FACULTY OF ENGINEERING

DEGREE OF BACHELOR OF ENGINEERING IN BIOMEDCAL ENGINEERING

DEPARTMENT OF BIOMEDICAL ENGINEERING

(REGULAR PROGRAMME)

CURRICULUM & SYLLABI
(2025-2026)

KARPAGAM ACADEMY OF HIGHER EDUCATION

(Deemed to be University)

(Established UnderSection3of UGCAct1956)

(Accredited with A^+ Grade by NAAC in the Second Cycle)

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KARPAGAM ACADEMY OF HIGHER EDUCATION

(Deemed to be University Established under Section 3 of UGC Act 1956)

Eachanari, Coimbatore-641 021. INDIA

FACULTY OF ENGINEERING

DEGREE OF BACHELOR OF ENGINEERING / TECHNOLOGY

REGULAR PROGRAMME

REGULATIONS 2025

CHOICE BASED CREDIT SYSTEM

These regulations are effective from the academic year 2025 – 2026 and applicable to the candidates admitted to B. E. / B. Tech programmes. during 2025- 2026 and onwards.

1. ADMISSION

1.1 Candidates seeking admission to the first semester of the eight semesters B. E./B.Tech Degree Programme:

Should have passed the Higher Secondary Examination (10+2) prescribed by the State Government
/ Central Government with Mathematics/ Physics/ Chemistry/ Computer Science/ Electronics/ Information Technology/ Biology/ Informatics Practices/ Biotechnology/ Technical Vocational subject/ Agriculture/ Engineering Graphics/ Business Studies/ Entrepreneurship. (Any of the above three subjects) or any similar Examination of any other institution/ University or authority accepted by the Karpagam Academy of Higher Education as equivalent thereto).
Should have obtained at least 45% marks (40% marks in case of candidates belonging to SC / ST reserved category) in the above subjects taken together.

1.2 Lateral Entry Admission

Candidates who possess Diploma in Engineering / Technology (10+3 or 10+2+2) awarded by the Directorate of Technical Education with passed minimum THREE years / TWO years (Lateral Entry) Diploma examination with at least 45% marks (40% marks in case of candidates belonging to SC / ST reserved category) in ANY branch of Engineering and Technology are eligible to apply for admission to the third semester of B. E./B. Tech., subject to vacancies in the First Year, in case the vacancies at lateral entry are exhausted. (The University will offer suitable bridge courses such as Mathematics, Physics, Engineering drawing, etc., for the students coming from diverse backgrounds to achieve desired learning outcomes of the programme)

(OR)

B.Sc. Degree from a recognized University as defined by UGC, with at least 45% marks (40%

marks in case of candidates belonging to SC / ST reserved category) and passed 10+2 examination with Mathematics as a subject.

(OR)

Passed D.Voc. Stream in the same or allied sector.

(The University will offer suitable bridge courses such as Mathematics, Physics, Engineering drawing, etc., for the students coming from diverse backgrounds to achieve desired learning outcomes of the programme)

Eligibility criteria for admission in the third semester is given in the table below.

S. No.	Programme	Eligibility criteria
1	B.E Bio Medical Engineering	Passed Minimum THREE years / TWO years (Lateral Entry) Diploma examination with at least 45% marks (40% marks in case of candidates belonging to reserved category) in ANY branch of Engineering and Technology. **OR** Passed B.Sc. Degree from a recognized University as defined by UGC, with at least 45%marks (40% marks in case of candidates belonging to SC / ST reserved category) and passed 10+2 examination with Mathematics as a subject. **OR** Passed D.Voc. Stream in the same or allied sector. (The Universities will offer suitable bridge courses such as Mathematics, Physics, Engineering drawing, etc., for the students coming from diverse backgrounds to achieve desired learning outcomes of the programme)
2	B. E. Civil Engineering	
3	B. E. Computer Science and Engineering	
4	B. E. Computer Science and Engineering (Cyber security)	
5	B. E. Electrical and Electronics Engineering	
6	B. E. Electronics and Communications Engineering	
7	B. E. Mechanical Engineering	
8	B. Tech. Artificial Intelligence and Data Science	
9	B. Tech. Computer Science and Business Systems	
10	B. Tech Bio – Technology	
11	B. Tech Food Technology	

1.3 Migration from other University

Candidates who are willing to migrate to Karpagam Academy of Higher Education for admission to their next semester of B. E./B. Tech programme may get admitted from 2nd semester onwards upto 5th semester. The student will be exempted from appearing for Examination of the equivalent courses passed in the earlier programme and will have to appear for courses which he/she has not done during the period of his/her earlier programme. Along with the request letter and mark sheets,

he/she has to submit a copy of syllabus of the programme duly attested by the Competent authority, he/she has undergone. Programme Equivalence Certificate shall be given by the respective Head of the Department of Karpagam Academy of Higher Education, after verifying the credentials.

2. PROGRAMMES OFFERED

A candidate may undergo a programme in any one of the branches of study approved by the University as given below.

List of B. E. and B. Tech. Degree Programmes

1. B.E Bio Medical Engineering
2. B. E. Civil Engineering
3. B. E. Computer Science and Engineering
4. B. E. Computer Science and Engineering (Cyber Security)
5. B. E. Electrical and Electronics Engineering
6. B. E. Electronics and Communications Engineering
7. B. E. Mechanical Engineering
8. B.Tech. Artificial Intelligence and Data Science
9. B. Tech. Computer Science and Business Systems
10. B. Tech. Bio-Technology
11. B. Tech Food Technology

3. MODE OF STUDY

3.1 Full-Time:

In this mode of study, the candidates are required to attend classes regularly on the specified working days of the University.

3.2 Change from one programme to another is not permitted.

4. STRUCTURE OF PROGRAMMES

4.1 Every programme will have a curriculum with syllabus consisting of theory and practical courses such as:

(i) General core courses comprising Mathematics, Basic Sciences, Engineering Sciences and Humanities.

(ii) Core courses of Engineering/Technology.

(iii) Elective courses for specialization in related fields.

(iv) Workshop practice, computer practice, engineering graphics, laboratory work, internship, seminar presentation, project work, industrial visits, camps, etc.

Every student is encouraged to participate in at least any one of the following programmes

- NSS / Sports/Physical exercise/NCC/YRC.
- Other Co-Curricular and Extra Curricular activities

(V) **Choice Based Credit System**

CBCS is introduced for students admitted in the academic year 2017-18 onwards. As per AICTE guidelines, CBCS is an approach in which students opt for courses of their choice. CBCS provides greater flexibility with multiple courses and enable students to undergo additional courses. CBCS is applicable to Full Time Undergraduate & Post Graduate Programmes of study. It provides a choice for students to select from the prescribed courses (Professional core, Professional Electives, Open Electives, Value added courses, Humanity Sciences, Basic sciences & Engineering sciences). A course designated as hard core for a particular programme of study must invariably be completed by the student to receive the degree in the programme. The Hardcore courses cannot be substituted by another courses. Students can exercise their choice among a set of soft core courses from the list of soft core courses specified for each Programme of study. **The student should meet the criteria for prerequisites to become eligible to register for that course. The student should request and register for the course for every semester within the first week of semester.** Maximum number of students to be registered in each course shall be decided by the HoD in consultation with the Dean. Registration of already requested courses by students in previous semester is not allowed.

4.2 Each course is normally assigned certain number of credits.

No. of credits per lecture period per week	:	1
No. of credits per tutorial period per week	:	1
No. of credits for 3 periods of laboratory course per week	:	2
No. of credits for 3 periods of project work per week	:	2
No. of credits for 2 weeks of field project/internship training during semester vacations	:	1

4.3 In every semester, the curriculum shall normally have a blend of theory courses not exceeding 6 and practical courses not exceeding 4.

4.4 The prescribed credits required for the award of the degree shall be within the limits specified below.

PROGRAMME	PRESCRIBED CREDIT RANGE
B. E./B. Tech.	160– 165

4.5 The medium of instruction for all Courses, Examinations, Seminar presentations and Project/ Thesis reports is English.

4.6 Value Added Course (VAC / Skill Development Course (SDC)

Besides core courses and elective courses, VAC / SDC are provided. The blend of different courses is so designed that the interested students would be trained for the holistic development to enhance employment opportunity. Upon completion of 30 Practical Hours / 15 Theory hours and evaluation, a student can claim for 1 additional credit.

4.7 Evaluation of the courses comprises of two parts, one is the Continuous Internal Assessment (CIA) and the other one is the End Semester Examination (ESE). Evaluation of a mandatory course may be by Internal Assessment only.

5. DURATION OF THE PROGRAMME

5.1 The prescribed duration of the programme shall be

Programme	Min. No. of semesters	Max. No. of semesters
B. E./B. Tech. (HSC Candidates)	8	14
B. E./B. Tech. (Lateral Entry Candidates)	6	12

5.2 Each semester shall normally consists of 90 working days or 540 hours.

5.3 Additional classes for improvement, conduct of model test, etc., over and above the specified periods shall be arranged, if required. But for the purpose of calculation of attendance requirement for eligibility to appear for the end semester Examinations (as per Clause 11) by the students, 540 hours conducted within the specified academic schedule alone shall be taken into account and the overall percentage of attendance shall be calculated accordingly.

6. REQUIREMENTS FOR COMPLETION OF THE SEMESTER

6.1 Ideally every student is expected to attend all classes and secure 100% attendance. However, in order to allow for certain unavoidable circumstances, the student is expected to attend at least75% of the classes and the conduct of the candidate has been satisfactory during the course.

6.2 A candidate who has secured attendance between 65% and 74.4% (both included), due to medical reasons (Hospitalization / Accident / Specific Illness) shall produce medical certificate and fitness certificate by a Registered Medical Practitioner. The Head of the Department has to verify and certify the genuineness of the case before recommending to the Dean concerned. However, the candidate has to execute a one-time bond in Stamp paper duly signed by the parent and the student.

6.3 Candidates who have not produced / submitted relevant documents for condonation will not

be permitted to proceed to the next semester and have to redo the course. However, they are permitted to write the arrear Examinations, if any.

7. Mentor

To help the students in planning their courses of study and for general advice on the academic programme, the Head of the Department will attach a certain number of students to a Faculty of the Department who shall function as Mentor for those students throughout their period of study. Such Mentors shall advise the students and monitor the courses undergone by the students, check the attendance and progress of the students and counsel them periodically. If necessary, the Mentor may display the cumulative attendance particulars in the Department notice board and also discuss with or inform the Parents/Guardian about the progress of the students. Each student shall be provided with course plan for each course at the beginning of each semester.

8. CLASS COMMITTEE

8.1. The class committee for a class under a particular branch is normally constituted by the Head of the Department. However, if the students of different branches are mixed in a class (like the first semester which is generally common to all branches), the class committee is to be constituted by the Dean.

8.2. Every class shall have a class committee consisting of teachers of the class concerned, Maximum of six student representatives [boys and girls] and the concerned Head of the Department. It is like the 'Quality Circle' with the overall goal of improving the teaching-learning process. The functions of the class committee include

- Clarifying the regulations of the degree programme and the details of rules therein particularly Clause 4 and 5 which should be displayed on Department Notice-Board.
- Informing all the students, the details of Regulations regarding weightage used for each assessment. In the case of practical courses (laboratory / drawing / project work / seminar, etc.) the breakup of marks for each experiment / exercise /module of work, should be clearly discussed in the class committee meeting and informed to the students.
- Solving problems experienced by students in the class room and in the laboratories.
- Informing the student representatives, the academic schedule, including the dates of assessments and the syllabus coverage for each assessment.
- Analyzing the performance of the students of the class after each test and finding the ways and means of solving problems, if any.
- Identifying the weak students, if any and requesting the teachers concerned to provide some additional academic support.

8.3 The class committee shall be constituted within the first week of each semester.

8.4 The Chairperson of the Class Committee may convene the meeting of the class committee.

8.5 The Dean may participate in any Class Committee of the Faculty.

8.6 The Chairperson is required to prepare the minutes of every meeting, submit the same to Dean through the HOD within two days of the meeting and arrange to circulate it among the students and teachers concerned. If there are some points in the minutes requiring action by the Executive Council, the same shall be brought to the notice of the Registrar/VC by the HoD through Dean.

8.7 The first meeting of the Class Committee shall be held within one week from the date of commencement of the semester, in order to inform the students about the nature and weightage of assessments within the framework of the regulations. Two subsequent meetings may be held in a semester at suitable intervals. During these meetings the student members representing the entire class, shall meaningfully interact and express their opinions and suggestions of the other students of the class in order to improve the effectiveness of the teaching-learning process.

9. COURSE COMMITTEE FOR COMMON COURSES

Each common theory course offered to more than one discipline or one batch of students shall have a "Course Committee" comprising of all the faculty teaching the common course with one of them nominated as Course Coordinator. The nomination of the Course Coordinator shall be made by the Head of the Department/Dean depending upon whether all the faculty teaching the common course belong to a single department or several departments. The "Course committee" shall meet at least three times and ensure uniform evaluation of the tests and arrive at a common scheme of evaluation for the tests. Wherever it is feasible, the course committee may also prepare a common question paper for the assessment test(s). The letter "**G**" is to be mentioned in the course code for the common course.

10. PROCEDURE FOR AWARDING MARKS FOR INTERNAL ASSESSMENT

10.1 Every teacher is required to maintain an 'ATTENDANCE AND ASSESSMENT RECORD' (Log book) which consists of attendance marked in each theory or practical or project work class, the test marks and the record of class work (topic covered), separately for each course.

10.2 **Continuous Internal Assessment (CIA):** The performance of students in each course will be continuously assessed by the respective teachers as per the guidelines given below:

a. THEORY COURSES

S. No.	CATEGORY	MAXIMUM MARKS
1.	Assignment	5
2.	Seminar *	5
3.	Attendance	5
4.	Test – I	12.5
5.	Test – II	12.5
Continuous Internal Assessment: TOTAL		40

*Evaluation shall be made by a seminar committee.

PATTERN OF TEST QUESTION PAPER (Test I & II)

INSTRUCTION	REMARKS
Maximum Marks	100
Duration	3 Hours
Part – A	Question no. 1 to 10 Two Mark Questions, covering 2.5 units of the syllabus. **(10 x 2= 20 Marks)**
Part- B	Question 11 to 15 will be of either-or type, covering 2.5 units of the syllabus. Each Question may have subdivision. **(5 x 16=80 Marks)**

b. PRACTICAL COURSES

S. No	CATEGORY	MAXIMUM MARKS
1.	Attendance	5
2.	Observation work	5
3.	Record work	5
4.	Internal Practical Assessment	15
5.	Viva – Voce [Comprehensive]	10
Continuous Internal Assessment: TOTAL		40

Every practical exercise / experiment shall be evaluated based on the conduct of exercise/ experiment and records maintained.

c. INTEGRATED THEORY AND PRACTICAL COURSES

The Continuous Internal Assessment for Integrated Theory and Practical Course is awarded for 40 Marks with mark split up similar to regular theory course. But Assignment and Seminar components are replaced by Observation and Record marks.

S.No.	CATEGORY	MAXIMUM MARKS
1.	Observation	5
2.	Record	5
3.	Attendance	5
4.	Test –I	12.5
5.	Test –II	12.5
Continuous Internal Assessment: TOTAL		40

The end semester evaluation of integrated practical component is for 50 Marks and it is scaled down to 15 Marks. Similarly, the end semester evaluation for integrated theory is 100 Marks and it is scaled down to 45 Marks. Hence, the external evaluation of integrated theory and practical elements accounts for 60 marks.

For the integrated course, the ESE mark distribution is as follows:

Theory	Practical	Total
45 marks	15 Marks	60 Marks

10.3 ATTENDANCE

Attendance carries a maximum of 5 marks and the distribution is as under:

S. No.	Attendance %	Marks
1	91 and above	5.0
2	81-90	4.0
3	76-80	3.0

10.4 PROJECT WORK/ INTERNSHIPS

10.4.1 Project Work

Final year project work will be normally in-house. However, as a special case, if a student is able to get a project from a government organization or private or public sector company, the student may be permitted to do his/her project work in that institution/research organization/industry.

The evaluation of Project phase I shall be through Continuous Internal assessment mode and Project phase II evaluation shall be through continuous assessments (Three reviews), evaluation of

project thesis report and viva-voce examination. Continuous assessment shall have the weightage of 40%. Evaluation of Project thesis report and viva-voce examination shall have the weightage of 60% each. Break-up of marks is as shown below:

Project Phase I Evaluation:

Continuous Internal Assessment (100 marks)		
Review I	**Review II**	**Review III**
30 marks	30 marks	40 marks

Project Phase II Evaluation:

Continuous Internal Assessment (40 marks)			**ESE (60 marks)**			
			Project Report (30 marks)		**VIVA VOCE (30 marks)**	
Review I	**Review II**	**Review III**	**Supervisors**	**External**	**Internal**	**External**
5 marks	15 marks	20 marks	15 marks	15 marks	15 marks	15 marks

10.4.2 Internships

Students must complete Internship for the duration specified in the program's corresponding curriculum. The industry in which the student intends to undergo internship should be aligned in line with the programme of study. The student must submit a report detailing observations, skills learned, usefulness, etc., together with the attendance certificate granted by the relevant industry after completing the internship or industrial training. A committee made up of three faculty members, appointed by the department head, will review this report. One faculty member will be designated as the coordinator. A student can claim one credit if he/she completes one week of training as per curriculum

Weightage for Assessment for Internship

Report	**Presentation**	**Viva-Voce**
30 Marks	40 Marks	30 Marks

11. REQUIREMENTS FOR APPEARING FOR END SEMESTER EXAMINATION(ESE)

A candidate shall normally be permitted to appear for the ESE of any semester commencing from I semester if he/she has satisfied the semester completion requirements (Subject to Clause 5.2) and has registered for Examination in all courses of the semester. Registration is mandatory for

Semester Examinations as well as arrear Examinations failing which the candidate will not be permitted to attend the next semester. A candidate already appeared for a course in a semester and passed the Examination is not entitled to reappear in the same course of the semester for improvement of grade.

12. END SEMESTER EXAMINATION

ESE will be held at the end of each semester for each course, for 100 marks, it is scaled down to 60 marks.

12.1 ONLINE EXAMINATIONS

The students who are going for Project / Internship / Coursework at National level are permitted to write their CIA test through Online Mode and ESE in Offline/Online mode. When they go for an International Project / Internship / Coursework, both the CIA and ESE shall be conducted through online mode.

PATTERN OF ESE QUESTION PAPER:

INSTRUCTION	REMARKS
Maximum Marks	100
Duration	3 Hours
Part – A	Question no. 1 to 10 Two Mark Questions, covering all the 5 units. **(10 x 2= 20 Marks)**
Part- B	Question 11 to 15 will be of either or type, covering Five units of the syllabus. Each Question may have subdivision. **(5 x 16=80 Marks).**

13. PASSING REQUIREMENTS

13.1 Minimum marks to pass: The minimum marks to pass for CIA is 20 (i.e. out of 40 marks). The minimum marks to pass for ESE is 30 (i.e. out of 60 marks). The overall minimum marks to pass for theory/laboratory course is 50 (Sum of his/her score in CIA and ESE) out of 100 marks.

13.1.1 The minimum marks to pass for the Value Added Course /Skill Development is 50 marks out of 100marks. There will be two tests, the first covering 50% of syllabus for 50 marks and the other for 50 marks.

13.2 If the candidate fails to secure a pass in ESE of a particular course, it is mandatory that candidate shall register and reappear for the Examination in that course during the subsequent

semester when Examination is conducted in that course. Further the candidate should continue to register and reappear for the Examination till a pass is secured in such supplementary Examination within the stipulated maximum duration of the programme (Clause 5.1).

The CIA marks obtained by the candidate in his/her first or subsequent appearance where he/she secures a pass shall be retained by the office of the Controller of Examinations and considered valid for all remaining attempts till the candidate secures a pass in his/her ESE.

13.3 If the candidate fails to secure a pass in CIA of a particular course, it is mandatory that candidate shall register and reappear for the CIA in that course during the subsequent semester when CIA is conducted in that course by the faculty member assigned for that particular course during that semester by the concerned HOD. Further, the candidate should continue to register and reappear for the CIA till a pass is secured in such subsequent Examination within the stipulated maximum duration of the programme (Clause 5.1). The Evaluation for the CIA reappearance is as follows:

Test 1	Test 2	Assignment	Total
15 marks	15 marks	10 marks	40 marks

13.4 CREDIT TRANSFER THROUGH ONLINE PLATFORM / INTERNATIONAL STUDIES

The MOOC coordinator shall assist the students for the online courses offered by the NPTEL/SWAYAM/Other online platforms periodically and also monitor their course.

Students are encouraged to enroll in courses offered by NPTEL/Swayam/ Swayam Plus platforms and international institutions of higher learning, either virtually or in person. The equivalent credits for these courses will be determined by a committee named Subject & Grade Equivalence Committee comprising the Dean of the Faculty as Chairman, Dean (R&D, Industrial Relations), Head of the Department (HoD) and one faculty member nominated by the Vice Chancellor as members. The committee's decision will be submitted for ratification/approval by the Board of Studies (BoS) and the Academic Council.

13.4.1 Online Courses / Self Study Courses

Students may be permitted to earn credit through online courses (which are provided with certificate) with the approval of Head of the Department and Dean. The credit may be transferred with the due approval for either programme core, elective or open elective course and complete at any time within the duration of the programme before the last semester.

13.4.2 One credit course

One credit elective course shall be offered by the department in collaboration with the industry/research organizations / higher learning institutions. A student shall be permitted to register for the one-credit courses offered by other departments with approval of both the Heads of the departments. A student shall replace a three credit programme elective / open elective course if he / she registered for three one credit courses and appear for the examination of the courses and get qualified in the examination. Three elective courses of 1 credit shall replace a 3-credit elective course as given in Table.

REPLACEMENTS OF ONE CREDIT COURSES

Number of credits earned		Eligible to replace	
Core electives	**Interdisciplinary electives**	**PEC**	**OEC**
3	0	1	-
2	1	1	-
1	2	-	1
0	3	-	1

Refer the Annexure I for NPTEL Course Durations and credit Equivalence. The Registration / Application form for Credit Transfer of SWAYAM-NPTEL / MOOC Courses shall be submitted as shown in Annexure I.

14. AWARD OF LETTER GRADES

14.1 All assessments of a course will be done on absolute mark basis. However, for the purpose of reporting the performance of a candidate letter grades, each carrying certain number of points will be awarded as per the range of total marks (out of 100) obtained by the candidate in each subject as detailed below:

Letter grade	Marks Range	Grade Point	Description
O	91 – 100	10	OUTSTANDING
A+	81- 90	9	EXCELLENT
A	71-80	8	VERY GOOD
B+	61- 70	7	GOOD
B	56-60	6	AVERAGE
C	50-55	5	PASS
RA	Below 50	-	REAPPEARANCE
AAA	-	-	ABSENT

14.2 GRADE SHEET

After results are declared, Grade sheet will be issued to each student which will contain the following details:

i. The list of courses enrolled during the semester and the grade scored

ii. The Grade Point Average (**GPA**) for the semester and

iii. The Cumulative Grade Point Average (**CGPA**) of all courses enrolled from first semester onwards.

GPA is the ratio of the sum of the products of the number of Credits (**C**) of courses enrolled and the Grade Points (**GP**) corresponding to the grades scored in those courses, taken for all the courses to the sum of the number of credits of all the courses in the semester.

$$\text{GPA} = \frac{\text{Sum of } [C * GP]}{sum\ of\ c}$$

CGPA will be calculated in a similar manner, considering all the courses enrolled from First semester. **RA** grade and value added course will be excluded for calculating **GPA** and **CGPA**.

14.3 REVALUATION

Revaluation and Re-totaling are allowed on representation. A candidate can apply for revaluation of his/her semester Examination answer paper in a theory course, within 2 weeks from the declaration of results, on payment of a prescribed fee through proper application to the Controller of Examinations through the Head of the Department and Dean. A candidate can apply for revaluation of answer scripts for not exceeding 5 subjects at a time. The Controller of Examinations will arrange for the revaluation and the results will be intimated to the candidate through the Head of the Department and Dean. Revaluation is not permitted for Supplementary Examinations, Practical Examinations, Technical Seminars, In-plant Training and Project Work.

14.4 TRANSPARENCY AND GRIEVANCE COMMITTEE

A student may get the Photostat copy of the answer script on payment of prescribed fee, if he/she wishes. The students can represent the grievance, if any, to the Grievance Committee, which consists of Dean of the Faculty, (if Dean is HoD, the Dean of another Faculty nominated by the University), HoD of the Department concerned, the faculty of the course and Dean from other discipline nominated by the University and the CoE. If the Committee feels that the grievance is genuine, the script may be sent for external valuation; the marks awarded by the External Examiner will be final. The student has to pay prescribed fee for the same.

15. ELIGIBILITY FOR AWARD OF DEGREE

A student shall be declared to be eligible for award of Degree if he/she has

- Successfully gained the required number of total credits as specified in the curriculum corresponding to his/her programme within the stipulated time.
- The award of the degree must be approved by the Board of Management of Karpagam Academy of Higher Education.

16. CLASSIFICATION OF THE DEGREE AWARDED

16.1 A candidate who qualifies for the award of the Degree (vide Clause 15) having passed the Examination in all the courses in his/her first appearance within the specified minimum number of semesters (vide Clause 5.1) securing a CGPA of not less than **7.5** shall be declared to have passed the Examination in First Class with Distinction.

16.2 A regular candidate/lateral entrant is eligible to register for B.E. (Honours)/ B.Tech.(Honours), if he/she has passed all the courses in first attempt from first/third semester onwards and holds / maintains a CGPA of 7.5 in III and IV Semester. Prior approval of the concerned Head of the Department and respective Dean for the enrolment into Honours degree before the commencement of V semester is mandatory. A candidate is eligible for the award of BE (Honours) / B.Tech.(Honours), if he/she earns an additional 18 credits by undergoing additional courses over and above the courses prescribed in the respective curriculum. The opted additional courses shall be Emerging / Multidisciplinary /MOOC /NPTEL courses which are related to the major discipline of study. All these 18 credits need to be completed in III year and IV year only. However, if he/she fails to secure 18 additional credits but maintains a CGPA of 7.5 and above is not eligible for Honours degree but eligible for First class with Distinction.

16.3 A candidate who qualifies for the award of the Degree (vide Clause 15) having passed the Examination in all the courses within the specified minimum number of semesters (vide Clause 5.1) plus one year (two semesters), securing CGPA of not less than 6.5 shall be declared to have passed the Examination in First Class.

16.4 All other candidates (not covered in Clauses 17) who qualify for the award of the degree (vide Clause 15) shall be declared to have passed the Examination in Second Class.

17. SUPPLEMENTARY ESE

After the publication of VIII semester results, if a student has **ONE** arrear in any theory course of the entire programme, he/she will be permitted to apply within 15 days of the publication of results, and appear for supplementary Examination.

18. DISCIPLINE

Every student is required to observe discipline and decorous behavior both inside and outside the University and not to indulge in any activity which will tend to bring down the prestige of the University. The erring student will be referred to the Disciplinary Committee constituted by the University, to enquire in to acts of indiscipline and recommend to the University about the disciplinary action to be taken.

If a student indulges in malpractice in any of the ESE/CIA he/she shall be liable for punitive action as prescribed by the University from time to time.

19. ADVANCED LEARNERS & ON-DEMAND EXAMINATION

Students

1. Who secure 7.5 CGPA and maintain an attendance of 75% in every semester
2. Clear all the courses in their first appearance itself

are referred to as advanced learners.

When a student fails to maintain any of the above conditions at any given time, he cannot be an advanced learner further.

These advanced learners can request for an on-demand examination for the courses from IV semester onwards. These students on prior permission can appear for such examinations well in advance and complete the entire courses well before the prescribed period of study and can progress for a full time Research Project/Internship/Minor Project during the remaining prescribed period of study. The Internal and External examinations will be conducted for these courses as like the other courses. One or more faculty mentors will be allocated based on the number of students/courses enrolled for the on-demand examination.

Also, these advanced learners can also register for online courses from NPTEL/Swayam/Swayam Plus portals on prior and proper approval from the department. The credits earned from those courses will be transferred to the mark statement of the students.

20. REVISION OF REGULATION AND CURRICULUM

The University may from time-to-time revise, amend or change the Regulations, Scheme of Examinations and syllabi, if found necessary on the recommendations of Board of Studies, Academic Council and Executive council of Karpagam Academy of Higher Education.

21. KARPAGAM INNOVATION AND INCUBATION COUNCIL (KIIC)

(A Section 8 Company)

Based on the 2019 National Innovation and Startup Policy and the 2019–2023 Tamil Nadu Startup Policy, KIIC has recommended to the KAHE students who are affiliated with the KIIC that it be incorporated in the university Program Regulations 2023-24 onwards and implement from this academic year.

21.1 Norms to Student Start-Ups

a) Any (UG/PG /(Ph.D.) Research scholars, student, right from the first year of their programme is allowed to setup a startup (or) to work as part time in a startup or work as intern in a startup.

b) Any (UG/PG / (Ph.D.) Research scholars) student right from the first year of their programme is allowed to earn credit for working on Innovative prototypes/business Models/ Pre incubation (case to case basis). Start Up activities will be evaluated based on the guidelines being given by the expert committee of the KIIC.

c) Student Entrepreneurs may use the address of incubation center (KIIC) to register their venture while studying in KAHE.

d) Students engaged in startups affiliated with the KIIC or those who work for them, their attendance may be accepted by KAHE for KAHE's attendance requirements for academic courses under current regulations, up to a maximum of 30% attendance per semester, including claims for ODs and medical emergencies. Potential Students who have been incubated at KIIC may be permitted to take their university semester exams even provided by the KIIC's attendance report, with the proper authorization from the head of the institution.

(On case-to-case basis depends upon the applicability strength, societal benefits and quality of the Innovation and Subsequent engagement of the students with the/ her business)

e) Any Students Innovators/entrepreneurs are allowed to opt their startup in place of mini project/ major project, /seminar and summer training etc. (In plant training, Internship, value added Course.). The area in which the student wishes to launch a Startup may be interdisciplinary or multidisciplinary.

f) Student's startups are to be evaluated by Expert committee, formed by KIIC and KAHE.

22.2 Guide lines to award Credits/ Marks to a Student startup

S. No.	Description/Startup phases	In place of the Subject / Course title	Grades/Credits /Marks
1	Idea stage/Problem Identification	Seminar/Presentation of concept	Same Marks/ Credits can be awarded that are listed in the course title's curriculum for the respective startup phases.
2	Proof of Concept (POC) /Solution development	In-plant training /Internship	
3	Product Development (Lab scale) /Prototype Model/ Company Registered	Mini Project/Value added Course	
4	Validation/Testing	Main Project phase I	
5	Business Model / Ready for Commercialization/ Implementation	Main Project phase II	

Student's startup stages are divided into five phases and these startup phases can be considered equally in place of the course title as mentioned below with the same credits allotted to the course title in university curriculum.

PROGRAM OUTCOMES (POS)

PO1: Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering
problems.

PO2: Problem Analysis: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)

PO3: Design/Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)

PO4: Conduct Investigations of Complex Problems: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions.
(WK8).

PO5: Engineering Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)

PO6: The Engineer and The World: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).

PO7: Ethics: Apply ethical principles and commit to professional ethics, human values diversity and inclusion; adhere to national & international laws. (WK9)

PO8: Individual and Collaborative Team work: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

PO9: Communication: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences

PO10: Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

PO11: Life-Long Learning: Recognize the need for, and have the preparation and ability for

i) independent and life-long learning

ii) adaptability to new and emerging technologies

and iii) critical thinking in the broadest context of technological change. (WK8)

KNOWLEDGE AND ATTITUDE PROFILE (WK)

WK1: A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.

WK2: Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.

WK3: A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.

WK4: Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.

WK5: Knowledge, including efficient resource use, environmental impacts, whole-life cost, reuse of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.

WK6: Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.
practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.

WK8: Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.

WK9: Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

PROGRAMME EDUCATIONAL OBJECTIVES(PEOs):

After graduation, students will be able to,

1. Apply principles of biomedical engineering in solving challenges of the healthcare industry that are reliable, affordable and socially acceptable.
2. Nurture skills to design, develop and operate indigenous products in biomedical engineering through project works.
3. Exhibit leadership, engage in lifelong learning and adhere to medical ethics through professional career in multidisciplinary fields of engineering, science and medicine

PROGRAMME SPECIFIC OUTCOMES(PSOs)

Engineering Graduates will be able to,

1. Design and implement assistive and rehabilitative system to improve end user quality of life
2. Develop clinical algorithms for solving theranostic problems

Annexure I

Credit Transfer of Online Courses (SWAYAM / NPTEL)

1. The credit transfer shall be applicable to the students of UG programme from 2022 Batch onwards

The proposed conversion from percentage marks given by (SWAYAM NPTEL) to the corresponding grades shall be as follows: -

NPTEL Course Durations and credit Equivalence		
S. NO	**Course Duration**	**Credit Equivalence for Transfer of Credits**
1	4 Weeks	1 Credit
2	8 Weeks	2 Credit
3	12 Weeks	3 Credit
4	16 Weeks	4 Credit

Type of NPTEL certificate	NPTEL Score	Equivalent Grade (KAHE)	KAHE Score
Elite + Gold	>=90	O	91-100
Elite + Silver	75-89	A+	81-90
Elite	60-74	A	71-80
Successfully completed	40-59	B+	66-70
No certificate	< 40	-	-

KARPAGAM ACADEMY OF HIGHER EDUCATION

(Deemed to be University Established Under Section 3 of UGC Act 1956)

Pollachi Main Road, Eachanari Post, Coimbatore – 641 021

Registration / Application form for Credit Transfer of SWAYAM-NPTEL / MOOC Courses (Academic Year 2025-2026)

1. Name of Student: _____
2. Register No : _____
3. Faculty :

	FOE		FASCM		FOP		FADP

4. Department/Centre _____
5. Name of the programme : _____ 5. Year/Semester:_____
6. Details of SWAYAM-NPTEL / MOOC Courses:

S. No.	NPTEL Course Title	Duration (In Weeks)	NPTEL Roll No	Month & Year of Exam	Registered Against			PE/OE (KAHE Course Code)
					PE	OE	EX	

PE: Professional Elective, OE: Open Elective, EX: Extra / add- on Course

Declaration by the Student:

I hereby declare that all the information given by me in this application are true and correct to the best of my knowledge and belief. I will comply with the all rules and regulations of SWAYAM NPTEL/MOOC's courses notified by the Course. I also undertake that after completion of the registered course/s, it's my duty to submit the course completion certificate to HOD otherwise my Marks / Grades shall not be incorporated in Grade Statement of the respective Semester.

Date:_____ **Signature of candidate**

For Dean / HoD Office:

As per the student application and provision in Academic Regulations, the courses of the above student is /are approved for Registration / Transfer of credits:

Sl. No	Course Title	Registered Approved			Semester (I / II / III /IV / V / VI / VII / VIII	Course Code Assigned	Name of Course Coordinator (If applicable)
		PE	OE	EX			

NPTEL Certificate verified by**: Name:** _____ **Signature:** _____

Approved by:

Coordinator **HoD** **Dean**

For Controller of Examinations Office:

NPTEL Course Durations and credit Equivalence (As per Regulation)		
S. No	Course Duration	Credit Equivalence for Transfer of Credits
1	4 Weeks	1 Credit
2	8 Weeks	2 Credit
3	12 Weeks	3 Credit
4	16 Weeks	4 Credit

Type of NPTEL certificate	NPTEL Score	Equivalent Grade (KAHE)	KAHE Score
Elite + Gold	>=90	O	91-100
Elite +Silver	75-89	A+	81-90
Elite	60-74	A	71-80
Successfully completed	40-59	B+	66-70
No certificate	< 40	-	-

S. No	Course Code (KAHE)	Course Title (KAHE)	NPTEL Certificate /Roll No	Duration	Credits	Marks	Grade Awarded

Grades to be incorporated in the Semester:

I		II		III		IV		V		VI		VII		VIII	

For Scrutiny and Tabulation Section:

Grades Incorporated in the Semester: _____ **Grade Awarded: _____**

CONTROLLER OF EXAMINATION

KARPAGAM ACADEMY OF HIGHER EDUCATION
(Deemed to be University Established Under Section 3 of UGC Act 1956)
FACULTY OF ENGINEERING
B.E -BIOMEDICAL ENGINEERING
COURSE OF STUDY AND SCHEME OF EXAMINATION
(2025 BATCH ONWARDS)

Semester – I													
Course code	**Course Title**	**Category**	**Outcomes**		**Instruction hours/wee k**			**Credit(s)**	**Maximum Marks**			**Page No.**
			PO	**PSO**	**L**	**T**	**P**		**CIA**	**ESE**	**TOTAL**	
25BEHS101G	Technical English I	HS	5,7,8,9,11	1	3	0	0	3	40	60	100	1
25BEHS103G	Matrices and Calculus	BS	1,2,3,11	1	3	1	0	4	40	60	100	3
25BEBME101	Biology for Engineers	ES	1,2,8,9	1	3	0	0	3	40	60	100	5
25BEHS145G	Engineering Chemistry	BS	1,2,3,6,7,8,9,11	1	3	0	2	4	40	60	100	7
25BTAD142G	Python Programming	ES	1,2,3,4,5,7,8,9, 11	1	3	0	2	4	40	60	100	9
25BEMC151G	Women Safety and Security	MC	-	-	1	0	0	0	100	-	100	182
25BEMC152G	தமிழர் மரபும் பண்பாடும்	MC	-	-	1	0	0	0	100	-	100	183
				Total	**17**	**1**	**4**	**18**	**400**	**300**	**700**	

Semester -II													
Course code	**Course Title**	**Category**	**Outcomes**		**Instruction hours/wee k**			**Credit(s)**	**Maximum Marks**			**Page No.**
			PO	**PSO**	**L**	**T**	**P**		**CIA**	**ESE**	**TOTAL**	
25BEHS201G	Technical English II	HS	7,8,9,11	1	3	0	0	3	40	60	100	11
25BEHS202CG	Transforms and its Applications	BS	1,2,3,11	1,2	3	1	0	4	40	60	100	13
25BEHS208G	Environmental Studies	BS	1,2,6,7,11	1	3	0	0	3	40	60	100	15
25BEBME201	Introduction to Biomedical Engineering	ES	1,2,6,8,9,11	1	3	0	0	3	40	60	100	17
25BEHS242G	Engineering Physics	ES	1,2,8,9,11	1	3	0	2	4	40	60	100	19
25BEBME241	Electronics for Biomedical Engineers	ES	1,2,8,9	1	3	0	2	4	40	60	100	21
25BEHS211G	Communication Skills Lab	HS	5,7,8,9,11	1	0	0	2	1	40	60	100	23
25BEMC251G	Yoga	SD	-	-	1	0	2	2	100	-	100	185
25BEMC252G	Vedic Mathematics	MC	-	-	1	0	0	0	100	-	100	186
				SEMESTER TOTAL	**20**	**1**	**8**	**24**	**480**	**420**	**900**	

SEMESTER-III

Course Code	Course Title	Category	Outcomes		Instruction Hours/week			Credit(s)	Maximum Marks			Page No
			PO	PSO	L	T	P		CIA	ESE	Total	
THEORY												
25BEHS301BG	Numerical Methods	BS	1,2,8,9 / 1,2,3	2 / 1	3	1	0	4	40	60	100	25
25BEBME302	Human Anatomy and Physiology	PC	1,2,8,9,11	1	3	0	0	3	40	60	100	27
25BEBME303	Biosensors and Measurements	PC	1,2,3,8,9,11	1	3	0	0	3	40	60	100	29
25BEBME304	Signals and Systems	PC	1,2,3,8,9,11	1	3	0	0	3	40	60	100	31
25BEBME305	Analog and Digital Integrated Circuits	PC	1,2,3,8,9,11	1	3	0	0	3	40	60	100	33
25BECS341AG	Data Structures and Algorithms	ES	1,2,3,5,8,9	2	3	0	2	4	40	60	100	35
PRACTICALS												
25BEBME311	Biosensors and Measurements Laboratory	PC	1,2,3,8,9,11	1,2	0	0	2	1	40	60	100	37
25BEBME312	Analog and Digital Integrated Circuits Laboratory	PC	1,2,3,4,8,9, 11	1,2	0	0	2	1	40	60	100	38
25BEBME313	Skill Development -I Medical Coding	SD	1,2,5,6,8,9, 11	2	0	0	2	1	100	-	100	39
MANDATORY COURSE												
25BEMC351G	Aptitude and Reasoning	MC	-		1	0	0	0	100	-	100	187
MINI PROJECT												
25BEBME391	Mini Project	PW	-		0	0	2	1	100	-	100	40
				SEMESTER TOTAL	**19**	**1**	**10**	**24**	**620**	**480**	**1100**	

SEMESTER-IV

Course Code	Course Title	Category	Outcomes		Instruction Hours/week			Credit(s)	Maximum Marks			Page No
			PO	PSO	L	T	P		CIA	ESE	Total	
THEORY												
25BEBME401	Microcontroller and Embedded system	PC	1,2,3,8,9,11	1,2	3	0	0	3	40	60	100	41
25BEBME402	Biomedical Signal Processing	PC	1,2,3,8,9,11	1,2	3	1	0	4	40	60	100	43
25BEBME403	Bio Instrumentation	PC	1,2,8,9,11	1,2	3	0	0	3	40	60	100	45
25BEBME404	Sustainable Biomaterials	PC	1,2,3,6,7,8,9, 11	1,2	3	0	0	3	40	60	100	47
25BEBME405	Biomedical waste Management	PC	1,2,3,4,5,6,7, 8,9,11	1	3	0	0	3	40	60	100	49
25BEBME444G	Java Programming	PC	1,2,3,4,5,6,7, 8,9,11	1,2	3	0	2	4	40	60	100	51
PRACTICALS												
25BEBME411	Biomedical Signal Processing Laboratory	PC	1,2,3,4,5,6,7 ,8,9,11	1,2	0	0	2	1	40	60	100	53
25BEBME412	Biomedical Instrumentation Laboratory	PC	1,2,3,7,8,9, 11	1,2,	0	0	2	1	40	60	100	54
25BEBME413	Skill Development -II Medical Device Calibration	SD	1,2,5,6,7,8,9 ,11	1,2	0	0	2	1	100	-	100	55
MANDATORY COURSE												
25BEMC452G	Essence of Indian Traditional Knowledge and Heritage	MC	-		1	0	0	0	100	-	100	189
25BEBME491	Internship / Field Project- I	PW	-		0	0	2	1	100	-	100	56
SEMESTER TOTAL			-		**19**	**1**	**10**	**24**	**620**	**480**	**1100**	

SEMESTER-V

Course Code	Course Title	Category	Outcomes		Instruction Hours/week			Credit(s)	Maximum Marks			Page No
			PO	PSO	L	T	P		CIA	ESE	Total	
THEORY												
25BEBME501	Internet of MedicalThings (IoMT)	PC	1,2,3,8,9, 11	1	3	0	0	3	40	60	100	57
25BEBME502	Biomedical Image Processing	PC	1,2,3,8,9, 11	1,2	3	0	0	3	40	60	100	59
25BEBME503	Biocontrol System	PC	1,2,3,8,9, 11	1	3	1	0	4	40	60	100	61
25BEBME504	Medical Diagnostic and TherapeuticEquipment	PC	1,2,3,6,7,8, 9,10	1,2	3	0	0	3	40	60	100	63
25BEBME5E--	Professional Elective-I	PE	-	-	3	0	0	3	40	60	100	68
25BEBME5E--	Professional Elective-II	PE	-	-	3	0	0	3	40	60	100	68
PRACTICALS												
25BEBME511	Internet of Medical Things Laboratory	PC	1,2,3,5,8,9, 11	1,2	0	0	2	1	40	60	100	65
25BEBME512	Biomedical Image Processing Laboratory	PC	1,2,3,5,8,9, 11	2	0	0	2	1	40	60	100	66
25BEBME513	Medical Diagnostic and TherapeuticEquipment Laboratory	PC	1,2,3,4,5,6, 8,9,10	1,2	0	0	2	1	40	60	100	67
MANDATORY COURSE												
25BEMC551G	Cyber Security	MC	-		1	0	0	0	100	-	100	190
SEMESTER TOTAL					**19**	**1**	**6**	**22**	**460**	**540**	**1000**	

SEMESTER-VI

Course Code	Course Title	Category	Outcomes		Instruction Hours/week			Credit(s)	Maximum Marks			Page No
			PO	PSO	L	T	P		CIA	ESE	Total	
THEORY												
25BEHS601G	Universal Human Values	HS	1,2,3,7,8,9, 11	1	1	0	2	2	40	60	100	69
25BEBME602	Artificial Intelligence in Healthcare	PC	1,2,3,6,7,8, 9,10	2	3	0	0	3	40	60	100	71
25BEBME603	Biomechanics	PC	1,2,3,6,7,8, 9,10	1,2	3	1	0	4	40	60	100	73
25BEBME6E_	Professional Elective-III	PE	-	-	3	0	0	3	40	60	100	79
25BEBME6E-	Professional Elective-IV	PE	-	-	3	0	0	3	40	60	100	79
PRACTICALS												
25BEBME611	Artificial Intelligence Laboratory	PC	1,2,3,4,5,9, 10	2	0	0	2	1	40	60	100	75
25BEBME612	Biomechanics Laboratory	PC	1,2,3,4,5, 6,7,8,9,10	1	0	0	2	1	40	60	100	76
25BEBME613	Community Engagement and Social Responsibility	ES	-	-	1	0	2	2	100	-	100	77
MANDATORY COURSE												
25BEMC651	Design Thinking	MC	-		1	0	0	0	100	-	100	191
				SEMESTER TOTAL	**15**	**1**	**8**	**19**	**480**	**420**	**900**	

SEMESTER-VII

Course Code	Course Title	Category	Outcomes		Instruction Hours/week			Credit(s)	Maximum Marks			Page No
			PO	PSO	L	T	P		CIA	ESE	Total	
THEORY												
25BEBME701	Rehabilitation Engineering	PC	1,2,3,8,9, 11	1	3	0	0	3	40	60	100	80
25BEBME702	Radiology and Nuclear medicine	PC	1,2,3,9, 10	1	3	0	0	3	40	60	100	82
25BEBME7E_ _	Professional Elective-V	PE	-	-	3	0	0	3	40	60	100	84
25BEBME7E_ _	Professional Elective -VI	PE	-	-	3	0	0	3	40	60	100	84
PROJECT WORK												
25BEBME791	Project Work Phase -I / Internship/Field Project-II	PW	-		0	0	8	4	80	120	200	84
SEMESTER TOTAL					**12**	**0**	**8**	**16**	**240**	**360**	**600**	

SEMESTER-VIII

Course Code	Course Title	Category	Instruction Hours/week			Credit(s)	Maximum Marks			Page No
			L	T	P		CIA	ESE	Total	
PROJECT										
25BEBME891	Project Work Phase - II	PW	0	0	16	8	120	180	300	85
SEMESTER TOTAL			**0**	**0**	**16**	**8**	**120**	**180**	**300**	

OPEN ELECTIVES

CourseCode	Course Title	Category	Instruction Hours/week			Credit(s)	Maximum Marks			Page No
			L	T	P		CIA	ESE	Total	
Open Elective-I	Swayam/NPTEL	OE	-	-	-	3	-	-	-	-
Open Elective-II	Swayam/NPTEL	OE	-	-	-	3	-	-	-	-
TOTAL			**0**	**0**	**0**	**6**	**-**	**-**	**-**	**-**
PROGRAMME TOTAL			**121**	**6**	**68**	**161**	**3420**	**3180**	**6600**	

PROFESSIONAL ELECTIVES

Professional Elective/ Vertical	Vertical 1	Vertical 2	Vertical 3	Vertical 4
	Bio Engineering	**Biowearable Systems**	**Embedded System**	**Medical Device Design and Development**
Professional Elective I	Cell Biology	Analog and Digital Communication	Embedded System	Medical Device Design
	Biomedical Informatics	Wearable Devices	ARM Controller	Applied Design thinking for Biomedical Engineers
Professional Elective II	BIOMEMS	Body Area Networks	Embedded Programming	Integrated Medical Product Development
	Clinical Engineering	Virtual Reality and Augmented Reality in Healthcare	Embedded Networking	Medical Ethics
Professional Elective III	Micro Fluidics	Telemedicine	Electronic System Design	Software Design tools for Biosensing and Control
	Biomimetics	Medical Sensors MEMS and NEMS	Real Time Operating System	Rapid Prototyping
Professional Elective IV	Biofluid Mechanics	Laser in Medicine	Hardware-Software Co-Design	Medical Regulatory Affairs
	Robotics and Automation in Medicine	Biometric Systems	Advanced Digital system design	Biomedical Device Design and Development
Professional Elective V	Intellectual Property Rights	Speech Processing	Embedded Communication software design	Quality Assurance and Safety in Healthcare
	Bioergonomics	Brain Computer Interface	Embedded Sensor Networks	Sterilization Techniques for Biomedical devices
Professional Elective VI	Genetic Engineering	Cognitive Engineering	Embedded Systems Security	Graphical System Design for Biomedical Engineers
	Quality Control for Biomedical Devices	Cognitive Psychology	Embedded Product Development	Healthcare System Design

Professional Elective												
Course Code	Course Title	Category	Outcomes		Instruction Hours/week			Credit(s)	Maximum Marks			Page No
			PO	PSO	L	T	P		CIA	ESE	Total	
ELECTIVE I												
25BEBME5E01	Cell Biology	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	86
25BEBME5E02	Biomedical Informatics	PE	1,2,3,8,9	1,2	3	0	0	3	40	60	100	88
25BEBME5E03	Analog and Digital Communication	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	110
25BEBME5E04	Wearable Devices	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	112
25BEBME5E05	Embedded System	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	134
25BEBME5E06	ARM Controller	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	136
25BEBME5E07	Medical Device Design	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	158
25BEBME5E08	Applied Design thinking for Biomedical Engineers	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	160
ELECTIVE II												
25BEBME5E09	BIOMEMS	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	90
25BEBME5E10	Clinical Engineering	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	92
25BEBME5E11	Body Area Networks	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	114
25BEBME5E12	Virtual Reality and Augmented Reality in Healthcare	PE	1,2,3,8,9	1,2	3	0	0	3	40	60	100	116
25BEBME5E13	Embedded Programming	PE	1,2,3,8,9	1,2	3	0	0	3	40	60	100	138
25BEBME5E14	Embedded Networking	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	140
25BEBME5E15	Integrated Medical Product Development	PE	1,2,3,8,9	1,2	3	0	0	3	40	60	100	162
25BEBME5E16	Medical Ethics	PE	1,2,3,7,8,9	1	3	0	0	3	40	60	100	164
ELECTIVE III												
25BEBME6E01	Micro Fluidics	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	94
25BEBME6E02	Biomimetics	PE	1,2,3,8,9	1,2	3	0	0	3	40	60	100	96
25BEBME6E03	Telemedicine	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	118
25BEBME6E04	Medical Sensors MEMS and NEMS	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	120
25BEBME6E05	Electronic System Design	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	142
25BEBME6E06	Real Time Operating System	PE	1,2,3,8,9	1,2	3	0	0	3	40	60	100	144
25BEBME6E07	Software Design tools for Biosensing and Control	PE	1,2,3,8,9	1,2	3	0	0	3	40	60	100	166
25BEBME6E08	Rapid Prototyping	PE	1,2,3,8,9	1,2	3	0	0	3	40	60	100	168

ELECTIVE IV												
25BEBME6E09	Biofluid Mechanics	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	98
25BEBME6E10	Robotics and Automation in Medicine	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	100
25BEBME6E11	Laser in Medicine	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	122
25BEBME6E12	Biometric Systems	PE	1,2,3,8,9	1,2	3	0	0	3	40	60	100	124
25BEBME6E13	Hardware Software Codesign	PE	1,2,3,8,9	1,2	3	0	0	3	40	60	100	146
25BEBME6E14	Advanced Digital system design	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	148
25BEBME6E15	Medical Regulatory Affairs	PE	1,2,3,7,8,9	1	3	0	0	3	40	60	100	170
25BEBME6E16	Biomedical Device Design and Development	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	172
ELECTIVE V												
25BEBME7E01	Intellectual Property Rights	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	102
25BEBME7E02	Bioergonomics	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	104
25BEBME7E03	Speech Processing	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	126
25BEBME7E04	Brain Computer Interface	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	128
25BEBME7E05	Embedded Communication Software Design	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	150
25BEBME7E06	Embedded Sensor Networks	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	152
25BEBME7E07	Quality Assurance and Safety in Healthcare	PE	1,2,3,7,8,9	1	3	0	0	3	40	60	100	174
25BEBME7E08	Sterilization Techniques for Medical devices	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	176
ELECTIVE VI												
25BEBME7E09	Genetic Engineering	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	106
25BEBME7E10	Quality Control for Biomedical Devices	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	108
25BEBME7E11	Cognitive Engineering	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	130
25BEBME7E12	Cognitive Psychology	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	132
25BEBME7E13	Embedded Systems Security	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	154
25BEBME7E14	Embedded Product Development	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	156
25BEBME7E15	Graphical System Design for Biomedical Engineers	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	178
25BEBME7E16	Healthcare System Design	PE	1,2,3,8,9	1	3	0	0	3	40	60	100	180

KARPAGAM ACADEMY OF HIGHEREDUCATION
(Deemed to be University Established Under Section 3 of UGC Act 1956)
Pollachi Main Road, Eachanari Post, Coimbatore – 641 021. INDIA
FACULTY OF ENGINEERING
DEPARTMENT OF BIOMEDICAL ENGINEERING

S.No.	Course work - subject area	Credits/Semester								Credits Total	No. of courses	Percentage
		I	II	III	IV	V	VI	VII	VIII			
1	Humanities and Social Sciences **(HS)**	3	4	-	-	-	4	-	-	11	5	6.8
2	Basic Sciences **(BS)**	8	7	4	-	-	-	-	-	19	5	11.8
3	Engineering Sciences **(ES)**	7	11	4	-	-	-	-	-	22	6	13.7
4	Professional Core **(PC)**	-	-	15	23	16	9	6	-	69	27	42.8
5	Professional Electives**(PE)**	-	-	-	-	6	6	6	-	18	6	11.2
6	Open Electives **(OE)**	-	-	-	-	-	3	3	-	6	2	3.7
7	Project Work **(PW)**	-	-	-	-	-	-	4	8	12	2	7.5
8	Mandatory Courses **(MC)**	-	2	1	1	-	-	-	-	4	10	2.5
9	Total	18	24	24	24	22	22	19	8	**161**	62	100
TOTAL CREDITS 161												

SEMESTER I

B.E BIOMEDICAL ENGINEERING **2025-2026**

25BEHS101G	**TECHNICAL ENGLISH I**	**SEMESTER – I** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: English at 10+2 or equivalent level

COURSE OBJECTIVES

The goal of this course is for students to:

- To acquire the fundamental reading and writing skills, proper grammar usage, listening, and speaking
- To understand and improve skills in listening and speaking, in expressing oneself formally in writing, and in deducing meaning from what one reads
- To apply one's receptive (reading and listening) and productive (writing and speaking) language skills

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Replicate grammar usage in reading, speaking, and writing skills. P2
- Describe precise transitions while reading, writing, and speaking to enhance communication coherence and clarity. A2
- Report the interpretation of linguistic parameters in day-to-day reading, listening, and speaking interactions. A2
- Point out errors to restructure paragraphs, compose, compile, and synthesize documents for presentations. P2
- Demonstrate proficiency in reading, writing, and critical listening and the ability to interpret and articulate complex ideas persuasively in written and oral forms. A3

*P- Psychomotor skills, A-Affective Domain Skills

UNIT I **09**

Grammar : Parts of Speech – Gerunds and infinitives – Sentence Pattern
Reading : Reading comprehension: (vocabulary, referents, and inferences/conclusions)
Writing : Business letter – e-mail Writing
Listening : Listening to different short recordings – Listen to a longer recording
Speaking : Introduction to Phonetics, Diphthongs

UNIT II **09**

Grammar : Tenses: Simple Tenses – Concord – Types of Sentences
Reading : Identifying main and secondary information
Writing : Check lists – Building Itineraries
Listening : Listening Comprehension – Job Description
Speaking : Pronunciation – Describing people, places, jobs and things – Asking and answering questions

UNIT III **09**

Grammar : Tenses: Progressive Tenses – Direct and Indirect speech – Concord
Reading : Identifying, organizing, comparing and Interpreting information
Writing : Writing Articles – Paragraph Writing
Listening : Telephonic conversation
Speaking : Stress, Intonation – Self Introduction

UNIT IV **09**

Grammar : Tenses: Perfect Tenses – Active and Passive voice
Reading : Reading Comprehension (Reconstruction, Rewording)
Writing : Memo – Notice – Agenda
Listening : Critical Listening
Speaking : Oral presentation

UNIT V **09**

Grammar : Tenses: Perfect Continuous Tenses – Reported Speech
Reading : Reading Comprehension (Cause and Effect identification)
Writing : Creative writing – Copy Writing
Listening : Listening and Interpretation of ideas
Speaking : Group Discussion

TOTAL -45 Hours

TEXT BOOKS:

1. Richards J C, Hull J, et al., "Interchange 2 Student's Book", 5th Edition, Cambridge University Press, 2022.
2. Kumar Sanjay and Pushp Latha, "English Language and Communication Skills for Engineers", 1st Edition, Oxford University Press, 2018.

REFERENCE BOOKS:

1. Swan Michael and Walter Catherine, "Oxford English Grammar Course", 1st Edition, Oxford University Press, 2019.
2. Sudharshana N P and Savitha C, "English for Engineers", 1st Edition, Cambridge University Press, 2018.
3. Brook-Hart G, "Business Benchmark: Upper intermediate: Business Vantage: Student's Book", 2nd Edition, Cambridge University Press, 2021.

WEBSITES:

1. www.onestopenglish.com
2. www.britishcouncil.org
3. www.cambridgeenglish.org/learning-english/

CO, PO PSO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	-	-	-	-	2	-	2	2	3	-	2	1	-
CO2	-	-	-	-	2	-	2	2	3	-	2	1	-
CO3	-	-	-	-	2	-	2	2	3	-	2	1	-
CO4	-	-	-	-	2	-	2	2	3	-	2	1	-
CO5	-	-	-	-	2	-	2	2	2	-	2	1	-
Average	**-**	**-**	**-**	**-**	**2**	**-**	**2**	**2**	**2.8**	**-**	**2**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E BIOMEDICAL ENGINEERING **2025-2026**

25BEHS103G	**MATRICES AND CALCULUS**	**SEMESTER – I** **4H-4C**

Instruction Hours/week: L:3 T:1 P:0

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: Nil

COURSE OBJECTIVES

The goal of this course is for students to:

- To provide sufficient knowledge in calculus and matrix algebra in the respective fields
- To find an extremum value for a function of several variables subject to a given constraint.
- To provide knowledge in evaluating double and triple integrals
- To apply mathematical tools to solve second and higher order ODE and PDE with constant coefficients.

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Make use of orthogonal transformation to reduce the quadratic form to canonical form**(K3)**
- Utilize differential calculus of multivariable to optimization problems**(K3)**
- Apply multiple integrals for finding area and volume **(K3)**
- Solve the nth order Ordinary Differential Equations (ODE) and Homogeneous equation of Euler's type
- Solve the nth order Partial Differential Equations **(K3)**

UNIT I **MATRICES** **12**

Eigenvalues and Eigenvectors of a real matrix– Characteristic equation – Properties of Eigenvalues and Eigenvectors – Cayley-Hamilton theorem – Diagonalization of matrices by orthogonal transformation – Reduction of a quadratic form to canonical form by orthogonal transformation – Nature of quadratic forms

UNIT II **DIFFERENTIAL CALCULUS OF MULTIVARIABLE FUNCTIONS** **12**

Partial differentiation – Homogeneous functions and Euler's theorem – Total derivative – Change of variables – Jacobians – Partial differentiation of implicit functions –Maxima and minima of functions of two variables – Lagrange's method of undetermined multipliers

UNIT III **MULTIPLE INTEGRALS** **12**

Definite and Indefinite Integrals – Double integrals – Change of order of integration – Double integrals in polar coordinates – Area using double integrals – Evaluation of Triple Integrals- Volume of Solids.

UNIT IV **ORDINARY DIFFERENTIAL EQUATIONS** **12**

Linear differential equation of second and higher order with constant coefficients –Cauchy-Euler linear differential equation – Method of Variation of parameters

UNIT V **PARTIAL DIFFERENTIAL EQUATIONS** **12**

Homogeneous linear partial differential equations of second and higher order with constant coefficients – Classification of partial differential equations.

TOTAL -45 + 15 Hours

TEXT BOOKS:

1. Hass, Heil and Weir, "Thomas Calculus", 14th Edition, Pearson Education, 2018.
2. Dennis G. Zill, "Advanced Engineering Mathematics", 7th Edition, Jones & Bartlett Learning, 2022.

REFERENCE BOOKS:

1. Rogawski, Adams and Franzosa, “Calculus”, 4th Edition, W. H. Freeman, 2019.
2. Boyce, DiPrima and Meade, “Elementary Differential Equations and Boundary Value Problems”, 12th Edition, John Wiley & Sons, 2021.
3. Alexander Graham, “Matrix Theory and Applications for Scientists and Engineers”, 1st Edition, Dover Publications Inc.,2018.
4. Grewal, B. S.,Higher engineering mathematics. 2018, Khanna Publishers, New Delhi.

WEBSITES:

1. www.classcentral.com/course/matrix-methods-13644
2. www.classcentral.com/course/brilliant-calculus-ii-59290
3. www.classcentral.com/course/differential-equations-engineers-13258

CO, PO PSO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	-	-	-	-	-	-	-	1	1	-
CO2	3	2	1	-	-	-	-	-	-	-	1	1	-
CO3	3	2	1	-	-	-	-	-	-	-	1	1	-
CO4	3	2	1	-	-	-	-	-	-	-	1	1	-
CO5	3	2	1	-	-	-	-	-	-	-	1	1	-
Average	**3**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, ‘-’ - No Correlation

B.E BIOMEDICAL ENGINEERING **2025-2026**

25BEBME101	**BIOLOGY FOR ENGINEERS**	**SEMESTER – I** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: Nil

COURSE OBJECTIVES

The goal of this course is for students to:

- Explain the cell structure and biomolecules
- Compare the bioengineering principle and bioinspired mechanism
- Infer the technological advancement in bioengineering for diseases diagnosis

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the structure and functions of cell (K2)
- Outline the applications of biomolecules (K2)
- Demonstrate the anatomical principles for bioengineering (K2)
- Interpret the nature inspired materials and mechanisms (K2)
- Summarize the trends in bioengineering (K2)

UNIT I **CELL** **09**

Introduction. Structure and functions of a cell. Stem cells and their application. Biomolecules: Properties and functions of Carbohydrates, Nucleic acids, proteins, lipids. Importance of special biomolecules: Properties and functions of enzymes, vitamins and hormones.

UNIT II **BIOMOLECULES** **09**

Carbohydrates in cellulose-based water filters production, PHA and PLA in bioplastics production, Nucleic acids in vaccines and diagnosis, Proteins in food production, lipids in biodiesel and detergents production, Enzymes in biosensors fabrication, food processing, detergent formulation and textile processing.

UNIT III **ANATOMICAL PRINCIPLES FOR BIOENGINEERING** **09**

Brain as a CPU system. Eye as a Camera system. Heart as a pump system. Lungs as a purification system. Kidney as a filtration system.

UNIT IV **BIOINSPIRED MECHANISMS** **09**

Echolocation, Photosynthesis. Bird flying, Lotus leaf effect, Plant burrs, Shark skin, Kingfisher beak. Human Blood substitutes - hemoglobin-based oxygen carriers (HBOCs) and perfluorocarbons (PFCs).

UNIT V **ADVANCEMENTS IN BIOENGINEERING FOR DISEASE DIAGNOSIS** **09**

Muscular and Skeletal Systems as scaffolds, scaffolds and tissue engineering, Bioprinting techniques and materials. Electronic tongue and nose, DNA origami and Biocomputing, Bioimaging and Artificial Intelligence for disease diagnosis

TOTAL -45 Hours

TEXT BOOKS:

1. Biology for Engineers, Rajendra Singh C and Rathnakar Rao N, Rajendra Singh C and Rathnakar Rao N Publishing, Bengaluru, 2023.
2. Human Physiology, Stuart Fox, Krista Rompolski, McGraw-Hill eBook. 16th Edition, 2022
3. Biology for Engineers, Thyagarajan S., Selvamurugan N., Rajesh M.P., Nazeer R.A., Thilagaraj W., Barathi S., and Jaganthan M.K., Tata McGraw-Hill, New Delhi, 2012.
4. Biology for Engineers, Arthur T. Johnson, CRC Press, Taylor and Francis, 2011
5. Biomedical Instrumentation, Leslie Cromwell, Prentice Hall 2011.

REFERENCE BOOKS:

1. Biology for Engineers, Sohini Singh and Tanu Allen, Vayu Education of India, New Delhi, 2014.
2. Biomimetics: Nature-Based Innovation, Yoseph Bar-Cohen, 1st edition, 2012, CRC Press.

WEBSITES:

1. https://nptel.ac.in/courses/121106008
2. https://www.coursera.org/courses?query=biology
3. https://onlinecourses.nptel.ac.in/noc19_ge31/preview
4. https://www.classcentral.com/subject/biology
   https://www.futurelearn.com/courses/biology-basic-concepts

CO, PO PSO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	2	1	-	-	-	-	-	1	1	-	-	1	-
CO5	2	1	-	-	-	-	-	1	1	-	-	1	-
Average	2	1	-	-	-	-	-	1	1	-	-	1	-

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEHS145G	ENGINEERING CHEMISTRY (THEORY & LABORATORY)	SEMESTER – I 5H-4C

Instruction Hours/week: L:3 T:0 P:2

Marks: Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

PREREQUISITES: Nil

i)Theory

COURSE OBJECTIVES

The goal of this course is for students to:

- Summarize water treatment process and engineering materials.
- Acquire knowledge on fuels, lubricants and principles of corrosion.
- Explain the concepts of analytical techniques and its applications

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Identify the quality of water and its treatment methodologies (K3)
- Interpret the basics of engineering materials and its applications (K2)
- Outline the methods to enhance the quantity & quality of fuels and Lubricants (K2)
- Illustrate the types of corrosion and its prevention techniques (K2)
- Demonstrate the principle and working of analytical techniques (K3)

UNIT I **WATER TECHNOLOGY** **09**

Sources-Characteristics - Specification for drinking water, BIS &WHO-Alkalinity- Types of alkalinities and determination - Hardness - Types and estimation by EDTA method - Domestic water treatment - Disinfection methods (Chlorination, Ozonation. UV treatment) - Boiler feed water - Requirements - Disadvantages of using hard water in boilers - Internal conditioning (Phosphate, Calgon and Carbonate conditioning methods) - External conditioning - Demineralization process - Desalination - Reverse osmosis.

UNIT II **ENGINEERING MATERIALS** **09**

Plastics – Thermoplastics & Thermosets. Preparation, properties and engineering applications of Poly vinyl chloride and Bakelite. Alloys – Introduction – Definition – Properties of alloys – Significance of alloying, functions and effect of alloying elements – Nichrome and stainless steel (18/8) – Heat treatment of steel. Refractories – Definition, classification, properties (refractoriness, refractoriness under load, porosity and thermal spalling), failure of refractories. Composites– Properties and applications of Metal matrix composites (MMC), Ceramic matrix composites and Polymer matrix composites.

UNIT III **FUELS AND LUBRICANTS** **09**

. Fuels – Introduction- Analysis of coal (proximate and ultimate), Carbonization- Manufacture of metallurgical coke (Otto Hoffmann method) – Petroleum and Diesel: Manufacture of synthetic petrol (Bergius process), Knocking – Octane number– Cetane number- Power alcohol and biodiesel. Lubricants – Introduction – Characteristics of a good lubricant – Classification, Physical and Chemical Properties – Mechanism of lubricants – Applications

UNIT IV **CORROSION AND ITS CONTROL** **09**

Chemical and Electrochemical corrosion - Galvanic corrosion - Differential aeration corrosion- Factors influencing the rate of corrosion - Corrosion control - Sacrificial anode and Impressed current cathodic methods - Corrosion inhibitors - Protective coatings - Organic coatings-Paints - Constituents and functions Inorganic coatings- Metallic coatings - Electroplating (Au) and Electro less plating (Ni) - Surface conversion coating - Hot dipping.

UNIT V ANALYTICAL TECHNIQUES AND APPLICATIONS 09

Introduction-Instrumentation and applications of Colorimetry, Flame Photometry, Potentiometry, Conductometry (Strong acid with strong base, Mixture of acids with strong base, precipitation titrations)- Electronic spectroscopy- Vibrational spectroscopy-Atomic Absorption spectroscopy.

TOTAL Hours: 45 + 30

TEXT BOOKS:

1. P C Jain & Monica Jain, Engineering Chemistry, 18th edition, Dhanpat Rai Publishing Company, 2022
2. Shivani Jaggi Guleria, "Engineering Chemistry", Concept for engineers, 1st Edition, Atlantic, 2021.
3. S S Dara, S S Umare, "A Text book of Engineering Chemistry", 12th Edition, S Chand, 2015.
4. B. H. Mahan, University chemistry, Pearson Education, 2010
5. R V Gadag, A Nithyananda Shetty, "Engineering Chemistry", 3rd Edition, Wiley India Pvt, 2019.

REFERENCE BOOKS:

1. M. J. Sienko and R. A. Plane, Chemistry: Principles and Applications. 5th edition, McGraw-Hill Higher Education, 1976
2. C. N. Banwell, Fundamentals of Molecular Spectroscopy, McGraw-Hill, 2001
3. P. W. Atkins, Physical Chemistry, Oxford University Press, 2022
4. B. L. Tembe, Kamaluddin and M. S. Krishnan, Engineering Chemistry (NPTEL Web- book)
5. K. P. C. Volhardt and N. E. Schore, 5th Edition, Organic Chemistry: Structure and Function, W.H. Freeman Publications, 2014

WEBSITES:

1. https://www.bspublications.net/downloads/0523ff2e4a5331_chemistry_ch_01_JNTUK.pdf
2. https://www.uobabylon.edu.iq/eprints/publication_10_31957_6172.pdf
3. https://www.researchgate.net/publication/265602506_chapter_engineering_materials_and_engineering_plastics

ii) Laboratory

LIST OF EXPERIMENTS

1. Determination of Ca / Mg using complexometric titration
2. Determination of chloride content of water
3. Determination of the rate of corrosion by weight loss method
4. Conductometry - Determination of conductance of solutions (strong acid Vs strong base)
5. pH Metry - Determination of Acid/Base
6. Potentiometry - Estimation of iron content in a water sample.
7. Estimation of Copper and Zinc in Brass

CO, PO PSO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	-	-	2	1	1	-	-	1	1	-
CO2	2	1	-	-	-	2	1	1	-	-	1	1	-
CO3	2	1	-	-	-	2	1	1	-	-	1	1	-
CO4	2	1	-	-	-	2	1	1	-	-	1	1	-
CO5	3	2	-	-	-	2	1	1	-	-	1	1	-
Average	**2.4**	**1.4**	**1**	**-**	**-**	**2**	**1**	**1**	**-**	**-**	**1**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E BIOMEDICAL ENGINEERING **2025-2026**

25BTAD142G	**PYTHON PROGRAMMING (THEORY & LABORATORY)**	**SEMESTER – I 5H-4C**

Instruction Hours/week: L:3 T:0 P:2

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: Nil

i) THEORY

COURSE OBJECTIVES

The goal of this course is for students to:

- Learn about basic python syntax and semantics like control structures and functions.
- Develop logical thinking abilities and to propose novel solutions for real world problems through object-oriented programming concepts.
- Model the empirical knowledge on applying programming on business domains

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Interpret the basic representation of the data structures and sequential programming (K2)
- Solve the problems using list, dictionaries, tuples, and sets core data structures (K3)
- Build applications using functions, modules and packages (K3)
- Examine the error-handling constructs for unanticipated states/inputs. (K4)
- Analyze the applications on real-world problems using object-oriented concepts (K4)

UNIT I INTRODUCTION TO PYTHON BASICS 09

Fundamentals of Computing - Building blocks of algorithms - Introduction to Programming - Elements of python - Variables - Data Types - Operators - Operator Precedence - Expressions - Conditional statement - Loops - Break, Continue and Pass - Illustrative problems: square root, GCD, LCM, Sum an array of numbers, Linear search, Binary search..

UNIT II PYTHON DATA STRUCTURES 09

Mutable vs immutable data types - String - Indexing and slicing - String functions - List - List slices - List methods - Iterate over a list - Mutability - Aliasing - Cloning lists - List parameters - List comprehension- Tuples- Tuple assignment - Tuple as return value - Dictionaries - Operations and methods - Set - Set operations - Illustrative programs: Simple sorting, pattern matching, Fibonacci, Factorial, Prime numbers.

UNIT III FUNCTIONS, MODULES AND PACKAGES 09

Built-in functions - User defined functions - Creating function - Calling functions - Types of function arguments - Recursion and lambda or anonymous functions - Packages: Defining - Creating and accessing a package - Python libraries NumPy, pandas, Matplotlib - Flask/Django

UNIT IV FILE HANDLING, CLASS AND OBJECT 09

Introduction to files - File path - Opening and closing files - Reading and writing files - File position - Decorators - Introduction to elements of OOP - Class - Object - Inheritance - Data abstraction - Encapsulation - Polymorphism - UML class diagram - Access specifiers - Creating classes - Creating object - Accessing members - init() method - Instance, static and class methods - Importance of self - Implementing encapsulation. Illustrative programs: File operations on TEXT and CSV, Scientific calculator using class and objects.

UNIT V **ERROR HANDLING, TESTING** **09**

Exception handling with try, except, finally - Exception handling: Errors vs exceptions - Handling exceptions - Raising exception - Creating user defined exception - Debugging techniques- Unit testing with unit test - Writing test cases - web scraping - Data analysis project - Automation script

TOTAL -45 Hours

TEXT BOOKS:

1. Allen B Downey,Jeffrey Elkne, Chris Meyers ,"How to Think Like a Computer Scientist: Learning with Python 3 Documentation",3rd Edition, Green Tea Press,2020.
2. Steven F. Lott ,Dusty Phillips,"Python Object-Oriented Programming: Build robust and maintainable object-oriented Python applications and libraries"4th Edition , Packt Publishing Limited ,2021.

REFERENCE BOOKS:

1. R. Nageswara Rao," Core Python Programming", 3rd Edition, Dream tech Press,2022.
2. Mark Lutz , "Learning Python" ,5th Edition , O'Reilly Publication , 2018.
3. Mark and Summerfield , "Programming in Python 3",2ndEdition ,Dorling Kindersley India Pvt. Ltd, 2019.

WEBSITES:

1. R https://realpython.com/
2. www.programiz.com/python-programming
3. https://www.geeksforgeeks.org/python-programming-language/
4. https://www.pythonspot.com/

ii) LABORATORY

LIST OF EXPERIMENTS:

1. Write conditional and looping statements in Python.
2. Create and manipulate strings using indexing, slicing,and various string functions.
3. Create and manipulate lists using operations, slices, methods, list comprehension, and looping.
4. Create and manipulate tuples, dictionaries, and sets, and understand the differences between mutable and immutable types.
5. Implement user-defined functions and understand the different types of function arguments, such as positional, keyword, and default arguments.
6. Implement inheritance and understand the different types of inheritance.
7. Implement polymorphism through method overloading, overriding, and operator overloading.

TOTAL HOURS: 30

CO, PO PSO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	1	-	-	-	-	-	2	2	-	1	-	3
CO2	3	2	1	-	-	-	-	2	2	-	1	-	3
CO3	3	2	1	-	-	-	-	2	2	-	1	-	3
CO4	3	3	2	1	-	-	-	2	2	-	1	-	3
CO5	3	3	2	1	-	-	-	2	2	-	1	-	3
Average	**2.8**	**2.4**	**1.4**	**1**	**-**	**-**	**-**	**2**	**2**	**-**	**1**	**-**	**3**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

SEMESTER II

B.E BIOMEDICAL ENGINEERING **2025-2026**

25BEHS201G	**TECHNICAL ENGLISH II**	**SEMESTER – II** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: Technical English - I

COURSE OBJECTIVES

The goal of this course is for students to:

- To acquire the context of grammar and the importance of Listening, Speaking, Reading and Writing
- To understand and develop critical Listening, Speaking, Reading, and Writing skills
- To apply students' capability to listen vigilantly, read proficiently, innovative writing, and speak fluently

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Demonstrate the aspects of writing, speaking, reading, and listening with grammar. P2
- Refine speaking, listening, reading, and writing skills in the social milieu. P3
- Justify the text critically in reading, writing, speaking, and listening. A3
- Differentiate grammatical structures in reading and listening and apply the structure in speaking and writing. A3
- Adapt writing, reading, listening, and speaking rules in formal and informal situations. P3

*P- Psychomotor skills, A-Affective Domain Skills

UNIT I **09**

Grammar : Prepositions – Adjectives – Adverbs
Reading : Reading comprehension: Skimming and Scanning
Writing : Letter writing (Formal and Informal) – Letter to Editor
Listening : Listening to Business talks – TED Talks

UNIT II **09**

Grammar : Use of sequence words – Modal Verbs
Reading : Mind Mapping (Structured thinking and related ideas)
Writing : Interpreting visual materials – Note Making – Recommendations
Listening : Listening to specific tasks – Focused Listening – Note Taking.
Speaking : Making presentations on given topics – Speaking in formal Situations

UNIT III **09**

Grammar : Contextual usage of Tenses – Connectives
Reading : Cohesion and Coherence in Reading
Writing : Paragraph writing: Compare and Contrast – Cause and Effect – Jumbled Sentences
Listening : Listening and responding to video lectures
Speaking : Role-play – Group Interaction

UNIT IV **09**

Grammar : WH Questions – Identifying Common Errors
Reading : Critical Reading Shifting facts from opinions
Writing : Resume writing with cover letter – Free writing
Listening : Watching videos or documentaries and answering
Speaking : Responding to questions – Mock Interviews

UNIT V **09**

Grammar : Use of Imperatives – Confusing words in English
Reading : Reading and making inference
Writing : Essay writing – Report – Proposals
Listening : Listening to different accents – Listening to Speeches
Speaking : Impromptu Speeches – Describing a process

TOTAL -45 Hours

TEXT BOOKS:

1. Richards J C, Hull J, et al. "Interchange 3 Student's Book", 5th Edition, Cambridge University Press, 2022.
2. Harding, Keith, and Appleby, Rachel, "International Express: Pre-Intermediate: Student's Book", 3rd Edition, Oxford University Press, 2019.

REFERENCE BOOKS:

1. Swan, Michael and Walter Catherine, "Oxford English Grammar Course", 1st Edition, Oxford University Press, 2019.
2. Sudharshana N P and Savitha C, "English for Engineers", 1st Edition, Cambridge University Press, 2018.
3. Brook-Hart G, "Business benchmark: Upper intermediate: Business vantage: Student's book", 2nd Edition, Cambridge University Press, 2021.

WEBSITES:

1. www.myenglishpages.com
2. www.cambridgeenglish.org/learning-english/
3. www.eslvideo.com/index.php

CO, PO PSO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	-	-	-	-	2	-	2	2	3	-	2	1	-
CO2	-	-	-	-	2	-	2	2	3	-	2	1	-
CO3	-	-	-	-	2	-	2	2	3	-	2	1	-
CO4	-	-	-	-	2	-	2	2	3	-	2	1	-
CO5	-	-	-	-	2	-	2	2	2	-	2	1	-
Average	**-**	**-**	**-**	**-**	**2**	**-**	**2**	**2**	**2.8**	**-**	2	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEHS202CG **TRANSFORMS AND ITS APPLICATIONS** **SEMESTER – II**
4H-4C

Instruction Hours/week: L:3 T:1 P:0

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: Matrices and Calculus

COURSE OBJECTIVES

The goal of this course is for students to:

- To understand the concept of periodic functions and represent it as Fourier series.
- To provide knowledge of Fourier series techniques in solving heat flow problems and wave equations.
- To acquaint Fourier transforms techniques used in various applications.
- To impart the knowledge of Laplace Transforms and Inverse Laplace Transforms techniques and its applications.

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Illustrate Fourier series representation of periodic functions (K2)
- Apply Fourier series in one dimensional heat flow and wave equation (K3)
- Make use of Fourier transform for converting elementary functions into frequency domain (K3)
- Utilize Laplace Transform to convert time-domain systems into frequency-domain systems (K3)
- Apply Inverse Laplace Transform in linear differential equations (K3)

UNIT I **FOURIER SERIES** **12**

Dirichlet's conditions – General Fourier series in the interval (0,2l) & (-l,l) – Half range sine series –Half range cosine series –Parseval's Identity – Harmonic analysis.

UNIT II **APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS** **12**

Fourier series solution for one dimensional wave equation – Fourier series solution for one dimensional heat equation with zero end conditions

UNIT III **FOURIER TRANSFORMS** **12**

Fourier Integral Theorem – Fourier transform pair –Fourier sine and cosine transforms –Properties – Convolution theorem – Parseval's identity of Fourier transform.

UNIT IV **LAPLACE TRANSFORM** **12**

Transforms of standard functions – Properties of Laplace transform – Transforms of derivatives and integrals –Initial and final value theorem – Transforms of periodic functions.

UNIT V **INVERSE LAPLACE TRANSFORM** **12**

Inverse Laplace transforms of standard functions – Inverse Laplace transform using second shifting theorem – Method of partial fractions– Convolution– Solution of ordinary differential equations with constant coefficients using Laplace transforms

TOTAL -45 +15 Hours

TEXT BOOKS:

1. Boyce, Diprima and Meade, "Elementary Differential Equations and Boundary Value Problems", 12th Edition, John Wiley & Sons, 2021.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, John Wiley and Sons, 2017

REFERENCE BOOKS:

1. T. Hillen, “Partial Differential Equations”, 2nd Edition, Friesen Press, 2019.
2. Dennis G. Zill, “Advanced Engineering Mathematics”, 7th Edition, Jones and Bartlett Publishers, 2020.
3. Richard Haberman, “Applied Partial Differential Equations with Fourier Series and Boundary Value Problems”, 5th Edition, Pearson, 2021.
4. Grewal B.S., “Higher Engineering Mathematics", 44thEdition, Khanna Publishers, New Delhi, 2018.

WEBSITES:

1. www.infocobuild.com/education/audio-video-courses/mathematics/Transform Techniques For Engineers-IIT-Madras/lecture-01.html
2. www.infocobuild.com/education/audio-video-courses/mathematics/ordinary-and-partial-differential-equations-iit-roorkee.html
3. www.electrical4u.com/laplace-transformation/

CO, PO PSO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	1	-	-	-	-	-	-	-	-	1	1	2
CO2	3	2	1	-	-	-	-	-	-	-	1	1	2
CO3	3	2	1	-	-	-	-	-	-	-	1	1	2
CO4	3	2	1	-	-	-	-	-	-	-	1	1	2
CO5	3	2	1	-	-	-	-	-	-	-	1	1	2
Average	**2.8**	**1.8**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**1**	**2**

1 - Low, 2 - Medium, 3 - High, ‘-’ - No Correlation

B.E BIOMEDICAL ENGINEERING **2025-2026**

25BEHS208G	**ENVIRONMENTAL STUDIES**	**SEMESTER – II** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: Nil

COURSE OBJECTIVES:

The goal of this course is for students to:

- Create a basic understanding about ecosystem and natural resources.
- Acquire knowledge on biodiversity conservation and pollution eradication.
- Introduce the roles and responsibilities about social issue and improvement in the interconnected world

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Outline the ecological processes supporting the life system (K2)
- Infer the importance of environment and impact of human activities on natural resources (K2)
- Demonstrate the levels and values of biodiversity and its conservation (K2)
- Summarize the problems of environmental pollution and its control measures (K2)
- Interpret the remediation methods for social issues and degraded environment (K2)

UNIT I **ENVIRONMENT & ECOSYSTEMS** **09**

Environment Definition, Scope and importance; layers of atmosphere-Ecosystem, Structure and functions of ecosystem. Energy flow, Food chains and food webs, Ecological succession. Classification of ecosystem. Forest ecosystem, Grassland Ecosystem, Desert ecosystem, Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries).

UNIT II **NATURAL RESOURCES** **09**

Natural resources - Renewable and Non - Renewable resources. Land resources and land use change, Land degradation, soil erosion and desertification. Forest resources- Deforestation: Causes and impacts due to mining, dam building on environment, forests, biodiversity and tribal populations. Water resources- Use and over-exploitation of surface and ground water, floods, droughts, conflicts over water. Use of alternate energy sources, growing energy needs, case studies. Role of an individual in conservation of natural resources. Equitable use of resources for sustainable lifestyles.

UNIT III **BIODIVERSITY AND ITS CONSERVATION** **09**

Levels of biological diversity – genetic, species and ecosystem diversity. Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational value. Bio-geographical classification of India. Biodiversity patterns (global, National and local levels). Hot-spots of biodiversity. India as a mega-diversity nation. Endangered and endemic species of India. Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts. Conservation of biodiversity: in-situ and ex-situ conservation of biodiversity.

UNIT IV **ENVIRONMENTAL POLLUTION** **09**

Definition, causes, effects and control measures of Air pollution, Water pollution, Soil pollution, Noise pollution, E-pollution. Nuclear hazards and human health risks. Solid waste management and control measures of urban, industrial and e-wastes. Role of an individual in prevention of pollution. Case studies.

UNIT V **SOCIAL ISSUES AND THE ENVIRONMENT** **09**

Concept of sustainability, Goals and sustainable development-circular economy- Water conservation -Rain water harvesting, watershed management. Climate change, global warming, ozone layer depletion, acid rain and its impacts on human communities and agriculture. Disaster management (floods, earthquake, cyclones and landslides). Environmental Movements (Chipko Silent valley, Bishnois of Rajasthan). Environmental ethics: Human population growth- Impacts on environment, human health and welfare-Variation among

nations.

TOTAL -45 Hours

TEXT BOOKS:

1. Anubha Kaushik., and Kaushik, C.P. 7Th Edition, 2021. Perspectives in Environmental Studies. New Age International Pvt. Ltd. Publications, New Delhi.
2. Prabhakar S Mithra, "Methodologies for environmental studies", 1st Edition, Academic Aspirations, 2021.
3. Arvind Kumar. 2004. A Textbook of Environmental Science. APH Publishing Corporation, New Delhi.
4. Erach Bharucha, "A Textbook of Environmental Studies for UG Courses" 3rd Edition, University Press India ltd, 2021.
5. Uberoi, N.K. 2005. Environmental Studies. Excel Books Publications, New Delhi.

REFERENCE BOOKS:

1. G.Tyler Miller and Scott Spoolman, "Living in the Environment", 20th Edition, Cengage Learning, 2021.
2. Linda D Williams, "Environmental Science" 1st Edition, Tata McGraw Hill, 2017.
3. Sing, J.S., Sing. S.P. and Gupta, S.R. 2022. Ecology, Environmental Science and Conservation. S. Chand & Publishing Company, New Delhi.
4. Mishra, D.D. 2010. Fundamental Concepts in Environmental Studies. S. Chand& Company Pvt. Ltd., New Delhi.
5. Singh, M.P., Singh, B.S., and Soma, S. Dey. 2004. Conservation of Biodiversity and Natural Resources. Daya Publishing House, New Delhi.

WEBSITES:

1. https://www.insightsonindia.com/2013/09/06/environment-biodiversity
2. https://www.nptelvideos.in/2012/11/energy-resources-and-technology.html
3. https://www.msubbu.in/ln/environment/

CO, PO PSO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	1	-	-	-	3	3				2	1	-
CO2	2	1	-	-	-	3	3				2	1	-
CO3	2	1	-	-	-	3	3				2	1	-
CO4	2	1	-	-	-	3	3				2	1	-
CO5	2	1	-	-	-	3	3				2	1	-
Average	**2**	**1**	**-**	**-**	**-**	**3**	**3**				**2**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E BIOMEDICAL ENGINEERING **2025-2026**

25BEBME201	**INTRODUCTION TO BIOMEDICAL ENGINEERING**	**SEMESTER – II 3H-3C**

Instruction Hours/week: L:3 T:0 P:0

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: Nil

COURSE OBJECTIVES

The goal of this course is for students to:

- Explain the structure and functions of human physiological systems
- Interpret the bio signals and imaging system
- Summarize the ethical principles in biomedical engineering

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the working principles of human physiological system (K2)
- Interpret the physiological signals (K2)
- Illustrate the functioning of medical imaging (K2)
- Relate the properties of biomaterials and biomechanical systems (K2)
- Summarize the ethical principles in biomedical engineering (K2)

UNIT I **BASIC BIOLOGY** **09**

Engineering in modern medicine, Physiological Systems-Cell Structure, Structure of nerve cell and functions, Heart & Circulatory system, Respiratory Physiology, Kidney function, Brain & Central Nervous System

UNIT II **PHYSIOLOGICAL SIGNALS** **09**

Signal representation, Signal in time and Frequency domain, Signal Estimation, Bioelectric Signals: ECG & EEG, Vital Signs, Biomagnetic Signals.

UNIT III **MEDICAL IMAGING SYSTEMS** **09**

Principles and Applications - X-ray & CT, Ultrasound Imaging, MRI, Nuclear Medicine, Microscopy, Biophotonics.

UNIT IV **BIOMECHANICS& BIOMATERIALS** **09**

Mechanical Properties of Tissue - Stress, Strain, Viscosity and Viscoelasticity, Applications of Sports Biomechanics, Biomaterials - Types, Properties, Applications - Artificial heart & Membrane Oxygenators.

UNIT V **SOCIAL AND ETHICAL ISSUES RELATED TO BIOMEDICAL ENGINEERING** **09**

Principles of clinical research, randomized controlled trials, Technology and community, Environmental aspects of technology related to healthcare delivery, Healthcare economics and health rationing.

TOTAL -45 Hours

TEXT BOOKS:

1. R. S. Khandpur, Biomedical Instrumentation: Technology and Applications, TATA McGraw-Hill, 2011
2. Leslie Cromwell, Biomedical Instrumentation and Measurement, Prentice Hall of India 2018

REFERENCE BOOKS:

1. John D. Enderle and Susan M. Blanchard Introduction to Biomedical Engineering, Elsevier International Projects Ltd, 2012
2. Laurence J. Street, Introduction to Biomedical Engineering Technology, CRC Press, 2008

WEBSITES:

1. www.nptel.ac.in/courses/102101068
2. www.nptel.ac.in/courses/102105090

CO, PO PSO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	1	-	-	-	1	-	1	1	-	1	1	-
CO2	2	1	-	-	-	1	-	1	1	-	1	1	-
CO3	2	1	-	-	-	1	-	1	1	-	1	1	-
CO4	2	1	-	-	-	1	-	1	1	-	1	1	-
CO5	2	1	-	-	-	1	2	1	1	-	1	1	-
Average	2	1	-	-	-	1	2	1	1	-	1	1	-

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEHS242G	**ENGINEERING PHYSICS (THEORY & LABORATORY)**	**SEMESTER – II 5H-4C**

Instruction Hours/week: L:3 T:0 P:2

Marks: Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

PREREQUISITES: NIL

i)THEORY

COURSE OBJECTIVES

The goal of this course is for students to:

- Introduce the concepts of quantum mechanics and crystal for diverse applications.
- Understand the basics of laser and optical fiber with appropriate applications.
- Inculcate the basics of properties of matter and its applications.

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Outline the basics of crystals, structures and its defects (K2)
- Examine the performance of light and laser (K3)
- Identify the numerical aperture and acceptance angle of an optical fibre (K3)
- Relate the quantum concepts in electron microscope (K2)
- Apply the elastic properties of the materials to understand the modulus of the material (K3)

UNIT I **CRYSTAL PHYSICS** **09**

Classification of solids: Crystalline and amorphous solids – crystal structure - unit cell, primitive cell – seven crystal systems, Bravais lattices, Miller indices – inter-planar distances (Qualitative) - Coordination number and atomic packing factor for Simple Cubic, Body Centered Cubic, Face Centered Cubic– Defects in crystal: Point & Line defect.

UNIT II **LASERS** **09**

LASER: Introduction - characteristics – Absorption- spontaneous emission- stimulated emission- Einstein's co-efficients derivation- principle of laser action- population inversion- pumping methods -Types of lasers - Nd: YAG, Semiconductor Laser (Homo Junction Laser)- Applications of LASER in industry and medicine

UNIT III **FIBRE OPTICS** **09**

Fiber optics – principle and propagation of light in optical fibers – numerical aperture and acceptance angle – types of optical fibers (Material, refractive index and mode) – types of losses in optical fibers -fiber optical communication system (block diagram)

UNIT IV **QUANTUM PHYSICS** **09**

Black body radiation - Energy Distribution laws (Qualitative): Stefan Boltzmann's law, Wein's Displacement law-Rayleigh Jeans Law. Photo electric effect (Qualitative) – Compton effect (Qualitative) – De Broglie hypothesis - uncertainty principle – physical significance of wave function - Schrödinger's Time dependent wave equation - Schrödinger's Time independent wave equation – Particle in one dimensional box- Scanning Electron Microscope and Transmission Electron Microscope

UNIT V **PROPERTIES OF MATTER ENGINEERING** **09**

Elasticity – stress – strain – Hookes law- classification of elastic modulus -Poisson's ratio - Stress-Strain diagram and its uses - factors affecting elastic modulus and tensile strength - Moment, Couple and Torque– Twisting couple on a wire – bending moment – cantilever- young's modulus uniform bending – I- shaped girders and its applications.

TOTAL HOURS - 45

TEXT BOOKS:

1. Bhattacharya D.K. & Poonam T., Engineering Physics, Oxford University Press, 2015.
2. Gaur R.K. and Gupta S.L, Engineering Physics, Dhanpat Rai Publications, 2012.
3. Pandey. B.K. & Chaturvedi. S, Engineering Physics, Cengage Learning India, 2012.
4. Charles Kittel, Kittel's Introduction to Solid State Physics, Wiley India Edition, 2019.
5. P.M. Mathews, K.Venkatesan, A text book of Quantum Mechanics, 2/e, Mc Graw Hill Education, 2017.
6. Laser Fundamentals, William T Silfvast, Cambridge Univ Press. 2012.
7. Fiber Optics and Optoelectronics, R P Khare, Oxford, 2012.
8. D.S. Mathur, Elements of properties of matter, S.Chand, 2010.

REFERENCE BOOKS:

1. Halliday.D. Resnick R. & Walker. J, Principles of Physics, Wiley, 2015.
2. Daniel V.Schroeder, An Introduction to Thermal Physics, Pearson, 2014.

WEBSITES:

1. www. nptel.ac.in/courses/122/103/122103011/
2. www.nptel.ac.in/courses/113/104/113104081/
3. www.hyperphysics.phy-astr.gsu.edu/hbase/optmod/lascon.html

ii) LABORATORY

LIST OF EXPERIMENTS

1. Determination of Band gap of a semiconductor.
2. Uniform bending – Determination of young's modulus.
3. Non-uniform Bending – Determination of young's modulus.
4. Laser - Determination of the wave length of the laser using grating
5. Laser – Determination of Particle size
6. Optical Fiber – Determination of Numerical Aperture and Acceptance angle of the optical fiber.
7. Air wedge – Determination of thickness of a thin sheet/wire.

TOTAL HOURS - 30

CO, PO PSO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	-	-	-	-	-	2	2	-	-	1	-
CO2	3	2	-	-	-	-	-	2	2	-	-	1	-
CO3	3	2	-	-	-	-	-	2	2	-	-	1	-
CO4	3	3	2	-	-	1	-	2	2	-	-	1	-
CO5	2	1	-	-	-	-	-	-	1	-	-	1	-
Average	**2.8**	**2.0**	**2.0**	**-**	**-**	**1.0**	**-**	**2.0**	**1.8**	**-**	**-**	**1.0**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME241	ELECTRONICS FOR BIOMEDICAL ENGINEERS (THEORY & LABORATORY)	SEMESTER – II 5H-4C

Instruction Hours/week: L:3 T:0 P:2

Marks: Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

PREREQUISITES: NIL

i) THEORY

COURSE OBJECTIVES

The goal of this course is for students to:

- Illustrate the principles of electronic devices
- Compare the characteristics of BJT and FET
- Infer the applications of semiconductor devices

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Illustrate the principles of semiconductor diodes (K2)
- Explain the configurations and characteristics of BJT (K2)
- Infer the VI characteristics of FET (K2)
- Compare the specification and applications of special diodes (K2)
- Summarize the working of power supply unit (K2)

UNIT I SEMICONDUCTOR DIODES 09

Semiconductors: Intrinsic semiconductor – extrinsic semiconductor – Fermi level in an intrinsic semiconductor, Semiconductor diodes : Formation of PN junction – working principle – VI characteristics – diode current equation – diode resistance – transition and diffusion capacitance.

UNIT II BIPOLAR TRANSISTORS 09

Bipolar Transistors: NPN - PNP - Construction – working – input- output characteristics, Transistor configurations (CB,CE,CC) - Early effect (base width modulation), Transistor as an amplifier Transistor as a switch.

UNIT III FIELD EFFECT TRANSISTORS 09

Junction Field-Effect Transistors: construction, working principle and VI characteristics of JFET – comparison of BJT and JFET. MOSFET: Working Principle and VI characteristics, enhancement MOSFET, depletion MOSFET - comparison of MOSFET with JFET.

UNIT IV SPECIAL PURPOSE DIODES AND WAVESHAPING CIRCUITS 09

Special purpose diodes: Light Emitting Diode, 7 Segment LED, Photo Diode, Tunnel diode, Varactor diode, PIN diode, Zener diode, Schottky diode. Wave Shaping Circuits: Clippers, Clampers, Schmitt Trigger using Transistor

UNIT V DC POWER SUPPLIES 09

Block Diagram of a typical DC power supply, Rectifiers – Half wave, full wave and Bridge - ripple factor and efficiency analysis. Filters – RC – LC. Voltage regulators: voltage regulation - Zener diode regulation - shunt regulator - transistor series regulator - transistor shunt regulator. Switched Mode Power Supply

TOTAL -45 Hours

TEXT BOOKS:

1. S. Salivahanan, Electronic Devices and Circuits, Tata Mcgraw Hill International, 2011
2. 2. G.K.Mithal, Electronic Devices and Circuits, Khanna Publishers , 2013

REFERENCE BOOKS:

1. Thomas L. Floyd, Electron Devices, Charles and Messil Publications, 2012
2. Gayakwad A R , Op-amps and Linear Integrated circuits, Pearson Education , 2011
   Millman and Halkias Electronic devices and Circuits Tata McGraw Hill International, 2010

WEBSITES:

1. https://nptel.ac.in/courses/108108112
2. https://nptel.ac.in/courses/108108122

ii) **LABORATORY**

List of Experiments

1. V-I Characteristics of PN diode
2. Simulate the Input and Output Characteristics of BJT CB configuration
3. Input and Output Characteristics of BJT CE configuration
4. Drain and transfer characteristics of JFET
5. V-I Characteristics of Zener diode
6. Simulate the characteristics of Clippers and Clampers
7. Half wave rectifier– with and without filter
8. Full wave rectifier – with and without filters

CO, PO PSO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	2	1	-	-	-	-	-	1	1	-	-	1	-
CO5	3	2	1	-	-	-	-	1	1	-	-	1	-
Average	**2.2**	**1.2**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E BIOMEDICAL ENGINEERING **2025-2026**

25BEHS211G	**COMMUNICATION SKILLS LABORATORY**	**SEMESTER –II** **2H-1C**

Instruction Hours/week: L:3 T:0 P:2

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: Nil

COURSE OBJECTIVES

The goal of this course is for students to:

- To acquire different listening techniques for understanding different kinds of audio content, including lectures, conversations, videos, etc. and to effectively communicate their ideas using a variety of media
- To understand the "English language skills" by engaging them in listening and reading activities that are relevant to authentic contexts and to help learners use language effectively in academic /work contexts
- To apply the communicative competence of learners in listening, speaking, reading and writing

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Organize the context, topic, and pieces of specific information of English through all four skills. (P1)
- Identify the purpose and clarity of facts and reflect their thoughts, opinions, and knowledge through all the language skills. (A1)
- Put together skimming, scanning, and listening techniques effectively to acquire the gist from the context. (P2)
- Demonstrate in communication more effectively with their peers, instructors, and colleagues. (A2)
- Master public speaking techniques, business writing, and listening with professional speaking techniques. (P3)

***P-Psychomotor Skills, A- Affective Domain Skills**

LIST OF EXPERIMENTS:

S.No.	SKILLS	TOPICS
1	Listening	Dialogues from TV/radio/Ted talk/Podcast
2	Listening	Listening for gist
3	Reading	Reading for detail, global understanding
4	Speaking	Presentations and interactive communication – Pair presentations
5	Listening	Listen and respond appropriately
6	Reading	Reading different genres
7	Writing	Documentary and Movie review
8	Writing	Informational or Analytical Reports
9	Speaking	Mock Interview
10	Speaking	Group Discussion

TOTAL: 30 Hours

CO, PO PSO Mapping

COPO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	-	-	-	-	2	-	2	3	3	-	2	1	-
CO2	-	-	-	-	2	-	2	3	3	-	2	1	-
CO3	-	-	-	-	1	-	2	3	3	-	2	1	-
CO4	-	-	-	-	1	-	1	2	3	-	2	1	-
CO5	-	-	-	-	1	-	1	2	3	-	2	1	-
Average	**-**	**-**	**-**	**-**	1.4	**-**	1.6	2.6	3	**-**	**2**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

SEMESTER – III

B.E BIOMEDICAL ENGINEERING **2025-2026**

25BEHS301BG	**NUMERICAL METHODS**	**SEMESTER – III** **4H-4C**

Instruction Hours/week: L:3 T:1 P:0

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: Transforms and its Applications

COURSE OBJECTIVES

The goal of this course is for students to:

- To inculcate the basic concepts of solving algebraic and transcendental equations.
- To understand the numerical techniques of interpolation in various intervals
- To develop proficiency on numerical differentiation and integration
- To provide the knowledge of solving ordinary differential equations and partial differential equations numerically

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Solve the systems of linear and nonlinear equations by iterative methods (K3)
- Make use of interpolation methods for finding the missing terms (K3)
- Apply numerical methods for finding differentiation and integration of a given function (K3)
- Solve ordinary differential equations using Euler's, Taylor's, Runge Kutta and Milne Thomson's method (K3)
- Utilize implicit and explicit methods in heat and wave equations (K3)

UNIT I SOLUTION OF EQUATIONS 12

Regula Falsi Method - Newton Raphson method for solving algebraic and transcendental equations -Solution of system of linear equations - Gauss elimination method - Gauss Jordan method -Gauss Seidel method

UNIT II INTERPOLATION 12

Interpolations with unequal intervals-Lagrange's interpolation -Newton's divided interpolation - Interpolation with equal intervals-Newton's forward and backward interpolation

UNIT III NUMERICAL DIFFERENTIATION AND INTEGRATION 12

Approximation of derivatives using Newton's forward and backward interpolation - Numerical integration using Trapezoidal, Simpson's 1/3 and 3/8 rule

UNIT IV NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS 12

Single step method- Euler's method-Taylor's series method-Fourth order Runge – Kutta method –Multi step method-Milne's predictor corrector method

UNIT V NUMERICAL SOLUTIONS OF PARTIAL DIFFERENTIAL EQUATIONS 12

Solutions of one-dimensional heat equation by Bender-Schmidt and Crank Nicholson methods – Numerical solutions of one-dimensional wave equation by explicit method

TOTAL -45 +15 Hours

TEXT BOOKS:

1. Steven C.Chapra, Raymond P.Canale, "Numerical Methods for Engineers", McGraw Hill Education, Seventh Edition 2015
2. Curtis F. Gerald, Patrick O. Wheatley, "Applied Numerical Analysis", Addison Wesley, Thirteenth Edition 2004

REFERENCE BOOKS:

1. Richard L. Burden, J. Douglas Faires, "Numerical Methods Brooks/Cole", 4th edition ,2012
2. Erwin Kreyszig, "Advanced Engineering Mathematics" , John Wiley and Sons, Tenth Edition , 2011
3. Steven Chapra, "Applied Numerical Methods with MATLAB", 5th Edition, Mcgraw-Hill Education, 2022.
4. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley and Sons, Tenth Edition, 2011.

WEBSITES:

1. www.classcentral.com/course/numerical-methods-engineers-32822
2. http://www.infocobuild.com/education/audio-video-courses/mathematics/numerical-analysis-iit-madras.html
3. http://www.infocobuild.com/education/audio-video-courses/mathematics/NumericalMethods-FiniteDifference-IIT-Roorkee/lecture-6.html

CO, PO PSO Mapping

COs /POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	-	-	-	-	-	-	-	1	-	1
CO2	3	2	1	-	-	-	-	-	-	-	1	-	1
CO3	3	2	1	-	-	-	-	-	-	-	1	-	1
CO4	3	2	1	-	-	-	-	-	-	-	1	-	1
CO5	3	2	1	-	-	-	-	-	-	-	1	-	1
Average	**3**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E BIOMEDICAL ENGINEERING **2025-2026**

25BEBME302	**HUMAN ANATOMY AND PHYSIOLOGY**	**SEMESTER – III** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0

Marks: Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES:

The goal of this course is for students to:

- Classify the fundamental components and functions of cells, blood, and tissues in relation to biomedical applications.
- Explain the physiological processes of major organ systems such as cardiovascular, respiratory, and nervous systems.
- Interpret the functions of sensory and endocrine systems

COURSE OUTCOMES:

Upon completion of this course, students will be able to:

- Outline the structure and function of cells, blood components, and tissues including electrical stimulation mechanisms. (K2)
- Relate the cardiac and nervous system functions to their physiological controls and bio-potential recordings. (K2)
- Illustrate the structure and functional aspects of the respiratory and muscular systems. (K2)
- Summarize the mechanisms involved in digestion, absorption, excretion, thermoregulation, and lymphatic circulation. (K2)
- Compare the sensory pathways and neurophysiology of vision and hearing with endocrine functions of selected glands.(K2)

UNIT I **FUNDAMENTAL ELEMENT OF HUMAN BODY** **09**

Structure of Cell - Description and function of cell components - Cell Membrane: Membrane and Action Potential - Generation and Conduction - Electrical Stimulation. Blood Cell: Composition - Origin of RBC - Blood Groups - Estimation of RBC, WBC and Platelet - Tissues and its functions.

UNIT II **CARDIAC AND NERVOUS SYSTEM** **09**

Heart, Major blood vessels - Cardiac Cycle - ECG - Blood Pressure - Feedback Control for Blood Pressure - Nervous Control of Heart - Cardiac output - Coronary and Peripheral Circulation - Structure and function of Nervous tissue: Neuron - Synapse - Reflexes – Receptors, Brain: Structure - Brainstem - Spinal cord – Reflex action - Conduction of Nerve Impulses – Electroencephalograph.

UNIT III **RESPIRATORY SYSTEM AND MUSCULOSKELETAL SYSTEM** **09**

Physiological aspects of respiration - Trachea and lungs - Exchange of gases - Regulation of respiration - Disturbance of respiration function - Pulmonary function test - Muscles - tissue - types structure of skeletal muscle - types of muscle and joints.

UNIT IV **DIGESTIVE, EXCRETORY AND LYMPHATIC SYSTEM** **09**

Organisation of GI System, Digestion and absorption - Movements of GI tract - Intestine - Liver - Pancreas - Structure of Nephron - Mechanism of Urine formation - Urine Reflex - Skin and Sweat Gland – Temperature regulation, Lymphatic: Parts and Functions of Lymphatic systems - Types of Lymphatic organs and vessels.

UNIT V SENSORY AND ENDOCRINE SYSTEMS 09

Optics of Eye - Retina - Photochemistry of Vision - Neurophysiology of eye - EOG, Structure of internal ear - Mechanism of hearing - Auditory Pathway, Hearing Tests - Endocrine - Pituitary and thyroid glands.

TOTAL -45 Hours

TEXT BOOKS:

1. Prabhjot Kaur, "Text Book of Anatomy and Physiology", Lotus Publishers, 2014
2. Elaine.N. Marieb, "Essential of Human Anatomy and Physiology". Pearson Education, New Delhi, 2016

REFERENCE BOOKS:

1. Frederic H. Martini, Judi L. Nath, Edwin F. Bartholomew, "Fundamentals of Anatomy and Physiology", Pearson Publishers, 2014
2. Gillian Pocock, Christopher D. Richards, "The human Body – An introduction for Biomedical and Health", Oxford University Press, USA, 2013
3. Eldra Pearl Solomon, "Introduction to Human Anatomy and Physiology", W.B. Saunders Company, 2015

WEBSITES:

1. https://openstax.org/details/books/anatomy-and-physiology
2. https://www.visiblebody.com/anatomy-and-physiology-apps/anatomy-and-physiology

CO, PO PSO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	1	-	-	-	-	-	1	1	-	1	2	-
CO2	2	1	-	-	-	-	-	1	1	-	1	2	-
CO3	2	1	-	-	-	-	-	1	1	-	1	2	-
CO4	2	1	-	-	-	-	-	1	1	-	1	2	-
CO5	2	1	-	-	-	-	-	1	1	-	1	2	-
Average	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**1**	**2**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E BIOMEDICAL ENGINEERING **2025-2026**

25BEBME303	**BIOSENSORS AND MEASUREMENTS**	**SEMESTER – III** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0

Marks: Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES:

The goal of this course is for students to:

- Explain the static and dynamic characteristics of transducers and the principles of sensor operations.
- Interpret the sensor technologies for measurement and fabrication process
- Summarize the applications of biosensors

COURSE OUTCOMES:

Upon completion of this course, students will be able to:

- Outline the static and dynamic characteristics of input transducers and instrumentation systems. (K2)
- Summarize the classification and functioning of different types of biosensors. (K2)
- Identify different types of transducers used for displacement, motion, pressure, and temperature measurement. (K2)
- Make use of sensor fabrication techniques for biomedical applications. (K2)
- Utilize various visualization devices like CRO, DSO, and recorders for effective monitoring. (K2)

UNIT I INTRODUCTION TO TRANSDUCERS AND ITS CHARACTERISTICS 09

Introduction: Generalized Instrumentation System, General Properties of Input Transducer Static Characteristics: Accuracy, Precision, Resolution, Reproducibility, Sensitivity, Drift, Hysteresis, Linearity, Input Impedance and Output Impedance. Dynamic Characteristics: First Order and Second Order Characteristics, Time Delay, Error Free Instrument, Transfer Functions. Design Criteria, Generalized Instrument Specifications.

UNIT II BIOSENSORS 09

Chemical Sensors: Blood gas and Acid - Base Physiology Potentiometric Sensors, Ion Selective Electrodes, ISFETS. Ampero metric Sensors, Clark Electrode with examples - pH, pO2, pCO2 Electrodes, Transcutaneous Arterial Oxygen Tension, Carbon Dioxide measurements: capnostat. Biosensor: Classifications: Biological phenomenon, Transduction Phenomenon i.e. Enzyme Sensor and Electrode based: Affinity Sensors (Catalytic Biosensors), Two examples of each Biosensors and Immunosensor.

UNIT III MEASUREMENT 09

Displacement, motion and Pressure Measurement: (with applications) Resistive: Potentiometers, Strain Gauges and Bridge Circuits. Inductive: Variable Inductance and LVDT Capacitive type, Piezoelectric Transducers. Types of Diaphragms, Bellows, Bourdon Tubes. Temperature Measurement: Thermistor, Thermocouple, Resistive Temperature Detector, IC based Temperature Measurement, Radiation Sensors and Applications.

UNIT IV SENSOR FABRICATION 09

Sensor Fabrications - an overview, Fabrication Technique - Pressure sensor - Pizorestive pressure sensor - capacitive pressure sensor - Micro sensor - Biomedical Application.

UNIT V APPLICATIONS OF BIOSENSORS IN HEALTHCARE 09

Biosensors and diabetes management, Microfabricated biosensors and point-of-care diagnostics systems, Noninvasive biosensors in clinical analysis; Surface plasmon resonance and evanescent wave biosensors, Biosensor in cancer and HIV early diagnosis.

TOTAL -45 Hours

TEXT BOOKS:

1. Hermann K P. Neubert, "Instrument Transducer– An Intro to their performance and design", Oxford University Press, 2000
2. Harry N, Norton, "Biomedical sensors –fundamentals and application", Noyes Publications, 2001
3. Nandini K, "Electronics in Medicine and Biomedical Instrumentation", Jog PHI Second Edition, 2013

REFERENCE BOOKS:

1. LaGeddesandL.E.Baker, "Principles of applied Biomedical Instrumentation", Wiley, 1997
2. LeslieCromwell,Fred., J.Weibell and Pfeiffer, "Biomedical instrumentation and measurement", Prentice Hall of India, 2002
3. Jacob Fraden, "Handbook of Modern Sensors – Physics, Design and Application",AIP press, 2000

WEBSITES:

1. https://onlinecourses.swayam2.ac.in/nou23_bt05/preview
2. https://vtu.ac.in/pdf/2022syll/handbook.pdf

CO, PO PSO Mapping

COs/POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	1	2	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	1	2	-
CO3	K3	3	2	1	-	-	-	-	1	1	-	1	2	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	1	2	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	1	2	-
Average		**2.4**	**1.6**	**1**	**-**	**-**	**-**	**-**	1	1	**-**	1	**2**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME304	**SIGNALS AND SYSTEMS**	**SEMESTER – III** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES:

The goal of this course is for students to:

- Classify continuous and discrete time signals and systems based on their types and characteristics.
- Explain the fundamental concepts of signal transformation techniques such as Fourier, Laplace, and Z-transforms.
- Apply mathematical tools to analyze and solve problems related to continuous and discrete time signals and systems.

COURSE OUTCOMES:

Upon completion of this course, students will be able to:

- Outline the classification and properties of continuous time and discrete time signals and systems.
- Summarize Fourier series, Fourier transform, and Laplace transform concepts for continuous time signal analysis.
- Apply convolution and differential equation methods to solve linear time-invariant continuous time systems.
- Identify the use of DTFT and Z-transform techniques in analyzing discrete time signals.
- Make use of differential equations and transforms for analyzing discrete time systems.

UNIT I **CLASSIFICATION OF SIGNALS AND SYSTEMS** **09**

Continuous time signals (CT signals) - Discrete time signals (DT signals) - Step, Ramp, Pulse, Impulse, Sinusoidal, Exponential, Classification of CT and DT signals - Periodic & Aperiodic signals, Deterministic & Random signals, Energy & Power signals - CT systems and DT systems- Classification of systems – Static & Dynamic, Linear & Nonlinear, Time-variant & Time invariant, Causal & Noncausal, Stable & Unstable.

UNIT II **ANALYSIS OF CONTINUOUS TIME SIGNALS** **09**

Fourier series analysis-spectrum of Continuous Time (CT) signals- Fourier and Laplace Transforms in CT Signal Analysis - Properties.

UNIT III **LINEAR TIME INVARIANT- CONTINUOUS TIME SYSTEMS** **09**

Differential Equation-Block diagram representation-impulse response, convolution integrals- Fourier and Laplace transform in analysis of CT systems.

UNIT IV **ANALYSIS OF DISCRETE TIME SIGNALS** **09**

Baseband Sampling - DTFT – Properties of DTFT - Z Transform– Properties of Z Transform

UNIT V **LINEAR TIME INVARIANT-DISCRETE TIME SYSTEMS** **09**

Difference Equations-Block diagram representation-Impulse response - Convolution sum-Discrete. Fourier and Z Transform Analysis of Recursive & Non-Recursive systems.

TOTAL -45 Hours

TEXT BOOKS:

1. Allan V. Oppenheim, S.Wilsky and S. H. Nawab, "Signals and Systems", Pearson, 2007
2. B.P. Lathi, "Principles of Linear Systems and Signals", Second Edition Oxford, 2009

REFERENCE BOOKS:

1. R. E. Zeimer, W. H. Tranter and R. D. Fannin, "Signals & Systems Continuous and Discrete", Pearson, 2007
2. John Alan Stuller, "An Introduction to Signals and Systems", Thomson, 2007
3. M. J. Roberts, "Signals & Systems Analysis using Transform Methods & MATLAB", Tata McGraw Hill, 2003

WEBSITES:

1. https://nptel.ac.in/courses/117104074
2. https://nptel.ac.in/courses/117101055

CO, PO PSO Mapping

COs/POs	KL	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	K2	2	1	-	-	-	-	-	1	1	-	1	2	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	1	2	-
CO3	K3	3	2	1	-	-	-	-	1	1	-	1	2	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	1	2	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	1	2	-
Average		**2.4**	**1.6**	**1**	**-**	**-**	**-**	**-**	1	1	**-**	1	**2**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME305	**ANALOG AND DIGITAL INTEGRATED CIRCUITS**	**SEMESTER – III** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES:

The goal of this course is for students to:

- Apply the knowledge of operational amplifiers to develop amplifier circuits, active filters, and waveform generators for analog signal processing applications.
- Build combinational and sequential digital circuits using logic gates, flip-flops, multiplexers, and decoders for arithmetic and logical operations.
- Utilize analog-to-digital and digital-to-analog converters along with phase-locked loop circuits to interface analog and digital systems efficiently.

COURSE OUTCOMES:

Upon completion of this course, students will be able to:

- Explain the working principles of Operational amplifiers, filters, multivibrators, Schmitt trigger, triangular wave generator. (K2)
- Interpret the operations of A/D and D/A converters and PLL circuits. (K2)
- Apply the concepts of number systems, Karnaugh map for the combinational circuits.(K3)
- Demonstrate the concepts in combinational circuit to explain decoders, multiplexers, and counters.(K2)
- Illustrate the use of sequential logic circuits to construct the various types of flipflops and counter circuits. (K2)

UNIT I INTRODUCTION TO OPERATIONAL AMPLIFIER AND ITS APPLICATIONS 09

Operational amplifier –ideal characteristics, Performance Parameters, Linear and Nonlinear Circuits and their analysis- voltage follower, Inverting amplifier, Non-inverting Amplifiers, Differentiator, Integrator, Voltage to Current converter, Instrumentation amplifier, Low pass, High pass filter and band pass filters, Comparator, Multivibrator and Schmitt trigger, Triangular wave generator.

UNIT II DIGITAL TO ANALOG AND ANALOG TO DIGITAL CONVERTERS AND PLL 09

Analog switches, High speed sample and hold circuit and IC‘s, Types of D/A converter -Weighted resistor, R-2R ladder DAC, D/A Accuracy and Resolution. A/D converter – Flash, Dual slope, Successive approximation, A/D Accuracy and Resolution. Voltage controlled oscillator, Voltage to Frequency converters. PLL-Closed loop analysis of PLL, Frequency multiplication/ division, FSK demodulator.

UNIT III THE BASIC GATES AND COMBINATIONAL LOGIC CIRCUITS 09

Number Systems – Decimal, Binary, Octal, Hexadecimal, 1‘s and 2‘s complements, Codes – Binary, BCD, 84-2-1, 2421, Excess 3, Biquinary, Gray, Alphanumeric codes, Boolean theorems, Logic gates, Universal gates, Sum of products and product of sums, Minterms and Maxterms, Karnaugh map and Tabulation methods. Logic families- TTL, MOS, CMOS, BiCMOS – Comparison of Logic families.

UNIT IV COMBINATIONAL LOGIC CIRCUITS 09

Problem formulation and design of combinational circuits – Code-Converters, Half and Full Adders, Binary Parallel Adder – Carry look ahead Adder, BCD Adder, Magnitude Comparator, Decoder, Encoder, Priority Encoder, Mux / Demux.

UNIT V SEQUENTIAL LOGIC CIRCUITS 09

Flip flops – SR, JK, T, D, Master/Slave FF, Triggering of FF, Analysis and design of clocked sequential circuits – state minimization, state assignment, circuit implementation. Counters, Ripple Counters, Ring

Counters. Types of Registers, Serial In – Serial Out, Serial In – Parallel out, Parallel In -Serial Out, Parallel In – Parallel Out, Universal Shift Register.

TOTAL -45 Hours

TEXT BOOKS:

1. Sergio Franco, "Design with operational amplifiers and analog integrated circuits", Mc Graw Hill Education, 3rd Edition, 2017
2. John.F.Wakerly, "Digital design principles and practices", Pearson Education, 5th Edition, 2018

REFERENCE BOOKS:

1. Taub and Schilling, "Digital Integrated Electronics", Mc Graw Hill, 2017.
2. Charles H. Roth, Jr, "Fundamentals of Logic Design", Jaico Books, 7th Edition, 2013.
3. M. Morris Mano and Michael D.Ciletti, "Digital Design", Pearson, 5th Edition, 2013.
4. S Salivahanan and V S Kanchana Bhaaskaran, Linear Integrated Circuits, McGraw Hill Education, 3rd Edition, 2018
5. Roy Choudhary, Linear Integrated Circuits, New Age International (P) Ltd, 2004

WEBSITES:

1. https://onlinecourses.nptel.ac.in/noc20_ee45/preview
2. https://ocw.mit.edu/courses/6-002-circuits-and-electronics-spring-2007/pages/lecture-notes/

CO, PO PSO Mapping

COs/Pos	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	1	2	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	1	2	-
CO3	K3	3	2	1	-	-	-	-	1	1	-	1	2	-
CO4	K2	3	2	1	-	-	-	-	1	1	-	1	2	-
CO5	K2	3	2	1	-	-	-	-	1	1	-	1	2	-
Average		**2.4**	**1.6**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**1**	**2**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BECS341AG	**DATA STRUCTURES AND ALGORITHMS (THEORY & LABORATORY)**	**SEMESTER – III 5H-4C**

Instruction Hours/week: L:3 T:0 P:2

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

i) THEORY

COURSE OBJECTIVES

The goal of this course is for students to:

- Understand the concepts of ADTs.
- Learn linear data structures – lists, stacks, and queues.
- Implement sorting, searching and hashing algorithms.

COURSE OUTCOMES

Up on completion of this course, the student will be able to:

- Interpret the concepts of linear and non-linear data structures (K2)
- Identify appropriate linear/non–linear data structure operations for solving a given problem (K3)
- Experiment with linear and non-linear data structure operations to understand their implementation, performance, and practical applications (K3)
- Apply searching and sorting algorithms for solving a problem (K3)
- Develop the application using suitable data structures (K3)

UNIT I **LISTS** **08**

Abstract Data Types (ADTs) – Elementary Data types – List ADT – Array-based implementation – Linked list implementation – Singly linked lists – Doubly-linked lists – Circularly linked lists – Applications of lists – Polynomial ADT – Multilists – Sparse Matrices.

UNIT II **STACKS AND QUEUES** **08**

Stack ADT – Operations – Applications – Balancing symbols – Evaluating arithmetic expressions – Infix to Postfix conversion – Function calls – Queue ADT – Operations – Circular queue – Deque – Applications of queues.

UNIT III **TREES** **08**

Tree ADT – Tree traversals – Binary tree ADT – Expression trees – Binary search tree ADT– AVL Trees – Red-Black trees – Priority queue (Heaps) – Binary heap.

UNIT IV **MULTIWAY SEARCH TREES AND GRAPHS** **09**

B-Tree – B+ Tree – Tries – Graph definition – Representation of graphs – Types of graphs – Breadth- first traversal – Depth-first traversal – Bi-connectivity – Euler circuits – Topological sort – Dijkstra's algorithm – Minimum spanning tree – Prim's algorithm – Kruskal's algorithm

UNIT V **SEARCHING, SORTING AND HASHING TECHNIQUES** **09**

Searching – Linear search – Binary search – Sorting – Bubble sort – Selection sort – Insertion sort – Shell sort – Quick sort – Merge sort – Heap sort – Radix sort – Hashing – Hash functions – Separate chaining – Open addressing – Rehashing – Extendible hashing

CONTEMPORARY TOPICS **03**

TOTAL -45 Hours

ii) LABORATORY

LIST OF EXPERIMENTS:

1. Implement array implementation of Stack, Queue, and Circular Queue ADTs.
2. Develop the implementation of a singly linked list.
3. Create linked list implementation of stack and linear queue ADTs.
4. Implement the evaluation of postfix expressions and infix to postfix conversion.
5. Develop the implementation of binary search trees and AVL Trees.
6. Implement insertion sort, merge sort and quick sort.
7. Create open addressing (Linear probing and Quadratic probing).

TEXT BOOKS:

1. Mark Allen Weiss, "Data Structures and Algorithm Analysis in C", 2nd Edition, Pearson Education, 2019
2. Thomas H. Cormen, Charles E. Leiserson, Ronald L.Rivest, Clifford Stein, "Introduction to Algorithms", 4th Edition, MIT Press, 2022

REFERENCE BOOKS:

1. Narasimha Karumanchi, "Data Structures and Algorithms Made Easy", 1st Edition, Career monk Publications, 2019
2. Langsam, Augenstein and Tanenbaum, "Data Structures Using C and C++", 2nd Edition, Pearson Education, 2020
3. Jan Wengrow, "A Common–Sense Guide to Data Structures and Algorithm", 2nd Edition, O'Reilly Publications, 2020
4. Yashavant Kanetkar, "Data Structures Through C", 4th Edition, BPB publications, 2022

WEBSITES:

1. https://nptel.ac.in/courses/106102064
2. www.coursera.org/learn/data-structures
3. www.cs.usfca.edu/~galles/visualization/Algorithms.html

CO, PO PSO Mapping

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	1	-	-	2	2	-	-	-	1
CO2	K3	3	2	1	-	1	-	-	2	2	-	-	-	1
CO3	K3	3	2	1	-	1	-	-	2	2	-	-	-	1
CO4	K3	3	2	1	-	1	-	-	2	2	-	-	-	1
CO5	K3	3	2	1	-	1	-	-	2	2	-	-	-	1
Average		**2.8**	**1.8**	**1**	**-**	**1**	**-**	**-**	**2**	**2**	**-**	**-**	**-**	**1**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME311 **BIOSENSORS AND MEASUREMENTS LABORATORY** **SEMESTER – III**
2H-1C

Instruction Hours/week: L:0 T:0 P:2

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES:

The goal of this course is for students to:

- Apply the principles of biomedical sensors and transducers for displacement and physiological signal measurements.
- Identify and analyze the characteristics of temperature, photonic, and piezoelectric sensors used in biomedical applications.
- Examine the acquisition and interpretation of physiological signals such as ECG, EEG, and EMG using simulation tools.

COURSE OUTCOMES:

Upon completion of this course, students will be able to:

- Apply the working principle of LVDT for displacement measurement in biomedical applications. (K3)
- Identify the characteristics of temperature sensors and photo transducers. (K3)
- Make use of piezoelectric transducers and phototransistors for physiological signal acquisition. (K3)
- Investigate the differences between contact and non-contact methods for skin temperature measurement. (K4)
- Examine the signal patterns recorded from ECG, EEG, and EMG simulators for clinical interpretation. (K4)

LIST OF EXPERIMENTS

1. Displacement measurement using LVDT
2. Characteristics of temperature sensors – thermistor and RTD.
3. Characteristics of thermocouple
4. Characteristics of photodiodes, phototransistor
5. Characteristics of Piezoelectric transducers.
6. Data acquisition of physiological signals
7. Measurement of skin temperature by both contact and non-contact method.
8. Recording of ECG using ECG simulator.
9. Recording of EEG using EEG simulator.
10. Recording of EMG using EMG simulator.

CO, PO PSO Mapping

COs/POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	2	1	-	-	-	-	1	1	-	1	2	1
CO2	3	3	2	1	-	-	-	-	1	1	-	1	2	1
CO3	3	3	2	1	-	-	-	-	1	1	-	1	2	1
CO4	4	3	3	2	1	-	-	-	1	1	-	1	2	1
CO5	4	3	3	2	1	-	-	-	1	1	-	1	2	1
Average		**3**	**2.4**	**1.4**	**1**	**-**	**-**	**-**	**1**	**1**	**-**	**1**	**2**	**1**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME312	ANALOG AND DIGITAL INTEGRATED CIRCUITS LABORATORY	SEMESTER – III 2H-1C

Instruction Hours/week: L:0 T:0 P:2

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES:

The goal of this course is for students to:

- Apply the fundamental principles of operational amplifiers, IC555 timers, and digital circuits to develop basic analog and digital electronic systems.
- Analyze the behavior of amplifier circuits, active filters, Schmitt triggers, and multivibrators to examine their suitability for specific applications.
- Utilize digital ICs to build combinational and sequential circuits such as adders, decoders, multiplexers, counters, and shift registers.

COURSE OUTCOMES:

Upon completion of this course, students will be able to:

- Apply the principles of operational amplifiers to develop amplifier circuits, integrators, differentiators, and Schmitt triggers. (K3)
- Utilize IC555 timers to build multivibrators for pulse and waveform generation applications. (K3)
- Make use of logic gates and flip-flops to design combinational and sequential circuits including adders, multiplexers, shift registers, and counters. (K3)
- Analyze and compare the performance of active filters and amplifier circuits for various signal conditioning tasks. (K4)
- Examine and categorize digital systems like mod-N counters and universal shift registers based on their design and functionality. (K4)

LIST OF EXPERIMENTS

1. Inverting, non-inverting amplifier and comparator
2. Integrator and Differentiator
3. Design and analysis of active filters using op amp
4. Schmitt trigger using operational amplifier
5. Multivibrators using IC555 Timer
6. Study of logic gates, Half adder and Full adder
7. Encoder and BCD to 7 segment decoder
8. Multiplexer and demultiplexer using digital ICs
9. Universal shift register using flip flops
10. Design of mod-N counter

CO, PO PSO Mapping

COs/POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	2	1	-	-	-	-	1	1	-	1	2	1
CO2	3	3	2	1	-	-	-	-	1	1	-	1	2	1
CO3	3	3	2	1	-	-	-	-	1	1	-	1	2	1
CO4	4	3	3	2	1	-	-	-	1	1	-	1	2	1
CO5	4	3	3	2	1	-	-	-	1	1	-	1	2	1
Average		**3**	**2.4**	**1.4**	**1**	**-**	**-**	**-**	**1**	**1**	**-**	**1**	**2**	**1**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME313	**SKILL DEVELOPMENT-I**	**MEDICAL CODING**	**SEMESTER – III** **2H-1C**

Instruction Hours/week: L:0 T:0 P:2

Marks: Internal**:100** External**:0** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES:

The goal of this course is for students to:

- Interpret the terminologies related to human anatomy and physiology
- Summarize the commonly used codes for medical coding
- Translate the medical data into EHR using state of the art tools and methods

COURSE OUTCOMES:

Upon completion of this course, students will be able to:

- Explain the basic anatomy and physiology of human body (K2)
- Outline the common terms used in the medical field (K2)
- Summarize the ICD-10-CM, CPT, HCPCS codes used in medical coding (K2)
- Relate the medical coding terminologies with conditions related to digestive and circulatory system (K2)
- Illustrate the process of medical coding using case studies with state of art tools (K2)

LABORATORY EXPERIMENTS

1. Basic anatomy and physiology
2. Common medical terms and abbreviations
3. ICD-10-CM (International Classification of Diseases, 10th Revision, Clinical Modification)
4. CPT (Current Procedural Terminology).
5. CPT Codes
6. HCPCS Codes
7. Digestive system and its disease coding.
8. Circulatory system and its disease coding
9. Introduction to coding software and electronic health records (EHR)
10. Case Studies and Practical Application

CO, PO PSO Mapping

COs/POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	**K2**	2	1	-	-	1	1	-	1	1	-	1	-	1
CO2	**K2**	2	1	-	-	1	1	-	1	1	-	1	-	1
CO3	**K2**	2	1	-	-	1	1	-	1	1	-	1	-	1
CO4	**K2**	2	1	-	-	1	1	-	1	1	-	1	-	1
CO5	**K2**	2	1	-	-	1	1	-	1	1	-	1	-	1
Average		**2**	**1**	**-**	**-**	**1**	**1**	**-**	**1**	**1**		**1**	**-**	**1**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME391	**MINI PROJECT**	**SEMESTER – III** **2H-1C**
Instruction Hours/week: L:0 T:0 P:2		**Marks:** Internal**:100** External**:00** Total**:100** **End Semester Exam:**3 Hours

SEMESTER – IV

B.E BIOMEDICAL ENGINEERING **2025-2026**

25BEBME401	**MICROCONTROLLER AND EMBEDDED SYSTEM**	**SEMESTER – IV** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Explain the architecture and function of 8085/8086 microprocessor
- Illustrate the working of real time operating system
- Build the embedded devices for biomedical applications

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Interpret the ALP for 8085/8086 microprocessor (K2)
- Illustrate the architecture and functions of 8051 microcontroller (K2)
- Explain the building blocks of embedded systems (K2)
- Outline the real time operating system used in embedded systems (K2)
- Develop embedded system for biomedical applications (K2)

UNIT I **MICROPROCESSOR- 8085/8086** **09**

Introduction to 8085- Introduction to 8086 -Register Organization -Architecture- Signals- Memory Organization-Bus Operation-I/O, Instruction set, Addressing Modes- Timing Diagram- Interrupts - Service Routines – I/O and Memory Interfacing concepts of 8085/8086 Assembly language programming (ALP).

UNIT II **8051 MICROCONTROLLERS** **09**

Microcontrollers for an Embedded System – 8051 – Architecture – Addressing Modes – Instruction Set – Program and Data Memory – Stacks – Interrupts – Timers/Counters – Serial Ports – Programming.

UNIT III **EMBEDDED SYSTEM ARCHITECTURE** **09**

Embedded System Design Process – Model Train Controller – ARM Processor – Instruction Set Preliminaries – CPU – Programming Input and Output – Supervisor Mode – Exceptions and Trap – Models for programs – Assembly, Linking and Loading – Compilation Techniques – Program Level Performance Analysis.

UNIT IV **REAL TIME OPERATING SYSTEM** **09**

Structure of a real time system – Task Assignment and Scheduling – Multiple Tasks and Multiple Processes – Multirate Systems – Pre emptive real – time Operating systems – Priority based scheduling – Interprocess Communication Mechanisms – Distributed Embedded Systems – MPSoCs and Shared Memory Multiprocessors – Design Example – Audio Player, Engine Control Unit and Video Accelerator

UNIT V **APPLICATION DEVELOPMENT** **09**

Discussions on Basics of Linux supportive RTOS - uCOS - C Executive for development of RTOS Application - Case study

TOTAL -45 Hours

TEXT BOOKS:

1. R. S. Gaonkar. Microprocessor Architecture: Programming and Applications with the 8085, Penram International Publishing, 2000.
2. Wolf, Marilyn. Computers as components: principles of embedded computing system design. Elsevier, 2012.
3. Liu, Jane WS. Real-time systems. Pearson Education India, 2006.

REFERENCE BOOKS:

1. Das, Lyla B. Embedded systems: An integrated approach. Pearson Education India, 2012.
2. Valvano, Jonathan W. Embedded microcomputer systems: real time interfacing. CL Engineering, 2011.
3. Simon, David E. An embedded software primer. Vol. 1. Addison-Wesley Professional, 1999.
4. Bhur, Raymond JA, and Donald L. Bialey. "An Introduction to real time systems: Design to networking with C/C++." (1999).
5. Prasad, K. V. K. K. Embedded Real-time Systems. DreamTec, 2005.
6. Iyer, Sriram, and Pankaj Gupta. Embedded realtime systems programming. Tata McGraw- Hill Education, 2003.

WEBSITES:

1. nptel.ac.in/courses/106/105/106105193/
2. https://nptel.ac.in/courses/117104072

CO, PO PSO Mapping

Cos / POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	1	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	1	-	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	1	1	-
CO4	K2	2	1	-	-	-	-	-	1	1	-	1	-	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	1	1	-
Average		**2.2**	**1.2**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**1**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME402	**BIOMEDICAL SIGNAL PROCESSING**	**SEMESTER – IV** **4H-4C**

Instruction Hours/week: L:3 T:1 P:0

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: SIGNALS AND SYSTEMS

COURSE OBJECTIVES

The goal of this course is for students to:

- Summarize the process of physiological signal acquisition
- Make use of mathematical models to eliminate the noise and artifacts in the biomedical signal
- Develop a mathematical model to perform signal classification and recognition

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the process of biomedical signal acquisition (K2)
- Apply time and frequency domain filters to remove noise from biomedical signal (K3)
- Choose appropriate mathematical model for cardiovascular applications (K3)
- Compare the statistical approaches used for neurological applications (K2)
- Apply machine learning approaches for biomedical signal classification (K3)

UNIT I **INTRODUCTION TO BIOMEDICAL SIGNALS** **12**

Sampling and aliasing, Signal reconstruction, Signal conversion systems, convolution – Correlation - FFT - decimation in time algorithm, Decimation in Frequency algorithm. Artificial intelligence in signal processing. Bio signal Characteristics of Electro Cardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG), Electrooculogram (EOG), Electroretinogram (ERG), Electrogastrogram (EGG), Electroneurogram (ENG), Event related potentials (ERPs), Phonocardiogram (PCG), Speech signal, Objectives of Biomedical signal analysis, Difficulties in Biomedical signal analysis, Computer-aided diagnosis.

UNIT II **FILTERING FOR REMOVAL OF ARTIFACTS** **12**

Time-domain Filters - synchronized averaging, Moving Average Filters, Derivative-based operators to remove low-frequency artifacts. Frequency-domain filters - Removal of High Frequency noise, Removal of low frequency noise, Removal of periodic artifacts, optimal filter- Wiener filter, Adaptive filters for removal of interference.

UNIT III **CARDIOVASCULAR APPLICATIONS** **12**

Noise & Artifacts, ECG Signal Processing: Baseline Wandering, Power line interference, Muscle noise filtering – QRS detection, Adaptive noise cancelling in ECG, improved adaptive filtering in FECG, Wavelet detection in ECG – structural features, matched filtering, adaptive wavelet detection, detection of overlapping wavelets. Wavelet transforms - mother wavelet, Computation of diagnostic signal parameters of ECG like Heart rate and QRS detection using Multivariate analysis (PCA and ICA). Segmentation of PCG, intensity patterns, Spectral modelling and analysis of PCG signals**.**

UNIT IV **NEUROLOGICAL APPLICATIONS** **12**

EEG rhythms & waveforms, EEG applications- Epilepsy, sleep disorders, brain computer interface. Modelling EEG- linear, stochastic models - Nonlinear modelling of EEG - artifacts in EEG & their characteristics and processing – Nonparametric spectral analysis, Model based spectral analysis - EEG segmentation - Joint Time- Frequency analysis - correlation analysis of EEG channels - coherence analysis of EEG channels. Evoked potentials- noise characteristics, Noise reduction by linear filtering.

UNIT V **ANALYSIS ON WAVESHAPE, SIGNAL CLASSIFICATION AND RECOGNITION** **12**

Modelling intramuscular EMG-Intramuscular signal decomposition-Fractal analysis of EMG signals. Statistical analysis of VAG signals. Analysis on amplitude and latency of MEG signals. Analysis of ERP effect. Signal classification and recognition – Statistical signal classification, linear discriminant function, direct feature selection and ordering, Back propagation neural network-based classification. Analysis of EEG using Empirical mode decomposition (EMD)

TOTAL -60 Hours

TEXT BOOKS:

1. John G. Proakis and Dimitris G.Manolakis, "Digital Signal Processing, Algorithms and Applications", PHI of India Ltd., New Delhi, 3rd Edition,2021
2. Rangaraj.M.Rangayyan, "Biomedical signal Analysis", Wiley-IEEE Press, 2015

REFERENCE BOOKS:

1. Sanjit K.Mitra, "Digital Signal Processing,A Computer Based Approach", Tata McGraw- Hill, New Delhi, 2001
2. D.C.Reddy, "Biomedical Signal Processing, Principles and Technique", TMH, New Delhi, 2005

WEBSITES:

1. tel.ac.in/courses/108105101
2. w.mit.edu/courses/res-6-008-digital-signal-processing-spring-2011/

CO, PO PSO Mapping

Cos / POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	1	1	2
CO2	K3	3	2	1	-	-	-	-	1	1	-	1	1	2
CO3	K3	3	2	1	-	-	-	-	1	1	-	1	1	2
CO4	K2	2	1	-	-	-	-	-	1	1	-	1	1	2
CO5	K3	3	2	1	-	-	-	-	1	1	-	1	1	2
Average		**2.6**	**1.6**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**1**	**1**	**2**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME403	**BIO INSTRUMENTATION**	**SEMESTER – IV** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Outline the process of recording the biopotential electrodes
- Illustrate the signal conditioning circuits and measurement of non-electrical parameters
- Develop biosensors to record biochemical parameters

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the process of acquiring biopotentials (K2)
- Illustrate the working of biopotential measuring systems (K2)
- Infer the principles of signal conditioning circuits for noise filtering (K2)
- Interpret the techniques for measuring non-electrical parameters (K2)
- Identify biochemical components using biosensors (K3)

UNIT I BIOPOTENTIAL ELECTRODES 09

Cell and its structure – resting potentials – action potentials – bioelectric potentials – measurement of potentials and their recording – Electrode theory – bipolar and Unipolar electrode-surface electrode – electrode impedance –equivalent circuit for extra cellular electrodes- micro electrodes. basic principles of ECG, EEG, EMG.

UNIT II BIOPOTENTIAL MEASUREMENTS 09

Bio signals characteristics – frequency and amplitude ranges. ECG – Einthoven‘s triangle, standard 12 lead system, Principles of vector cardiograph. EEG – 10-20 electrode system, unipolar, bipolar and average mode. EMG– unipolar and bipolar mode. Recording of ERG, EOG and EGG

UNIT III SIGNAL CONDITIONING CIRCUITS 09

Need for bio-amplifier - single ended bio-amplifier, differential bio-amplifier, Impedance matching circuit, isolation amplifiers – transformer and optical isolation - isolated DC amplifier and AC carrier amplifier., Power line interference, Right leg driven ECG amplifier, Band pass filtering

UNIT IV MEASUREMENT OF NON-ELECTRICAL PARAMETERS 09

Blood Pressure: indirect methods - Auscultatory method, oscillometric method, direct methods: electronic manometer, Pressure amplifiers, Systolic, diastolic, mean detector circuit. Blood flow and cardiac output measurement: Indicator dilution, thermal dilution and dye dilution method, Electromagnetic and ultrasound blood flow measurement. Measurement of heart sounds – phonocardiography. Cardiac pacemakers – internal and external pacemakers, defibrillators. Plethysmography –photo electric and impedance plethysmographs

UNIT V BIOCHEMICAL MEASUREMENT AND BIOSENSORS 09

Biochemical sensors - pH, pO2 and pCO2, Ion selective Field effect Transistor(ISFET), Immunologically sensitive FET (IMFET), Blood glucose sensors, Blood gas analyzers - colorimeter, Sodium Potassium Analyzer, spectrophotometer, blood cell counter, auto analyzer (simplified schematic description) – Bio Sensors – Principles – amperometric and voltometric techniques.

TOTAL -45 Hours

TEXT BOOKS:

1. Khandpur R.S, "Handbook of Biomedical Instrumentation", Tata McGraw-Hill, New Delhi 2014
2. John G. Webster Medical Instrumentation Application and Design John Wiley and sons 2020

REFERENCE BOOKS:

1. Leslie Cromwell, Biomedical Instrumentation and Prentice hall of India, New Delhi 2007
2. Myer Kutz,Standard Handbook of Biomedical Engineering & Design,McGraw-Hill, 2003

WEBSITES:

1. https://ocw.mit.edu/courses/20-309-biological-engineering-ii-instrumentation-and-measurement-fall- 2006/pages/syllabus/

CO, PO PSO Mapping

Cos / POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	1	2	1
CO2	K2	2	1	-	-	-	-	-	1	1	-	1	2	1
CO3	K2	2	1	-	-	-	-	-	1	1	-	1	2	1
CO4	K2	2	1	-	-	-	-	-	1	1	-	1	2	1
CO5	K3	3	2	1	-	-	-	-	1	1	-	1	2	1
Average		**2.2**	**1.2**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	1	**2**	**1**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME404 **SUSTAINABLE BIOMATERIALS** **SEMESTER – IV**
3H-3C

Instruction Hours/week: L:3 T:0 P:0

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES:

The goal of this course is for students to:

- Explain the biomaterials and its types of metallic materials
- Classify the polymeric and tissue replacement implants
- Develop the standard biological testing procedure of biomaterials

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

- Infer the classification and characteristics of biomaterials (K2)
- Identify the metallic and ceramic materials for implants (K3)
- Interpret the polymeric implant materials (K2)
- Illustrate the need of tissue replacement implants (K2)
- Make use of the testing standards applied for biomaterials (K3)

UNIT I **INTRODUCTION TO BIO-MATERIALS** **09**

Definition and classification of bio-materials, mechanical properties, visco elasticity, biomaterial performance, body response to implants, wound healing, blood compatibility, Nano scale phenomena.

UNIT II **METALLIC AND CERAMIC MATERIALS** **09**

Metallic implants – Stainless steels, co-based alloys, Ti-based alloys, shape memory alloy, nanostructured metallic implants, degradation and corrosion, ceramic implant – bio inert, biodegradable or bioresorbable, bioactive ceramics, nanostructured bio ceramics.

UNIT III **POLYMERIC IMPLANT MATERIALS** **09**

Polymerization, factors influencing the properties of polymers, polymers as biomaterials, biodegradable polymers, Bio polymers: Collagen, Elastin and chitin. Medical Textiles, Materials for ophthalmology: contact lens, intraocular lens. Membranes for plasma separation and Blood oxygenation, electro spinning: a new approach.

UNIT IV **TISSUE REPLACEMENT IMPLANTS** **09**

Small intestinal sub mucosa and other decullarized matrix biomaterials for tissue repair: Extracellular Matrix. Soft tissue replacements, sutures, surgical tapes, adhesive, Percutaneous and skin implants, maxillofacial augmentation, Vascular grafts, hard tissue replacement Implants, joint replacements, tissue scaffolding and engineering using Nano biomaterials.

UNIT V **TESTING OF BIOMATERIALS** **09**

Biocompatibility, blood compatibility and tissue compatibility tests, Toxicity tests, sensitization, carcinogenicity, mutagenicity and special tests, Invitro and Invivo testing; Sterilisation of implants and devices: ETO, gamma radiation, autoclaving. Effects of sterilization.

TOTAL -45 Hours

TEXT BOOKS:

1. Sujata V. Bhatt. Biomaterials. Narosa Publishing House, 2005.
2. Sreeram Ramakrishna, MuruganRamalingam. Biomaterials: A Nano Approach. CRC Press, 2010

REFERENCE BOOKS:

1. Myer Kutz. Standard Handbook of Biomedical Engineering& Design. McGraw Hill, 2003.
2. BD Ratner, AS Hoffmann, FJ Schoen. An Introduction to Materials in Medicine. Academic Press, 2012

WEBSITES:

1. https://www.nature.com/subjects/biomaterials
2. https://www.sciencedirect.com/journal/biomaterials

CO, PO PSO Mapping

Cos / POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	1	1	1	1	-	1	1	2
CO2	K3	3	2	1	-	-	1	1	1	1	-	1	1	2
CO3	K2	2	1	-	-	-	1	1	1	1	-	1	1	2
CO4	K2	2	1	-	-	-	1	1	1	1	-	1	1	2
CO5	K2	2	1	-	-	-	1	1	1	1	-	1	1	2
Average		**2.2**	**1.2**	**1**	**-**	**-**	1	**1**	**1**	**1**	**-**	**1**	**1**	**2**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME405	**BIOMEDICAL WASTE MANAGEMENT**	**SEMESTER – IV** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Outline the biomedical waste and segregation process
- Identify the bioethics and hospital generated waste and its disposal methods

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Illustrate the segregation and disposal of biomedical wastes (K2)
- Classify the types of biomedical waste usage (K2)
- Interpret the cross infections through hospital generated wastes and
- its Prevention measures (K2)
- Outline the procedure and methods for biomedical waste disposal (K2)
- Explain the awareness and seriousness in handling biomedical waste. (K2)

UNIT I **INTRODUCTION & WASTE SEGREGATION** **09**

General Introduction, Definition of Biomedical Waste, General and Hazardous health care waste – color Coding and types of containers for disposal of medical waste, Segregation, Collection & Disposal.

UNIT II **TYPES OF BIOMEDICAL WASTE** **09**

Infectious waste, Genotoxic waste, Waste Sharps – Categories, Categorization and composition of biomedical waste. Liquid Biomedical Waste - Radioactive wastes, Metals, Chemicals & drugs.

UNIT III **TYPES OF WASTE DISPOSAL** **09**

Disinfections unit container for Autoclaving, Sharp waste containers for storage & transportation, autoclaving, Incineration, Plasma Pyrolysis /Gasification systems, Composting.

UNIT IV **BIOETHICS AND RECENT TRENDS APPLICATION** **09**

Disinfections unit container for Autoclaving, Sharp waste containers for storage & transportation, autoclaving, Incineration, Plasma Pyrolysis /Gasification systems, Composting.

UNIT V **BIOETHICS AND RECENT TRENDS APPLICATION** **09**

Modern Technology for handling Biomedical Wastes – Monitoring & Controlling of Cross Infections, Protective Devices – Bioethics and Handling of Waste Management.

TOTAL -45 Hours

TEXT BOOKS:

1. Singh Anantpreet, Kaur Sukhjit. Biomedical Waste Disposal. Jaypee Brothers Publishers, 2012.
2. Prof. Dr. Mahendra Pal. The Complete Book on Waste Treatment Technologies. Niir Project Consultancy Services, 2015

REFERENCE BOOKS:

1. Peter A. Reinhardt. Infectious and Medical Waste Management, CRC Press, 1st edition 2018.
2. Sujata Sanjay Pawar. Legal Perspective on Biomedical Waste Management. Create Space Independent Publishing Platform, 2016

WEBSITES:

1. https://dth.ac.in/medical/courses/Microbiology/block-9/3/index.php
2. http://www.digimat.in/nptel/courses/medical/microbiology/MB93.html
3. https://nptel.ac.in/courses/105105160

CO, PO PSO Mapping

Cos / POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	2	1	1	1	-	1	1	-
CO2	K2	2	1	-	-	-	2	1	1	1	-	1	1	-
CO3	K2	2	1	-	-	-	2	1	1	1	-	1	1	-
CO4	K2	2	1	-	-	-	2	1	1	1	-	1	1	-
CO5	K3	3	2	1	-	-	2	1	1	1	-	1	1	-
Average		**2.2**	**1.2**	**1**	**-**	**-**	**2**	**1**	**1**	**1**	**-**	**1**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME444G	JAVA PROGRAMMING (THEORY & LABORATORY)	SEMESTER – IV 5H-4C

Instruction Hours/week: L:3 T:0 P:2 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

PREREQUISITES: NIL

i) THEORY

COURSE OBJECTIVES

The goal of this course is for students to:

- Learn the fundamental concepts of Java programming
- Acquire the knowledge of inheritance, abstraction, exception and package in Java
- Obtain the knowledge of Java Collection API, Multithreading, JDBC and Lambda expression in Java

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Infer the fundamental concepts, architecture, and features of Java Programming (K2)
- Solve programming challenges using object-oriented paradigms (K3)
- Build applications using multi-tasking mechanisms, and exception handling strategies (K3)
- Construct robust and efficient Java applications using JDBC, lambda expressions and interface (K3)
- Develop Java applications by amalgamating object-oriented design, collection usage and advanced data manipulation (K3)

UNIT I INTRODUCTION TO JAVA 09

History of Java – Features of Java – Java Architecture – Comments – Data Types – Variables – Operators – Type Conversion and Casting – Flow Control Statements – Reading Input from keyboard – Command Line Arguments – Using Scanner Class – Arrays – Classes and Objects – UML Class diagram – Methods – Constructors – static variables and Methods – this Keyword – Encapsulation – Concept of Access Control.

UNIT II INHERITANCE 09

Inheritance – Types of Inheritance – Super and Sub Classes – super keyword – final class and methods – Object class –Polymorphism – Types of polymorphism – Method Overloading – Constructor Overloading – Method Overriding – Dynamic Method Dispatching – garbage collection – String class –String Buffer class –String Builder class.

UNIT III DATA ABSTRACTION 09

Packages – Introduction to Packages – User Defined Packages – Accessing Packages – Abstract classes and Methods – Interface – Defining an interface – implementing interfaces – extending interfaces – Multiple Inheritance Using Interface – Exception Handling – Errors vs Exceptions – Exception hierarchy – usage of try – catch – throw – throws and finally – built in exceptions – user defined exceptions.

UNIT IV COLLECTION API AND LAMBDA 09

Introduction to wrapper classes – Predefined wrapper classes – Conversion of types – Concept of Auto boxing and unboxing – Java Collections API – Introduction to Collection – Generics – List implementations – Set implementations – Map implementations – Functional Interfaces – Lambda Expressions – Accessing local variables – Accessing class variables – Predicates – Functions – Suppliers – Consumers – Stream API – Filter – Sorted – Map – Reduce – Count – Parallel Streams.

UNIT V JDBC AND MULTITHREADING 09

JDBC – Introduction to JDBC – Establishing connection – Executing query – Processing results – Prepared Statement – Callable Statement – Transactions – Meta Data objects – Multithreading: Introduction to Multithreading – Process Vs Thread –Thread life cycle – Thread class – Runnable Interface – Thread creation – Thread control and priorities – Thread synchronization.

Total: 45 Hours

ii) LABORATORY

LIST OF EXPERIMENTS:

1. Develop programs using flow control statements and arrays to manage execution flow and data organization effectively.
2. Implement programs using inheritance and polymorphism to promote code reusability and dynamic method binding.
3. Develop programs incorporating packages, abstract classes, and interfaces to structure code modularly and enforce abstraction.
4. Implement programs using exception handling mechanisms to ensure robust error detection and graceful recovery.
5. Create programs using the Collection API and lambda expressions to manage groups of objects with flexibility and high performance.
6. Implement programs using JDBC to establish and manage database connections for data persistence and retrieval.
7. Develop programs using multithreading to achieve concurrent execution and improve application performance.

TEXT BOOKS:

1. Herbert Scheldt, "Java: The Complete Reference", 12th edition, Tata McGraw-Hill, 2022
2. Cay S Horstmann and Gary Cornell, "Core Java: Volume I – Fundamentals", 12th edition, Prentice Hall, 2021

REFERENCE BOOKS:

1. David Flanagan and Benjamin Evans, "Java in Nutshell", 8th edition, O'Reilly Media, 2022.
2. Kathy Sierra, Bert Bates, Trisha Gee, "Head First Java", 3rd edition, O'Reilly Media, Inc, 2022.
3. Joshua Bloch, "Effective Java", 3rd Edition, Addison-Wesley Professional, 2018

WEBSITES:

1. www.https://docs.oracle.com/javase/tutorial/java/nutsandbolts
2. www. https://javabeginner.com/learn-java
3. www. https://dev.java/learn
4. https://www.w3schools.com/java/java_intro.asp

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	1	-	-	2	2		-	-	2
CO2	K3	3	2	1	-	1	-	-	2	2		-	-	2
CO3	K3	3	2	1	-	1	-	-	2	2		-	-	2
CO4	K3	3	2	1	-	1	-	-	2	2		-	-	2
CO5	K3	3	2	1	-	1	-	-	2	2		-	-	2
Average		**2.8**	**1.8**	**1**	**-**	**1**	**-**	**-**	**2**	**2**		**-**	**-**	**2**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME411 **BIOMEDICAL SIGNAL PROCESSING LABORATORY** **SEMESTER – IV**
2H-1C

Instruction Hours/week: L:0 T:0 P:2

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES:

The goal of this course is for students to:

- Apply the fundamental operations on biomedical signals
- Inspect the sampling and filtering operations
- Make use of mathematical approach to extract statistical features of bio signals

COURSE OUTCOMES:

Upon completion of this course, the student will be able to:

- Construct elementary time signals(K3)
- Identify the convolution and correlation of signals (K3)
- Analyze the frequency response of biosignals (K4)
- Examine IIR and FIR filters (K4)
- Apply mathematical model to extract statistical features of biosignals (K3)

LIST OF EXPERIMENTS

1. Construct elementary Discrete Time signals
2. Compare Linear and Circular convolution
3. Construct Auto Correlation and Cross Correlation
4. Analyze the frequency response using FFT
5. Utilize scaling parameter for up and down sampling
6. Design of FIR LPF and HPF Filters
7. Design of FIR BPF and BSF Filters
8. Design of IIR Butterworth filter (LPF and HPF)
9. Design of IIR Chebyshev filter (BPF and BSF)
10. Identify the first order statistical features of biosignal

CO, PO PSO Mapping

COs/POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K3	3	2	1	-	3	-	-	2	2	-	1	2	1
CO2	K3	3	2	1	-	3	1	1	2	2	-	1	2	1
CO3	K4	3	3	2	1	3	1	1	2	2	-	1	2	1
CO4	K3	3	2	1	-	3	1	1	2	2	-	1	2	1
CO5	K4	3	3	2	1	3	1	1	2	2	-	1	2	1
Average		**3**	**2.4**	**1.4**	**1**	**3**	**1**	**1**	**2**	**2**	**-**	**1**	**2**	**1**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME412 **BIO INSTRUMENTATION LABORATORY** **SEMESTER – IV**
2H-1C

Instruction Hours/week: L:0 T:0 P:2

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES:

The goal of this course is for students to:

- Design amplifier circuits to capture maximal information while acquiring biopotentials
- Measure electrical and non-electrical parameters effectively
- Construct a PCB layout for the required electronic circuit

COURSE OUTCOMES:

Upon completion of this course, students will be able to:

- Develop amplifier circuits for biomedical signal acquisition (K3)
- Identify pH and conductivity (K3)
- Make use of biosensors to calculate pulse rate and blood pressure (K3)
- Experiment with ECG and EEG recordings (K3)
- Plan a PCB layout for the required electronic circuits for recording bio signal (K3)

LABORATORY EXPERIMENTS

1. Simulate ECG Amplifier
2. Simulate EMG Amplifier
3. Simulate EEG Amplifier
4. Measurement of pulse-rate using Photo transducer.
5. Measurement of pH and conductivity.
6. Measurement of blood pressure using a sphygmomanometer.
7. Monitoring of Electrocardiogram (ECG) for bipolar limb leads L1, L2 and L3
8. Monitoring of Electrocardiogram (ECG) for augmented leads aVL, aVF and aVR
9. Monitoring of Electroencephalogram (EEG) signal for different lobes
10. Design a PCB layout for any bio amplifier using software tool

CO, PO PSO Mapping

COs/POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K3	3	2	1	-	-	-	-	2	2	-	1	2	1
CO2	K3	3	2	1	-	-	-	-	2	2	-	1	2	1
CO3	K3	3	2	1	-	-	-	2	2	2	-	1	2	1
CO4	K3	3	2	1	-	-	-	2	2	2	-	1	2	1
CO5	K3	3	2	1	-	-	-	-	2	2	-	1	2	1
Average		**3**	**2**	**1**	**-**	**-**	**-**	**2**	**2**	**2**	**-**	**1**	**2**	**1**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME413	SKILL DEVELOPMENT -II MEDICAL DEVICE CALIBRATION	SEMESTER – IV 2H-1C

Instruction Hours/week: L:0 T:0 P:2

Marks: Internal**:100** External**:0** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES:

The goal of this course is for students to:

- Understand calibration principles
- Interpret the international standards and safety norms
- Make use of the calibration techniques to provide quality care to the patients.

COURSE OUTCOMES:

Upon completion of this course, students will be able to:

- Illustrate the electrical safety and grounding aspects in hospital. (K2)
- Explain the performance of vital devices. (K2)
- Utilize the calibration instruments at par with standard protocol. (K2)
- Identify the need for maintenance and troubleshooting of ICU equipment. (K2)
- Experiment with electronic calibration unit to formulate a solution for equipment failure. (K2)

LABORATORY EXPERIMENTS

1. Electrical Safety Analyzer Calibration
2. Gas Flow Analyzers
3. SpO2 functional tester
4. Ventilator Tester
5. Infusion Pump Calibration
6. RF / High Frequency Calibration
7. Defibrillator calibration equipment
8. Pressure Calibration
9. Vital signs simulator
10. Electronic Calibration

CO, PO PSO Mapping

COs/POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	2	1	-	-	1	1	1	1	1	-	1	2	1
CO2	2	2	1	-	-	1	1	1	1	1	-	1	2	1
CO3	2	2	1	-	-	1	1	1	1	1	-	1	2	1
CO4	2	2	1	-	-	1	1	1	1	1	-	1	2	1
CO5	2	2	1	-	-	1	1	1	1	1	-	1	2	1
Average		**2**	**1**	**-**	**-**	**1**	**1**	**1**	**1**	**1**	**-**	**1**	**2**	**1**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME491	**INTERNSHIP / FIELD PROJECT-1**	**SEMESTER – IV** **2H-1C**

Instruction Hours/week: L:0 T:0 P:2

Marks: Internal**:100** External**:00** Total**:100**

End Semester Exam:3 Hours

SEMESTER – V

B.E BIOMEDICAL ENGINEERING **2025-2026**

25BEBME501	**INTERNET OF MEDICAL THINGS (IoMT)**	**SEMESTER – V** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0

Marks: Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Illustrate the IoT Architectures
- Interpret IoMT protocols
- Construct IoMT systems for biomedical applications

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Infer the fundamentals of IoT (K2)
- Interpret the IoT protocols (K2)
- Build IoT Systems using Arduino and Raspberry Pi (K3)
- Apply data analytics for IoMT (K3)
- Model IoMT for healthcare application (K3)

UNIT I **FUNDAMENTALS OF IOT** **09**

Evolution of Internet of Things - Enabling Technologies – IoT Architectures: one M2M, IoT World Forum (IoTWF) and Alternative IoT models – Simplified IoT Architecture and Core IoT Functional Stack -– Fog, Edge and Cloud in IoT – Functional blocks of an IoT ecosystem–Sensors, Actuators, Smart Objects and Connecting Smart Objects.

UNIT II **IOT PROTOCOLS** **09**

IoT Access Technologies: Physical and MAC layers, topology and Security of IEEE802.15.4,802.15.4g, 802.15.4e, 1901.2a, 802.11ah and LoRa WAN–Network Layer: IP versions, Constrained Nodes and Constrained Networks – Optimizing IP for IoT: WPAN, Routing over Low Power and Lossy Networks– Application Transport Methods: Supervisory Control and Data Acquisition–Application Layer Protocols: CoAP and MQTT.

UNIT III **DESIGN AND DEVELOPMENT** **09**

Design Methodology - Embedded computing logic - Microcontroller, System on Chips -IoT system building blocks - Arduino - Board details, IDE programming - Raspberry Pi –Interfaces and Raspberry Pi with Python Programming.

UNIT IV **DATA ANALYTICS AND SUPPORTING SERVICES** **09**

Structured Vs Unstructured Data and Data in Motion Vs Data in Rest – Role of Machine Learning – No SQL Databases – Hadoop Ecosystem – Apache Kafka, Apache Spark –Edge Streaming Analytics and Network Analytics – Xively Cloud for IoT, Python Web Application Framework–Django–AWS for IoT–System Management with NETCONF-YANG.

UNIT V **INTERNET OF MEDICAL THINGS** **09**

Case studies – Novel Symmetrical Uncertainty Measure (NSUM) Technique for Diabetes Patients, Healthcare Monitoring system through Cyber-physical system, An IoT Model for Neuro sensors, AdaBoost with feature selection using loT for somatic mutations evaluation in Cancer, A Fuzzy-Based expert System to diagnose Alzheimer's Disease, Secured architecture for IoT enabled Personalized Healthcare Systems, Healthcare Application Development in Mobile and Cloud Environments.

TOTAL -45 Hours

TEXT BOOKS:

1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry "IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things", Cisco Press, 2017.
2. Arsh deep Bahga, Vijay Madisetti "Internet of Things – A hands-on approach" Universities Press,2015.

REFERENCE BOOKS:

1. Jan Ho¨ller, Vlasios Tsiatsis, Catherine Mulligan, Stamatis, Karnouskos, Stefan Avesan, David Boyle. "From Machine-to-Machine to the Internet of Things –Introduction to a Newge of Intelligence, Elsevier, 2014.
2. Olivier Hersent, David Boswarthick, Omar Elloumi, "The Internet of Things – Key applications and Protocols", Wiley, 2012.
3. Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), "Architecting the Internet of Things", Springer, 2011.

WEBSITES:

1. https://ocw.mit.edu/courses/20-309-biological-engineering-ii-instrumentation-and-measurement-fall- 2006/pages/syllabus/

CO, PO PSO Mapping

COs/POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	1	2	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	1	2	-
CO3	K3	3	2	1	-	-	-	-	1	1	-	1	2	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	1	2	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	1	2	-
Average		**2.4**	**1.6**	**1**	**-**	**-**	**-**	**-**	1	1	**-**	1	**2**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME502 **BIOMEDICAL IMAGE PROCESSING** **SEMESTER – V**
3H-3C

Instruction Hours/week: L:3 T:0 P:0

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Illustrate the concepts of images and its relation between pixels
- Apply image transforms and filtering techniques
- Develop the image compression, reconstruction and restoration techniques

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the fundamentals of image processing (K2)
- Illustrate image transformations and its properties (K2)
- Make use of statistical approach for enhancing medical images (K3)
- Utilize filtering and transform techniques for image restoration and reconstruction (K3)
- Apply image compression techniques on medical images (K3)

UNIT I **DIGITAL IMAGE FUNDAMENTAL** **09**

Elements of digital image processing systems, Elements of Visual perception, structure of human eye and image formation, Image sampling and quantization, Some Basic relationships between pixels, Matrix and Singular Value representation of discrete images.

UNIT II **IMAGE TRANSFORMS** **09**

2D DFT, Cosine, Sine Hadamard, Haar, Slant, KL transform, Fourier transform and their properties.

UNIT III **IMAGE ENHANCEMENT** **09**

Histogram – Modification and specification techniques, Enhancement by point processing Image smoothening, Image sharpening, generation of spatial masks from frequency domain specification, Homomorphic filtering, and color image processing, color model – RGB Color Model and HIS color model.

UNIT IV **IMAGE RESTORATION AND RECONSTRUCTION OF MEDICAL IMAGE** **09**

Image degradation models, Unconstrained and Constrained restoration, mean filters, inverse filtering, Band pass filter, Band reject filter, Least mean square filter, Image reconstruction from projections– Radon transforms, Filter back projection algorithm, Fourier slice theorem, Fourier reconstruction of MRI Images.

UNIT V **APPLICATIONS AND EXPERT SYSTEMS** **09**

Run length, Huffman coding, arithmetic coding, Golomb coding, Symbol based coding, Pixel coding, transform coding, JPEG Standard, predictive techniques, Wavelet coding. Application of image processing techniques in thermography, SPECT, PET images.

TOTAL -45 Hours

TEXT BOOKS:

1. Rafael C, Gonzalez and Richard E. Woods, “Digital Image Processing”, Pearson Education, Asia, 2017.
2. Anil K. Jain, “Fundamentals of Digital Image Processing”, Prentice Hall of India, 2015.

REFERENCE BOOKS:

1. William K. Pratt, “Digital Image Processing”, John Wiley, 2010.
2. S.Sridhar, “Digital Image processing”, Oxford University press, 2016.

WEBSITES:

1. https://nptel.ac.in/courses/102105090
2. https://nptel.ac.in/courses/108105091
3. https://ocw.mit.edu/courses/hst-582j-biomedical-signal-and-image-processing-spring-20

CO, PO PSO Mapping

COs/POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	1	2	2
CO2	K2	2	1	-	-	-	-	-	1	1	-	1	2	2
CO3	K3	3	2	1	-	-	-	-	1	1	-	1	2	2
CO4	K3	3	2	1	-	-	-	-	1	1	-	1	2	2
CO5	K3	3	2	1	-	-	-	-	1	1	-	1	2	2
Average		**2.4**	**1.6**	**1**	**-**	**-**	**-**	**-**	1	1	**-**	1	**2**	**2**

1 - Low, 2 - Medium, 3 - High, ‘-’ - No Correlation

25BEBME503	**BIOCONTROL SYSTEM**	**SEMESTER – V** **4H-4C**

Instruction Hours/week: L:3 T:1 P:0

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Interpret the blocks of biocontrol systems
- Model thermal regulation and physiological system of human body
- Develop mathematical models to control autonomous and musculoskeletal functions

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Illustrate the blocks of bio control systems (K2)
- Compare engineering and physiological control system (K2)
- Construct thermal regulation process of human body (K3)
- Model a biocontrol system for autonomous function (K3)
- Develop a biocontrol system for musculoskeletal system (K3)

UNIT I INTRODUCTION TO BIOCONTROL SYSTEM 12

Introduction: Technological control system, transfer function, mathematical approaches, system stability, introduction to biological control system, Modelling and block diagram, closed loop dynamics of first order and second order control system, similarities between biological and engineering control system, biological receptors and receptor characteristics.

UNIT II PROCESS REGULATION 12

Difference between engineering and physiological control systems, generalized system properties, models with combination of system elements. Physiological system modelling, Linear model of respiratory mechanics, model of chemical regulation of ventilation, linear model of muscle mechanics, model of regulation of cardiac output, model of Neuromuscular reflex motion

UNIT III MODELING OF HUMAN THERMAL REGULATORY SYSTEM 12

Parameters involved, control system model etc. Biochemistry of digestion, types of heat loss from body, models of heat transfer between subsystems of human body like skin - core etc. and systems like within body, body environment.

UNIT IV BIOLOGICAL CONTROL I 12

Cardiac rate, blood pressure, respiratory rate, mass balancing of lungs, oxygen uptake by RBC and pulmonary capillaries, oxygen and carbon dioxide transport in blood and tissues.

UNIT V BIOLOGICAL CONTROL II 12

Urine formation and control, Pupil control systems, skeletal muscle servomechanism and semicircular canal. Free swinging limbs, Endocrine control system.

TOTAL -60 Hours

TEXT BOOKS:

1. Concise Medical Physiology by Sujit K.Chaudhuri, New Central Book agency, 2006
2. Modern control engineering by Ogata Katsuhika, 2nd edition, Prentice Hall, 2001

REFERENCE BOOKS:

1. Learning and Physiological Regulation by Barry R.Dworkin, University Of Chicago Press,1994.
2. Modelling and Control in Biomedical Systems 2000 by E.Carson, E. Salzsieder, Pergamon Publishing, 2001.

WEBSITES:

1. www.mit.edu
2. nptel.ac.in/courses/107/106/107106081/

CO, PO PSO Mapping

COs/POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	1	2	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	1	2	-
CO3	K3	3	2	1	-	-	-	-	1	1	-	1	2	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	1	2	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	1	2	-
Average		**2.4**	**1.6**	**1**	**-**	**-**	**-**	**-**	1	1	**-**	1	**2**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME504	MEDICAL DIAGNOSTIC AND THERAPEUTIC EQUIPMENT	SEMESTER – V 3H-3C

Instruction Hours/week: L:3 T:0 P:0

Marks: Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

PREREQUISITES: BIO CONTROL SYSTEM

COURSE OBJECTIVES

The goal of this course is for students to:

- Outline the diagnostic medical device for cardiac and respiratory mechanism
- Apply the electrical stimulator techniques for nerve and muscles
- Illustrate radio therapy equipment and its application in medicine

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the working mechanism of cardiac equipment (K2)
- Illustrate the principles of respiratory devices (K2)
- Choose the stimulation methods for pain relief system (K3)
- Make use of electro therapeutic equipment in special cases (K3)
- Infer the principles of laser and radiation therapeutic equipment and its types (K2)

UNIT I CARDIAC EQUIPMENT 09

External and Implantable pacemakers, Programmable pacemakers, Power sources, Design of encapsulation and leads, Pacing system analyzers. Cardiac Defibrillators, Basic principles and comparison of different Defibrillators, Energy requirements, Synchronous operation, Implantable Defibrillators, Defibrillator analyzers.

UNIT II RESPIRATORY EQUIPMENT 09

Principles of constant pressure and constant volume ventilators, Basic principles of electromechanical, Pneumatic and electronic ventilators, Nebulizer, Ventilator testing.

UNIT III ELECTROTHERAPY EQUIPMENT-I 09

Electro diagnosis, Electrotherapy, Electrodes, Stimulators for Nerve and Muscle, Stimulator for pain relief, Interferential current therapy, Spinal cord stimulator, Functional Electrical Stimulation.

UNIT IV ELECTROTHERAPY EQUIPMENT-II 09

High frequency heat therapy, Principle, Shortwave diathermy, Microwave diathermy, Ultrasonic therapy, Lithotripsy, Therapeutic IR radiation, Therapeutic UV lamps.

UNIT V THERAPEUTIC LASERS 09

Basic principles of Biomedical LASERS: Applications of lasers in medicine, CO2 laser, He- Ne laser, Nd-YAG and Ruby laser.

Total: 45 Hours

TEXT BOOKS:

1. Khandpur R.S, “Hand book of Biomedical Instrumentation”, Third Edition, McGraw Hill Education (India) Private Limited, 2014.
2. John G. Webster, Amit J. Nimunkar, “Medical Instrumentation, Application and Design”, Fifth Edition. Wiley &sons, Inc., New York, 2020.
3. Joseph J. Carr, John M. Brown, “Introduction to Biomedical Equipment Technology”, Sixth edition. Pearson Education Inc., New Delhi, 2011.

REFERENCE BOOKS:

1. Leslie Cromwell, Fred J.Weibell & Erich, A.Pfeiffer, " Biomedical Instrumentation and Measurements", Second Edition. Pearson India, 2015.
2. Val Robertson, Alex Ward, John Low & Ann Reed, "Electrotherapy Explained, Principles and Practice", Fourth Edition. Butterworth Heinemann Ltd, Elsevier, 2008.

WEBSITES:

1. https://www.mayoclinic.org/tests-procedures/implantable-cardioverter-defibrillators/about/pac-20384692
2. https://www.spine-health.com/treatment/pain-management/all-about-electrotherapy-and-pain-relief

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	1	1	2	1	-	1	3	1
CO2	K2	2	1	-	-	-	1	1	2	1	-	1	3	1
CO3	K3	3	2	1	-	-	1	1	2	1	-	1	3	1
CO4	K3	3	2	1	-	-	1	1	2	1	-	1	3	1
CO5	K2	2	1	-	-	-	1	1	2	1	-	1	3	1
Average		**2.4**	**1.4**	**1**	**-**	**-**	**1**	**1**	**2**	**1**	**-**	**1**	**3**	**1**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME511 **INTERNET OF MEDICAL THINGS LABORATORY** **SEMESTER – V**
2H-1C

Instruction Hours/week: L:0 T:0 P:2

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES:

The goal of this course is for students to:

- Explain the principles of embedded programming
- Make use of development board for medical application
- Develop prototypes for IoMT applications

COURSE OUTCOMES:

Upon completion of this course, students will be able to:

- Explain the arithmetic programs using embedded C (K2)
- Build timer-based applications (K3)
- Develop biomedical applications using embedded systems (K3)
- Plan simple control systems using embedded systems (K3)
- Construct interfacing system for medical application (K3)

LABORATORY EXPERIMENTS

1. Write Basic and arithmetic Programs Using Embedded C.
2. Write Embedded C program to test interrupt and timers.
3. Develop Real time applications–clock generation, waveform generation, counter using embedded C.
4. Interface LED/Buzzer with platform/Arduino/Raspberry Pi. And write an embedded C program to turn on/off LED/Buzzer with specified delay.
5. Interface DC/stepper motor using relay with open platform /Arduino/Raspberry Pi and write an embedded C program to turn on the motor if push button is pressed.
6. Develop simple applications–testing infrared sensors–IoT Applications–using open platform/Raspberry Pi.
7. Develop a simple application to interface DHT11 sensor with and write a program to display temperature humidity readings in LCD.
8. Develop IoMT Application using open platform /Arduino/Raspberry Pi and sensors such as temperature, ECG, Pulse etc

CO, PO PSO Mapping

COs/POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	2	1	-	-	3	-	-	2	2	-	1	3	2
CO2	3	3	2	1	-	3	-	-	2	2	-	1	3	2
CO3	3	3	2	1	-	3	-	-	2	2	-	1	3	2
CO4	3	3	2	1	-	3	-	-	2	2	-	1	3	2
CO5	3	3	2	1	-	3	-	-	2	2	-	1	3	2
Average		**2.8**	**2**	**1**	**-**	**3**	**-**	**-**	**2**	**2**	**-**	**1**	**3**	**2**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME512 **BIOMEDICAL IMAGE PROCESSING LABORATORY** **SEMESTER – V**
2H-1C

Instruction Hours/week: L:0 T:0 P:2

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES:

The goal of this course is for students to:

- Apply mathematical operations for biomedical image analysis
- Make use of filtering techniques to remove noise and enhance images
- Experiment with transform techniques for restoration and reconstruction of medical images

COURSE OUTCOMES:

Upon completion of this course, students will be able to:

- Experiment with scaling operators on medical images (K3)
- Apply filtering and transformation techniques for image enhancement (K3)
- Utilize boundary detection algorithms for edge detection (K3)
- Make use of mathematical models for image restoration and reconstruction (K3)
- Develop a workflow for biomedical image analysis (K3)

LABORATORY EXPERIMENTS

1. Digital image fundamentals.
2. Brain tumour image enhancement using filtering operation
3. Transformation of medical images using mathematical approach
4. Identify the edge and boundary of brain tumour image using boundary tracing techniques
5. Removal of noise in medical images.
6. Segmentation of user defined regions in retina images
7. Restoration and reconstruction of medical images
8. Image compressions
9. Feature extraction from medical images
10. Determine the SNR of medical images

CO, PO PSO Mapping

COs/POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	2	1	-	3	-	-	2	2	-	1	-	2
CO2	3	3	2	1	-	3	-	-	2	2	-	1	-	2
CO3	3	3	2	1	-	3	-	-	2	2	-	1	-	2
CO4	3	3	2	1	-	3	-	-	2	2	-	1	-	2
CO5	3	3	2	1	-	3	-	-	2	2	-	1	-	2
Average		**3**	**2**	**1**	**-**	**3**	**-**	**-**	**2**	**2**	**-**	**1**	**-**	**2**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME513	MEDICAL DIAGNOSTIC AND THERAPEUTIC EQUIPMENT LABORATORY	SEMESTER – V 2H-1C

Instruction Hours/week: L:0 T:0 P:2

Marks: Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

PREREQUISITES: BIOMEDICAL INSTRUMENTATION

COURSE OBJECTIVES

The goal of this course is for students to:

- Demonstrate the recording of different biopotentials
- Utilize the function of therapeutic equipment
- Make use of electrical safety measurements to save the life of equipment

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Analysis the QRS waveform and heart rate using ECG (K4)
- Experiment with diathermy and medical stimulator (K3)
- Inspect Audiogram and Spirometer (K4)
- Make use of ESU and biotelemetry (K3)
- Test for electrical safety parameters (K4)

LIST OF EXPERIMENTS

1. Simulation of ECG – detection of QRS complex and heart rate
2. Measurement of physiological parameters using patient monitor
3. Demonstrate shortwave diathermy unit
4. Demonstrate and ultrasonic diathermy unit
5. Exhibit the application of biotelemetry
6. Measurement of respiratory parameters using spirometry.
7. Exhibit the muscle stimulator.
8. Demonstrate the ESU – cutting and coagulation modes
9. Recording of Audiogram
10. Electrical safety measurements

Total Periods : 30

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K4	3	3	2	1	1	1	-	1	1	-	1	3	2
CO2	K3	3	2	1	-	1	1	-	1	1	-	1	3	2
CO3	K4	3	3	2	1	1	1	-	1	1	-	1	3	2
CO4	K3	3	2	1	-	1	1	-	1	1	-	1	3	2
CO5	K4	3	3	2	1	1	1	-	1	1	-	1	3	2
Average		**3**	**2.4**	**1.4**	**1**	**1**	**1**	**-**	**1**	**1**	**-**	**1**	**3**	**2**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E BIOMEDICAL ENGINEERING		2025-2026
25BEBME5E- -	**PROFESSIONAL ELECTIVE-I**	**SEMESTER – V** **3H-3C**
Instruction Hours/week: L:3 T:0 P:0		**Marks:** Internal**:60** External**:40** Total**:100** **End Semester Exam:**3 Hours

B.E BIOMEDICAL ENGINEERING		2025-2026
25BEBME5E- -	**PROFESSIONAL ELECTIVE-II**	**SEMESTER – V** **3H-3C**
Instruction Hours/week: L:3 T:0 P:0		**Marks:** Internal**:60** External**:40** Total**:100** **End Semester Exam:**3 Hours

25BEHS601G	UNIVERSAL HUMAN VALUES	SEMESTER – VI 3H-2C

Instruction Hours/week: L:1 T:0 P:2

Marks: Internal:**40** External:**60** Total:**100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students :

- To help students to understand the need, basic guidelines, content and process of value education and distinguish between values and skills.
- To help students initiate a process of dialog within themselves to know what they 'really want to be' in their life and profession
- To help students to understand the meaning of happiness within their selves and the meaning of prosperity for a human being.

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Illustrate the significance of value inputs in a classroom, distinguish between values and skills. (K2)
- Interpret the need, basic guidelines, content and process of value education, explore the meaning of happiness and prosperity and do a correct appraisal of the current scenario in the society (K2)
- Distinguish between the Self and the Body; understand the meaning of Harmony in the Self the Co-existence of Self and Body. (K4)
- Illustrate the value of harmonious relationship based on trust, respect and other naturally acceptable feelings in human-human relationships. (K2)
- Identify their role in ensuring a harmonious society. (K3)

UNIT I — COURSE INTRODUCTION - NEED, BASIC GUIDELINES, CONTENT AND PROCESS FOR VALUE EDUCATION — 10

Understanding the need, basic guidelines, content and process for Value Education, Self Exploration–what is it? - its content and process; 'Natural Acceptance' and Experiential Validation- as the mechanism for self-exploration, Continuous Happiness and Prosperity- A look at basic Human Aspirations, Right understanding, Relationship and Physical Facilities- the basic requirements for fulfillment of aspirations of every human being with their correct priority, Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario, Method to fulfill the above human aspirations: understanding and living in harmony at various levels

UNIT II — UNDERSTANDING HARMONY IN THE HUMAN BEING HARMONY IN MYSELF — 10

Understanding human being as a co-existence of the sentient 'I' and the material 'Body', Understanding the needs of Self ('I') and 'Body' - Sukh and Suvidha, Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer), Understanding the characteristics and activities of 'I' and harmony in 'I', Understanding the harmony of I with the Body: Sanyam and Swasthya; correct appraisal of Physical needs, meaning of Prosperity in detail, Programs to ensure Sanyam and Swasthya

UNIT III — UNDERSTANDING HARMONY IN THE FAMILY AND SOCIETY HARMONY IN HUMAN-HUMAN RELATIONSHIP — 05

Understanding harmony in the Family- the basic unit of human interaction , Understanding values in human-human relationship; meaning of Nyaya and program for its fulfillment to ensure Ubhay- tripti; Trust (Vishwas) and Respect (Samman) as the foundational values of relationship, Understanding the meaning of Vishwas;

Difference between intention and competence, Understanding the meaning of Samman, Difference between respect and differentiation; the other salient values in relationship, Understanding the harmony in the society (society being an extension of family): Samadhan, Samridhi, Abhay, Sah-astitva as comprehensive Human Goals, Visualizing a universal harmonious order in society Undivided Society (AkhandSamaj), Universal Order (Sarvabhaum Vyawastha)- from family to world family

Total: 30 Hours

TEXT BOOKS:

1. R R Gaur, R Sangal and G P Bagaria (2009).“A Foundation Course in Human Values and Professional Ethics”
2. Ivan Illich, 1974, Energy & Equity, The Trinity Press, Worcester, and Harper Collins, USA
3. E.F. Schumacher, 1973, Small is Beautiful: a study of economics as if people mattered, Blond & Briggs, Britain.
4. Sussan George, 1976, How the Other Half Dies, Penguin Press. Reprinted 1986, 1991
5. Donella H. Meadows, Dennis L. Meadows, Jorgen Randers, William W. Behrens III, 1972, Limits to Growth – Club of Rome’s report, Universe Books.
6. A Nagraj, 1998, Jeevan Vidya Ek Parichay, Divya Path Sansthan, Amarkantak.
7. P L Dhar, RR Gaur, 1990, Science and Humanism, Commonwealth Publishers.
8. A N Tripathy, 2003, Human Values, New Age International Publishers.

WEBSITES:

1. https://fdp-si.aicte-india.org/
2. https://uhv.org.in/UHV-I_Course_Material
3. https://uhv.org.in/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	2	1	1	-	1	1	-
CO2	K2	2	1	-	-	-	-	2	1	1	-	1	1	-
CO3	K2	2	1	-	-	-	-	2	1	1	-	1	1	-
CO4	K3	3	2	1	-	-	-	2	1	1	-	1	1	-
CO5	K2	2	1	-	-	-	-	2	1	1	-	1	1	-
Average		**2.2**	**1.2**	**1**	**-**	**-**	**-**	**2**	**1**	**1**	**-**	**1**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, ‘-’ - No Correlation

B.E BIOMEDICAL ENGINEERING **2025-2026**

25BEBME602	**ARTIFICIAL INTELLIGENCE IN HEALTHCARE**	**SEMESTER – VI** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Outline the concept of AI and basic production system
- Make use of knowledge-based representation for expert system
- Develop an expert system for biomedical applications

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Illustrate the characteristics of AI and production systems in healthcare (K2)
- Interpret the methods for knowledge representation (K2)
- Infer the production-based system using knowledge inference algorithm (K2)
- Explain the concept of plan generation system and machine learning approaches (K2)
- Model an expert system for biomedical applications (K3)

UNIT I INTRODUCTION TO AL AND PRODUCTION SYSTEMS 09

Introduction to AI-Problem formulation, Problem Definition -Production systems, Control strategies, Search strategies. Problem characteristics, Production system characteristics - Specialized production system-Problem solving methods – Problem graphs, Matching, Indexing and Heuristic functions -Hill Climbing-Depth first and Breath first, Constraints satisfaction – Related algorithms, Measure of performance and analysis of search algorithms.

UNIT II REPRESENTATION OF KNOWLEDGE 09

Game playing – Knowledge representation, Knowledge representation using Predicate logic, Introduction to predicate calculus, Resolution, Use of predicate calculus, Knowledge representation using other logic-Structured representation of knowledge. Control Systems - Artificial Intelligence based optimal control - Reinforcement learning

UNIT III KNOWLEDGE INFERENCE 09

Knowledge representation -Production based system, Frame based system. Inference – Backward chaining, Forward chaining, Rule value approach, Fuzzy reasoning – Certainty factors, Bayesian Theory-Bayesian Network-Dempster – Shafer theory.

UNIT IV PLANNING AND MACHINE LEARNING 09

Basic plan generation systems – Strips -Advanced plan generation systems – K strips -Strategic explanations - Why, why not and how explanations. Learning- Machine learning, adaptive Learning

UNIT V APPLICATIONS AND EXPERT SYSTEMS 09

Expert systems – Architecture of expert systems, Roles of expert systems – Knowledge Acquisition – Meta knowledge, Heuristics. Typical expert systems – MYCIN, DART, XOON, Expert system shells. Blood

pressure control, Speech Recognition – Robot control for surgical applications - Hardware - Perception - Planning – Moving image guidance

TOTAL -60 Hours

TEXT BOOKS:

1. Deepak Khemani "Artificial Intelligence", Tata McGraw Hill Education, 2013.

REFERENCE BOOKS:

1. Peter Jackson, "Introduction to Expert Systems", 3rd Edition, Pearson Education, 2007.
2. Stuart Russel and Peter Norvig "AI – A Modern Approach", 2nd Edition, Pearson Education, 2007

WEBSITES:

1. https://www.javatpoint.com/knowledge-representation-in-ai
2. https://aimaterials.blogspot.com/p/unit-iv.html

CO, PO PSO Mapping

COs/POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	1	1	2	1	-	1	-	2
CO2	K2	2	1	-	-	-	1	1	2	1	-	1	-	2
CO3	K2	2	1	-	-	-	1	1	2	1	-	1	-	2
CO4	K2	2	1	-	-	-	1	1	2	1	-	1	-	2
CO5	K3	3	2	1	-	-	1	1	2	1	-	1	-	2
Average		**2.2**	**1.2**	**1**	**-**	**-**	**1**	**1**	**2**	**1**	**-**	**1**	**-**	**2**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E BIOMEDICAL ENGINEERING **2025-2026**

25BEBME603	**BIOMECHANICS**	**SEMESTER – VI** **4H-4C**

Instruction Hours/week: L:3 T:1 P:0

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: BIO CONTROL SYSTEM

COURSE OBJECTIVES

The goal of this course is for students to:

- Illustrate the fundamental concepts of kinetics and kinematics of human motion
- Make use of mechanical properties of musculoskeletal, cardiovascular, respiratory and joint mechanics
- Infer the ergonomics factors

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Outline the principles of kinetics and kinematics operations of biomechanics (K2)
- Infer the mechanical properties of bone, muscle and tissues (K2)
- Utilize the netwonian fluids to measure the viscosity and interaction mechanism
- between blood and lung (K3)
- Classify the biomechanics of multiple joints and its functional movement (K2)
- Identify the factors affecting the ergonomics (K3)

UNIT I INTRODUCTION TO MECHANICS 12

Introduction – Scalars and vectors, Statics – Force types, Resolution and composition of forces, Moments of force and couple, Resultant force determination, parallel forces in space, equilibrium coplanar forces, Dynamics, Basic principles – Linear motion, Newton‘s laws of motion, Impulse and Momentum, Work and Energy Kinetics – Velocity and acceleration, Kinematics – Link segment models, Force transducers, Force plates, Introduction to Constitutive equations –Constitutive equations of Non viscous fluid, Newtonian Viscous fluid and Hookean Elastic solid

UNIT II MUSCULOSKELETAL MECHANICS 12

Bone structure and composition, Mechanical properties of bone: Electrical properties of bone, fracture mechanism and crack propagation in bones, fracture fixators, repairing of bones. Muscle structure, Muscle Actions - Mechanical Methods of Muscle Action Analysis, Tissue loads, Response of tissue to forces, Biomechanics of passive Muscle - Tendon units, ligament, Mechanical characteristics of muscles - Stretch shortening cycles, Force -Time Principle, Gait Analysis.

UNIT III CARDIOVASCULAR AND RESPIRATORY MECHANICS 12

Hook's law, Newtonian Fluid, Non-Newtonian fluid-. Blood flow: Laminar and Turbulent - Haematology and Blood Rheology - Relationship between diameter, velocity and pressure of blood flow - Resistance against flow. Mechanical properties of blood vessels - Arteries, arterioles,
capillaries, veins, vascular graft-Prosthetic heart valves- TAH - heart valve dynamics. Interaction of blood and lung-Alveoli mechanics, P-V curve of lung - Airway resistance - Physics of lung diseases

UNIT IV BIOMECHANICS OF JOINTS 12

Skeletal joints, forces and stresses in human joints, Analysis of rigid bodies in equilibrium, Freebody diagrams, Structure of joints, Types of joints, Biomechanical analysis of elbow, shoulder, spinal
column, hip, knee and ankle, Lubrication of synovial joints, Gait analysis, Motion analysis using video.

UNIT V MODELING AND ERGONOMICS 12

Introduction to Finite Element Analysis, finite element analysis of lumbar spine; Ergonomics – Musculoskeletal disorders, Ergonomic principles contributing to good workplace design , Process of seeing – visual capabilities-factors affecting visual acuity and contrast sensitivity – human factor aspects of hard copy text and computer screen text Whole body vibrations, Hand transmitted vibrations.

Total: 60 Hours

TEXT BOOKS:

1. Y.C. Fung, "Bio-Mechanics- Mechanical Properties of Tissues" Springer-Verlag, 1998.
4. Duane Knudson, "Fundamentals of Biomechanics", Second Edition, Springer, 2007.

REFERENCE BOOKS:

1. Sheraz S. Malik and Shahbaz S. Malik, "Orthopaedic Biomechanics Made Easy", Cambridge University Press, 2015.
2. Jay D. Humphrey, Sherry De Lange, "An Introduction to Biomechanics: Solids and Fluids", Analysis and Design, Springer Science Business Media, 2004.
3. Shrawan Kumar, "Biomechanics in Ergonomics, Second Edition", CRC Press, 2007.
4. Neil J. Mansfeild, "Human Response to Vibration", CRC Press, 2005

WEBSITES:

1. https://nptel.ac.in/courses/112105305
2. https://nptel.ac.in/courses/112106248
3. https://ocw.mit.edu/courses/hst-021-musculoskeletal-pathophysiology-january-iap-2006/pages/lecture-notes

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	1	1	1	1		1	2	1
CO2	K2	2	1	-	-	-	1	1	1	1		1	2	1
CO3	K3	3	2	1	-	-	1	1	1	1		1	2	1
CO4	K2	2	1	-	-	-	1	1	1	1		1	2	1
CO5	K3	3	2	1	-	-	1	1	1	1		1	2	1
Average		**2.4**	**1.4**	**1**	**-**	**-**	**1**	**1**	**1**	**1**		**1**	**2**	**1**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME611 ARTIFICIAL INTELLIGENCE LABORATORY **SEMESTER – VI 2H-1C**

Instruction Hours/week: L:0 T:0 P:2

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Build turbo PROLOG program for medical diagnosis
- Analyze the factorial and fibonacci of given number using AI based algorithms
- Outline the Hill climbing algorithm

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Interpret the functions of PROLOG programming language (K2)
- Develop the programe for a given problem (K3)
- Identify the turbo PROLOG program for medical diagnosis (K3)
- Solve the 4-queen and salesman problems using PROLOG (K3)
- Analyze LISP and Hill climbing algorithms (K4)

LIST OF EXPERIMENTS

1. Study of PROLOG programming language and its functions
2. Write simple fact for the statements using PROLOG
3. Write predicates one converts centigrade temperature to Fahrenheit, the other checks if a temperature is below freezing
4. Write a program to solve the monkey banana problem using PROLOG
5. WAP in turbo prolog for medical diagnosis and show the advantages and disadvantages of green and red cuts.
6. WAP to implement factorial, Fibonacci of given number using prolog
7. Write a program to solve 4-queen problem using prolog
8. Write a program to implement travelling salesman problem using prolog
9. Write a program to solve water jug problem using LISP
10. Write a program to implement Hill climbing algorithm

Total Periods : 30

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	2	-	-	2	2	-	-	-	2
CO2	K3	3	2	1	-	2	-	-	2	2	-	-	-	2
CO3	K3	3	2	1	-	2	-	-	2	2	-	-	-	2
CO4	K3	3	2	1	-	2	-	-	2	2	-	-	-	2
CO5	K4	3	3	2	1	2	-	-	2	2	-	-	-	2
Average		**2.8**	**2**	**1.3**	**1**	**2**	**-**	**-**	**2**	**2**	**-**	**-**	**-**	**2**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME612 **BIOMECHANICS LABORATORY** **SEMESTER – VI**
2H-1C

Instruction Hours/week: L:0 T:0 P:2

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: BIOMEDICAL INSTRUMENTATION

COURSE OBJECTIVES

The goal of this course is for students to:

- Outline the Musculoskeletal model
- Develop the application for diagnosing hamstring, ankle and wrist injuries
- Analyze the GAIT pattern and plantar pressure

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Model the Musculoskeletal of lower extremity, joint and muscle tendon length calculation (K3)
- Inspect the hamstring injury, ankle injuries and wrist injury (K4)
- Test the Ankle-foot Orthosis (K4)
- Examine the parameters for GAIT pattern and plantar pressure (K4)
- Analyse the force measurement for Rehabilitation (K4)

LIST OF EXPERIMENTS

1. Musculoskeletal model of a lower extremity
2. Estimation of joint length angles and Muscle tendon length
3. Assessment of hamstring injury
4. Simulation of ankle injuries
5. Evaluate ankle inversion injury during a drop landing on a sloped surface
6. Ankle-foot Orthosis and its effects on ankle inversion
7. Assessment of wrist injury
8. Assessment of GAIT pattern using accelerometer
9. Force measurement for Rehabilitation
10. Plantar pressure: Static and Dynamic analysis

Total Periods : 30

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K3	3	2	1	-	1	-	1	1	1	-	1	3	-
CO2	K4	3	3	2	1	1	-	1	1	1	-	1	3	-
CO3	K4	3	3	2	1	1	-	1	1	1	-	1	3	-
CO4	K4	3	3	2	1	1	-	1	1	1	-	1	3	-
CO5	K4	3	3	2	1	1	-	1	1	1	-	1	3	-
Average		**3**	**2.8**	**1.8**	**1**	**1**	**-**	**1**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME613	**COMMUNITY ENGAGEMENT AND SOCIAL RESPONSIBILITY**	**SEMESTER – VI** **3H-2C**

Marks: Internal**:100** External**:00**
Total**:100**

Instruction Hours/week: L:1 T:0 P:2

End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES:

The goal of this course for students is to:

- Achieve socio economic development through active community engagement.
- Improve the quality of research for better understanding of issues in the society.
- Create awareness on the role of a citizen in improving the community and hence the nation

COURSE OUTCOMES:

Upon completion of this course, the student will be able to:

- Interpret the role of community engagement in the development of the nation.
- Infer the role of rural institutions and community involvement
- Explain the social problems, social contribution of community networking and various government schemes supporting the community engagement.
- Analyze the factors that mitigate the distress & disasters
- Understand the role of Indian citizens towards community development by adopting a village and carrying out the field work

UNIT I **09**

Concept, Ethics and Spectrum of Community Engagement-Local community, Rural culture and Practice of community engagement. Stages, Components and Principles of community development, Utility of public resources – Contributions of self-help groups

UNIT II **09**

Rural Development Programs and Rural institutions- Local Administration and Community Involvement

UNIT III **09**

Social contribution of community networking, various government schemes– Programmes of community engagement and their evaluation

UNIT IV **09**

Community Engaged Research and Ethics in Community Engaged Research- Rural Distress, Rural Poverty, Impact of COVID-19 on Migrant Laborers, Mitigation of Disaster. .

UNIT V (Field work) **09**

Service-learning: address the challenges of a specific community, Community-based Participatory Research (CBPR) approaches, Knowledge sharing and knowledge mobilization to the local community, social innovations by students

TOTAL -45 Hours

REFERENCE BOOKS:

1. Principles of Community Engagement, 2nd Edition, NIH Publication No. 11-7782, Printed June 2011

WEBSITES:

1. https://onlinecourses.swayam2.ac.in/ugc23_ge04/preview

CO, PO, PSO Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	-	3	-	-	1	1	-	3	1	-
CO2	-	-	-	-	-	3	-	-	1	1	-	3	1	-
CO3	-	-	-	-	-	3	-	-	1	1	-	3	1	-
CO4	-	-	-	-	-	3	-	-	1	1	-	3	1	-
CO5	-	-	-	-	-	3	-	-	3	3	3	3	1	-
Average	**-**	**-**	**-**	**-**	**-**	**3**	**-**	**-**	**1.4**	**1.4**	**3**	**3**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E BIOMEDICAL ENGINEERING		2025-2026
25BEBME6E- -	**PROFESSIONAL ELECTIVE-III**	**SEMESTER – VI** **3H-3C**
Instruction Hours/week: L:3 T:0 P:0		**Marks:** Internal**:60** External**:40** Total**:100** **End Semester Exam:**3 Hours

B.E BIOMEDICAL ENGINEERING		2025-2026
25BEBME6E- -	**PROFESSIONAL ELECTIVE-IV**	**SEMESTER – VI** **3H-3C**
Instruction Hours/week: L:3 T:0 P:0		**Marks:** Internal**:60** External**:40** Total**:100** **End Semester Exam:**3 Hours

SEMESTER – VII

B.E BIOMEDICAL ENGINEERING **2025-2026**

25BEBME701	**REHABILITATION ENGINEERING**	**SEMESTER – VII 3H-3C**

Instruction Hours/week: L:3 T:0 P:0

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Explain the need for medical aids and the sensory rehabilitation systems.
- Interpret the use of the orthopaedic prosthetics and orthotics in rehabilitation.
- Make use of rehabilitation medicine its advocacy and the prosthetic devices

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Demonstrate Engineering Concepts in Sensory and Motor rehabilitation. (K2)
- Infer different sensory assist devices, orthotics and prosthetics for rehabilitation applications. (K2)
- Develop specific Hearing aids and visual aids and assistive devices (K3)
- Understand the need of virtual reality-based rehabilitation. (K2)
- Identify the legal aspects for building rehabilitation aids for the needed people.(K3)

UNIT I INTRODUCTION TO REHABILITATION 09

What is Rehabilitation, Epidemiology of Rehabilitation, Health, Levels of Prevention, Preventive Rehabilitation, Diagnosis of Disability, Functional Diagnosis, Importance of Psychiatry in Functional diagnosis, Impairment disability handicap, Primary & secondary Disabilities, Rehabilitation team Classification of members, Need for proper delivery of rehabilitation care, Community based rehabilitation and its aspects.

UNIT II PRINCIPLES OF REHABILITATION 09

Introduction, The Human Component, Principles of Assistive Technology Assessment, Principles of Rehabilitation Engineering- Key Engineering Principles, Key Ergonomic Principles Practice of Rehabilitation and Assistive Technology.

UNIT III THERAPEUTIC EXERCISE TECHNIQUE 09

Co-ordination exercises, Frenkels exercises, Gait Analyses-Pathological Gaits, Gait Training, Relaxation exercises-Methods for training Relaxation, Strengthening exercises-Strength training, Types of Contraction, Mobilization exercises, Endurance exercises.

UNIT IV MANAGEMENT OF COMMUNICATION & VIRTUAL REALITY 09

Impairment-introduction to communication, Aphasia, Types of aphasia, Treatment of aphasic patient, Augmentative communication-general form of communication, types of visual aids, Hearing aids, Types of conventional hearing aid, Writing aids. Introduction to virtual reality, Virtual reality-based rehabilitation, Hand motor recovery systems with Phantom haptics, Robotics and Virtual Reality Applications in Mobility Rehabilitation.

UNIT V ORTHOTIC, PROSTHETIC DEVICES & RESTORATION TECHNIQUES 09

General orthotics, Classification of orthotics-functional & regional, General principles of Orthosis, Calipers-FO, AFO, KAFO, HKAFO. Prosthetic devices: Hand and arm replacement, Body powered prosthetics,

Myoelectric controlled prosthetics and externally powered limb prosthetics. Functional Electrical Stimulation Systems-Restoration of hand function, restoration of standing and Walking, Hybrid Assistive Systems (HAS).

TOTAL -45 Hours

TEXT BOOKS:

1. Sunder, "Textbook of Rehabilitation", Jaypee Brothers Medical Publishers Pvt. Ltd, New Delhi, 2007.
2. Joseph D. Bronzino, "Biomedical Engineering Fundamentals Medical Devices and Systems Tissue Engineering and Artificial Organs", Taylor & Francis, 2000.
3. Joseph D. Bronzino, "The Biomedical Engineering Handbook", CRC press 2nd edition Volume 1, 2000.

REFERENCE BOOKS:

1. Warren E. Finn, Peter G. Lo Presti, "Hand book of Neuroprosthetic Methods", Plenum press, New York, 2003.
2. Rory A Cooper (Editor), HisaichiOhnabe (Editor), Douglas A.Hobson (Editor), "An Introduction to Rehabilitation Engineering Series in Medical Physics and Biomedical Engineering", CRC Press, 2006.

WEBSITES:

1. https://ocw.mit.edu/
2. https://www.nibib.nih.gov/science-education/science-topics/rehabilitation-engineering
3. https://biomed.iitgn.ac.in/rehabilitation/

CO, PO PSO Mapping

COs/POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	1	2	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	1	2	-
CO3	K3	3	2	1	-	-	-	-	1	1	-	1	2	-
CO4	K2	2	1	-	-	-	-	-	1	1	-	1	2	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	1	2	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	1	1	**-**	1	**2**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E BIOMEDICAL ENGINEERING **2025-2026**

25BEBME702	RADIOLOGY AND NUCLEAR MEDICINE	SEMESTER – VII 3H-3C

Instruction Hours/week: L:3 T:0 P:0

Marks: Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Explain the operation of X-ray and its uses in imaging.
- Interpret the concepts of nuclear medicine and working of nuclear medicine imaging system
- Infer the principles of radiation therapy and radiological protection

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the characteristics of radioactivity and working of X-ray equipment. (K2)
- Illustrate the principles of nuclear medicine. (K2)
- Identify the applications of nuclear imaging modalities (K3)
- Interpret the principle of radiation therapy, treatment plans and dosimetry. (K2)
- Apply the principles of radiological protection and ICRP regulations. (K3)

UNIT I **X-RAY EQUIPMENT** **09**

Nature of X-rays, X-Ray absorption, Tissue contrast. Quality of X-rays, X-Ray Equipment (Block Diagram), X-Ray Tube, the collimator, Bucky Grid, power supply, Digital Radiography, discrete digital detectors, storage phosphor and film scanning, X-ray Image Intensifier tubes, Fluoroscopy, Digital Fluoroscopy.

UNIT II **NUCLEAR MEDICINE** **09**

Basic characteristic and units of radioactivity, ionization chamber, GM tubes, Gas filled detectors, scintillation detectors, semiconductor detectors, Liquid scintillation counter, Statistical aspects of nuclear medicine.

UNIT III **NUCLEAR MEDICINE IMAGING SYSTEM** **09**

Rectilinear scanners, Scintillation Camera, principle of operation, collimator, photomultiplier tube, Pulse height Analyzer, computerized multi crystal Gamma camera, Principles of PET and SPECT

UNIT IV **RADIATION THERAPY** **09**

Principles of Radiation Therapy, Radio therapy treatment planning Dose in Radiotherapy, Mega voltage therapy, Intensity modulated Radiation therapy, Brachytherapy, Radiotherapy using radio isotopes.

UNIT V **RADIOBIOLOGY AND RADIOLOGICAL PROTECTION** **09**

Radiation sensitivity of biological materials, Evidence on radiobiological damage from cell survival curve, Radiation effects on humans, Maximum permissible dose equivalent limits, Hazard from ingested radioactivity, substances, ICRP regulations, Quality factor and sievert, Principles of radiological protection, personnel dosimetry

Total: 45 Hours

TEXT BOOKS:

1. Dendy, P. P., & Heaton, B Physics for diagnostic radiology. CRC Press, Taylor & Francis Group, 2012
2. Khan, F. M The Physics of Radiation Therapy. Lippincott Williams & Wilkins.

REFERENCE BOOKS:

1. Saha, G. B., & Springer link (Online Service), Physics and radiobiology of nuclear Medicine, Springer, 2006
2. Allisy-Roberts, P., Williams, J. R., & Farr, R. F. (2008). Farr's physics for medical imaging. Saunders.

WEBSITES:

1. nptel.ac.in/courses/102/105/102105090
2. https://ocw.mit.edu/courses/22-058-principles-of-medical-imaging-fall-2002/pages/lecture-notes

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	1	1	1	1	-	1	3	-
CO2	K2	2	1	-	-	-	1	1	1	1	-	1	3	-
CO3	K3	3	2	1	-	-	1	1	1	1	-	1	3	-
CO4	K2	2	1	-	-	-	1	1	1	1	-	1	3	-
CO5	K3	3	2	1	-	-	1	1	1	1	-	1	3	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**1**	**1**	**1**	**1**	**-**	**1**	**3**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E BIOMEDICAL ENGINEERING		2025-2026
25BEBME7E- -	PROFESSIONAL ELECTIVE-V	SEMESTER – VII 3H-3C
Instruction Hours/week: L:3 T:0 P:0	Marks: Internal:60 External:40 Total:100 End Semester Exam:3 Hours	

B.E BIOMEDICAL ENGINEERING		2025-2026
25BEBME7E- -	PROFESSIONAL ELECTIVE-VI	SEMESTER – VII 3H-3C
Instruction Hours/week: L:3 T:0 P:0	Marks: Internal:60 External:40 Total:100 End Semester Exam:3 Hours	

B.E BIOMEDICAL ENGINEERING		2025-2026
25BEBME791	PROJECT WORK PHASE-I / INTERNSHIP / FIELD PROJECT - II	SEMESTER – VII 8H-4C
Instruction Hours/week: L:0 T:0 P:8	Marks: Internal:80 External:120 Total:200 End Semester Exam:3 Hours	

SEMESTER VIII

B.E BIOMEDICAL ENGINEERING		**2025-2026**
25BEBME891	**PROJECT WORK PHASE-II**	**SEMESTER – VIII** **16H-8C**
Instruction Hours/week: L:0 T:0 P:16	**Marks: Internal:120 External:180 Total:300** **End Semester Exam:3 Hours**	

PROFESSIONAL ELECTIVES
BIO ENGINEERING

B.E Biomedical Engineering		**2025-2026**
2BEBME5E01	**CELL BIOLOGY**	**Elective 3H-3C**
Instruction Hours/week: L:3 T:0 P:0		**Marks: Internal:40 External:60 Total:100 End Semester Exam:3 Hours**

PREREQUISITES: Human Anatomy and Physiology

COURSE OBJECTIVES
The goal of this course is for students to:
- Summarize the structure and functions of cells
- Illustrate the working of transportation mechanism in human body
- Apply signal transduction methods to study the nature cells

COURSE OUTCOMES
Upon completion of this course, the student will be able to:
- Explain the structure and functions of cell
- Infer the cell division, cell cultures and their applications.
- Compare the process of Ion transportation between cell membranes
- Illustrate the secondary messengers and signal transduction mechanism
- Utilize the state of art methods to detect the type of cell

UNIT I CELL STRUCTURE AND FUNCTION OF THE ORGANELLES 09
Prokaryotic, Eukaryotic cells, Sub-cellular organelles and functions. Principles of membrane organization membrane proteins, cytoskeletal proteins. Extra cellular matrix, cell-cell junctions.

UNIT II CELL DIVISION, CANCER, APOPTOSIS AND IMMORTALIZATION OF CELLS 09
Cell cycle – Mitosis, Meiosis, Molecules controlling cell cycle, cancer, role of Ras and Raf in oncogenesis and apoptosis. Stem cells, Cell culture and immortalization of cells and its applications.

UNIT III TRANSPORT ACROSS CELL MEMBRANE 09
Passive and Active Transport, Permeases, Ion channels, ATP pumps. Na+ / K+ /Ca+2Tpumps, uniport, symport antiporter system. Ligand gated / voltage gated channels, Agonists and Antagonists.

UNIT IV SIGNAL TRANSDUCTION 09
Receptors – extracellular signaling, Cell surface / cytosolic receptors and examples, Different classes of receptors antocrine / paracrine / endocrine models, Secondary messengers molecules.

UNIT V TECHNIQUES USED TO STUDY CELLS 09
Cell fractionation and flow cytometry, Morphology and identification of cells using microscopic studies like SEM, TEM and Confocal Microscopy. Localization of proteins in cells – Immunostaining.

Total: 45 Hours

TEXT BOOKS:

1. Lodish, Harvey etal., Molecular Cell Biology, 7th Edition, W.H.Freeman, 2013
2. Cooper, G.M. and R.E. Hansman, The Cell: A Molecular Approach, 8th Edition, Oxford University Press, 2018
3. Alberts, Bruce etal. Molecular Biology of the Cell, W.W. Norton, 2014

REFERENCE BOOKS:

1. Becker, W.M. etal., The World of the Cell, 9th Edition, Pearson Education, 2003.
2. Campbell, N.A., J.B. Recee and E.J. Simon, Essential Biology, VIIth Edition, Pearson International 2007

WEBSITES:

1. https://onlinecourses.nptel.ac.in/noc22_bt33
2. https://ocw.mit.edu/courses/7-60-cell-biology-structure-and-functions-of-the-nucleus-spring-2010/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME5E02	BIOMEDICAL INFORMATICS	Elective 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

PREREQUISITES: NA

COURSE OBJECTIVES
The goal of this course is for students to:
- Understand the fundamental concepts of Biomedical Informatics
- Illustrate the performance of data processing of high-dimensional datasets
- Summarize the applications of Biomedical Informatics

COURSE OUTCOMES
Upon completion of this course, the student will be able to:
- Explain health informatics and hospital information system
- Compare the medical standards for medical data storage and analysis
- Outline the process of medical data storage and automation
- Illustrate the bioinformatics procedures
- Model the process of bioinformatics for medical applications

UNIT I MEDICAL INFORMATICS 09
Introduction, Medical Informatics, Bioinformatics, Health Informatics, Structure of Medical Informatics Functional capabilities of Hospital Information System, On-line services and off, line services, History taking by computer, Dialogue with the computer

UNIT II MEDICAL STANDARDS 09
Evolution of Medical Standards, IEEE 11073, HL7, DICOM, IRMA, LOINC, HIPPA, Electronics Patient Records, Healthcare Standard Organizations, JCAHO (Join Commission on Accreditation of Healthcare Organization), JCIA (Joint Commission International Accreditation), Evidence Based Medicine, Bioethics.

UNIT III MEDICAL DATA STORAGE AND AUTOMATION 09
Plug in Data Acquisition and Control Boards, Data Acquisition using Serial Interface, Medical Data formats, Signal, Image and Video Formats, Medical Databases, Automation in clinical laboratories, Intelligent Laboratory Information System, PACS, Datamining

UNIT IV HEALTH INFORMATICS 09
Bioinformatics Databases, Bio-information technologies, Semantic web and Bioinformatics, Genome projects, Clinical informatics, Nursing informatics, Public health informatics, Education and Training.

UNIT V RECENT TRENDS IN MEDICAL INFORMATICS 09
Medical Expert Systems, Virtual reality applications in medicine, Virtual Environment, Surgical simulation, Radiation therapy and planning, Telemedicine, virtual Hospitals, Smart Medical Homes, Personalized e-health services, Biometrics, GRID and Cloud Computing in Medicine.

Total: 45 Hours

TEXT BOOKS:

1. R.D.Lele, Computers in medicine progress in medical informatics, Tata McGraw Hill Publishing computers Ltd, New Delhi, 2005.
2. Mohan Bansal, Medical informatics, Tata McGraw Hill Publishing Computers Ltd, NewDelhi, 2003.
3. N.Mathivanan, PC-Based Instrumentation, Prentice Hall of India Pvt Ltd, New Delhi, 2007

REFERENCE BOOKS:

1. Orpita Bosu and Simminder Kaur Thukral, Bioinformatics Databases, Tools and Algorithms, Oxford University press, New Delhi, 2007.
2. Yi, Ping Phoebe Chen, Bioinformatics Technologies, Springer International Edition, NewDelhi, 2007.

WEBSITES:

1. https://onlinecourses.nptel.ac.in/noc21_bt06
2. https://ocw.mit.edu/courses/6-092-bioinformatics

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	2
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	2
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	2
CO4	K2	2	1	-	-	-	-	-	1	1	-	-	1	2
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	2
Average		**2.2**	**1.2**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**2**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME5E09	**BIOMEMS**	**Elective 3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

PREREQUISITES: Biomaterials

COURSE OBJECTIVES
The goal of this course is for students to:
- Explain the working principles of MEMS sensors
- Illustrate the properties of sensors suitable for medical application
- Construct MEMS device for biological applications

COURSE OUTCOMES
Upon completion of this course, the student will be able to:
- Classify MEMS fabrication techniques
- Illustrate the principles of mechanical and thermal sensors
- Summarize the properties of electrostatic and piezoelectric sensors
- Outline the working of microfludic systems
- Make use of MEMS devices for medical applications

UNIT I **MEMS MATERIALS AND FABRICATION** **09**
Typical MEMs and Microsystems, materials for MEMS - active substrate materials- Silicon and it compounds, Silicon piezo resistors, Gallium Arsenide, quartz, polymers. Micromachining photolithography, thin film deposition, doping, etching, bulk machining, wafer bonding, LIGA

UNIT II **MECHANICAL AND THERMAL SENSORS AND ACTUATORS** **09**
Mechanics for MEMs design- static bending of thin plates, mechanical vibration, thermomechanics, fracture and thin film mechanics. Mechanical sensors and actuators – beam and cantilever – microplates, strain, pressure and flow measurements, Thermal sensors and actuators- actuator based on thermal expansion, thermal couples, thermal resistor, Shape memory alloys- Inertia sensor, flow sensor.

UNIT III **ELECTROSTATIC AND PIEZOELECTRIC SENSORS AND ACTUATORS** **09**
Parallel plate capacitor, pull in effect, Electrostatic sensors and actuators- Inertia sensor, Pressure sensor, flow sensor, tactile sensor, comb drive. Properties of piezoelectric materials, Piezoelectric sensor and actuator –inchworm motor, inertia sensor, flow sensor.

UNIT IV **MICROFLUIDIC SYSTEMS** **09**
Fluid dynamics, continuity equation, momentum equation, equation of motion, laminar flow in circular conduits, fluid flow in micro conduits, in submicrometer and nanoscale. Microscale fluid, expression for liquid flow in a channel, fluid actuation methods, dielectrophoresis, microfluid dispenser, microneedle, micropumps-continuous flow system, micromixers

UNIT V **APPLICATIONS OF BIOMEMS** **09**
CAD for MEMs, Drug delivery, micro total analysis systems (MicroTAS) detection and measurement methods, microsystem approaches to polymerase chain reaction (PCR), DNA sensor, MEMS based drug delivery

Total: 45 Hours

TEXT BOOKS:

1. Tai-Ran Hsu, MEMS & Microsystems- Design, Manufacture and Nanoscale Engineering, 2nd Edition, John Wiley & Sons, 2008.
2. Wanjun Wang & Steven A.Soper, BioMEMS- Technologies and applications, CRC Press, 1st Edition, 2007.

REFERENCE BOOKS:

1. Nitaigour Premchand Mahalik, MEMS, Tata McGraw Hill, 2nd Reprint, 2008.
2. Chang Liu, Foundations of MEMS, Pearson Education International, New Jersey, USA, 2006

WEBSITES:

1. https://onlinecourses.nptel.ac.in/noc22_me81
2. https://ocw.mit.edu/courses/6-777j-design-and-fabrication-of-microelectromechanical-devices-spring-2007/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	2	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	2	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	2	-
CO4	K2	2	1	-	-	-	-	-	1	1	-	-	2	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	2	-
Average		**2.2**	**1.2**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**2**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E Biomedical Engineering **2025-2026**

25BEBME5E10 **CLINICAL ENGINEERING** **Elective 3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

PREREQUISITES: Professional Ethics

COURSE OBJECTIVES

The goal of this course is for students to:

- Summarize roles and activity of the clinical engineering
- Explain the challenges of healthcare technology management and patient safety
- Make use of advance technology in patient safety system

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Summarize roles of the clinical engineering
- Explain the process of medical technology management
- Interpret the challenges healthcare package system
- Outline the parameters of clinical engineering program indicator
- Apply an advanced patient safety system in health care sector

UNIT I **INTRODUCTION** **09**

Clinical engineering: Definition, Evolution, Role, Responsibilities, Functional status, History of clinical engineering and Technology in Health Care System, Enhancing patient safety.

UNIT II **MEDICAL TECHNOLOGY MANAGEMENT PRACTICES** **09**

Strategic Medical Technology Planning, Scope , Clinical necessity operational support, strategic planning process – Technology assessment: Technology audit, Budget strategies, Prerequisite for medical technology assessment – Management Practice for Medical Equipment - Device evaluation, Risk reduction, Asset management, ESHTA.

UNIT III **ESSENTIAL HEALTH CARE TECHNOLOGY PACKAGE (EHTP)** **09**

Introduction – Package development: Methodology, Logical framework, Implementation, Information promotion and dissemination – EHTP Justification – EHTP matrix – EHTP advantages – Impact Analysis.

UNIT IV **CLINICAL ENGINEERING PROGRAM INDICATOR** **09**

Clinical engineering: program services, Program database – Clinical Engineering Program management, Program indicator, Managing clinical engineering performance using program indicators – Indicator management process.

UNIT V **ADVANCED TECHNOLOGY FOR PATIENT SAFETY** **09**

Factors Contributing to Medical Errors: Healthcare Reimbursement, Health Care Failure Mode and Effect Analysis (HFMEA), Patient Safety Best Practices Model: Bar coding, Computerized Physician Order Entry (CPOE), and Clinical data repositories – Process analysis, Methodology. Computerized medical equipment management systems.

Total: 45 Hours

TEXT BOOKS:

1. Ernesto Iadanza, Joseph Dyro, Clinical Engineering Handbook, Elsevier,Academic Press,2014.

REFERENCE BOOKS:

1. Robert Miniati Clinical Engineering from Devices to Systems Academic Press 23-Dec2015

WEBSITES:

1. https://nptel.ac.in/courses/102101068
2. https://ocw.mit.edu/courses/20-380j-biological-engineering-design-spring-2010/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E Biomedical Engineering **2025-2026**

25BEBME6E01	**MICRO FLUIDICS**	**Elective 3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

PREREQUISITES: Biomechanics

COURSE OBJECTIVES

The goal of this course is for students to:

- Infer the concepts of microfluidics, materials and fabrication processes
- Illustrate the working of detection and control of microfluidic systems
- Model a microfluidic device for biomedical applications

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the fundamentals of microfluidics
- Compare the materials and fabrication processes for microfluidics
- Summarize the methods for detection and control of fluidic systems
- Outline the principles of microdevice technologies
- Construct a microfluidic system for medical applications

UNIT I **BASIC MICROFLUDIC CONCEPTS** **09**

Introduction to Microfluidics- Introduction to Microfluidics- The microfluidic advantage- Fluidics and Transport Fundamentals: The continuum approximation- Laminar flow- Diffusion in microfluidic systems - Surface forces and droplets- 1 Pumps and valves- Electrokinetics- Electro-osmosis- Electrophoresis

UNIT II **MATERIALS AND FABRICATION PROCESSES FOR MICROFLUIDIC** **09**

Materials for Microfluidic Devices- Silicon Based Materials- Glass Based Materials- Polymers Based Material- Fabrication of Microfluidics devices- Photolithography & its techniques- Additive Techniques- Subtractive Techniques- Silicon microfabrication- Injection molding and Hot embossing- Casting & Lithography- Fabrication of microfluidic channels in SU-8- Microfluidic networks created in biodegradable materials.

UNIT III **FLUIDIC CONTROL METHODS AND DETECTION METHODS** **09**

Fluid Control :Basic theory- Pressure –Driven Flow- Shear driven Flow- Shear driven flow examples- Electrokinetically –driven flow- Electrokinetically –driven flow problem and examples- Single Molecule Detection Methods- Optical detection methods- Electrochemical method examples- Measurement of Fluidic Properties: Non Intrusive flow measurement techniques- Current monitoring in electroosmotic flowcimetry- Laser-induced fluorescence photobleaching anemometer with stimulated emission depletion

UNIT IV **MICRODEVICE TECHNOLOGIES** **09**

Actuators for micropumps- Actuators for Microvalves- Flow sensors- Microarrays- Microreactors- Pipettes and Dispensers- Microanalytical Chips- Electrochemical microfluidics devices- Paper Microfluidics devices- 3D Printed Microfluidic Devices

UNIT V ADVANCEMENTS IN BIOENGINEERING 09

Electrophoresis:DNA separation- Case study :DNA separation- Shear-driven flow: Biomolecular separation- Case study : Biomolecular separation- Ion Transport with case study- Concentration with case study- Bioanalysis:Immunoassay- DNA analysis- On-chip separations and combinations- Sample injection and separation- Micro-gas chromatography: Micro gas sensors for micro GC- Case study for a micro GC- Micro-scale impedance measurements- Biosensor- Nano- Biosensors

Total: 45 Hours

TEXT BOOKS:

1. Patric Tabeling, Introduction to Microfluidics, Oxford U. Press, New York,2005.
2. Yujun Song, Daojian Cheng& Liang Zhao, Microfluidics: Fundamentals, Devices, and Applications, Wiley VCH, First edition, 2018.
3. Xiujun (James) Li and Yu Zhou, Microfluidic devices for biomedical applications, Woodhead Publishing Limited, 16th edition, 2013.

REFERENCE BOOKS:

1. Wei-Cheng Tian, Erin Finehout, Microfluidics for Biological Applications, Springer, 2008.
2. Nam-Trung Nguyen, Steven T. Wereley, Fundamentals And Applications of Microfluidics, Artech Print on Demand, Second Edition, 2006.

WEBSITES:

1. https://nptel.ac.in/courses/112105187
2. https://ocw.mit.edu/courses/10-52-mechanics-of-fluids-spring-2006/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME6E02	**BIOMIMETICS**	**Elective 3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

PREREQUISITES: Biosensors and measurements

COURSE OBJECTIVES

The goal of this course is for students to:

- Interpret the concept and mechanisms of biomimetic technologies for cognition and open ended design automation
- Summarize the importance of bio-inspired devices for biomimetic applications
- Develop a bio-inspired biomimetic system for diagnostic and therapeutic applications

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the concepts of biomimetics
- Illustrate the mechanism of cognition and open-ended design automation.
- Summarize the importance of bio-inspired sensors and biomimetic actuators.
- Outline the concepts in the biomimetic of motion.
- Construct the biomimetic device for real time applications

UNIT I **INTRODUCTION TO BIOMIMETICS** **09**

Introduction: Biologically Inspired Mechanisms, Biologically Inspired Structures and Parts, Defense and Attack Mechanisms in Biology, Materials and Processes in Biology, Bio-Sensors. Robotics Emulating Biology- Robotics Emulating Biology, Muscle function, Muscle design, Muscle adaptation, Biomimetics of muscle design, Bio-inspired fiber composites.

UNIT II **MECHANISM OF COGNITION AND OPEN-ENDED DESIGN AUTOMATION** **09**

Mechanized Cognition, Training and Education, Language Cognition, Sound Cognition, Visual Cognition, Machine Bodies and Brains: Evolving Controllers and Some Aspects of the Morphology, Evolving Bodies and Brains, Morphology Representations: Tree representations Developmental representations, Regulatory network representations, Evolving Machines in Physical Reality, Economy of Design Automation, Principles of Design, Research Methodology.

UNIT III **BIO-INSPIRED SENSORS AND BIOMIMETIC ACTUATORS** **09**

Biomimetic tactile sensing:Human sense of touch, Biomimetic artificial touch, Examples of bio-inspired tactile sensing, Bio-Inspired hair based interial sensors: Hair structures for inertial sensing, Cricket-inspired accelerometer, Fly-inspired gyroscope, Olfactory sensor system for the e-nose, Olfactory classification-data processing, Polymer network actuators, Biomimetic vision systems, Novel biomimetic materials :Introduction, Design of self-oscillating polymer gel, Control of self-Oscillating chemomechanical behaviors, Design of biomimetic soft actuators, Design of autonomous mass transport systems, Self-oscillating fluids.

UNIT IV **BIOMIMETICS OF MOTION** **09**

Biomechanics of motion: Control center, Passive & Active external and internal actuation, Agonist Mechanism: Hygroscopic mechanism, Agonist Mechanism: Hygroscopic mechanism, Muscular Antagonism, Power amplification: Elastic amplification, Deformation of a constant volume, Mechanics of hydrostatic systems: Single compartment systems, Multiple compartment systems, Rhythmics of motion: Gait, Passive Locomotion, Limbless locomotion, Multiple limb locomotion.

UNIT V APPLICATION OF BIOMIMETIC TECHNOLOGIES 09

Artificial intelligence through symbolic connectionism, Localist symbolic connectionism, Distributed symbolic connectionism, Symbolic connectionism in biological models, Neurofuzzy systems, Bio-Inspired adhesion technologies, Bio-Inspired adhesion technologies, Size and current technology, Quadruped robot system: Mechanical components, Electrical components of quadruped robot, Biologically inspired antenna array design Biologically inspired antenna array design.

Total: 45 Hours

TEXT BOOKS:

1. Yoseph Bar-Cohen, "BIOMIMETICS Biologically Inspired Technologies", CRC Press, 1 st Edition, 2006.
2. Trung Dung Ngo, "Biomimetic Technologies: Principles and Applications", Wood head Publishing Ltd, 1 st Edition, 2015.

REFERENCE BOOKS:

1. Sandra Persiani, "Biomimetics of Motion: Nature-Inspired Parameters and Schemes for Kinetic Design", Springer, 1 st Edition, 2019.
2. P Gruber, D Bruckner, C Hellmich, · H B. Schmiedmayer, H. Stachelberger, I C. Gebeshuber, "Biomimetics – Materials,Structuresand ProcessesExamples, Ideas and Case Studies", Springer, 1 st Edition, 2011

WEBSITES:

1. http://digimat.in/nptel/courses/video/108105192/L58.html
2. https://ocw.mit.edu/courses/2-a35-biomimetic-principles-and-design-fall-2013/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	1
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	1
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	1
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	1
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	1
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	1

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E Biomedical Engineering		2025-2026
25BEBME6E09	BIOFLUID MECHANICS	Elective 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

PREREQUISITES: Biomechanics

COURSE OBJECTIVES

The goal of this course is for students to:

- Outline the fundamentals of soft tissue mechanics
- Compare the macrocirculation and microcirculation systems
- Make use of biofluid mechanics of organ systems

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the fundamentals of soft tissue mechanics
- Show the various transports in biological systems
- Interpret the role of biofluid mechanics in various organ systems
- Illustrate the concepts of cardiac systems and its biofluid mechanics
- Utilize the concept of biofluid mechanics for medical applications

UNIT I FUNDAMENTAL OF SOFT TISSUE MECHANICS 09

Introduction: Structural organization of skeletal muscle- Muscle fiber- Motor unit- Fiber types- Fiber architecture- Muscle function- Maximum Muscle Stress- Maximum Muscle Contraction Velocity- Types of Muscle Models- Huxley biochemical models- Hill phenomenological models- Constitutive models- Tendon-morphology- Tendon-properties- Ligament –morphology- Ligament –properties- Articular cartilage – morphology and properties

UNIT II BASIC CONCEPT OF BIOFLUIDS 09

Introduction –Body fluids, Dimension and unit-Basic Concepts and Definitions of Fluid Mechanics-Fluid Kinematics and Viscosity-Newtonian Fluids-Non-Newtonian Fluids-Dimensionless Numbers of Biofluid Mechanics-Steady versus Unsteady Flow and Laminar Versus Turbulent Flow-Boundary Conditions and No Slip Boundary Condition -Navier Stokes Equations-Bernoulli Equation-Hagen Poiseuille Equation-Steady Flow Along Tube, Hematology and blood rheology

UNIT III MACROCIRCULATION AND MICROCIRCULATION SYSTEM 09

Introduction of macrocirculation and microcirculation-Pulsatile flow properties-Arteries-Veins-Vascular bifurcations and branches-Blood flow through curved vessels-Mechanical and elasticity properties of vessels-Atherosclerosis characteristics-Blood flow through stenosis-Arterioles and blood flow aspects-Capillaries and venules-Fahraeus and Fahraeus lindqvist effects-Mass transport in tissue-Porosity, tortuosity and permeability-Governing equations in porous media-Fluid transport in poroelastic media

UNIT IV CARDIAC MECHANICS 09

Introduction-Cardiac Geometry and Structure- Ventricular Geometry-Myofiber Architecture-Extracellular Matrix Organization-Cardiac Pump Function: Ventricular Hemodynamics-Ventricular Pressure--Volume Relations and Energetics-Myocardial Material Properties: Muscle Contractile Properties-Muscle Contractile Properties-Resting Myocardial Properties-Regional Ventricular Mechanics: Stress and Strain

UNIT V BIOFLUID MECHANICS OF ORGANS SYSTEM 09

Kidney :Structure and function-Fluid flow in an artificial kidney model- Liver: structure and function-Hepatic acinus model-Fluid flow in hepatic acinus model- Lung : Structure and function-Elasticity of the lung blood vessels and alveoli-Pressure-volume relationship for air flow in the lungs-Oxygen/carbon dioxide diffusion and transport in the blood-Compressible fluid flow-Lubrication of joints: function-Formation of synovial fluid-Synovial fluid flow-Mechanical forces within joint.

Total: 45 Hours

TEXT BOOKS:

1. David A. Rubenstein, Wei Yin & Mary D. Frame, Biofluid mechanics: An introduction to fluid mechanics, macrocirculation and microcirculation (Biomedical Engineering), Elsevier,2nd edition,2012.
2. Clement Kleinstreuer, Biofluid Dynamics: Principles and Selected Applications, CRC Press; 1 edition,2016.

REFERENCE BOOKS:

1. Susan Hall, Basic Biomechanics, McGraw-Hill Education,6th edition,2011.
2. Ali Ostadfar, Biofluid Mechanics -Principles and Applications, Elsevier,1st edition,2016.

WEBSITES:

1. https://onlinecourses.nptel.ac.in/noc19_bt27/preview
2. https://ocw.mit.edu/courses/10-52-mechanics-of-fluids-spring-2006/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E Biomedical Engineering **2025-2026**

25BEBME6E10 **ROBOTICS AND AUTOMATION IN MEDICINE** **Elective 3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Infer the principles and basic mechanism of robotic subsystems.
- Illustrate the design, analysis and working principle of manipulators and actuators.
- Build a robotic architecture to assist in the medical field.

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Outline the concepts of robotics.
- Explain the working principles of actuators and grippers.
- Classify manipulators and its types.
- Make use of the power source of sensors in robotics.
- Model prototypes of robotic system in medical application.

UNIT I **INTRODUCTION OF ROBOTICS** **09**

Introduction to Robotics and its history, Overview of robot subsystems, Degrees of freedom, configurations and concept of workspace, Automation, Mechanisms and movements, Dynamic stabilization- Applications of robotics in medicine.

UNIT II **ACTUATORS AND GRIPPERS** **09**

Pneumatic and hydraulic actuators, Stepper motor control circuits, End effectors, Various types of Grippers, Design consideration in vacuum and other methods of gripping, PD and PID feedback actuator model.

UNIT III **MANIPULATORS & BASIC KINEMATICS** **09**

Construction of Manipulators, Manipulator Dynamic and Force Control, Electronic and pneumatic manipulator, Forward Kinematic Problems, Inverse Kinematic Problems, Solutions of Inverse Kinematic problems.

UNIT IV **POWER SOURCES AND SENSORS** **09**

Sensors and controllers, Internal and external sensors, position, velocity and acceleration sensors, Proximity sensors,force sensors, laser range finder, variable speed arrangements, Path determination - Machinery vision, Ranging, Laser- Acoustic, Magnetic fiber optic and Tactile sensor.

UNIT V **ROBOTICS IN MEDICINE** **09**

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.

Total: 45 Hours

TEXT BOOKS:

1. Nagrath and Mittal, “Robotics and Control”, Tata McGraw-Hill, 2018.
2. Reza N.Jazar, Theory of Applied Robotics Kinematics, Dynamics and Control, Springer, First Indian Reprint 2016.
3. Spong and Vidhyasagar, “Robot Dynamics and Control”, John Wiley and Sons,First edition, 2015.

REFERENCE BOOKS:

1. Jacob Rosen, Blake Hannaford & Richard M Satava, “Surgical Robotics: System Applications & Visions”, Springer 2011.
2. Constantinos Mavroidis, Antoine Ferreira, “Nanorobotics: Current approaches and Techniques”, Springer 2011.

WEBSITES:

1. https://onlinecourses.nptel.ac.in/noc19_me74/preview
2. https://ocw.mit.edu/courses/2-12-introduction-to-robotics-fall-2005/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, ‘-’ - No Correlation

25BEBME7E01 **INTELLECTUAL PROPERTY RIGHTS** **Elective 3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Infer the fundamentals and the codes of medical ethics
- Explain about intellectual property rights, patents and copyrights
- Utilize the overall idea about trademarks and geographical indicators

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Outline the importance of medical ethics
- Apply the knowledge of Intellectual Property Rights.
- Interpret the protocols and principles of patents
- Outline the key aspects on copyrights
- Make use of the concepts of trademarks and geographical indicators

UNIT I **CLINICAL TRIALS** **09**

Definition and historic evolution of bioethics - Definition and historic evolution of bioethics - Medical ethics:some basic issues - Teaching and learning medical ethics - Codes of conduct - Rights of patients - Rights of patients - Malpractice - Negligence - Care of the terminally ill - Distributive Justice in Health Care – Human experimentation and Clinical trials.

UNIT II **INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS** **09**

Introduction to Intellectual Property Rights - History of IPR - Importance and need for protection of intellectual property - Importance and need for protection of intellectual property - Patentable subject matter - Emerging trends and issues in IPR - Emerging trends and issues in IPR - Emerging trends and issues in IPR - Public Vs. Private - Public Vs. Private - World Intellectual Property Organization(WIPO) - World Trade Organisation (WTO) - General Agreement on Tariffs and Trade(GATT) agreement - Major Conventions on IP - Berne Convention - Paris Convention - TRIPS agreement - Basic forms of intellectual property rights.

UNIT III **PATENTS** **09**

Definition of patents - Purpose of a patent - What sort of things can be patented, Patentable and non-patentable inventions – What sort of things can be patented, Patentable and non-patentable inventions - Invention vs Innovation - Process Patent - Product Patent – Types of patent applications - Precautions while patenting - Patent specification, Patent claims - Disclosures and non-disclosures, Patent rights and infringement, Rights of a patent owner – Patent cooperation treaty - Paris convention for the protection of industrial property - Paris convention for the protection of industrial property

UNIT IV **COPYRIGHTS** **09**

What is copyright - Why copyright - Literature and artistic works - Literature and artistic works - Protection of copyright - Protection of copyright - Right of public performance- broadcasting, translation, Adaptation- Transfer of copyright - Transfer of copyright - Transfer of copyright - International conventions and treaties- International conventions and treaties- Works that are protected by copyright.

UNIT V TRADEMARKS AND GEOGRAPHICAL INDICATORS 09

Trademark and purpose of a trademark - Characteristics of trademark - Functions of trademarks – Guidelines for the registration of a trademark - Nontraditional trademarks - Major types of trademarks - Protection of a trademark, Purpose of a trademark – Madrid system for the International registration of trademarks - Industrial design-Purpose of industrial design - Protection of industrial design The Hague agreement Geographical indication - Appellation of origin - Protection of geographical indication(GI) – Protection of geographical indication(GI).

Total: 45 Hours

TEXT BOOKS:

- Ramakrishna B and Anil Kumar H S, 'Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers', Notion Press, 2017.
- C M Francis, Medical Ethics, Second Edition, Jaypee Brothers, 2004.

REFERENCE BOOKS:

1. Chawla H S, Introduction To Intellectual Property Rights, Oxford and IBH Publishing, 2020.

WEBSITES:

1. https://onlinecourses.nptel.ac.in/noc22_hs59/preview
2. https://ocw.mit.edu/courses/15-628j-patents-copyrights-and-the-law-of-intellectual-property-spring-2013/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E Biomedical Engineering		2025-2026
25BEBME7E02	**BIOERGONOMICS**	**Elective 3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Infer the ergonomic principles and mechanics of muscle physiology concepts.
- Outline the process of hearing and factors in anthropometric design of work space surfaces
- Make use of the mathematical models, analysis and design of biomedical devices using case studies.

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the principles of ergonomics.
- Analyse the factors in design of work space surfaces
- Illustrate the mathematical models, analysis and design of biomedical devices using case studies.
- Apply the principles of good ergonomic design in anthropometry
- Model prototypes by applying ergonomics in medical fields

UNIT I VISUAL AND AUDITORY ERGONOMICS 09

Process of seeing – visual capabilities-factors affecting visual acuity and contrast sensitivity – human factor aspects of hard copy text and computer screen text, factors in selecting graphic representations symbols, qualitative visual display-process of hearing-principles of auditory display.

UNIT II MUSCLE PHYSIOLOGY 09

Muscle physiology -muscle metabolism-respiratory response-joint motion study- measure of physiological in-efficiency and energy consumption-work rest cycles-aspects of manual and posture study, material handling (MMH) Bio-mechanical recommended limits of MMH.

UNIT III CONTROLS AND DISPLAYS 09

Spatial compatibility physical arrangement of displays and controls- movement capability- rotary controls and rotar displays movement of displays orientation of the operator and movement relationships control orders and control responses- human limitations in tracking task.

UNIT IV ANTHROPOMETRY 09

Anthropometry- anthropometric design principles –work space envelope- factors in design of work space surfaces- principles of seat design –principles of control panel. Organization classification of human errors theories of accident causation-reducing accidents by altering behavior.

UNIT V CASE STUDIES 09

Case Study 1: computer design, control panel design of an electronic instrument, computer key board, hand drill etc. Case Study 2: Biomedical Application, Design optimization of Medical Equipment.

Total: 45 Hours

TEXT BOOKS:

1. Pascale Carayon, Handbook of Human Factors and Engineering, Second Edition, CRC Press,2016.
2. Robert.N. Bailey, Human Performance Engineering, Third Edition, Prentice Hall,1996

REFERENCE BOOKS:

1. Martin Helander, Guide to Human Factors and Ergonomics, Second Edition, CRC Press,2005.

WEBSITES:

1. https://onlinecourses.nptel.ac.in/noc20_me11/preview

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME7E09 **GENETIC ENGINEERING** **Elective 3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

PREREQUISITES: Human anatomy and physiology

COURSE OBJECTIVES

The goal of this course is for students to:

- Relate the concepts of DNA technology and libraries
- Summarize the concepts of genome sequencing and mapping
- Develop a genome sequencing system

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the concepts of DNA technology
- Interpret the concepts of DNA libraries
- Outline the concepts of gene and genome sequencing techniques
- Classify the structure of Genome mapping
- Build a genome sequencing system

UNIT I BASICS OF RECOMBINANT DNA TECHNOLOGY 09

Manipulation of DNA – Restriction and Modification enzymes, Design of linkers and adaptors. Characteristics of cloning and expression vectors based on plasmid and bacteriophage, Vectors for insect, yeast and mammalian system, Prokaryotic and eukaryotic host systems, Introduction of recombinant DNA in to host cells and selection methods.

UNIT II DNA LIBRARIES 09

Construction of genomic and cDNA libraries, Artificial chromosomes – BACs and YACs, Chromosomal walking, Screening of DNA libraries using nucleic acid probes and antisera.

UNIT III SEQUENCING AND AMPLIFICATION OF DNA 09

Maxam Gilbert's and Sanger's methods of DNA sequencing. Inverse PCR, Nested PCR, AFLP- PCR, Allele specific PCR, Assembly PCR, Asymmetric PCR, Hot start PCR, inverse PCR, Colony PCR, single cell PCR, Real-time PCR/qPCR – SYBR green assay, Taqman assay, Molecular beacons. Site directed mutagenesis.

UNIT IV ORGANIZATION AND STRUCTURE OF GENOMES 09

Organization and structure of genomes, Genome sequencing methods, Conventional and shotgun genome sequencing methods, Next generation sequencing technologies , Ordering the genome sequence, Genetic maps and Physical maps, STS content based mapping, Restriction Enzyme Finger Printing, Hybridization mapping, Radiation Hybrid Maps, Optical mapping. ORF finding and functional annotation.

UNIT V CURRENT STATUS OF GENOME SEQUENCING PROJECTS 09

Current status of genome sequencing projects, Introduction to Functional genomics, Microarrays, Serial Analysis of Gene expression (SAGE), Subtractive hybridization, DIGE, TOGA, Yeast Two hybrid System, Comparative Genomics, Proteogenomics, Web resources for Genomics, Applications of genome analysis and genomics.

Total: 45 Hours

TEXT BOOKS:

1. ld RW, Primrose SB, Principles of Gene Manipulation, An Introduction to Genetic Engineering, Blackwell Science Publications,1993.
2. S.B.Primrose and R.M.Twyman, Principles of Genome Analysis and Genomics 3rd Ed. Blackwell Publishing.

REFERENCE BOOKS:

1. Isil Aksan Kurnaz, Techniques in Genetic Engineering, CRC Press,2015.
2. Oksana Ableitner, Introduction to Molecular Biology: Working with DNA and RNA (essentials), Springer International,2022.
3. Arun K. Shukla, Proteomics in Biology, Academic Press, 2017.

WEBSITES:

1. https://archive.nptel.ac.in/courses/102/103/102103013/
2. https://ocw.mit.edu/courses/9-322j-genetic-neurobiology-fall-2005/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E Biomedical Engineering		2025-2026
25BEBME7E10	**QUALITY CONTROL FOR BIOMEDICAL DEVICES**	**SEMESTER – IV 3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:**40 **External:**60 **Total:100**

End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Explain the principles and standards to improve the quality of medical devices
- Summarize the tools for efficient quality control and performance of medical devices
- Select the standards and procedure to improve the quality of devices

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Summarize the principles of quality management
- Outline the standards and requirements of medical devices
- Interpret the concept of statistical process control.
- Explain the tools of TQM
- Make use of standards to improve the performance of medical device

UNIT-I INTRODUCTION TO QUALITY 09

Quality: Terminologies – Dimensions of Quality – Quality Planning. Basic concepts of Total Quality Management – Principles of TQM, Leadership – Concepts: Role of Senior Management – Quality Council – Quality Council – Strategic Planning Barriers to TQM Implementation.

UNIT II MEDICAL DEVICES STANDARDS AND REQUIREMENTS 09

Customer satisfaction – Customer Perception of Quality, Customer Complaints – Service Quality – Customer Retention, Employee Involvement Motivation Empowerment Teams Team Work Recognition and Reward Recognition and Reward..

UNIT III STATISTICAL PROCESS CONTROL 09

The seven tools of quality, Cause-and-effect diagram – Check sheet – Control chart Histogram – Pareto chart – Scatter diagram – Stratification – Six sigma.

UNIT IV TQM TOOLS 09

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

UNIT V STANDARDS FOR MEDICAL DEVICES 09

Standards, Need for standards, Types – Medical device safety – Medical device quality management systems requirements ISO 9000:2000 Quality System – Clauses – FDA Functions – ASTM International – Description – CE – CE marking – IEC – Specifications.

Total: 45 Hours

TEXT BOOKS:

1. Rose J.E, Total Quality Management, Kogan Page Ltd., 1993
2. Cesar A. Cacere, Albert Zana,The Practise of clinical Engineering, Academic Press,1997
3. Greg Bounds, Beyond Total Quality Management-Toward the emerging paradigm, McGraw Hill, 2013.

REFERENCE BOOKS:

1. Joseph J.Carr, Elements of Electronics Instrumentation and Measurement, 2nd ed., Pearson Education, 2003.
2. Jerrold T. Bushberg, John M. Boone, The essential physics of medical imaging, 3rd ed., Lippincott Williams & Wilkins, 2011.

WEBSITES:

1. https://archive.nptel.ac.in/courses/127/106/127106136/
2. https://ocw.mit.edu/courses/2-996-biomedical-devices-design-laboratory-fall-2007/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

PROFESSIONAL ELECTIVES
BIOWEARABLE SYSTEMS

B.E Biomedical Engineering		**2025-2026**
25BEBME5E03	**ANALOG AND DIGITAL COMMUNICATION**	**ELECTIVE 3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Explain the principles and techniques in analog and digital communications
- Compare the data and pulse communication techniques
- Make use of source and error control coding in multi-user radio communication

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Interpret the concepts of analog and digital communication techniques
- Compare the data and pulse communication techniques
- Illustrate the source and error control coding
- Develop modulation and demodulation techniques in pulse communication system
- Apply the channel assignment in multi-user radio communication

UNIT I ANALOG COMMUNICATION 09

Noise: Source of Noise – External Noise- Internal Noise – Noise Calculation. Introduction to Communication Systems: Modulation – Types – Need for Modulation. Theory of Amplitude Modulation- Evolution and Description of SSB Techniques – Theory of Frequency and Phase Modulation –Comparison of various Analog Communication System (AM – FM – PM).

UNIT II DIGITAL COMMUNICATION 09

Amplitude Shift Keying (ASK) – Frequency Shift Keying (FSK) Minimum Shift Keying (MSK) –Phase Shift Keying (PSK) – BPSK – QPSK – 8 PSK – 16 PSK – Quadrature Amplitude Modulation (QAM) – 8QAM – 16 QAM – Bandwidth Efficiency– Comparison of various Digital Communication System (ASK– FSK – PSK – QAM).

UNIT III DATA AND PULSE COMMUNICATION 09

Amplitude Shift Keying (ASK) – Frequency Shift Keying (FSK) Minimum Shift Keying (MSK) –Phase Shift Keying (PSK) – BPSK – QPSK – 8 PSK – 16 PSK – Quadrature Amplitude Modulation (QAM) – 8QAM – 16 QAM – Bandwidth Efficiency– Comparison of various Digital Communication System (ASK– FSK – PSK – QAM).

UNIT IV SOURCE AND ERROR CONTROL CODING 09

Entropy Source encoding theorem, Shannon Fano coding, Huffman coding, mutual information, channel capacity, channel coding theorem, Error Control Coding, linear block codes, cyclic codes, convolution codes, Viterbi decoding algorithm.

UNIT V MULTI-USER RADIO COMMUNICATION 09

Advanced Mobile Phone System (AMPS) – Global System for Mobile Communications (GSM) – Code Division Multiple Access (CDMA) – Cellular Concept and Frequency Reuse – Channel Assignment and Hand off – Overview of Multiple Access Schemes – Satellite Communication – Bluetooth

Total: 45 Hours

TEXT BOOKS:

1. Kennedy G, Kennedy's Electronic Communication Systems, McGraw Hill, 2014
2. Wayne Tomasi, Electronic Communication Systems: Fundamentals through Advanced Pearson Education, 2014

REFERENCE BOOKS:

1. Rappaport T.S, Wireless Communications: Principles and Practice, Pearson Education, 2010
2. B. P.Lathi, Modern Analog and Digital Communication Systems, Oxford University Press, 2011

WEBSITES:

1. https://onlinecourses.nptel.ac.in/noc21_ee74/preview
2. https://nptel.ac.in/courses/117101051

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME5E04	WEARABLE DEVICES	ELECTIVE 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60**
Total:100
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Outline the need of developing wearble diagnostic and therapeutic systems
- Relate the energy requirements of sensors used in wireless health monitoring systems
- Interpret the need of signal processing techniques in wireless devices.

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the recent trends and need for wearable systems.
- Interpret sensors and signal processing techniques
- Illustrate energy harvesting techniques for wearable systems.
- Outline the need for wireless health care systems
- Apply the principles of diagnostic wearable devices

UNIT I SENSORS 09

Need for wearable systems, Sensors for wearable systems-Inertia movement sensors, Respiration activity sensor, Inductive plethysmography, Impedance plethysmography, pneumography, Wearable ground reaction force sensor, GSR, Radiant thermal sensor, Wearable motion sensors, CMOS, Based Biosensors, E-Textiles, Bio compatibility.

UNIT II SIGNAL PROCESSING 09

Wear ability issues-physical shape and placement of sensor, Technical challenges-sensor design, signal acquisition, Constraint on sampling frequency for reduced energy consumption, light weight signal processing, Rejection of irrelevant information, Data mining.

UNIT III ENERGY HARVESTING FOR WEARABLE DEVICES 09

Amplitude Shift Keying (ASK) – Frequency Shift Keying (FSK) Minimum Shift Keying (MSK) –Phase Shift Keying (PSK) – BPSK – QPSK – 8 PSK – 16 PSK – Quadrature Amplitude Modulation (QAM) – 8QAM – 16 QAM – Bandwidth Efficiency– Comparison of various Digital Communication System (ASK– FSK – PSK – QAM).

UNIT IV WIRELESS HEALTH SYSTEMS 09

Need for wireless monitoring, Definition of Body area network, BAN and Healthcare, Technical Challenges- System security and reliability, BAN Architecture, Introduction, Wireless communication techniques.

UNIT V APPLICATIONS OF WEARABLE SYSTEMS 09

Medical Diagnostics, Medical Monitoring- Patients with chronic disease, Hospital patients, Elderly patients, Multi parameter monitoring, Neural recording, Gait analysis, Sports Medicine, Smart Fabrics.

Total: 45 Hours

TEXT BOOKS:

1. Kennedy G, Kennedy's Electronic Communication Systems, McGraw Hill, 2014
2. Wayne Tomasi, Electronic Communication Systems: Fundamentals through Advanced Pearson Education, 2014

REFERENCE BOOKS:

1. Rappaport T.S, Wireless Communications: Principles and Practice, Pearson Education, 2010
2. B. P.Lathi, Modern Analog and Digital Communication Systems, Oxford University Press, 2011

WEBSITES:

1. https://onlinecourses.nptel.ac.in/noc23_ee95/preview
2. https://ocw.mit.edu/courses/6-777j-design-and-fabrication-of-microelectromechanical-devices-spring-2007/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E Biomedical Engineering		2025-2026
25BEBME5E11	BODY AREA NETWORKS	ELECTIVE 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**

End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Explain the architectures of BAN
- Illustrate the communication and safety protocols to be followed in BAN
- Make use of BAN device for biomedical applications

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Outline the concepts of body area networks
- Illustrate the hardware architecture for BAN.
- Interpret the wireless communication and network protocols.
- Explain the challenges and security protocol in BAN
- Apply the principles of BAN devices for biomedical applications

UNIT I INTRODUCTION 09

Definition, BAN and Healthcare, Technical Challenges- Sensor design, biocompatibility, Energy Supply, optimal node placement, number of nodes, System security and reliability, BSN Architecture.

UNIT II HARDWARE FOR BAN 09

Processor-Low Power MCUs, Mobile Computing MCUs, Integrated processor with radio transceiver, Memory, Antenna-PCB antenna, Wire antenna, Ceramic antenna, External antenna, Sensor Interface, Power sources- Batteries and fuel cells for sensor nodes.

UNIT III WIRELESS COMMUNICATION AND NETWORK 09

RF communication in Body, Antenna design and testing, Propagation, Base Station Network Topology-Stand, Alone BAN, Wireless personal Area Network Technologies IEEE 802.15.1, IEEE P802.15.13, IEEE 802.15.14, Zigbee.

UNIT IV COEXISTENCE ISSUES WITH BAN 09

Interferences, Intrinsic - Extrinsic, Effect on transmission, Counter measures- on physical layer and data link layer, Regulatory issues -Medical Device regulation in USA and Asia, Security and Self-protection Bacterial attacks, Virus infection, Secured protocols, Selfprotection.

UNIT V APPLICATIONS OF BAN 09

Monitoring patients with chronic disease, Hospital patients, Elderly patients, Cardiac arrhythmias monitoring, Multi patient monitoring systems, Multichannel Neural recording, Gait analysis, Sports Medicine, Electronic pill.

Total: 45 Hours

TEXT BOOKS:

1. Annalisa Bonfiglio, Danilo De Rossi, "Wearable Monitoring Systems", Springer, 2014.
2. Sandeep K.S. Gupta, Tridib Mukherjee, Krishna Kumar Venkatasubramanian, “Body Area Networks Safety, Security, and Sustainability,” Cambridge University Press, 2013.

REFERENCE BOOKS:

1. Zhang, Yuan-Ting, “Wearable Medical Sensors and Systems”, Springer, 2013.
2. Guang -Zhong Yang (Ed.), “Body Sensor Networks”, Springer, 2006.
3. Mehmet R. Yuce, Jamil Y. Khan, “Wireless Body Area Networks Technology, Implementation, and applications”, Pan Stanford Publishing Pte. Ltd, Singapore, 2012.

WEBSITES:

1. https://archive.nptel.ac.in/courses/117/102/117102062/
2. https://ocw.mit.edu/courses/20-440-analysis-of-biological-networks-be-440-fall-2004/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, ‘-’ - No Correlation

25BEBME5E12	**VIRTUAL REALITY AND AUGMENTED REALITY IN HEALTHCARE**	**ELECTIVE 3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Explain the concepts AR/VR
- Utilize the principles of modeling in AR/VR systems
- Develop AR/VR system for diagnostic and therapeutic applications

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Interpret the concepts of virtual and augmented reality
- Explain the geometric modelling and Virtual environment
- Illustrate Virtual Environment and Augmented Reality systems
- Explain the Hardware and Software tools for AR/VR
- Model the VR environment for biomedical applications

UNIT I **INTRODUCTION TO AUGMENTED REALITY AND VIRTUAL REALITY** **09**

Virtual Reality and Virtual Environment: Introduction, Computer graphics, Real time computer graphics,Flight Simulation, Virtual environment requirement, benefits of virtual reality, Historical development of VR, Scientific Landmark. Augmented Reality Concepts: History of Augmented Reality, Multimodal displays: Haptic, Tactile and Tangible Displays, Visual Perception

UNIT II **GEOMETRIC MODELLING** **09**

Geometric Modelling: Introduction, From 2D to 3D, 3D space curves, 3D boundary representation. Geometrical Transformations: Introduction, Frames of reference, Modelling transformations, Instances, Picking, Flying, Scaling the VE, Collision detection

UNIT III **VIRTUAL ENVIRONMENT AND AUGMENTED REALITY SYSTEMS** **09**

Animating the Virtual Environment: Introduction, The dynamics of numbers, Linear and Nonlinear interpolation, the animation of objects, linear and non-linear translation, shape & object inbetweening, free from deformation, particle system. Augmented Reality Systems – Types, Taxonomy of Augmented Reality, Helmet, Headup display, Smart Glasses, Projection

UNIT IV **VR HARDWARE AND SOFTWARE** **09**

Human Factors: Introduction, the eye, the ear, the somatic senses. VR Hardware: Introduction, sensor hardware, Head-coupled displays, Acoustic hardware, Integrated VR systems. VR Software: Introduction, Modelling virtual world, Physical simulation, VR toolkits, Introduction to VRML, Khronos Group – AR Toolkit – Augmented Reality Operating System – Role of Augmented Reality interfaces – Players and Platforms

UNIT V **AV/VR FOR BIOMEDICAL APPLICATIONS** **09**

Introduction, Engineering, Entertainment, Science, Training. The Future: Virtual environment, modes of interaction. Physical Simulation: Introduction, Objects falling in a gravitational field, Rotating wheels, Elastic collisions, projectiles, Augmenting Dental Care, Virtual Reality for Rehabilitation , Medical Model Generation.

Total: 45 Hours

TEXT BOOKS:

1. John Vince, “Virtual Reality Systems “, Pearson Education Asia, 2007.
2. Dieter Schmalstieg, Tobias Hollerer, “Augmented Reality: Principles and Practice”, AddisonWesley Professional, 2016.

REFERENCE BOOKS:

1. Anand R., “Augmented and Virtual Reality”, Khanna Publishing House, Delhi.
2. Adams, “Visualizations of Virtual Reality”, Tata McGraw Hill, 2000.
3. Grigore C. Burdea, Philippe Coiffet , “Virtual Reality Technology”, Wiley Inter Science, 2nd Edition, 2006.
4. William R. Sherman, Alan B. Craig, “Understanding Virtual Reality: Interface, Application and Design”, Morgan Kaufmann, 2008.
5. Jon Peddie, “Augmented Reality – Where We Will All Live”, Springer International Publishing AG, 2017.

WEBSITES:

1. https://archive.nptel.ac.in/courses/121/106/121106013/
2. https://ocw.mit.edu/courses/6-s897-machine-learning-for-healthcare-spring-2019/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	1
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	1
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	1
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	1
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	1
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	1

1 - Low, 2 - Medium, 3 - High, ‘-’ - No Correlation

25BEBME6E03	TELEMEDICINE	ELECTIVE 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**

End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Infer the key principles and ethical aspects of telemedicine
- Outline information and communication infrastructure for telemedicine
- Apply telemedicine concepts in the streams of healthcare

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the basic concepts and benefits of telemedicine
- Summarize the types of information and communication infrastructure for telemedicine
- Outline the ethical and legal aspects of telemedicine
- Build the picture archiving and communication systems of telemedicine
- Apply the concepts of telemedicine and e-health in real world scenarios

UNIT I FUNDAMENTALS OF TELEMEDICINE 09

History of telemedicine, definition of telemedicine, tele-health, tele-care, scope, Telemedicine Systems, benefits & limitations of telemedicine.

UNIT II TYPE OF INFORMATION & COMMUNICATION INFRASTRUCTURE FOR TELEMEDICINE 09

Audio, video, still images, text and data, fax-type of communications and network: PSTN, POTS, ANT, ISDN, internet, air/ wireless communications, GSM satellite, micro wave, Mobile health and ubiquitous healthcare.

UNIT III ETHICAL AND LEGAL ASPECTS OF TELEMEDICINE 09

Confidentiality, patient rights and consent: confidentiality and the law, the patient doctor relationship, access to medical records, consent treatment - data protection & security, jurisdictional issues, intellectual property rights.

UNIT IV PICTURE ARCHIVING AND COMMUNICATION SYSTEM 09

Introduction to radiology information system and ACS, DICOM, PACS strategic plan and needs assessment, technical Issues, PACS architecture.

UNIT V APPLICATIONS OF TELEMEDICINE 09

Teleradiology, Telepathology, Telecardiology, Teleoncology, Teledermatology, Telesurgery, e Health and Cyber Medicine.

Total: 45 Hours

TEXT BOOKS:

1. Khandpur R S, TELEMEDICINE– Technology and Applications, PHI Learning Pvt Ltd, 2017
2. Norris A C Essentials of Telemedicine and Telecare, John Wiley, New York, 2002

REFERENCE BOOKS:

1. H K Huang PACS and Imaging Informatics: Basic Principles and Applications Wiley, New Jersey 2010
2. Richard Wootton, John Craig, Victor Patterson Introduction to Telemedicine Taylor & Francis 2017

WEBSITES:

1. https://archive.nptel.ac.in/courses/117/105/117105081/
2. https://ocw.mit.edu/courses/hst-s14-health-information-systems-to-improve-quality-of-care-in-resource-poor-settings-spring-2012/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E Biomedical Engineering		2025-2026
25BEBME6E04	MEDICAL SENSORS MEMS AND NEMS	ELECTIVE 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60**
Total:100
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Summarize the working principle of medical sensors.
- compare the fabrication and characterization techniques of MEMS
- Utilize the software tools for MEMS development in medical application

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the principle of sensors
- Illustrate the principles of MEMS and NEMS
- Outline the material synthesis, fabrication and characterization of the micro sensors
- Choose the biosensor for medical application
- Make use of software tools for MEMS development.

UNIT I CLASSIFICATION OF MEDICAL SENSORS 09

Sensors for Pressure Measurement- Sensors for Motion and Force Measurement- Sensors for Flow Measurement -Temperature Measurement- Sensors for speed, torque, vibration- smart sensors, design of interface system. Artificial intelligence in sensor technology.

UNIT II MICROSYSTEM DESIGN 09

Technological Breakthrough, Dielectrics for Use in MEMS Applications, Piezoelectric Thin Films for MEMS Applications, Modeling of Piezoelectric MEMS, Interface Circuits for Capacitive MEMS Gyroscope, Advanced MEMS Technologies for Tactile Sensing and Actuation, MEMS-Based Micro Hot-Plate Devices, Inertial Sensor. Design of microsystem for sensing and control. Case study. Machine Learning tools in system design and analysis.

UNIT III MATERIAL FOR MEMS AND NEMS WITH FABRICATION METHODS 09

Working principle of Microsystems, materials for MEMS and Microsystems, micromachining, System modeling, Properties of materials, Synthesis, selection and characteristics of materials. Artificial intelligence in material characteristics. Clean room, microfabrication methods, Lithography, epitaxy, sputtering, deposition, surface and bulk micromachining.

UNIT IV MEDICAL SENSORS 09

Mechanical sensors and actuators – beam and cantilever, piezoelectric materials, thermal sensors and actuators- micromachined thermocouple probe, Peltier effect, heat pumps, thermal flow sensors, micro gripper microlens, microneedle, micropumps-Testing of the performance using software tools. Deep learning in actuator design and analysis.Applications of Optimization tools.

UNIT V SOFTWARE TOOLS 09

Modeling and design, using MatLab, Design of sensors, pressure sensor, vibration sensor, actuators Analysis using solvers, MatLab, Comsol, mechanical solver, electrical solver. Machine learning tools in design and analysis

Total: 45 Hours

TEXT BOOKS:

1. VikasChoudhary, Krzysztof Iniewski, "MEMS: Fundamental Technology and Applications", CRC Press, UK, 2017.
2. 2. Tatsuo Togawa; Toshiyo Tamura; P. Ake Oberg, "Biomedical Sensors and Instruments", CRC Press, UK 2011.

REFERENCE BOOKS:

1. Octavian Adrian Postolache and Subhas Chandra Mukhopadhyay, "Sensors for Everyday Life: Healthcare Settings (Smart Sensors, Measurement and Instrumentation), CRC Press, 2017.
2. 2. Gabor Harsanyi, "Sensors In Biomedical Applications: Fundamentals, Technology & Applications", CRC Press, USA, 2000.
3. 3. Tai Ran Hsu, "MEMS and Microsystems Design and Manufacture", Tata McGraw Hill Publishing Company, New Delhi, 2002.
4. 4. Marc J. Madou 'Fundamentals of Microfabrication: The Science of Miniaturization', CRC Press, 2002.
5. 5. Mohammad Ilyas, Imad Mahgoub, "Handbook of Sensor Networks Compact Wireless and Wired Sensing Systems" CRC Press, USA. 2005

WEBSITES:

1. https://nptel.ac.in/courses/117105082
2. https://ocw.mit.edu/courses/mas-836-sensor-technologies-for-interactive-environments-spring-2011/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E Biomedical Engineering		2025-2026
25BEBME6E11	LASER IN MEDICINE	ELECTIVE 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**

End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Explain the functions of a laser system
- Compare LASER types
- Summarize the therapeutic and surgical applications of laser

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the working principle of laser
- Classify the LASER and its types
- Interpret the applications of laser in Urology, Gynaecology and dentistry
- Outline the therapeutic applications of laser
- Make use of LASER in surgical application

UNIT I LASER SYSTEM 09

Laser – Definition-Properties of laser-Characteristics of Laser, Construction and working principle of laser system-Mono-chromaticity, Coherence-Directionality, Brightness-Laser Characteristics as applied to medicine and biology-Laser tissue Interaction

UNIT II TYPES OF LASER 09

Construction- Working principle- Molecular Laser Construction- Working principle, Dye Laser ConClassification of Laser, Solid state Laser Construction- Working principle, Atomic lasestruction

UNIT III NON-THERMAL DIAGNOSTIC APPLICATIONS 09

Optical coherence tomography, Elastography, Laser Induced Fluorescence (LIF)-Imaging, FLIM Raman Spectroscopy and Imaging, FLIM, Holographic and speckle application of lasers in biology and medicine.

UNIT IV THERAPEUTIC APPLICATIONS 09

Phototherapy, Photodynamic therapy (PDT) - Principle and mechanism - Oncological and non-oncological applications of PDT - Bio stimulation effect, applications-Laser Safety Procedures, Laser hazards

UNIT V SURGICAL APPLICATIONS OF LASERS 09

Lasers in ophthalmology- Dermatology, Dentistry-Urology-Otolaryngology- Tissue welding, Applications of Lasers in Orthopedics, Applications of laser in neurology

Total: 45 Hours

TEXT BOOKS:

1.Markolf H. Niemz, “Laser-Tissue Interaction Fundamentals and Applications”, Springer, 2019.

REFERENCE BOOKS:

1. Paras N. Prasad, “Introduction to Bio photonics”, A. John Wiley and sons, Inc. Publications, 2003

WEBSITES:

1. https://nptel.ac.in/courses/104104085
2. https://ocw.mit.edu/courses/res-6-005-understanding-lasers-and-fiberoptics-spring-2008/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, ‘-’ - No Correlation

B.E Biomedical Engineering		2025-2026
25BEBME6E12	BIOMETRIC SYSTEMS	ELECTIVE 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60**
Total:100
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Understand the concepts of biometric systems.
- Compare the face, hand geometry and Iris recognition system
- Develop a multimodal biometrics for biomedical applications

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the characteristics of biometric systems
- Infer the techniques used in finger print technology
- Compare the face recognition and hand geometry
- Interpret the functions of iris recognition system
- Build multimodal biometrics for biomedical applications

UNIT I INTRODUCTION TO BIOMETRICS 09

Introduction and back ground, biometric technologies, passive biometrics, active biometrics, Biometric characteristics, Biometric applications, Biometric Authentication systems- Taxonomy of Application Environment, Accuracy in Biometric Systems- False match rate- False non-match rate- Failure to enroll rate- Derived Metrics-Biometrics and Privacy.

UNIT II FINGERPRINT TECHNOLOGY 09

History of finger print pattern recognition-General description of finger prints-finger print sensors, finger print enhancement, Feature Extraction- Ridge orientation, ridge frequency, finger print matching techniques- correlation based, Minutiae based, Ridge feature based, finger print classification, Applications of finger prints, Finger scanstrengths and weaknesses, Evaluation of fingerprint verification algorithms.

UNIT III FACE RECOGNITION AND HAND GEOMETRY 09

Introduction to face recognition, face recognition using PCA, LDA, face recognition using shape and texture, face detection in color images, 3D model-based face recognition in video images, Neural networks for face recognition, Hand geometry, scanning, Feature Extraction, classification.

UNIT IV IRIS RECOGNITION 09

Introduction, Anatomical and Physiological underpinnings, Iris sensor, Iris representation and localization- Daugman and Wildes approach, Iris matching, Iris scan strengths and Weaknesses, System performance, future directions.

UNIT V VOICE SCAN AND MULTIMODAL BIOMETRICS 09

Voice scan, speaker features, short term spectral feature extraction, Mel frequency cepstral coefficients, speaker matching, Gaussian mixture model, NIST speaker Recognition Evaluation Program, Introduction to multimodal biometric system, Integration strategies, Architecture, level of fusion, combination strategy, examples of multimodal biometric systems, Securing and trusting a biometric transaction, matching location, local host - authentication server, match on card (MOC)

Total: 45 Hours

TEXT BOOKS:

1. JamesWayman, AnilJain, DavideMaltoni Biometric Systems, Technology Design and Performance Evaluation Springer 2005
2. S.Y.Kung, S.H.Lin,M. W.Mak Biometric Authentication: A Machine Learning Approach Prentice Hall 2005

REFERENCE BOOKS:

1. "Biometrics: Advanced Identity Verification: The Complete Guide" by Julian Ashbourn

WEBSITES:

1. https://nptel.ac.in/courses/106104119
2. https://ocw.mit.edu/courses/20-453j-biomedical-information-technology-fall-2008/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	1
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	**1**
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	**1**
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	**1**
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	**1**
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	1

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E Biomedical Engineering		2025-2026
25BEBME7E03	SPEECH PROCESSING	ELECTIVE 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**

End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Understand the fundamentals of speech processing
- Compare the features of speech signal
- Build a speech recoginition and synthesis system

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the concept of speech mechanism
- Compare the features of speech signal
- Build feature extraction algorithms for the speech signal
- Classify speech recoginition system
- Model a speech synthesis system.

UNIT I BASIC CONCEPTS 09

Speech Fundamentals: Articulatory Phonetics, Production and Classification of Speech Sounds; Acoustic Phonetics, Acoustics of speech production; Review of Digital Signal Processing concepts; Short-Time Fourier Transform, Filter-Bank and LPC Methods.

UNIT II SPEECH ANALYSIS 09

Features, Feature Extraction and Pattern Comparison Techniques: Speech distortion measures, mathematical and perceptual, Log, Spectral Distance, Cepstral Distances, Weighted Cepstral Distances and Filtering, Likelihood Distortions, Spectral Distortion using a Warped Frequency Scale, LPC, PLP and MFCC Coefficients, Time Alignment and Normalization, Dynamic Time Warping, Multiple Time, Alignment Paths.

UNIT III SPEECH MODELING 09

Hidden Markov Models: Markov Processes, HMMs, Evaluation, Optimal State Sequence, Viterbi Search, Baum-Welch Parameter Re-estimation, Implementation issues.

UNIT IV SPEECH RECOGNITION 09

Large Vocabulary Continuous Speech Recognition: Architecture of a large vocabulary continuous speech recognition system, acoustics and language models, n-grams, context dependent sub-word units; Applications and present status.

UNIT V SPEECH SYNTHESIS 09

Text-to-Speech Synthesis: Concatenative and waveform synthesis methods, sub-word units for TTS, intelligibility and naturalness, role of prosody, Applications and present status.

Total: 45 Hours

TEXT BOOKS:

1. Daniel Jurafsky and James H Martin, "Speech and Language Processing, An Introduction to Natural Language Processing", Computational Linguistics, and Speech Recognition‖, Pearson Education, 2019.
2. Claudio Becchetti and Lucio Prina Ricotti, "Speech Recognition", John Wiley and Sons, 2008

REFERENCE BOOKS:

1. Ben Gold and Nelson Morgan, Speech and audio signal processing, Processing and Perception of Speech and Music", Wiley- India Edition, 2006 Edition.
2. Thomas F Quatieri, "Discrete-Time Speech Signal Processing, Principles and Practice", Pearson Education, 2004
3. Lawrence Rabiner and Biing-Hwang Juang, "Fundamentals of Speech Recognition", Pearson Education, 2003.

WEBSITES:

1. https://archive.nptel.ac.in/courses/117/105/117105145/
2. https://ocw.mit.edu/courses/6-345-automatic-speech-recognition-spring-2003/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E Biomedical Engineering		2025-2026
25BEBME7E04	BRAIN COMPUTER INTERFACE	ELECTIVE 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60**
Total:100
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Understand the concept of BCI and its types
- Illustrate the feature extraction methods involved in developing BCI
- Build a machine learning model for BCI for biomedical applications

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the concepts and types of BCI system
- Illustrate the types of brain activation function
- Interpret the methods used for data filtering in BCI systems
- Infer machine learning models used in BCI system
- Develop the BCI system for biomedical applications

UNIT I INTRODUCTION TO BRAIN COMPUTER INTERFACES 09

Concept of BCI, Invasive and Non-invasive Types, EEG Standards, Signal Features, Spectral Components, EEG Data Acquisition, Pre-processing, Hardware and Software, Artifacts, Methods to Remove, Near Infrared BCI. Machine learning for brain computer interface

UNIT II BCI APPROACHES 09

Movement Related EEG Potentials, Mental States, Visual Evoked Potential. P300 virtual platform. Design and construction, Interaction between human and computerized technical systems.

UNIT III EEG FEATURE EXTRACTION METHODS 09

Time/Space Methods, Fourier Transform, Wavelets, AR models, Band pass filtering, PCA, Laplacian Filters, Linear and Non-linear Features. Deep learning and artificial intelligence in feature extraction methods

UNIT IV EEG FEATURE TRANSLATION METHODS 09

LDA, Regression, Memory Based Vector Quantization, Gaussian Mixture Modeling, Hidden Markov Modeling

UNIT V APPLICATIONS OF BCI 09

Case Studies - Invasive BCIs: decoding and tracking arm (hand) position, controlling prosthetic devices such as orthotic hands, Cursor and robotic control using multi electrode array implant, Cortical control of muscles via functional electrical stimulation. Non-invasive BCIs: P300 Mind Speller, Visual cognitive BCI, Emotion detection, Ethics of Brain Computer Interfacing

Total: 45 Hours

TEXT BOOKS:

1. Rajesh.P.N.Rao, Brain-Computer Interfacing: AnIntroduction Cambridge University Press, First edition 2013
2. Jonathan Wolpaw, Elizabeth Winter Wolpaw, Brain Computer Interfaces: Principles and practice, Oxford University Press, USA, Edition 1, 2012

REFERENCE BOOKS:

1. Ella Hassianien, A& Azar.A.T Brain-Computer Interfaces Current Trends and Applications Springer 2015
2. Andrew Webb Statistical Pattern Recognition Wiley International 2002.

WEBSITES:

1. https://onlinecourses.nptel.ac.in/noc24_ee01/preview
2. https://ocw.mit.edu/courses/res-9-008-brain-and-cognitive-sciences-computational-tutorials/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E Biomedical Engineering		2025-2026
25BEBME7E11	COGNITIVE ENGINEERING	ELECTIVE 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60**
Total:100
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Understand the concepts of neural networks and its types.
- Interpret the concept fuzzy logic and genetic algorithm
- Develop a hybrid soft computing system

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the concepts of neural network
- Classify neural networks
- Interpret the concept fuzzy logic
- Summarize the concepts of genetic algorithm
- Build a hybrid soft computing system

UNIT I INTRODUCTION TO ARTIFICIAL NEURAL NETWORKS 09

Characteristics- learning methods – taxonomy – Evolution of neural networks- McCulloch-Pitts neuron - linear separability - Hebb network - supervised learning network: perceptron networks - adaptive linear neuron, multiple adaptive linear neuron. Artificial intelligence in medical applications

UNIT II TYPES OF NEURAL NETWORKS 09

BPN, RBF, TDNN- associative memory network: auto-associative memory network, hetero-associative memory network, BAM, hopfield networks, iterative autoassociative memory network & iterative associative memory network – unsupervised learning networks: Kohonenself organizing feature maps, LVQ – CP networks, ART network. Case studies on biomedical applications

UNIT III FUZZY LOGIC 09

Membership functions: features, fuzzification, methods of membership value assignments-Defuzzification: lambda cuts - methods - fuzzy arithmetic and fuzzy measures: fuzzy arithmetic - extension principle – fuzzy measures - formation of rules-decomposition of rules, fuzzy inference systems-overview of fuzzy expert system-fuzzy decision making. Case studies on biomedical applications.

UNIT IV GENETIC ALGORITHM 09

Genetic algorithm and search space - general genetic algorithm, operators - Generational cycle, stopping condition, constraints. Classification, genetic programming, multilevel optimization, real life problem, Advances in GA. Case studies on biomedical applications using deep learning.

UNIT V HYBRID SOFT COMPUTING TECHNIQUES AND APPLICATIONS 09

Neuro-fuzzy hybrid systems - genetic neuro hybrid systems - genetic fuzzy hybrid and fuzzy genetic hybrid systems - simplified fuzzy ARTMAP. Case studies on biomedical applications. A fusion

approach of multispectral images with SAR, optimization of traveling salesman problem using genetic algorithm approach, soft computing-based hybrid fuzzy controllers. Case studies on biomedical applications.

Total: 45 Hours

TEXT BOOKS:

1. Laurene V. Fausett, "Fundamentals of Neural Networks: Architectures, Algorithms and Applications" Pearson Education, 2010.
2. S.N.Sivanandam and S.N.Deepa, "Principles of Soft Computing", Wiley India Pvt Ltd, 2011.

REFERENCE BOOKS:

WEBSITES:

1. https://archive.nptel.ac.in/courses/112/104/112104293/
2. https://ocw.mit.edu/courses/9-10-cognitive-neuroscience-spring-2006/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME7E12 **COGNITIVE PSYCHOLOGY** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

- Explain the cognitive psychology and its blocks
- Summarize the cognitive and memory learning system
- Identify the process of cognitive thinking

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Compare cognitive psychology and its types
- Explain the blocks of cognitive learning system
- Classify the memory learning system
- Interpret communication and perceptual process
- Organize the process of cognitive thinking

UNIT I **INTRODUCTION** **09**

Pre-scientific era, structuralism, functionalism, associationism, behaviorism, gestalt psychology, psychoanalysis, humanistic & existential psychology, cognitive psychology, fields, emerging fields; Physiological foundations of cognition: peripheral & central nervous systems, impulse transmission, brain imaging & basic neural processes

UNIT II **COGNITIVE DEVELOPMENT** **09**

During infancy, early childhood, later childhood, adolescence, adulthood & old age, cognitive dissonance and cognitive framework in self-attribution; learning & cognition: basic learning processes- habituation, conditioning: classical & operant, cognitive learning, avoidance learning, punishment, generalization & discrimination, concept learning, verbal, motor learning and transfer of learning;

UNIT III **MEMORY** **09**

Basic neural operations, systems: sensory, STM, organization in STM, working memory, phonological Loop, visuo-spatial sketch pad, LTM, levels of processing, implicit vs. Explicit memory, autobiographical memory, constructive memory, measurement of retention, forgetting, theories, improving memories and loss of memory;

UNIT IV **LANGUAGE & COGNITION** **09**

Language elements, meaning & concepts, pragmatics, verbal & nonverbal communication and psycholinguistics; perceptual processes: vision, audition & other senses;

UNIT V **THINKING** **09**

Level of processing approach, role of symbols, images & language, concept attainment, problem solving: strategies & stages, reasoning, stages of creative thinking, artificial intelligence.

Total: 45 Hours

TEXT BOOKS:

1. M. Eysenck and M. T. Keane, Cognitive Psychology: A Student's Handbook, 4 th Ed, Psychology Press, 2000.

2. M. W. Eysenck, Principles of Cognitive Psychology, 2 nd Ed, Psychology Press, 2001.

REFERENCE BOOKS:

1. Parker, E. L. Wilding and T. J. Bussey, The Cognitive Neuroscience of Memory, Psychology Press, 2002.
2. Rapp, The Handbook of Cognitive Neuropsychology, Psychology Press, 2000

WEBSITES:

1. https://onlinecourses.nptel.ac.in/noc20_hs29/preview
2. https://ocw.mit.edu/courses/9-52-c-computational-cognitive-science-spring-2003/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

PROFESSIONAL ELECTIVES
EMBEDDED SYSTEM

B.E Biomedical Engineering		**2025-2026**
25BEBME5E05	**EMBEDDED SYSTEMS**	**Elective 3H-3C**
Instruction Hours/week: L:3 T:0 P:0		**Marks: Internal:40 External:60 Total:100 End Semester Exam:3 Hours**

PREREQUISITES: NIL

COURSE OBJECTIVES
The goal of this course is for students to:
- Understand the architecture of embedded system
- Illustrate the programming of ARM processor
- Explain the concepts of Real-time Operating systems

COURSE OUTCOMES
Upon completion of this course, the student will be able to:
- Explain the design methodologies employed in embedded system design with an example.
- Illustrate ARM architecture and the built-in peripherals for application development.
- Compare various Communication bus protocols.
- Interpret the Embedded C Programming for various application development.
- Build the concept of real-time programming using tasks in RTOS.

UNIT I INTRODUCTION TO EMBEDDED SYSTEM 09
Definition of Embedded System, Embedded Systems vs. General Computing Systems - Embedded system components - Embedded System Design Process, Classification of an Embedded System, Examples of an embedded system - Core of Embedded system, RISC vs. CISC controllers, Harvard vs. Von Neumann architecture.

UNIT II ARM PROCESSOR AND PERIPHERALS 09
ARM Architecture Versions, ARM Architecture - Instruction Set, Stacks and Subroutines - Features of the LPC 214X Family, Peripherals, Timer Unit, Pulse Width Modulation Unit, UART.

UNIT III COMMUNICATION BUS PROTOCOLS FOR EMBEDDED SYSTEM 09
UART and SPI Communication Protocol, I2C Communication Protocol, Advantages & Disadvantages of I2C Protocols, USB Communication Protocol, PCI-bus Communication Protocol, CAN Protocol.

UNIT IV EMBEDDED NETWORKING BY PROCESSORS 09
Embedded Networking: Introduction, I/O Device Ports & Buses- multiple interrupts and interrupt service mechanism – Serial Bus communication protocols -RS232 standard–RS485–USB–Inter Integrated Circuits (I2C)- CAN Bus –Wireless protocol based on Wifi , Bluetooth, Zigbee – Introduction to Device Drivers.

UNIT V EMBEDDED C PROGRAMMING 09

Overview of C Compiler and Optimization, Basic C data types, C Looping Structures, Register Allocations - Function Calls, Pointer Aliasing, Structure Arrangement, Bit-fields, Floating Point, Inline Functions, and Inline Assembly – C programs for General purpose I/O, PWM Modulator, UART, I2C Interface, SPI Interface, ADC, DAC.

Total: 45 Hours

TEXT BOOKS:

1. Rajkamal. (2017). Embedded Systems: Architecture, Programming and Design. Tata McGraw Hill. 3rd Edition.
2. Steve Heath. (2023). Embedded System Design. Elsevier. 2 nd Edition.
3. Frank Vahid & Givargis. (2006). Embedded Systems Design: A Unified Hardware/Software Introduction. Wiley Publications.

REFERENCE BOOKS:

1. Jonathan W. Valvano. (2011). Embedded Microcomputer Systems – Real Time Interfacing. Cengag Learning. 3rd Edition.
2. Marilyn Wolf. (2012). Computers as Components - Principles of Embedded Computing Systen Design. Morgan Kaufmann Publisher (An imprint from Elsevier). 3rd Edition.

WEBSITES:

1. https://nptel.ac.in/courses/108102045
2. https://archive.nptel.ac.in/courses/106/105/106105193/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	-	1	1	1	1	-
CO2	K2	2	1	-	-	-	-	-	-	1	1	1	1	-
CO3	K2	2	1	-	-	-	-	-	-	1	1	1	1	-
CO4	K3	2	1	-	-	-	-	-	-	1	1	1	1	-
CO5	K3	3	2	1	-	-	-	-	-	1	1	1	1	-
Average		**2.2**	**1.2**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**1**	**1**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E Biomedical Engineering		2025-2026
25BEBME5E06	ARM CONTROLLER	Elective 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of this course is for students to:

- Understand the architecture of ARM 7 processor and assembly programming of ARM.
- Explain the ARM assembly system
- Interpret the C language programs and supporting hardware

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Infer the features of embedded systems, architecture of ARM7 and applications.
- Explain the instruction set and development tools of ARM
- Illustrate the THUMB state and achieve competency in assembly programming of ARM.
- Interpret the exception, interrupts and interrupt handling schemes
- Analyze the hardware and interfacing peripheral devices to LPC2148

UNIT I **ARM EMBEDDED SYSTEMS AND ARM PROCESSOR FUNDAMENTALS** **09**

The RISC design philosophy, ARM design philosophy, embedded system hardware- AMBA bus protocol, embedded system software- applications. ARM core data flow model, Registers, CPSR-Processor modes, Banked registers. Pipeline- Characteristics.

UNIT II **ARM INSTRUCTION SET** **09**

Fundamentals of ARM instructions, Barrel shifter, Classification and explanation of instructions with examples-Data processing, Branch, Load-store, SWI and Program Status Register instruction.

UNIT III **INTRODUCTION TO THUMB AND ARM PROGRAMMING** **09**

Introduction to THUMB, Differences between ARM and THUMB, Register usage in Thumb, ARM Thumb Interworking. General Structure of ARM assembly module, Assembler directives- AREA, ENTRY, END, SPACE, DCD, DCB, DCW, DCI, DCQ, EQU, EXPORT, ALIGN, CODE16, CODE32, DATA. Simple ALP programs on Arithmetic & logical operations, Factorial, string operation, sorting, searching, and Scan.

UNIT IV **EXCEPTION AND INTERRUPT HANDLING SCHEMES** **09**

Exception handling- ARM processor exceptions and modes, vector table, exception priorities, link register offsets. Interrupts- assigning interrupts, interrupt latency, IRQ and FIQ exceptions with example- code for enabling and disabling IRQ and FIQ exceptions, Comparison between exception and interrupts. Interrupt handling schemes- nested interrupt handler, non-nested interrupt handler. Basic interrupt stack design.

UNIT V **LPC2148 ARM CPU** **09**

LPC 2148 - Salient features, applications, block diagram, memory mapping. Functional features of Interrupt controller, RTC, USB, UART, I2C, SPI, SSP controllers, watch dog timers and other system control units.

Total: 45 Hours

TEXT BOOKS:

1. ARM System Developer's guide –Andrew N. SLOSS, ELSEVIER Publications
2. ARM Assembly Language – William Hohl, CRC Press
3. ARM System-on-chip Architecture by Steve Furber, Pearson Education

REFERENCE BOOKS:

1. Embedded Systems: A Contemporary Design Tool- James K. Peckol

WEBSITES:

1. https://archive.nptel.ac.in/courses/117/106/117106111/
2. www.Arm.com

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	2	1	-	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.2**	**1.2**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E Biomedical Engineering		2025-2026
25BEBME5E13	EMBEDDED PROGRAMMING	Elective 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of this course is for students to:

- Explain the fundamentals of embedded Programming
- Illustrate the GNU C Programming Tool Chain in Linux.
- Interpret the concepts of embedded C.

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Infer C programming and its salient features for embedded systems
- Explain programming languages/software compatible with embedded processes.
- Interpret the C programming in the Linux environment.
- Summarize the embedded applications of python programming
- Apply the recent trends in embedded programming

UNIT I BASIC C PROGRAMMING 09

Typical C Program Development Environment - Introduction to C Programming - Structured Program Development in C - Data Types and Operators - C Program Control - C Functions - Introduction to Arrays.

UNIT II EMBEDDED C 09

Adding Structure to 'C' Code: Object oriented programming with C, Header files for Project and Port, Examples. Meeting Real-time constraints: Creating hardware delays - Need for timeout mechanism - Creating loop timeouts - Creating hardware timeouts.

UNIT III C PROGRAMMING TOOL-CHAIN IN LINUX 09

C preprocessor - Stages of Compilation - Introduction to GCC - Debugging with GDB - The Make utility - GNU Configure and Build System - GNU Binary utilities - Profiling - using gprof - Introduction to GNU C Library.

UNIT IV PYTHON PROGRAMMING 09

Introduction - Parts of Python Programming Language - Control Flow Statements - Functions - Strings - Lists - Dictionaries - Tuples and Sets.

UNIT V MODULES, PACKAGES AND LIBRARIES IN PYTHON 09

Python Modules and Packages - Creating Modules and Packages - Practical Example - Libraries for Python - Library for Mathematical functionalities and Tools - Numerical Plotting Library - GUI Libraries for Python - Imaging Libraries for Python - Netoworking Libraries.

Total: 45 Hours

TEXT BOOKS:

1. Paul Deitel and Harvey Deitel, “C How to Program”, 8th Edition, Pearson Education Limited, 2016.
2. Michael J Pont, "Embedded C", Addison-Wesley, An imprint of Pearson Education, 2002.
3. William von Hagen, "The Definitive Guide to GCC", 2nd Edition, Apress Inc., 2006.
4. Gowrishankar S and Veena A, "Introduction to Python Programming", CRC Press, Taylor & Francis Group, 2019.

REFERENCE BOOKS:

1. Noel Kalicharan, "Learn to Program with C", Apress Inc., 2015.
2. Fabrizio Romano, “Learn Python Programming”, Second Edition, Packt Publishing, 2018.
3. John Paul Mueller, "Beginning Programming with Python for Dummies", 2nd Edition, John Wiley & Sons Inc., 2018.

WEBSITES:

1. https://archive.nptel.ac.in/courses/106/105/106105171/
2. https://onlinecourses.nptel.ac.in/noc23_cs93/preview

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	2	1	-	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.2**	**1.2**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, ‘-’ - No Correlation

B.E Biomedical Engineering		2025-2026
25BEBME5E14	EMBEDDED NETWORKING	Elective 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of this course is for students to:

- Understand the serial and parallel communication protocols.
- Explain the concept of ethernet and its controllers.
- Illustrate the development of wireless sensor network communication protocols

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the fundamental role of communication protocols in embedded systems.
- Illustrate the architecture and operational principles of the USB and CAN bus systems.
- Summarize the process of data encapsulation and transmission over Ethernet.
- Outline the integration of embedded devices into enterprise IT infrastructures via Ethernet.
- Build communication systems through wired, wireless technology.

UNIT I EMBEDDED COMMUNICATION PROTOCOLS 09

Introduction: Serial/Parallel Communication – Serial communication protocols: RS232 standard – RS485 – Synchronous Serial Protocols -Serial Peripheral Interface (SPI) – Inter Integrated Circuits (I2C) – PC Parallel port programming -ISA/PCI Bus protocols

UNIT II USB AND CAN BUS 09

USB bus: Introduction – Speed Identification on the bus – USB States – USB bus communication: Packets –Data flow types –Enumeration –Descriptors –CAN Bus: Introduction – Frames –Bit stuffing –Types of errors – Nominal Bit Timing – PIC microcontroller CAN Interface.

UNIT III ETHERNET 09

Elements of a network – Inside Ethernet – Building a Network: Hardware options – Cables, Connections and network speed – Design choices: Selecting components –Ethernet Controllers – Using the internet in local and internet communications – Inside the Internet protocol

UNIT IV EMBEDDED ETHERNET 09

Exchanging messages using UDP and TCP – Serving web pages with Dynamic Data – Serving web pages that respond to user Input – Email for Embedded Systems – Using FTP – Keeping Devices and Network secure.

UNIT V WIRELESS EMBEDDED NETWORKING 09

Wireless sensor networks: Introduction –Network Topology – Localization – Time Synchronization – Energy efficient MAC protocols –Energy efficient and robust routing – Data Centric routing

Total: 45 Hours

TEXT BOOKS:

1. Frank Vahid, Givargis 'Embedded Systems Design: A Unified Hardware/Software Introduction', Wiley Publications
2. Jan Axelson, 'Parallel Port Complete', Penram publications
3. Dogan Ibrahim, 'Advanced PIC microcontroller projects in C', Elsevier 2008

REFERENCE BOOKS:

1. Jan Axelson 'Embedded Ethernet and Internet Complete', Penram publications
2. Bhaskar Krishnamachari, 'Networking wireless sensors', Cambridge press 2005

WEBSITES:

1. https://nptel.ac.in/
2. www.Arm.com

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	2	1	-	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.2**	**1.2**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E Biomedical Engineering		2025-2026
25BEBME6E05	ELECTRONIC SYSTEM DESIGN	Elective 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of this course is for students to:

- Understand electronic components and circuit design.
- Explain digital-to-analog and analog-to-digital conversion, and CMOS technology.
- Apply techniques for cabling, filtering, grounding, protection, and packaging.

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the fundamental electronic principles in basic circuit configurations.
- Illustrate the data conversion systems using ADCs, DACs, and CMOS technologies.
- Summarize the cabling solutions for signal integrity.
- Infer the effective noise reduction and grounding techniques in electronic circuits.
- Make use of evaluation strategies for electronic system protection and packaging.

UNIT I INTRODUCTION TO ELECTRONICS 09

characteristics of passive and active components, op amps and its characteristics, AC Performance of operational amplifiers: band width, slew rate and noise. Properties of a high quality instrumentation amplifier. instrumentation amplifier and its applications. Isolation amplifier basics. Active filers: design of low pass, high pass and band pass filters. Power supplies: Characteristics, design of full wave bridge regulated power supply. Circuit layout and grounding in mixed signal system.

UNIT II ADC, DAC AND CMOS 09

Characteristics of ADC, DAC, interfacing to microcontrollers. Selecting an ADC. understanding and interpreting data sheets & specifications of various CMOS& BiCMOS family Logic devices. Electrical behavior (steady state & dynamic) of CMOS& BiCMOS family logic devices. Benefits and issues on migration of 5-volt and 3.3 volt logic to lower voltage supplies. CMOS/TTL Interfacing Basic design considerations for live insertion.

UNIT III CABLING 09

Capacitive coupling, effect of shield on capacitive coupling, inductive coupling, effect of shield on inductive coupling, effect of shield on magnetic coupling, magnetic coupling between shield and inner conductor, shielding to prevent magnetic radiation, shielding a receptor against magnetic fields, coaxial cable versus shielded twisted pair, ribbon cables.

UNIT IV FILTERING AND GROUNDING 09

Safety grounds, signal grounds, single-point ground systems, multipoint-point ground systems, hybrid grounds, functional ground layout, practical low frequency grounding, hardware grounds, grounding of cable shields, ground loops, shield grounding at high frequencies. power line filtering, decoupling filters, high frequency filtering, system bandwidth.

UNIT V PROTECTING AND PACKAGING 09

Static generation, human body model, static discharge, ESD protection in equipment design, software and ESD protection, ESD versus EMC, Effect of environmental factors on electronic system (environmental specifications), nature of environment and safety measures. Packaging's influence and its factors.

Total: 45 Hours

TEXT BOOKS:

1. Electronic Instrument Design, 1st edition; by: Kim R.Fowler; Oxford University Press.
2. Noise Reduction Techniques in Electronic Systems, 2nd edition; by: Henry W.Ott; John Wiley & Sons.
3. Digital Design Principles& Practices, 3rd edition by: John F. Wakerly; Prentice Hall International, Inc.

REFERENCE BOOKS:

1. Printed Circuit Boards - Design & Technology, 1 st edition; by: W Bosshart; Tata McGraw Hill.
2. Operational Amplifiers and linear integrated circuits, 3rd edition by: Robert F. Coughlin; Prentice Hall International, Inc
3. Intuitive Analog circuit design by: Mark.T Thompson; Published by Elsevier

WEBSITES:

1. https://nptel.ac.in/
2. www.Arm.com

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	2	1	-	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.2**	**1.2**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E Biomedical Engineering		2025-2026
25BEBME6E06	REAL TIME OPERATING SYSTEM	Elective 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of this course is for students to:

- Understand real-time and embedded systems
- Illustrate communication and synchronization system
- Utilize RTOS platforms for application development.

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the foundational concepts of operating systems
- Illustrate the core components of Real-Time Operating Systems (RTOS)
- Interpret the characteristics of real-time programming languages
- Infer the process of porting an RTOS to a target system
- Apply knowledge of Linux-supportive RTOS, uCOS, and C Executive

UNIT I REVIEW OF OPERATING SYSTEMS 09

Basic Principles - Operating System structures – System Calls – Files – Processes – Design and Implementation of processes – Communication between processes – Introduction to Distributed operating system – Embedded operating systems

UNIT II OVERVIEW OF RTOS 09

RTOS Task and Task state –Multithreaded Preemptive scheduler- Process Synchronization- Message queues– Mail boxes -pipes – Critical section – Semaphores – Classical synchronization problem – Deadlocks

UNIT III REALTIME MODELS AND LANGUAGES 09

Event Based – Process Based and Graph based Models – Real Time Languages – RTOS Tasks – RT scheduling - Interrupt processing – Synchronization – Control Blocks – Memory Requirements.

UNIT IV REALTIME KERNEL 09

Principles – Design issues – Polled Loop Systems – RTOS Porting to a Target – Comparison and Basic study of various RTOS like – VX works – Linux supportive RTOS – C Executive.

UNIT V APPLICATION DEVELOPMENT 09

Discussions on Basics of Linux supportive RTOS – uCOS-C Executive for development of RTOS Application – Case study

Total: 45 Hours

TEXT BOOKS:

1.Silberschatz,Galvin,Gagne" Operating System Concepts,6th ed,John Wiley,2003
2. Charles Crowley, "Operating Systems-A Design Oriented approach" McGraw Hill,1997 3. Raj Kamal,

REFERENCE BOOKS:

1. Raj Kamal, "Embedded Systems- Architecture, Programming and Design" Tata McGraw Hill,2006.
2. Karim Yaghmour,Building Embedded Linux System",O'reilly Pub,2003
3. MukeshSighal and N G Shi "Advanced Concepts in Operating System", McGraw Hill,2000

WEBSITES:

1. https://nptel.ac.in/
2. www.Arm.com

CO – PO – PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	1
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CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	1
CO4	K3	2	1	-	-	-	-	-	1	1	-	-	1	1
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	1
Average		**2.2**	**1.2**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**1**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E Biomedical Engineering		2025-2026
25BEBME6E13	HARDWARE AND SOFTWARE CODESIGN	Elective 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

COURSE OBJECTIVES
The goal of this course is for students to:

- Explain the principles of hardware-software co-design.
- Illustrate the methodologies for designing embedded systems.
- Compare the trade-offs between hardware and software components.

COURSE OUTCOMES
Upon completion of this course, the student will be able to:

- Explain the design issues and synthesis algorithms.
- Compare the different emulation techniques.
- Illustrate the different compilation techniques.
- Infer the specification and verification of computation models.
- Identify the languages of system-level specifications.

UNIT I CO- DESIGN AND CO- SYNTHESIS 09
CO- DESIGN ISSUES: Co- Design Models, Architectures, Languages, A Generic Co-design Methodology.

CO- SYNTHESIS ALGORITHMS: Hardware software synthesis algorithms: hardware — software partitioning distributed system co-synthesis.

UNIT II PROTOTYPING AND EMULATION 09
Prototyping and emulation techniques, prototyping and emulation environments, future developments in emulation and prototyping architecture specialization techniques, system communication infrastructure.

UNIT III TOOLS FOR EMBEDDED PROCESSOR ARCHITECTURES 09
Architecture Specialization techniques, Target Architecture and Application System classes, Modern embedded architectures, embedded software development needs, compilation technologies, practical consideration in a compiler development environment.

UNIT IV DESIGN SPECIFICATION AND VERIFICATION 09
Design, co-design, the co-design computational model, concurrency coordinating concurrent computations, interfacing components, design verification, implementation verification, verification tools, interface verification

UNIT V LANGUAGES FOR SYSTEM 09
System — level specification, design representation for system level synthesis, system level specification languages. Heterogeneous specifications and multi language co-simulation, the cosyma system and lycos system.

Total: 45 Hours

TEXT BOOKS:

1. Jorgen Staunstrup, Wayne Wolf, "Hardware / Software Co-Design Principles and Practice" Springer, 2009.

2. Giovanni De Micheli, Mariagiovanna Sami "Hardware /Software Co- Design", Kluwer Academic Publishers, 2002.

REFERENCE BOOKS:

1. Patrick, R. Schaumont "A Practical Introduction to Hardware/Software Co-design", Springer, 2010.

WEBSITES:

3. https://nptel.ac.in/
4. www.Arm.com

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	1
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CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	1
CO4	K3	2	1	-	-	-	-	-	1	1	-	-	1	1
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	1
Average		**2.2**	**1.2**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**1**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E Biomedical Engineering		2025-2026
2BEBME56E14	ADVANCED DIGITAL SYSTEM DESIGN	Elective 3H-3C
Instruction Hours/week: L:3 T:0 P:0		Marks: Internal:40 External:60 Total:100 End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of this course is for students to:

- Explain the hazards in asynchronous sequential circuits.
- Interpret the fault testing procedure for digital circuits.
- Design and implement digital circuits using programming tools.

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain synchronous sequential circuits.
- Interpret asynchronous sequential circuits.
- Summarize the testing procedure for combinational circuit and PLA.
- Infer the functions of PLD and ROM.
- Apply the programming tools for implementing digital circuits of industry standards.

UNIT I SEQUENTIAL CIRCUIT DESIGN 09

Analysis of Clocked Synchronous Sequential Circuits and Modelling- State Diagram, State Table, State Table Assignment and Reduction-Design of Synchronous Sequential Circuits Design of Iterative Circuits-ASM Chart and Realization using ASM.

UNIT II ASYNCHRONOUS SEQUENTIAL CIRCUIT DESIGN 09

Analysis of Asynchronous Sequential Circuit – Flow Table Reduction-Races-State Assignment Transition Table and Problems in Transition Table- Design of Asynchronous Sequential Circuit - Static, Dynamic and Essential hazards – Mixed Operating Mode Asynchronous Circuits – Designing Vending Machine Controller.

UNIT III FAULT DIAGNOSIS AND TESTABILITY ALGORITHMS 09

Fault Table Method-Path Sensitization Method – Boolean Difference Method - D Algorithm — Tolerance Techniques – The Compact Algorithm – Fault in PLA – Test Generation - DFT Schemes – Built in Self Test.

UNIT IV SYNCHRONOUS DESIGN USING PROGRAMMABLE DEVICES 09

Programming Logic Device Families – Designing a Synchronous Sequential Circuit using PLA/PAL – Designing ROM with PLA – Realization of Finite State Machine using PLD – FPGA – Xilinx FPGA - Xilinx 4000.

UNIT V SYSTEM DESIGN USING VERILOG 09

Hardware Modelling with Verilog HDL – Logic System, Data Types And Operators For Modelling In Verilog HDL - Behavioural Descriptions In Verilog HDL – HDL Based Synthesis – Synthesis Of Finite State Machines– Structural Modelling – Compilation And Simulation Of Verilog Code – Test Bench - Realization Of Combinational And Sequential Circuits Using Verilog – Registers – Counters – Sequential Machine – Serial Adder – Multiplier- Divider – Design Of Simple Microprocessor, Introduction To System Verilog.

Total: 45 Hours

TEXT BOOKS:

Charles H.Roth jr., “Fundamentals of Logic Design” Thomson Learning,2013.

2. M.D.Ciletti , Modeling, Synthesis and Rapid Prototyping with the Verilog HDL, Prentice Hall, 1999

3. M.G.Arnold, Verilog Digital – Computer Design, Prentice Hall (PTR), 1999.

4. Nripendra N Biswas “Logic Design Theory” Prentice Hall of India,2001.

5. Paragk.Lala “Fault Tolerant and Fault Testable Hardware Design” B S Publications,2002

6. Paragk.Lala “Digital System Design Using PLD” B S Publications,2003.

REFERENCE BOOKS:

WEBSITES:

1. https://nptel.ac.in/
2. www.Arm.com

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	2	1	-	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.2**	**1.2**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, ‘-’ - No Correlation

B.E Biomedical Engineering		2025-2026
2BEBME7E05	**EMBEDDED COMMUNICATION SOFTWARE DESIGN**	**Elective 3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of this course is for students to:

- Explain core networking concepts and communication architectures
- Apply efficient software for network devices
- Develop robust and fault-tolerant multi-board communication systems

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the OSI reference model and communication layer.
- summarize the procedure used in software partitioning
- Interpret the concepts of Data structures
- Infer the management schemes in communication software design
- Develop the modules for multiboard communication

UNIT I **OSI REFERENCE MODEL** **09**

OSI Reference Model – Communication Devices – Communication Echo System – Design Consideration – Host Based Communication – Embedded Communication System – OS Vs RTOS.

UNIT II SOFTWARE PARTITIONING **09**

Software Partitioning – Limitation of strict Layering – Tasks & Modules – Modules and Task Decomposition – Switch - Bridges - Routers – Protocol Implementation: STP - RSTP – Management Types (SNMP) – Debugging Protocols.

UNIT III **DATA STRUCTURES** **09**

Tables & other Data Structures – Partitioning of Structures and Tables – Implementation – Speeding Up access – Table Resizing – Table access routines – Buffer and Timer Management – Third Party Protocol Libraries.

UNIT IV **MANAGEMENT SCHEMES** **09**

Management Software – Device Management – Management Schemes – Router Management – Management of Sub System Architecture – Device to manage configuration – System Start up and configuration.

UNIT V **MULTI BOARD COMMUNICATION** **09**

Multi Board Communication Software Design – Multi Board Architecture – Single control Card and Multiple line Card Architecture – Interface for Multi Board software – Failures and Fault – Tolerance in Multi Board Systems – Hardware independent development – Using a COTS Board – Development Environment – Test Tools.

Total: 45 Hours

TEXT BOOKS:

1. Sridhar .T, Designing Embedded Communication Software‖, CMP Books, 2003.
2. Ahmed Amine Jerraya, Sungjoo Yoo, Diederix Veskest and Norbest Whn,
3. Embedded Software for SOC‖, 1st Edition, Kulwar Academic Publishers, 2004.
4. Comer. D, Computer networks and Internet‖, 3rd Edition, Prentice Hall, 2001.

WEBSITES:

1. https://nptel.ac.in/
2. www.Arm.com

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	2	1	-	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.2**	**1.2**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E Biomedical Engineering		2025-2026
2BEBME7E06	EMBEDDED SENSOR NETWORKS	Elective 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

COURSE OBJECTIVES
The goal of this course is for students to:

- Explain the core principles and applications of wireless sensor networks.
- Analyze communication protocols and infrastructure techniques for sensor networks.
- Develop basic programming skills for sensor network data management and platforms.

COURSE OUTCOMES
Upon completion of this course, the student will be able to:

- Explain the components of sensor networks
- Illustrate the types of sensor networking protocol.
- Interpret the infrastructure establishment in sensor networks
- Outline the networking database environment.
- Apply the software concepts in python programming.

UNIT I SENSOR NETWORKS 09
Overview of sensor networks - Constraints and Challenges – Advantages of sensor networks – Applications – Collaborative Processing – Key definitions in sensor networks – Tracking scenario – Problem formulation –Distributed representation and interference of states – Tracking multiple objects – Sensor models – performance comparison and metrics.

UNIT II SENSOR NETWORKING PROTOCOL 09
Key assumptions – Medium access control – S-MAC Protocol,-TCP/IP – IEEE 802.15.4 standard and ZigBee – General Issues – Geographic, Energy-Aware Routing – Attribute based routing –Classification and Applications of Nano sensor.

UNIT III INFRASTRUCTURE ESTABLISHMENT 09
Topology control – Clustering-Time synchronization – Localization – Task driven sensing Role of sensor nodes – Information based tasking – Routing and aggregation.

UNIT IV SENSOR NETWORK DATABASE 09
Sensor Database Challenges – Querying the physical environment – Interfaces – In-network aggregation – Data centric storage – Data indices and range queries – Distributed Hierarchical aggregation – Temporal data.

UNIT V SENSOR NETWORK PLATFORMS AND TOOLS 09
Basics of PYTHON Programming Syntax and Style – Python Objects– Dictionaries comparison with C programming on Conditionals and Loops – Files – Input and Output – Errors and Exceptions –Functions – Modules – Classes and OOP – Execution Environment.

Total: 45 Hours

TEXT BOOKS:

Feng Zhao, Leonidas Guibas, "Wireless Sensor Networks An information processing approach", Mogan Kanufmann Publishers, 2004

2. Richard Zurawski, "Embedded System Hand Book", CRC Press, 2009.

3. Iran Stojmenovic, "Hand book of sensor networks", John Wiley & Sons, 2005.

REFERENCE BOOKS:

4. Michel Banatre, Pedre Jose Marron, Anibal Ollero and Adam Wilisz, "Cooperating Embedded System and Wireless sensor Network", John Willy, 2008.

5. Embedded System Handbook, "Networked Embedded Systems", 2nd Edition, CRC press, 2009.

WEBSITES:

1. https://nptel.ac.in/
2. www.Arm.com

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	2	1	-	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.2**	**1.2**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E Biomedical Engineering		2025-2026
2BEBME7E13	EMBEDDED SYSTEMS SECURITY	Elective 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of this course is for students to:

- Explain the Embedded Cryptography and Data Protection Protocols
- Infer the practical aspects of Embedded System Security.
- summarize the concepts about system security and attacks.

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the significance of Security.
- Infer the major concepts and techniques related to Cryptography.
- Interpret the aspects of Embedded System Security.
- Outline the role of Security Aspects during Data Transfer and Communication.
- Apply the Security Algorithms for Real-time Applications.

UNIT I BACKGROUND AND INTRODUCTION 09

Computer and Network Security Concepts: Computer Security Concepts – The OSI Security Architecture – Security Attacks – Security Services – Security Mechanisms – Fundamentals of Security Design Principles – Attack Surfaces and Attack Trees – A Model for Network Security. Introduction to Number Theory: Divisibility and the Division Algorithm – The Euclidean Algorithm – Modular Arithmetic – Prime Numbers – Fermet's and Euler's Theorems – Testing for Primality – The Chinese Remainder Theorem – Discrete Logarithms.

UNIT II SYMMETRIC CIPHERS 09

Classical Encryption Techniques: Symmetric Cipher Model – Substitution Techniques – Transposition Techniques. Block Ciphers and the Data Encryption Standard (DES): Traditional Block Cipher Structure – The Data Encryption Standard – A DES Example – Strength of DES. Advanced Encryption Standard: Finite Field Arithmetic – AES Structure – AES Transformation Functions – AES Key Expansion – An AES Example – AES Implementation.

UNIT III PUBLIC-KEY ENCRYPTION AND HASH FUNCTIONS 09

Introduction to Number Theory – Public-Key Cryptography and RSA – Key Management – Diffie-Hellman Key Exchange – Elliptic Curve Cryptography – Message Authentication and Hash Functions – Hash Algorithms – Digital Signatures and Authentication Protocols.

UNIT IV NETWORK SECURITY PRACTICE 09

Authentication Applications – Kerberos – X.509 Authentication Service – Electronic mail Security – Pretty Good Privacy – S/MIME - IP Security architecture - Authentication Header – Encapsulating Security Payload – Key Management.

UNIT V PRACTICAL EMBEDDED SYSTEM SECURITY 09

Network Communications Protocols and Built-in Security – Security Protocols and Algorithms – The Secured Socket Layer – Embedded Security – Wireless – Application-Layer and Client/Server Protocols – Choosing and Optimizing Cryptographic Algorithms for Resource-Constrained Systems – Hardware Based Security.

Total: 45 Hours

TEXT BOOKS:

1. "Cryptography and Network Security Principles and Practice", 7th Edition – Global Edition, William Stallings, Pearson Education Limited, 2017.
2. "Embedded Systems Security - Practical Methods for Safe and Secure Software and Systems Development", David Kleidermacher and Mike Kleidermacher, Newnes (an imprint of Elsevier),2012.

REFERENCE BOOKS:

1. "Practical Embedded Security - Building Secure Resource-Constrained Systems", Timothy Stapko, Newnes (an imprint of Elsevier), 2008.
2. W. Mao, "Modern Cryptography – Theory and Practice", Pearson Education, Second Edition, 2007.
3. Charles P. Pfleeger, Shari Lawrence Pfleeger – Security in computing Third Edition – Prentice Hall of India 2006.
4. Forouzan, "Cryptography And Network Security", McGraw Hill Education, 3th edition, 2015

WEBSITES:

1. https://nptel.ac.in/
2. www.Arm.com

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CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
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CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	2	1	-	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.2**	**1.2**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E Biomedical Engineering		2025-2026
2BEBME7E14	EMBEDDED PRODUCT DEVELOPMENT	Elective 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of this course is for students to:

- Explain the approaches of product development
- Interpret the industrial design strategies
- Infer the embedded product design

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Infer the basics concept of product design, product features and its architecture.
- Interpret the stages in product design and development for industrial applications.
- Outline the design strategies with appropriate case studies
- Explain the suitable methods by considering various factors involved in modeling a product
- Develop a simple product using suitable firmware development tools.

UNIT I CONCEPTS OF PRODUCT DEVELOPMENT 09

Need for PD- Generic Product Development Process Phases- Product Development Process Flows-Product Development organization structures- Understanding customer and behavior analysis. Concept Generation, Five Step Method-Basics of Concept selection-Creative thinking –creativity and problem solving- creative thinking methods- generating design concepts.

UNIT II APPROACHES FOR NEW PRODUCT DEVELOPMENT 09

Product development management - establishing the architecture - creation - architecture of the chunks - creating detailed interface specifications-Portfolio Architecture-competitive benchmarking- Approach for the benchmarking process-Principles of prototyping – Planning for prototypes- Economic & Cost Analysis -Testing Methodologies- Product Branding.

UNIT III INDUSTRIAL DESIGN STRATEGIES 09

Role of Integrating CAE, CAD, CAM tools for Simulating product performance and manufacturing processes electronically- Basics on reverse engineering – Reverse engineering strategies – Finding reusable software components – Recycling real-time embedded software based approach and its logical basics–Case study on Visualization of smart city: PHEV

UNIT IV ELECTRONIC PRODUCT DEVELOPMENT STAGES 09

Product Development Stages -Embedded product modeling-Grounding and noise elimination methods, Thermal protection with heat management – PCB design steps – Software design and testing method – documentation, Case study on smart garbage system.

UNIT V EMBEDDED PRODUCTS DESIGN 09

Creating general Embedded System Architecture (with Case study example: Mobile Phone as a product) - Intelligent traffic controller, smart streetlight- Architectural Structures - Criteria in selection of Hardware & Software Components-Choosing Bus Communication Standards, Need for Developing with IDE, Translation & Debugging Tools & Application Software, Performance Testing, Costing, Benchmarking ,Documentation.

Total: 45 Hours

TEXT BOOKS:

1. Anita Goyal, Karl T Ulrich, Steven D Eppinger, "Product Design and Development ", McGraw –Hill International Edns.1999/ Tata McGraw Education, ISBN-10-007-14679-9.
2. R.G. Kaduskar and V.B. Baru, "Electronic Product Design", Wiley, 2014.
3. Stephen Armstrong, Engineering and Product Development Management; The Holistic Approach, CAMBRIDGE UNIVERSITY PRESS (CUP),2014

REFERENCE BOOKS:

1. Rajkamal, 'Embedded System-Architecture, Programming, Design', TMH,2011.
2. KEVIN OTTO & KRISTIN WOOD, "Product Design and Development ", 4th Edition, 2009, Product Design Techniques in Reverse Engineering and New Product Development, Pearson Education (LPE),2001./ISBN 9788177588217.
3. Yousef Haik, T. M. M. Shahin, "Engineering

WEBSITES:

1. https://nptel.ac.in/
2. www.Arm.com

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	2	1	-	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.2**	**1.2**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

PROFESSIONAL ELECTIVES

MEDICAL DEVICE DESIGN AND DEVELOPMENT

B.E Biomedical Engineering		**2025-2026**
25BEBME5E07	**MEDICAL DEVICE DESIGN**	**Elective 3H-3C**
Instruction Hours/week: L:3 T:0 P:0		**Marks: Internal:40 External:60 Total:100 End Semester Exam:3 Hours**

COURSE OBJECTIVES

The goal of this course is for students to,

- Illustrate the design procedure and quality assessment of medical devices.
- Introduce the medical device standards and requirements.
- Understand the validation and verification of various medical devices

COURSE OUTCOMES

Upon completion of this course, students will be able to:

- Summarize the concept of medical device development.
- Analyze the medical device standards
- Illustrate the engineering design and project metrics.
- Apply medical equipment testing and validation
- Interpret the designing and manufacturing techniques of medical devices

UNIT I NEEDS FINDING AND CONCEPT GENERATION 09

Strategic Focus – observation and problem identification – Need statement development. Ideation and Brainstorming – concept screening, concept selection: intellectual property basics – reimbursement basics – business models – prototyping – final concept selection. Safety and Risk Management - Tools, Documents and Deliverables.

UNIT II MEDICAL DEVICES STANDARDS AND REQUIREMENTS 09

Signal representation, Signal in time and Frequency domain, Signal Estimation, Bioelectric Signals: ECG & EEG, Vital Signs, Biomagnetic Signals.

UNIT III DESIGN ENGINEERING 09

Hardware Design, Hardware Risk Analysis, Design and Project Metrics, Design for Six Sigma, Software Design, Software Coding, Software Risk Analysis, Software Metrics.

UNIT IV TESTING AND VALIDATION 09

Basis and Types of Testing, Hardware Verification and Data Analysis, Software Verification and Data Analysis.

UNIT V DESIGN TRANSFER AND MANUFACTURING 09

Transfer to Manufacturing, Hardware Manufacturing, Software Manufacturing, Configuration Management, Intellectual Property-Copy Rights-Trademarks-Trade Secrets. Case Study.

Total: 45 Hours

TEXT BOOKS:

1. Zenios, Makower and Yock, ―Biodesign – The process of innovating medical technologies, Canbridge University Press, 2009
2. Theodore R. Kucklick , The Medical Device R&D Handbook, Second Edition, CRC Press,2012.
3. Peter Ogrodnik,Medical Device Design Innovation from Concept to Market, Elsevier, 2013.

REFERENCE BOOKS:

1. Richard C. Fries and Marcel Dekker AG, Handbook of Medical Device Design,2ndedition, 2005.
2. Gail Baura, Medical Device Technologies: A Systems Based Overview Using Engineering, Elsevier science, 2012.
3. Matthew Bret Weinger, Michael E. Wiklund, Daryle Jean Gardner-Bonneau‘Handbook of Human Factors in Medical Device Design‘,CRC press,2010.
4. Jagdish Chaturvedi, Inventing medical devices: A perspective from India, Create Space Independent Publishing Platform, 1st edition, 2015.

WEBSITES:

1. https://nptel.ac.in/courses/102101068
2. https://nptel.ac.in/courses/102105090

CO-PO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, ‘-’ - No Correlation

Elective

25BEBME5E08 APPLIED DESIGN THINKING FOR BIOMEDICAL ENGINEERS 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of this course is for students to,

- Outline the tools & techniques of design thinking for innovative product
- Illustrate customer-centric product innovation using on simple
- Outline principles of solution concepts & their evaluation

COURSE OUTCOMES

Upon completion of this course, students will be able to:

- Explain the principles design thinking
- Illustrate clinical customer validations and innovations.
- Interpret the solution concept using the design thinking tools
- Infer the concept of design generation techniques.
- Apply system thinking concepts in medical field.

UNIT-I DESIGN THINKING PRINCIPLES 9

Exploring Human-centered Design - Understanding the Innovation process, discovering areas of opportunity, Interviewing & empathy-building techniques, Mitigate validation risk with FIR [Forge Innovation rubric] - Case studies

UNIT-II END USER-CENTRIC INNOVATION 9

Importance of customer-centric innovation - Problem Validation and Customer Discovery - Understanding problem significance and problem incidence - Customer Validation. Target user, 218 User persona & user stories. Activity: Customer development process - Customer interviews and field visit

UNIT-III DESIGN THINKING TOOLS 9

Concept of Minimum Usable Prototype [MUP] - MUP challenge brief - Designing & Crafting the value proposition - Designing and Testing Value Proposition; Design a compelling value proposition; Process, tools and techniques of Value Proposition Design

UNIT-IV CONCEPT GENERATION 9

Solution Exploration, Concepts Generation and MUP design- Conceptualize the solution concept; explore, iterate and learn; build the right prototype; Assess capability, usability and feasibility. Systematic concept generation; evaluation of technology alternatives and the solution concepts

UNIT-V SYSTEM THINKING **9**

Transfer to Manufacturing, Hardware Manufacturing, Software Manufacturing, Configuration Management, Intellectual Property-Copy Rights-Trademarks-Trade Secrets. Medical/ Clinical Case Study.

Total periods : 45

TEXTBOOKS:

1. Steve Blank, (2013), The four steps to epiphany: Successful strategies for products that win, Wiley.
2. Alexander Osterwalder, Yves Pigneur, Gregory Bernarda, Alan Smith, Trish Papadakos, (2014), Value.
3. Proposition Design: How to Create Products and Services Customers Want, Wiley

REFERENCES:

1. Donella H. Meadows, (2015), "Thinking in Systems -A Primer", Sustainability Institute.
2. Tim Brown,(2012) "Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation", Harper Business.

WEBSITES:

https://nptel.ac.in/courses/102101068

1. https://nptel.ac.in/courses/102105090
2. https://www.ideou.com/pages/design-thinking#process
3. https://blog.forgeforward.in/valuation-risk-versus-validation-risk-in-product-innovations49f253ca86
4. https://blog.forgefor ward.in/product-innovation-rubric-adf5ebdfd356
5. https://blog.forgefor ward.in/evaluating-product-innovations-e8178e58b86e
6. https://blog.forgefor ward.in/user-guide-for-product-innovation-rubric-857181b253dd
7. https://blog.forgefor ward.in/star tup-failure-is-like-true-lie-7812cdfe9b85

CO-PO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
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CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME5E15	**INTEGRATED MEDICAL PRODUCT DEVELOPMENT**	**Elective 3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of this course is for students to,

- Understand the types of product and services
- Develop product management plan for a new product development
- Explain the system modeling for system, sub-system and their interfaces

COURSE OUTCOMES

Upon completion of this course, students will be able to:

- Explain the trends in product development.
- Interpret the requirements and design system.
- Illustrate the functions of design and testing.
- Summarize the sustenance engineering and end-of-life (eol) support.
- Develop the business dynamics in engineering services industry.

UNIT-I BASICS OF PRODUCT DEVELOPMENT 9

Global Trends Analysis and Product decision - Social Trends - Technical Trends- Economical Trends - Environmental Trends - Political/Policy Trends - Introduction to Product Development Methodologies and Management - Overview of Products and Services - Types of Product Development - Overview of Product Development methodologies - Product Life Cycle – Product Development Planning and Management.

UNIT-II REQUIREMENTS AND SYSTEM DESIGN 9

Requirement Engineering - Types of Requirements - Requirement Engineering - traceability Matrix and Analysis - Requirement Management - System Design & Modeling - Introduction to System Modeling - System Optimization - System Specification - Sub-System Design - Interface Design.

UNIT-III DESIGN AND TESTING 9

Conceptualization - Industrial Design and User Interface Design - Introduction to Concept generation Techniques – Challenges in Integration of Engineering Disciplines - Concept Screening & Evaluation - Detailed Design - Component Design and Verification – Mechanical, Electronics and Software Subsystems - High Level Design/Low Level Design of S/W Program - Types of Prototypes, S/W Testing- Hardware Schematic, Component design, Layout and Hardware Testing – Prototyping - Introduction to Rapid Prototyping and Rapid Manufacturing - System Integration, Testing, Certification and Documentation

UNIT-IV SUSTENANCE ENGINEERING AND END-OF-LIFE (EOL) SUPPORT 9

Introduction to Product verification processes and stages - Introduction to Product Validation processes and stages - Product Testing Standards and Certification - Product Documentation - Sustenance - Maintenance and Repair – Enhancements - Product EoL - Obsolescence Management – Configuration Management - EoL Disposal

UNIT-V BUSINESS DYNAMICS – ENGINEERING SERVICES INDUSTRY 9

The Industry - Engineering Services Industry - Product Development in Industry versus Academia –The IPD Essentials - Introduction to Vertical Specific Product Development processes - Manufacturing/Purchase and assembly of Systems - Integration of Mechanical, Embedded and Software Systems – Product Development Trade-offs - Intellectual Property Rights and Confidentiality – Security and Configuration Management.

Total periods : 45

TEXTBOOKS:

1. Karl T Ulrich and Stephen D Eppinger, "Product Design and Development", Tata McGraw Hill, Fifth Edition, 2011.
2. John W Newstorm and Keith Davis, "Organizational Behavior", Tata McGraw Hill, Eleventh Edition, 2005.

REFERENCES:

1. Hiriyappa B, “Corporate Strategy – Managing the Business”, Author House, 2013.
2. Peter F Drucker, “People and Performance”, Butterworth – Heinemann [Elsevier], Oxford, 2004.
3. Vinod Kumar Garg and Venkita Krishnan N K, “Enterprise Resource Planning – Concepts”, Second Edition, Prentice Hall, 2003.
4. Mark S Sanders and Ernest J McCormick, "Human Factors in Engineering and Design", McGraw Hill Education, Seventh Edition, 2013.

WEBSITES:

1. https://nptel.ac.in/courses/102101068
2. https://nptel.ac.in/courses/102105

CO-PO MAPPING

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CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, ‘-’ - No Correlation

2BEBME5E16 **MEDICAL ETHICS** **Elective 3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of this course is for students to:

- Understand Core Ethical Principles
- Enhance Professional Responsibility
- Apply accreditation and safety standards in healthcare settings

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Discuss the fundamental responsibilities of doctors towards patients
- Apply ethical theories and principles to address complex autonomy
- Explain the significance and policies of Accreditation
- Illustrate the life safety standards
- Explain the safety handling of medical equipment

UNIT I INTRODUCTION TO MEDICAL ETHICS 09

Definition of Medical ethics, Scope of ethics in medicine, American medical Association code of ethics, CMA code of ethics- Fundamental Responsibilities ,The Doctor And The Patient, The Doctor And The Profession, Professional Independence, The Doctor And Society.

UNIT II ETHICAL THEORIES & MORAL PRINCIPLES 09

Theories-Deontology & Utilitarianism ,Casuist theory, Virtue theory, The Right Theory. PrinciplesNon-Maleficence, Beneficence, Autonomy, Veracity, Justice. Autonomy & Confidentiality issues in medical practice, Ethical Issues in biomedical research ,Bioethical issues in Human Genetics & Reproductive Medicine.

UNIT III HOSPITAL ACCREDITATION STANDRADS 09

Accrediation- JCI Accreditation & its Policies. Patient centered standards, Healthcare Organization management standards.

UNIT IV HOSPITAL SAFETY STANDARDS 09

Life Safety Standards- Protecting Occupants, Protecting the Hospital From Fire, Smoke, and Heat, Protecting Individuals From Fire and Smoke, Providing and Maintaining Fire Alarm Systems, Systems for Extinguishing Fires Environment of Care Standards-Minimizing EC Risks, Smoking Prohibitions, Managing Hazardous Material and Waste, Maintaining Fire Safety Equipment, Features, Testing, Maintaining, and Inspecting Medical Equipment.

UNIT V MEDICAL EQUIPMENT SAFETY STANDARDS 09

General requirements for basic safety & essential performance of medical equipments.IEC 60601 standards- Base Standard-general requirement of electrical medical devices, Collateral StandardsEMC radiation protection &programmable medical device system, Particular Standards-type of medical device

Total: 45 Hours

TEXT BOOKS:

1. Domiel A Vallero "Biomedical Ethics for Engineers", Elsevier Pub. 1st edition, 2007
2. Biomedical Ethics: A Canadian Focus. Johnna Fisher (ed.), Oxford University Press Canada
   (2009)
3. Robert M Veatch" Basics of Bio Ethics", Second Edition. Prentice- Hall, Inc 2003

REFERENCE BOOKS:

1. Physical Environment Online: A Guide to The Joint Commission's Safety Standards is published by HCPro, Inc. 2010
2. Joint Commission Accreditation Standards for Hospitals ,2 nd edition 2003
3. Bioethics-"An Introduction for the biosciences", 2nd edition 2008, Ben Mepham, Oxford

WEBSITES:

1. https://onlinecourses.nptel.ac.in/noc24_ge33/preview
2. https://ocw.mit.edu/courses/21a-302j-dilemmas-in-bio-medical-ethics-playing-god-or-doing-good-fall-2013/

CO – PO – PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

Elective

25BEBME6E07 SOFTWARE DESIGN TOOLS FOR BIOSENSING AND CONTROL **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of this course is for students to,

- Explain the software tools available for sensor and control system design.
- Understand structural mechanics.
- Infer implementation of controllers in real time.

COURSE OUTCOMES

Upon completion of this course, students will be able to:

- Select the software design tools for biosensor design.
- Illustrate the structural mechanics of biosensors for medical applications.
- Analyze the software tools for micro bio sensing.
- Apply software tools for designing and control.
- Make use of controllers in real time biomedical applications.

UNIT-I SOFTWARE TOOLS FOR SENSOR DESIGN **9**

Introduction to history of sensor design software tools, importance and need of software tools. Recent developments in sensor design and analysis software tools. Introduction to COMSOL Multiphysics.

UNIT-II STRUCTURAL MECHANICS **9**

Analysis of mechanical structures to static or dynamic loads. Stationary, transient, eigen mode/modal, parametric, quasi-static and frequency-response analysis. Electrical: AC/DC Module for simulating electric, magnetic, and electromagnetic fields in static and low-frequency applications. Design and simulation of biosensors and bioactuators using COMSOL.

UNIT-III SOFTWARE TOOLS FOR MICRO SENSOR DESIGN **9**

Introduction to IntelliSuite, mechanism design, development of sensors and actuators. Introduction to Coventorware, Description of main modules, Architect, Designer, Analyzer and Integrator. System-level and physical-level design approaches. Introduction to meshing and result visualization. Design and simulation of sensors using Coventorware. Application in Biosensors design.

UNIT-IV SOFTWARE TOOLS FOR CONTROL DESIGN **9**

Introduction to MATLAB, Simulink and Scilab. Introduction to toolboxes. Control design problems using classical control. Control design problems using state space approach.

UNIT-V IMPLEMENTATION OF CONTROLLERS IN REAL TIME 9

Introduction to various hardware platforms, control design and implementation for electrical/mechanical/electromechanical/chemical processes using dSPACE, LabVIEW and OPAL-RT. Example Biomedical applications.

Total periods : 45

TEXTBOOKS:

1. Roger W. Pryor, Multiphysics Modeling Using COMSOL®: A First Principles Approach, Jones and Bartlett Publishers, 1st Edition, 2011.
2. Tamara Bechtold, Gabriela Schrag and Lihong Feng, System-level Modeling of MEMS, Wiley-VCH Verlag GmbH & Co, 1st Edition, 2013.
3. Holly Moore, MATLAB for Engineers, Pearson Education, 5th Edition, 2017.

REFERENCES:

1. Mehrzad Tabatabaian, COMSOL 5 for Engineers, Mercury Learning & Information, 1st Edition, 2015.
2. S R Otto and J P Denier, An Introduction to Programming and Numerical Methods in MATLAB, Springer-Verlag, 1st Edition, 2005.
3. Amos Gilat, MATLAB – An Introduction with Applications, John Wiley & Sons, Inc., 5th Edition, 2014.

WEBSITES:

1. https://nptel.ac.in/courses/102101068
2. https://nptel.ac.in/courses/108105376

CO-PO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

Elective

25BEBME6E08 **RAPID PROTOTYPING** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of this course is for students to,

- Explain the need and fundamentals of rapid prototyping
- Understand the concepts of design and assembling of various parts
- Illustrate droplet formation and beam deposition process

COURSE OUTCOMES

Upon completion of this course, students will be able to:

- Explain the principle of protype development process
- Interpret the assembly techniques for the desired task.
- Summarize the SLA techniques.
- Illustrate the process of fused deposition in sheet lamination
- Analyze the phases in printing process

UNIT-I INTRODUCTION 9

Overview –Need -Development of Additive Manufacturing Technology -Principle – AM Process Chain-Classification –Rapid Prototyping-Rapid Tooling –Rapid Manufacturing – Applications Benefits –Case studies.

UNIT-II DESIGN FOR ADDITIVE MANUFACTURING 9

Design tools: Data processing -CAD model preparation –Part orientation and support structure generation –Model slicing –Tool path generation-Design for Additive Manufacturing: Concepts and objectives-AM unique capabilities –DFAM for part quality improvement-Customised design and fabrication for medical applications.

UNIT-III PHOTO POLYMERIZATION AND POWDER BED FUSION PROCESSES 9

Photo polymerization: SLA-Photo curable materials –Process -Advantages and Applications. Powder Bed Fusion: SLS-Process description –powder fusion mechanism –Process Parameters – Typical Materials and Application. Electron Beam Melting.

UNIT-IV EXTRUSION BASED AND SHEET LAMINATION PROCESSES 9

Extrusion Based System: FDM-Introduction –Basic Principle –Materials –Applications and Limitations –Bio extrusion. Sheet Lamination Process: LOM-Gluing or Adhesive bonding –Thermal bonding.

UNIT-V PRINTING PROCESSES AND BEAM DEPOSITION PROCESSES 9

Droplet formation technologies –Continuous mode –Drop on Demand mode –Three Dimensional Printing –Advantages –Bioplotter -Beam Deposition Process: LENS-Process description –Material delivery –Process parameters –Materials –Benefits –Applications.

Total periods : 45

TEXTBOOKS:

1. Chua C.K., Leong K.F., and Lim C.S., Rapid prototyping: Principles and applications, World Scientific Publishers, Third edition, 2010.
2. Liou L.W. and Liou F.W., Rapid Prototyping and Engineering applications: A tool box for prototype development, CRC Press, 2007.
3. Kamrani A.K. and Nasr E.A., Rapid Prototyping: Theory and practice, Springer, 2006.

REFERENCES:

1. Ian Gibson, David W.Rosen, Brent Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010.
2. Tom Page Design for Additive Manufacturing, LAP Lambert Academic Publishing, 2012.
3. Hilton, P.D. and Jacobs, P.F., Rapid Tooling: Technologies and Industrial Applications,CRC press, 2005.

WEBSITES:

1. https://onlinecourses.nptel.ac.in/noc22_me74/preview
2. https://ocw.mit.edu/courses/16-810-engineering-design-and-rapid-prototyping-january-iap-2007/

CO-PO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

25BEBME6E15	MEDICAL REGULATORY AFFAIRS	SEMESTER – VII 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Outline the regulatory testing factors for food and drug administration
- Summarize the Indian medical device rules and regulations
- Select the regulatory standards and safety procedures for biomedical device development

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the medical device testing factors
- Infer the regulatory standards for Food and Drug administration
- Summarize the Indian medical device rules and regulation
- Show the importance of product safety and compliance
- Identify the regulatory standards for biomedical applications

UNIT I DEFINITION OF TESTING 09

Parsing test requirements, test protocol, test methodology, purpose of the test, failure definition, determining sample size and test length, types of testing. Analysis of test data- failure rate, mean time between failure, reliability, confidence level, confidence limits, minimum life, graphical analysis. Reliability and liability- negligence, strict liability, breach of warranty, defects, plaintiff's conduct, defendant's conduct, defendant related issues, manufacturers and physicians responsibilities, accident reconstruction and forensics.

UNIT II FOOD AND DRUG ADMINISTRATION 09

History of device regulation, device classification, registration and listing, 510(k) process, declaration of conformance to a recognized standard, PMA application, investigational device exemptions, good laboratory practices, good manufacturing practices, human factors, design control, FDA and software classification, FDA inspection, advice on dealing with the FDA regulations and standards- definition of medical device, MDD, United States Domestic Standards, rest of the world standards.

UNIT III INDIAN MEDICAL DEVICE RULES AND REGULATIONS 09

Indian medical device rules and regulations-2017, licensing patents, copyrights and trade secrets, trademarks. Manufacturing and quality control- GMP regulations, design for manufacturability, design for assembly, manufacturing process

UNIT IV PRODUCT SAFETY AND LEGAL ISSUES 09

Learning from failure, design for failure, design for convenience, universal design, design for assembly, prevention through design, design for the environment, pokayoke, product life issues, product testing issues. Product safety and legal issues, accident reconstruction and forensics, biomechanics and traffic-accident investigations. professional issues, BME – related professional societies, standards setting groups, professional engineering licensure, rules of professional conduct, codes of ethics, forensics and

consulting, continuing education.

UNIT V CASE STUDIES 09

Multi-detector brain scanning system development, testing of anesthetists, apnea detection system, cancer clinic charting, EKG analysis techniques & module.

Total: 45 Hours

TEXT BOOKS:

1. Seeram Ramakrishna, "Medical Devices Regulations, Standards and Practices", Wood Head Publishing series in Biomaterials, UK, 2015

REFERENCE BOOKS:

1. Val Theisz, "Medical Device Regulatory Practices", An International Perspective, CRC Press 2016

WEBSITES:

1. https://nptel.ac.in/courses/127106136
2. https://nptel.ac.in/courses/127106010

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E Biomedical Engineering		2025-2026
25BEBME6E16	BIOMEDICAL DEVICE DESIGN AND DEVELOPMENT	Elective 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of this course is for students to,

- Illustrate the design procedure and quality assessment of medical devices.
- Introduce the medical device standards and requirements.
- Understand the validation and verification of various medical devices

COURSE OUTCOMES

Upon completion of this course, students will be able to:

- Explain the design and development of biomedical products
- Illustrate the processes to ensure quality, testing, and approval of biomedical products.
- Apply signal processing techniques required for product development
- Analyze the medical device standards and regulations
- Build software development process

UNIT I **PRODUCT DESIGN** **09**

Product Development process, Market Survey, Design lifecycle, Classification of medical Devices, Design process-Product specification, Design Evaluation, Risk Assessment, Product Life cycle, Design History File, Case studies: ECG System design

UNIT II **PRODUCT DEVELOPMENT** **09**

Process to Design Realization, Computer Aided Design- Rapid prototyping, 3D Visualization, Prototype Development, Risk Analysis and Management, Clinical Validation, Medical Device Calibration, Scalability, Commercialization, Case studies on development of ECG system.

UNIT III **SIGNAL PROCESSING** **09**

Discrete Representation of Analog systems, Discrete Fourier Transform, Spectrum, Power spectral density function, Signal Denoising using Filtering, Case studies on signal denoising

UNIT IV **MEDICAL DEVICE STANDARDS AND REGULATIONS** **09**

Medical Device Quality Management System- ISO 13485, Technical Standards for Medical Devices, Safety requirement of Medical Devices, Electromagnetic Compatibility test- IEC 60601-1, IEC 60601-2, Medical Device Regulations, Medical Device Certification, Case studies on Medical Device Standards.

UNIT V **MEDICAL SOFTWARE** **09**

Guidelines on Software design, Software development process, Standards for Medical Software, Risk management in Software, Cloud Computing Model, Case studies on Medical Software.

Total: 45 Hours

TEXT BOOKS:

1. Zenios, Makower and Yock, ―Biodesign – The process of innovating medical technologies, Canbridge University Press, 2009
2. Theodore R. Kucklick , The Medical Device R&D Handbook, Second Edition, CRC Press,2012.
3. Peter Ogrodnik,Medical Device Design Innovation from Concept to Market, Elsevier, 2013.

REFERENCE BOOKS:

1. Richard C. Fries and Marcel Dekker AG, Handbook of Medical Device Design,2ndedition, 2005.
2. Gail Baura, Medical Device Technologies: A Systems Based Overview Using Engineering, Elsevier science, 2012.
3. Matthew Bret Weinger, Michael E. Wiklund, Daryle Jean Gardner-Bonneau‘Handbook of Human Factors in Medical Device Design‘,CRC press,2010.
4. Jagdish Chaturvedi, Inventing medical devices: A perspective from India, Create Space Independent Publishing Platform, 1st edition, 2015.

WEBSITES:

1. https://nptel.ac.in/courses/112107217
2. https://ocw.mit.edu/courses/15-783j-product-design-and-development-spring-2006/

CO-PO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, ‘-’ - No Correlation

B.E Biomedical Engineering		2025-2026
2BEBME7E07	QUALITY ASSURANCE AND SAFETY IN HEALTHCARE	Elective 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of this course is for students to:

- Understand quality management and standardization in healthcare..
- Explain the healthcare safety protocols for property, staff, and patients.
- Analyze quality healthcare and patient satisfaction.

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the necessity of standardization and quality management
- Illustrate the regulatory requirements for healthcare
- Implement security and safety measures for hospital
- Identify sources of electrical shocks (macro & micro) and their hazards
- Apply methods for measuring quality care

UNIT I **STANDARDIZATION OF QUALITY MEDICAL CARE IN HOSPITALS** **09**

Define Quality- Need for Standarization & Quality Management, TQM in Health care organizationQuality assurance methods ,QA in (Medical Imaging & Nuclear medicine) Diagnostic services – Classification of equipments

UNIT II **REGULATORY REQUIREMENT FOR HEALTH CARE** **09**

FDA regulations, Accreditation for hospitals - JCI, NABH and NABL, Other regulatory Codes

UNIT III **HOSPITAL SAFETY** **09**

Security & Safety of Hospital -Property, Staff & Patients, Radiation safety, Safety precautions, hazardous effects of radiation, allowed levels of radiation, ICRP regulations for radiation safety, Disposal of Biological waste.

UNIT IV **ELECTRICAL & FIRE SAFETY** **09**

Sources of shocks, macro & micro shocks -Hazards, monitoring and interrupting the Operation from leakage current- Elements of fire, causes of fire , Action to be taken in case of fire in a Hospital.

UNIT V **ASSESSING QUALITY HEALTH CARE** **09**

Patient Safety Organization- Governmental & Independent, Measuring Quality care – Evaluation of hospital services – six sigma way, Quality Assurance in Hospitals Sop's – Patient Orientation for Total Patient Satisfaction. 5S techniques

Total: 45 Hours

TEXT BOOKS:

1. Cesar A. Cacere & Albert Zana, The Practice of Clinical Engg. Academic press, New York, 1977.
2. Webster J.G and Albert M.Cook, Clinical Engg, Principles & Practices, Prentice Hall Inc., Engle wood Cliffs, New Jersy, 1979.
3. B.M.Sakharkar, Principles of Hospital administration and Planning, JAYPEE Brothers, Medical Publishers (P) Ltd.

REFERENCE BOOKS:

1. K.Shridhara Bhat, Quality Management, Himalaya Publishing House.
2. Karen Parsley, Karen Parsley Philomena Corrigan" Quality improvement in Healthcare, 2nd edition ,Nelson Thrones Pub, 2002
3. Sharon Myers "Patient Safety & Hospital Accreditation - A Model for Ensuring Success" Springer Publishers 2012

WEBSITES:

1. https://archive.nptel.ac.in/courses/110/105/110105160/
2. https://ocw.mit.edu/courses/hst-s14-health-information-systems-to-improve-quality-of-care-in-resource-poor-settings-spring-2012/

CO - PO - PSO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

Elective

25BEBME7E08 STERILIZATION TECHNIQUES FOR MEDICAL DEVICES 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of this course is for students to,

- Explain the principles of sterilization
- Illustrate sterilization techniques, distinguishing their mechanisms of action.
- Design a microsystem for a given medical application

COURSE OUTCOMES

Upon completion of this course, students will be able to:

- Explain the fundamental principles of sterilization
- Illustrate the effectiveness of different sterilization methods based on requirements.
- Identify and describe the different sterilization techniques
- Infer the sterilization guidelines and standards to ensure safety and efficacy in sterilization practices.
- Model the micro system for medical application.

UNIT-I DEVICE STERILIZATION 9

Various materials used in medical devices, Types of sterilizations – dry heat, steam, ethylene oxide, hydrogen peroxide, water quality used for steam sterilization, air quality used for drying, Cleaning of medical devices, cleaning products, cleaning methods, mechanical cleaning,

UNIT-II MEDICAL DEVICE REPROCESSING 9

Preparation and packaging for reprocessing, post cleaning inspection, Packaging and wrapping material – packaging techniques, materials, specific guidelines for various sterilization techniques, Labelling, Chemical disinfectants, Decontamination of endoscopes

UNIT-III STERILIZATION OF REUSABLE MEDICAL DEVICES 9

Sterilization of reusable medical devices, Immediate use steam sterilization (IUSS) system ("flash" sterilization), Reuse of singleuse medical devices, Transporting medical devices to and from a decontamination facility, Processing of instruments in dental practice

UNIT-IV RADIATION STERILIZATION: METHODS AND COMPLIANCE 9

Radiation Sterilization, Gamma irradiators, Electron accelerators, Dosimetry and the radiation sterilization process, microbiological aspects of radiation sterilization.

UNIT-V REGULATORY FRAMEWORKS AND STANDARDS 9

Regulatory issues for sterilization centers and facilities, Reuse of single-use medical devices: ethical, safety, and regulatory considerations. International standards: ISO 13485 (Quality Management Systems), ISO 11137 (Radiation Sterilization), ISO 11135 (EtO Sterilization), ISO 17665 (Moist Heat Sterilization),

ISO 11139 (Vocabulary).

Total periods : 45

TEXTBOOKS:

1. VikasChoudhary, Krzysztof Iniewski, “MEMS: Fundamental Technology and Applications”, CRC Press, UK, 2017.
2. Tatsuo Togawa; Toshiyo Tamura; P. Ake Oberg, “Biomedical Sensors and Instruments”, CRC Press, UK 2011.

REFERENCES:

1. Trends in Radiation Sterilization of Health Care Products, International Atomic Energy Agency, Vienna, 2008
2. Decontamination and Reprocessing of Medical Devices for Health-care Facilities
3.

WEBSITES:

1. https://onlinecourses.nptel.ac.in/noc22_ee76/preview
2. https://ocw.mit.edu/courses/mas-836-sensor-technologies-for-interactive-environments-spring-2011/

CO-PO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, ‘-’ - No Correlation

Elective

22BEBME7E15 GRAPHICAL SYSTEM DESIGN FOR BIOMEDICAL ENGINEERS 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of this course is for students to,

- Understand the basics of Programming Techniques
- Illustrate the data acquisition and control of a device by interfacing to a computer.
- Design virtual instruments for various biomedical measurements and applications.

COURSE OUTCOMES

Upon completion of this course, students will be able to:

- Explain the Concept of LabVIEW programming.
- Apply the front panel and block diagram objects of VIs software in a simple program.
- Interpret the functions of data communication and synchronization.
- Build signal processing VIs using LabVIEW.
- Apply virtual instrumentation for biomedical applications.

UNIT-I LABVIEW PROGRAMMING PRINCIPLES & ENVIRONMENT 9

Data flow – Definition, and importance of data flow in LabVIEW – Identify programming practices that enforce data flow in block diagram, Virtual instrumentation (VI), and sub-VIs - Identify programming practices that break data flow – Polymorphism - Define polymorphism - Identify benefits of polymorphism - Determine output or intermediate values of data elements in VI that utilizes polymorphic inputs LabVIEW Environment -Front panel window, block diagram, and connector pane - Identify which types of VIs do not have a block diagram - Identify the purpose of the connector pane and icon – Palettes

UNIT-II SOFTWARE CONSTRUCTS & PROGRAMMING FUNCTIONS 9

Front panel window and block diagram objects - Controls, indicators, IO controls, and refnums - Property Nodes - Data types and data structures - Working with objects and data types on front panel windows – Program control structures and data storage - Flat and Stacked sequence structures - Event structures- FormulaNode - Arrays and clusters.

UNIT-III DATA COMMUNICATION & SYNCHRONIZATION 9

Local, global, and shared variables – Data Socket - TCP and UDP – Synchronization – Notifiers – Queues -VI Server - configuring the VI Server - Error handling VIs and functions - Debugging tools and techniques .

UNIT-IV VIRTUAL INSTRUMENTATION (VI) DESIGN & SUB VI DESIGN TECHNIQUES 9

Simple state machine - User interface event handler - Queued message handler - Producer/consumer (data) and producer/consumer (events) - Functional global variables - Connector panes and connection types - Polymorphic subVIs - Options related to subVIs - Error handling – User interface design and block diagram layout - Modular and hierarchical design - SubVI icons and connector pane layout (standard) - VI properties Documenting VIs.

UNIT-V Applications **9**

Applications of LabVIEW in displaying and monitoring vital parameters, Biomedical signal processing,controlling assistive devices.

Total periods : 45

TEXTBOOKS:

1. S. Sumathi, P.Surekha, "LabVIEW based Advanced Instrumentation Systems", Springer 2007.
2. Gary Jonson, 'LabVIEW Graphical Programming', McGraw Hill, New York, Fourth edition 2006.

REFERENCES:

1. Jon B Olansen and Eric Rosow, "Vitrual Bio-Instrumentation Biomedical, Clinical and Healthcare Applications in LabVIEW" 2001.
2. Rick Bitter, TaqiMohiuddin, Matt Nawrocki "LabVIEW: Advanced Programming Techniques" Second Edition, CRC press, 2007.
3. Lisa K. Wells & Jeffrey Travis, 'LabVIEW for Everyone', Prentice Hall Inc., First edition 1997.
4. S. Gupta, J.P. Gupta, 'PC interfacing for Data Acquisition & Process Control', Instrument Society of America, Second Edition, 1994.

WEBSITES:

1. https://nptel.ac.in/courses/107106009
2. https://onlinecourses.nptel.ac.in/noc21_ee105/preview

CO-PO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

Elective

25BEBME7E16 **HEALTHCARE SYSTEM DESIGN** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks:** Internal**:40** External**:60** Total**:100**
End Semester Exam:3 Hours

COURSE OBJECTIVES

The goal of this course is for students to,

- Understand the needs for wearable devices and the technology
- Explain the concepts in digital health care and digital hospitals
- Apply the tools in design, testing and developing digital health care equipment.

COURSE OUTCOMES

Upon completion of this course, students will be able to:

- Explain the technology for wearable healthcare devices.
- Interpret the concepts of digital radiology.
- Select the modality for e-health.
- Utilize the ethical standards in digital health.
- Summarize the recent trends in e-health system.

UNIT-I **WEARABLE DEVICES AND M-HEALTH CARE** **9**

Introduction to mobile health caredevices-economy-average length of stay in hospital, outpatient care, health care costs, mobile phones, 4G, smart devices, wearable devices, Uptake of e-health and m-health technologies. Standards, system Design and case study.

UNIT-II **DIGITAL RADIOLOGY** **9**

Digital radiology for digital hospital, picture archiving and communication, system integration, digital history of radiology, medical image archives, storage and networks.

UNIT-III **E-HEALTH & MODALITY** **9**

Health care networking, medical reporting using speech recognition, physiological tests and functional diagnosis with digital methods, tele-consultation in medicine and radiology. Multimodality registration in daily clinical practice. Mobile healthcare.

UNIT-IV **DIGITAL HEALTH** **9**

Requirements and best practices, Laws and regulations in Digital health, Ethical issues, barriers and strategies for innovation.

UNIT-V **STANDARDS FOR INTER OPERABILITY** **9**

Selection and Implementation in e-Health project, design of medical equipment based on user needs. Security and privacy in digital health care.

Total periods : 45

TEXTBOOKS:

1. Wlater Hruby, " Digital revolution in radiology – Bridging the future of health care, second edition, Springer, New York. 2006.
2. Christoph Thuemmler, Chunxue Bai, "Health 4.0: How Virtualization and Big Data are Revolutionizing Healthcare", Springer, 1st ed. 2017.
3. Samuel A. Fricker, Christoph Thümmler , Anastasius Gavras, "Requirements Engineering for Digital Health", Springer, 2015.

REFERENCES:

1. Rick Krohn (Editor), David Metcalf, Patricia Salber, "Health-e Everything: Wearables and The Internet of Things for Health, ebook. 2013.
2. Khandpur,R.S,"Handbook of Biomedical Instrumentation ",Second Edition. Tata Mc Graw Hill Pub. Co., Ltd. 2003
3. John, G. Webster. Medical Instrumentation: Application and Design. Second Edition. Wiley Publisher, New Delhi. 2013.

WEBSITES:

1. https://onlinecourses.nptel.ac.in/noc23_ee95/preview
2. https://archive.nptel.ac.in/courses/102/105/102105090/

CO-PO MAPPING

COs /POs	KL	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO2	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO3	K2	2	1	-	-	-	-	-	1	1	-	-	1	-
CO4	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
CO5	K3	3	2	1	-	-	-	-	1	1	-	-	1	-
Average		**2.4**	**1.4**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation

B.E BIOMEDICAL ENGINEERING **2025-2026**

25BEMC151G	WOMEN SAFETY AND SECURITY	SEMESTER – I 1H-0C

Instruction Hours/week: L:1 T:0 P:0 **Marks: Internal:100 External:0 Total:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

The goal of this course is for the students to

- Make aware about the practical issues concerning gender and politics.
- Acquaint knowledge about the national policies and programmes and the gendered structures of governance and polity
- Observe the liability of women and women's work in the context of globalization.

COURSE OUTCOMES

Upon completion of this course the students will be able to

- Infer into the basic concepts related to sex, gender, femininity etc.
- Demonstrate the rationale for women's studies
- Compare Gender Equality Issues and Movements in Women's Studies
- Summarize the Social construction of Gender, Gender Roles and Gender stereotyping.
- Illustrate Social Structures, Changing Status of Women in India.

UNIT I FUNDAMENTAL CONCEPTS OF WOMEN'S STUDIES

Definition- Objectives of Women's Studies; Importance of Women's Studies; Women's Studies as an Academic Discipline; Role of UGC Centre for Women's Studies

UNIT II SOCIAL EMPOWERMENT

Women in Higher Education; Gender issues in Health, Environment, Family welfare Measures, Indecent representation of Women in media; Women in Difficult circumstances; Constitutional.

UNIT III POLITICAL EMPOWERMENT

Women leaders in politics- Women in Local Governance- Barriers- Reservation policies- Women's Political Rights, Property Rights - Violence against Women - Women's work

TEXT BOOKS:

1. Amy S. Wharton. (2005). "The Sociology of Gender: An Introduction to Theory and Research". (Key Themes in Sociology) Blackwell Publishing, UK, Indian Reprint, Kilaso Books, New Delhi.
2. Devaki Jain and Pam Rajput (Ed). (2003). "Narratives from the Women"s Studies Family: Recreating Knowledge, Sage, and New Delhi.
3. Jasbir Jain (Ed). (2005). "Women in Patriarchy: Cross Cultural". Rawat Publication Jaipur.

25BEMC152G **தமிழர் மரபும் பண்பாடும்** **பருவம் -I**
1H-0C

கற்பித்தல் நேரம்/வாரம்: **L:1 T:0 P:0** **மதிப்பெண்: இடைத்தேர்வு: 100**
மொத்தம்:100

PREREQUISITES: NIL

பாடத்திட்ட பயன் விளைவு:

- வரலாற்றிற்கு முற்பட்ட தமிழகத்தை மாணவர்களுக்கு அறிமுகப்படுத்துதல்
- பழந்தமிழர் பண்பாடு சார்ந்த வாழ்க்கை முறையை மாணவர்கள் அறிய ஊக்குவித்தல்
- தமிழ் மொழியின் பழைமையும், திராவிட மொழிகளில் தமிழ்மொழியின் தனிச்சிறப்பையும் மாணவர்களுக்கு அறிமுகப்படுத்துதல்.
- தமிழர்களின் வாழ்வியல், தமிழர்கலைகள், ஆற்றங்கரைப்பண்பாடுகள் குறித்து மாணவர்கள் அறியச்செய்தல்.
- இந்தியக்குடியுரிமைப்பணி முதலான போட்டித்தேர்வுகளில் விருப்பப்பாடமாக இடம்பெறுகின்ற தமிழ்நாகரிகமும் பண்பாடும் குறித்த முழுமையான அறிமுகம் பெற்றிருத்தல்

பாடத்திட்டப் பொதுநோக்கம்:

- இந்தியக்குடியுரிமைப்பணி முதலான போட்டித்தேர்வுகளில், விருப்பப்பாடமாக இடம்பெறுகின்ற, ‘தமிழ்இலக்கியவரலாறு’ குறித்த முழுமையான அறிமுகம் பெற்றிருத்தல்.
- கல்வெட்டியல், ஓலைச்சுவடியியல் மற்றும் தொல்லியல் சார்ந்த ஆவணத்தேடலுக்குரிய ஆய்வுமனப்பான்மையுடன், இலக்கியங்களை அணுகுதல்.
- தமிழின்வளர்ச்சித்துறையாகிய, ‘அறிவியல்தமிழ்’ ; ‘ இணையதமிழ்’ குறித்த பன்நோக்கு அணுகுமுறையிலான ஆய்வுச்சிந்தனை மேம்பாடு.
- வேலைவாய்ப்புக்குரிய சுயதிறன் மேம்பாட்டுடன், படைப்பாக்கத்திறன் மேம்பாடும் பெற்றிருத்தல்.
- சமுதாய மற்றும் வாழ்வியல் மதிப்புகளைப்பேணுவதற்குக்கருவியாக இலக்கியங்களை நாடுகின்ற மனப்பான்மைவளர்ச்சி. மொழிபெயர்ப்புத்துறை சார்ந்த வேலைவாய்புத்திறன் பெற்றிருத்தல்.

அலகு I **தமிழர் மரபு**

மரபு-விளக்கம்-சங்ககால தமிழர் மரபு – திணைப்பகுப்பும் தமிழர் மரபும்- உலகப்பொதுமை – அகத்திணை மரபு – புறத்திணை மரபு- இடைக்காலத்தமிழர் மரபு – பிற்கால மரபும் மாற்றமும் – தற்கால தமிழர்மரபு - வளர்ச்சி.

அலகு II **தமிழர் பண்பாடு**

பண்பாடு – விளக்கம் – பழந்தமிழர் பண்பாடு – இயற்கை சார்ந்த வாழ்வியல் – தமிழர் சமயம் – அரசியல் நிலை–சமூகப் பழக்கவழக்கங்கள் – நம்பிக்கைகள் – வாழ்வியல் அறங்கள் – வணிகம் போன்றவை.

அலகு III **தமிழர் கலைகள்**

தமிழகத்தில் கலைகளின் வளர்ச்சி – சிற்பக்கலை வளர்ச்சி –கோயில் கலை – கற்கோவில்கள் - ஓவியக்கலை – அழகுக்கலைகள் - கூத்துக்கலை – மருத்துவக்கலை – நாடகக்கலை– இசைக்கலை போன்றவை.

அலகு IV **தமிழர் சமயம்**

பழந்தமிழரின் சமயம் – சங்ககால சமயம் – தொல்காப்பியத்தில் சமயம் – சைவ சமயம் – வைணவம் – தமிழ்ப் பண்பாட்டில் பௌத்தம் – தமிழ்ப் பண்பாட்டில் சமணத்தின் தாக்கம்–தமிழ்ப் பண்பாட்டில் இசுலாம் மற்றும் கிறித்துவ சமயத்தின் தாக்கம்- தமிழர் பண்பாட்டில் விழாக்கள்- கோயில்களும் விழாக்களும்- சமூக ஒருங்கிணைப்பில் விழாக்களின் பங்கு- சங்க இலக்கியத்தில் விழாக்கள் பற்றிய குறிப்புகள்-இடைக்கால இலக்கியங்களில் விழாக்கள் பற்றிய செய்திகள் – விழாக்களின் சமூகப்பங்களிப்பு – தற்காலத்தில் தமிழர் விழாக்கள் - விளையாட்டும் விழாக்களும்.

அலகு V **இலக்கியங்களில் தமிழர் பண்பாட்டுப் பதிவுகள்**

சங்க இலக்கியமும் வாழ்வியலும்-திருக்குறளில் வாழ்வியல் நெறிகள் – இரட்டைக் காப்பியங்களும் வாழ்வியலும் – சிற்றிலக்கியங்களில் வாழ்வியல் பதிவுகள்-இக்கால இலக்கியமும் வாழ்வியலும்.

பார்வைநூல்கள்:

1. தமிழ் இலக்கிய வரலாறு – தமிழண்ணல், மீனாட்சி புத்தக நிலையம்-மதுரை-இரண்டாம் பதிப்பு-ஜூலை – 2000.
2. தமிழர் நாகரிகமும் பண்பாடும், அ. தட்சிணாமூர்த்தி, ஐந்திணைப் பதிப்பகம், சென்னை, திருத்திய பதிப்பு – 2022.
3. தமிழர் வரலாறும் பண்பாடும், நா. வானமாமலை, நியூசெஞ்சுரி புக் ஹவுஸ், சென்னை, ஆறாம்பதிப்பு – 2007
4. தமிழக வரலாறு மக்களும் பண்பாடும், கே.கே. பிள்ளை, உலகத் தமிழராய்ச்சி நிறுவனம், சென்னை.

B.E BIOMEDICAL ENGINEERING **2025-2026**

25BEMC251G	**YOGA**	**SEMESTER – II** **3H-2C**

Instruction Hours/week: L:1 T:0 P:2 **Marks:** Internal**:100** External**:0** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course, is for the students to:

- Understand the concepts of Yoga and Physical Health
- Provide value education to improve the students character, understanding greatness of life force and Mind.
- Learning introspection practices like analysis of Thought, Moralization of Desires, Neutralization of Anger and Eradication of Worries

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Practice physical activities and yoga for strength, flexibility and relaxation.
- Use techniques for increasing concentration and decreasing anxiety for stronger academic performance.
- Perform yoga exercises in various combination and forms.
- Improve personal fitness through participation in sports and yoga activities.
- Follow sound nutritional practices for maintaining good health and physical performance.

UNIT I **INTRODUCTION TO PHYSICAL FITNESS**

Explain importance of physical education - Describe importance of Physical Fitness & Wellness - Explain the components of physical fitness - Demonstrate healthy life style - Prevent health threats by changing life style

UNIT II **FUNDAMENTALS OF ANATOMY & PHYSIOLOGY IN SPORTS & YOGA**

Explain importance of anatomy and physiology - Describe effects of exercise in various body systems- Describe concept of correct posture - Explain corrective measures for posture deformities.

UNIT III **YOGA & PRANAYAMA**

Explain importance of yoga - Perform various pranayama for increasing concentration - Use meditation and other relaxation techniques for improving concentration.

TEXT BOOKS:

1. Ajmer Singh, Modern Trends and Physical Education class 11 & class 12, Kalyani Publication, New Delhi ISBN:9789327264319.
2. B. K. S. Iyengar, Light on Yoga, Thomson's Publication, New Delhi ISBN: 8172235011
3. V. K. Sharma, Health and Physical Education, NCERT Books; Class 11, 12 Saraswati House Publication, New Delhi
4. Acharya Yatendra, Yoga and Stress Management, Finger print Publishing ISBN:938905303X
5. Swami Vivekanand, Patanjali Yoga Sutras, Fingerprint Publishing ISBN:9389567351.
6. Ramdev, Pranayam Rahasya, Patanjali-Divya Prakashan, Haridwar ISBN:978-8189235017
7. Ramdev, Yoga its Philosophy & Practice, Divya Prakashan, Haridwar.

B.E BIOMEDICAL ENGINEERING **2025-2026**

25BEMC252G	VEDIC MATHEMATICS	SEMESTER – II 1H–0C

Instruction Hours/week: L:1 T:0 P:0 **Marks:** Internal**:100** External**:0** Total**:100**
End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course, is for the students to:

- To overcome the fear of maths, acquire knowledge in Logical thinking, increase concentration and improve critical thinking.
- To build the skill to perform basic math fast and accurately with confidence.
- To enhance computation skills through Vedic Mathematics

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Apply Vedic sutras for arithmetic computation. (K3)
- Utilize Urdhva Tiryagbhyam for solving complex multiplication problems. (K3)
- Make use of Vedic division method for basic word problems. (K3)

UNIT I **(5)**

Application of vedic sutras, Arthimetic computation, Shudh method for a list of number, Rapid Addition- Single to Double-Digit, Subtraction using Nikliam

UNIT II **(5)**

Multiplication by Thumb Rule, Multiplication Vertically and cross wise, Urdhvatiryagbhyam, Anurupyena.

UNIT III **(5)**

Squaring numbers, Traditonal Division, Straight Division, Facts of Division, Basic Word Problems.

Total Hours: 15

REFERENCES:

1. Jagadguru swami sri Bharathi krsnatirthajimaharaja,"Vedic Mathematics", International Best seller, New RevisedEdition.
2. Sri Bharati Krsna Tirthaji, "Vedic Mathematics", published by Motilal Banarsidass, 1965.
3. Williams K.R. "Discover Vedic Mathematics." Vedic Mathematics Research Group, 1984.
4. Rajesh Kumar Thakur, "Advanced Vedic Mathematics", Rupa Publications India Pvt. Ltd 2019.:

WEBSITES:

1. www.nptel.ac.in/courses/111101080

2. www.https://vedicmathworld.com/

B.E BIOMEDICAL ENGINEERING		2025-2026
25BEMC351G	**APTITUDE AND REASONING**	**SEMESTER – III** **1H-0C**

Instruction Hours/week: L:1 T:0 P:0 **Marks:** Internal**:100** External**:0** Total**:100**

End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for the students to

- Apply thought processes to distinguish between concepts of Quantitative methods.
- Explain the fundamentals related to various possibilities and probabilities related to quantitative aptitude.
- Solve puzzle-related questions from competitive tests.

COURSE OUTCOMES

Upon completion of this course, the students will be able to

- Explain the basic concepts of quantitative ability
- Infer the basic concepts of logical reasoning Skills
- Interpret the satisfactory competency in the use of reasoning
- Solve campus placements aptitude papers covering quantitative ability, and Logical Reasoning
- Apply for competitive exams like CAT, CMAT, GATE, GRE, GATE, UPSC, GPSC etc.

UNIT I **Quantitative Ability (Basic Mathematics)** **(6)**

1.1. Number Systems
1.2. LCM and HCF
1.3. Decimal Fractions
1.4. Simplification
1.5. Square Roots and Cube Roots
1.6. Problems on Ages
1.7. Surds & Indices
1.8. Percentages

UNIT II **Quantitative Ability (Applied & Engineering Mathematics)** **(6)**

2.1. Logarithm
2.2. Permutation and Combinations
2.3 Probability
2.4 Profit and Loss
2.5 Simple and Compound Interest
2.6. Time, Speed and Distance
2.7. Time & Work
2.8. Ratio and Proportion
2.9. Area
2.10 Mixtures and Allegation

UNIT III **Verbal – Aptitude** **(3)**

3.1. Words
3.2. Idioms
3.3. Phrases in Context
3.4. Reading comprehension techniques
3.5. Narrative sequencing
3.6. Data interpretation

Total Hours: 15

TEXT BOOKS:

1. A Modern Approach to Verbal & Non-Verbal Reasoning By R S Agarwal
2. Analytical and Logical Reasoning By Sijwali B S
3. Quantitative aptitude for Competitive examination By R S Agarwal
4. Analytical and Logical Reasoning for CAT and other management entrance tests By Sijwali B S
5. Quantitative Aptitude by Competitive Examinations by Abhijit Guha 4th edition

WEBSITES:

1. https://prepinsta.com/
2. https://www.indiabix.com/
3. https://www.javatpoint.com/

B.E BIOMEDICAL ENGINEERING **2025-2026**

25BEMC452G	ESSENCE OF INDIAN TRADITIONAL KNOWLEDGE AND HERITAGE	SEMESTER – IV 1H-0C

Instruction Hours/week: L:1 T:0 P:0 **Marks:** Internal**:100** External**:0** Total**:100**

End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for the students to

- Infer a holistic understanding about Indian Culture and Thoughts from a Historical perspective.
- Explain the critical appreciation of the Indian thoughts and cultural manifestations.
- Make use of Indian cultural heritage and various epistemological inquiries.

COURSE OUTCOMES

Upon completion of this course the students will be able to

- Explain the cultural diversity
- Infer the need of cultural unity
- Realize the power of Indian educational system called gurukul

UNIT I INTRODUCTION TO INDIAN THOUGHT AND CULTURE (5)

Plurality of Indian Culture - Cultural Diversity and Cultural Unity -Different Manifestations of Indian Culture: Indus Valley culture -Vedic Culture and Dravidian culture.-The Medieval Bhakti Culture

UNIT II TRADITIONAL KNOWLEDGE SYSTEMS OF INDIA (5)

Introduction to the Traditional Indian Education System of Gurukul - Parampara -Understanding Indian Philosophy: Vedic Thought and the nine schools of Philosophy - Indigenous Knowledge and Women in India

UNIT III PROTECTION OF TRADITIONAL KNOWLEDGE (5)

Protection of traditional knowledge: The need for protecting traditional knowledge Significance of TK Protection, the value of TK in the global economy, Role of Government to harness TK

Total Hours : 15

TEXT BOOKS:

1. Chatterjee, Satishchandra and Dhirendramohan Datta. (2007) Introduction to Indian Philosophy. Rupa Publications, New Delhi.
2. Husain,S. Abid. (2003). The National Culture of India. National Book Trust, New Delhi.

B.E BIOMEDICAL ENGINEERING **2025-2026**

25BEMC551G	**CYBER SECURITY**	**SEMESTER – V** **1H-0C**

Instruction Hours/week: L:1 T:0 P:0 **Marks:** Internal**:100** External**:0** Total**:100**

End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Explain the field of digital security and concepts of access control mechanism.
- Infer the network basic and familiarize on security of network protocols
- Interpret the cyber-attacks and data privacy

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Infer the importance of a network basics and brief introduction on security of network protocols
- Apply a solid foundation in digital security and measures taken to protect device from threats.
- Relate cyber-attacks and data privacy issues and preventive measures.
- Make use of tools and methods used in cyber security.
- Explain Cyber security organizational implications.

UNIT I **CYBER SECURITY FUNDAMENTALS**

Information Assurance Fundamentals – Authentication-Authorization-Nonrepudiation-Confidentiality-Integrity-Availability.

UNIT II **CRYPTOGRAPHY**

Basic Cryptography- Symmetric Encryption- Example of Simple Symmetric Encryption with Exclusive OR (XOR)- Public Key Encryption

UNIT III **FRAUD TECHNIQUES**

Phishing- Smishing- Vishing. Mobile Malicious Code-Phishing against Mobile Devices. Rogue Antivirus-Following the Money: Payments . Click Fraud-Pay-per-Click-Click Fraud Motivations-Click Fraud Tactics and Detection- Threat Infrastructure-Botnets-Fast-Flux.

Total Hours: 15

TEXT BOOKS:

1. Introduction to Cyber Security,Guide to the world by Anand Shinde, Wiley Publisher, 2021
2. 2. James Graham, Ryan Olson and Rick Howard, “Cyber Security Essentials”, First Edition, CRC Press, 2010.

B.E BIOMEDICAL ENGINEERING **2025-2026**

25BEMC651	DESIGN THINKING	SEMESTER – VI 2H-0C

Instruction Hours/week: L:0 T:0 P:2 **Marks:** Internal**:100** External**:0** Total**:100**

End Semester Exam:3 Hours

PREREQUISITES: NIL

COURSE OBJECTIVES

The goal of this course is for students to:

- Illustrate design thinking concepts and principles
- Utilize design thinking methods in every stage of the problem
- Plan for various product and service communication in design thinking

COURSE OUTCOMES

Upon completion of this course, the student will be able to:

- Explain the design thinking process, tools and theories. K2
- Identify the types of users and the requirements of customers. K3
- Examine the concepts of Prototyping and its testing. K4
- Analyze design thinking strategies in product and service design. K4
- Inspect the existing products by utilizing design thinking strategies. K4

UNIT I INTRODUCTION (6)

Understanding Design thinking and tools - Human-Centric Design Process - Design Thinking Process- DT Activity with case studies.

UNIT II EMPATHISE WITH USERS (6)

Five Whys - Needs of user - Types of user research -Customer Journey Mapping - Observational Research.

UNIT III PROTOTYPING (6)

Ideas to presentable concepts - Scenario-based Prototyping – Testing prototypes - Usability and ergonomic testing - Rapid prototyping

UNIT IV PRODUCT AND SERVICE DESIGN (6)

Product Design - Interaction Design- Service Design - Communication Design - Transportation Design.

UNIT V DESIGN AND INNOVATION (6)

DT For strategic innovations - Extreme Competition - Experience design - Standardization - Humanization - Creative Culture.

Total: 30 Hours

TEXT BOOKS:

1. Bala Ramadurai, "Karmic Design Thinking", 2020.
2. Christian Mueller-Roterberg, “Handbook of Design thinking”, Amazon Digital Services LLC - KDP Print US, 2018.
3. Tim Brown, “Change by Design”, Harper Business Publisher, 2019
4. Hasso Plattner, Christoph Meinel and Larry Leifer, "Design Thinking: Understand –Improve Apply", Springer, 2011
5. Idris Mootee, "Design Thinking for Strategic Innovation: What They Can't Teach You at Business or Design School", John Wiley & Sons 2013.

CO, PO, PSO Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	1	1	-	-	-	-	1	1	1	-	3	-
CO2	3	2	1	-	-	-	-	2	1	1	-	3	-
CO3	3	2	2	1	-	2	1	2	2	2	-	3	-
CO4	3	3	2	1	-	2	1	2	2	2	-	3	-
CO5	3	3	2	1	-	2	1	2	2	2	-	3	-
Average	**2.8**	**2.2**	**1.6**	**1**	**-**	**2**	**1**	**1.8**	**1.6**	**1.6**	**-**	**3**	**-**

1 - Low, 2 - Medium, 3 - High, '-' - No Correlation