ANNAMALAI UNIVERSITY

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRONICS & INSTRUMENTATION ENGINEERING

M.E. (REHABILITATIVE INSTRUMENTATION) DEGREE PROGRAMME

CHOICE BASED CREDIT SYSTEM (CBCS)

REGULATIONS

R1. CONDITION FOR ADMISSION

Candidates for admission to M.E. Degree Program in Rehabilitative Instrumentation, shall be required to have passed the B.E / B. Tech in Electronics & Instrumentation Engineering or Instrumentation & Control Engineering or Electronics and Communication Engineering or Electrical and Electronics Engineering or Bio medical Engineering or Mechatronics or an Examination of any other authority accepted by the Syndicate of this University as equivalent thereto. They shall satisfy the conditions regarding qualifying marks and physical fitness as may be prescribed from time to time by the Syndicate of the Annamalai University.

R2. CREDITS

ME full-time program will have a duration of four semesters and part time six semesters.

The number of credits for each semester for the full-time program shall be as follows:

First and second semesters	: 20 credits per semester
Third Semester	: 12 credits
Fourth Semester	: 13 credits

The number of credits for each semester for the part-time program shall be as follows:

First and second semesters	: 9 credits per semester
Third and Fourth Semester	: 11 credits
Fifth Semester	: 12 credits
Sixth Semester	: 13 credits

The total credits for both the program will be 65 each. For the award of the degree, a student has to earn a minimum of 65 credits.

R3. DURATION OF THE PROGRAMME

A student of the full-time program is normally expected to complete in four semesters but any case not more than four years from the time of admission.

A student of the part-time program is normally expected to complete in six semesters but any case not more than six years from the time of admission.

R4. REGISTRATION FOR COURSES

A student newly admitted will automatically be registered for all the courses prescribed for the first semester, without any option.

Every other student shall submit a completed registration form indicating the list of courses intended to be credited during the next semester. This registration will be done a week before the last working day of the current semester. Late registration with the approval of the Dean on the recommendation of the Head of the Department along with a late fee will be done up to the last working day.

Registration for the thesis phase-I and phase-II shall be done at the appropriate semesters.

R5. ASSESSMENT

The break-up of assessment and examination marks for theory courses is as follows.

First assessment (I Mid Term Test)	: 10
Second assessment (II Mid Term Test)	: 10
Third assessment	: 05
Examination	: 75

The break-up of assessment and examination marks for practical courses/Thesis is as follows.

First assessment	: 15
Second assessment	: 15
Third assessment	: 10
Examination	: 60

The thesis phase-I will be assessed for 40 marks by a committee consisting of the Head of the Department, the guide and a minimum of two members nominated by the Head of the Department. The Head of the Department will be the chairman. 60 marks are allotted for the thesis work and viva voce examination at the end of the pre-final semester. The same procedure will be adopted in the final semester also.

R6. COUNSELLOR

To help the students in planning their course of study and for general advice on the academic program, the Head of the Department will attach a certain number of students to a member of the faculty who shall function as counselor throughout their period of study. Such counselors shall advise the students, give preliminary approval for the courses to be taken by the students during each semester and obtain the final approval of the Head of the Department.

R7. CLASS COMMITTEE

For each semester, separate class committee will be constituted by the respective Heads of Departments.

The composition of the class committee for each semester except the final semester shall be as follows:

Teachers of the individual courses.

A project co-coordinator (in the prefinal and final semester committee only) who shall be appointed by the Head of the Department from among the project supervisors.

One professor or Reader, preferably not teaching the concerned class, appointed as chairman by the Head of the Department.

The Head of the Department may opt to be a member or the Chairman.

All student counselors of the class, the Head of the Department (if not already a member) and any staff member nominated by the Head of the Department may serve as special invitees.

The class committee shall meet four times during the semester.

The first meeting will be held within two weeks from the date of commencement of the class to decide the type of assessment like test, assignment etc. for the three assessments and the dates of completion of the assessments.

The second and third meetings will be held within a week after the completion of the first and second assessments respectively to review the performance and for follow-up action.

The fourth meeting will be held on completion of all the assessments except the end semester examination and at least one week before the commencement of the end semester examinations.

During this meeting the assessment on a maximum of 40 marks will be finalized for every student and tabulated and submitted to the Head of the Department for approval and transmission to the Controller of Examinations.

R8. WITHDRAWAL FROM A COURSE

A student can withdraw from a course at any time before a date fixed by the Head of the Department prior to the second assessment, with the approval of the Dean of the faculty on the recommendation of the Head of the Department.

R9. TEMPORARY BREAK OF STUDY

A student can take a one-time temporary break of study covering the current semester and/or the next semester with the approval of the Dean on the recommendation of the Head of the Department, not later than seven days after the completion of the second assessment test. However, the student must complete the entire program within the maximum period of four years for full-time.

R10. SUBSTITUTE ASSESSMENTS

A student who has missed one or more of the assessments of a course other than the end semester examination, for genuine reasons accepted by the Head of the Department, may take a substitute assessment for any one of the missed assessments. The substitute assessment must be completed before the date of the fourth meeting of the respective class committee.

A student who wishes to have a substitute assessment must apply to the Head of the Department within a week from the date of the missed assessment.

R11. ATTENDANCE REQUIREMENTS

To be eligible to appear for the examination in a particular course, a student must put in a minimum of 80% of attendance in that course. However, if the attendance is 75% or above but less than 80% in any course, the authorities can permit the student to appear for the examination in that course on payment of the prescribed condemnation fee.

A student who withdraws from or does not meet the minimum attendance requirement in a course must re-register for and repeat the course.

R12. PASSING AND DECLARATION OF EXAMINATION RESULTS

All assessments of all the courses on an absolute marks basis will be considered and passed by the respective results passing boards in accordance with the rules of the University. The marks for each course shall be converted to the corresponding letter grade as follows. Thereafter, computation of the Grade Point Average (GPA) and Overall Grade Point Average(OGPA) shall be done.

Grade	
90 to 100 marks	: Grade S
80 to 89 marks	: Grade A
70 to 79 marks	: Grade B
60 to 69 marks	: Grade C
55 to 59 marks	: Grade D
50 to 54 marks	: Grade E
Less than 50 marks	: Grade F
Insufficient attendance	: Grade I
Withdrawn from the course	: Grade W

In order to pass a course the student has to score 30 marks out of 75(end semester examination) for theory courses and to score 24 marks out of 60 (end semester examination) for practical courses and 50 marks out of 100(total marks).

A student who earns a grade of S, A, B, C, D or E for a course is declared to have successfully completed that course and earned the credits for that course. Such a course cannot be repeated by the student.

A student who obtains letter grades I or W in a course must reregister for and repeat the course.

A student who obtains letter grade F in a course has to reappear for the examination in that course.

A student who obtains letter grade I or W or F in thesis phase-I must reregister in the next semester. Registration for thesis phase-II for such students can be done in the subsequent semesters.

The following grade points are associated with each letter grade for calculating the GPA and OGPA.

S - 10; A - 9; B - 8; C - 7; D - 6; E - 5; F - 0

Courses with grades I and W are not considered for calculation of grade point average or cumulative grade point average. F grade will be considered for computing GPA and OGPA

A student can apply for retotalling of one or more of his/her examination answer papers within a week from the date of issue of grade sheet to the student on payment of the prescribed fee per paper. The application must be made to the Controller of Examinations with the recommendation of the Head of the Department.

After results are declared, grade cards will be issued to the students. The grade card will contain the list of courses registered during the semester, the grades scored and the grade point average for the semester.

GPA is the sum of the products of the number of credits of a course with the grade point scored in that course, taken over all the courses for the semester, divided by the sum of the number of credits for all courses taken in that semester. OGPA is similarly calculated considering all the courses taken from the time of admission.

The results of the final semester will be withheld until the student obtains passing grades in all the courses of all the earlier semesters.

R13. AWARDING DEGREE

After successful completion of the program, the degree will be awarded with the following classifications based on OGPA.

For First class with Distinction the student must earn a minimum of 65 credits within four semesters for full-time and six semesters for part-time from the time of admission, pass all the courses in the first attempt and obtain a OGPA of 8.25 or above.

For First class, the student must earn a minimum of 65 credits within two years and six months for full time and seven semesters for part-time from the time of admission and obtain a OGPA of 6.75 or above.

For second class, the student must earn a minimum of 65 credits within four years for full-time and six years for part-time from the time of admission.

R14. RANKING OF CANDIDATES

The candidates who are eligible to get the M.E. degree in First Class with distinction will be ranked on the basis of OGPA for all the courses of study from I to IV Semester for M.E. Full time and I to VI semesters for Part-Time

The candidates passing with First class and without failing in any subjects from the time of admission will be ranked next to those with distinction on the basis of OGPA for all the courses of study from me to IV Semester for M.E. Full time and I to VI semesters for Part-Time

R15. ELECTIVES

Apart from the various elective courses offered in the curriculum of the branch of specialization, a student can choose a maximum of two electives from any specialization under the faculty during the entire period of study, with the approval of the Head of the Department and the Head of the Department offering the course.

R16. TRANSITORY REGULATIONS

If a candidate studying under the old regulations could not attend any of the courses in his/her program, shall be permitted to attend equal number of courses, under the new regulation and will be examined in those courses. The choice of courses will be decided by the concerned Head of the Department. However he/she will be permitted to submit the thesis as per the old regulations. The results of such candidates will be passed as per old regulations.

The University shall have powers to revise or change or amend the regulations, the scheme of examinations, the courses of study and the syllabi from time to time.

M.E. FULL-TIME (TWO YEAR) DEGREE

PROGRAMME IN REHABILITATIVE INSTRUMENTATION

CHOICE BASED CREDIT SYSTEM

Subject of Study and Scheme of Examinations

FIRST SEMESTER

Code	Subjects	Period / Week		Duration of exam. Hrs.	Marks			Credits
		L	P		CA	FE	Total	
RIC-101	Applied Mathematics	4		3	25	75	100	3
RIC-102	Medical Physiology	4		3	25	75	100	3
RIC-103	Biosensors and Transducers	4		3	25	75	100	3
RIC-104	Impairment Engineering	4		3	25	75	100	3
RIC-105	Bio signal Processing	4		3	25	75	100	3
RIE-106	Elective - I	4		3	25	75	100	3
RIP-107	Bio Signal and Image Processing Laboratory		3	3	40	60	100	2
	Total	**24**	**3**		**190**	**510**	**700**	**20**

SECOND SEMESTER

Code	Subjects	Period / Week		Duration of exam. Hrs.	Marks			Credits
		L	P		CA	FE	Total	
RIC-201	Biomedical Instrumentation	4		3	25	75	100	3
RIC-202	Modelling and Control of Biological Systems	4		3	25	75	100	3
RIE-203	Elective - II	4		3	25	75	100	3
RIE-204	Elective – III	4		3	25	75	100	3
RIE-205	Elective – IV	4		3	25	75	100	3
RIE-206	Elective – V	4		3	25	75	100	3
RIP-207	Biomedical Instrumentation Laboratory		3	3	40	60	100	2
	Total	**24**	**3**		**190**	**510**	**700**	**20**

THIRD SEMESTER

Code	Subjects	Period / Week		Duration of exam. Hrs.	Marks			Credits
		L	P		CA	FE	Total	
RIE - 301	Elective-VI	4		3	25	75	100	3
RIE - 302	Elective-VII	4		3	25	75	100	3
RIT - 303	Thesis Phase-I				40	60	100	6
	Total	**8**			**90**	**210**	**300**	**12**

FOURTH SEMESTER

Code	Subjects	Period / Week		Duration of exam. Hrs.	Marks			Credits
		L	P		CA	FE	Total	
RIT - 401	Thesis Phase-II				40	60	100	13
	Total						**100**	**13**

L : Lecture

CA : Continuous Assessment

FE : Final Examination

P : Practical

MASTER OF ENGINEERING
(REHABILITATIVE INSTRUMENTATION)

SIX SEMESTER SYSTEM (PART-TIME)

CHOICE BASED CREDIT SYSTEM
Subject of Study and Scheme of Examinations

FIRST SEMESTER

Code	Subjects	Period / Week		Duration of exam. Hrs.	Marks			Credits
		L	P		CA	FE	Total	
PTRIC-101	Applied Mathematics	4		3	25	75	100	3
PTRIC-102	Medical Physiology	4		3	25	75	100	3
PTRIC-103	Biosensors and Transducers	4		3	25	75	100	3
	Total	**12**			**75**	**225**	**300**	**09**

SECOND SEMESTER

Code	Subjects	Period / Week		Duration of exam. Hrs.	Marks			Credits
		L	P		CA	FE	Total	
PTRIC-201	Biomedical Instrumentation	4		3	25	75	100	3
PTRIC-202	Modelling and Control of Biological Systems	4		3	25	75	100	3
PTRIE-203	Elective - I	4		3	25	75	100	3
	Total	**12**			**75**	**225**	**300**	**09**

THIRD SEMESTER

Code	Subjects	Period / Week		Duration of exam. Hrs.	Marks			Credits
		L	P		CA	FE	Total	
PTRIC-301	Impairment Engineering	4		3	25	75	100	3
PTRIC-302	Bio signal Processing	4		3	25	75	100	3
PTRIE-303	Elective – II	4		3	25	75	100	3
PTRIP-304	Bio Signal and Image Processing Laboratory		3	3	40	60	100	2
	Total	**12**	**3**		**115**	**285**	**400**	**11**

FOURTH SEMESTER

Code	Subjects	Period / Week		Duration of exam. Hrs.	Marks			Credits
		L	P		CA	FE	Total	
PTRIE-401	Elective – III	4		3	25	75	100	3
PTRIE-402	Elective – IV	4		3	25	75	100	3
PTRIE-403	Elective – V	4		3	25	75	100	3
PTRIP-404	Biomedical Instrumentation Laboratory		3	3	40	60	100	2
	Total	**12**	**3**		**115**	**285**	**400**	**11**

FIFTH SEMESTER

Code	Subjects	Period / Week		Duration of exam. Hrs.	Marks			Credits
		L	P		CA	FE	Total	
PTRIE - 501	Elective-VI	4		3	25	75	100	3
PTRIE - 502	Elective-VII	4		3	25	75	100	3
PTRIT - 503	Thesis Phase-I				40	60	100	6
	Total	**8**			**90**	**210**	**300**	**12**

SIXTH SEMESTER

Code	Subjects	Period / Week		Duration of exam. Hrs.	Marks			Credits
		L	P		CA	FE	Total	
RIT - 601	Thesis Phase-II				40	60	100	13
	Total						**100**	**13**

L **:** Lecture

CA **:** Continuous Assessment

FE **:** Final Examination

P **:** Practical

LIST OF ELECTIVES

1. Medical Diagnostic Instrumentation
2. Biomechanics
3. Medical Image Processing
4. Vision Impairment and Therapy
5. Hearing Impairment and Therapy
6. Audiology and Speech Therapy
7. Soft Computing Techniques
8. Bio MEMS and Nanotechnology
9. Lasers and fiber Optics in Medicine
10. Artificial Organ System
11. Mediembedded Systems and RTOs
12. Modeling of Physiological Systems
13. Computers in Medicine
14. Tissue and Stem Cell Engineering
15. Transportation in Living Systems
16. Hospital Engineering
17. Telemedicine
18. Bioinformatics
19. Cancer Biology

RIC 101/ PTRIC 101. APPLIED MATHEMATICS

OBJECTIVES:

To enable the student to build up their mathematical ability and acquire the knowledge to understand the concepts with a sense of applicability

Numerical Solution of Partial Differential Equations: Elliptic equation – Poison's equation and Laplace equation – Liebmann iterative method. Hyperbolic equation: one-dimensional wave equation and radio equation. Parabolic equation: one-dimensional heat equation and telegraph equation – Bender - Schmidt method – Crank Nicolson method.

Introduction to Finite Element Method for solving field problems:Stress and Equilibrium-Boundary conditions - Strain Displacement relations - Stress-strain relations.

One Dimensional problems: Finite element modelling - coordinates and shape functions. Potential Energy approach: Assembly of Global stiffness matrix and load vector - Finite element equations - Treatment of boundary conditions -quadrate shape functions.

Introduction to two dimensional modelling using Finite element method.Two dimensional problems with constant strain triangles and treatment of boundary conditions. Finite element modelling of Axisymmetrix solids subjected to Axisymmetrix loading with triangular elements.

Wavelets: Introduction- Continuous wavelet transform – wavelet time – frequency characteristics - Discrete wavelet transform - wavelet decomposition– reconstruction – denoising – medical applications

References:

1. M.K. Venkataraman, Numerical Methods in Science and Engineering, National Publishing Company, 1986.
2. T.R. Chandrupatla and A.D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall, 2003
3. Ronald.L. Allen, Duncan W. mills, Signal analysis Time, Frequency, Scale and Structure A.John Wiley&Sons, Inc., Publication, 2004

RIC 102 / PTRIC 102 MEDICAL PHYSIOLOGY

OBJECTIVES:

To impart knowledge on cell divisions, blood vascular system, ductless/endocrine glands, digestive system and nervous system and familiarize medical physiology to the students

Cell divisions and development of human body: Cell structure-functions. Tissues: Types of tissues, epithelial & connective, muscle and nervous. Classification of epithelial and connective tissues with their locations. Muscular architecture: Structure of skeletal, smooth and cardiac muscles -differences. Single unit and multi-unit smooth muscle -properties of muscle - muscle contraction sterling laws – mechanisms - E C coupling -muscle fatigue -rigor mortis - sliding filament theory -slow and fast muscle fibres -isotonic and isometric contraction.

Blood Vascular System:Composition and functions of blood, coagulation -actionof platelets, functions, mechanisms. Hemoglobin: functions - compounds and derivatives. Erythrocyte Sedimentation Rate (ESR) - significance. Blood coagulation – factors – process – anticoagulants - prothrombin time - clotting time - bleeding time - blood groups – ABO systems and Rh factors - Ultra structure and functions of blood vessels (artery and vein).

Ductless/endocrine glands: various ductless glands: pituitary glands – hypothalamus and adenohypohysis. Hormone secretion – actions of hormone and related applied physiology – thyroid gland – histology - blood and hormone secretion – action of hormone- Parathyroid gland and adrenal gland.

Digestive System: Anatomy – histology of gastro intestinal tract –oral cavity (mouth)- teeth-salivary glands - structure, composition and functions of saliva. Circulatory system: Anatomy - functions – heart valves – heart rhythm – conducting system of heart – blood supply - properties of cardiac muscles – action potential of single cardiac fiber - special junctionaltissue of heart -myogenic and neurogenic heart-conducting system of heart -E.C.G.

Nervous system: Anatomy - classification – structure of a typical neuron -synapse – synaptic transmission, neuro transmitter, Central Nervous System (CNS) – anatomy of brain and its sub divisions. Functions of brain–central canal of the spinal cord – thalamus and hypothalamus - spinal cord and transverse section effects. Peripheral nervous system – classifications of motor nerves – description- voluntary and involuntary action- Autonomic nervous system - classifications – functions. Neural Transmission: Introduction - sympathetic and parasympathetic response.CNS synaptic, electrical and chemical transmissions.Neuro muscular Junction: Structure- events in transmission- end-plate potential- post tetanic potential.

References:

1. Arthur C.Guyton and John E. Hall, Text book of Medical Physiology, Saunders (Elsevier), NJ, 11th Edition, 2005.
2. B.G.King, W.J.Showers, Human Anatomy & Physiology, W.B.Saunders Co., NY,6th edition, 1969.
3. Ross and Wilson,Anatomy and Physiology in health and illness,Churchill Living Stone,11th edition,2010.

RIC 103 / PT RIC 103 BIOSENSORS AND TRANSDUCERS

OBJECTIVES:

To impart knowledge on various bio sensors and transducers

The transducer and transduction principles: active transducers- passive transducers- sensor error sources- transducers for biomedical applications. Principles of transduction and measurement: Sensor Classification - Medically significant measurands– strain – force – pressure – acceleration – flow – volume - temperature and biopotentials. Functional specifications of medical sensors: static and dynamic characteristics of measurement systems.

Sensors: Resistives, capacitive, inductive types -reactance type – electromagnetic type. Signal conditioning: Wheatstone bridge - AC bridges. Amplifiers: AC - instrumentation - isolation – carrier - electrostatic shields - phase-sensitive detectors - interference types and reduction - shield grounding.

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Recording Electrodes: Electrode-tissue interface – polarization - skin contact impedance - motion artifacts - Electrodes for ECG, EEG and EMG -electrical conductivity of electrode jellies and creams.

Biosensor: Sensors/receptors in the human body -ion exchange membrane electrodes - enzyme electrode -Glucose and immune sensors. Optical sensor: Photo detectors - optical fibre sensors - indicator mediated transducers - general principles of optical sensing - optical fibre temperature sensors. Pulse sensor: photoelectric pulse transducer - strain gauge pulse transducer.

Optical biosensor: indicator labelled bioassay - solid phase absorption label sensors - immunological sensors. Chemoreceptors: Hot and cold receptors – baroreceptors - sensors for smell, sound, vision, osmolality and taste.Transducers for the measurement of ions and dissolved gases:Ion exchange membrane electrodes - measurement of pH - glass pH electrodes -measurement of pO_2 - measurement of pCO_2 - ISFET for glucose and urea.

References:

1. John G. Webster, Medical Instrumentation-Application and Design, John Wiley and Sons Inc., 3rd revised Ed., 2009.
2. L. A. Geddes and L. E. Baker, Principles of Applied Biomedical Instrumentation, John Wiley Publications, 3rd Edition,2008.
3. Brain R.Eggins, Biosensors: An Introduction, John Wiley Publication, 1997
4. Khandpur. R.S., Hand Book of Biomedical Instrumentation, Tata McGraw Hill Pub Co. Ltd., New Delhi,2nd ed., 2003.
5. D. L. Wise,Applied Bio Sensors, Butterworth Publishers, London 1989.

RIC 104 / PTRIC 301 IMPAIRMENT ENGINEERING

OBJECTIVES:

To impart knowledge on impairment, sensory and auditory rehabilitation, orthopaedic prosthetics and orthotics in rehabilitation

Impairment: Introduction – impairment types - handicaps –measurements – assessment and characterization concepts in sensory and motor rehabilitation. Anthropometry: Static and dynamic Measurements - Area - movement, measurement of Muscular Strength and Capabilities.

Measurement tools and processes: Fundamental principles – structure – functioning - performance and behaviour – Subjective and objective. Ergonomic aspects in designating devices: Design of information devices - traditional Devices -V.D.Uâ€™ s, Using colour and Control designs

Sensory and Auditory rehabilitation: Sensory augmentation and substitution.Visual system: Visual augmentation -tactual vision substitution, and Auditory vision substitution. Auditory system: Auditory augmentation – Audiometer - Hearing aids - cochlear implantation - visual auditory substitution - tactual auditory substitution. Tactual system:Tactual augmentation and substitution.

Orthopedic Prosthetics and Orthotics in rehabilitation: Motor rehabilitation: Introduction – concepts - applications. Intelligent prosthetic knee -hierarchically controlled prosthetic hand-self-aligning orthotic knee joint. Externally powered and controlled Orthotics and Prosthetics: FES systems-restoration of hand function, standing and walking- Hybrid Assistive Systems (HAS). Active Prostheses:Active above knee prostheses -myoelectric hand andarm prostheses - different types.The MARCUS intelligent Hand prostheses.

Computer applications in Rehabilitation and Robotic Manipulation Aids: Modes of operation and control - interfaces in compensation for visual perception -improvement of orientation and mobility. Computer assisted lipreading - Brain computer interface - concepts.

References:

1. Joseph D. Bronzino,Handbook of biomedical engineering,CRC Press,3rd edition, 2006
2. Robinson C.J, Rehabilitation engineering. CRC press,2003.
3. Horia-Nicolai L Teodorescu, L.C.Jain, Intelligent systems and technologies in rehabilitation engineering; CRC Press; December 2000.
4. Etienne Grandjean, Harold Oldroyd, Fitting the task to the man, London:Taylor & Francis,4th edition, 1988.

RIC 105 / PTRIC 302 BIO SIGNAL PROCESSING

OBJECTIVES:

To impart knowledge on bio signal processing through spectral analysis and adaptive filters

Signals and Systems: Introduction to discrete time signals and systems - Properties - LTI system. Signal conversion :conversion requirement for biomedical signals – signal conversion circuits. Discrete Fourier Transform (DFT) – properties – circular convolution – FFT computation using DIT and DIF algorithms.

FIR design: Windowing techniques – need and choice of windows – Linear phase characteristics. IIR design: Analog filter design –approximation methods – Warping - prewarping – Frequency transformation. Wavelet transformation: Introduction – basic principles.

Spectral analysis: Estimation of power density spectrum - periodogram - parametric model based spectral linear prediction theory - estimation using Auto Regressive (AR), Moving Average (MA) andAuto Regressive Moving Average (ARMA) models. Estimation of parameters- spectral error measure - EEG analysis.

Adaptive filters: Principle noise canceller model – 50 Hz adaptive cancelling using a sine wave model – maternal ECG cancellation in fetal electrocardiography - ECG QRS detection techniques – estimation of R-R interval – estimation of ST segment inclination – arrhythmia analysis monitoring – long term ECG recording – basics of ECG data reductiontechniques.

Electromuscular Signal Processing: Basic electromyography, EMG data acquisition, rectification and averaging. Neurological signal processing: The EEG Signals and its Characteristics - EEG Analysis - time frequency domain method -detection of spikes and spindles - detection of alpha, beta and gamma waves. Least squares and polynomial modelling: The Markov model and Markov chain -dynamics of sleep-wake Transition - hypnogram Model Parameters.

References:

1. Rangaraj M Rangayyan: Biomedical Signal Analysis, John Wiley, 2002.
2. John G Proakis, Dimitris G Manolakis: Digital Signal Processing – Principles, Algorithms and Applications, Prentice Hall of India,4th edition, 2005.
3. P. Ramesh Babu: Digital Signal Processing, ScitechPublications,India,4th edition, 2007.
4. John L.Semmlow: Biosignal and Medical Image Processing – Matlab Based Applications,Marcel Dekker Inc., New York, 2nd edition, 2009.
5. D. C. Reddy, Biomedical Signal Processing – Principles and Techniques, Tata McGraw Hill Publishing company Ltd., 2nd reprint, 2006.

RIC 201 / PTRIC 201 BIOMEDICAL INSTRUMENTATION

OBJECTIVES:

To familiarize the student with bio medical instrumentation using ECG, EEG and ultra sound instrumentation.

Basic medical instrumentation system: Block diagram – design and performance requirements – constraints in design – types of biomedical equipments – analytical, diagnostic, therapeutic, surgical – manual, microprocessor and PC based equipments – regulation of medical devices and testing of biomedical equipments.

Electrocardiography: ECG machine –recording of ECG -artifacts in ECG recording - types of ECG machines – vectorcardiograph – phonocardiograph – patient monitoring systems – bedside monitoring –cardiotocograph – methods of monitoring fetal heart rate - Holter monitoring and recording – cardiac stress testing – bicycle and treadmill tests.

Electroencephalograph: Block diagram – amplifiers, filters – sensitivity control – applications of EEG.Evoked potential measurement system – types and stimulations – analysis and storage of VEP, AEP and Somatosensory EP – brain mappers

Clinical applications of electrotherapy :Diathermy – measuring devices. Impedance Techniques : Bipolar and tetrapolar circuits - detection of physiological activities -impedance plethysmography- resistance and capacitance type -pulmonary function measurements and analysers–respiratory parameters – Spirometry – basic system – types and applications. Oximeters:Types – pulse oximeter- audiometers – pure tone and speech audiometers. Blood cell counters. Blood flowmeters: Electromagnetic– ultrasonic– NMR and Laser Doppler blood flowmeters.

Ultrasound Instrumentation: Doppler - Magnetic Resonance Imaging (MRI) - principles – pulse sequence- image acquisition and reconstruction techniques – MRI instrumentation – Functional MRI - Application of MRI. X-Ray Fluoroscopy – Computed tomography – Principles of sectional imaging – scanner configuration - data acquisition system.

References:

1. R. S. Khandpur, Biomedical Instrumentation Technology and Applications, McGraw-Hill Professional, 2004.
2. Raja Rao. C; Guha. S.K, Principles of Medical Electronics and Biomedical Instrumentation, Orient Longman Publishers, 2001.
3. R.Anandanatarajan, Biomedical Instrumentation, PHI Learning, 2011
4. L. A. Geddes and L. E. Baker, Principles of Applied Biomedical Instrumentation, John Wiley Publications, 3rdEdition, 2008.
5. Khandpur. R. S., Handbook of Bio-Medical Instrumentation, Tata McGraw Hill, 2nd edition, 2003
6. Richard Aston, Principles of Biomedical Instrumentation and Measurements, Merril Publishing Co., 1990.

RIC 202 / PTRIC 202 MODELLING AND CONTROL OF BIOLOGICAL SYSTEMS

OBJECTIVES:

To impart knowledge on modelling and control of biological system in particular human thermal system and few case studies.

Feedback system: Basic feedback concepts - effect of feedback on noise -distortion analysis - open loop control system-control system with feed Back. Mathematical descriptions of systems: transfer function matrix - state space representation - state-variable description - mathematical description of composite systems. Solution of dynamical equation: state transition matrix - impulse response matrix - controllability and observability.

Biological control system: Introduction - dynamical systems– modelling– similarities between biological and engineering control system - biological receptors and receptor characteristics.The pupil control systems:General structure – dynamic response characteristics– open and closed loop instability – automatic aperture control.

Human thermal system: Basic concepts - modelling– thermo regulation - cold and warm bloodedness – lumped and partial differential equations. Case Study: Heat transfer example. Modeling the body as compartment: behavior in simple compartmental system – pharmaco kinetic model – urea distribution model. Multi compartmental system: Dissolution of drugs in solid form – distribution and accessibility of body water and tissue compartments – basis for zero and first order chemical kinetic behavior in the biological system.

Modeling of human thermal regulatory system: Parameters involved - control system model - biochemistry of digestion - types of heat loss from body - heat transfer models - subsystems of human body like skin, core.

Case Study Applications: Cardiac rate - blood pressure - respiratory rate - mass balancing of lungs - oxygen uptake by RBC and pulmonary capillaries - oxygen and carbon dioxide transport in blood and tissues.

References:

1. Benjamin C. Kuo, FaridGolnaraghi, Automatic Control Systems, John Wiley & Sons, Inc., NY, 9th edition, 2009.
2. M.Gopal, Digital Control and State Variable Analysis, Tata McGraw Hill, 2008.
3. David O. Cooney,Biomedical Engineering Principles - An introduction to Fluid, Heat, andMass transport processes, CRC Press, 1976.
4. John H Milsum, Biological Control Systems, McGraw Hill, 1966.
5. Howard T Milhorn, The application of control theory to physiological systems, Saunders, Philadelphia, 1966.
6. E. Carson, E. Salzsieder, Modelling and Control in Biomedical Systems 2000 (including Biological Systems) (IFAC Proceedings Volumes) (Paperback), Pergamon Publishing, January 2001.

RIP-107/PTRIP-304 Bio signal & Image Processing Lab
RIP-207/PTRIP-404 Bio Medical Instrumentation Lab

The list of Experiments will be finalized by the course teacher in consultation with the HOD depending on the availability of equipments, the state of art and recent trends.

ELECTIVES

1. MEDICAL DIAGNOSTIC INSTRUMENTATION

OBJECTIVES:

To familiarize the student with medical diagnostic instrumentation using ECG, EEG and heart lung machine.

Electrocardiograph: Fibrillators and Defibrillators - Pacemakers – Arrhythmia Simulator. Ventilators: Basic principles – generators -inspiratory phase - cycling mechanisms - expiratory phase - ventilatory adjuncts - anaesthetic machines.

Electro EncephaloGraph: Multi channel EEG recording system –epilepsy -evokedpotential – Visual, Auditory and Somatosensory - MEG (Magneto Encephalon Graph) -EEG bio feedback instrumentation. Sliding theory of contraction: Recording and analysis of EMG waveforms – fatigue characteristics - Muscle stimulators - nerve stimulators -nerve conduction velocity measurement.

Measurement of mechanics of breathing: Spirometer-Lung volumeand vital capacity - measurements of residual volume -pneumotachometer–airway resistance measurement - whole body plethysmography -intra-alveolar and thoracic pressure measurements -apnea Monitor -types of ventilators – pressure –volume and time controlled –flow -patient cycle ventilators –humidifiers –nebulizers -inhalators.

Diagnosis: Basic principles of echo technique - display techniques A, B and M mode - ultrasound as diagnostic tool – echocardiogram – abdomen – obstetrics –gynaecology - ophthalmology.

Heart lung machine: Disc and membrane type oxygenerators - finger pump - roller pump, - Haemo Dialyser unit – Lithotripsy -principles of cryogenic technique – application – endoscopy -laproscopy. Patient monitoring system: ICU - post operative – ICCU -single and multichannel telemetry. Transmission of Biosignals over telephone lines -digital central monitoring systems for patient monitoring.

References:

1. Joseph J. Carr and John M. Brown, Introduction to Biomedical equipment technology, Pearson education, 4th edition, 2008.
2. John G.Webster, Medical Instrumentation Application and Design, Wiley India Edition, 3rdedition, 2007.
3. L. A. Geddes and L. E. Baker, Principles of Applied Biomedical Instrumentation, John Wiley Publications, 3rdEdition,2008.

2. BIOMECHANICS

OBJECTIVES:

To impart knowledge on bio mechanics in hard and soft tissues and bones and joints and locomotion

Basic Biological Principles: Diffusion - surface tension and viscosity – characteristics – influencingfactors - biological applications. Introduction to mechanics: Review of principles of mechanics -vector mechanics- Resultant forces of Coplanar and Non-coplanar- Concurrent and non-concurrent forces - parallel force in space - Equilibrium of coplanar forces - Newton's laws of motion -work and energy -moment of inertia. Fluid mechanics: Introduction - viscosity and capillary viscometer -rheological properties of blood - laminar flow -Couette flow and Hagen-poiseuille equation - turbulent flow.

Hard tissues: Bone structure - composition and mechanical properties of bone -, viscoelastic properties - Maxwell and Voight models – anisotropy -electrical properties of bone - fracture mechanism and crack propagation in bones - fracture fixators - repairing of bones - mechanical properties of collagen rich tissues, teeth and its properties.

Soft tissues: Structure and functions of cartilages, tendons – ligaments - stress-strain relationship - soft tissue mechanics - mechanical testing of soft tissues standard sample preparation - cross-section measurement - clamping of the specimen - strain measurement - environmental control, time dependent properties of testing.

Bones, joints and loco motor systems: Joints - classification based on structural, functional and regional- characters – mechanism of lubrication of synovial joints. Bone – composition-classification. Biomechanics of joints: Skeletal joints - basic considerations - basic assumption and limitations - forces and stresses - mechanics of the elbow, shoulder, spinal column, hip, knee and ankle.

Locomotion: Basis - gait analysis and goniometry –ergonomics -foot pressure measurements – force platform - mechanics of foot. Total Hip Prosthesis: requirements - types of components - Stress analysis and instrumentation, Knee Prosthesis. Cardiovascular mechanics: Heart valves - artificial valves - biological and mechanical valves development - testing.

References

1. Donald R. Peterson and Joseph D. Bronzino, Biomechanics Principles and applications, CRC press, Taylor & Francis Group, LLC, 2008 .
2. Duane Knudson, Fundamentals of Biomechanics, Springer publication, 2nd Edition, 2007
3. R. McNeill Alexander, Biomechanics, Chapman and Hall, New York, 1975.
4. D. N.Ghista, Biomechanics of Medical Devices, Marcel Dekker, New York, 1982.
5. A Z Tohen and C T Thomas, Manual of Mechanical Orthopaedics
6. D N Ghista and Roaf, Orthopaedic Mechanics:Procedures and Devices, Academic Press, London, 1978.
7. V.C. Mow and W.C. Hayes, Basic Orthopedic Biomechanics, Lippincott- Raven Publishers, Philadelphia, 1997.

3. MEDICAL IMAGE PROCESSING

OBJECTIVES:

To impart knowledge on Medical image processing through X-rays, fluoroscopy angiography and MRI

Introduction to Driving problems in biomedical imaging: Signal input - image matrix, digital image quality - digital image processing - picture archiving and communication system (PACS) -sources of imaging data acquisition and noise - elementary image processing - Grenander's Pattern Theory.

X-rays: Production X-rays - various components of radiographic systems - X-ray tube design - X-ray spectrum - rating charts of X-ray tubes. Electrical circuit for X-ray machine - filament circuits and mA control - HT circuits - KV control - control of exposure timers - collimators, scatter and grids - absorbed dose - basics of tables and arms - properties of X -ray films and screens - dark room accessories - types of X-ray tubes for various medical applications.

Fluoroscopy and angiography: Fluoroscopic imaging system – principle - specific system design. Digitalfluoroscopy-c-arm system -Digital Subtraction Angiography (DSA) - digital subtraction programming. Ultra Sound in Medicine: Introduction – generation - acoustic impedance - ultrasonic transducers and types - transmitter and detector principles - probe design - principles of image formation. Display system: Principles of A-mode, B-mode and M-mode display - scan conversion - image processing - Doppler Ultrasound andColour flow mapping -application of diagnostic ultra sound.

Magnetic Resonance Imaging (MRI): Introduction - principles- instrumentation – magnets - gradient system - RF coils receiver system - pulse sequence - image acquisition and reconstruction techniques -functional MRI - application of MRI. Radio isotope imaging / Nuclear medicine: Radio nuclides for imaging - radionuclide production: cyclotron production, reactor production, generator production. Rectilinear scanners - Linear scanners – SPECT – PET - Gamma Camera - Comparison of other tomographic techniques.

Infra red Imaging: Physics of thermography -imaging systems - clinical themography - liquid crystal thermography. Special imaging techniques: Cineradiography –cinefluorography - stereoscopic radiography - magnification radiography – microradiography – tomography - neutron radiography.

References:

1. David J. Dowsett, Patrick A. Kenny, R. Eugene Johnston, The Physics of Diagnostic Imaging, Chapman & Hall Medical, Madras/London.2nd edition, 2006.
2. S. Webb, The Physics of Medical Imaging, Adam Hilger, Bristol.Taylor and Francis group, New York, 1988.
3. Rangaraj M. Rangayyan, Biomedical Image Analysis, CRC press, 2005.

4. VISION IMPAIRMENT AND THERAPY

OBJECTIVES:

To impart knowledge on various vision impairment and associated therapy

Visual Impairment: Definitions and categories – Causes- hereditary- congenital - adventitious. Concept of impairment - international classification of impairment including ICF 2005 - definition and classification of blindness and low vision - incidence and prevalence of visual impairment.

Eye and Eye care: Visual Acuity – refraction – fusion - depth perception -visual deficit tunnel vision - loss of visual field - central scotoma - low vision -refractive errors –myopia – hyperopia – persbiopia- astigmatism. Physical Medicine and Eye Diseases: Electotherapy- Actinotherapy - Occular Prosthetics - Eye Bank. Common eye diseases:Cataract – glaucoma – traucoma - corneal ulcer –Xerophthalmia - retinitis pigmentosa - macular degeneration - optic atrophy.

Education of Low Vision Children: Assessment of low vision - educational problems of low vision children - vision stimulation and visual efficiency - low vision aids – magnifiers - large print materials - computers. Education of low vision children with associated intellectual impairment - hearing impairment and neurological impairment including classifications - assessment - teaching strategies.

Psycho-social Implications of Visual Impairment: Psychological and social implications of visual impairment - effects of blindness on growth and development -physical, social, intellectual and emotional. Effects of visual impairment on personality development - verbalism and mannerism.

Social Disposition to Visual Impairment: Attitude towards visual disability-parental attitudes - attitude of siblings - peer group attitude and stereotypic attitude towards blindness. Teachers' attitudes - social attitudes - attitude modification - role of teacher in developing positive Attitude. Visually Impaired Children with Associated Disabilities**:** Concept - Types of associated disabilities -hearing impairment - mental retardation -locomotor and neurological disorders - learning disabilities -importance of early intervention- support services -modify and implications.

Reference books

1. Mani. M.N.G, Techniques of Teaching Blind Children. New Delhi:Sterling Publishers, 1992
2. Mani. M.N.G, Concept Development of Blind Children. Coimbatore: SriRamakrishna Vidyalaya Printing Press, 1992.
3. Mani. M.N.G. Ingredients of IED.Mukkimalai:Nivis Publishers, 1992.
4. Moores. D.F. Educating the Deaf: Psychology, Principles and Practices, Princeton, NJ: Houghton Mifflin, 5th edition, 2001.
5. R. S. Pandey, LalAdvani Perspectives in Disability and Rehabilitation.New Delhi: Vikas Publishing House,1995.
6. Punani. B and Rawal. N (1997). Community Based Rehabilitation (Visually Impaired).Bombay: NAB.

5. HEARING IMPAIRMENT AND THERAPY

OBJECTIVES:

To impart knowledge on various hearing impairment and associated therapy

Medical Rehabilitation of Persons with Hearing Impairment(HI) : Introduction and advantages of early identification for children with HI - consequences of late identification of HI –screening modes and durations - advantages and disadvantages of current screening methods - preferred model for hearing screening and follow up. The Management of deafness in children: Multi disciplinary management - the corner stone of effective habilitation-medical management - investigating the causes of deafness - genetic counselling.

Syndromes related to persons with Hearing Impairment: Cleidocranial Dysplasia Syndrome - Usher's syndrome –Treacher Collins –Hemifacial Microsomis – Neurofibromatosis - Waardenburg Syndrome.Cochlear Implantation and management in deaf children: Sensation and processing of sound and selection criteria - cochlear implants - pre-operative investigations, assessment and adjustment of speech processor - cost-effectiveness and evaluation of cochlear implants -pre-implant counselling and formal evaluation - fitting / tune-up, Follow-up of Aural Rehabilitation.

Auditory-verbal therapy: Existing and emerging trend–philosophy - principles of auditory-verbal practice- therapy process. Auditory verbal: Basic components -preparation, implementation and effectiveness -manpower development -assistive devices - cochlear implant as a tool. Social and vocational rehabilitation of persons with Hearing Impairment: Misconceptions and facts relating to Hearing Impairment - public awareness - pre-vocational and vocational assessment.

Psycholinguistics for the persons with Hearing Impairment: Parts of the brain - functions and organisation of language in the brain - anatomy of language - Broca's area, Wrenicke's area. The organisation of the brain - Fundamental of the cortex -Major and minor hemispheres - language modality and the brain -the effects of spatialization of language - inter play between language and visual spatial cognition.

Education and Assistive Technology for Children with Hearing Impairment: The Concept of Education Technology - need and important of education technology -meaning concept and nature of education technology. Defining Assistive Technology: Accommodation –adaptation -common types of assistive technology - uses of assistive technology - appropriate assistive technology. Assistive Devices: Amplifying devices- induction loop system -alerting systems – speech to text transcription.

References:

1. Graham Martin Ballantyne's Deafness edited by John Graham, Mike Martin, John Graham, David Baguley,7th edition, 2009.
2. TureJohnson, Inclusive Education, VNDP Inter-Regional programmes fordisabled people, 1995
3. Bamford and Saunders, Hearing Impaired, auditory perception andlanguage disability, New Delhi; LakshmanchandArya Publishing Company, 1994
4. Richard.W. Fling, History of Hearing Impairment.New Delhi; A.I.T.B.S.Publishers, 1995

6. AUDIOLOGY AND SPEECH THERAPY

OBJECTIVES:

To familiarize the student with audiology and impart knowledge on various speech therapy

Auditory Mechanism: Phylogeny - basic embryology - development of the ear - Outer ear, Middle ear, Inner ear -anatomy of the ear through temporal bone -physiology of hearing - auditory nerve - brainstem pathway.

Audiology: Lineage of audiology - visual reinforcement audiometry - puretone audiometry – equipment –procedure -interpretation of audiograms -educational and rehabilitation implications. Tympanometry / Impedance Audiometry: Equipment –procedure -interpretation of audiograms - educational and rehabilitation implications -speech and electric response audiometry.

Hearing Aids and Ear Moulds: Hearing aid as a system - history and development of hearing aids - hearing aid orientation and counselling. Components and characteristics of hearing aids: Types -body worn -ear level - bone conduction- CROS -extended frequency -group hearing aids -digital programmable hearing systems.Hearing aid selection and evaluation: Ear moulds–requirements – types -process of making an ear mould, care and maintenance.

Speech as a human function : Definition -anatomy of speech organs - speech mechanism - respiratory organs - phonatory organs - articulatory organs - development of speech in hearing children - development of speech in hearing impaired children - Supra-segmental aspects of speech - seven stage development .

Phonetics, Speech problems and Correction: Phonetics - basic concepts -introduction to International Phonetic Alphabet -articulatory aspects of phonetics -acoustic phonetics -perceptual phonetics.Phonation and Voice Production- learning and teaching speech - speech problems, correction and evaluation - voice problems and therapy.

References:

1. Frederick N. Martin, John Greer Clark, Introduction toAudiology U.S.A,Allyn and Bacon.9th edition, 2006.
2. Hayes A. Newby, Gerald R. Popelka, Audiology, U.S.A.; Prentice - Hall International., 6th edition, 1992.
3. Ivan Tucker, Michael Nolan, Educational Audiology,U.S.A.; Croom Helm Limited, 1994.
4. StigArlinger, Manual of practical audiometry, Volume 2,Whurr, 1991.

7. SOFT COMPUTING TECHNIQUES

OBJECTIVES:

To impart knowledge on various soft computing techniques like ANN and fuzzy logic

.

Introduction to Artificial Neural Networks and Biological Neuron: Fundamental concepts of –weights, biases and thresholds-linear separability-common activation functions-learning rules and learning methods of ANN-single layer feed forward network-multilayer feed forward network**.**

Neural Network Architectures and Algorithms: Mucullochpitts neuron-Hebb net-Perceptron-Back propagation neural net-Hopfield net-Hamming net–Kohonenself organizing maps-Adaptive resonance theory**.**

Applications of Neural Networks: Dynamic Back propagation for bio system identification and control -pattern recognitions -image processing -biological sequence alignment and drug design -robotics and sensors - information retrieval systems -natural language processing.

Fuzzy Sets: Basic definition– set-theoretic operations – membership functions – fuzzy rules and fuzzy reasoning – fuzzy relations –composition of fuzzy relations –fuzzy relation equations -arithmetic operations on fuzzy numbers -fuzzy inference systems – Mamdani fuzzy models – Sugeno fuzzy models – input space partitioning and fuzzy modelling.

Fuzzy Systems: Fuzzification methods - defuzzification methods- Fuzzy rule base- fuzzy logic controller- Mamdani and Sugeno type Fuzzy systems**.** Adaptive neurofuzzy inference systems- GA in adaptive fuzzy system.

References:

1. LaureneFausett, Fundamentals of Neural Networks, Prentice- Hall, New Jersey, 3rd edition, 2008.
2. Timothy J. Ross, Fuzzy logic with Engineering applications, McGraw Hill, New York, 3rd edition, 2010.
3. Valluru.B.Rao, Hayagriva.Rao, Neural Networks & Fuzzy Logic, BPB Publications, New Delhi, 2003.
4. D.Driankov, H. Helleneloorn, M.Reinframe, An Introduction To Fuzzy Control, Narosa Publishing Co., New Delhi, 1996.
5. Jacek M. zurada, Introduction to Artificial Neural Systems,Jaico Publishing House, New Delhi, 1997.
6. Rajasekaran.S, VijayalakshmiPai.G.A, Neural Networks, Fuzzy logic and Genetic Algorithms, Prentice-Hall of India private limited, New Delhi,2003.

8.BIO MEMS AND NANO TECHNOLOGY

OBJECTIVES:
To impart knowledge on bio MEMS and nano technology.

MEMS and Microsystems: Typical MEMs and Microsystems - materials for MEMS - active substrate materials – siliconand its compounds -silicon piezoresistors - Gallium Arsenide – quartz - polymers.Micromachining– photolithography - thin film deposition – doping – etching - bulk machining -wafer bonding.

Microsensors and Acuators: Mechanics for MEMs design- static bending of thin plates - mechanical vibration –thermomechanics - fracture and thin film mechanics. Mechanical sensors and actuators – beam and cantilever – microplates - strain, pressure and flow measurements – gyroscope -piezoactuators. Thermal sensors and actuators- micromachined thermocouple probe –Peltier effect hat pumps - thermal flow sensors.

Micro Opto Electro Mechanical Systems (MOEMS): Fundamental principles - light modulators - light detectors - optical switch.Microfluidic Systems: Fluid dynamics - continuity equation, momentum equation, equation of motion -fluid flow in circular conduits –microconduits -submicrometer and nanoscale. Microscalefluid - expression for liquid flow in a channel -microfluid dispenser, microneedle, micropumps-continuous flow system.

Fundamentals of Nanoscience: Size dependence of properties - particle size determination - bulk to nano transition - semiconducting nanoparticles - carbon nanostructures –mechanical, optical and electrical properties of nanotubes. Preparation of Nanosystems: Introduction to nanolithography - carbon nanotubes -synthesis and preparation of nanomaterials (crystalline and thinfilm) - physical and chemical methods - control and stability (size, shape, composition).

Medical Applications: Nanotubes, nanowires, and nanodevices- functional nanostructures. Introduction to molecular electronics - field emission and shielding - molecular and supramolecular switches – biosensors – Qdots – Nanoshells – Nanobiotix – cancer detection – drug delivery using nanoparticles and molecular carriers.Nanoelectromechanical systems (NEMs) - CAD for MEMs -drug delivery - micro total analysis systems (MicroTAS) detection andmeasurement methods - microsystem approaches to polymerase chain reaction (PCR), DNA, hybridization.

References:

1. Di Ventra, Massimiliano; Evoy, Stephane; Heflin, James R., Introduction to Nanoscale Science and Technology, Springer publications, 2004.
2. VinodLabhasetwar, Diandra L. Leslie-Pelecky, Biomedical Applications of Nanotechnology, Wiley–Interscience, A John Wiley & Son, Inc., Publication, 2007.
3. Chattopadhyay, Introduction to Nanoscience and Nanotechnology, PHI, 2009
4. Wanjun Wang, Stephen A.Soper,BioMEMs: Technologies and applications, CRCPress, New York, 2007.
5. NitaigourPremchandMahalik, MEMS, Tata McGraw Hill Publishing Company,New Delhi, 2007.

9. LASERS AND FIBER OPTICS IN MEDICINE

OBJECTIVES:
To impart knowledge on use of lasers and fiber optics in biology and surgery

Introduction to Fiber Optics: Basic fiber link – applications - principles of light. EM spectrum, light as a wave, particle - speed of light - internal and external reflections - Snell's law -optical fiber numerical aperture - Fresnel reflection -optical fiber and its properties – construction - propagation of light - modes of operation - refractive index – types – dispersion - data rate - bandwidth - attenuation - losses.

Optical Sources and Detectors: Introduction - creation of photons – LED – ILD. Photo detectors: Introduction - PIN photodiode - avalanche photodiode - photodiode parameters - detector noise - speed of response and SNR.Modulation scheme for fiber optic transmission: Introduction - digital modulation -analog modulation schemes and multiplexing -applications of fiber optics in medical field.

Laser Systems: Introduction - types of Lasers - Laser characteristics: Single frequency operation - coherence of laser - spatial distribution - intensity of laser emission - polarization of laser emission - measurement of pulsed laser energy -principles of laser applications in medicine and biology.

Laser in biology: Optical properties of tissue -pathology of laser reaction in skin, thermal effects - laser irradiation -non thermal reactions of laser energy in tissue - effect of adjuvant.

Lasers in surgery: Surgical instrumentation of CO_2, Ruby, Nd-YAG, He-Ne, Argon ion, Q-switched operations - continuous wave, Quasi – continuous - surgical applications of these lasers. Laser applications: Lasers in dermatology – ophthalmology – photocoagulations – dentistry –cytometry -transillumination and diaphanography - speckle intereferometry, holography - application safety with biomedical Lasers.

References

1. Leon Goldman, The Biomedical LASER Technology and Clinical Applications, Springer-Verlag, 1981.
2. Leon Goldman, Lasers in Medicine and Surgery, Springer-Verlag, 1982.
3. Pratesi E.D.R, and Sacchi, Lasers in Photomedicine and photo Biology, Springer-Verlag.
4. BashtM.L.Wel, Laser applications in medicine and biology, Vol I,II,III, Plenum Press 1974.
5. Nandini K. Jog, Electronics in medicine and biomedical instrumentation, Prentice-Hall of India Pvt. Ltd., 2006.

10.ARTIFICIAL ORGAN SYSTEM

OBJECTIVES:

To familiarize the student with artificial organ systems like artificial heart and circulatory assist devices , artificial heart-lung machine

Bio materials: Definition of biomaterials- Requirements of biomaterials- classification of biomaterials- Comparison of properties of some common biomaterials- Effects of physiological fluid on the properties of biomaterials- Biological responses (extra and intra-vascular system). Surface properties of materials- physical properties of materials- mechanical properties- Biomaterial outlook for organ transplant, design considerations.

Introduction to artificial organs: Biomaterials used in artificial organs and prostheses - inflammation, rejection, correction. Rheological properties of blood - blood viscosity variation- effect of shear rate –hematocrit- temperature and protein contents - Casson equation - flow properties of blood through the blood vessels - problems associated with extracorporeal blood flow.

Artificial Heart and circulatory assist devices: Engineering design of artificial heart and circulatory assist devices.Artificial kidney: Structure - function – filtration - basic methods of artificial waste removal –hemo dialysis - equation for artificial kidney - middle molecule hypothesis. Hemo dialysers: flat plate type - coil type - hollow fiber -analysis of mass transfer in dialysers - regeneration of dialysate - membrane configuration - wearable artificial kidney machine - separation of antigens from blood in ESRD patients.

Artificial heart-lung machine: Introduction - gaseous exchange / transport - artificial heart-lung devices. Oxygenators: bubble, film oxygenators and membrane oxygenators -gas flow rate and area for membrane oxygenators. Liver support system - artificial pancreas - blood - skin.

Audiometry: air conduction - bone conduction – masking– diagram. Hearing aids: Types - receiver amplifiers –opthalmoscope –retinoscope -I.A.B.P principle and application. Rehabilitation Engineering: Rehabs for locomotion, visual, speech and hearing -artificial limb and hands - prosthetic heart valves - gait study- spinal rehabilitation.

References:

1. Joseph D.Bronzino, The Biomedical Engineering Handbook, CRC Press, 2000.
2. Khandpur. R. S., Hand Book of Biomedical Instrumentation, Tata McGraw Hill Pub Co. Ltd., New Delhi,2nded., 2003.
3. Erie.D.Blom and Howard.B.Rothman,Artificial Organs, 1994.
4. David O. Cooney Biomedical Engineering Principles (Volume – II), Marcel Dekker Inc,New York, 1976.
5. Rory A Cooper; HisaichiOnabe; Douglas A. Hobson, Introduction to Rehabiliation
6. Engineering, CRC press, 2006.
7. E.Ballabio, Rehabilitation Engineering, IOS press, 1993.

11. MEDIEMBEDDED SYSTEMS AND RTOS

OBJECTIVES:

To impart knowledge medi embedded system and associated RTOS

Overview of Embedded System: Features of Embedded System – categories – requirements-challenges and issues - applications of Embedded Systems in biomedical systems and health care systems. Software: Source code – object code and assembler using high level language– fetch and execute operation of CPU – instruction set–addressing modes – basic operation– microcontroller arithmetic and condition code register- program flow control using looping and branching.

Stack subroutines: stack to store data– subroutines– modular programming using subroutine and subroutine operation. Interrupts and Resets: Concepts of interrupts– interrupt vectors– interrupt operation- hardware interrupts and resets– software and CPU controlled interrupts.

Hardware: Bus– tri state logic- address encoding- different modes of operation– different memory technology (RAM EPROM, FLASH, CONFIG, and INIT). Serial sub system: Asynchronous communication system- serial communication interface- SCI registers– serial peripheral interface– SPI topologies and applications–SPI software and error handling.

Microchip PIC16 family: PIC16F873 processor – features – architecture – memory organization – register file map – I/O ports – Port A,B and C – Data EEPROM and flash program memory – Asynchronous serial port – SPI mode – I^2C mode. ARM family of microcontrollers: Introduction– ARM Arichitecture– Instruction formats–ARM derivatives– Programming with ARM Embedded Controllers – software tools for ARM – GNU 'C'- Keil – Peripheral interfacing - ARM applications – General features of ARM7, ARM9, ARM Cortex.

Embedded Real Time Software Design: Embedded operating system – comparison with general purpose OS – Real Time Operating System (RTOS) – tasks – kernel – RT scheduling – interrupt processing – memory management using RTOS – synchronization – message queues – control blocks – porting of RTOS to the target board – comparison and study of various RTOS like Windows CE, Embedded Linux, μcos, QNX, VXWORKS, Nucleus. Embedded system for biomedical applications: Hospital data base applications– Biosignal analysis– Hospital automation.

References:

1. G.J. Lipovsk, Single and Multiple Chip Microcomputer Interfacing, Prentice Hall, 1988.
2. W.J. Tompkins & J.G. Webster, Interfacing Sensors to the IBM PC, Prentice Hall, Englewood Cliffs, NJ, 1988.
3. John B**.** Peatman**,** Design with PIC Microcontrollers**,** Prentice Hall, 1998.
4. David Seal, ARM Architecture Manual, Addison-Wesley,2nd edition, 2000.
5. Raj kamal, Embedded systems, Tata McGraw Hill, 2003.
6. Steve furber, ARM System on chip architecture, Pearson education2nd edition,

12. MODELING OF PHYSIOLOGICAL SYSTEMS

OBJECTIVES:
To impart knowledge on nonparametric and electric circuit modelling of physiological system

Biological control system: similarities and differences - components of living control system- Model and Analog- system properties- resistance- storage- distributed and lumped systems. Mathematical approach- electrical analogues. Approaches to modelling: Mathematical modelling - classification of models - characteristics of models. Purpose of physiological modeling and signal analysis - linearization of nonlinear models -model formulation –identification -validation and Simulation Different approaches of modeling physiological systems -linear modeling -distributed modeling -nonlinear modeling- time-varying modeling.

Nonparametric modeling: Volterra models - Wienermodels -efficient volterra kernel estimation -analysis of estimation errors. Parametric modeling: Basic parametric model forms -estimation procedures -Volterra kernels of nonlinear differential equations -discrete-time volterra kernels of NARMAX models -from Volterra kernel measurements to Parametric models -equivalence between continuous and Discrete -parametric models.Introduction to various process controls like cardiac rate - blood pressure - respiratory rate -blood - glucose regulation -pharmacokinetic modeling-compartmental models - blood-tissue models.

Equivalent circuit model: Electromotive, resistive and capacitive properties of cell membrane - change in membrane potential with distance - voltage clamp experiment - voltage dependent membrane constant and simulation of the model - model for strength-duration curve - model of the whole neuron - Huxley model of isotonic muscle contraction -modeling of EMG - motor unit firing - amplitude measurement - motor unit and frequency analysis.

Physiological modelling: Electrical analog of blood vessels - model of systematic blood flow - model of coronary circulation - transfer of solutes between physiological compartments by fluid flow - counter current model of urine formation - model of Henle's loop -linearized model of the immune response - Germ, Plasma cell, Antibody, system equation and stability criteria.

Electrical circuit model of oxygenation: A model of immune response to disease (Block Diagram) -modelling of multi input/multi output systems: The two-input case - Applications of two-input modelling to physiological systems - Multi-input case spatiotemporal and spectro temporal modelling. Respiratory system: Modeling oxygen uptake by RBC and pulmonary capillaries mass balancing by lungs - gas transport mechanism of lungs and O_2 and CO_2 transport in blood and tissues.
Case studies on modeling of physiological system:
Modeling of nerve action potential: Hodgkin-Huxley model.
Modeling of skeletal muscle contraction: Huxley Cross Bridge Model.
Modeling of myoelectrical activity.
Modeling of cardiovascular system: Block diagram representation of cardio vascular system,

References:

1. David T. Westwick, Robert E. Kearney, Identification of Nonlinear Physiological Systems, Wiley-IEEE Press, 2003.
2. Michael C. K. Khoo, Physiological Control Systems -Analysis, simulation and estimation, Prentice Hall of India, 2001.
3. J. Enderle**, S.** Blanchard**,** J. Bronzino, Introduction to Biomedical Engineering**,** Academic Press, 3rd edition, 2012
4. Suresh.R.Devasahayam, Signals & Systems in Biomedical Engineering, Springer,2000.
5. V.Z. Marmarelis, Advanced methods of physiological system modeling, Springer,1999.
6. James V. Candy, Signal Processing: The Model Based approach,John Wiley sons, Newyork, 2006.
7. L.Stark, Neurological Control System, Plenum Press, New York, 1968.
8. R.B. Stein, Nerve and Muscle, Plenum Press, New York, 1980.

13.COMPUTERS IN MEDICINE

OBJECTIVES:

To familiarize the student with use of computers in medicine

Introduction: Computer hardware and software - programming languages - use in medical field - need of computing hospitals - cost effectiveness - help of computerization to physicians.

Patient data base management: Computerized medical records - security. Computer in clinical laboratory -database approach - automated clinical laboratory and analysis - computerized specimen analysis - analysis of ECG, EEG and EMG. Chromosome analysis by computer - computerized cytology and histogram - automated scanning for cervical cancer.

Basics of computer assisted medical imaging: Nuclear medicine - digital subtraction radiography – computerized ultra sonography – X-ray, CT, Nuclear magnetic resonance.
Basics of computer assisted medical decision making - general model algorithms - fuzzy set theory - cognitive set theory - cognitive models - QMR, KES and TIA.

Computer in intensive care units: metabolic balance up keeping- pulmonary function evaluation- Cardio vascular evaluation- Computer assisted therapy- computer for case of renal disorders.

Computer aids for the handicapped: basic discussion with examples- introduction to computer assisted instruction in medicine- ISDN in medicine.

Reference:

1. R.D. Lele, Computers in medicine, Tata McGraw-Hill Publishing Company Limited, 2nd reprint, 2008.

14. TISSUE AND STEM CELL ENGINEERING

OBJECTIVES:
To familiarize the student with tissue and stem cell engineering

Tissue: Definition -structure - organization and types. Vascularity and angiogenesis - basic wound healing - cell migration - therapeutic and in-vitro testing.

Cell: Types – differentiations - different kind of matrix - cell-cell interaction. Cell culture: expansion – transfer - storage - characterization. Molecular biology: Cell signalling molecules - hormone - growth factor and delivery in tissue engineering. Cell attachment: differential cell adhesion - receptor-ligand binding - cell surface markers.

Scaffold and transplant: Biomaterials for tissue engineering -degradable materials (collagen, silk and polylactic acid) – porosity - mechanical strength - 3-D architecture - cell incorporation. Tissues for replacing bone – cartilage – tendons – ligaments - skin and liver. Basic transplant immunology - stems cells – introduction -haematopoiesis.

Case study: cell transplantation for liver – musculoskeletal - cardiovascular and neural systems. Ethical - FDA and regulatory issues of tissue engineering.

Stem Cells: Origin, characterization, potential applications of human stem cells- Protocols for isolation and identification of stem cells – Differentiation of cells from human- neurospheres into neurons – astrocytes and oligo dendrocytes –Immuno labelling. Gene therapy: immune rejection in stem cell therapy – new therapy for autoimmune disease – prenatal diagnosis of genetic abnormalities using fetal CD34+ stem cells.

References:

1. Sameul E Lynch, De Robertis, J Geng, Tissue Engineering, Elsevier, 3rd Edition, 2007.
2. Clemens van Blitterswijk, Tissue Engineering, Academic Press, 2008
3. Robert. P.Lanza, Robert Langer & William L. Chick, Principles of Tissue Engineering, Academic Press,2007.
4. B. Palsson, J.A. Hubbell, R.Plonsey and J.D. Bronzino, Tissue Engineering, CRC Press, 2003.
5. Kursad and Purksen, Embryonic Stemcell, Humana Press, 2002.

15. TRANSPORTATION IN LIVING SYSTEMS

OBJECTIVES:
To familiarize the student with various transportation mechanism in living systems

Introduction: Organization of the human body – cells – tissues - different organs.
Heat transport: Body temperature regulation based on thermostat principle and its operation - transportation in tissues - muscle, skin and other organs in different environmental temperatures.

Transportation of fluids: Blood transport through internal organs –urogenitary - cardio pulmonary and central nervous system.

Gastro intestine system: Diffusion – osmosis - electro osmosis - ultra filtration -reverse osmosis through natural membrane and artificial synthetic membranes.

Lymph: Transportation through internal organs, urogenitary, cardio pulmonary, central nervous and gastro intestine systems. Problems on lymph transfer in human body.

Mass transfer: Constituents of blood, urine, mass transfer in kidney, skeletal, nervous, gastro intestine and cardio pulmonary systems. Comparison with artificial organs.

References

1. David O.Cooney,An introduction to fluid, heat & mass transport process- Principles, Vol.1, Marcel Dekker Inc., Newyork, 1976.
2. William F. Ganong, Review of Medical Physiology, McGraw-Hill Medical; 22nd edition, 2005.
3. Charles Herbert Best, Norman Burke Taylor, John Burnard West, Best and Taylor's physiological basis of medical practice,Williams and Wilkins, Baltimore, 12th edition, 1991.

16. HOSPITAL ENGINEERING

OBJECTIVES:

To impart knowledge on various aspects of hospital engineering along with management and information system.

Hospital Engineering: General and specialized hospital, primary health care – their role and functions. Hospital services: inpatient, outpatient and emergency. Location and environment of hospital – Hierarchy of medical and paramedical staff & their functions and responsibilities – Modern Hospital Architecture- space in a hospital building– design of ward, intensive care units, air conditioning, plumbing & sanitation, gas supply, waste disposal, cleaning, dietary, sterilizing, laundry, storage and operation theatre systems, radiology, central labs, blood banks, OPD, Casualty.

Electrical systems in hospitals: Safety and protective systems. Design of sub stations, breakers, surge protectors, EMI filters, voltage stabilizers, generator sets and Uninterrupted Power Supply for ICU and computerized monitoring units. Specification and estimation for hospital wiring - case study.

Air conditioning & gas supply systems: Air conditioning and refrigeration systems for small and large areas. Air changes, filtering and sterility. Deodorization- disinfection- dehumidification and cryogenic systems- Centralized supply of air, oxygen, nitrous oxide and vacuum, liquid oxygen. Management of lifts and fire fighting equipments.

Hospital Management: Importance of RI department – servicing and maintenance, testing, acceptance and maintenance protocols, MROs. Training of men for medical equipments preventive and periodical maintenance procedures- Preparation of estimates, specifications, tender details etc. Importance of ISO 9000 certificates - obtaining ISO certificates in hospitals.

Hospital Information system: Role of database in HIS- Need of Networking in HIS- Overview of Networking, topologies and configuration. Structuring medical records to carry out functions like admissions, discharges, treatment history etc. Computerization in pharmacy & billing. Automated clinical laboratory systems & radiology information system.

References:

1. Harold E. Smalley, Hospital Management Engineering – A guide to the improvement of hospital management system, PHI, 2003.
2. Sharma, Essentials for Hospital Support Services and Physical Infrastructure, Jaypee Medical Publishers,1/e, 2003.
3. C. A. Caceras, The Practice of Clinical Engineering**,** Academic Press, New York, 1977.
4. C.S. Ward, A.J. Davey, J.T.B. Moyle, Ward's Anaesthetic Equipment,W.B. Saunders Company, 4th edition, 1992.
5. Bhaumick and Bhattachary, EHV Substation equipments.
6. Alexander Kusko, Emergency and Standby Power Systems, McGraw-Hill, 1989.
7. Balagune Swamy, Reliability Engineering.
8. Anantha Narayanan, Basic Refrigeration and Air Conditioning, Tata McGraw-Hill, 3rd edition, 2006.

17. TELEMEDICINE

OBJECTIVES:
To familiarize the student with various aspects of telemedicine

Telemedicine, telehealth and telecare: History of telemedicine- Main phases of telemedicine- Pre electronic telemedicine. Electronic telemedicine Technical Requirements - Type of information and standards, audio, data, Fax, Video Types of communications and networking- networking architecture. POTS, ISDN, ATM Other Fixed networks- Air/airless communications, RF, Microwaves, Satellite, GSM, CDPD (Cellular Digital Packet Data) Acquisition/ displays- Acquisition systems Cameras, Scanners, Other medical specialized acquisition system.

Display systems: Analogue devices, LCD, Laser displays, Holographic representations, Virtual screen devices Computation / storage systems: Magnetic, Mixed, Optical (laser) devices (only brief description required).

Telemedicine applications: Teleradiology: Basic parts of a teleradiography system, Image acquisition and management, display, communication, interpretation Telepathology: Applications, requirements, security and confidentiality tools, telequantitation at distance. Telecytology: Applications, Telecardiology: requirements, portable solutions Telehome-Care Home based applications, Teleoncology: Applications, Telesurgery, telepsychiatry, Teledermatology Techniques.

Internet in telemedicine: Basic concepts - Security – secure socket layer – Firewalls – proxies. Personal Communication, Medical data sharing needs for telemedicine -Internet problems, Distant training, teleworking and telecasting. Ethical and legal aspects of telemedicine: confidentiality, patient rights and consent-ethical and legal aspects of internet-telemedical malpractice.

Constraints for the wide spread use of telemedicine: constraints linked to economy, social acceptance Strategic planning for telemedicine implementation. Analysis of the present situation and the demand Objectives and strategies- Plan of implementation, Forces affecting technology transfer scenarios for telemedicine.

References:

1. Olga Ferrer, Roca M. Sosa, Marcelo C, Handbook of telemedicine, IOS Press, 3rd edition, 2002.
2. Ling Guan, Multimedia image and video processing, CRC Press 2000.
3. Thorsten M Buzug, Heinz Handels, Dietrich Holz, Telemedicine: Medicine and Communication, Springer – Verlag, 2001
4. Douglas V. Goldstein, e-Healthcare: Harness the power of Internet, e-commerce and e-care, Jones and Barlett Publishers.
5. A. C. Norris, Essentials of Telemedicine and Telecare, John Wiley& Sons 2002.

18. BIOINFORMATICS

OBJECTIVES:
To impart knowledge on various aspects of bioinformatics

Basic Concepts of Molecular Biology: Cells - Chromosomes, DNA, RNA, Proteins, Central dogma of molecular biology, Genomes and Genes - Genetic code, Transcription, Translation and Protein synthesis. Web based genomic and proteomic data bases: NCBI, Gen Bank.

Sequence alignments: Dot plot-Pair-wise sequence alignments - local and global -Sequence similarity and distance measures - Smith-Waterman algorithm, Needleman-Wunch algorithm, Multiple sequence alignment –Sum-of-Pairs measure - Star and tree alignments – PAM and BLOSUM, Phylogenetic analysis.

Informational view of Genomic data: Genomic Signal Processing- DNA Spectrograms- Identification of protein coding regions- Gene expression- Microarrays, Microarray image analysis.

Gene structure in Prokaryotes and Eukaryotes: Molecular Structure Prediction- Basic concepts and terminologies related to molecular structures- Basic molecular Visualization- RNA secondary structure prediction- Protein folding problem- Protein Threading- Protein Visualization- Introduction to Drug Discovery.

Software Tools: Use of Tools for basic and specialized sequence processing such as: BLAST, FASTA, RasMol, Phylip, ClustalW.

References:

1. Setubal, Meidanis, Introduction to Computational Molecular Biology, Thomson: Brooks/Cole, International Student Edition, 2003
2. Jean-Michel Claverie, Cedric Notredame,Bioinformatics - A Beginners Guide, Wiley-Dreamtech India Pvt Ltd, 2nd edition, 2007.
3. Lesk, Introduction to Bioinformatics, Oxford University Press, Indian Edition, 3rd edition, 2008.
4. Higgins and Taylor,Des Higgins, Willie R. Taylor, Bioinformatics: Sequence, structure and databanks, Oxford University Press, Indian Edition, 2003
5. Bryan P. Bergeron, Bioinformatics Computing, Prentice hall of India, 2003
6. Jiang, Xu and Zhang, Current topics in Computational Molecular Biology, Ane Books, New Delhi, 2004.

19. CANCER BIOLOGY

OBJECTIVES:
To familiarize the student with cancer biology

Fundamentals of cancer biology : Regulation of cell cycle – Mutations that cause changes in signal molecules – Effect on receptor– Signal switches – Tumor suppressor genes – Modulation of cell cycle in cancer – Different forms of cancers, diet and cancer – Cancer screening and early detection – Detection using biochemical assays – Tumor markers – Molecular tools for early diagnosis of cancer.

Principles of carcinogenesis: Theory of carcinogenesis – Chemical carcinogenesis – Metabolism of carcinogenesis – X-ray radiation – Mechanism of radiation carcinogenesis.

Principles Of Molecular Cell Biology Of Cancer: Signal targets and cancer – Activation of kinases – Oncogenes – Identification of oncogenes –Retroviruses and oncogenes – Detection of oncogenes – Oncogenes/proto oncogene activity –Growth factors related to transformation – Telomerases.

Principles of cancer metastasis: Clinical significances of invasion – Heterogeneity of metastatic phenotype – Metastatic phenotype – Metastatic cascade – Basement membrane disruption – Three step theory of invasion – Proteinases and tumor cell invasion.

New molecules for cancer therapy: Different forms of therapy – Chemotherapy – Radiation therapy – Detection of cancers –Prediction of aggressiveness of cancer – Advances in cancer detection – Use of signal targets towards therapy of cancer.

References:

1. Weinberg, R.A., The Biology of Cancer, Garland Science, 2007.
2. Pelengaris, S. and Khan. M., The Molecular Biology of Cancer, Blackwell Publishing, 2006.
3. Macdonald, F. and Ford, C.H.J., Molecular Biology of Cancer, BIOS ScientificPublication, 2005
4. Roger John Benjamin King, Mike W. Robins, Cancer Biology, Pearson prentice hall, 3rd edition, 2006.
5. Ruddon, R. W., Cancer Biology, Oxford University Press, 2ndEdition, 1995