UNIVERSITY OF CALCUTTA

Notification No. CSR/ 13 /14

It is notified for the information of all concerned that in terms of the provisions of Section 54 of the Calcutta University Act, 1979, (as amended), and, in exercise of his powers under 9(6) of the said Act, the Vice-Chancellor has, by an order dated 11.04.2014, approved the **Regulations and Syllabus** for the ***M.Tech***. course of study in ***Biomedical Instrumentation*** *offered by* Department of Applied Optics and Photonics, University of Calcutta and as laid down in the accompanying pamphlet.

The above will take effect **from the Academic Session 2014-2015.**

21.04.2014

SENATE HOUSE
KOLKATA-700073
The 21st April, 2014

(Prof. Basab Chaudhuri)

Registrar

Regulations and Syllabus of M.Tech degree course in **BIOMEDICAL INSTRUMENTATION**

offered by

Department of Applied Optics and Photonics

University of Calcutta

REGULATIONS

1. The Department Of Applied Optics and Photonics, University College Of Technology, University Of Calcutta shall provide instructions leading towards the *two years* M. Tech. degree in Biomedical Instrumentation.

2 [a] A candidate with B.Tech. degree in Biomedical Instrumentation/ Biomedical Engineering/ Electronics and Communication Engineering/ Instrumentation Engineering/ Optics & Optoelectronics/ or equivalent degree recognized by AICTE, M.Sc. in Physics/Electronics and Medical doctors with MBBS degree are is eligible for admission to the first semester of the said degree in Biomedical Instrumentation.

[b] All Candidates shall be selected on the basis of interview

[c] The total number of seats would be 10 + 5 (for sponsored candidates) + SC / ST candidates (as per rule).

3. The duration of the course will be divided into 4 semesters while the duration of each semester will be of 6 months.

4. The academic program to be pursued during the Course will be as follows :

[a] 19 Theoretical Papers

[b] 6 Practical Papers

[e] Project work [Two parts : Preliminary and Final]

[f] Comprehensive VIVA

5. The CREDIT assigned to each Theoretical, Practical, Project and General Viva Voce and the corresponding teaching hours to be devoted per week are indicated in the following table :

Paper	*Hours per week*	*Full CREDIT assigned*
Theoretical	1	1
Practical	3	2
Project Preliminary	[for 3rd Semester only]	2
Project Final	4th Semester	6
General Viva Voce	-	2

6. Number of lecture hours per week for each theoretical and tutorial paper and number of hours per week for practical papers along with seminars and project work are as indicated in the course structure.

7. A candidate will get full CREDIT for a paper provided he/she prosecutes regular course of studies in the Department of Applied Optics and Photonics and Photonics maintaining at least 65% of attendance both in theoretical and practical classes and successfully completes the corresponding examination according to the criterion stated below.

8. A candidate has to earn a total of 100 CREDITs to complete the entire M.Tech. Course.

9. Examinations will be held at the end of each semester on all the papers covered in that semester. The examination will be referred to as Semester - (I, II, III or IV) examination, as the case may be, in Biomedical Instrumentation offered by Department of Applied Optics and Photonics, University of Calcutta.

10. The study leave after the completion of regular classes and before the commencement of examination will generally be of 10 calendar days.

11. [a] Examination of a Theoretical paper carrying 3 credits will be of 3 hour duration and will usually carry 70 marks.

[b] Paper setters and examiners for theoretical papers will be appointed by a board of examiners consisting of all the faculty members of the department and the honorary / guest lecturers, if any.

[c] 30 marks for each paper will be set aside for continuous assessments to be evaluated by the teacher(s) assigned for that class. Methodology for continuous assessment will be decided by consensus opinion at the Board of Examiners meeting.

12. [a] Evaluation of a Practical paper will be based on the performance of a candidate along with a viva voce at the end of the semester and on the report of the experiments conducted. Corresponding allocation of marks are as follows :

(i) 50% for the class performance.

(ii) 40% for viva voce

(iii) 10% on the submitted report

[b] Sessional work will be evaluated by the concerned teacher(s)-in-charge.

[c] Evaluation of the report and the viva voce will be conducted by a board consisting of at least two faculty members.

13. The performance of a candidate in any theoretical or practical or tutorial papers, seminar, project work and general viva voce will be awarded in terms of GRADE and GRADE POINTS earned by the candidate. The equivalence between GRADE, GRADE POINT and PERCNTAGE MARKS (out of stipulated full marks) is given below :

Percentage of marks	*Grade*	*Grade points*
$\geq 90\%$	Ex	10
$\geq 80\%$ but $< 90\%$	A	09
$\geq 70\%$ but $< 80\%$	B	08
$\geq 60\%$ but $< 70\%$	C	07
$\geq 50\%$ but $< 60\%$	D	06
$< 50\%$	F	00

GRADE – F implies failure to earn minimum required CREDITs. GRADEs higher than F indicate successful completion of the subject and the candidate will earn the corresponding GRADE POINT – P and CREDIT – C assigned to the unit.

14. [a] The overall performance of a candidate who earns all the credits in a particular [$j^{th}, 1 \le j \le 4$] Semester examination in one chance, will be assessed by the SEMESTER GRADE POINT AVERAGE (SGPA) $\rightarrow S^{(j)}$ to be computed as follows :

$$S^{(j)} = \frac{\sum_i P_i^{(j)} C_i^{(j)}}{\sum_i C_i^{(j)}}$$

Where P_i stands for the GRADE POINT earned by the candidate and C_i stands for the corresponding CREDIT in a specific i^{th} course, whereas $\sum_i C_i^{(j)} = C^{(j)}$ is the total CREDIT of the j^{th} Semester.

[b] On completion of the entire course when 100 CREDITs have been earned by any candidate the CONSOLIDATED GRADE POINT AVERAGE (*CGPA*) will be computed from the following formula :

$$CGPA = \frac{\sum_{j=1}^{6} S^{(j)} C^{(j)}}{\sum_{j=1}^{6} C^{(j)}} = \frac{\sum_{j=1}^{6} S^{(j)} C^{(j)}}{100}$$

15. [a] Each candidate will be assigned a topic for his/her project work at the beginning of the III-rd Semester. He/she has to carry out the work independently under the supervision of one faculty member. If the candidate opts to do his/her project work outside the department, the internal supervisor, in consultation with the departmental committee, may include one joint supervisor from the institute/industry where he/she will carry out the work.

[b] At the end of III-rd Semester, each candidate will have to submit through the respective supervisors, the Preliminary Project Report. The Preliminary Project Work will be evaluated at the end of the semester from his/her performance during the course of the work by his/her supervisor and through a viva voce by a Board consisting of at least four Examiners of whom at least one should be external examiner.

[c] At the end of IV-rd Semester, each candidate shall have to submit a Dissertation on the assigned topic independently and shall be required to defend his/her dissertation (project) in an open seminar. A report (two copies) on Dissertation (Project) has to be submitted at least 5 days before the open defence.

[d] 50% of the stipulated full marks on Dissertation (Project) will be set apart for his/her performance during the course of his/her work which will be evaluated from his/her performance during the course of the work by his/her supervisor. Rest 50% of the stipulated marks will be evaluated in an open defence by a Board of Examiners consisting of all the Faculty Members of the Department along with at least two External Examiners.

16. At the end of IV-th Semester, each candidate shall have to appear at a General Viva Voce test to be conducted by a Board of Examiners consisting of three Faculty Members of the Department along with at least two External Examiners.

17. [a] II-nd to IV-th Semester classes will begin after a week of recess on completion of the previous Semester Examination.

[b] A candidate will be automatically allowed to continue in the following Semesters (from II-nd to III-rd) provided he/she earns at least 20 CREDIT in the previous semester.

[c] A candidate who earns at least 20 CREDITs necessarily including 4 CREDITs for Preliminary Project Work in the III-rd Semester will be allowed to continue in the IV-th Semester.

[d] If a candidate earns less than 20 CREDITs in any semester (from I-st to III-rd), he/she will be considered as failed in that semester examination. A failed candidate will not be allowed to continue in the next semester and will have to revert to the same semester in the next academic session.

[e] All the total 15 CREDITs in the IV-th semester has to be earned at one time in order to complete that semester successfully.

[f] If a candidate fails to earn CREDITs for any particular topic, he/she will have to earn those CREDITs in a supplementary examination to be conducted during the currency of subsequent semester. He/She fails again to earn credit in the supplementary examination, he (she) will have to sit for regular examination of the next semester for the back papers only. Total chances to clear the credits will be limited to three. Attendance in the classes corresponding to the back CREDIT(s) is not mandatory.

[g] The total 'back' CREDIT carried by any candidate at any stage should not exceed 20. If at the end of any semester the accumulated 'back' CREDIT of any student exceeds 20, he/she will not be allowed to pursue the course further. After earning the 'back' CREDIT within the stipulated chances he/she will be allowed to continue the course.

[h] In order to complete the M.Tech. course, a candidate will have to utilize all allowed chances within 3 consecutive academic sessions or 6 consecutive Semesters from the date of admission to the M.Tech course.

[i] A candidate who fails to earn all the CREDITs of the M.Tech. course within the allowed chances will be treated as failed and will not be allowed to continue the course.

18. (**I)** After evaluation of all examinations in each Semester (I-IV), the syndicate shall publish separate lists of candidates in the following manner .

[a] The first list will show the results of the candidates who have earned all Semester CREDITs in the first chance and are allowed to continue in the next Semester. The list will show the SGPA earned by the candidates.

[b] The second list will show the results of the candidates who have earned at least 20 CREDITs in the first chance but not stipulated CREDITs and are allowed to continue in the next Semester. SGPA of such candidates will not be computed and hence, will not be displayed in the list.

[c] The third list showing the results of the candidates who appeared in the examination only to earn back CREDIT.

(**II**) GRADE SHEETs showing the GRADE POINTs and the CREDITs earned will be issued to each candidate at the end of each Semester.

19. After evaluation of all the examination of IV-th Semester, the syndicate shall publish separate lists of candidates in the following manner .

[a] The first list will show the results of the candidates who have earned all IV-th Semester CREDITs in the first chance along with the corresponding SGPA earned.

[b] The second list will show the results of the candidates who failed to earn all CREDITs of the IV-th Semester.

[c] The third list will show the results of the candidates who appeared in the IV-th Semester only to earn back CREDITs.

20. [a] The final list of the M.Tech. Examination will show the results of the candidates, in order of merit, who earned all the CREDITS of the entire M.Tech. course in a single and first chance on the basis of the combined results of all six Semester examinations along with the corresponding CGPA earned.

[b] The final second list will show the results of the candidates who earned all the CREDITs of the entire M.Tech. course that includes back CREDITs in at least one topic of the entire M.Tech. course along with the corresponding CGPA earned.

[c] A consolidated GRADE SHEET, showing the combined results of all the Semester examinations of the M.Tech. course will be issued to a candidate after earning all CREDITs of the entire course. Two different categories of the GRADE SHEET according to the clauses 21[d & e] will be issued to the candidates along with IV-th Semester GRADE SHEET. The candidates who have completed the course in more than six Semesters will have to apply for the consolidated GRADE SHEET by submitting copies of all the Semester GRADE SHEETs.

21. The Degree of "**Master of Technology in Biomedical Instrumentation**" under the seal of the University of Calcutta shall be awarded to a successful candidate mentioning the corresponding CGPA earned.

Course Overview: in Biomedical Instrumentation

		Marks	L	P	Credits
	SEMESTER - 1				
MTBMI-11	Essentials of Electronics	50	3	0	3
MTBMI-12	Essentials of Anatomy and Physiology/ Digital Electronics (for medical doctors)	50	3	0	3
MTBMI-13	Electrical & Electronic Devices for Biomedical Measurement	50	3	0	3
MTBMI-14	Optics, Ultrasonics and Imaging	50	3	0	3
MTBMI-15	Basis of Biomedical measurements, Sensors & Transducers in Biomedical applications	50	3	0	3
MTBMI-16	Micro Processor & Micro Controller	50	3	0	3
	PRACTICAL				
MTBMI P-I	Applied Electronics, sensors and transducers	50	0	6	4
MTBMI P-II	Digital Electronics & Microprocessor	50	0	6	4
		400	18	12	**26**
	SEMISTER II				
MTBMI-21	Fundamentals of Lasers and Fibre optics	50	3	0	3
MTBMI-22	Digital Signal Processing	50	3	0	3
MTBMI-23	Clinical Laboratory Instruments	50	3	0	3
MTBMI-24	Biochemistry & Biomaterial	50	3	0	3
MTBMI-25	Analytical instruments	50	3	0	3
MTBMI-26	Bio Mathematics	50	3	0	3
	PRACTICAL				
MTBMI P-III	Optical Instruments & Lasers	50	0	6	4
MTBMI P-IV	Clinical Laboratory Instruments	50	0	6	4
		400	**18**	**12**	**26**
	SEMESTER – III				
MTBMI-31	Patient monitoring and life support systems	50	3	0	3
MTBMI-32	Optical Instrumentation and Lasers in Biomedical Sciences	50	3	0	3
MTBMI-33	I.Cardio Pulmonary Instruments in Critical Care II. Hospital management and Telemetry and Telemedicine	50	3	0	3

MTBMI-34	Cardiovascular and Cardiothoracic Instruments and Techniques	50	3	0	3
MTBMI-35	Endoscopy, Urological Instruments, Dialyses and Renal Technique	50	3	0	3
	PRACTICAL				
MTBMI P-V	Hospital Training	50	0	6	4
MTBMI P-VI	I. Patient Monitoring and Life Support System II. Medical Imaging -I	50	0	6	4
MTBMI PJ-I	Project –preliminary	50	0	0	4
		400	**15**	**12**	**27**
	SEMESTER IV				
MTBMI-41	I. Radioisotopes and Nuclear Medicine, II. Medical Imaging System -II	50	3	0	3
MTBMI-42	Elective Paper 1.Opthalmological Instruments, Advanced microscopy and CT 2. Medical Physics 3. Pollution Control and Hospital waste management 4. Implants and artificial organs 5. Forensic science	50	3	0	3
MTBMI-43	Comprehensive VIVA	50	3	0	4
MTBMI PJ-II	Project Final: Thesis presentation	150	0	0	10
		300	**6**	**0**	**20**
	Total	**1500**			**100**

DETAILED SYLLABUS

Paper code	**SEMESTER – 1**
MTBMI-11	**Essentials of Electronics** Electronic components; Passive & Active components, Resistors, Capacitors, Inductors Active , PN junction diodes, characteristics of semiconductor diodes. Rectifiers: half wave, Full wave. Rectifier circuits. Filter circuits for power supplies: Inductor input, LC filter, Multiple LC filters. CLC or filters, comparison of filter circuits. Analysis of simple diode circuits; DC and AC load lines. Zener diode characteristics and applications in regulators. Fundamentals of transistors: Introduction to transistor circuits: Graphical analysis of transistor circuits for CB,CE and CC configurations. Transistor biasing and bias stability. Transistor power amplifiers: circuits and operatios of class A, class B. Class C and Push-pull configuration. Small signal low

	frequency analysis of CE,CB and CC amplifiers. Introduction to Field Effect Transistors: FET, JFET and MOSFET: Characteristics , biasing methods. Power devices. Power diodes & transistors, SCR, Diac, Triac & UJTs, Regulated power supply and SMPS, Opto-electronic devices, LED, 'L-,D and opto- couplers & detectors. ICS: Bipolar & MOS, linear IC, differential amplifier, Operational amplifiers and their applications in amplification signal conditioning. Feed backing amplifiers, and oscillators. Schmitt trigger circuit; Multivibrators and wave shaping circuits.
MTBMI-12	**Essentials of Anatomy and Physiology/ Digital Electronics (for medical doctors)** General structure of the body, Basic terminology, cavities, regions, systems and functional units: the cell, Body Fluids - Structure and functions. Muscle tissue: Anatomy, types of muscles, physiology of contraction, physics and muscle functioning-levers. Musculo-skeletal system. Nervous systems. Autonomic and central nervous systems. Endocrine system: Anatomy and function in detail. Biological control concepts. Feed back control. The heart: Anatomy from the electro physiological view point. Origin and conduction of heart beat, cardiac cycle Cardiac output. Control of cardiac cycle, Basic principles of pressure, flow and resistance, Regulation of arterial pressure. Diseased states of heart., Blood and circulation: characteristics, Volume, composition. Division of vascular system. The respiratory Organs, Anatomy of Lungs: Physiology of respiration in the Alveolar and tissue capillaries, level control of respiration, Organs of Respiration : Cellular. Maximum oxygen intake of cardio vascular respiratory interactions, Mechanics of Breathing The urinary system: Anatomical disposition of urinary system. Physiology of water and electrolyte, balance, acid base regulation. Kidney- Anatomy & Physiology in brief Digestive systems: Parts of digestive system structure, nerve and blood supply accessory. Bones of scalp and thorasic cage, the skeleton of the upper limb, bones of wrist and hand. The skeleton of the lower limbs. Joints of skeleton, joints of the hands and finger, joints of fort, muscle of the skeleton. Mathematical models about the physiological systems and their implications in instruments design. **MBMI-111-II: Digital Electronics** Brief overview of number systems, logic gates, Minimisation technique (K-map method). Multiplexer, Decoder/Demultiplexer, Encoder, Parity checker/generator, comparator and their uses (use the commercially available IC chips (TTL or CMOS) for the circuit design). Adders, Subtractor, CLA adder, BCD adder, Multiplier, codes and code converter, ALU design (2) <u>Flip-Flops</u> : Brief introduction to RS, JK, D and T flip-flops-operations, characteristic equation, conversion of one type of flip-flop to another. <u>Counters</u> : (a) Asynchronous counters – Ripple, Modulo, UP/DOWN and presentable counters (b) synchronous [Counts-Binary Counter Module Counter, UP/counters(use JK or D-flip-plops for the design) Interlocution] and uses of a few commercially available asynchronous and synchronous counter IC chips. (5) <u>Shift Registers</u> : Introduction, shift register using flip-flops, Universal shift register, commercially available shift register IC chips. Applications of shift registers for counter design (Ring and Johnson), wave form generation,

	Time delay and keyboard encoding, Multiplexed display. (3) Timer : Introduction to 555 timer. Astable and Monostable multivirators , Schmitt trigger using 555 timer. (2) Memory : Organisation of static and Dynamic memory . RAM cells, ROM cells, EPROM, E^2 ROM, Cascading of memory. Introduction to a few commercially available memory IC chips. (3) DAC and ADC : Introductions to weighted register and R-2R ladder type of DAC. Introduction to counter-ramp, dual slope and successive approximate type ADC.
MTBMI-13	**BMI S 13: Electrical and Electronics devices and principles for Biomedical Measurements** Voltage and current measuring equipment - PMMC, electrodynamics and moving iron type. Resistance measurements - Low, medium and high resistance; Ohm meter, Megger, Wheatstones bridge. Energy measurements -Induction type watt — hour meter. Electronic measurements - Voltage, current and resistance measurement; Electronic Voltmeter, Ammeter, Ohm meter and Digital Multimeter. Signal Generator & Waveform measurements -with counters - sine, square & triangular wave generator. Crystal oscillator - Frequency and Time delay measurements with counter. Waveform measurements with CRO —construction, operation and applications. Phase lock loop – Basic principles, Frequency response. The use of phase lock loop (PLL) IC chip Instruction and Isolation Amplifier – Standard circuit, Gain control, CMRR adjustment and a few practical applications of Instrumentation Amplifier. Voltage Regulator : Op-Amp voltage regulator with adjustable output voltage and current. Voltage regulator IC chips and the design of voltage regulator using regulator IC chips. Introduction to SMPS power supply.
MtBMI-14	**Optics, Ultrasonics and Imaging** The nature of light. Optical elements and working relations: Types of Prisms, lenses and gratings. Interference: Principle of superposition, interference, coherent and incoherent waves,conditions for maxima and minima, Interference in thin films (reflected and transmitted lights); Interference in thin wedge, shaped film, Newton's rings determination of wavelength, Antireflection coatings. Polarization: Differences between unpolarized, light and polarized light , representation of polarized light (Brewster's law), polarization, by reflection, polarization by double refraction, Nicol's prism, concept of QWP and HWP, production and analysis of polarized light. Diffraction: Fresnel and Fraunhofer diffraction, Far field diffraction patterns for circular and rectangular apertures, Far field diffraction as Fourier transform.

	Imaging theory: Ray-Optical Theory of Imaging; Diffraction Theory of Imaging; Resolution and Contrast Image Quality: PSF, MTF and OTF of Optical Imaging systems from the viewpoint of system theory and practical applications. Stereoscopic Imaging principles. Ultrasonics: Properties, production – Magnetostriction, Piezoelectric methods, detection – scattering from human tissue, piezoelectric detector, acoustic grating, Kundt's tube method. Applications – Industrial (drilling,welding, soldering, cleaning, SONAR, NDT (pulse echo, transmission, resonance technique), basics of medical imaging using ultrasonics.
MTBMI-15	**Basis of Biomedical measurements, Sensors & Transducers in Biomedical applications** Measurement theory; categories of measurements; measurement errors; definitions: accuracy, precision, sensitivity, resolution, threshold. Units of radiation – rad, rem & roentgen. Sources of bio-medical signals: bio-electric, bio-acoustic, bio-mechanical. bio-chemical and bio-optical; characteristics of ECG, EEG & EMG signals; sources of noise; invasive vs non-invasive, in vivo vs in vitro measurements. Types of electrodes; electrodes for biophysical sensing; electrode-tissue interface; equivalent circuits; polarizing vs non-polarizing electrodes; electrodes for EEG, ECG, EMG; microelectrodes. Classification of sensors, transducers and actuators; physical principles; active vs. passive sensors; pressure and temperature sensors; force, displacement and flow sensors; strain gauges; silicon sensors; capacitive and piezoelectric transducers-ultrasonics; magnetic sensors; examples – b.p. measurement, CAT and MRI; lasers and applications; optical fibre sensors – endoscopy; biosensors; integrated and smart sensors, MEMS, nanosensors.
MTBMI-16	**Micro Processor & Micro Controller** Introduction to Microcomputer based system. History of evolution of microprocessors and microcontrollers and their advantages and disadvantages. Architecture of 8085 microprocessor. Address/data bus demultiplexing, status signals, control signals and the control signal generations. Instruction set of 8085 microprocessor, classification of instructions, addressing modes, timing diagram of the instruction (a few examples) Assembly language programming with examples, Interrupets of 8085 processor, programming using interrupts. Serial and parallel data transfer-programmed I/O, interrupt driven I/O, DMA, asynchronous and synchronous serial transmission using SID and SOD pins of 8085 processor. Introduction to MCS-51 microcontroller- Architecture, memory organization, Hardware features of MCS-51, external memory inter facing, timers, interrupts, power management, serial posts. Addressing modes, assembly language programming. Support IC chips – 8255, 8253, 8259, 8279 and 8251 and their interfacing with 8085 and microcontroller 8051. Keyboard and display interfacing with 8085 and 8051. Memory interfacing with 8085 and 8051

	ADC and DAC interfacing with the processor 8085 and 8051.
PRACTICAL	
MTBMI P-I	**Applied Electronics, sensors and transducers** **MTBMI-P-I: Applied Electronics, Sensors and Transducers** (i) Graphical analysis of transistor circuits for CE, CB and CC modes. (ii) Half wave and full wave rectifier. (iii) Regulated power supply using zener diode . (iv) RC coupled amplifier. (v) Adder and subtractor using OP-Amp. (vi) Integrator and Differentiator using OP-Amp. (vii) Schmitt trigger using OP-Amp. (viii) Clipper and Clamper using OP-Amp. (ix) RC phase shift oscillator. (x) Mano and Astable multivibrator using 555 timer. (xi) Sensors and Transducers
MTBMI P-II	**Digital Electronics & Microprocessor** <u>Digital Electronics</u> (i) Realisations logic functions using basic logic gate. (ii) Implementation of Half and Full Adder. (iii) Implementation of multiplier (w bit X 2 bit). (iv) Multiplexer as a logic functions generator. (v) Cascading of multiplexer. (vi) Implementation of logic function using Decoder. (vii) Counter design using Filp-flops (a) Asynchronous and synchsonous (up to 4bit) (b) Different Mo counter (c) Presettable counter (d) UP/Down counters (viii) Implementation of Ring and Johnson counter (ix) Study of 8 bit DAc and 8bit ADC <u>Microprocessors</u> Study of prewritten programs on trainer kit using the basic instruction set (data transfer, Load/Store, Arithmetic, Logical) Assignments based on above. Familiarization with 8085 and 8051simulator on PC. Study of prewritten programs using basic instruction set (data transfer, Load/Store, Arithmetic, Logical) Assignments based on above. Programming using kit and simulator for: i) Table look up' ii) Copying a block of memory iii) Shifting a block of memory iv) Packing and unpacking of BCD numbers v) Addition of BCD numbers

	vi) Binary to ASCH conversion String Matching shift and add method and Multiplication using Booth's Algorithm. Program using subroutine calls and IN/OUT instructions using 8255 PPI on the trainer kit e.g. subroutine for delay, reading switch state and glowing LEDs accordingly. Study of timing diagram of an instruction on oscilloscope. Interfacing of 8255 : Keyboard and Multi-digit Display with multiplexing using 8255. Programming to interface.
SEMISTER II	
MTBMI-21	**Fundamentals of Lasers and Fibre optics** Light-Matter Interaction : Spontaneous Emission – Stimulated Emission – Stimulated absorption – Einsteins' Relations – Induced Transition Rate for Two-level System – Line Shape Function – Homogeneous and Inhomogeneous Broadening Operational Characteristics of Lasers : Three-level and Four-level Lasers – Gain and Gain Saturation – Hole Burning Laser Cavity Characteristics : Fabry-Perot Laser Cavities – Population Inversion in 3-level and 4-level Lasers Issues of Output Power Coupling in Laser Cavities – Laser Efficiency Mode Locking – Q-switching Laser Systems : Classification – Significance of Electronic, Vibrational and Rotational States Continuous and pulsed lasers, Q switching and its advantages. Study of He-Ne Laser system. Laser safety. Light transmission through optical fiber – Acceptance angle, Numerical Aperture Dielectric guides, planar guides and cylindrical guides – Step index and graded index fiber – Single mode fiber – Mode field diameter and spot size Transmission characteristics of optical fibers – Losses: intrinsic and extrinsic – absorption – Rayleigh scattering – Modal birefringence – Polarization maintaining fiber Preparation of optical fibers – optical fiber connections, joints, couplers and splices – Fiber cabling

	Dispersion in Fiber – Material dispersion, waveguide dispersion and modal dispersion – Zero dispersion fiber, dispersion flattened fibre, dispersion compensated fibre.
MTBMI-22	**Digital Signal Processing** Introduction; scope and relevance in Biomedical Imaging Digital Image Acquisition: Sampling and quantization; spatial, grey level and temporal resolution, CCIR and RS170 monochrome standards, output signal organization and voltage levels. Image Histogram: significance and interpretation. Spatial domain Processing: Pixel point processing: linear and piecewise linear transformations, log and power law transformations, histogram equalization, Arithmetic and logic operation between image frames. Pixel Group Processing: Convolution in spatial domain, low frequency and high frequency filtering, gradient filters. Frequency Domain Processing: Relation with spatial domain convolution, standard low pass and high pass spatial domain filters Morphological operations: Translation, Reflection, Complement, Difference, Dilation, Erosion, Opening and Closing, Hit or miss transform, Boundary extraction, Region filling. Colour Image Processing: RGB and HIS colour models and interrelation, pseudocolour intensity slicing, colour segmentation. Image Compression Standards: Lossy and lossless compressions, BMP, TIFF & JPG image formats.
MTBMI-23	**Clinical Laboratory Instruments** Physiological basis of diseases: Pathogenesis Environment – Microbes – Antigen – Ageing Specimens of the Clinical laboratory – Hazards –Safety Principle of Diagnosis of Diseases by the aid of Pathological Tests Introduction to Clinical Laboratory – Classification – Organisation – Management Instrumental classification – Accessory instruments – Measuring instruments Instruments in Clinical Pathology Laboratory – Light, Phase Contrast and Dark-field Microscopy and Fluorescence Microscopy Instruments in Haematological Laboratory – Light Microscopy – Automated Cell Counter (Impedance/Coulter Counter) – Five Parts Cell Counter (Flow –cytometer)

	Instruments in Microbiology Laboratory - Laminar flow hood, Bactech Culture instruments, Calorimetric instrument and PCR instruments Instruments in Clinical Biochemistry Laboratory: – Genesis in Photometry/Spectophotometry – Colorimeter to Spectrophotometer, – Semi-Automated Biochemistry Analyser – Automated Batch Biochemistry Analyser – Automated Biochemistry Analyser – Fluorometer – Spectrofluorometer. – Flame Photometer – Potentiometer – pH meter, ISE Instruments, Blood Gas Analyser – Instruments based on Immunotechnology assay principle– RIA Instruments/ELISA Reader – Instruments based on scattering light emission detection principle in immuno-technology assay principle– Turbidimetry and Nephelometry – Luminometer – Chemiluminescence instrument – Electrophoresis – Chromatography – paper, thin layer, and Low Pressure column chromatography – gel permission, ion-exchange, reverse phase & HPLC. Instruments in Histopathology (Biopsy) Laboratory – Tissue Preparation instruments – Microtome – Freezing Microtome – Microscopy.
MTBMI-24	**Biochemistry & Biomaterial** Theory and operation of Elisa Reader, Flame Photometer and Colorimeter, and their use in Biochemical Test. Theory and Operation of Semi Auto Analyser and Auto Analyser, Fault Finding, Repairing and Maintenance of Biochemical Measurement Instruments. Introduction to macromolecules including biomacromolecules. Biomaterials, definition, classification, different applications. Structure-property relationship of biomaterials like protein, polysaccharides, lipopolysaccharides collagen rich and mineralized materials etc.. Properties of polymeric biomaterials as compared to metals, ceramics, composites. Chemical and biochemical evaluation of biomaterials. Principles of fluorescence and CD. Tissue and cellular response to biomaterial implants. Systemic effect of implants. Biocompatibility. Toxicity sterilization, biomaterial scaffolds. Test for suitability of biomaterials – in vitro and in vivo. Characterization, evaluation, processing of important polymeric biomaterials: polyolefins, acrylics, cellulosics, epoxy resins, fluro polymers, vinly polymers, polyurethanes, silicones, hydrogels, etc.. Novel biomaterials – nanoelectronics, optic fibers, doped biomaterials. Preparation of nonthrombogenic and heparinized surfaces. Biodegradable polymers.
MTBMI-25	**Analytical instruments** <u>Common analytical instruments</u> : UV- visible spectrophotometer; liquid scintillation counter; pH meter; ultracentrifuges, AAS. <u>Optical Microscopy</u> : Phase, ultraviolet, and interference microscopes; their basic principles; optical systems and ray diagrams; their application in medical biology, fluorescence microscope; Multi —photon microscope. <u>Electron Microscopy</u>: Theory of magnetic and electrostatic lenses and their focal length; construction of electron microscope; limiting resolution and useful magnification; contrast formation; shadowing and staining techniques; scanning electron microscopy; specimen preparation techniques; application of electron

	microscopy in medical sciences; embedding and section cutting. Atomic Force Microscopy: for nano-order particle analysis, Piezoelectric scanners, Probes and cantilevers, Cantilever geometry, tip sharp, Tip functionality, Detection methods, Optical detectors : Laser beam deflection and interferometry, Electrical detectors : electron tunneling, capacitance, piezoelectric cantilevers, control systems, AFM electronics, Vibration isolation : Thermal and mechanical.
MTBMI-26	**Bio Mathematics** **MTBMI-26: Biomathematics** Functional relation, notation and representation. Review of basic functions. Complex functions. Functions of several variables. Application to biological problems. Numerical generation of functions. Differential and Integral Calculus: Derivative and differential, review of basic concepts. Taylor's formula and series. Concept of extremum. Partial derivative. Numerical differentiation. Indefinite and definite integral. Numerical intregration. Ordinary Differential Equations: Review of basic concepts. Numerical methods for ODE. Partial Differential Equations: Review of basic concepts and application to biological problems. Numerical methods for PDE. Interpolation and Approximate Methods: Approximating roots of equation. Interpolation formulas. Systems of Linear Algebra equations: Determinants. Numerical treatment of determinants. Linear mappings. Systems of linear algebraic equations. Matrices. Eigenvectors and eigen values. Numerical treatment of matrix inversion. Series: Number, functional, power series and trigonometric series. Fourier series. Fourier transformation and their applications. Discrete Fourier transform. Probability in Medicine and Biology: Bayes Theorem. Random Sampling, Population parameters and analysis of variance.
	PRACTICAL
MTBMI P-III	**Optical Instruments & Lasers** **MTBMI-PIII: Optical Instruments and Lasers** Optical Microscope: Anatomy of optical microscope, determination of focal length, Numerical aperture and resolving power of different objectives, interfacing the microscope with CCD. Optics of the two arm interferometer, setting up of TG interferometer, flatness testing and fringe analysis Laser beam parameter measurement: size and location of beam waist, beam divergence, Rayleigh length,

	polarization state and wavelength. Study of basic telescopic system. Study of the He-Ne laser.
MTBMI P-IV	**Clinical Laboratory Instruments** **MTBMI-PIV: Clinical laboratory Instruments** Instrumental classification – Accessory instruments – Measuring instruments Instruments in Clinical Pathology Laboratory – Light, Phase Contrast and Dark-field Microscopy and Fluorescence Microscopy Instruments in Haematological Laboratory – Light Microscopy – Automated Cell Counter (Impedance/Coulter Counter) – Five Parts Cell Counter (Flow –cytometer) Instruments in Microbiology Laboratory - Laminar flow hood, Bactech Culture instruments, Calorimetric instrument and PCR instruments Instrument in Clinical Biochemistry Laboratory Colorimeter to Spectrophotometer, Semi-Automated Biochemistry Analyser – Automated Batch Biochemistry Analyser – Automated Biochemistry Analyser. Instruments in Histopathology (Biopsy) Laboratory – Tissue Preparation instruments – Microtome – Freezing Microtome – Microscopy. Colorimeter to Spectrophotometer, Semi-Automated Biochemistry Analyser – Automated Batch Biochemistry Analyser Automated Biochemistry Analyser Fluorometer – Spectrofluorometer. Flame Photometer Potentiometer – pH meter, ISE Instruments, Blood Gas Analyser Instruments based on Immunotechnology assay principle– RIA Instruments/ELISA Reader Luminometer – Chemiluminescence instrument Electrophoresis – Chromatography – paper, thin layer, and Low Pressure column

SEMESTER – III	
MTBMI-31	**Patient monitoring and life support systems** Respiratory Care Unit – RCU, Suction apparatus, Nebuliser, Ventilator, Blood Gas Analyzer, Humidifiers, Air Compressor Spirometer, Ambu bag and Resuscitation Accessories, Laryngoscope, Operating Microscope, Laparoscopic unit for microsurgery, C.Arm Sterilizer, Autoclave ETO
MTBMI-32	**Optical Instrumentation and Lasers in Biomedical Sciences** Advantages and scope of optical Instrumentation. Basic optical systems: Optics and anatomy of microscopic and telescopic systems. Microscope objective types. Optoelectronic devices: characteristics of optical sources and detectors in UV, visible and IR, CCD and CMOS cameras, Liquid crystal displays and Spatial Light Modulators. Interferometric systems. Types and basic principles of Fibre Optic based sensors. Properties, types and application of lasers in Biomedical Instrumentation: Argon-ion, Helium Neon, Krypton, Ruby, CO_2, Nd-YAG. Eximer Lasers: ArF, KrF, XeCl, XeF. Argon ion laser as photo coagulator, Cauterization using CO_2 laser. 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. Laser applications: Lasers in dermatology, lasers in ophthalmology, laser in dentistry, Laser flow cytometry, Laser transillumination & diaphanography - Speckle intereferometry, Holography: Principles and applications. Safety with biomedical Lasers.
MTBMI-33	**Cardio, Pulmonary and Critical Care Units** Oxygenerator, Cardiotomy reservoirs. Tubing, Filters. Membrane oxygenation- Introduction. History of membrane lung, Assessment of membrane devices, Extra corporeal membrane oxygenation . Monitoring- ECG, Arterial blood pressure, CXVP, LAP & PA Wedge, Arterial pump flow rate, Suction pump flow. Anesthesia for CPB – Premedication monitoring, Anesthesia and maintenance of cardio vascular stability. Cannulation- Preparation for cannulation, Cannulation technique, decompression of heart during CPB, cannulation in emergency situations. Adequeacy of perfusion- General considerations, specific aspect of perfusion Monitoring of the adequacy of CPB. Blood flow requirement at different temperatures, safe circulatory arrest duration at various temperature , Technique of circulatory arrest, Complications. Pathophysiology and technique of cardio pulmonary bypass: Perioperative hypertension, pathogenesis and treatment, Renal effects, CPB in chronic renal disease, cerebral dysfunction following CPB, central nervous system injury during surgery of descending aorta, coagulation abnormalities with CPB, platelet physiology during CPB, Blood conservation, CPB with heamoglobinopath. 5 Unit Heart-Lung-Machine, Intra – Aortic-Baloon-Pump-Machine. **Hospital Management, Telemetry and telemedicine** Hospital management overview, Health Manpower and its Management, Inventory Management Marketing of Health core Equipments, Quality of Diagnostic centre, Training process Biomedical instrumentation, Purchasing techniques in Bio Equipments Management, Computerization of Diagnostic centre, MIS in Health care, Bio Medical waste Management including Lab. Waste Management, Equipment

	management and audit, Ethics in Health Care Organization, Case Studies, Case Studies and Evaluation Physiotherapy Equipment, Ultra sound therapy, Short wave diathermy, Traction Unit, IFT Telemetry & Telemedicine: Trans telephonic ECG , Medical data transfer system , Wireless telemetry.
MTBMI-34	**Cardiovascular and Cardiothoracic Instruments and Techniques** Oxygenerator, Cardiotomy reservoirs. Tubing, Filters. Membrane oxygenation- Introduction. History of membrane lung, Assessment of membrane devices, Extra corporeal membrane oxygenation . Monitoring- ECG, Arterial blood pressure, CXVP, LAP & PA Wedge, Arterial pump flow rate, Suction pump flow. Anesthesia for CPB – Premedication monitoring, Anesthesia and maintenance of cardio vascular stability. Cannulation- Preparation for cannulation, Cannulation technique, decompression of heart during CPB, cannulation in emergency situations. Adequeacy of perfusion- General considerations, specific aspect of perfusion Monitoring of the adequacy of CPB. Blood flow requirement at different temperatures, safe circulatory arrest duration at various temperature , Technique of circulatory arrest, Complications. Pathophysiology and technique of cardio pulmonary bypass: Perioperative hypertension, pathogenesis and treatment, Renal effects, CPB in chronic renal disease, cerebral dysfunction following CPB, central nervous system injury during surgery of descending aorta, coagulation abnormalities with CPB, platelet physiology during CPB, Blood conservation, CPB with heamoglobinopath. 5 Unit Hart-Lung-Machine, Intra – Aortic-Baloon-Pump-Machine
MTBMI-35	**Endoscopy, Urological Instruments, Dialyses and Renal Technique** Endoscopy : Flexible and Rigid endoscopes; video endoscopy, recorder, sigmoidoscopy, colonescopy Urological Instruments :Lithopleast, cystoscopy, Endoscopic Surgery [telescope, light sense, Fiber-optic-cable, Camera System,. Monitor, Operative Instruments], ESWL (Extra-corporeal-short wave lithotripsy), PCNL (Per-cutaneous-Nephro-lithodomy) Nephroscope, Ureteroscope, Ultrasonic Clearner, Steriliser, Sidex, Uroflowmetry, Urodynamics Dialysis & Renal Techniques and Applications : Principle of dialysis in the Artificial Kidney Dialyzers, parallel flow Dlalvzers, Coil Haemodialyzer, Hollow Fibre. Haelmodialyzer, Performance Analysis of Dialyzers, Residual Blood volume, Membranes for Haemo dialysis, Haemodialysis Machine : Proportioning pumps, Dialysate Temperature Control and Measurement, Conductivity Measurement, Dialysate Pressure Control and measurement, Venous Pressure Measurement, Blood leak Detector, Ultrafoltrate Monitor, Multipatient Dialysate Delivery system.
	PRACTICAL
MTBMI P-V	**Hospital Training** Common Items: Various sterilization procedure, Oxygen , Nitrous , Vacuum pipeline, Electrical safety, Hygiene management, Calibration of Lifesaving equipment, Human Values & Ethics (Including professional Ethics) OT Equipments : Operation Theatre, Anesthesia Machine , Vaporisers, Regulated Floor Suction apparatus, O.T Shadow less, cold light, O.T Table, Surgical Diathermy Hospital Management: Hospital management overview, Health Manpower and its Management, Inventory Management

	Marketing of Health core Equipments, Quality of Diagnostic centre, Training process Biomedical instrumentation, Managing Purchases of Bio Equipments, Computerization of Diagnostic centre, MIS in Health care, Bio Medical waste Management including Lab. Waste Management, Equipment management and audit, Ethics in Health Care Organization, Case Studies and Evaluation
MTBMI P-VI	**Patient Monitoring and Life Support System** Respiratory Care Unit – RCU, Suction apparatus, Nebuliser, Ventilator, Blood Gas Analyzer, Humidifiers, Air Compressor, Spirometer, Ambu bag and Resuscitation, ECG, TMT, Holter monitor, Event Recorder, Cardiology ICCU , ITU Therapeutic & support equipment, Defibrillator, Pacemaker, Intra aortic Balloon Pump (IABP), ECG Bed side Monitor, Multi parameter monitor - ECG , NIBP(Non invasive blood pressure) , SpO2(Pulse oxymeter , EtCO2, IBP(Invasive blood pressure) , Temp (Skin & Rectal) , CO (Cardiac output), Echo cardiography, Syringe infusion pump, Volume infusion pump, Na+ & k Analyzer, Catheter. Lab., Gluco meter, Oxygen therapy Equipment & Accessories, Central Monitoring system, Dialysis, CRRT, Dialyser reuse system, RO water plant **Medical Imaging:** EEG, EMG, NCV, Nerve stimulator, USG.
MTBMI PJ-I	**Project –preliminary**
SEMESTER IV	
MTBMI-41	**Medical Imaging-II:** Radiology: generation and detection X-rays, Properties of X-rays, Types of machines and their control, X-ray image, X-ray films, and their processing. Measurement of contrast, Effect of scattered radiation. Fluroscopy, Image amplification and recording. Special techniques in X-ray diagnosis, Neuro Radiography, Subtraction technique. Physics of Ultrasonic Waves. Medical Ultrasound, Basic Pulse echo apparatus, A-scan, Electrocardiograph, Real time USG , digital scan converter, Biological Effects of Ultrasound. Application of Ultrasonic Transducers using M-mode, B-mode, Two dimensional ultrasonic scanning, Doppler principles to measure flow, velocity of blood flow etc. Ultrasonic Machines of phased arrays, Doppler applications. Video imaging. Recorders, Recorder systems. Laser printers for two dimensional Ultrasonic images. Images of Head, Lung, Kidneys, Brain etc., and the techniques of obtaining the images. Two dimensional colour displays, Central Nervous System Instruments. Details of Electro encephalograms, data acquisition, Computed Tomography, System Components.

MTBMI-42	**Elective Paper** **I. Radioisotopes and Nuclear Medicine** Principles of nuclear medicine; properties of nuclei; stable and unstable nuclei; radioisotopes; radioactive decay; α-decay, β-decay, γ-decay; physics of radioactive decay; half-life; decay constant; activity; cumulated activity; specific activity; radioactive equilibrium; parent-daughter relationship; transient and secular equilibrium; biological half-life; effective half-life; production of radioisotopes; Molybdenum-Technetium radioisotope generator (technetium cow). Characteristics of radioisotopes used in nuclear medicine; different types of radiation sources; labeling; tracer; radioisotope calibrator; detectors; scintillating crystal; activated scintillator; thalium activated sodium iodide crystal NaI(Tl); photomultiplier tube (PMT); photomultiplier gain; performance of a scintillation detector; resolution and efficiency of detector; voltage supply to PMT; photodiodes; radiation detection equipment; pulse height analyser (PHA); single channel analyser (SCA); multichannel analyser (MCA); different types of ADC used in MCA. Use of radioisotopes in diagnostics; different types of collimators; dynamic studies in nuclear medicine; renogram, kidney test, thyroid uptake test; use of radioisotopes in thyroids and other organs; distribution of radioactivity in the body; iodine uptake monitoring equipment; thyroid uptake measurement; rectilinear scanner; dual probe scanner; gamma camera; emission computed tomography; single photon emission computed tomography (SPECT); positron emission tomography (PET). **2. Medical Physics** Quantum concept of radiation; EM radiation family; ionizing and non-ionizing radiation; X-rays; production and properties; bremstrahlung and characteristic radiation; X-ray machines; collimators and grids; Van-de-Graff generator, linear accelerator, cyclotron, synchrotron. Passage of charged particles through matter; energy loss of charged particles in matter, stopping power; Bragg curve and importance in radiation therapy; Interaction of x-rays and gamma rays with matter; attenuation coefficient; half value layer (HVL); filtration of x-rays; x-ray beam quality. Absorption of energy from x- and gamma rays; fluence; flux; mass energy transfer coefficient; mass energy absorption coefficient; exposure, roentgen; dose, calculation of dose; absorbed dose; linear energy transfer (LET); radiobiological equivalent (RBE); quality factor (QF); dose equivalent; rad, rem and their SI equivalent; Measurement of exposure and dose; ionization chamber; GM counter; measurement of dose; Bragg-Gray principle and its use in dosimeter; chemical dosimeter; calorimetry; thermoluminescence dosimeter (TLD); other dosimeters. Medical uses of x-rays: shadowgraph; contrast; intensifying screen; fluorescence screen; x-ray image intensifier; tomography; computer tomography (CT): CT machines (1^{st} generation to 5^{th} generation); CT reconstruction; CT number. **3. Opthalmological Instruments, Advanced microscopy and CT** Anatomy and optics of the eye. Indirect Ophthalmoscope, Direct Ophthalmoscope, Slit Lamp: Haag- Streit, Photo-slit lamp, Lensometer. Lens gauge, Tonometer, Fundus Camera, External eye photography, Auto-refractometer Corneal Examination Apparatus: Placido disc, Keterometer, V KG, Specular Microscopy, Aesthesiometer, Exophthalmometer, Perimeter – Manual & automated, Orthoptics Instruments - Haploscope/Home devices, Heidelberg Retino-tomography HRT –II, Nerve fiber analyzer, Frequency doubling perimeter, Non Contact Tonometer, Heidelberg Analmascope, Pachometers, Contrast sensitivity tests, Glare

	acuity tests, Colour vision tests, Dark adaptometer. Advanced Microscopy: Illumination techniques, infinity corrected microscopes, Principle and construction of phase contrast microscopy, interference microscopy and low coherence microscopy Computerized Tomography: Principles, instrumentation and image reconstruction Optical Coherence Tomography; Direct and Spectral measurements. **4. Pollution Control and Hospital waste management** Human Anatomical waste, Animal waste, Microbiology & Biotechnology waste, waste sharps, Disconded medicines & cytotoxic drugs, solid waste, liquid waste, incineration ash, chemical waste, waste carrying container; Plastic bag, Disinfected container, puncture container, Biohazard symbol, cytotoxic hazard symbol, handling with care, Standards for treatment and dispose of Bio-medical waste, Standards for waste Autoclearing, emission standards, Incinerators emit toxic air pollutants, Incineration ASH is potentially hazardous, International convention on the Elimination of Persistent organic pollutants (POPS), Waste reduction and segregation, low heat thermal processes, Mechanical Processes, Hospital Wastes: Environmental standards and Guidelines for Management, Recording of operational parameters, Thermal Sterilization **5. Implants and artificial organs** Introduction to biomaterials, uses of biomaterials, biomaterials in organs & body systems, materials for use in the body, performance of biomaterials Metallic biomaterials**:** Introduction, Stainless steel, Cobalt-Chromium alloy, Titanium alloys, Titanium-Nickel alloys, Dental metals, Corrosion of metallic implants, Manufacturing of implants. Ceramic biomaterials**,** Polymeric biomaterials, Composite biomaterials, Biodegradable polymeric biomaterials, Tissue derived biomaterials, Hard tissue replacements**,** Preservation techniques for biomaterials: Phase behavior, nonfreezing storage-hypothermic, freeze-thaw technology, freeze-drying, vitrification. Artificial implants: Substitutive medicine, outlook for organ replacement, design consideration, evaluation process. Artificial heart and circulatory assist devices: blood interfacing implants – introduction, total artificial hearts & ventricular assist devices, vascular prostheses, Non-blood interfacing implants for soft tissues- sutures and allied augmentation devices, percutaneous and skin implants, maxillofacial implants, eye and ear implants. Cardiac valve prostheses: Mechanical valves, tissue valves, current types of prostheses, tissue versus mechanical, engineering concerns and hemodynamic assessment of prosthetic heart valves, implications for thrombus deposition, durability, current trends in valve design, vascular grafts-history, synthetic grafts, regional patency, thrombosis, neointimal hyperplasia, graft infections. Artificial kidney: renal transplantation, artificial kidney, Artificial blood: Artificial oxygen carriers, flurocarbons, hemoglobin for oxygen carrying plasma expanders, hemoglobin based artificial blood. Tracheal replacement devices, laryngeal replacement devices, Artificial esophagus Artificial Skin: Vital functions of skin, current treatment of massive skin loss, design principles for permanent skin replacement. **6. Forensic science**

	Introduction to Forensic Science, Scope and relevance. Tools, Techniques and Instrumentation: SEM, UV – lamp, Electrostatic Dust Print Lifter, Gel Lifter, Cast, Camera, Swab, Ninhydrin, Scalpel, Gunshot Residue Kit, GC-MS, RAMAN Spectral Comparator, Glass Refractive Index-Measurement, EFIT, Fuming Cabinet.
MTBMI-43	**Comprehensive VIVA**
MTBMI PJ-II	**Project Final: Thesis presentation**