Dr. Babasaheb Ambedkar Technological University, Lonere.

Dr. Babasaheb Ambedkar Technological University
(Established as a University of Technology in the State of Maharashtra)
(under Maharashtra Act No. XXIX of 2014)
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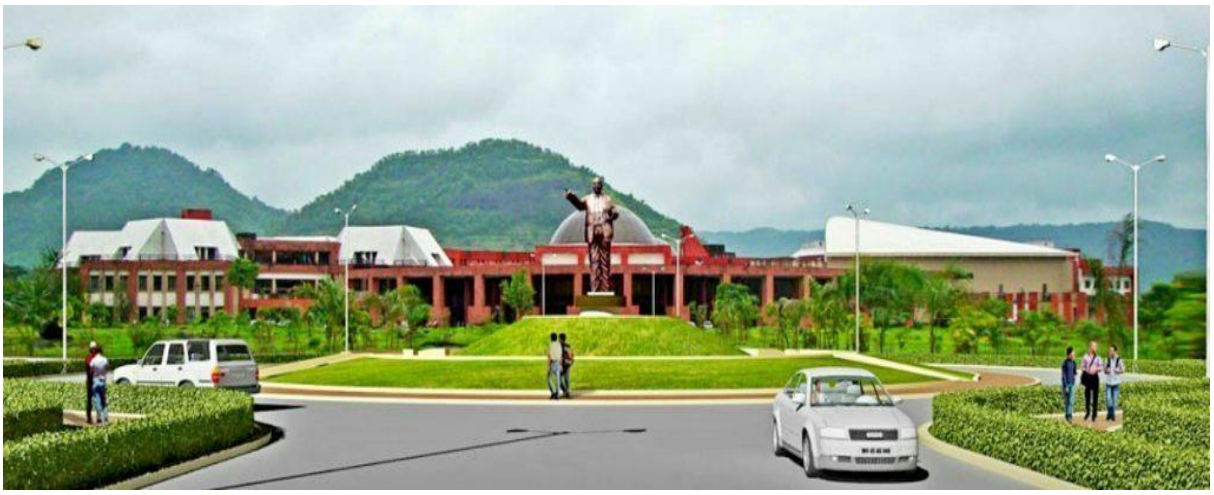
PROPOSED CURRICULUM UNDER GRADUATE PROGRAMME B.TECH IN

BIOMEDICAL ENGINEERING

FROM ACADEMIC YEAR 2022-2023



Rules and Regulations

1. The normal duration of the course leading to B.Tech degree will be EIGHT semesters.
2. The normal duration of the course leading to M.Tech. Degree will be FOUR semesters.
3. Each academic year shall be divided into 2 semesters, each of 20 weeks duration, including evaluation and grade finalization, etc. The Academic Session in each semester shall provide for at least 90 Teaching Days, with at least 40 hours of teaching contact periods in a five to six days session per week. The semester that is typically from Mid-July to November is called the ODD SEMESTER, and the one that is from January to Mid-May is called the EVEN SEMESTER. Academic Session may be scheduled for the Summer Session/Semester as well. For 1st year B. Tech and M. Tech the schedule will be decided as per the admission schedule declared by Government of Maharashtra.
4. The schedule of academic activities for a Semester, including the dates of registration, mid-semester examination, end-semester examination, inter-semester vacation, etc. shall be referred to as the Academic Calendar of the Semester, which shall be prepared by the Dean (Academic), and announced at least TWO weeks before the Closing Date of the previous Semester.
5. The Academic Calendar must be strictly adhered to, and all other activities including co-curricular and/or extra -curricular activities must be scheduled so as not to interfere with the Curricular Activities as stipulated in the Academic Calendar.

REGISTRATION:

1. Lower and Upper Limits for Course Credits Registered in a Semester, by a Full-Time Student of a UG/PG Programme:

A full time student of a particular UG/PG programme shall register for the appropriate number of course credits in each semester/session that is within the minimum and maximum limits specific to that UG/PG programme as stipulated in the specific Regulations pertaining to that UG/PG programme.

2. Mandatory Pre-Registration for higher semesters:
   In order to facilitate proper planning of the academic activities of a semester, it is essential for the every institute to inform to Dean (Academics) and COE regarding details of total no. of electives offered (Course-wise) along with the number of students opted for the same. This information should be submitted within two weeks from the date of commencement of the semester as per academic calendar.
3. PhD students can register for any of PG/PhD courses and the corresponding rules of evaluation will apply.
4. Under Graduate students may be permitted to register for a few selected Post Graduate courses, in exceptionally rare circumstances, only if the DUGC/DPGC is convinced of the level of the academic achievement and the potential in a student.

Course Pre-Requisites:

1. In order to register for some courses, it may be required either to have exposure in, or to have completed satisfactorily, or to have prior earned credits in, some specified courses.
2. Students who do not register on the day announced for the purpose may be permitted LATE REGISTRATION up to the notified day in academic calendar on payment of late fee.
3. REGISTRATION IN ABSENTIA will be allowed only in exceptional cases with the approval of the Dean (Academic) / Principal.
4. A student will be permitted to register in the next semester only if he fulfills the following conditions:

(a) Satisfied all the Academic Requirements to continue with the programme of Studies without termination
(b) Cleared all Institute, Hostel and Library dues and fines (if any) of the previous semesters;
(c) Paid all required advance payments of the Institute and hostel for the current semester;
(d) Not been debarred from registering on any specific ground by the Institute.

EVALUATION SYSTEM:

1. Absolute grading system based on absolute marks as indicated below will be implementeds from academic year 2019-20,starting from I year B.Tech.

Perentage of marks	Letter grade	Grade point
91-100	EX	10.0
86-90	AA	9.0
81-85	AB	8.5
76-80	BB	8.0
71-75	BC	7.5
66-70	CC	7.0
61-65	CD	6.5
56-60	DD	6.0
51-55	DE	5.5
40-50	EE	5.0
<40	EF	0.0

2. Class is awdared based on CGPA of all eigth semster of B.Tech Program.

CGPA for pass is minimum 5.0	
CGPAupto<5.50	Pass class
CGPA ≥ 5.50 &<6.00	SecondClass
CGPA ≥ 6.00 &<7.50	First Class
CGPA ≥ 7.50	Distinction
[Percentage of Marks =CGPA*10.0]	

3. A total of 100 Marks for each theory course are distributed as follows:

MidSemester Exam (MSE) Marks	20
ContinuousAssesment Marks	20
End SemesterExamination(ESE)Marks	60

4.A total of 100 Marks for each practical course are distributed as follows:

1.	Continuous Assesment Marks	60
2.	End Semester Examination (ESE)Marks	40

It is mandatory for every student of B.Tech to score a minimum of 40 marks out of 100, with a minimum of 20 marks out of 60 marks in End Semester Examination for theory course.
This will be implemented from the first year of B.Tech starting from Academic Year 2019-20

5. Description of Grades:

EX Grade: An 'EX' grade stands for outstanding achievement.
EE Grade: The 'EE' grade stands for minimum passing grade.
The students may appear for the remedial examination for the subjects he/she failed for the current semester of admission only and his/her performance will be awarded with EE grade only. If any of the student remain Absent for the regular examination due to genuine reason and the same will be verified and tested by the Dean (Academics) or committee constituted by the University Authority.
FF Grade: The 'FF' grade denotes very poor performance, i.e. failure in a course due to poor performance .The students who have been awarded 'FF' grade in a course in any semester must repeat the subject in next semester.

6. Evaluation of Performance:

1. Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA)

(A) Semester Grade Point Average (SGPA) The performance of a student in a semester is indicated by Semester Grade Point Average (SGPA) which is a weighted average of the grade points obtained in all the courses taken by the student in the semester and scaled to a maximum of 10. (SGPI is to be calculated up to two decimal places). A Semester Grade Point Average (SGPA) will be computed for each semester as follows:

$$SGPA = \frac{[\sum_{i=1}^{n} c_i g_i]}{[\sum_{i=1}^{n} c_i]}$$

Where
'n' is the number of subjects for the semester,
'ci' is the number of credits allotted to a particular subject, and
'gi' is the grade-points awarded to the student for the subject based on his performance as per the above table.
-SGPA will be rounded off to the second place of decimal and recorded as such.

(B) Cumulative Grade Point Average (CGPA): An up to date assessment of the overall performance of a student from the time he entered the Institute is obtained by calculating Cumulative Grade Point Average (CGPA) of a student. The CGPA is weighted average of the grade points obtained in all the courses registered by the student since s/he entered the Institute. CGPA is also calculated at the end of every semester (upto two decimal places).Starting from the first semester at the end of each semester (S), a Cumulative Grade Point Average (CGPA) will be computed as follows:

$$CGPA = \frac{[\sum_{i=1}^{m} c_i g_i]}{[\sum_{i=1}^{m} c_i]}$$

Where
'm' is the total number of subjects from the first semester onwards up to and including the semester S,
'ci' is the number of credits allotted to a particular subject, and
'gi' is the grade-points awarded to the student for the subject based on his/her performance as per the above table.

-CGPA will be rounded off to the second place of decimal and recorded as such.

Award of Degree of Honours

Major Degree

The concept of Major and Minors at B.Tech level is introduced , to enhance learning skills of students, acquisition of additional knowledge in domains other than the discipline being pursued by the student, to make the students better employable with additional knowledge and encourage students to pursue cross-discipline research.

A. Eligibility Criteria for Majors

1. The Student should have Minimum CGPA of 7.5 up to 4th Semester
2. Student willing to opt for majors has to register at the beginning of 5th Semester
3. The Student has to complete 5 additional advanced courses from the same discipline specified in the curriculum. These five courses should be of 4 credits each amounting to 20 credits. The students should complete these credits before the end of last semester.
4. Student may opt for the courses from NPTEL/ SWAYAM platform. (if the credits of NPTEL/ SWAYAM courses do not match with the existing subject proper scaling will be done)

Student complying with these criteria will be awarded B. Tech. (Honours) Degree.

B. Eligibility Criteria for Minors

1. The Student should have Minimum CGPA of 7.5 up to 4th Semester
2. Student willing to opt for minors has to register at the beginning of 5th Semester
3. The Student has to complete 5 additional courses from other discipline of their interest, which are specified in the respective discipline. These five courses should be of 4 credits each amounting to 20 credits.
4. Student may opt for the courses from NPTEL/ SWAYAM platform. (if the credits of NPTEL/ SWAYAM courses do not match with the existing subject proper scaling will be done)

Student complying with these criteria will be awarded with B.Tech Degree in ------- Engineering with Minor in ------ --Engineering.
(For e.g.: B. Tech in Civil Engineering with Minor in Computer Engineering)

For applying for Honours and Minor Degree the student has to register themselves through the proper system.

ATTENDANCE REQUIREMENTS:

1. All students must attend every lecture, tutorial and practical classes.
2. To account for approved leave of absence (eg. representing the Institute in sports, games or athletics; placement activities; NCC/NSS activities; etc.) and/or any other such contingencies like medical emergencies, etc., the attendance requirement shall be a minimum of 75% of the classes actually conducted.

If the student failed to maintain 75% attendance, he/she will be detained for appearing the successive examination.

The Dean (Academics)/ Principal is permitted to give 10% concession for the genuine reasons as such the case may be.

In any case the student will not be permitted for appearing the examination if the attendance is less than 65%.

3. The course instructor handling a course must finalize the attendance 3 calendar days before the last day of classes in the current semester and communicate clearly to the students by displaying prominently in the department and also in report writing to the head of the department concerned.
4. The attendance records are to be maintained by the course instructor and he shall show it to the student, if and when required.

TRANSFER OF CREDITS

The courses credited elsewhere, in Indian or foreign University/Institutions/ Colleges/Swayam Courses by students during their study period at DBATU may count towards the credit requirements for the award of degree. The guidelines for such transfer of credits are as follows:

a) 20 % of the total credit will be considered for respective calculations.
b) Credits transferred will be considered for overall credits requirements of the programme.
c) Credits transfer can be considered only for the course at same level i.e UG, PG etc.
d) A student must provide all details (original or attested authentic copies)such as course

contents, number of contact hours, course instructor /project guide and evaluation system for the course for which he is requesting a credits transfer. He shall also provide the approval or acceptance letter from the other side. These details will be evaluated by the concerned Board of Studies before giving approval. The Board of Studies will then decide the number of equivalent credits the student will get for such course(s) in DBATU. The complete details will then be forwarded to Dean for approval.

e) A student has to get minimum passing grades/ marks for such courses for which the credits transfers are to be made.

f) Credits transfers availed by a student shall be properly recorded on academic record(s) of the student.

g) In exceptional cases, the students may opt for higher credits than the prescribed.

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Number of Courses	Semester							
	I	II	III	IV	V	VI	VII	VIII
1	BTBS101	BTBS201	BTBS 301	BTBMC 401	BTBMC 501	BTBMC 601	Open Elective IV	BTBMP 801 (Project/ Internship)
2	BTBS102	BTBS202	BTBMC 302	BTBMC 402	BTBMC 502	BTBMC 602	Prof Elective IV	--
3	BTES103	BTES203	BTBMC 303	BTHM 403	Prof Elective II	Prof Elective III	Prof Elective V	--
4	BTHM104	BTES204	BTBMES 304	Prof. Elective I	Open Elective II	Open Elective III	Open Elective V	--
5	BTES105	BTES205	BTBMC 305L	Open Elective 1	BTBMC 505L	BTHM605	BTHM 705	--
6	BTES106	BTES206	BTBMC 306L	BTBMC 406L	BTBMC 506L	BTBMC 606L	BTHM 706	--
7	BTBS107 L	BTBS207 L	BTBMS 307	BTBMS407	BTBMC 507L	BTBMM 607	BTBMM 707	--
8	BTES108 L	BTES208 L	BTBMP 211(Internship 1 Evaluation	BTBMP408 (Internship 2)	BTBMP408 (Internship – 2 Evaluation)	BTBMP608 (Internship – 3)	BTBMP608 (Internship – 3 Evaluation)	--
9	BTHM109L	BTES209 S	--	--	-	--	-	--
10	--	BTBMP211 (Internship - 1)	--	--	--	--	--	--

Degree Requirements:

Category of courses	**Minimum credits to be earned**
Basic Science Course (BSC)	**12**
Engineering Science Course (ESC)	**22**
Humanities and Social Science including Management Courses (HSSMC)	**19**
Professional Core Course (PCC)	**44**
Professional Elective Course (PEC)	**20**
Open Elective Course (OEC)	**20**
Seminar/Mini Project/ Internship/Major Project	**23**
Total	**160**

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BIO-MEDICAL ENGINEERING

Program Educational Objectives and Outcomes

A. Program Educational Objectives (PEOs)

Graduate will –

1. To prepare our students for skilled and ethical service to their communities by creating a free and open learning environment that enhance their intellectual growth.
2. To engage our students to work in collaborative projects, corporate and academic communities in effective manner.
3. To create innovative technologies for the improvement of health care sectors and contributes positively to the needs of society.

B. Program Outcomes

Engineering Graduate will be able to –

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and

design documentation, make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

C. Program Specific Outcomes (PSOs)

1. Apply advanced science and engineering to solve the problems at the interface of engineering and healthcare.
2. Demonstrate understanding of the principles and working of the hardware and software aspects of biomedical systems.
3. Use professional and ethical practices, strategies and tactics for the development, operation and maintenance of biomedical technologies.
4. Provide effective and efficient real time solutions using acquired knowledge in various domains

B. Tech Course in Biomedical Engineering

Curriculum for Second Year

SEMESTER III

Course category	Course code	Course title	Teaching scheme			Evaluation scheme				Credit
			L	T	P	CA	MSE	ESE	Total	
BSC	BTBS301	Engineering Mathematics – III	3	1	-	20	20	60	100	4
PCC 1	BTBMC302	Human Anatomy and Physiology	3	1	-	20	20	60	100	4
PCC 2	BTBMC303	Analog and Digital Circuits	3	1	-	20	20	60	100	4
ESC	BTBMES304	Basics of Bio-medical Instrumentation	3	1	-	20	20	60	100	4
LC	BTBMC305L	Human Anatomy and Physiology Lab	-	-	2	60	-	40	100	2
LC	BTBMC306L	Analog and Digital Circuits Lab	-	-	4	60	-	40	100	2
Seminar	BTBMS307	Seminar-1	-	-	4	60	-	40	100	2
Internship	BTBMP211	Internship – 1 Evaluation	-	-	-	-	-	-	-	Audit
		TOTAL	**12**	**4**	**10**	**260**	**80**	**360**	**700**	**22**

BSC = Basic Science Course, ESC = Engineering Science Course, PCC = Professional Core Course PEC = Professional Elective Course, OEC = Open Elective Course, LC = Laboratory Course HSSMC = Humanities and Social Science including Management Courses

B. Tech Course in Biomedical Engineering

Curriculum for Second Year

SEMESTER IV

Course category	Course code		Course title	Teaching scheme			Evaluation scheme				Credit
				L	T	P	CA	MSE	ESE	Total	
PCC 3	BTBMC401		Biomedical Equipment	3	1	-	20	20	60	100	4
PCC 4	BTBMC402		Biomedical signal Processing	3	1	-	20	20	60	100	4
HSSMC	BTHM403		Basic Human Rights	3	-	-	20	20	60	100	3
PEC 1	PROEL E-I	BTBMPE404A	Biomechanics	3	1	-	20	20	60	100	4
		BTBMPE404B	Network Analysis								
		BTBMPE404C	Principal of Communication System								
OEC 1	OPEN ELE-I	BTBMOE405A	Medical Radiation Safety Engineering	3	1	-	20	20	60	100	4
		BTBMOE405B	Quality Control and Regulatory Aspects in Medical Devices								
LC	BTBMC406L		Biomedical Equipment Lab & Biomedical signal Processing Lab	-	-	4	60	-	40	100	2
Seminar	BTBMS407		Seminar 2	-	-	4	60	-	40	100	2
Internship	BTBMP408		Field Training / Internship/Industrial Training (minimum of 4 weeks which can be completed partially in third semester and fourth semester or in atone time).(Internship2)	-	-	-	-	-	-	-	Credits To be evaluate d in V Sem.
			TOTAL	**15**	**4**	**8**	**220**	**100**	**380**	**700**	**23**

PROFESSIONAL ELECTIVE I

Course Code	Course Title
BTBMPE404 A	Biomechanics
BTBMPE404 B	Network Analysis
BTBMPE404 C	Principal of Communication System

OPENELECTIVE I

Course Code	Course Title
BTBMOE405 A	Medical Radiation Safety Engineering
BTBMOE405 B	Quality Control and Regulatory Aspects in Medical Devices

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B. Tech Course in Biomedical Engineering

Curriculum for Third Year

SEMESTER V											
Course category	**Course code**		**Course title**	**Teaching scheme**			**Evaluation scheme**				**Credit**
				L	**T**	**P**	**CA**	**MSE**	**ESE**	**Total**	
PCC 1	BTBMC501		Medical Image Processing	3	1	-	20	20	60	100	4
PCC 2	BTBMC502		Microprocessor and Microcontroller Based Biomedical Instrumentation	3	1	-	20	20	60	100	4
PEC 2	PROELE-II	BTBMPE503A	Artificial Intelligence & Neural Networks	3	1	-	20	20	60	100	4
		BTBMPE503B	Rehabilitation Engineering								
		BTBMPE503C	Embedded & Real Time System								
OEC 2	OPENELE-II	BTBMOE504A	Applied Optoelectronics in Medicine	3	1	-	20	20	60	100	4
		BTBMOE504B	Biomedical MEMS								
LC	BTBMC505L		Medical Image Processing LAB	-	-	2	60	-	40	100	2
LC	BTBMC506L		Microprocessor & Microcontroller Based Biomedical Instrumentation LAB	-	-	4	60	-	40	100	2
Project	BTBMM508		Mini Project – 1	-	-	4	60	-	40	100	2
Internship	BTBMP408		Internship – 2 Evaluation	-	-	-	-	-	-	-	Audit
			TOTAL	**12**	**4**	**10**	**260**	**80**	**360**	**700**	**22**

PROFESSIONAL ELECTIVE- II

Course Code	Course Title
BTBMPE503 A	Artificial Intelligence & Neural Networks
BTBMPE503 B	Rehabilitation Engineering
BTBMPE503 C	Embedded & Real Time System

OPEN ELECTIVE- II

Course Code	Course Title
BTBMOE504 A	Applied Optoelectronics in Medicine
BTBMOE504 B	Biomedical MEMS

B. Tech Course in Biomedical Engineering

Curriculum for Third Year

SEMESTER VI

Course category	Course code		Course title	Teaching scheme			Evaluation scheme				Credit
				L	T	P	CA	MSE	ESE	Total	
PCC 1	BTBMC601		Biomedical Control Systems	3	1	-	20	20	60	100	4
PCC 2	BTBMC602		Microelectronics and integrated Circuits	3	1	-	20	20	60	100	4
PEC 3	PRO. ELE-III	BTBMPE603A	Artificial Organs	3	1	-	20	20	60	100	4
		BTBMPE603B	Applied Neural Networks and Fuzzy Logic in Medicine								
		BTBMPE603C	Robotics & Automation								
OEC 3	OPEN ELE-I	BTBMOE604A	Brain-Computer Interface Development Engineering	3	1	-	20	20	60	100	4
		BTBMOE604B	Electro Physiology For Human System								
HSSMC	BTHM605		Employability & Skill Development	3	-	-	20	20	60	100	3
LC	BTBMC606L		Microelectronics and integrated circuits LAB	-	-	4	60	-	40	100	2
Project	BTBMM607		Mini Project 2	-	-	4	60	-	40	100	2
Internship	BTBMP608		Field Training / Internship/Industrial Training (minimum of 4 weeks which can be completed partially in third semester and fourth semester or in at one time).(Internship 3)	-	-	-	-	-	-	-	Credits To be evaluated in VII Sem.
			TOTAL	**15**	**4**	**8**	**220**	**100**	**380**	**800**	**23**

PROFESSIONAL ELECTIVE- III

Course Code	Course Title
BTBMPE603 A	Artificial Organs
BTBMPE603 B	Applied Neural Networks and Fuzzy Logic in Medicine
BTBMPE603 C	Robotics & Automation

OPEN ELECTIVE- III

Course Code	Course Title
BTBMOE604 A	Brain-Computer Interface Development Engineering
BTBMOE604 B	Electro Physiology For Human System

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SEMESTER III

BTBS301 ENGINEEING MATHEMATICS-III

Credit	Lecture	Tutorial	Practical	CA1	MSE	ESE	Total
4	3	1	-	20	20	60	100

Course Objectives:

After completion of the course, students will have adequate background, conceptual clarity and knowledge of appropriate solution techniques related to:

1. Linear differential equations of higher order using analytical methods and numerical methods applicable to Control systems and Network analysis.
2. Transforms such as Fourier transform, Laplace transform and applications to Communication systems and Signal processing.
3. Vector differentiation and integration required in Electromagnetics and Wave theory.
4. Complex functions, conformal mappings, contour integration applicable to Electrostatics, Digital filters, Signal and Image processing.

Course Outcomes:

On completion of the course, students will be able to:

- Solve higher order linear differential equation using appropriate techniques for modeling and analyzing electrical circuits.
- Solve problems related to Fourier transform, Laplace transform and applications to Communication systems and Signal processing.
- Obtain Interpolating polynomials, numerically differentiate and integrate functions, numerical solutions of differential equations using single step and multi-step iterative methods used in modern scientific computing.
- Perform vector differentiation and integration, analyze the vector fields and apply to Electromagnetic fields.
- Analyze conformal mappings, transformations and perform contour integration of complex functions in the study of electrostatics and signal processing.

Unit 1: Laplace Transform **9 Hours**

Definition – conditions for existence ; Transforms of elementary functions ; Properties of Laplace transforms - Linearity property, first shifting property, second shifting property, transforms of functions multiplied by t^n, scale change property, transforms of functions divided by t, transforms of integral of functions, transforms of derivatives ; Evaluation of integrals by using Laplace transform ; Transforms of some special functions- periodic function, Heaviside-unit step function, Dirac delta function.

Unit 2: Inverse Laplace Transform **9 Hours**

Introductory remarks ; Inverse transforms of some elementary functions ; General methods of finding inverse transforms ; Partial fraction method and Convolution Theorem for finding inverse Laplace transforms ; Applications to find the solutions of linear differential equations and simultaneous linear differential equations with constant coefficients.

Unit3: Fourier Transform **9 Hours**

Definitions – integral transforms; Fourier integral theorem (without proof); Fourier sine and cosine integrals; Complex form of Fourier integrals; Fourier sine and cosine transforms
; Properties of Fourier transforms; Parseval's identity for Fourier Transforms.

Unit 4: Partial Differential Equations and Their Applications **9 Hours**

Formation of Partial differential equations by eliminating arbitrary constants and functions; Equations solvable by direct integration; Linear equations of first order (Lagrange's linear equations); Method of separation of variables – applications to find solutions of one

Dimensional heat flow equation (), and one-dimensional wave equation

Unit 5: Functions of Complex Variables **9 Hours**

Analytic functions; Cauchy- Riemann equations in Cartesian and polar forms; Harmonic functions in Cartesian form; Cauchy's integral theorem; Cauchy's integral formula; Residues; Cauchy's residue theorem (All theorems without proofs).

Text Books

1.Higher Engineering Mathematics by B. S. Grewal, Khanna Publishers, New Delhi.
2.Higher Engineering Mathematics by H. K. Das and Er. Rajnish Verma, S. Chand & CO. Pvt. Ltd., New Delhi.
3. A course in Engineering Mathematics (Vol III) by Dr. B. B. Singh, Synergy Knowledge ware, Mumbai.
4. Higher Engineering Mathematics by B. V. Ramana, Tata McGraw-Hill Publications, New Delhi.

Reference Books

1. Advanced Engineering Mathematics by Erwin Kreyszig, John Wiley & Sons, New York.
2. A Text Book of Engineering Mathematics by Peter O' Neil, Thomson Asia Pte Ltd. , Singapore.
3. Advanced Engineering Mathematics by C. R. Wylie & L. C. Barrett, Tata Mcgraw-Hill Publishing Company Ltd., New Delhi.
4. Integral Transforms and their Engineering Applications by Dr. B. B. Singh, Synergy Knowledgeware,Mumbai.
5. Integral Transforms by I. N. Sneddon, Tata McGraw-Hill , New York.

General Instructions:

1. The tutorial classes in Engineering Mathematics-III are to be conducted batch wise. Each class should be divided into three batches for the purpose.
2. The internal assessment of the students for 20 marks will be done based on assignments, surprise tests, quizzes, innovative approach to problem solving and percentage attendance.
   The minimum number of assignments should be eight covering all topics.

TBMC302 Human Anatomy and Physiology

Credit	Lecture	Tutorial	Practical	CA1	MSE	ESE	Total
4	3	1	2	20	20	60	100

Course Objectives:

1. To understand clearly and identify the various parts of the human body, their anatomical position, their functions and how these can be used in the design of effective biomedical systems.

Course Outcomes:

- Learner will be able to learn basics of human body, cell and blood
- Learner will be able to study about the positioning and functioning of the cardio vascular system
- Learner will be able to study about the positioning and functioning of the respiratory systems and muscle tissue.
- Learner will be able to study about the positioning and functioning of the excretory and digestive system
- Learner will be able to study about the positioning and functioning of the Central Nervous System

UNIT I – Introduction to Cell& B

lood **07 Hours**

Sub cellular structure and morphology, Transport across cell membranes and membrane potentials. Characteristics of Blood, Composition and function of blood, Plasma proteins, Red blood cells, White Blood cells, Physiology of Blood Clotting. Elementary Knowledge of human- skeletal system.

UNIT II – Heart (Circulatory System) **07 Hours**

Structure of Heart, Properties of Cardiac muscles, Cardiac Cycle, Cardiac output, Impulse generation and Transmission, Electrocardiogram, Heart sound, Regulation of Heart rate and its measurement, Regulation and Maintenance of Blood Pressure.

UNIT III - Respiratory System & Muscle Tissue **07 Hours**

Anatomy of respiratory system, Pulmonary Circulation, Physiology of respiration in the alveolar and tissues Capillaries, Mechanism of Respiration, Regulation of Respiration Structure & Function of muscles, Types of muscles, Physiology of muscles contraction. Generation of action potential.

UNIT IV - Excretory System & Digestive System **07 Hours**

Anatomy of urinary system and kidney, structure of kidney and urinary tracts, Nephron, Physiology of urine formation, Anatomy of digestive system, digestion and absorption of carbohydrates, Proteins and fats, Gastrointestinal tract, Role of pancreas and liver.

UNIT V – Central Nervous System **07 Hours**

Anatomy and function of different parts of brain, spinal cord, autonomic nervous system , Neuron, sense organ for sight and hearing.

TEXT BOOKS

1. K. Sembulingam, J.P Brothers, Essentials of MedicalPhysiology.
2. A.C. Guyton, Text Book of Medical Physiology, ElsevierSaunders.
3. William F. Ganong: Review of Medical Physioliogy, Prentice Hall InternationalInc.
4. Gerard J. Tortora and Nicholas, P. Anangnostakos: Principle of Anatomy and Physiology, Harper and Row,NewYork
5. Keele and neil: Samson Wright Applied Physiology.
6. A.J. Vander, J.H Sherman and D.C. Lucian: HumanPhysiology

BTBMC303 ANALOG AND DIGITAL CIRCUITS

Credit	Lecture	Tutorial	Practical	CA1	MSE	ESE	Total
4	3	1	4	20	20	60	100

Course Objectives:

1. The purpose of this course is to impart knowledge in the field of Analog & Digital Electronics and its application in the field of Biomedical Engineering.

Course Outcomes:

- To understand the basic analog & digital logic circuits.
- To familiarize the concepts of counters and flip-flops
- To gain knowledge about the memory organization and memory devices
- To understand the concepts of different digital logic families for various applications
- To study the applications of digital systems in the medical field

UNITI 07 Hours

Physical structure and equivalent circuit models (large and small signal) of diode. Zener, photo-diode, Schoktty diode, tunnel diode, power diode. Solar cell, direct band gap materials. Load line, graphical and iterative methods to obtain the current in a circuit that has a linear element like resistor and a non-linear device like diode. Rectifier circuits, Peak detector, voltage doubler, Shunt regulator using zener diodes.

UNITII 07 Hours

Physical structure and large and small signal models of BJT. Hybrid p model with Early effect, Logic Inverter, transistor as a switch, CE amplifier, biasing network, basic current mirror, current steering circuits, improved current mirrors such as Wilson current mirror, Widlar current source, etc.BJT differential pair, CMRR, active loads, Darlington pair, cascade amplifier, BJT based input differential amplifier, intermediate stage and output stages of a typical operational amplifier.

UNITIII 07 Hours

Physical structure and large and small signal models of MOSFETs, biasing, differential amplifier, current mirrors, improved current mirrors using MOSFETs, enhancement load device, body effect, active loads, CMOS Technology, NMOS inverter, NMOS inverter with active load, Design of CMOS inverters.

UNITIV 07 Hours

Number-base conversion, logic gates, fundamental laws of Boolean algebra and their application in simplification of Boolean functions. K-Map , Half adder, Full adder, half subtractor, Full subtractor, Parallel Binary adder, Look Ahead carry adder, Serial adder, BCD adder. Code converter, Magnitude Comparator. Decoder, Encoder, Multiplexer, Demultiplexer. Parity Generator & Checker

UNITV 07 Hours

Flip-Flops & Timing Circuit, S-R Latch; D Latch; J-K flip-Flop; T Flip-Flip, S-R Flip-Flop, D Flip-Flop, Edge-triggered Flip-Flop; Master - Slave Flip-Flop; Direct Preset and Clear Inputs. PIPO, SIPO, PISO, SISO, Bi-Directional Shift Registers; Universal Shift register. Asynchronous Counter, Synchronous Counter, Up Counter, Down Counter, Ring counter, Johnson counter, Twisted Ring Counter, Effect of propagationdelay.

TEXT BOOKS

1. J. Miliman & C. Halkias Integrated electronics. Tata Mc Graw Hill.1991.
2. Albert Paul Malvino, “Electronics Principle”, Tata Mc GrawHill.
3. Bernard & Grob, “Basic Electronics”, Mc GrawHill.
4. Milliman & Gabrel, “Micro Electronics”, Tata Mc GrowHill
5. Fundamentals of Digital Circuits: A. Anand Kumar,PHI
6. Digital Integrated Electronics: H. Taub and D. Schilling:TMH

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BTBMES304Basics of Biomedical Instrumentation

Credit	Lecture	Tutorial	Practical	CA1	MSE	ESE	Total
4	3	1	-	20	20	60	100

Course Objective:

To gain knowledge about the biological instruments and the methods of measurement.

Course Outcomes:

- Learner will be able to get the basic idea of measurements and the errors associated with measurement
- Learner will be able to know about the types of transducers available
- Learner will be able to understand the function of signal generators and analyzers
- Learner will be able to gain knowledge on functioning of the various measuring instruments and display devices in the application of biomedical signal recorders

UNIT I–Transducers **07 Hours**

Classification, Selection, Resistive strain gauge, Gauge factor, Displacement, Capacitance, Inductance, Potentiometric transducers, velocity, photoelectric, photo magnetic and piezoelectric transducers. Temperature measurement, resistance thermometers. thermistors. Thermocouple and digital transducers.

UNIT II –Physiological Signals **07 Hours**

Characteristics of ECG, EMG, EEG, PCG and instrumentation for measuring these signals. Measurement of blood flow by electromagnetic Doppler and plethymorgraphic methods.

UNIT III –Biochemical Transducers & Amplifiers for Biomedical Application **07 Hours**

Working Principles and characteristics of electrode, electrode–electrolyte model, half-cell potential, electrode models, microelectrodes. Patient lead device, diode circuits, diode bridge current limiters, JEET limiter, isolated leads.

UNIT IV – Clinical Laboratory Equipment **07 Hours**

Medical diagnosis with chemical tests, Spectrophotometry and this type of instrument, colorimeter, spectrophotometer, Automated Biochemical Analysis System, Flame photometer, Selective ion electrodes based electrolytes analyzer. Blood gas analyzer Acid –base balance, Blood Ph measurement of blood PCO2, blood PO2, Intra –arterial Blood Gas Analyzers ,Blood cell counters Types of Blood cells, Methods of cell counting, coulter counter, Automatic recognition and differential blood cell counting.

UNIT V – Neonatal Instrument, Respiratory Measurements & Electrical Hazards 07 Hours

Incubator, Principal and techniques of impedance pneumography and pneumomotachography, Apnea monitor, study of mechanical ventilators, Nebulizers & Humdifiers, Anesthesia machine, capnograph. Safety code standards Micro and macro shock and its physiological effects. Leakage currents and protection by use of isolation transformers, equipotential grounding and earth freemonitoring.

TEXT BOOKS

1. Joseph Dubovy: Introduction to Biomedical Electronics. McGraw Hill book Company, I978
2. John G. Webster: Medical Instrumentation Application & Design Haughton Mifflin, Co. Boston. USA, I978
3. Weikowisty Etal: Biomedical Instruments – Theory and Design. Academic press.1976,
4. R.S. Khandpur: Hand Book of Biomedical Instrumentation. Tata McGraw Hill,1975.
5. L.A. Gedders & L.E. Baker: Principles of Applied Medical Instrumentation. John Wiley & Sons. NY. USA.1978

SEMESTER IV

BTBMC401 Biomedical Equipment

Credit	Lecture	Tutorial	Practical	CA1	MSE	ESE	Total
4	3	1	2	20	20	60	100

Course Objective:

To gain knowledge about the measuring instruments and the methods of measurement.

Course Outcomes:

- Learner will be able to get the basic idea of measurements and the errors associated with measurement
- Learner will be able to know about the types of transducersavailable
- Learner will be able to understand the function of signal generators andanalyzers
- Learner will be able to gain knowledge on functioning of the various measuring instruments and display devices in the application of biomedical signalrecorders

Unit I- Defibrillators & concepts ofcoronarycare **07 Hours**

Basics, AC defibrillators, DC defibrillators, capacitance discharge and delay line capacitance discharge, defibrillator waveforms, electrodes used with defibrillators: types and their features, Cardioverters: working, principles. Systems Organization, critical physiological characters to be monitored, and layout and safety precautions

Unit II- Cardiac pacemakers & Heartlung machine **07 Hours**

Pacemaker: Modes of operation (Asynchronous and Synchronous), External and Implantable; Block diagram and circuit diagram of a blocking oscillator asynchronous pacemaker. Implantable pacemakers: Technical and qualitative requirements of power supplies, transcutaneous RF powered Cardiac pacemaker systems, susceptibility of implantable pacemakers to electrical interference and remedial measures, Lead wires and electrodes used with pacemakers. Heart lung machine: Governing principles, qualitative requirements, functional details of bubble, thin film, and membrane type of blood oxygenator

Unit III- Electrosurgical Unit & Electrical Hazardsin hospitals **07 Hours**

Electro-surgical unit: Principles of cutting, coagulation, fulguration; Electrosurgical generators: spark gap & solid state generators, Safety features. Electrical hazards in hospitals: Patient electrical safety, types of hazards, patient isolation, physical effects of current, let go current, Micro shocks, different ways for electrical accident to occur, safety instruction circuits, electrical grounding & effects.

Unit IV – Hemodialysis & Ultrasound **07 Hours**

Hemodialysis: Qualitative requirements, general scheme of operations, types of exchangers, block diagram electronic control & monitoring Systems. Ultrasound: Characteristics of Ultrasound, Ultrasound Transducers, Different Modes of operations, Characteristics of Ultrasound beams, interaction between ultrasound and matter, design and application of real time ultrasound machine, Doppler techniques, Doppler transducer and modes of operation, color Doppler

Unit V- X Rays, Computed Tomography & Magnetic Resonance Imaging **07 Hours**

x-ray: Production Of X-rays, X-rays generators, properties of X-rays, basic interaction between X-ray and matter, X-ray grids, detection of X-ray. Computed tomography: Basic Principle, generations of CT scan machines, data accumulation, data handling system, component of CT scan machine, factors of image quality. magnetic resonance imaging: Principle of MRI, Elementary physics of MRI, Nuclear magnetic resonance, Magnetic field gradient, Bloch equation, Receiver-transmitter and different RF coils for MRI machines

TEXT BOOKS

1. John C. Webster, Medical Instrumentation Leighton, Mifflin Co Boston,USA
2. R. S. Khandpur Handbook of Biomedical Instrumentation, Tata McGraw hill, Pub. Co. Ltd., NewDelhi.
3. Applied Biomedical Instrumentation, La Geddes and L.E.Baker

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BTBMC402 Biomedical signal Processing

Credit	Lecture	Tutorial	Practical	CA1	MSE	ESE	Total
4	3	1	2	20	20	60	100

Course Objectives:

1. To make them understand the fundamentals of signal processing for various bio-signal analysis
2. To impart knowledge about filter characteristics and to design various filters
3. To provide an in-depth knowledge about the basic concepts of wavelet and speech analysis
4. To apply various signal processing techniques in analyzing the various bio-signal
5. To study about the characteristics of non-stationary signals

Course outcomes:

- To learn the fundamental concepts of signal processing
- To apply common signal processing techniques for various biomedical signals.

UNIT I – Fundamentals of Signal System **07 Hours**

Introduction to continuous and discrete time signals and systems; Signals, types of signal, singularity functions, exponential and sinusoidal signal, sinc and signum function, gate signal, manipulation and operation on signals, Energy and power signal, System and types of system, Conversion of analog signal to digital signal, review of Fourier series and Fourier transform.

UNIT II – Introduction and application of Z- Transform &Fourier Transform **07 Hours**

Review of Z-transform, Transfer function, Frequency Response, Convolution, correlation, Power spectral Density, Autocorrelation, DTFT,DFT,FFT, Stationary and Non stationary signal, Time frequency analysis of Biomedical signals, Short term Fourier transform, Wavelet.

UNIT III – Filters & Bio sign analysis **07 Hours**

Elements of Digital filtering, Active and Passive Filters, General Idea of L.P.F, H.P.F, B.P.F and N.F, First order Passive Filters (L.P.F, H.P.F, B.P.F and N.F), IIR and FIR Filters. EEG signal Characteristics and Analysis, ECG signal parameters and their estimation; Arrhythmia analysis monitoring; ECG data reduction techniques.

UNIT IV – Noise analysis of bio signal **07 Hours**

Noise Analysis and Cancellation for Biomedical Application: Source of noise, Types of Noise, Frequency domain temperature, Noise bandwidth, A Review of Weiner filter problem, Noise Analysis and Cancellation Using adaptive Filter, Adaptive Noise Canceller and its application, Signal Averaging.

UNIT V –Random Theory **07 Hours**

Probability & Random Signal theory: set theory, introduction probability, conditional probability& statistical independence, bay's theorem, random variables, discrete random variable, continuous random variables, joint distribution, characteristics of random variables, binomial, Poisson & normal distribution, uniform & other distribution, Probability density Function and Probability Distribution Function, random processes, markov processes.

TEXT BOOKS:

1. Oppenheim, Wilskey and Nawab "Signals and System", Prentice HallIndia.
2. D.C.Reddy, " Biomedical Signal Processing",TMH.
3. Hayken & Van Veen- "Signals andSystem".Willey.
4. Taub & Schilling-" Principles of Communication System" , TataMcGraw-Hill.
5. Kennady & Davis –"Electronics Communication System", Tata McGrawHill.
6. Gayakwad "Op-Amp and Integrated circuits", Prentice HallIndia.

BTHM403 Basic Human Rights

Credit	Lecture	Tutorial	Practical	CA1	MSE	ESE	Total
3	3	-	-	20	20	60	100

Course Objectives:

1) To train the young minds facing the challenges of the pluralistic society and the rising conflicts and tensions in the name of particularistic loyalties to caste, religion, region and culture.
2) To give knowledge of the major "signposts" in the historical development of human rights, the range of contemporary declarations, conventions, and covenants.
3) To enable them to understand the basic concepts of human rights (including also discrimination, equality, etc.), the relationship between individual, group, and national rights.
4) To develop sympathy in their minds for those who are denied rights.
5) To make the students aware of their rights as well as duties to the nation.

Course Outcomes:

- Students will be able to understand the history of human rights.
- Students will learn to respect others caste, religion, region and culture.
- Students will be aware of their rights as Indian citizen.
- Students will be able to understand the importance of groups and communities in the society.
- Students will be able to realize the philosophical and cultural basis and historical perspectives of human rights.

UNIT I:

The Basic Concepts: - Individual, group, civil society, state, equality, justice. Human Values , Human rights and Human Duties: - Origin, Contribution of American bill of rights, French revolution. Declaration of independence, Rights of citizen, Rights of working and exploited people

UNIT II

Fundamental rights and economic programme. Society, religion, culture, and their inter relationship. Impact of social structure on human behavior, Social Structure and Social Problems: - Social and communal conflicts and social harmony, rural poverty, unemployment, bonded labor.

UNIT III

Migrant workers and human rights violations, human rights of mentally and physically challenged. State, Individual liberty, Freedom and democracy. NGOs and human rights in India: - Land, Water, Forest issues.

UNIT IV

Human rights in Indian constitution and law:-
i) The constitution of India: Preamble ii) Fundamental rights. iii) Directive principles of state policy. iv) Fundamental duties. v) Some other provisions.

UNIT V

Universal declaration of human rights and provisions of India. Constitution and law. National human rights commission and state human rights commission.

Reference books:

Shastry, T. S. N., *India and Human rights: Reflections*, Concept Publishing Company India (P Ltd.), 2005
Nirmal, C.J., *Human Rights in India: Historical, Social and Political Perspectives(Law in India)*, Oxford India

PROFESSIONAL ELECTIVE –I

Credit	Lecture	Tutorial	Practical	CA1	MSE	ESE	Total
4	3	1	-	20	20	60	100

BTBMPE404A Biomechanics

Course Objectives

1. To recall the general characteristics, mechanical properties of bone and tissues.
2. To analyze the forces at joints for various static and dynamic human activities; analyze the stresses and strains in biological tissues.

Course Outcomes

A learner will be able to:

- Understand the definition of biomechanics and its classification and design principles.
- Develop a better understanding of how mechanical principles influence human motion during everyday life.

UNIT I – Bio fluid Mechanics **07 Hours**

Newton's law, stress, strain, elasticity, Hooke's law, viscosity, Newtonian fluid, Non- Newtonian fluid, visco elastic fluids, Vascular tree. Relationship between diameters, Velocity and pressure of blood flow, Resistance against flow

UNIT II –Cardiac Mechanics **07 Hours**

Cardiovascular system, Mechanical properties of blood vessels: arteries, arterioles, capillaries, and veins. Prosthetic heart valves and replacements.

UNIT III -Respiratory Mechanics **07 Hours**

Alveoli mechanics, Interaction of blood and lung, P-V curve of lung. Breathing mechanism, Airway resistance, Physics of lung diseases.

UNIT IV – Soft tissue Mechanics **07 Hours**

Pseudo elasticity, non-linear stress-strain relationship, viscoelasticity. Structure function and mechanical properties of skin, ligaments and tendons.

UNIT V -Orthopedic Mechanics **07 Hours**

Mechanical properties of cartilage. Diffusion properties of articular cartilage. Mechanical properties of bone. Kinetics and Kinematics of joints. Lubrication ofjoints.

TEXT BOOKS

1. Biomechanics: Y CFung
2. Basic Biomechanics: Susan B. Hall, Tata McGrawHill.
3. Fundamentals of Biomechanics: Duane Knudson,Springer.
4. Biomechanics: Principles & Applications, Donald R. Peterson & Joseph D. Bronzino, CRCPress.
5. Physics of Coronary Blood Flow: M. Zamir,Springer.

BTBMPE404B Network Analysis

Course Objectives:

1. To learn about the basic laws of electric circuits as well as the key fundamentals of the communication channels, namely transmission lines.
2. To understand the need of simplification techniques of complicated circuits
3. To learn about the comprehensive insight into the principle techniques available for characterizing circuits, networks and their implementation in practice.
4. To learn about the use of mathematics, need of different transforms and usefulness of differential equations for analysis of networks.
5. To train the students for handling analog filter design through theory of NA along with practical, this is basic requirement of signal processing field.

Course Outcomes:

On completion of the course, students will be able to:

- Apply knowledge of mathematics to solve numerical based on network simplification and it will be used to analyze the same.
- Design passive filters and attenuators theoretically and practically. To apply knowledge for design of active filters as well as digital filters and even extend this to advance adaptive filters.
- Identify issues related to transmission of signals, analyze different RLC networks.
- Find technology recognition for the benefit of the society.

UNIT I - Network Topology & Review of loop and mode 07 Hours

Graph of a network. Concept of tree and links. Incidence matrix, Tie set & cut set schedules, solution of network, and principles of duality & network transformation. Linearly independent KVL & KCL equation. Method of analysis of DC and AC networks. Network reduction using Y-A transformations. Coupled circuits. Locus Diagram.

UNIT II- Networks theorems &Resonant circuits 07 Hours

Reciprocity, Thevenin's, Norton's Maximum power transformation, Tellegen's and Miller's theorem. Series and parallel resonance, Frequency - response of series and parallel circuits, Q-factor, Bandwidth.

UNIT III - Transient Behavior and initial conditions in networks 07 Hours

Behavior of circuit element under switching condition and their representation. Evaluation of initial and final conditions in RL, RC & RLC circuits for AC & DC excitation

UNIT IV - Transient Behavior and initial conditions in networks 07 Hours

L.T. for Fourier transformation Definition & Properties of Laplace Transformation. Inverse Laplace transform. Partial fraction expansion, initial & final value theorem. Shifting theorem. Convolution Integral. Step, Ramp and Impulse functions. Delayed functions. Laplace transform of Periodic and non-periodic signals.

UNIT V - One & two port network parameters 07 Hours

Driving point admittance & transfer function. Pole- zero concepts of the network function. Open circuit impedance parameters, Short circuit impedance parameters, Transmission parameters, H-parameters. Calculation of these parameters for two port networks.

TEXT BOOKS:

1. Network Analysis, M.E. Van ValkenburgPill.
2. Network Analysis and synthesis – Fraklin F.Kuo.
3. Electric circuits: Joseph Edminister Schaum's series. Mc GrawHill.
4. R.P. Punagin : Electrical circuit theory andAnalysis.

BTBMPE404C Principal of Communication System

Course Objectives:

To impart knowledge about transmission of analog and digital information using various modulation techniques and methods of enabling secured communication.

Course Outcomes:

- Learner will be able to understand the different types of AM Communication systems
- Learner will be able to study in detail about the different types of FM Communication systems
- Learner will be able to familiarize about the base band data Communication systems
- Learner will be able to gain knowledge about the different digital communication techniques
- Learner will be able to know the spread spectrum modulation techniques and error control coding techniques

Unit I: Amplitude modulation **07 Hours**

Amplitude modulation systems: suppressed carrier system (DSB-SC), signals side band modulation (SSB), vestigial sideband modulation (VSM), amplitude modulation with large Carrier (AM), QAM, Generation of AM waves, de-modulation of AM waves, Frequency division multiplexing, AM Transmitters &Receivers.

Unit II: Angle modulation **07 Hours**

Frequency Modulation (FM) & Phase Modulation (PM), Relation between FM & PM, Spectrum of FM, Narrow band FM, Wideband FM, Phasor diagram of AM & FM, FM generation & demodulation, FM transmitters & Receivers, Pre-emphasis &De-emphasis.

Unit III: pulse modulation **07 Hours**

Sampling, Sampling theorem, Natural Sampling, Flat top sampling ,PAM, PWM, PPM, Quantization, PCM, DPCM, Delta modulation, Delta sigma modulation, Adaptive delta modulation, Time division multiplexing.

Unit IV: Digital modulation techniques **07 Hours**

ASK, BPSK, BFSK, DEPSK, DPSK, QPSK, QASK, MSK, M-ary FSK, M-ary PSK, Probability of error for ASK, BPSK, BFSK.

Unit V:Information theory &coding **07 Hours**

Information, Entropy, Information rate, Mutual Information, Channel capacity, Types of channels, Joint Entropy, Shannon theorem of channel capacity, Shannon's Hartley Theorem, Linear block codes, Cyclic codes, Shannon Fano & Huffman coding, Convolution codes.

TEXT BOOKS:

1. Taub& Schilling, Principle of Communication System, 2nd Ed., Tata McGraw-Hill.
2. Carlon, Communication System, 4th Ed. Tata McGraw-Hill.
3. Kennedy & Davis, Electronics Communication System, 4th Ed. Tata McGraw-Hill.
4. B.P. Lathi, Morden and analog Communication System, 3rd Ed. Oxford University Press

OPEN ELECTIVE –I (OPEN)

Credit	Lecture	Tutorial	Practical	CA1	MSE	ESE	Total
4	3	1	-	20	20	60	100

BTBMOE405 A MEDICAL RADIATION SAFETY ENGINEERING

Course Objectives:

To impart sufficient information on the various precautionary and safety measures for radiation protection in medicine.

Course Outcomes:

- To provide an insight to the basics of radiation physics.
- To enable them understand the guidelines of radiation protection and radiation detectors.
- To provide information on safety measures related to UV, laser and nuclear medicine

UNIT I - INTRODUCTION TO RF ANDMICROWAVERADIATION 07 Hours

Sources of radio frequency radiation- Effects of radio frequency radiation Development of standards for human safety- Calculation of RF field quantities- RF radiation measuring instruments and methods.

UNIT II - RADIATION DETECTIONANDMEASUREMENT 07 Hours

Fundamentals of radiation detection- Conducting radiation measurements and surveys- Gas detectors- Designing to reduce radiation hazards- Radio frequency radiation safety management and training-Scintillation detectors- Statistics of counting- minimum detectable activity- Quality assurance of radiation counters.

UNIT III - RADIATION SAFETY IN NUCLEAR MEDICINE AND RADIOTHERAPY

Design and description of NM department- Radiation protection in nuclear industry- Guidelines for radiation protection- Molecular medicine and radiation safety program-procedures for safe operation of radiation equipment- Radiation protection in external beam radiotherapy- Radiation protection in brachytherapy Radioactive wastes.

UNIT IV - LASER AND ULTRAVIOLETRADIATIONSAFETY 07 Hours

Classification of UV radiation -Sources of UV- Biological effects of UV- Hazards associated with UV radiation- UV control measures - Safety management of UV- Classifications of LASER and its radiation hazards- control measures Emergencies and incident procedures.

UNIT V - MONITORING ANDINTERNALDOSIMETRY **07 Hours**

Monitoring methods-personal radiation monitoring- Records of personal dosimetry- ICRP method- MIRD method- Internal doses from radiopharmaceuticals- Bioassay of radioactivity- Hazard and risk in radiation protection- radiological incidents and emergencies- Regulation to radiation protection.

TEXTBOOKS/ REFERENCES

1. Jamie V, Trapp, Thomas Kron, "An introduction to radiation protection in medicine", crc press Taylor &Francis group,2008.
2. Alan Martin, Samuel Harbison, Karen Beach, Peter Cole, Hodder Arnold, "An Introduction to radiation protection", 6th edition 2012.
3. Max Hlombardi, "Radiation safety in nuclear medicine", CRC Press Taylor & Francis group, 2nd edition,2007.
4. Aruna Kaushik, Anupam mondal, Dwarakanath B.S, Tripathi R P, "Radiation protection manual", INMAS, DRDO,2010.
5. Ronald kitchen, "RF and microwave radiation safety", Newness publishers, 2nd edition,2001.

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BTBMOE405B QUALITY CONTROL AND REGULATORY ASPECTS IN MEDICALDEVICES

COURSE OBJECTIVES:

The course is designed to make the student better understanding of Quality standards and management methodologies in Biomedical Engineering.

COURSE OUTCOMES:

- To understand the various quality standards & regulations used for healthcare
- To get an overview of various methodologies used for management in healthcare

UNIT I - FUNDAMENTALS OFQUALITYMANAGEMENT 07 Hours

Definition of Quality, Dimensions of Quality, Quality Planning - Quality costs. Analysis Techniques of quality Cost - Basic concepts of Total Quality Management, Historical Review. - Principles of TQM, Leadership – Concepts, Role of Senior Management - Quality Council, Quality Statements – Strategic Planning - Deming Philosophy - Barriers to TQM Implementation

UNIT II - QUALITYMANAGEMENT PRINCIPLES 07 Hours

Customer satisfaction – Customer Perception of Quality - Customer Complaints, Service Quality, Customer Retention - Employee Involvement – Motivation, Empowerment - Teams and Team Work - Recognition and Reward, Performance Appraisal, Benefits - Continuous Process Improvement – Juran Trilogy – PDSA Cycle, 5S, Kaizen - Supplier Partnership – Partnering, sourcing, Supplier, Selection, Supplier Rating, Relationship Development - Performance Measures – Basic Concepts, Strategy, Performance Measure

UNIT III - STATISTICALPROCESSCONTROL 07 Hours

Seven Tools of Quality: I, II, and III - Concept of Six Sigma: I and II - New Seven Management tools: I and II - Statistical Fundamentals – Measures of central Tendency and Dispersion, Population and Sample - Normal Curve, Control Charts for variables and attributes, Process capability

UNIT IV -TQMTOOLS 07 Hours

Benchmarking – Reasons to Benchmark - Benchmarking Process – Quality Function Deployment (QFD) – House of Quality - QFD Process - Benefits Taguchi Quality, Loss Function - Total Productive Maintenance (TPM) – Concept, Improvement Needs - FMEA – Stages of FMEA

UNIT V - REGULATORY ORGANIZATIONSINMEDICINE **07 Hours**

Need for ISO 9000 and Other Quality Systems - ISO 9000:2000 Quality System – Elements, Implementation of Quality System - Quality Auditing - Need for Accreditation of hospitals - FDA Regulations- Joint Commission – Regulatory Bodies of India-Medical Council of India - Pharmacy Council Of India, Indian Nursing Council - Dental Council of India, Homeopathy Central Council

TEXTBOOKS/ REFERENCES

1. Rose J.E, “Total Quality Management”, Kogan Page Ltd.,1993.
2. Cesar A. Cacere & Albert Zana, ”The Practise of clinical Engineering”, Academic Press, Newyork,1997.
3. John Bank, "The Essence of Total Quality Management", Prentice Hall of India,1993.
4. Webster J G, and Albert Cook M, “Clinical Engineering, Principles & Practices”, Prentice Hall Inc., Engle wood cliffs, New Jersey,1979.

BTBMOE405B QUALITY CONTROL AND REGULATORY ASPECTS IN MEDICALDEVICES

COURSE OBJECTIVES:

The course is designed to make the student better understanding of Quality standards and management methodologies in Biomedical Engineering.

COURSE OUTCOMES:

- To understand the various quality standards & regulations used for healthcare
- To get an overview of various methodologies used for management in healthcare

UNIT I - FUNDAMENTALS OFQUALITYMANAGEMENT 07 Hours

Definition of Quality, Dimensions of Quality, Quality Planning - Quality costs. Analysis Techniques of quality Cost - Basic concepts of Total Quality Management, Historical Review. - Principles of TQM, Leadership – Concepts, Role of Senior Management - Quality Council, Quality Statements – Strategic Planning - Deming Philosophy - Barriers to TQM Implementation

UNIT II - QUALITYMANAGEMENT PRINCIPLES 07 Hours

Customer satisfaction – Customer Perception of Quality - Customer Complaints, Service Quality, Customer Retention - Employee Involvement – Motivation, Empowerment - Teams and Team Work - Recognition and Reward, Performance Appraisal, Benefits - Continuous Process Improvement – Juran Trilogy – PDSA Cycle, 5S, Kaizen - Supplier Partnership – Partnering, sourcing, Supplier, Selection, Supplier Rating, Relationship Development - Performance Measures – Basic Concepts, Strategy, Performance Measure

UNIT III - STATISTICALPROCESSCONTROL 07 Hours

Seven Tools of Quality: I, II, and III - Concept of Six Sigma: I and II - New Seven Management tools: I and II - Statistical Fundamentals – Measures of central Tendency and Dispersion, Population and Sample - Normal Curve, Control Charts for variables and attributes, Process capability

UNIT IV -TQMTOOLS 07 Hours

Benchmarking – Reasons to Benchmark - Benchmarking Process – Quality Function Deployment (QFD) – House of Quality - QFD Process - Benefits Taguchi Quality, Loss Function - Total Productive Maintenance (TPM) – Concept, Improvement Needs - FMEA – Stages of FMEA

UNIT V - REGULATORY ORGANIZATIONSINMEDICINE **07 Hours**

Need for ISO 9000 and Other Quality Systems - ISO 9000:2000 Quality System – Elements, Implementation of Quality System - Quality Auditing - Need for Accreditation of hospitals - FDA Regulations- Joint Commission – Regulatory Bodies of India-Medical Council of India - Pharmacy Council Of India, Indian Nursing Council - Dental Council of India, Homeopathy Central Council

TEXTBOOKS/ REFERENCES

5. Rose J.E, “Total Quality Management”, Kogan Page Ltd.,1993.
6. Cesar A. Cacere & Albert Zana, ”The Practise of clinical Engineering”, Academic Press, Newyork,1997.
7. John Bank, "The Essence of Total Quality Management", Prentice Hall of India,1993.
8. Webster J G, and Albert Cook M, “Clinical Engineering, Principles & Practices”, Prentice Hall Inc., Engle wood cliffs, New Jersey,1979.

SEMESTER V

BTBMC501 Medical Image Processing

Credit	Lecture	Tutorial	Practical	CA1	MSE	ESE	Total
4	3	1	2	20	20	60	100

COURSE OBJECTIVES:

1. To learn the image fundamentals and mathematical transforms necessary for image processing
2. To study the various image enhancement techniques
3. To apply various image restoration procedures in Medical images.
4. To gain knowledge about the basic concepts of image compression procedures.
5. To study about the various segmentation techniques applied to Medical Images.

COURSE OUTCOMES:

- Learner will be able to learn the fundamental concepts of medical image acquisition
- Learner will be able to understand how to apply the image processing techniques for various medical images.

Unit I: Introduction &fundamentals **07 Hours**

Origin of DIP, examples of fields that use DIP, fundamentals of DIP, components of an DIP system, Digital image representation, Image characteristics & quality, Image viewing conditions, Elements of visual perception, light and the EM spectrum, a simple image formation model, image sampling and quantization, some basic relationships between pixels.

Unit II: Image enhancement in spatial domain & frequency domain **07 Hours**

Image Enhancement in Spatial Domain: Background, some basic gray level transformations, Histogram processing, enhancement using arithmetic and logic operations, basic of spatial filtering, smoothing spatial filters, sharpening spatial filters. Image Enhancement in the Frequency Domain: Background, Introduction to FT and frequency domain, smoothing frequency domain filters, sharpening frequency domain filters, homomorphism filtering, additional properties of the 2-DFT, convolution and correlation theorems.

Unit III: Image compression **07 Hours**

Fundamentals, image compression models, elements of information theory, error free

Compression, run length coding, loss less predictive coding, lossy predictive coding, image compression standards, JPEG, video compression standards.

Unit IV:Imagesegmentation **07 Hours**

Detection of discontinuities, point detection, line detection, edge detection, gradient operators, edge linking and boundary detection, thresholding, region based segmentation.

Unit V: Image representation, description &recognition **07 Hours**

Representation, Boundary descriptors, Regional descriptors, Principal component analysis, Recognition based on decision theoretic & structural methods.

TEXT BOOKS

1. Digital Image Processing by Rafael .C .Gonzalez and Richard.E.
2. Digital Image Processing – by William K. Pratt 3rd Edition John Wiley and SonsInc.
3. P. Suetens, Fundamentals of image processing, Cambridge University Press,2002.
4. R. C. Gonzalez, R. E. Woods, S. L. Eddins , Digital Image Processing Using MATLAB(R) ,Course Technology, 1 edition,2004
5. A. K Jain, Fundamentals of image processing, prentice hall, Eagle cliffs, New Jersey, 1989
6. Chanda & Majumdar, Digital image processing and analysis, PHI,2003

BTBMC502 Microprocessor and Microcontroller Based Biomedical Instrumentation

Credit	Lecture	Tutorial	Practical	CA1	MSE	ESE	Total
4	3	1	2	20	20	60	100

Course Objectives:

1. To understand the functioning of different microprocessors and microcontrollers and to use microprocessor for various applications in biomedicalinstrumentation

Course outcomes:

- Learner will be able to study the concept of basic microprocessor8085
- Learner will be able to study the concept of microprocessor8086
- Learner will be able to get knowledge about various interfacingdevices
- Learner will be able to interface device with theprocessors
- Learner will be able to study the concept ofmicrocontroller.

UNIT I-MICROPROCESSOR-8085 **07 Hours**

Evolution & Importance of microprocessor, Microprocessor-8085: Introduction, feature, architecture, pin diagram, addressing mode, instruction set, timing diagram, interrupt- Programming exercise

UNIT II -MICROPROCESSOR-8086 **07 Hours**

Microprocessor-8086: Introduction, comparison with microprocessor-8085, feature, architecture, pin diagram, addressing mode, instruction set, minimum- and maximum- mode, assembler directives and operators, interrupts- Programming exercise

UNIT III -PERIPHERALDEVICES **07 Hours**

Interfacing: Memory- and I/O- interfacing- Programmable Peripheral Interface (PPI)-8255: Pin diagram, block diagram, and operating modes- Programmable Communication Interface (PCI)-8251 USART: Pin diagram, block diagram, and command word- Programmable Interrupt Controller (PIC)-8259A: Pin diagram, block diagram, interrupt sequence, and cascading- Keyboard/Display Controller- 8279: Pin diagram, block diagram, operating modes- DMA Controller-8237: Pin diagram, and blockdiagram

UNIT IV-MICROCONTROLLER-8051 **07 Hours**

Introduction to 8 bit microcontroller, bus configuration, reset circuitry – power down considerations, architecture of 8031/8051, Signal descriptions of 8051, Register set of 8051, Memory- and I/O Interfacing: Interrupts, instruction set, and addressing mode- Simple Programs

UNIT V - APPLICATIONSIN MEDICINE **07Hours**

Mobile phone based bio signal recording, microprocessor based vision architecture for integrated diagnostic helping devices, and Microprocessor based remote health monitoring system: Concept and systems, and system operation.

TEXTBOOKS

1. Ramesh S Gaonkar, "Microprocessor architecture, programming and its application with 8085", Penram Int. Pub. (India), Fifth edition,2002.

2. Roy A, Bhurchandi K K.M, "Intel Microprocessors Architecture, Programming and Interfacing", McGraw Hill International Second Edition2006.

REFERENCES

1. Muhammad Ali Mazidi and Janica Gilli Mazidi, "The 8051 microcontroller and embedded systems", Pearson Education, Fifth edition,2003.

2. Rafiquzzaman M, "Microprocessors - Theory and Applications" Intel and Motorola, Prentice Hall of India Pvt. Ltd, Second edition,2001.

3. Douglas V Hall, "Microprocessors and Interfacing programming and hardware", Tata McGraw Hill, Fourth Edition,2003.

PROFESSIONAL ELECTIVE-II

Credit	Lecture	Tutorial	Practical	CA1	MSE	ESE	Total
4	3	1	-	20	20	60	100

BTBMPE503A Artificial Intelligence & Neural Networks

COURSE OBJECTIVES:

1. To understand the basic concepts of Artificial intelligence and Neural Network
2. To understand the concepts of knowledge representation in AI
3. To give an insight knowledge about the different types of classification techniques
4. To study about the application of AI in medical field

COURSE OUTCOMES:

- To enable the students to acquire knowledge about the artificial intelligence techniques and its application in medicine

UNIT-I **07 Hours**

Introduction to Artificial Intelligence: Definition of A.I. Applications of A.I. Representation. Properties of internal Representation, General problem solving, production system, control strategies: forward and backward chaining.

UNIT-II **07 Hours**

Heuristic search techniques. Depth First Search, Breadth First Search, Best first search, mean and end analysis, A* and AO* Algorithm.

UNIT-III **07 Hours**

Knowledge representation using predicate logic: predicate calculus, Predicate and arguments, resolution and unification Semantic, Frame System, Scripts, conceptualDependency.

UNIT-IV **07 Hours**

Knowledge representation using non-monotonic logic: TMS (Truth maintenance system), statistical and probabilistic reasoning, fuzzy logic, structure knowledge representation.

UNIT-V **07 Hours**

Introduction to Artificial Neural Network, supervised and unsupervised learning, pattern recognition problems, perception, Back propagation network, Application of neural network.

TEXT BOOKS

1. Eugene, Charniak, Drew Mcdermott: Introduction to artificialintelligence.
2. Elaine Rich and Kerin Knight: ArtificialIntelligence.
3. Kishen Mehrotra, Sanjay Rawika, K Mohan; Artificial NeuralNetwork..

BTBMPE503B Rehabilitation Engineering

COURSE OBJECTIVES:

To learn the basic concepts of rehabilitation engineering and assist devices and to understand the importance of biomedical engineering in rehabilitation.

COURSE OUTCOMES:

- Learner will be able to study basics of Rehabilitation Engineering
- Learner will be able to learn the design of Wheelchairs
- Learner will be able to gain knowledge of the recent developments in the field of rehabilitation engineering.
- Learner will be able to understand various assistive technology for vision &hearing Learner will be able to study various orthotic & prosthetic devices

UNIT-I: ENGINEERING CONCEPTS IN REHABILITATION ENGINEERING, ANTHROPOMETRY 07Hours

Methods for Static and dynamic Measurements: Area Measurements, Measurement of characteristics and movement, Measurement of Muscular Strength and capabilities. Measurement tools and processes in Rehabilitation engineering: fundamental principles, structure, function; performance and behavior. Subjective and objective measurement methods.

UNIT-II: ERGONOMIC ASPECTS INDESIGNATINGDEVICES: 07 Hours
Introduction to Models in Process Control, Design of Information Devices, Traditional Devices, V.D.U' s, Using color, Design of Controls

UNIT-III: ENGINEERING CONCEPTS IN SENSORY REHABILITATION ENGINEERING. SENSORY AUGMEN- TATION AND SUBSTITUTION: 07Hours
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, Tactual substitution,

UNIT-IV: ORTHOPEDIC PROSTHETICS AND ORTHOTICS IN REHABILITATION:
Engineering concepts in motor rehabilitation, applications. Computer Aided Engineering in Customized Component Design. Intelligent prosthetic knee. A hierarchically controlled prosthetic

hand. A self-aligning orthotic knee joint. externally powered and controlled Orthotics and Prosthetics. FES systems-Restoration of hand function, restoration of standing and walking, Hybrid Assistive Systems (HAS).

UNIT-V: COMPUTER APPLICATIONS IN REHABILITATION ENGINEERING:
Interfaces in compensation for visual perception. Improvement of orientation and mobility, Computer assisted lip reading, Brain computer interface.

TEXT BOOKS

1. Bronzino, Joseph; Handbook of biomedical engineering. 2nd edition, CRC Press,2000.

REFERENCE BOOKS

1. Horia- Nocholai Teodorecu, L.C.Jain , intelligent systems and technologies in rehabilitation engineering; CRC; December2000.
2. Robinson C.J Rehabilitation engineering. CRC press1995
3. Etienne Grandjean, Harold Oldroyd, Fitting the task to the man, Taylor & Francis, 1988
4. Principles of deadlock – deadlock prevention, detection and avoidance dining philosophers problem – example Systems.

BTBMPE503C Embedded & Real TimeSystem

COURSE OBJECTIVES:

To enable the students to acquire knowledge about the principles & application of embedded systems.

COURSE OUTCOMES:

- Learner will be able to understand the working principle of embeddedsystems.
- Learner will be able to understand the conceptsRTOS.
- Learner will be able to understand the designtechnologies.

UNIT-I:EMBEDDEDSYSTEMS: 07 Hours
Overview, design challenge, processor technology, IC technology, Design Technology, Trade-offs. Single purpose processors RT-level combinational logic, sequential logic (RT-level), custom single purpose processor design (RT-level), optimizing custom single purpose processors.

UNIT-II: GENERALPURPOSEPROCESSORS: **07 Hours**
Basic architecture, operation, Pipelining, Programmer's view, development environment, Application Specific Instruction-Set Processors (ASIPs) – Micro Controllers and Digital Signal Processors.

UNIT-III: STATE MACHINE AND CONCURRENTPROCESSMODELS: 07 Hours
Introduction, models Vs. languages, finite state machines with data path model (FSMD), using state machines, program state machine model (PSM), concurrent Process model, concurrent processes, communication among processes, synchronization among processes, implementation, data flow model, real-time systems. COMMUNICATION INTERFACE: Need for communication interfaces, RS232 / UART, RS422 / RS485, USB, Infrared, IEEE 1394 Firmware, Ethernet, IEEE 802.11,Bluetooth.

UNIT-IV: EMBEDDED / RTOS CONCEPTS–I: 07 Hours
Architecture of the Kernel, Tasks and Task scheduler, Interrupt service routines, Semaphores, Mutex. EMBEDDED / RTOS CONCEPTS – II: Timers, Memory Management, Priority inversion problem, Embedded operating systems Embedded Linux, Real-time operating systems, RT Linux, Handheld operating systems, WindowsCE.

UNIT-V:DESIGNTECHNOLOGY: 07 Hours
Introduction, Automation, Synthesis, Parallel evolution of compilation and synthesis, Logic Synthesis, RT synthesis, Behavioral Synthesis, Systems Synthesis and Hardware/ Software Co-Design, Verification, Hardware/Software co-simulation, Reuse of intellectual property codes.

TEXT BOOKS

1. Embedded System Design – A Unified Hardware/Software Introduction – Frank Vahid, Tony D. Givargis, John Wiley,2002.
2. Embedded / Real Time Systems – KVKK Prasad, Dreamtech Press,2005.

REFERENCE BOOKS

1. Embedded Microcomputer Systems – Jonathan W. Valvano, Brooks / Cole, ThompsonLearning.
2. An Embedded Software Primer – David E. Simon, Pearson Ed.,2005.
3. Introduction to Embedded Systems – Raj Kamal, TMS,2002.

OPEN ELECTIVE-II

Credit	Lecture	Tutorial	Practical	CA1	MSE	ESE	Total
4	3	1	-	20	20	60	100

BTBMOE504A Applied Optoelectronics in Medicine

COURSE OBJECTIVES:

1. To know the basics of solid state physics and understand the nature and characteristics of light
2. To understand different light modulation techniques and the concepts and ' applications of optical switching
3. To study the integration process and application of opto- electronic ' integrated circuits in transmitters and receivers

COURSE OUTCOMES:

- To get familiar with the different types of optical emission, detection, modulation and opto-electronic integrated circuits and their applications

UNIT I - LIGHT SOURCES ANDDISPLAY DEVICES 07Hours

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Photo Luminescence, Cathode Luminescence, Electro Luminescence, Injection Luminescence, LED, Laser Emission, Absorption, Population Inversion, Threshold condition, Optical Feedback, Laser Modes, Classes of Lasers, Pulsed Lasers, Plasma Display, Liquid Crystal Displays, NumericDisplays'

UNIT II - OPTO-ELECTRONICDETECTIONMETHODS 07 Hours

Basic principles of opto-electronic detection, Types of Photodiodes, Thermal detector, Photo Devices, Photo conductors, Photo detectors, Detector performance, Noiseconsiderations

UNIT III -OPTOELECTRONIC MODULATOR 07 Hours

Basic principles, Analog and digital modulation, Electro-optic modulators, Magneto optic devices, Acousto-optic devices, Optical switching, Logic devices-opticalswitching,

UNIT IV - OPTICAL AMPLIFIER & OPTOELECTRONIC INTEGRATED CIRCUITS

Semiconductor optical amplifier, Erbium doped fiber amplifier, Fiber Raman Receivers, Guided wave devices, Principles of optical biosensors, Application of opto-electronic integrated circuits

UNIT V - APPLICATIONS OF OPTOELECTRONIC DEVICES **07 Hours**

Cardiovascular and intensive care sensors, FBG for strain and temperature measurement.

TEXTBOOKS

1. Wilson J and Hawkes J.F.B, *"Opto Electronics - An Introduction"*, second edition, Prentice Hall of India Pvt. Ltd., New Delhi,1998.
2. Safa O Kasap, *Optoelectronics and Photonics: Principles and practices*, firstt edition, PHI,2009.

REFERENCES

1. John G, Webster, "Medical Instrumentation application and design", JohnWiley, 3rd Edition,1997.
2. Carr Joseph J, Brown, John M, "Introduction to Biomedical equipment technology", John Wiley and sons, New York, 4th Edition,1997.

BTBMOE504B Biomedical MEMS

COURSE OBJECTIVES:

1. To enable the students to acquire knowledge about the principles & application of Bio MEMS.

COURSE OUTCOMES:

- Learner will be able to understand the working principle ofMEMS.
- Learner will be able to understand the CMOS MEMSTechnology.
- Learner will be able to understand the concepts of Bio MEMS & its application inhealthcare.

UNIT-I:INTRODUCTION: 07 Hours

History of MEMS, market for MEMS, overview of MEMS processes properties of silicon, a sample MEMS process. BASICS OF MICRO TECHNOLOGY: Definitions and terminology, a sample process, lithography and etching. MEMS BIOSENSORS: Bio Flow Sensors, MEMS Images. Introduction to MEMS Pro design software.

UNIT-II:MICROMACHINING: 07 Hours

Subtractive processes (wet and dry etching), additive processes (evaporation, sputtering, epitaxial growth). FUNDAMENTAL DEVICES AND PROCESSES: Basic mechanics and electrostatics for MEMS, parallel plate actuators, pull-in point, comb drives.

UNIT-III: FUNDAMENTAL DEVICESANDPROCESSES: 07Hours

More electrostatic actuators; MEMS foundries, Cronos MUMPs (multi user MEMS process). MUMPS MULTI USER MEMS PROCESS: JDS Uniphase MUMPs processing sequence and design rules. MUMPS AND SUMMIT**:** Design rules; applications; micro hinges and deployment Actuators

UNIT-IV:CMOSMEMS: 07 Hours

CMOS foundry processes, integrated IC/MEMS, MEMS post processing, applications. Clean room lab techniques: clean rooms, gowning procedures; safety, fire, toxicity; acids and bases; photolithography.

UNIT-V: MEMS PACKAGINGAND ASSEMBLY: 07 Hours

Micro-assembly: serial and parallel, deterministic and stochastic; micro-grippers: HexSil process; packaging techniques. FUTURE OF MEMS: Bio MEMS - neural implants, gene chips, diagnostic chips; MEMS in space; mechanical computers; invisible and ubiquitouscomputing.

TEXT BOOKS

1. HSU, TAI RAN, MEMS AND MICROSYSTEMS Design And Manufacture, Tata McGraw-Hill, 2002.
2. Rai-Choudhury, Prosenjit; Mems and Moems Technology and Applications SPIE2000.

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SEMESTER VI

BTBMC601 Biomedical Control Systems

Credit	Lecture	Tutorial	Practical	CA1	MSE	ESE	Total
4	3	1	2	20	20	60	100

COURSE OBJECTIVES:

1. To understand the system concepts and different mathematical modeling techniques applied in analyzing any given system.
2. To analyze the given system in time domain and frequency domain.
3. To study the techniques of plotting the responses in both domain analyses using various plots.
4. To learn the concepts of physiological modeling
5. To apply these analysis to understand the biological systems

COURSE OUTCOMES:

- To gain basic knowledge about the concepts of control systems and study its application in physiological modeling.

Unit I-Introduction to control systems &Mathematical modeling of control system

Introduction to control system: Open loop and closed loop system and illustrations. Mathematical modeling of control system: Block diagram representation of control system; Transfer function, Block reduction techniques and Signal flow graphs. State space Analysis; AC-DC servo motors, characteristics of feedback and feed forward back control system.

Unit II-Stability & Time domain analysis 07 Hours

Stability: Concept of stability, Necessary conditions for stability, Pole-zero locations in S-plane For stability study ; Routh and Routh Herwitz stability criteria. Time domain analysis: Use of standard test signals for time response study; Time response 2ndorder system. Performance specification steady state error constants. Root locus technique concept and construction of root locus and driving stability information.

Unit III-Introduction to physiological control system & Human thermal systems 07 Hours

Introduction to physiological control system: Physiological system differential equations, Modeling the body as compartments, behavior in simple compartmental system, pharmacy kinetic model, urea distribution model, basics of zero order and first order chemical kinetic behavior. Human thermal systems: Heat production. Loss of heat to environment. Heat transfer within the body. Thermo regulation.

Unit IV-Frequencydomainanalysis **07 Hours**

Frequency domain analysis: Closed loop frequency response performance specifications; frequency response curve; Relation between time and frequency domain specification. Polar plot; Bode plots-gain margin and phase margin for stability determination. Derivation of transfer function form Bode plots. Nyquist stability Criterion-Stability and relative stability study lines using Nyquist plots.

Unit V-Respiratory models&System **07 Hours**

Respiratory models & System, Cardiovascular control system. Skeletal muscles servo mechanism Biologicalreceptors.

TEXT BOOKS

1. The Applications of control theory of physiological system. Howard T. MilhornSounders1966
2. Automatic control systems, Benjamin C.KUO, Prentice Hall, India 46th Ed.1985.
3. Biological Control systems, analysis John. H. Milsun, McGraw Hill1966.
4. Bio-Medical Engg. Principles. David Ocooney. Marcel Dekken INC. New York andBasel.

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BTBMC602 Microelectronics and integrated circuits

Credit	Lecture	Tutorial	Practical	CA1	MSE	ESE	Total
4	3	1	4	20	20	60	100

COURSE OBJECTIVES:

1. To understand characteristics of IC and Op-Amp and identify the internal structure.
2. To introduce DC Amplifier.
3. To study various op-amp parameters and their significance for Op-Amp.
4. To analyze and identify linear and nonlinear applications of Op-Amp.
5. To understand functionalities of filters.

COURSE OUTCOMES:

On completion of the course, students will be able to:

- Understand the characteristics of IC and Op-Amp and identify the internal structure.
- Understand and identify DC Amplifier
- Derive and determine various performances based parameters and their significance for Op-Amp.
- Analyze and identify linear and nonlinear applications of Op-Amp.
- Understand and verify results (levels of V & I) with hardware implementation.
- Understand and apply the functionalities of filters.

Unit I: Introduction to microelectronics **07 Hours**

Monolithic and hybrid integrated circuits - Bipolar and MOS Technology- Fabrication of active and passive components, bonding packaging. Concept of SSI, LSI, VLSI.

Unit II: Thin film & thick film technologies &differential amplifiers **07 Hours**

Introduction to thick film and thin film technologies, resistors & capacitors, comparison- Optical integrated circuits. Differential Amplifiers: DC Amplifier- problems with straight DC amplifier- difference amplifier. Common mode and difference mode operation- CMRR- merits and demerits- use of constant current source, drift and offset problems - current mirror and its use.

Unit III: Introduction to operational amplifiers **07 Hours** Linear Circuits using Op Amps &Non Ideal effects of Op-Amp: Internal structure & block diagram. Characteristics of idea lop-amps. Inverting amplifier, non-inverting amplifier, instrumentation amplifier, adder, subtractor, log and antilog amplifier, integrator, differentiator, peak detector, precision rectifier. Offset, drift, finite gain, finite gain bandwidth products, finite CMRR , finite Ri, non-zero Ro, slew rate, effect of finite gain or inverting and non-inverting amplifiers, offset compensation, frequencycompensation.

Unit IV: Nonlinear circuits and filters using Op amps& Filters **07 Hours**

Nonlinear circuits using op-amp-comparators, multi-vibrators, function generators, Voltage regulators, functional diagram of 723 voltage regulator, IC short circuit protection. Active filters – general transfer functions, advantages, design of second order Chebychev and Butter worth filters – low pass, high pass, band pass, band stop, filters – Gyrator – negative impedance converter, filter using simulated inductance, Universal active filter (KHN) , All passfilters.

Unit V:Op-ampapplications **07 Hours**

Sample & Hold Circuits, 555 timers: principles and working, Introduction to ADC's & DAC's. Phase Locked Loop: Principle of operation, application. Analog Multiplier: Various Types and Applications.

TEXT BOOKS:

1. Clayton "OperationalAmplifiers"
2. "Operational Amplifiers" IHRDEPublications
3. "High Frequency Electronics " learning material series, ISTE, NewDelhi
4. Sergio Franco "Design with Op-Amps and Analog Integrated Circuits" MHInternational
5. K.R. Botkar, Integrated Circuit, KhannaPublication.
6. Boylestead and Nashelesky " Electronic Devices and Circuits "PHI
7. Gayakwad "Op-Amp and Integratedcircuits"

PROFESSIONAL ELECTIVE- III

Credit	Lecture	Tutorial	Practical	CA1	MSE	ESE	Total
4	3	1	-	20	20	60	100

BTBMPE603A Artificial organs

COURSE OBJECTIVES:

- To gain knowledge in linear models of biologicalsystems.

COURSE OUTCOMES:

- Learner will be able to understand the principles and biology underlying the design of artificial organs.

UNIT-I: ARTIFICIAL HEART & CIRCULATORYASSISTDEVICES: 07 Hours

Engineering Design of artificial Heart & Circulatory Assist Devices; Detailed Design to execute the plant; Heart Assist Technology; Blood Pumps; Prosthetic Heart Valves.

UNIT-II: ARTIFICIAL KIDNEY: 07 Hours

Structure & functions of Kidney; Hemodialysis: Principle, Dialysis membrane, membrane support structure, Dialyzer effectiveness; Hem filtration; Plasma pheresis.

UNIT-III:ARTIFICIAL BLOOD: 07 Hours

Blood components & characteristics; Oxygen carrying plasma expanders; Blood substitutes; Crystalloid & colloidal solutions as volume expanders; Artificial oxygen carriers; Fluoro carbons; Hemoglobin based artificial blood. COCHLEAR IMPLANT: Introduction; candidates for implant; the auditory system; the auditory periphery; theory of operation; evaluation of cochlear prosthesis; benefits & risks of implantation; the cost of implantation; the future of cochlear prosthesis.

UNIT-IV: ARTIFICIALSKIN: 07 Hours

Structure & functions of skin; Characteristics & clinical use of skin substitutes; Two conceptual stages in the treatment of massive skin loss; Skin substitutes: characteristics & uses, types of skin substitutes.

UNIT-V :ARTIFICIAL PANCREAS: 07 Hours

Structure & function of Pancreas; Endocrine pancreas & insulin secretion; Diabetes; Insulin therapy; Insulin administration systems; Insulin production systems. ARTIFICIAL LUNGS: Gas exchange systems; Cardiopulmonary Bypass; Oxygen & CO2transport; Coupling of oxygen & CO2exchange; Shear-Induced Transport Augmentation and Devices for Improved Gas Transport.

TEXT BOOKS:

1. The Biomedical Engineering Handbook, Joseph D. Bronzino, CRC press. Artificial Organs, Nadey S. Hakim,Springer.

REFERENCE BOOKS:

i. Artificial Organs, Gerald E. Miller, Morgan & Claypool Publishers.
ii. Biomaterials Science: An Introduction to Materials in Medicine Buddy D. Ratner, Frederick J. Schoen, Allan, S. Hoffman, Jack E. Lemons

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BTBMPE603B Applied Neural Networks and Fuzzy Logic in Medicine

Course Objectives:

1. To understand the basic concepts of Artificial intelligence structures and strategies
2. To understand the concepts of knowledge representation in AI
3. To study the different pattern recognition techniques and feature extraction based on clustering
4. To give an insight knowledge about the different types of classification techniques
5. To study about the application of AI in medical field

Course Outcomes:

- To enable the students to acquire knowledge about the artificial intelligence techniques
- To recognize the patterns and its application in medicine.

UNIT I -ARTIFICIALINTELLIGENCE **07 Hours**

Artificial Intelligence (AI): Introduction, definition & history, Components, Problem definition- Structures and Strategies for state space search- Depth first and breadth first search- DFS with iterative deepening- Heuristic Search- Best First Search - A* Algorithm- AND, OR Graphs, Problems

UNIT II - KNOWLEDGE REPRESENTATIONIN AI **07 Hours**

Propositional- and Predicate- calculus, Theorem proving by resolution, AI representational schemes- Semantic nets, Conceptual graphs: Using frames and scripts- Production system, Rule based expert system

UNIT III - PATTERN RECOGNITION **07 Hours**

Classes, patterns & features- Pattern similarity and PR Tasks- Pattern discrimination-Feature space metrics & Covariance matrix- Feature assessment- Unsupervised clustering- Tree clustering- K-means clustering, Statistical, syntactic and descriptive approaches.

UNIT IV - CLASSIFICATION **07 Hours** Linear discriminants, Bayesian classification, Bayes rule for minimum risk, minimum error rate classification, discriminant functions, and decision surfaces, Model free technique - ROC Curve, Classifier evaluation, Back propagation learning, Competitivelearning.

UNIT V - APPLICATIONSIN MEDICINE **07 Hours**

Diagnosis of disease using AI, Biometrics: Face recognition and Gene matching- Automated drug delivery systems- Computer aided diagnosis- Mining of electronic health record- Computervision

TEXTBOOKS

1. George F Luger, "Artificial Intelligence- Structures and Strategies for Complex Problem Solving", 4/e, 2002, Pearson Education.
2. Duda and Hart P E, "Pattern classification and scene analysis", Johnwiley
3. and sons, NY,1973.

REFERENCES

1. Earl Gose, Richard Johnsonbaugh, and Steve Jost; "PatternRecognition and Image Analysis", PHI Pvte. Ltd., NewDelhi-1,1999.
2. Fu K S, "Syntactic Pattern recognition and applications", Prentice Hall, Eaglewood cliffs, N J,1982.
3. Rochard O, Duda and Hart P E, and David G Stork, "Pattern classification", 2nd Edn., John Wiley & Sons Inc.,2001.
4. Carlo Combi, Yuval Shahar; "Artificial Intelligence in Medicine" - 12th Conference - Springer.

BTBMPE603C Robotics &Automation

COURSE OBJECTIVES:

- To study about the basic concepts of robots and types ofrobots.
- To study about manipulators, actuators andgrippers.
- To study about various types of sensors and powersources
- To study the various applications of robot in the medicalfield.

COURSE OUTCOMES:

- To provide the basic knowledge on design, analysis, control and working principle of robotics in surgery, rehabilitation and drug delivery (Nanorobot).

UNIT-I:BASICCONCEPTS: 07 Hours

Automation and Robotics, An overview of Robotics – present and future applications, Classification by coordinate system and control system, Dynamic stabilization of Robotics. POWER SOURCES AND SENSORS: Hydraulic, Pneumatic and electric drivers – Determination HP of motor and gearing ratio, variable speed arrangements, Path Determination - Machinery Vision – Ranging – Laser – Acoustic, Magnetic Fiber Optic and TactileSensor

UNIT-II:MANUPULATORS: 07 Hours

Construction of Manipulators, Manipulator Dynamic and Force Control, Electronic and Pneumatic manipulators. ACTUATORS AND GRIPPERS: Pneumatic, Hydraulic Actuators, Stepper Motor Control Circuits, End Effecter, Various types of Grippers, Design consideration.

UNIT-III:KINEMATICS: 07 Hours

Forward and Inverse Kinematic Problems, Solutions of Inverse Kinematic problems, Multiple Solution, Jacobian Work Envelop – Hill Climbing Techniques.

UNIT-IV:PATH PLANNING: 07 Hours

Trajectory planning and avoidance of obstacles, path planning, Skew motion, joint integrated motion – straight line motion – Robot programming, languages and software packages.

UNIT V - ROBOTICSINMEDICINE 07 Hours

Da Vinci Surgical System, Image guided robotic systems for focal ultrasound based surgical applications, System concept for robotic Tele-surgical system for off-pump CABG surgery, Urologic applications, Cardiac surgery, Neuro-surgery, Pediatric-, and General- Surgery, Gynecologic Surgery, General Surgery and Nano robotics.

TEXT BOOKS

a. Industrial Robotics / Groover M P /PearsonEdu
b. Robotics / Fu K S/ McGrawHill.

REFERENCE BOOKS

1. Robotics, CSP Rao and V.V. Reddy, Pearson Publications (Inpress)
2. Robotics and Control / Mittal R K & Nagrath I J /TMH.
3. An Introduction to Robot Technology, / P. Coiffet and M. Chaironze / Kogam Page Ltd. 1983 London.
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OPEN ELECTIVE -III

Credit	Lecture	Tutorial	Practical	CA1	MSE	ESE	Total
4	3	1	-	20	20	60	100

BTBMOE604A Brain-Computer Interface Development Engineering

COURSE OBJECTIVES:

1. To gain knowledge in linear models of biological systems.
2. To study the hardware and software components of BCI
3. To familiarize the concepts of the classifiers for BCI
4. To understand the feature extraction methods for classifying BCI
5. To gain knowledge in BCI based on visually evoked potentials

COURSE OUTCOMES:

- Learner will be able to understand the biophysical basis of non-invasive brain signals, to apply signal processing, discrimination, and classification tools to interpret these signals, and to implement these tools into a control system for a brain-computer interface.

UNIT I - HARDWARE/SOFTWARE COMPONENTSOFBCI 07Hours

Introduction, Components and signals, Electrodes, Bio signal amplifier, Real-time processing environment, Motor imagery, P300 spelling device, SSVEP, Accuracies achieved with different BCI principles, Applications-twitter, second life, smart home control with BCI

UNIT II - APPLIED ADVANCED CLASSIFIERSFORBCI 07 Hours

Introduction, Signal processing and feature selection, Flow of the online and offline activities, Windowing, FFT, Statistical analysis procedure, Reduction of the feature space dimensionality, Neural network Classifier for BCI devices , Experimental procedures-ANN,SVM.

UNIT III - FEATURE EXTRACTION METHODS IN CLASSIFYING EEG SIGNAL FOR BCI 07 Hours

Introduction-Methods, Mutual information, Min max mutual information, Experimental setup, Data set, Results, P300-based BCI Paradigm Design- Event- Related Potentials (ERPs), P300 detection, Applications ofP300.

UNIT IV - BCI BASED ON THE FLASH ONSET ANDOFFSETVEP 07 Hours

Introduction- Methods- Peak-to-valley amplitudes in the onset and offset FVEPs,

Determination of gazed target, Usability of Transient VEPs in BCIs- VEPs, Availability of transient VEPs, Machine learning approach

UNIT V - VISUO-MOTOR TASKS IN ABCI ANALYSIS **07 Hours**

Introduction-Visuo motor tasks, Subjects and EEG sessions-Signal processing and fuzzy estimator, Advances in Non-Invasive BCI for Control and Biometry-Beam forming BCI, EEG based biometry

TEXTBOOKS

1. Reza Fazel-Rezai, *"Recent Advances in Brain-Computer Interface Systems"*, Intech Publications, First Edition, 2011.
2. Theodre Berger W, John k Chapin et all, *"Brain computer interfaces, An International assessment of research and developmental trends"*, Springer, First Edition,2008.

REFERENCES

1. Guido Dornhege, "Toward brain-computer interfacing", MIT Press, First Edition,2007.

BTBMOE604B Electro Physiology for Human System

COURSE OBJECTIVES:

1. To understand the basics of the cell physiology
2. study about the electro cardiology
3. perform the electrical activity of the muscles physiology
4. understand the function and nerve conduction study about the peripheral nervous system

COURSE OUTCOMES:

- Learner will be to understand the concepts and methods of electrical bio physics in the diagnosis and treatment of human diseases.

UNIT I - INTRODUCTION TOCELL PHYSIOLOGY **07 Hours**

Level of organizing the body-chemical level, cellular level, organ level, organism level-Concept of membrane potential-Membrane potential is separation opposes changes. Electrical field in cells and Organism-Electrical structure of the living organism-extracellular field and currents-passive - action potential-electrical tissue and cell suspension-single cell in external electrical field-manipulation of cell by electric field.

UNIT II - ELECTRICALCARDIACPHYSIOLOGY **07 Hours**

Electrical activity of the heart-cardio auto rhythmic display pace maker activity, the action potential of contractile cell-ECG record is record of the overall spread electrical activity through the heart, different part of the ECG record can be correlated specific events, ECG diagnosis the abnormal events-Mechanical events of the cardiac cycle-Cardiac output its control.

UNIT III - ELECTRICALMUSCLEPHYSIOLOGY **07 Hours**

Molecular basis of the skeletal muscle contraction-Skeletal muscle fibred, myosin forms thick filaments-Muscle mechanics- Group of muscle fiber, types of contraction, EMG motor unit: EMG conduction motor unit, Muscle motor unit recruitment, Muscles fiber frequency of stimulation- Types of muscles based on the ATP hydrolysis and synthesis.

UNIT IV -NERVECONDUCTION **07 Hours**

Nerve impulse-neurotransmitter and synapse- Passive transport and den tries-active transport and Hodgkin-Huxley equation-EEG- neurotransmitter-nerve conduction of EEG signal-Simulation of action potential-excitation threshold, neuronal refractoriness, repetitive spiking-Fitzhugh-Nagumo model-action potential in earthworm nerve fiber.

UNIT V - PERIPHERAL NERVOUS SYSTEM:SPECIALSENSE 07 Hours

Pain-simulation of nociceptors elicits the perception of the pain plus motivational and emotional response. Eye: protective mechanism help of prevent eye injuries-light controlled by iris-EOG oculography measure the resting potential of retina. ENG (Electronystagmography), oculomotor evaluation-position testing-caloric simulation of the vestibularsystem.

TEXTBOOKS

1 Laura lee Sherwood, "Human Physiology from cell to system", eighth edition,2012.
2 Laura lee Sherwood, "Fundamental of Physiology of Excitable Cells",2010.

REFERENCES

1 Lionel Opie, "Heart Physiology"2009.
2 Aidley, "7he Physiology of Excitable Cells", 3rd/4 the edition, 2008.
Cambridge PressJames Cal Comb, Jonathan Tran "Introductory Biophysics",2009.
3 Roland Glaser, "Biophysics an introduction", Second edition,2009.

BTHM605 Employability & Skill Development

Credit	Lecture	Tutorial	Practical	CA1	MSE	ESE	Total
3	3	-	-	20	20	60	100

COURSE OBJECTIVES:

1. To develop analytical abilities.
2. To develop communication skills.
3. To introduce the students to skills necessary for getting, keeping and being successful in profession.
4. To expose the students to leadership and team-building skills.

COURSE OUTCOMES:

On completion of the course, student will be able to:

- Have skills and preparedness for aptitude tests.
- Be equipped with essential communication skills (writing, verbal and non-verbal)
- Master the presentation skill and be ready for facing interviews.
- Build team and lead it for problem solving.

UNIT-I Soft Skills &Communication basics **Hours 07** Soft skills Vs hard skills, Skills to master, Interdisciplinary relevance, Global and national perspectives on soft skills. Resume, Curriculum vitae, How to develop an impressive resume, Different formats of resume – Chronological, Functional, Hybrid, Job application or cover letter, Professional presentation- planning, preparing and delivering presentation, Technical writing.

UNIT-II Arithmetic and Mathematical Reasoning **07 Hours**
Aspects of intelligence, Bloom taxonomy, multiple intelligence theory, Number sequence test, mental arithmetic (square and square root, LCM and HCF, speed calculation, reminder theorem).

UNIT-III Analytical Reasoning and Quantitative Ability **07 Hours**
Matching, Selection, Arrangement, Verifications (Exercises on each of these types). Verbal aptitude (Synonym, Antonym, Analogy).

UNIT-IV Grammar and Comprehension **07 Hours**
English sentences and phrases, Analysis of complex sentences, Transformation of sentences, Paragraph writing, Story writing, Reproduction of a story, Letter writing, précis writing, Paraphrasing and e-mail writing.

UNIT-V Skills for interviews **07 Hours**
Interviews- types of interviews, preparatory steps for job interviews, interview skill tips, Group discussion- importance of group discussion, types of group discussion, difference between group

discussion, panel discussion and debate, personality traits evaluated in group discussions, tips for successful participation in group discussion, Listening skills- virtues of listening, fundamentals of good listening, Non-verbal communication-body movement, physical appearance, verbal sounds, closeness, time.

TEXT BOOKS:

1. R. Gajendra Singh Chauhan, Sangeeta Sharma, “Soft Skills- An integrated approach to maximize personality”, ISBN: 987-81-265-5639-7, First Edition 2016, Wiley Wren and Martin, "English grammar and Composition", S. Chand publications.
2. R. S. Aggarwal, "A modern approach to verbal reasoning", S. Chand publications.
3. Philip Carter, "The Complete Book of Intelligence Test", John Willey & Sons Ltd.
4. Philip Carter, Ken Russell, "Succeed at IQ test", Kogan Page.
5. Eugene Ehrlich, Daniel Murphy, "Schaum’s Outline of English Grammar", McGraw Hills
6. David F. Beer, David A. Mc Murrey, “A Guide to Writing as an Engineer”, ISBN: 978-1-118-30027-5 4th Edition, 2014, Wile