UNIVERSITY OF MUMBAI
No.UG / 252of 2009

CIRCULAR :-

A reference is invited to the Ordinances, Regulations and syllabi relating to the Bachelor of Engineering degree courses *vide* this office Circular No.UG/461 of 2003, dated 19th September, 2003 and the Principals of the affiliated colleges in Engineering are hereby informed that the recommendation made by the Faculty of Technology at its meeting held on 1st April, 2009 has been accepted by the Academic Council at its meeting held on 27th May, 2009 *vide* Item No.4.13 and that, in accordance therewith, the syllabus for the Third Year Biomedical Engineering (Sem. V and VI) of the B.E. degree course is revised as per Appendix and that the same has been brought into force with effect from the academic year 2009-2010.

MUMBAI-400 032
7th July, 2009

PRIN K VENKATARAMANI
REGISTRAR

To,
The Principals of the affiliated colleges in Engineering.

A.C./4.13/27.05.2009

No.UG/252- A of 2009, MUMBAI-400 032 7th July, 2009

Copy forwarded with compliments for information to: -

1) The Dean, Faculty of Technology.
2) The Chairman, Board of Studies in Electrical Engineering.
3) The Controller of Examinations,
4) The Co-ordinator, University Computerization Centre.

07/07/09

(D.H. KATE)
DEPUTY REGISTRAR
(U.G./P.G SECTION)

Copy to: -

The Director, Board of College and University Development, the Deputy Registrar (Eligibility and Migration Section), the Director of Students Welfare, the Executive Secretary to the Vice-Chancellor, the Pro-Vice-Chancellor, the Registrar and the Assistant Registrar, Administrative sub-center, Ratnagiri for information.

The Controller of Examinations (10 copies), the Finance and Accounts Officer (2 copies), Record Section (5 copies), Publications Section (5 copies), the Deputy Registrar, Enrolment, Eligibility and Migration Section (3 copies), the Deputy Registrar, Statistical Unit (2 copies), the Deputy Registrar (Accounts Section),Vidyanagari (2 copies), the Deputy Registrar, Affiliation Section (2 copies), the Director, Institute of Distance Education, (10 copies) the Director University Computer Center (IDE Building), Vidyanagari, (2 copies) the Deputy Registrar (Special Cell), the Deputy Registrar,(PRO) , the Assistant Registrar, Academic Authorities Unit (2 copies)and the Assistant Registrar, Executive Authorities Unit (2 copies) . They are requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to in the above Circular and that, no separate Action Taken Report will be sent in this connection. the Assistant Registrar Constituent Colleges Unit (2 copies), BUCT(1 copy), the Officer in charge Director, Centralize Computing Facility (1 copy), the Superintendent, Post-

Enclosure to Item No. 4.13
27.5.2009

UNIVERSITY OF MUMBAI

Revised Syllabus for the Third Year Biomedical Engineering (Semester V & VI)

(With effect from the academic year 2009-2010)

University of Mumbai

Syllabus Structure (R-2007)

at

T.E. (Biomedical Engineering)

Semester-V

S. No.	Subject	Scheme of Instructions Periods per Week (Each 60 min.)		Scheme of Evaluation					
		Theory	Practical/ Tutorial	Paper		TW	Practical and Oral	Oral	Total Marks
				Hours	Marks				
1.	Microprocessors	04	02	3	100	25	25	---	150
2.	Principles of Analog and Digital Communication	04	02	3	100	25	---	25	150
3.	Biomedical Instrumentation – I	04	02	3	100	25	---	25	150
4.	Design of Analog Circuits	04	02	3	100	25	50	---	175
5.	Signals and Systems	04	02(T)	3	100	25	---	25	150
6.	Environmental Studies	02	*01(T)	2	50	25	---	---	75
	Total	22	11	---	550	150	75	75	850

* Tutorial to be conducted class wise.

University of Mumbai

Syllabus Structure (R-2007)

at

T.E. (Biomedical Engineering)

Semester-VI

S. No.	Subject	Scheme of Instructions Periods per Week (Each 60 min.)		Scheme of Evaluation					
		Theory	Practical/ Tutorial	Paper		TW	Practical & Oral	Oral	Total Marks
				Hours	Marks				
1.	Microcontrollers and Embedded Systems	04	02	3	100	25		25	150
2.	Medical Imaging-I	04	02	3	100	25	---	25	150
3.	Biomedical Instrumentation – II	04	02	3	100	25	25	---	150
4.	Biological Modeling and simulations	04	02	3	100	25	---	25	150
5.	Biostatistics	04	01(T)	3	100	25	---	---	125
6.	Digital Signal Processing for Biomedical Applications	04	02	3	100	25	---	---	125
	Total	24	11		600	150	25	75	850

University of Mumbai			
Class: T.E.	**Branch:** Biomedical Engineering		**Semester:** V
Subject: Microprocessors			
Periods per Week (Each 60 min.)	Lecture	04	
	Practical	02	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	03	100
	Practical & Oral	02	25
	Oral	---	---
	Term Work	---	25
	Total	05	150

Module	Content	Time (hrs)
1	**8085 Microprocessor** Basic 8085 Microprocessor architecture and its functional blocks, 8085 microprocessor IC pin outs and signals, address data and control buses. Clock signals, instruction cycles, machine cycles, and timing states, instruction timing diagram(eg MOV,MVI, LDA,LDAX,XCHG, WAIT, HALT)	10
2	**Intel 8086/8088 microprocessor family** Architecture and organization of 8086/8088 microprocessor family. Study of its Instruction set. Assembly language programming, Introduction to mixed language programming using Assembly language. 8086 interrupt structure. 8086 family minimum and maximum mode operation. Study of 8288 bus controller. Timing diagram for 8086 family in maximum and minimum mode.	12

3	**Memory And I/O design** Memory system design for 8086 family including interface of dynamic Read/ write memory. Considerations for memory interfacing. Connection of I/O Controllers 8255AH programmable peripheral Interface, Programmable Interrupt Controller 8259A, UART 8250, programmable D.M.A. Controller 8237.	10
4	**8087 Math Co-processor** Study of architecture of 8087 floating point co- processor. Data types supported by 8087. Host and co-processor interface, Assembly language Programming for 8086 - 8087 based systems.	11
5	**Introduction to Multiprocessor systems** Multiprocessor configurations. Study of the 8289 bus arbiter. Design of 8086 based multiprocessor systems (without timing considerations).	05

Theory Examination:

1. Question paper will comprise of total 7 questions, each of 20 marks.
2. Only 5 questions need to be solved.
3. Q.1 will be compulsory and based on the entire syllabus.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Practical & Oral Examination:

Practical examination will be based on one experiment performed from the list of experiments and the oral will be based on entire subject.

Term work:

Term work will consist of at least Eight Assignments/ Laboratory Experiments based on the above syllabus and a written test. Test and Seminars be suitably graded by teachers and attached in the journal. The distribution of the term work shall be as follows,

Lab work (Assignments/ Laboratory Experiments & Seminar) :15 marks

Test (at least one) :10 marks

Attendance (Practical and Theory) :05 marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

Text Books:

1. Microprocessor Architecture, Programming and Applications with 8085 - Gaonkar - John Wiley Eastern Ltd. Publication
1. John Uffenback, 8086 / 8088 Design, Programming and Interfacing, second edition, ninth Indian reprint, Prentice Hall of India, 2001
2. Douglas Hall, Microprocessors interfacing and programming, Tata McGraw Hill, third edition

Reference:

1. John Uffenback, The 80X86 family Design, Programming and Interfacing, third edition,
2. Pearson Education Asia, 2002Intel Corporation,
3. Data manuals of microprocessors

University of Mumbai			
Class: T.E.	**Branch:** Biomedical Engineering	**Semester:** V	
Subject: Principles of Analog and Digital Communication			
Periods per Week (Each 60 min.)	Lecture	04	
	Practical	02	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	03	100
	Practical & Oral	---	---
	Oral		25
	Term Work	---	25
	Total	03	150

Module	Content	Time (hrs)
1.	**Introduction to Communication System:** Elements of communication system, Types of electronic communication system, Noise, Signal to Noise ratio, Noise factor, Noise figure, Noise Temperature.	04
2.	**Amplitude Modulation:** Mathematical analysis of AM wave, Different types of AM (DSBFC, DSBSC, SSB, ISB with & without pilot carrier), Modulator Circuits, Spectrum, Bandwidth, Waveforms, Low level & High level transmitter.	05
3.	**AM Receivers:** Receiver Parameters – Sensitivity, selectivity, fidelity, image frequency and its rejection, double spotting, dynamic range. TRF receiver, Super heterodyne receiver, Double conversion receiver. AM detectors – Simple & Practical Diode detector. Principles & types of tracking, Principles & types of AGC. Demodulation of DSBSC & SSB waves.	08
4.	**FM Transmission & Reception:** Principle of FM, waveforms, spectrum, bandwidth, FM generation – Direct FM & Indirect FM, Principle of AFC, Pre-emphasis & De-emphasis in FM, Effect of noise in FM, Noise triangle. FM Demodulation – Simple slope detector, balanced slope detector, Foster Seely Discriminator, Ratio detector, Quadrature detector, Block diagram of FM receiver, Capture effect in FM receivers, Comparison of AM & FM systems.	09
5.	**Analog Pulse Modulation Techniques:** Sampling theorem for low pass signals & Band pass signals, Proof of sampling theorems, Concept of Aliasing, PAM, PWM, PPM – Generation, detection, advantages, disadvantages, comparison.	06
6.	**Digital Pulse Modulation Techniques:**	07

	Advantages & disadvantages of Digital Transmission, PCM – Transmitter, Receiver, Quantization, Companding, DPCM, DM, ADM – Transmitter, Receiver, Advantages, Disadvantages.	
7.	**Digital Transmission:** Types of Digital transmission methods – ASK, FSK, PSK, Generation, Detection, Advantages, Disadvantages, Comparison.	04
8.	**Multiplexing Techniques** Concept of multiplexing and multiple access, FDM, TDM – Transmitter, Receiver, Hierarchy, Applications, Advantages, Disadvantages. PCM – TDM system, FDMA,TDMA, CDMA	05

Theory Examination:

1. Question paper will comprise of total 7 questions, each of 20 marks.
2. Only 5 questions need to be solved.
3. Q.1 will be compulsory and based on the entire syllabus.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Oral Examination:

Oral exam will be based on entire subject.

Term work:

Term work consists of minimum eight experiments from the list mentioned below and a written test. The distribution of the term work shall be as follows,

Laboratory work (Assignments and Journal) :15 marks

Test (at least one) :10 marks

~~Attendance (Practical and Theory)~~ ~~:05 marks~~

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

List of Experiments:

1. DSB-FC, DSB-SC, SSB AM generation

2. AM detection.
3. FM generation and detection.
4. Pre-emphasis and De-emphasis.
5. Sampling and reconstruction.
6. PAM generation and detection.
7. PWM generation and detection.
8. PPM generation and detection.
9. PCM generation and detection.
10. DM generation and detection.
11. Time division multiplexing.
12. Frequency division multiplexing.

Text Books:

- Electronic Communication Systems – Wayne Tomasi, Pearson Education.
- Electronic Communication Systems – Roy Blake, Thomson Learning.
- Electronic Communication Systems – Kennedy and Davis, TMH.

Reference Books:

- Digital and Analog Communication Systems – Leon W Couch, Pearson Education.
- Principles of Communication Systems - Taub and Schilling, TMH.

University of Mumbai		
Class: T.E.	Branch: Biomedical Engineering	Semester: V
Subject: Biomedical Instrumentation - I		
Periods per Week	Lecture	04

(Each 60 min.)	Practical	02	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	03	100
	Practical & Oral	02	--
	Oral	---	25
	Term Work	---	25
	Total	05	150

Module	Content	Time (hrs)
1.	Basic principle, technical specification, working and applications of Analytical and Laboratory Instruments. 1. Spectrophotometer 2. Colorimeter 3. pH meter 4. Cell and Plasma Separator. 5. Centrifuge 6. Electrolyte Analyser 7. Blood cell counter 8. Electrophoresis 9. Chromatography and mass spectroscopy 10. Autoanalyser 11. Microscopes 12. ELISA reader & WASH	14
2.	**Blood Gas Analyser:** Measurements of Blood pH, pCo2 pO2 and complete Blood Gas analyser.	05
3.	**Blood Flow Measurement:** Electromagnetic, Ultrasonic, NMR and Laser Doppler flow metry, cardiac output measurement, impedance plethysmography.	08
4.	**Pulmonary Function Analyser and Ventilator:** Respiration measurement technique: Lung volume and capacities. Spirometry, Pulmonary function measurement and analyser, spirometer	12

	and respiratory function analyzer. Oximetry, Ventilators Respiratory Therapy Equipment and Anesthesia Equipment	
5.	**Heart Lung machine**	04
6.	**Audiometers:** Basic audiometer, Pure tone and Speech audiometer, evoked response Audiometry.	05

Theory Examination:

6. Question paper will comprise of total 7 questions, each of 20 marks.
7. Only 5 questions need to be solved.
8. Q.1 will be compulsory and based on the entire syllabus.
9. Remaining questions will be mixed in nature.
10. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Oral Examination:

The oral examination will be based on entire syllabus.

Term work:

Term work will consist of at least Eight Laboratory Experiments/Demonstrations based on the above syllabus and a written test. Test and Assignments/Seminars be suitably graded by teachers and attached in the journal. The distribution of the term work shall be as follows,

Laboratory work (Experiments and Journal) :15 marks

Test (at least one) :10 marks

~~Attendance (Practical and Theory)~~ ~~:05 marks~~

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

Text Books:

- Handbook of Biomedical Engineering By R.S. Khandpur (TMH Pub).

- Handbook of Analytical Instruments By R.S. Khandpur (TMH Pub).
- Medical Instrumentation, Application and Design By J.G. Webster.
- Medical Electronics – A.G. Patil ,R K Jha, R Hariharan(Excel Books, New Delhi)

References:

- Encyclopedia of medical devices and instrumentation - J.G. Webster Vol I, II, III, IV (John Willey).
- Introduction to Biomedical Equipment Technology By Carr.-Brown (Pearson Education Pub)
- Introduction to Biomedical Engineering – Joseph Bronzino (CRC Press)
- Various Instruments Manuals.

University of Mumbai			
Class: T.E.	**Branch:** Biomedical Engineering	**Semester: V**	
Subject: Design of Analog Circuits			
Periods per Week (Each 60 min.)	Lecture	04	
	Practical	02	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	03	100
	Practical and oral	02	50
	Oral	---	---
	Term Work	---	25
	Total	05	175

Module	Content	Time (hrs)
	Practical Operational Amplifiers	08
1	**Static and Dynamic op amp limitations**: Simplified Op-amp circuit diagram, Input bias and Offset current, Low input offset op-amps, Input offset voltage, Low input offset voltage op-amps, Input offset error compensation, maximum ratings, Circuits to measure opamp parameters as above, Open loop response, Closed loop response, Input and output impedances, Transient response, Effect of finite GBP (on integrator circuit, filter circuit,) Current feedback amplifiers	
2	**Noise and Stability**: Noise properties, Noise dynamics, Sources of noise, Op amp noise, noise in photodiode amplifiers, Low noise op amplifiers, Noise reduction techniques. The stability problems, Stability in constant GBP in on op amp circuit, Internal frequency compensation, External frequency compensation, Stability in CFA (Current Feedback Amplifiers) circuits	08
3	**Specialized opamp applications** : Negative impedance converter, opamp with offset, instrumentation amplifiers and INA 101, analog switches, sample and hold circuits, multipliers, dividers, op amp based fixed voltage reference circuits, DC-DC converter circuits, voltage limiters,	07
4	**Active Filters**: Transfer function, First order active filter and application, Standard second order response, KRC filter, Multiple feedback filters, State variable filters, Filter approximation, Cascade design, Generalized impedance converter, Direct design, The capacitor filter, Switched capacitor filters.	10
5	**Study, design and applications of Special Function Integrated Circuits** (It is essential to remember the design concepts and selection criterion rather than IC pin configuration) Waveform Generation and Wave shaping: (IC 555 and	15

	applications, PLL – (IC 4046), IC's –IC 8038), V to F and F to V converters – (AD 537),Comparators (function and specifications) applications of comparator (such as level detector, window detector, Pulse width modulation, Schmitt trigger) comparator IC (LM 339), Opto-couplers / Opto-isolators (4N25/35),Isolation Amplifiers (ISO 101), PWM controller (SG3525 (or equivalent))	

Theory Examination:

11. Question paper will comprise of total 7 questions, each of 20 marks.
12. Only 5 questions need to be solved.
13. Q.1 will be compulsory and based on the entire syllabus.
14. Remaining questions will be mixed in nature.
15. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Practical & Oral Examination:

Practical examination will be based on one experiment performed during the semester based on the above syllabus and the oral will be based on entire subject.

Term work:

Term work will consist of at least 8 hardware design experiments (atleast 3 on opamps and 5 on special function IC'c) based on the above syllabus and a written test. Test and Seminars be suitably graded by teachers and attached in the journal. The distribution of the term work shall be as follows,

Lab work (Assignments/ Laboratory Experiments & Seminar) :15 marks

Test (at least one) :10 marks

~~Attendance (Practical and Theory)~~ ~~:05 marks~~

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

Text Books:

1. Operational Amplifiers by Ramakant Gaikwad, PHI

2. Design With Operational Amplifiers & Analog Integrated Circuits by Sergio Franco.
3. Design and applications of Analog Integrated Circuits by Sidney Soclof

REFERENCE:

1. Data Manuals of IC Manufacturers.
2. Op amps and Linear Integrated Circuits for Technicians- Frank R Dungan

University of Mumbai			
Class: T.E.	Branch: Biomedical Engineering	Semester: V	
Subject: Signal and Systems			
Periods per Week (Each 60 min.)	Lecture	04	
	Practical	--	
	Tutorial	02	
		Hours	Marks
Evaluation System	Theory	03	100
	Practical & Oral	---	---
	Oral	---	25
	Term Work	---	25
	Total	03	150

Module	Content	Time (hrs)
I.	**Introduction to Signals:** Basic of continuous time signals and discrete time signals like unit step, ramp, exponential, operation on signals like flipping, shifting, scaling,	07

	and multiplication. Classification of signals: Periodic /Aperiodic, Power and Energy, Even and Odd	
2.	**Introduction to Systems** System representation in the continuous and discrete time domain. Classification of systems on the basis of Causal/non-Causal, Time variance/Time invariance, Linear/Non-Linear, Stable/Unstable. Continuous convolution, Discrete convolution	07
3.	**Fourier Analysis of Continous time Signals** Orthogonal functions, Representation of signals in terms of weighted orthogonal basis functions, Coefficient calculation on the basis of minimum square error Fourier series: Representation of Fourier series in terms of sine, cosine, exponential functions. The complex Fourier spectrum, Properties of Fourier series, convergence of Fourier series, Gibbs phenomenon. Fourier transform and its properties. Fourier transform of singular functions. Energy density spectrum	10
4.	**Laplace transform:** Convergence, properties of Laplace transform, double sided Laplace transforms, applications of Laplace transform to the solution of differential equations. Relationship between Laplace and Fourier transform	06
5.	**Time domain and Frequeny domain behaviour of Systems** Transfer function and its properties for linear, lumped and stable systems, Impulse response of a system, Zero input and zero state response of a system. Time domain analysis of first order and second order systems. Condition of BIBO stability in time domain. Pole zero diagram, Frequency response of linear systems. Stability and Routh array, Bode plots, Root Locus, Polar & Nyquist Plots	10

6.	**Z transform** Definition, Convergence, properties and inversion of z transform. Analysis of discrete time systems using Z-transform. Relationship between Laplace and Z transform.	08

Theory Examination:

6. Question paper will comprise of total 7 questions, each of 20 marks.
7. Only 5 questions need to be solved.
8. Q.1 will be compulsory and based on the entire syllabus.
9. Remaining questions will be mixed in nature.
10. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Oral Examination:

Oral exam will be based on entire subject.

Term work:

Term work consists of minimum six assignments and a written test. The distribution of the term work shall be as follows,

Tutorials (Assignments and Journal) :10 marks

Test (at least one) :10 marks

~~Attendance (Tutorial and Theory) :05 marks~~

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

Text Books:

1. Signals and systems : Oppenheim, Wilsky and Young, Latest edition
2. Signals and systems :James Cadzow, Latest edition

Reference Books:

1. Signals and systems: Gabar
2. Principles of signals and systems: F.J. Taylor

University of Mumbai

CLASS: T.E. Bio-Medical Engineering — Semester - V

SUBJECT: Environmental Studies

Periods per week (each of 60 min.)	Lecture	2	
	Practical	-	
	Tutorial	1*	
		Hours	Marks
Evaluation System	Theory Examination	2	50
	Practical examination	-	-
	Oral Examination	-	-
	Term Work	-	25
	Total		75
* Class wise Tutorial			

Objective: This course is to create environmental awareness, of variety of environmental concerns.

Module	Contents	Hrs
1	The Multidisciplinary nature of environmental studies Definition, scope and importance Need for public awareness	1
2	Natural resources Renewable and non-renewable resources Natural resources & associated problem. a. Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forests and tribal people. b. Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems. c. Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies. d. Food resources: World food problems overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies. e. Energy resources: Growing energy needs, renewable and non renewable energy sources, use of alternate energy sources. Case studies. f. Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification. • Role of an individual in conservation of natural resources. Equitable use of resources for sustainable lifestyles.	4
3	• Ecosystems • Concepts of an ecosystem. • Structure and function of an ecosystem. • Producers, consumers and decomposers. • Energy flow in the ecosystem.	3

	• Ecological succession. • Food chains, food webs and ecological pyramids. • Introduction, types, characteristic features, structure and function of the following ecosystem: a. Forest ecosystem b. Grassland ecosystem c. Desert ecosystem d. Aquatic ecosystem (ponds, streams, lakes, rivers, oceans, estuaries)	
4	Biodiversity and its conservation • Introduction-Definition: genetic species and ecosystem diversity • Bio-geographical classification of India • Value of biodiversity : Consumptive use, productive use, social, ethical, aesthetic and option values • Bio-diversity at global, national, local levels • India as a mega diversity nation • Hot spots of bio-diversity • Threats to biodiversity: Habitat loss, poaching of wild life, man-wildlife conflicts • Endangered and endemic species of India • Conservation of biodiversity: In- situ and Ex-situ conservation of biodiversity	4
5	Environmental Pollution Definition – • Causes, effects and control measures of: a. Air pollution b. Water pollution c. Soil pollution d. Marine pollution e. Noise pollution f. Thermal pollution g. Nuclear Hazards • Solid waste management: Causes, effect and control measures of urban and industrial wastes • Role of an individual in prevention of pollution • Pollution case studies • Disaster management: floods, earthquake, cyclone and land slides	4
6	Social issues and environment • From unsustainable to sustainable development • Urban problems related to energy • Water conservation, rain water harvesting, watershed management • Re-settlement and rehabilitation of people: Its problems and concerns. Case studies. • Environmental ethics: issues and possible solution • Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case studies. • Wasteland reclamation • Consumerism and waste products • Environment protection act • Air(Prevention and control of pollution) act • Water (Prevention and control of pollution) act • Wildlife protection act	4

	• Forest conservation act • Issues involved in enforcement of environmental legislation • Public awareness	
7	Human population and the environment • Population growth, variation among nations • Population Explosion- family welfare program • Environment and human health • Human rights • Value education • HIV/AIDS • Women and child welfare • Role of information technology in environment and human health • Case studies	4
8	**Understanding Existence and Co-existence** Interrelation and Cyclicity between Material order, Bio-order, Animal order and Human order **Understanding the human conduct:** Relationship in Family, Justice in Relationship, Relationship of Human with Nature (Environment), Human Behavior, Human Values, Nature and Morality **Understanding the human society** Dimensions of Human Endeavor and Objectives, Interrelationship in Society, Mutual Fulfillment and Cyclicity in Nature.	6

Theory Examination:

1. Question paper will be comprising of total 7 questions, each of 10 marks.
2. Only 5 questions need to be solved.
3. Question number 1 will be compulsory and covering the all modules.
4. Remaining questions will be mixed in nature. (e.g.- suppose Q.2 has part (a) from, module 3 then part (b) will be from any module other than module 3.)
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Term work:

Term work shall consist of minimum five projects (PROJECTS SHALL BE DESIGNED ON THE SAME GUIDE- LINE OF GIVEN TEXT BOOK) and a written test.
The distribution of marks for term work shall be as follows,
Laboratory work (Tutorial/Project and Journal) : 15 marks.
Test (at least one) : 10 marks.
The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

Recommended Books:

1. Erach Bharucha, text book of environmental studies, Universities Press/Orient Blackswan
2. Jagdish Krishnaswami, R J Ranjit Daniels, 'Environmental Studies", Wiley India Private Ltd. New delhi
3. Anindita Basak, 'Environmental Studies", Pearson
4. Deeksha Dave, "Text book of , 'Environmental Studies", Cengage learning, Thomason India edition
5. Benny Joseph , 'Environmental Studies", Tata McGRAW HILL
6. D L Manjunath, , 'Environmental Studies",Pearson
7. R Rajgopalan, , 'Environmental Studies", Oxford
8. Alok Debi, 'Environmental science and Engineering", University press
9. A. Nagraj, Jeevan Vidya- A Primer.

T.E. (BIOMEDICAL ENGINEERING)

SEMESTER - VI

University of Mumbai			
Class: T.E.	Branch: Biomedical Engineering	Semester: VI	
Subject: Microcontrollers and Embedded Systems			
Periods per Week (Each 60 min.)	Lecture	04	
	Practical	02	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	03	100
	Practical & Oral	---	---
	Oral	---	25
	Term Work	---	25
	Total	03	150

Module	Content	Time (hrs)
1	**Hard ware of 8051 microcontrollers, Intel MCS 51 family** Introduction to Single chip microcontrollers of Intel MCS 51 family. Comparison of microprocessor and microcontroller, architecture and pin functions of 8051 Single chip microcontroller, C.P.U. timing and machine cycles, internal memory organization, Program counter & stack, input/ output ports, counters & timers, serial data input & output Interrupts. Connection of external memory. Power saving modes. Interfacing of 8051 with EPROM	08
2	**8051 Assembly language programming** Instruction set addressing modes, immediate , registers , direct & indirect	10

	data movement & Exchange instructions, push and pop op-codes, arithmetic and logic instructions, bit level Operations , jump and call instructions, input/output port programming, programming timers Asynchronous serial data communication, timer and hardware interrupt service routines.	
3	**Microcontroller Design And Interfacing** External memory and memory address decoding, memory mapped I/O, time delay subroutine look up table implementation, interfacing matrix keyboard and seven segment displays through scanning and interrupt driven programs, interfacing ADC and DAC. Interfacing of LCD display.	12
4	**Embedded Software** Introduction to Embedded Systems ,Examples of embedded system , their characteristics and their typical hardware components , Software Embedded into a system embedded software architecture , Processor and Memory organization Structural Units in a processor, Processor Selection for an embedded system, Memory devices, Memory selection for an embedded system, Allocation of Memory to program segments and blocks and memory map of a system, Direct Memory access, Interfacing processor, memories and I/O devices	08
5	**Devices and Buses for Device networks** I/O devices, Timer and counting devices, Serial Communication using the 'I2C','CAN' and Advanced I/O Buses between the networked multiple Devices, host system or computer parallel communication between the networked I/O Multiple Devices using the PCI, PCI-X and advanced buses	05
6	**Device Drivers and Interrupts Servicing Mechanism** Device drivers, Parallel port device drivers in a system, serial port device Drivers in a system, device drivers for internal programmable timing devices, Interrupt servicing (handling) mechanism, Deadline and Interrupt Latency.4	05

Theory Examination:

16. Question paper will comprise of total 7 questions, each of 20 marks.
17. Only 5 questions need to be solved.
18. Q.1 will be compulsory and based on the entire syllabus.

19. Remaining questions will be mixed in nature.
20. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Oral Examination:

Oral examination will be based on mini project performed and on entire subject.

Term work:

Term work will consist of at least 5 experiments. The students will also have to perform a mini project based on 8051. Test and Seminars be suitably graded by teachers and attached in the journal. The distribution of the term work shall be as follows,

Lab work (Assignments/ Laboratory Experiments & Seminar) :15 marks

Test (at least one) :10 marks

~~Attendance (Practical and Theory)~~ ~~:05 marks~~

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work. .

Text Books:

1. The 8051 microcontrollers-Kenneth J Ayala
2. Rajkamal, Embedded systems-architecture, programming and design, Tata McGraw Hill
3. Frank Vahid,Toney Givargis-Embedded System Design: A unified Hardware/Software Introduction John Wiley publication
4. David E. Simon -An Embedded Software Primer Pearson Education

Reference:

1. Muhammad A Mazidi, The 8051 Microcontroller and Embedded Systems, Pearson Education
2. Sriram Iyer and Pankaj Gupta, Embedded Realtime systems programming, Tata McGraw Hill
3. Embedded Microcomputer Systems- Real time Interfacing -Valvano

T.E. (BIOMEDICAL ENGINEERING)

SEMESTER - VI

University of Mumbai			
Class: T.E.	Branch: Biomedical Engineering	Semester: VI	
Subject: MEDICAL IMAGING- I			
Periods per Week (Each 60 min.)	Lecture	04	
	Practical	02	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	03	100
	Practical & Oral	---	--
	Oral	---	25
	Term Work	---	25
	Total	03	150

Module	Content	Time (hrs)
1.	**Ultrasound in Medicine** Introduction , Production and Characteristics of Ultrasound.	03
	Display System: A-mode, B-mode and M-mode display and applications.	03
	Ultrasound transducers and instrumentation.	04
	Real-Time Ultrasound, Continuous wave and Pulsed wave Doppler Ultrasound systems , Color flow imaging, applications.	04
	Ultrasound contrast agents and applications.	02
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 Devices, Controls, X-ray Film development technique.	12
3.	Fluoroscopy Imaging and X-ray Image intensifier	04
4.	Computed Radiography and Digital Radiography	04
5.	Angiography techniques	02
6.	Mammography, Principle, Equipment, Digital Mammography	03
7.	Medical Thermography: Physics of thermography, thermographic equipment, applications	04
8.	Endoscopy: Equipment, Imaging and its applications	03

Theory Examination:

1. Question paper will comprise of total 7 questions, each of 20 marks.
2. Only 5 questions need to be solved.
3. Q.1 will be compulsory and based on the entire syllabus.

4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Oral Examination:

Oral will be based on entire syllabus.

Term work:

Term work will consist of at least Eight Assignments/ Laboratory Experiments based on the above syllabus and a written test. Test and Seminars be suitably graded by teachers and attached in the journal. The distribution of the term work shall be as follows,

Lab work (Assignments/ Laboratory Experiments & Seminar) :15 marks

Test (at least one) :10 marks

~~Attendance (Practical and Theory)~~ ~~05 marks~~

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

Text Books:

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

References Books:

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

T.E. (BIOMEDICAL ENGINEERING)

SEMESTER – VI

University of Mumbai			
Class: T.E.	Branch: Biomedical Engineering	Semester: VI	
Subject: BIOMEDICAL INSTRUMENTATION - II			
Periods per Week (Each 60 min.)	Lecture	04	
	Practical	02	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	03	100
	Practical & Oral	02	25
	Oral	---	---
	Term Work	---	25
	Total	05	150

Module	Content	Time (hrs)
1.	**Generation of Bioelectric Potentials:** 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. ECG, EMG, EEG, EOG, ERG. Phonocardiography. Measurement of skin resistance	10
3.	**Patient Monitoring System:**	08

	Measurement of Heart Rate, Pulse rate, Blood pressure, Temperature and Respiration rate, Apnea Detector.	
4.	**Arrhythmia and Ambulatory Monitoring Instruments:** Cardiac Arrhythmias. Ambulatory monitoring instruments.	06
5.	**Foetal and Neonatal Monitoring System:** Cardiotocograph , Methods of monitoring of Foetal Heart rate and labour activity, Foetal scalp PH measurement, Incubator and Infant warmer.	06
6.	**Biotelemetry, Telemedicine concepts and its application**	06
7.	**Biofeedback Technique: EEG, EMG**	04
8.	**Electrical Safety in Biophysical Measurements.**	02

Theory Examination:

1. Question paper will comprise of total 7 questions, each of 20 marks.
2. Only 5 questions need to be solved.
3. Q.1 will be compulsory and based on the entire syllabus.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Practical & Oral Examination:

Practical examination will be based on one experiment performed during the semester and oral examination will be based on the entire syllabus.

Term work:

Term work will consist of at least 08 Laboratory Experiments based on the above syllabus and a written test. Test and Assignments/Seminars be suitably graded by teachers and attached in the journal. The distribution of the term work shall be as follows,

Laboratory work (Experiments and Journal) :15 marks

Test (at least one) :10 marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

Text Books:

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

References Books:

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

University of Mumbai			
Class: T.E.	**Branch:** Biomedical Engineering	**Semester:** VI	
Subject: Biological Modeling and Simulations			
Periods per Week (Each 60 min.)	Lecture	04	
	Practical	02	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory	03	100
	Practical & Oral	---	---
	Oral	---	25
	Term Work	---	25
	Total	03	150

Module	Content	Time (hrs)
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.	09
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.	13
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.	04
6.	**Modeling the immune response:** Behavior of the immune system, linearized model of the immune response.	04
7.	Pharmacokinetics Drug delivery	02
8.	Modeling of Insulin Glucose feedback system and Pulsatile Insulin secretion	04

Theory Examination:

11. Question paper will comprise of total 7 questions, each of 20 marks.
12. Only 5 questions need to be solved.
13. Q.1 will be compulsory and based on the entire syllabus.
14. Remaining questions will be mixed in nature.

15. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Oral Examination:

Oral exam will be based on entire subject.

Term work:

Term work consists of minimum six assignments and a written test. The distribution of the term work shall be as follows.

Tutorials (Assignments and Journal) :15 marks

Test (at least one) :10 marks

~~Attendance (Tutorial and Theory)~~ ~~:05 marks~~

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

List of Experiments/Assignments

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

Text Books:

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

Reference Books:

1. Biomedical Engineering Handbook by Bronzino (CRC Press)

	distributed population	
4.	**Analysis of Variance**: Purpose of Analysis of variance, Linear Mathematical model for analysis of variance, The completely randomized design, Randomized Complete Block diagram, Repeated measures design, The factorial experiment. Two-factor Experiments with Replication.	08
5.	**Curve fitting, Regression and Correlation**: Curve fitting, Regression and Correlation Model, Sample regression equation, using regression equation, Correlation coefficient, Multiple Linear regression model, Multiple Linear Correlation model, Obtaining Multiple Linear regression equation, evaluating Multiple Linear regression equation, Regression analysis-Qualitative independent variables, Variable selection procedures	06
6.	**Tests of Hypothesis and Significance**: Statistical decisions, Statistical Hypothesis, Null Hypothesis, Type I and Type II errors, level of significance, One Tailed and Two Tailed tests, Relationship between Estimation theory and Hypothesis testing. Yates' Correction for Continuity	06
7.	**Chi-square Distribution and analysis of frequencies**: Mathematical properties of chi-square distribution, Tests of goodness-of-fit, tests of independence, tests of homogeneity, The fisher exact test	05
8.	**Non-parametric and distribution-free statistics**: The sign test, The Wilcoxon signed-rank test for location, The median test, The spearman rank correlation coefficient, Non Parametric Regression Analysis, Classification (differential, diagnosis) : sequential clinical trials, and other applications	04

Theory Examination:

16. Question paper will comprise of total 7 questions, each of 20 marks.
17. Only 5 questions need to be solved.
18. Q.1 will be compulsory and based on the entire syllabus.

19. Remaining questions will be mixed in nature.
20. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Term work:

Term work consists of minimum eight assignments and a written test. The distribution of the term work shall be as follows,

Laboratory work (Assignments and Journal) :10 marks

Test (at least one) :10 marks

~~Attendance (Practical and Theory)~~ ~~:05 marks~~

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

Text Books:

- Wayne W. Daniel Biostatistics : A Foundation For Analysis in Health Sciences Wiley Series
- Murray R. Spiegel , Probability and Statistics, Schaum's Series
- Martin Bland : An Introduction to Medical Statistics, Oxford University Press, 1987.

University of Mumbai			
Class: T.E.	**Branch:** Biomedical Engineering	**Semester:** VI	
Subject: Digital Signal Processing for Biomedical Applications			
Periods per Week (Each 60 min.)	Lecture	04	
	Practical	02	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	03	100
	Practical & Oral	---	---

	Oral	---	---
	Term Work	---	25
	Total	03	125

Module	Content	Time (hrs)
1.	**Discrete Time(DT) signals & systems** Review of Discrete time signals and systems	04
2.	**Z Transform** Review of Z transform , Analysis of LTI systems in Z domain	04
3.	**Frequency Analysis of DT signal** DTFS definitions from orthogonal complex exponentials ,CTFS & DTFS and Properties of DTFS ,Power Density Spectrum ,DTFT and Properties of DTFT ,Energy Density Spectrum Relationship between DTFT & Z transform	06
4.	**Discrete Fourier Transform (DFT)** DTFT, DFT and DFT properties ,Block convolution using DFT by Overlap-add & Overlap-save methods ,Fast Fourier transform (FFT)	10
5.	**System realization of DT Systems** System Transfer function, System realizations using direct, cascade, parallel & Lattice forms. System Analysis: Impulse response, zero input and zero state response Signal generation	06
6.	**Design of Digital Filters:** Design of FIR filters, Design of IIR filters from analog filters, frequency transformations, Design of digital filters based on least squares method digital filters from analogue filters, Properties of FIR digital filters, Design of FIR filters using windows, Comparison of IIR and FIR filters, and Linear phase filters. Application of Filters on Biomedical Signals like ECG, EEG, EMG, Receiver, Advantages, Disadvantages.	14
7.	**DSP Processors** Need for Special Architecture , Difference between DSP Processor & microprocessor , general DSP Processor	05

Theory Examination:

21. Question paper will comprise of total 7 questions, each of 20 marks.
22. Only 5 questions need to be solved.
23. Q.1 will be compulsory and based on the entire syllabus.
24. Remaining questions will be mixed in nature.
25. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Term work:

Term work consists of minimum eight assignments and a written test. The distribution of the term work shall be as follows,

Laboratory work (Assignments and Journal) :10 marks

Test (at least one) :10 marks

~~Attendance (Practical and Theory)~~ ~~:05 marks~~

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

Text Books:

1. Ashok Ambardar, Analog and Digital Signal Processing, Thomson Learning Publication, second edition, first reprint, 2001.
2. Proakis and Manolakis ,Digital Signal Processing Pearson
3. Oppenheim & Schafer with Buck, Discrete- Time Signal Processing, Prentice Hall, Signal Processing series, second edition, 2000.
4. S.K Mitra, Digital Signal Processing, Tata McGraw Hill Publication.
5. T.J Cavicchi, Digital Signal Processing, Wiley Publications, 2002