorials covering entire syllabus must be given during the '**class wise tutorial'**. The tutorials should be students' centric and meaningful, interesting and innovative.

The distribution of the term work shall be as follows,
Tutorials :15 marks
Attendance (Tutorial and Theory) :10 marks
The final certification and acceptance of term-work ensures the satisfactory performance in tutorial. Term work assessment must be based on the overall performance of the student.

Sub Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Pract.	Tut	Theory	Pract.	Tut	Total
TEBM603	Biological Modeling and Simulation (abbreviated as BMS)	3	2	-	3	1	-	4

Sub Code	Subject Name	Examination scheme							
		Theory Marks				Term work	Pract.	Oral	Total
		Internal Assessment			End Sem exam				
		Test 1	Test 2	Avg.					
TEBM603	Biological Modeling and Simulation	20	20	20	80	25	-	25	150

Course Objectives	To make students understand basic concepts of modeling which will help them develop biological model and simulate physiological processes for better understanding.
Course Outcomes	The students will be able to design hardware and develop software for various biomedical systems. Students will learn to use various simulation software for modeling biological systems.

Module	Contents	Time
1.	**Physiological Modeling**: Steps in Modeling, Purpose of Modeling, lumped parameter models, distributed parameter models, compartmental modeling, modeling of circulatory system, regulation of cardiac output and respiratory system.	04
2.	**Model of Neurons:** Biophysics tools, Nernst Equation, Donnan Equilibrium, Active Transport (Pump) GHK equation, Action Potential, Voltage Clamp, Channel Characteristics, Hodgkin- Huxley Conductance Equations, Simulation of action potential, Electrical Equivalent model of a biological membrane, impulse propagation- core conductor model , cable equations.	11
3.	**Neuromuscular System:** modeling of skeletal muscle, mono and polysynaptic reflexes, stretch reflex, reciprocal innervations, two control mechanism, Golgi tendon, experimental validation, Parkinson's syndrome.	06
4.	**Eye Movement Model:** Four eye movements, quantitative eye movement models, validity criteria.	06
5.	**Thermo regulatory systems:** Thermoregulatory mechanisms, model of thermoregulatory system, controller model, validation and application.	03
6.	**Modelling of other physiological systems.** **Modelling the Immune response:** Behavior of the immune system, linearized model of the immune response.	06

	Modelling of Drug delivery systems. **Modelling of Insulin Glucose feedback system** and Pulsatile Insulin secretion	

List of Experiments/Assignments:

Experiments can be carried out using any of these softwares.

1. Simulations using MATLAB
2. Simulations using HHSim
3. Simulations using Neurons in Action
4. Developing a model of neuron using NEURON

Text books:

1. Bioengineering, Biomedical, Medical and Clinical Engg.: A.Teri Bahil.
2. Signals and systems in Biomedical Engg.: Suresh R Devasahayam.
3. Bio-Electricity A quantitative approach by Barr and Ploncey

Reference Books:

1. Biomedical Engineering Handbook by Bronzino (CRC Press)

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the tests will be considered for final Internal Assessment.

End Semester Examination:

Question paper will comprise of 6 questions, each carrying 20 marks.
The students need to solve total 4 questions.
Question No.1 will be compulsory and based on entire syllabus.
Remaining question (Q.2 to Q.6) will be selected from all the modules.

Term Work:

Term work consists of minimum six experiments and two assignments. The distribution of the term work shall be as follows:

Laboratory work (Experiments and Journal) :15 marks
Attendance (Practical and Theory) :10 marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and completion of journal. Term work assessment must be based on the overall performance of the student.

Sub Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Pract.	Tut	Theory	Pract.	Tut	Total
TEBM604	Microcontrollers and Embedded Systems (abbreviated as MES)	4	2	-	4	1	-	5

Sub Code	Subject Name	Examination scheme							
		Theory Marks				Term work	Pract.	Oral	Total
		Internal Assessment			End Sem exam				
		Test 1	Test 2	Avg.					
TEBM604	Microcontrollers and Embedded Systems	20	20	20	80	25	-	25	150

Course Objectives	Students will learn the basics of Microcontroller designing and interfacing. Students will understand and improve programming concepts.
Course Outcomes	Students will develop understanding of hardware design and will be able to design controller based real time applications. Students will develop programming skills for designing and developing automated and user friendly systems.

Module	Contents	Time
1.	**Embedded Systems** Definition of embedded systems, overview of embedded systems and its classification, design challenges, processor technology, IC technology, design technology and tradeoffs, examples of embedded systems	04
2.	**MCS-51 Microcontroller** 8051 architecture ; its variants and comparision, comparision of microprocessor and microcontrollers, CPU timing and machine cycle, memory organisation, SFR's, integrated prepherials such as timers/counters, serial ports, parallel I/O ports, interrupt structure, memory interfacing power saving and power down modes.	10
3.	**8051programming** Assembly language programming process, programming tools, Instruction set in detail and addressing modes, Programming practice using assembly and C compilers	12
4.	**Microcontroller design and interfacing case studies** Interfacing with external memories, Interfacing with 8255, Interfacing with 7 segment display, Interfacing with keyboard, interfacing with LCD, Interfacing with ADC,DAC and Sensors, Interfacing with stepper motor Interfacing with PC using RS232	12
5.	**Serial Communication Protocols** Operation of serial port, programming for asynchronous serial communication, Serial Communication using the 'I2C', SPI, Introduction to USB & CAN bus.	05

6.	**Real time operating system** Introduction to RTOS concept, RTOS scheduling models interrupt latency and response times of the tasks as performance metric. Example of any small RTOS system	05

Text books:

1.The 8051 microcontrollers-Kenneth J Ayala
2.Embedded systems-architecture, programming and design, Rajkamal, Tata McGraw Hill
3.Embedded System Design: A unified Hardware/Software Introduction Frank Vahid,Toney Givargis- John Wiley publication
3.An Embedded Software Primer David E. Simon - Pearson Education
4.The 8051 Microcontroller and Embedded Systems Muhammad A Mazidi, , Pearson Education
5.Using MCS-51 Microcontroller Han-Way Huang,.
6. 8051 microcontroller hardware, software applications.V U dayashankara, M S Mallikarjunaswamy,

Reference Books:

1. Sriram Iyer and Pankaj Gupta, Embedded Realtime systems programming, Tata McGraw Hill

2. Embedded Microcomputer Systems- Real time Interfacing -Valvano

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the tests will be considered for final Internal Assessment.

End Semester Examination:

Question paper will comprise of 6 questions, each carrying 20 marks.
The students need to solve total 4 questions.
Question No.1 will be compulsory and based on entire syllabus.
Remaining question (Q.2 to Q.6) will be selected from all the modules.

Oral Examination:

Oral examination will be based entire syllabus and on the course-project.

Term Work:

Term work consists of minimum five experiments and a course - project based on the syllabus. The distribution of the term work shall be as follows:
Laboratory work (Experiments, course - project and Journal) :15 marks
Attendance (Practical and Theory) :10 marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and completion of journal. Term work assessment must be based on the overall performance of the student.

Sub Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Pract.	Tut	Theory	Pract.	Tut	Total
TEBM605	Medical Imaging-I (abbreviated as MI-I)	4	2	-	4	1	-	5

Sub Code	Subject Name	Examination scheme							
		Theory Marks				Term work	Pract.	Oral	Total
		Internal Assessment			End Sem exam				
		Test 1	Test 2	Avg.					
TEBM605	Medical Imaging-I	20	20	20	80	25	-	25	150

Course Objectives	To familiarize the students with the various Imaging techniques in medicine operating principles and quality control aspects of various imaging modalities. To keep the students abreast with the technological developments in the field of Medical Imaging
Course Outcomes	The students will able to understand essential physics, concepts of Medical Imaging and how they are employed in diagnosis and therapy. The students will also get familiar with the current techniques of medical Imaging along with their clinical applications. The students will also be able to apprehend the importance of radiation constructive utilization and safety.

Module	Contents	Time
1.	**Ultrasound in Medicine:** Introduction , Production and Characteristics of Ultrasound Display System : A mode ,B mode and M mode display and applications. Ultrasound transducers and Instrumentation. Real time Ultrasound ,Continuous wave and Pulsed wave Doppler Ultrasound systems, color flow imaging,applications.	12
2.	**X- ray Imaging:** Properties of X rays,production of X rays, X ray interaction with matter . Total radiographic System : X –ray tubes, Rating of X ray tubes. X –ray generators, X ray Image and beam Limiting Deices, Controls, X ray Film Development Technique.	12
3.	**Flouroscopic Imaging and x ray Image Intensifier Digital subtraction Angiography**	06
4.	**Computed Radiography and Digital Radiography ,Mammography**	10
5.	**Medical Thermography: Physics of thermgraphy, Thermographic equipment, applications.**	04
6.	**Endoscopy : Equipment , Imaging and its applications**	04

Text books:

1. Christensen's Physics of Diagnostic Radiology
2. Medical Imaging Physics William .R.Hendee

Reference Books:

1. Biomedical Technology and Devices by James Moore .
2. Biomedical Engineering Handbook by Bronzino
3. Physics of Diagnostic images –Dowsett

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the tests will be considered for final Internal Assessment.

End Semester Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No.1 will be compulsory and based on entire syllabus.
4. Remaining question (Q.2 to Q.6) will be selected from all the modules.

Term Work:

Term work consists of minimum eight experiments. The distribution of the term work shall be as follows:

Laboratory work (Experiments and Journal)	:15 marks
Attendance (Practical and Theory)	:10 marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and completion of journal. Term work assessment must be based on the overall performance of the student.

Sub Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Pract.	Tut	Theory	Pract.	Tut	Total
TEBM606	Digital Image Processing (abbreviated as DIP)	4	2	-	4	1	-	5

Sub Code	Subject Name	Examination scheme							
		Theory Marks				Term work	Pract.	Oral	Total
		Internal Assessment			End Sem exam				
		Test 1	Test 2	Avg.					
TEBM606	Digital Image Processing	20	20	20	80	25	50*	-	150

*Both Practical and Oral examination

Course Objectives	Introduce to the students the basic theory of digital image processing. Expose students to various available techniques and possibilities of this field. Learn basic image enhancement, transforms, segmentation, compression, morphology, representation, description techniques & algorithms. Prepare students to formulate solutions to general image processing problems. Develop hands-on experience in using computers to process images. Familiarize with MATLAB / C/ Labview/ similar software for processing digital images.
Course Outcomes	Students shall demonstrate the ability: To acquire the fundamental concepts of a digital image processing system such as image acquisition, enhancement, segmentation, transforms, compression, morphology, representation and description. To analyze images in the spatial domain. To analyze images in the frequency domain through the Fourier transform. To design and implement with MATLAB/C/Labview algorithms for digital image processing operations such as point processing, histogram processing, spatial and frequency domain filtering, denoising, transforms, compression, and morphological processing.

Module	Contents	Time
1.	**Basics of Image Processing**: Image acquisition, Processing, Communication, Display; Electromagnetic spectrum; Elements of visual perception - Structure of the human eye, Image formation in the eye, Brightness adaptation and discrimination, Image formation model, Uniform and non-uniform sampling, Quantization, Image formats.	05
2.	**Image Enhancement**: Spatial domain - Point processing techniques, Histogram processing, Neighbourhood processing, Frequency domain techniques - 2D-DFT, Properties of 2D-DFT, Low pass, High pass, Noise removal, Homomorphic filters, Basics of colour image processing.	12

3.	**Image Segmentation**: Basic relationships between pixels - Neighbours, Adjacency, Connectivity, Regions, Boundaries, Distance measures; Detection of discontinuities, Point, Line, Edge detection, Edge linking, Hough transform, Thresholding-based segmentation, Region-based segmentation.	08
4.	**Image Transforms**: DFT, FFT, DCT, DST, Hadamard, Walsh, Haar, Slant, K-L Transforms, Basis functions and basis images, Introduction to wavelet transform.	08
5.	**Image Compression**: Fundamentals of image compression models, Lossless compression - RLE, Huffman, LZW, Arithmetic coding techniques. Lossy compression - IGS coding, Predictive coding, Transform coding, JPEG, JPEG 2000.	08
6.	**Morphology, Representation and Description**: Dilation, Erosion, Open, Close, Hit-or-miss, Boundary extraction, Region filling, Thinning and thickening; Chain Codes, Polygonal approximations, Signatures; Fourier descriptors, Moments.	07

List of Experiments (using Matlab / C/ Labview/ similar software)

1. Point Processing techniques (At least 4 experiments).
2. Spatial domain Filtering.
3. Histogram Processing (Histogram Stretching and Equalisation).
4. Frequency Domain Filtering (Plotting 2D-DFT, Low pass and High Pass- Ideal, Butterworth and Gaussian Filters).
5. Segmentation-Gradient operators.
6. Transforms-DCT.
7. Morphology-Dilation Erosion.

Text books:

1. Digital Image Processing, Gonzalez and Woods- Pearson Education.
2. Fundamentals of Digital Image Processing, A.K. Jain –P.H.I.
3. Digital Image Processing and Analysis, Chanda Majumder-Printice Hall India.

Reference Books:

1. Digital Image Processing and Computer Vision, Sonka, Hlavac, Boyle-Cengage learning.
2. Digital Image Processing, William Pratt- John Wiley.

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the tests will be considered for final Internal Assessment.

End Semester Examination:

Question paper will comprise of 6 questions, each carrying 20 marks.
The students need to solve total 4 questions.
Question No.1 will be compulsory and based on entire syllabus.
Remaining question (Q.2 to Q.6) will be selected from all the modules.

Term Work:
Term work consists of minimum eight experiments. The distribution of the term work shall be as follows:

Laboratory work (Experiments and Journal)	:15 marks
Attendance (Practical and Theory)	:10 marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and completion of journal. Term work assessment must be based on the overall performance of the student.